

Life skills in school health promotion: challenges and solutions

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Life skills in school health promotion: challenges and solutions

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Editorial: Life skills in school health promotion: challenges and solutions

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Editorial on the Research Topic

[Life skills in school health promotion: challenges and solutions](#)

This Research Topic on “*Life skills in school health promotion: challenges and solutions*” aims to address the ongoing challenges in defining and understanding life skills within school health promotion and beyond. By deepening the current literature and engaging with health education and promotion professionals, it seeks to identify and resolve the conceptual ambiguities that hinder a unified comprehension of life skills. The ultimate objective is to propose more precise and applicable definitions and frameworks that can be embraced by health promotion policies and programmes globally. This endeavor will provide clarity and direction for policymakers, educators, and stakeholders striving to enhance health outcomes and the development of life skills among children, young people, adults and older people. A total of 41 manuscripts were submitted for consideration. Following a rigorous peer-review process and revisions based on expert feedback, 25 (60.1%) were accepted for publication. Among these, 9 explore *health promotion and wellbeing*, 8 examine *mental health and emotional competencies*, and 8 address *physical activity*.

Health promotion and wellbeing

The original concept of health promotion refers to the process of enabling individuals and communities to increase control over the factors that influence their health and, consequently, to improve it (1). Wellbeing, in turn, encompasses a person's overall quality of life, including physical, mental, emotional, social, and spiritual dimensions (2). Health promotion extends beyond the healthcare sector, involving governments, educational institutions, workplaces, healthcare systems, families, and communities, rather than health professionals alone. Wellbeing, meanwhile, reflects the experience of living a healthy, meaningful, and fulfilling life (2).

Together, health promotion and wellbeing represent a holistic approach to health that empowers individuals and communities to enhance their health and quality of life by strengthening personal capacities, creating supportive environments, and addressing the social, economic, cultural, and environmental determinants of health. This approach aims to enable people to flourish physically, mentally, and socially while living in healthy and sustainable environments. Widely adopted in public health, education, and international policy, it reflects a paradigm shift from viewing health merely as the absence of disease to recognizing it as a positive resource for everyday life (Magalhães-Júnior et al.).

The nine articles included in the *Health Promotion and Wellbeing* Section address the following issues: Salque et al. analyzed the French Explo'Santé programme, a school-based health promotion intervention that combines structured health education sessions with supportive environments, showing that it supports the development of key psychosocial competencies, contributing to understanding how school-based health promotion can foster more equitable developmental trajectories; Wang, Li et al. reported that Chinese nursing interns' digital literacy and self-efficacy are moderate, requiring improved training in digital competencies with psychological empowerment strategies to enhance interns' skills in digital healthcare environments; Xu et al. observed that Chinese nursing students show low electronic health literacy skills to retrieve, evaluate, and apply digital health information in clinical practice and health education, recommending that hospitals should establish health consultation centers or virtual platforms to assist nursing students in identifying and evaluating online health information and addressing their practical health needs; Magalhães-Júnior et al. analyzed Portuguese children's social representations of coronavirus to design school health education strategies that must include scientific knowledge and develop critical analysis of social media disseminating information; Zhao et al. applied the Knowledge-Attitude-Behavior (KAB) model to Chinese college students, showing that Knowledge influenced Behavior directly and Attitudes indirectly, indicating that teaching disease prevention needs to be improved, particularly on hazards of antibiotics; Dumitru et al. adapted and validated the Standardized Patient Performance Rating Scale—Student Version (SPRS-S) for evaluating simulated patients during first aid training of school-aged students in Greece, the results of which showed three distinct performance clusters and indicated that this Greek version constitutes a clear and targeted assessment tool that is not affected by possible demographic differences; Ferreira Borges Paschoalini and da Silveira Paschoalini analyzed an experiential learning project where first-year medical students promoted menstrual health education within Brazil's school health programme for adolescents, showing that it provided a dual-purpose intervention, fostering socially accountable, humanistic competencies in future physicians while simultaneously advancing adolescent health literacy and dignity; Niu et al. used a self-developed scale to assess fertility awareness among Chinese university students, showing that the fertility awareness level of Chinese university students is generally low, and recommended healthcare institutions should implement targeted intervention measures to improve reproductive health outcomes; Zhuang et al. verified that Chinese female college students' trust in

healthcare professionals affects price-related barriers and identified the high-risk profile “low trust and high price” as the dominant factor for HPV vaccination hesitancy.

Mental health and emotional competencies

Mental health refers to an individual's capacity to realize their potential, cope effectively with life's stresses, work productively, and contribute meaningfully to their community (3). As a fundamental component of overall wellbeing, mental health encompasses a dynamic state of balance across cognitive, emotional, and behavioral domains (4). Within this context, social and emotional learning has become a central component of contemporary education, which encompasses the knowledge, attitudes, and life skills required to understand and regulate emotions, establish and achieve positive goals, develop healthy relationships, and make responsible decisions (5). These life skills are essential for healthy child development (Alkahtani et al.) and remain equally important during adolescence, a developmental period characterized by profound physical, psychological, and social changes that shape identity formation, foster increasing autonomy, and strengthen the acquisition of life skills (6).

Schools play a critical role in promoting mental health and wellbeing while addressing factors that threaten them. One such challenge is school bullying, a widespread phenomenon observed across diverse cultural contexts worldwide (7). School-based anti-bullying interventions seek to equip children and adolescents with the knowledge, skills, and coping strategies needed to prevent, respond to, and resist bullying behaviors (8).

Mental health challenges are not limited to childhood and adolescence but extend into adulthood. University and vocational students, particularly those enrolled in health-related programmes, are especially vulnerable due to demanding academic workloads, irregular class and clinical schedules, and the emotional and psychological pressures associated with providing patient care during their professional training (Wang, Ishak et al.; Abdulrahman et al.).

The eight articles included in the Section on *mental health and emotional competencies* address the following issues: Alkahtani et al. verified that a social and emotional learning (SEL) programme can effectively promote competencies in Saudi Arabian preschool children at risk of emotional and behavioral disorders, leading to recommendations for teacher training in SEL practices to improve communication with children and foster positive behaviors in the classroom; Al-ketbi applied a multi-method participatory approach for the development of a comprehensive school anti-bullying logic model in the Emirate of Abu Dhabi (UAE), offering a strategic roadmap for schools to effectively implement policies and programmes to minimize bullying and establish a safer, more supportive learning environment, emphasizing the need for concerted effort in solving intricate problems such as bullying to ensure that solutions are practical, relevant, and sustainable; Guevara-Cabello et al. explored how adolescents in a Peruvian public school perceive daily challenges, mobilize

General Resistance Resources (GRRs), and exercise agency from a salutogenic perspective, showing that adolescents mobilized diverse GRRs (personal, social, spiritual, digital, and institutional) for emotional regulation, problem-solving, and meaning-making, although with gender effects; [Liu et al.](#) implemented training based on mindfulness among Chinese university students, who encounter culturally distinct stressors including academic pressure and familial expectations, demonstrating that mindfulness was negatively correlated with psychological distress and suggesting that the relationship between mindfulness and distress is contingent upon cultural factors; [Wang, Mao et al.](#) collaborators explored the mental health problems of Chinese higher vocational nursing students and their influencing factors and concluded that hospital, gender, liking for the nursing profession, thinking that the nursing profession was respected, feeling cared for during internship and self-efficacy were all significantly associated with the nursing students' mental health during internship; [Wang, Ishak et al.](#) conducted a study applying the Sidek Module Development Model (SMDM) to design and validate a multi-component lifestyle intervention module aimed at improving sleep quality among vocational nursing students in China, having validated it as scientifically robust, educationally feasible, and culturally responsive lifestyle designed to promote sleep health among nursing students; [Mei et al.](#) investigated the relationship between electronic device use time, sleep quality, psychological stress and self-rated health among Chinese medical students, providing insights to enhance health awareness and promote healthier behaviors; [Bin Abdulrahman et al.](#) developed a systematic review examining the proposals and consequences of stress management for students in medical education, acknowledging the challenges inherent to their academic journey and, from their analyses, they concluded that institutions can more effectively prepare their medical learners to overcome educational challenges and cultivate empathetic, resilient professionals skilled in delivering healthcare services.

Physical activity

The World Health Organization's (WHO) *Guidelines on Physical Activity and Sedentary Behavior* emphasize that regular physical activity improves cardiopulmonary fitness, metabolic health, and mental wellbeing by reducing symptoms of anxiety and depression, thereby enhancing overall quality of life (9). Regular physical activity is also effective in preventing and managing non-communicable diseases (NCDs), including cardiovascular disease, stroke, diabetes, breast cancer, and colorectal cancer, while reducing the risk of hypertension, overweight, and obesity (10). Despite these well-established benefits, global participation in physical activity remains insufficient, with approximately 70% of the world's population failing to achieve the recommended minimum of 150 min of moderate-intensity physical activity per week (11). In response, the WHO has set a global target of reducing physical inactivity by 15% by 2030 (12).

The WHO's *Guidelines on Physical Activity and Sedentary Behavior* further recommend that children and adolescents aged

5–17 years engage in at least 60 minutes of moderate-to-vigorous physical activity daily throughout the week (13), including muscle- and bone-strengthening activities on at least 3 days per week (14). Accordingly, promoting regular physical activity during childhood and adolescence is widely recognized as a fundamental strategy for fostering healthy physical growth, psychological wellbeing, and lifelong healthy behaviors.

Similarly, concerns have emerged regarding the health of university students. National surveys have documented a sustained decline in physical fitness over the past two decades (15), accompanied by a persistent increase in mental health problems (16). These challenges are further intensified by growing academic demands, the transition to independent living, and increasing societal expectations (17). The rising prevalence of these interconnected physical and mental health concerns has reinforced the need for comprehensive, holistic educational approaches that integrate health promotion into higher education, with physical education playing a central role in supporting students' overall wellbeing (18).

The eight articles included in the *physical activity* section address the following issues: [Watanabe et al.](#), assuming that healthy life expectancy requires attention not only to physical fitness but also to the development of cognitive self-regulation skills during childhood, incorporated assessments of cognitive inhibitory control into early health education using the go/no-go task to assess inhibitory control alongside conventional physical fitness testing in children aged 3–14 years in Nagano (Japan), providing an enriched understanding of children's self-regulatory capacity; [Kong et al.](#) evaluated a family-school-community collaborative physical activity (PA) intervention on PA and exercise cognition in Chinese primary school students in a quasi-experimental study, showing that the intervention was associated with improvements in exercise cognition and perceived benefits, which supports the potential value of strengthening positive exercise perceptions within coordinated PA promotion efforts; [Jing, Zhai et al.](#) showed that exercise self-efficacy is associated with physical activity both directly and indirectly via behavioral intention, in vocational education students in Shanghai (China), also indicating that interventions enhancing self-efficacy and behavioral intention may support higher activity levels; [Jia et al.](#) investigated how combinations of factors lead to high physical activity levels among Chinese female university students, using methods grounded in Social Cognitive Theory (SCT), revealing the characteristics of “multiple conjunctural causation” and “causal asymmetry” in forming physical activity behaviors and complex compensatory and substitutive mechanisms among factors, moving beyond traditional linear models; [Ma et al.](#) explored the intensity characteristics of integrated “Learning, practice and competition” (L-P-C) badminton teaching in China, and showed that it primarily elicits moderate-intensity exercise, which is influenced by gender and skill levels, and improves cardiorespiratory fitness and psychological wellbeing; [Wang, Feng et al.](#) developed a policy-based Education Policy Dosing Index (EPDI, 0–100) from four exam-oriented domains (compulsory test intensity, elective test diversity, scoring/enforcement strictness, and competition & incentive provision) for the Chinese junior-middle-school PE examination scheme, showing that EPDI

around 60 is a practical, exam-aligned planning benchmark, with diminishing marginal returns beyond the breakpoint and equity-relevant heterogeneity by sex and grade; Genç et al. demonstrated that Life Kinetik exercises effectively enhance motor coordination and cognitive performance in Turkish adolescents with intellectual disabilities (MID), more specifically, motor coordination and cognitive performance, suggesting that integrative exercise programmes may be a valuable non-pharmacological strategy to support motor and cognitive development in this population; Jing, Yang et al. employed a single-group pre-test/post-test design in a 21-day school-based regular aerobic exercise intervention in a comprehensive university in Sichuan (China), showing association with improvements in post-traumatic stress disorder (PTSD)-related symptoms and psychological resilience.

In summary, the 25 articles published in the Public Health Research Topic *Life skills in school health promotion: challenges and solutions* represent contributions from researchers across 14 countries spanning multiple continents. This broad international representation highlights the vitality and global relevance of this field of research. Collectively, these studies offer diverse approaches, perspectives, and methodological insights that enrich our understanding of life skills in health promotion. At the same time, they underscore the field's dynamic and evolving nature, revealing numerous opportunities for further multidisciplinary and cross-cultural research.

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GC: Conceptualization, Funding acquisition, Project administration, Validation, Writing – original draft, Writing – review & editing, Supervision. TV: Funding acquisition, Methodology, Resources, Validation, Writing – review & editing. CM-J: Data curation, Methodology, Validation, Writing – review & editing. AD-B: Conceptualization, Methodology, Validation, Writing – review & editing.

References

1. WHO. *The Ottawa Charter for Health Promotion* (1986). Available online at: <http://www.phac-aspc.gc.ca/ph-sp/docs/charter-chartre/pdf/charter.pdf> (Accessed July 27, 2026).
2. WHO. *Health Promotion* (2026). Available online at: https://www.who.int/health-topics/health-promotion#tab=tab_1 (Accessed July 27, 2026).
3. Galderisi S, Heinz A, Kastrup M, Beezhold J, Sartorius N. Toward a new definition of mental health. *World Psychiatry*. (2015) 14:231–3. doi: 10.1002/wps.20231
4. Keyes, CLM. Mental health as a complete state: the case for promoting mental health as a strategy for preventing mental illness. *J Consult Clin Psychol*. (2005) 73:539–48. doi: 10.1037/0022-006X.73.3.539
5. CASEL - Collaborative for Academic, Social and Emotional Learning. *What is the CASEL Framework* (n/d). Available online at: <https://casel.org/fundamentals-of-sel/what-is-the-casel-framework/> (Accessed July 27, 2026).
6. UNICEF. *Child and Adolescent Health and Well-Being* (n/d). Available online at: <https://www.unicef.org/health/child-and-adolescent-health-and-well-being> (Accessed July 27, 2026).
7. UNESCO. *School Violence and Bullying: Global Status and Trends, Drivers and Consequences*. Paris: United Nations Educational, Scientific and Cultural Organization (2018).
8. Hensums M, de Mooij B, Kuijper SC, Cross D, DeSmet A, Garandeau CF et al. What works for whom in school-based anti-bullying interventions? An individual-participant data meta-analysis. *Prev Sci*. (2023) 24:1435–46. doi: 10.1007/s11121-022-01387-z
9. WHO. *WHO Guidelines on Physical Activity and Sedentary Behaviour*. Geneva: World Health Organization (2022).
10. WHO. *World Health Organization Eastern Mediterranean Region* (2024). Available online at: <https://www.who.int/about/accountability/results/who-results-report-2024-2025/region-EMRO/> (Accessed July 27, 2026).
11. WHO. *World Health Organization Nearly 1.8 Billion Adults at Risk of Disease From not Doing enough Physical Activity* (2024). Available online at: <https://www.who.int/news/item/26-06-2024-nearly-1.8-billion-adults-at-risk-of-disease-from-not-doing-enough-physical-activity/> (Accessed July 27, 2026).

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12. WHO. *World Health Organization. Global Action Plan on Physical Activity 2018–2030: More Active People for a Healthier World* (2018). Available online at: <https://www.who.int/publications/i/item/9789241514187/> (Accessed July 27, 2026).
13. Chaput J-P, Willumsen J, Bull F, Chou R, Ekelund U, Firth J, et al. 2020 WHO guidelines on physical activity and sedentary behaviour for children and adolescents aged 5–17 years: summary of the evidence. *Int J Behav Nutr Phys Act.* (2020) 17:141. doi: 10.1186/s12966-020-01037-z
14. Messing S. How can physical activity be promoted among children and adolescents? A systematic review of reviews across settings. *Front Public Health.* (2019) 7:55. doi: 10.3389/fpubh.2019.00055
15. Cai S, Zhang Y, Chen Z, Liu Y, Dang J, Li J, et al. Secular trends in physical fitness and cardiovascular risks among Chinese college students: an analysis of five successive national surveys between 2000 and 2019. *Lancet Reg Health West Pac.* (2025) 58:1015160. doi: 10.1016/j.lanwpc.2025.101560
16. Rackoff GN, Fitzsimmons-Craft EE, Taylor CB, Eisenberg D, Wilfley DE, Newman MG. Psychotherapy utilization by United States college students. *J Am Coll Health.* (2025) 73:503–10. doi: 10.1080/07448481.2023.2225630
17. Rockwell DM, Kimel SY. A systematic review of first-generation college students' mental health. *J Am Coll Health.* (2023) 73:519–31. doi: 10.1080/07448481.2023.2225633
18. Mat Yusoff S, Mohamed AMD, Mohamad Marzaini AF, Mohd Radzi FA, Basal MH, Hassan MH. Towards embodied criticality: reframing physical education curriculum for whole-person development. *Sport Educ Soc.* (2025) 1–16. doi: 10.1080/13573322.2025.2563694



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Development of a comprehensive school anti-bullying logic model in Abu Dhabi: a multi-method participatory approach

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Background: Bullying remains a critical issue affecting the well-being, academic performance, and long-term development of school-aged children. This study documents the participatory development of a Comprehensive School Anti-Bullying Logic Model in the Emirate of Abu Dhabi, United Arab Emirates (UAE).

Methods: Utilizing a multi-method process consisting of stakeholders' interviews, focus group discussions (FGDs), group workshops, and a scoping review—the study sought to construct a culturally sensitive and actionable anti-bullying logic model.

Results: Themes that emerged from interviews and FGDs were underreporting of bullying, the requirement of clearer policies, and a call for more support mechanisms. The logic model developed has organized components: inputs/resources, activities, outputs, outcomes, impact and assumption and external factors. This model combines global best practices with local knowledge and provides a strategic framework for efficient policy design and implementation for all schools in the Emirate. The process emphasizes the necessity of multi-stakeholder involvement in solving intricate education problems. This collaborative process led to a strategic, culturally suitable anti-bullying logic model. The model provides a blueprint for effective implementation and evaluation within and between schools in the emirate. The creation of this Abu Dhabi Comprehensive School Anti-Bullying Logic Model is a reflective and culturally appropriate approach in reducing bullying in schools. The utilization of a multi-method study and involving a broad cross-section of stakeholders has yielded a framework that is underpinned by local context and international best practice.

Conclusion: This model offers a strategic roadmap for schools to effectively implement policies and programs to minimize bullying and establish a safer, more supportive learning environment. The research highlights the need for concerted effort in solving intricate problems such as bullying to ensure that solutions are practical, relevant, and sustainable.

KEYWORDS

school-bullying, logic models, mental health, academic performance, UAE

1 Introduction

Bullying, defined as intentional, repeated aggressive behavior involving an imbalance of power, bullying can be physical, verbal, relational, or increasingly, digital (cyberbullying) in nature (1), is highly prevalent and variable in form (1–3). In terms of labeling behavior as bullying, repetition, intentionality, and a power imbalance are required conditions (2–4).

School bullying has been observed to happen in various cultures all over the world (5), where around one-third of children across the world go through bullying and school violence (6). Within the United Arab Emirates (UAE) context, research regarding bullying has begun to pick up pace, uncovering comparable issues (7). High number of students have been reported to be bullied (8, 9). Another Abu Dhabi school study emphasized that both students and employees frequently lacked the training and resources to spot, report, and intervene in bullying incidents (10). The results confirm regional concerns within the Gulf Cooperation Council (GCC) where youth mental health and school safety are becoming policy priorities (11).

In a bid to manage bullying among schoolchildren, various programs meant for bullying prevention have been designed and integrated into schools worldwide (12). School-based anti-bullying programs are the most common (8), where the aim is to equip children with resources and strategies to resist bullying (13–15). These anti-bullying programs are known by various names, e.g., bullying prevention programs (16), anti-bullying programs (17), social skills training programs (13, 18), and conflict resolution programs (19). Nonetheless, they involve an unstated assumption about the way bullying behavior in schools is to be handled. Some interventions aim to assist the victimized students and enable them to cope with bullying behaviors (20–22). Other interventions target modifying the school's social climate and preventing all students' behavior (19).

In recent years, great attention has been diverted to identify programs explicitly targeting bystander behavior in the school setting (23, 24). In an attempt to tackle the bullying problem comprehensively, logic models are normally formulated and applied (25). Application of Logic Models as an intentional prevention strategy in responding to numerous behavior problems in community-places, including school setting, have also been applied widely in context of youth engagement (26), prevention of sexual violence (27), and teen listener training (28). Logic models are practical and visual tools employed to plan interventions, develop plans for the evaluation of interventions, track programs of work, carry out research, and report the results of research (24, 29). The central emphasis of the application of logic models as a tool for assisting in design, planning, organization and representation of the outcome through the formulation and sharing of program theory (30). Program theory is an express theory of the manner in which an intervention causes a chain of processes and outcomes that can influence participants' results and contribute to

broader impact (31). A logic model is one program theory configuration, when applied enables researchers to articulate and explain how an intervention is postulated to effect outcomes and the main pathways and moderators to outcome achievement.

There are many ways to depict logic models as these may be simple or complex. The type and complexity of the logic model will depend on program focus, the purpose of the logic model, and the audience. Sometimes, programs may utilize several logic models with differing levels of complexity for different purposes and audiences or to highlight different program elements (32). The simplest form of a logic model includes four components as shown in Figure 1.

Logic models illustrate sequential chains of events or processes; and when interpreting, most logic models may be read as a series of “if ... then ...” Statements (32, 33). The simple model outlined in the text gives a clear illustration of a cause (if)-and-effect (then) relationship in an intervention. This “if ... then” structure basically describes the sequence of actions in the intervention, with each action precipitating an intended result. Collectively, these “if ... then” statements describe a step-by-step logical process by which each action hinges on the other, establishing a chain of causality that results in the eventual outcome: prevention of diabetes exacerbations through improved education and drug compliance. Additionally, if, for instance, the logic model depicted in Figure 1 is dissected further, the “if ... then” story can be constructed as below: “If teachers teach and a curriculum is developed on diabetes self-management, then more children are given diabetes self-management education.” This supposes that if a curriculum (particularly on diabetes self-management) is developed and taught by teachers, then more children will be given education on how to manage their diabetes. This is an underlying assumption, implying that the intervention will find its target group and the material will be well transmitted. “If children get diabetes self-management education, then their diabetes medication adherence improves.” The second step assumes that learning about diabetes management by children will result in better compliance with their asthma medication treatment. The reasoning behind this is that children are given the information of why and how they must take their medication, and this can have a positive effect on their behavior. Medication adherence and diabetes exacerbations will probably happen. “If adherence to diabetes medication improves, then diabetes exacerbations decrease.” The last link in the chain indicates that better adherence to medication will result in less fluctuation and abnormality in blood sugar levels. This presumes that adherence to medication protocols prescribed is central to the management of diabetes symptoms and avoiding exacerbations.

While many countries have constructed anti-bullying logic models, there is little evidence regarding the effectiveness and contextual suitability of these models in the United Arab Emirates (UAE), specifically Abu Dhabi. This research fills this void through the creation of a culturally responsive, integrated anti-bullying logic



FIGURE 1

The simplest form of a logic model: inputs are the various resources available to support the program (e.g., staff, materials, curricula, funding, and equipment). Activities are the action components of the program (e.g., develop or select a curriculum, write a plan, implement a curriculum, train educators, pull together a coalition). These are sometimes referred to as process objectives. Outcomes are the intended accomplishments of the program. They include short-term, intermediate, and long-term or distal outcomes.

model for Abu Dhabi schools that addresses the unique needs and challenges of those schools. Interventions are scarce to address multiple types of school bullying in low- and middle-income countries, and few have been subject to rigorous testing (34–36). Exceptions are the “Good School Toolkit” (37, 38) in Uganda and the 130 sessions “Right to Play” Intervention, piloted in Grade 6 students in Pakistan (39).

The lack of effective interventions indicates the necessity of both further intervention development and piloting, as well as investigation of adaptation of highly successful interventions that already exist. Although earlier worldwide initiatives have generated useful models of bullying prevention (34, 35), most such frameworks have been developed without incorporating local stakeholders or tailored to the socio-cultural fabric of the UAE. For example, current Abu Dhabi school policies tend to be reactive in disciplinary measures rather than proactive systemic prevention approaches (40, 41). In addition, research shows that bullying in the area can be underreported as a result of stigma (42, 43), trust issues with reporting mechanisms (34, 39, 43, 44), and uncertain definitions of bullying actions (45)—factors typically not targeted in general interventions (46). Logic model strategy in healthcare research networks, this research transfers the same planning and evaluation rules to the education field (47).

Through the use of a participatory process among educators, students, parents, and policymakers, the research ensures that the outcome of the resulting logic model is not only evidence-based, but also locally grounded in real-world experience as well as cultural appropriateness. Drawing on a comprehensive literature review, the research team established that notwithstanding growing recognition of bullying in UAE schools, there are a number of fundamental gaps within the formulation and application of anti-bullying programs. To start with, most anti-bullying models brought into Abu Dhabi were borrowed from Western environments without adequate customization to native institutional arrangements, social patterns, and cultural practices (10). Such has led to interventions that may not fully represent the nature of Emirati and expatriate students. Most of these programs have been designed and delivered from a top-down perspective with minimal input from key stakeholders including the students, teachers, school counselors, and parents. Lacking participatory design makes the interventions to lack ownership in communities as well as non-sustainable. Third, the UAE’s education system has no established assessment tools to monitor, evaluate, and adjust anti-bullying programs over the years, which makes it impossible to measure the impact or replicate effectiveness (48). Lastly, whereas in other countries, logic models have been employed to inform program development and evaluation in education and public health, their application in school bullying prevention in the UAE is limited and underreported in the literature (49).

In order to meet the main gaps determined in the study, a number of main questions were formulated to inform the development of a successful anti-bullying intervention for Abu Dhabi schools. The research first queried what the key components of a robust anti-bullying logic model need to include—namely, the inputs, activities, outputs, outcomes, and final impact best suited for the immediate school environment. Second, it looked at how various groups—students, teachers, parents, and school administrators—view existing anti-bullying work and what they recommend as improvements. Third, the study investigated how employing participatory design practices, in which stakeholders are engaged directly in defining the program, may contribute to the

development of a locally relevant, culturally appropriate, and sustained solution. Lastly, the research was meant to determine what short- and long-term alterations would be anticipated when such a logic model is completely brought to application in schools throughout Abu Dhabi.

Based on these research gaps and research questions, the primary aim of the current study is thus to create a culturally grounded school anti-bullying logic model through a participatory, multi-method process entailing qualitative research and professional consultation. The goal centers on crafting an organized framework that captures the distinct cultural, educational, and social features of Abu Dhabi schools. Realizing that most global anti-bullying models could not possibly conform to all local norms, values, and structures, the research utilized a participatory development process to provide contextual focus. The process integrated several qualitative research approaches, such as: (1) focus group discussions (FGDs) among students, parents, and teachers on experiencing and understanding lived lives, perceptions of bullying, and expectations of effective prevention; (2) Semi-structured interviews with school counselors and educational leaders on institutional challenges and system-level gaps; and (3) scoping review of international anti-bullying logic models and interventions to determine best practices adaptable and core components. The evolution of the logic model was also enhanced through expert panel sessions, in which education, child psychology, school health, and UAE school system experts reviewed and tested every element of the model. The experts gave systematic feedback on the model’s inputs (training, resources, policies), activities (school culture interventions, AI-driven reporting, awareness campaigns), short-term and long-term outcomes (behavioral change, decreased bullying), and facilitating contextual factors. This participatory, iterative process ensured that the resulting logic model was not only evidence-informed but also grounded in the cultural realities and operational dynamics of Abu Dhabi’s school system. The final model is designed to serve as a practical planning, implementation, and evaluation tool for bullying prevention efforts that are both effective and culturally appropriate.

2 Materials and methods

2.1 Research design

Mouton (50) offers a typology of research design to guide planning for a research study. Non-empirical research approach is adopted in this study. Mainly, this study is non-empirical in nature because it aims to examine, monitor and analyze current literature on school bullying. This study subsequently synthesizes literature review to systematically develop the Anti-Bullying logic model. Following this, an empirical research approach is conducted to gain knowledge and insight into the application of policy analysis on schools anti-bullying process. The outcomes presented by the logic model are subsequently used to present research findings on how policy analysis can be utilized as a decision-making model for an initiative such as schools Anti-Bullying initiative.

2.2 Research settings

School bullying is very common in UAE. Therefore, school bullying must be addressed by the UAE not only for the safety and

well-being of students but also for the creation of a positive, inclusive, and successful learning environment that is consistent with national values and objectives. Preventing bullying helps to build a healthier, more resilient community, decreases mental health issues, improves academic success, and facilitates the development of responsible, empathetic citizens who will help make the UAE a prosperous and harmonious nation for generations to come. The scholars at the Institute of Public Health, College of Medicine and Health Sciences, United Arab Emirates University (UAEU) for the doctoral research on “Policymaker’s Perspectives and Student Experiences of Bullying at Schools in the UAE: A Mixed-Method Approach,” have already put out some pioneering work on the topic (51). From their work in this challenging but emerging health field, the group, as an initial starting point, has been engaged in developing a School Anti-Bullying Logic Model in Abu Dhabi as a potential solution and path forward for the prevalence of school bullying across the UAE.

2.3 Research participants

The participants ($n = 12$) comprised experts from public health, child protection center, UNICEF, telecommunications, Islamic affairs, statistics center, Ministry of Education (MOE), transport, judicial department, school health services and other related authorities and institutions. Participants in the interviews were recruited using purposive sampling and the snowball technique which was considered based on participant introduction of another participant to the study. Purposeful selection was utilized to choose staff for the interviews. Proper sample size in qualitative research, especially the number of interviews, is usually established when saturation is achieved. Sadly, little consensus exists about the definition of saturation, how to tell when it has been achieved, or whether this can be pre-determined in

qualitative research. The sample size for this research was derived from the differential experience of the participants with bullying and the organizational position they held. This method aimed at gaining a well-rounded perspective of bullying (52). In this research, inclusion criteria of being older than 18 years and employed in the emirate of Abu Dhabi and exclusion criteria of being younger than 18 and residents of other emirates, were used. Participants characteristics are provided in Table 1.

2.4 Data collection tools and procedure

Numerous primary data sources informed data collection. These included training on logic model, documents review, naturalistic observations, email correspondence and teleconferences, Focus Group Discussions (FGDs); structured Interviews and workshops.

2.4.1 Logic model training sessions

The Research team organized a logic modeling training session and the related materials in hard and soft forms. The training utilized published reports on theory-driven, realist evaluation principles and logic modeling; and concentrated on how mapping program inputs, activities and outcomes can assist in developing early hypotheses for provisional relevant Contexts, Mechanisms, Outcomes and configurations. While a range of logic model formats were discussed during training, a columnar and multilayer format was selected to enable the outputs, activities, inputs, and outcomes to be identified. Possible contextual factors influencing the program outcomes and outputs were also identified and clarified by the participants. The identification process of contextual factors began by gathering a wide list of possible contextual factors that might affect processes required to attain inputs, outputs and outcomes in

TABLE 1 Participants characteristics – education and professional experience.

Code	Gender	Age	Level of education	Profession	Organization	Organization type	Years of experience
NA-UAEU	Female	45	PHD	Dean/Administrator	UAEU	Federal	
SA-AWQAF	Female		Bachelor	Religious Figure	AWQAF	Federal	
AA-TRA	Male	28	Bachelor	Security Analyst	TRA	Federal	3
AA-MOI	Male			Military Officer	MOI-CPC	Federal	10
IA-PMO	Male	54	PHD	Advisor	MOI-Aqder	Federal	54
MA-MOE	Female			Education Specialist	MOE	Federal	
FA-PMO	Female	28		Research Analyst	PMO	Federal	
NS-ADSHS	Female	50	Bachelor	Education Specialist	ADSHS	Local	17
SA-ED	Male	35		Trainer/Educator	ED	Private	14
OF-ET	Male	39		Safety Officer	ET	Federal	16
MA-SC	Male	39		Statistician	ADSC	Local	12
KK-MHC	Male	47		Child Mental Health Consultant	MHC	Private	20
ME-UNICEF	Male	64		Program Officer	UNICEF	International	6
MA-ADPHC	Female			Maternal and child health officer	ADPHC	Local	6
AA-ADDFP	Female			Prosecutor	ADDFP	Local	13

the antibullying program Team agreement was realized in accordance with the significance of the evaluation questions, academic rigor and the assumed role in possible outcome patterns. Contextual factors were subsequently ordered at micro, meso and macro levels utilizing knowledge from the conceptual framework for the realist evaluation.

2.4.2 Document review

A checklist based on case study literature was used to list the common documents the research team were looking for. The kinds of documents they wanted to review were strategic plans/planning documents, operating procedures and organizational policies, communications (e.g., website, media releases, email, meeting minutes), annual reports, administrative databases/files, evaluation reports, third party consultant reports, and routine numerically collected data that captured implementation outcomes. As each document was found, it was dated, numbered, and listed in the case study database with a brief description of the content pertaining to the research objectives. A total of 57 documents were examined across the case sites.

2.4.3 Naturalistic observations

The onsite observations were made over a period of 1 week, where normal organizational activities were observed. The research staff engaged school-staff, inquired, and clarified the observation that was occurring; they did not interfere with normal working practices. Observation enabled us to see how any antibullying program functioned and compare that with written processes and procedures. It also enabled the observation of non-verbal responses and staff interaction. 105 h were spent on the observations.

2.4.4 Email correspondence and teleconferences

based on the above steps, a draft logic model was developed by the first author and was circulated with policy makers and implementers to set out their version of the model. In particular, monthly teleconferences and regular email discussions with implementers and policy makers helped to iterate and improve the draft model until it captured stakeholders' collective thinking about how the anti-bullying program ought to function in the UAE context. Improving the logic model involved making explicit and agreeing on relationships between program components. Consultation and interaction with local stakeholders ensured that solely integral elements of the multi-intervention antibullying program were captured in the LM. The selection process of information to incorporate into the LM was iterative and dynamic, and entailed the addition of newly emerging/relevant components as well as the elimination of those considered unnecessary for responding to our evaluation questions.

Focus group discussions (FGDs), interviews and technical workshop: as a final step to further build consensus on the developed logic model, FGDs, interviews and technical workshops were used. Three focus group discussions (FGDs) were conducted in May 2021 with a small group of six to eight participants of the same experience and background in each FGD to discuss their interests and experiences about bullying. With the facilitation of these FGDs, information about what different groups of stakeholders and members of educational administration believe about the current bullying situation in Abu Dhabi, its interventions and implementation was collected. The duration of each FGD was 90 to 120 min and all

three FGDs were recorded with a recorder and were transcribed in MS Word in Arabic and English. Individual interview participants were asked to take part in the study using purposive sampling in which participant referrals adopted the snowball technique. The interview participants inclusion criteria were to be above 18 years old and work within the emirate of Abu Dhabi, while those above 18 years old were excluded and others from other emirates. FGDs and interviewing were employed to disentangle program elements and contextual factors influencing the implementation and effects of antibullying program, and then formulate early working theories regarding how, why and in what contexts the theories can function.

2.5 Checklist to evaluate the proposed model

The final model was assessed by a group of experts ($n = 5$) against a checklist prepared for the purpose of the present study using criteria set by some previous work (53, 54). These experts provided a written consent form prior to participate in the study. The experts used this checklist with questions on different parts of the logic model. The experts were asked to respond each question with notes, if applicable, and write in front of each question "yes/no/". the experts also provided general comments, in the light of which, the model was refined. A summary of these comments is provided in [Supplementary File S1](#).

2.6 Data analysis

Data collected from various sources—document reviews, stakeholder consultations, observations, interviews, and focus group discussion—were analyzed with a mix of thematic content analysis and realist evaluation-informed framework analysis. FGDs and interviews were audio-recorded, transcribed, and inductively coded to reveal patterns and emerging themes on bullying perceptions, implementation challenges, contextual factors, and hoped-for outcomes. Applying the Iterative Logic Model (ILM) framework, qualitative data were used to map against key logic model constructs: inputs, activities, outputs, outcomes, and contextual factors at micro, meso, and macro levels. This mapping facilitated the building and refinement of an extensive anti-bullying logic model. Findings were triangulated and validated through training session, teleconference, and document review data. The analysis was done in collaboration, with ongoing consultations involving stakeholders to achieve credibility, relevance, and contextual fit of the end model. NVivo or equivalent qualitative software was used optionally to handle excessive qualitative data and ensure coding consistency across the researchers.

The study was approved from the UAE University Human Medical Research Ethics Committee (ERS_2019_5867).

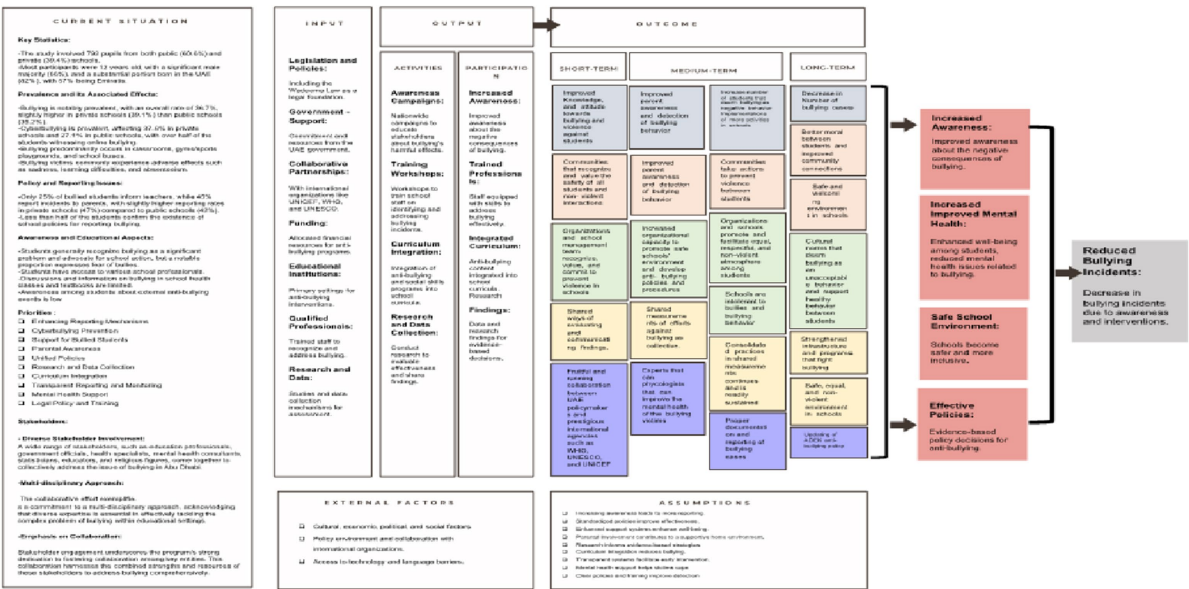
3 Results

The logic model developed in this study is illustrated in [Figure 2](#). Key components of the Logic Model are given in [Table 1](#). Further details on UAE Schools Antibullying Logic Model are provided in [Supplementary Tables 1–6](#).

This research yielded the creation of a Comprehensive School Anti-Bullying Logic Model that was tailor-made for Abu Dhabi schools.

School Anti-Bullying Logic Model

School bullying presents grave risks to learners' psychological health, academic performance, and general safety. In Abu Dhabi, mounting instances of verbal, physical, and cyberbullying have led education officials to pursue holistic solutions. Our research group has collaboratively developed an inclusive, evidence-based, and contextually appropriate anti-bullying logic model for UAE schools. Since there is a pressing need for sustainable solutions at community, local and national levels, this Comprehensive School Anti-Bullying Logic Model in Abu Dhabi is expected to help in tackling the problem of bullying in schools.



Empirically informed and stakeholder-inclusive in nature, the model presents a strategic blueprint for countering bullying within UAE school systems. The logic model is composed of five interconnected elements: Inputs, Activities and Outputs, Outcomes (Short-, Medium-, and Long-Term), and Assumptions and External Factors.

3.1 Current situation and problem identification

The model was created as a reaction to widespread bullying problems realized in the local setting. Whereas more than 75% of students in public and private schools have reportedly been bullied, and low rates of incident reporting, there is a great need for a systemic, culturally specific intervention. Current anti-bullying programs are plagued by variable implementation, inadequate stakeholder engagement, and absence of monitoring and evaluation mechanisms.

3.2 Inputs

The model specifies core resources and institutional processes required to implement anti-bullying interventions including:

- a) Legislation and Policy: Harmonization with UAE legislations and child protection laws.

- b) Governmental Commitment: Endorsement and strategic alignment from the Ministry of Education and concerned authorities.
- c) Partnerships: Active collaboration with partners like WHO, UNICEF, school boards, judicial agencies, and healthcare services.
- d) Educational Institutions: Engagement of schools and universities as implementation and research partners.
- e) Funding and Resources: Financial and technical assistance for training, AI-powered reporting systems, awareness campaigns, and program assessment.

3.3 Outputs (activities and participation)

Major activities undertaken to achieve the model goals were:

- a) Awareness Campaigns: Grassroots activity to create awareness regarding bullying and its effects.
- b) Training Workshops: Capacity development for teachers, counselors, and administrative staff.
- c) Curriculum Integration: Incorporating anti-bullying messages in academic and civic education.
- d) Research and Data Collection: Collection of qualitative and quantitative data to aid in model validation and refinement.
- e) Participation of Stakeholders: Participative inclusion of teachers, students, parents, policy-makers, and outside experts.

- f) These outputs combined were intended to produce trained professionals, enhanced curriculum content, and participative stakeholders able to identify and act against bullying.

3.4 Outcomes

A Short-Term Outcomes:

- Increased awareness among students and staff about bullying behaviors and preventive measures.
- Greater awareness of support mechanisms and reporting routes.
- Common conceptualization of intervention objectives and program logic across stakeholders.
- Early institutional buy-in to adopt anti-bullying efforts.

B Medium-Term Outcomes:

- Relatable improvements in student conduct and peer interactions.
- Improved coordination among education, health, and judiciary sectors.
- Incorporation of welcoming school policies and provision of mental health services.
- Sufficient early evidence in favor of replication and scaling of the intervention to other emirates.

C Long-Term Outcomes:

- Drastic decrease in reported bullying incidents.
- Improved student mental well-being, academic achievement, and school participation.
- Development of safe and welcoming learning spaces.
- Institutionalization of evidence-based anti-bullying policies nationally.

3.5 Assumptions and external factors

The logic model is based on assumptions such as sustained stakeholder participation, cultural awareness, sustainable funding, and technology integration. External influences like social norms, political processes, media impact, and language differences were also identified as potential impinging factors for the success of the model.

3.6 Impact pathway

Through a coherent and evidence-based sequence of inputs, activities, and outcomes, the logic model demonstrates a viable pathway to reducing bullying incidents. The model integrates improved awareness, mental health support, policy reform, and safer school environments, contributing to a more holistic and sustainable solution to school-based bullying in Abu Dhabi.

3.7 Checklist used for evaluation of the logic model

The results on the checklist used for evaluation of the logic models demonstrate that,

- The structure of the logic model is strong and adheres to all Global Affairs standards. It is coherent, horizontally and vertically logical, and clear to external assessors.
- The ultimate outcome addresses all criteria and is logically connected to lower-level changes and the theory of change for the project. The intermediate outcomes are logical, measurable, achievable, and connected to the ultimate outcome with complete regard for equity and human rights.
- The immediate outcomes in the logic model represent focused capacity changes, are logically connected to outputs and intermediate outcomes, and both measurable and attainable within the project's scope.
- The outputs in the model are specific, properly constituted, and directly connected to the immediate outcomes. They are measurable, evidence-based, and sensibly posited within the scope of the anti-bullying project.
- The theory-of-change story (based on the assumed anti-bullying model) is exhaustive and satisfies all evaluation requirements. It links logic model components transparently, addresses inclusivity and human rights, foresees risks, and exhibits systemic thinking.

A summary of the checklist evaluation is provided in [Table 2](#).

In summary, the logic model developed for the anti-bullying intervention in Abu Dhabi schools adheres closely to the structural standards established by Global Affairs Canada. The model includes a single, clearly defined ultimate outcome supported by a realistic number of intermediate outcomes, each of which is logically linked to two immediate outcomes and associated outputs, ensuring vertical alignment and traceability of results. Each is typed into a separate cell in brief, one unique alteration to each statement, and eschews phrasing that is compound. The structure of the logic model is equally balanced, holds on one page, and outlines a vertically logical and horizontally complementary plan of the project's theory of change. Outputs are clearly positioned under their associated immediate outcomes, and the logic model provides sufficient clarity for an external reviewer to comprehend the project's projected changes and how they will be realized. Additionally, the model is consistent with wider programmatic priorities and demonstrates gender equality, human rights, and stakeholder engagement throughout. This format is a transparent, evidence-based framework that operationalizes the project's theory of change and facilitates effective performance measurement.

4 Discussion

School bullying presents grave risks to learners' psychological health, academic performance, and general safety. In Abu Dhabi, mounting instances of verbal, physical, and cyberbullying have led education officials to pursue holistic solutions (55). Acutely aware of the limitations of disjointed or responsive interventions, this research sought to collaboratively develop an inclusive, evidence-based, and contextually appropriate anti-bullying logic model for UAE schools. Since there is a pressing need for sustainable solutions at community, local and national levels, the current study is an important attempt to formulate a Comprehensive School Anti-Bullying Logic Model in Abu Dhabi to tackle the problem of bullying in schools.

TABLE 2 Summary of the checklist to evaluate the proposed anti-bullying logic model.

S. No.	Criterion	Met?	Notes
1	Uses internationally recognized and/or Global Affairs Canada logic model template	Yes	Clearly follows required structure
2	One outcome per box	Yes	No compound or multiple ideas per outcome
3	One ultimate outcome	Yes	Focused on student well-being
4	2–3 intermediate outcomes	Yes	Three defined
5	2 immediate outcomes per intermediate outcome	Yes	Logical and achievable links
6	1–3 outputs per immediate outcome	Yes	Relevant and measurable
7	Outputs placed beneath immediate outcomes	Yes	Proper structure followed
8	Fits on one page	Yes	Concise and visually clear
9	Logical vertical relationships	Yes	Clear cause-effect chain from outputs to outcomes
10	Logical horizontal complementarity	Yes	Each outcome is distinct yet contributes to higher-level change
11	Presents an evidence-based theory of change	Yes	Informed by stakeholder inputs and a scoping review
12	Addresses the original problem	Yes	Focuses on bullying reduction in schools
13	Aligns with regional/country program outcomes	Yes	Linked to education and child protection goals
14	Understandable to external audiences	Yes	Clear, jargon-free statements

This study also used a systematic method grounded on Global Affairs Canada's Results-Based Management (RBM) framework to design and test the logic model underpinning the Abu Dhabi school anti-bullying intervention (53). The RBM framework offers a systematic means of describing, monitoring, and measuring development programs through clear-cut outcomes at multiple levels—final, intermediate, immediate, and outputs. The process was initiated with a well-defined mission: establishing a secure and

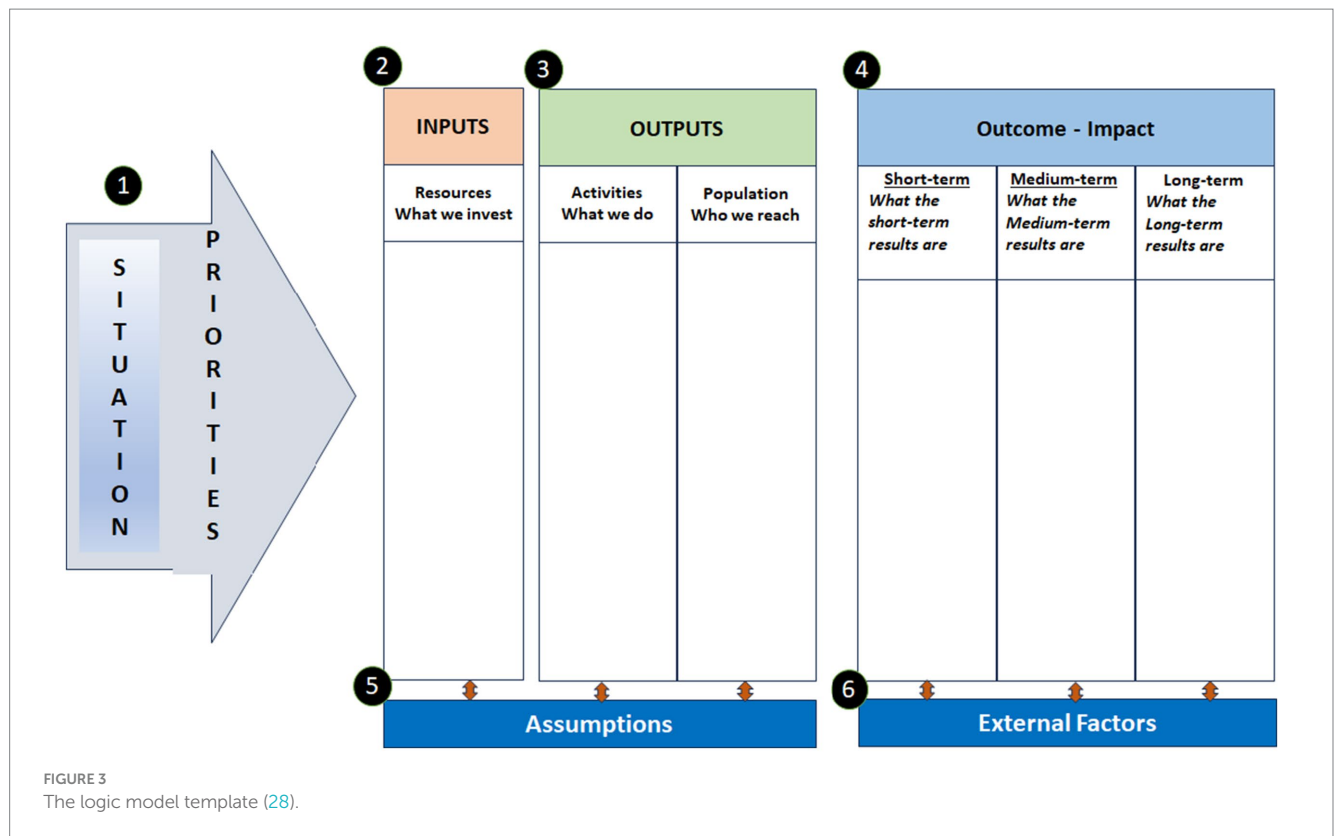
protective school climate in Abu Dhabi through the systematic reduction of bullying. The intended audience was students, educators, parents, school personnel, and policymakers. In line with Hayes et al. stakeholder involvement was a key factor (47). Adopting a participatory approach akin to the PBRN method, stakeholders were meaningfully engaged via interviews, focus group discussions, and workshops. This served to ensure the logic model captured different viewpoints and local applicability. The process developed through a coherent sequence that started with knowing the wider context, such as institutional objectives, current initiatives, and contextual issues. This guided the priorities and objectives of the program. Inputs were identified as resources such as trained personnel, finance, educational resources, and technology. Activities comprised campaigns, training teachers, counseling students, and policy formulation. Outputs were concrete and quantifiable, such as the number of workshops organized or materials handed out. Process indicators and strategies were employed to assess if intended activity had been implemented efficiently and reached the target population. Outcomes were measured in short- to medium-term terms, for example, enhanced awareness and better reporting of bullying. Indicators supported measuring progress toward these goals. Lastly, long-term effects such as decreases in bullying and the establishment of more secure school settings were tracked to assess the overall effectiveness of the intervention.

Development of this model was partly guided by the process described by Hayes et al., for their article on logic models for evaluation and planning in primary care practice-based research networks (PBRNs) (47). They provide a focus on an organized process involving mission statement development, stakeholder engagement, and explicit identification of inputs, activities, outputs, outcomes, and impact.

In addition, this research also partly used a systematic method using the Global Affairs Canada. Results-Based Management (RBM) (53) approach to develop and evaluate the logic model that supports the Abu Dhabi school anti-bullying intervention. The RBM system provides a systematic means of specifying, tracking, and judging development interventions by concentrating on well-stated results at several levels: ultimate result, intermediate results, immediate results, and outputs.

Once a rough draft had been established (Figure 3), it was useful to specify and recognize assumptions and external factors. Assumptions were defined as conditions regarding how the program will function and the individuals that are involved. Based on assumptions regarding the external and internal environment, what the program hopes to accomplish, and the participants learning styles, behavior, and motivation. It's necessary to say assumptions out loud as a group in order to recognize and change faulty assumptions. External Factors included the environment or context in which the program or project was found to occur (e.g., schools). External factors consisted of: the culture, the weather, economic structure, housing patterns, demographic patterns, political climate, participants' background and experiences, media influence, and shifting policies. It is worth taking into consideration the hindrances that these factors bring but leveraging them as strengths to enable advancement.

The methodology is participatory since it engaged multiple stakeholders in the model development and design, such that the resulting product was not only useful but also appropriate for the



cultural and local traditions and culture of UAE. The study incorporated a multi-method strategy, which enabled deep investigation into the problem and the development of a strong framework. A Multi-Method Approach was utilized with stakeholder interviews, focus group discussions (FGDs), group workshops, and scoping review used as the strategies for gathering the insights and developing the Logic Model (40). This triangulation of the qualitative and review methods enabled the researchers to conduct data triangulation to achieve an in-depth grasp of the problem of bullying and how it would be solved. Stakeholder Interviews were performed with essential individuals, like educators, administrators, parents, and students, to collect detailed personal views on the existing situation of bullying in schools. Interviews possibly uncovered loopholes in present policies, practices, and resources. Focus Group Discussions (FGDs) provided participants with the opportunity to engage in a more interactive discussion about bullying, allowing researchers to identify common issues, shared experiences, and solutions. FGDs would have offered some insight into perceptions about bullying across various community members and offered a greater understanding of local issues and expectations. These workshops included stakeholders working together to generate ideas and solutions. They probably allowed participants to work on hands-on problem-solving, providing tangible and actionable recommendations for anti-bullying interventions. A scoping review is a research technique applied to map out current literature on a given topic. In this instance, it entailed examining international best practices and current anti-bullying models from across the globe, which guided the creation of the Abu Dhabi-specific logic model. The interviews and FGDs identified several main themes that required mention in the logic model (51).

One of the major challenges discovered was bullying wasn't being reported frequently enough. This may be due to fear of reprisal, unfamiliarity with the reporting procedures for bullying, or mistrust in the system. The logic model most probably answers this by recommending measures to facilitate the reporting procedures and build the system's credibility. There was a perceived demand for more specific and transparent anti-bullying policies (56). Clear, consistent policies would assist in ensuring all parties involved—students, teachers, parents, and administrators—knew what bullying was and what should be done if and when it happened. Our study suggested that further support structures be implemented to guide students who are victims of bullying and students with bullying tendencies (57). These structures would encompass counseling sessions (58), peer counseling groups (59), and staff development for educators on how to effectively manage bullying (60).

The research generated a Comprehensive School Anti-Bullying Logic Model with five organized components:

- 1 *Situation and Priorities:* The situational factor with the greatest influence on the focus and priorities of the program is the rising trend and patterns of school-bullying in UAE, which has been on the rise for years (55). more worrisome is the fact that despite countless efforts made in every corner of this problem in school bullying at several levels to lock down, still it feels that the phenomenon has a tendency of escalating toward being more commonplace. Studies have demonstrated that multisectoral strategy with one objective and clearly defined aims is the key to solving the problem since school bullying is a multifaceted issue and solving it must be based on the involvement of all the stakeholders (61).

- 2 *Inputs/Resources*: This is the resources needed to put the anti-bullying program into practice effectively. These may be funding, trained personnel, educational program materials, or outside expertise. What activities we do. These are the interventions or actions that schools will take to prevent and deal with bullying. Activities may include anti-bullying campaigns, staff and student training, support network establishment, and reporting systems development. What population we reach. The primary subjects are those inside the school environment (students, teachers, administration) and outside the school environment (local community, administration, parents etc.).
- 3 *Outcomes*: Outputs are the tangible outcomes of the activities, including the number trained students, bullying incidents reported numbers, or providing support services for schools. They assist in capturing the intervention's immediate effects. These may also be the longer-term consequences that arise due to the activities and outputs. For instance, better student well-being, higher awareness and knowledge about bullying, and a reduction in bullying incidents are likely desired outcomes.
- 4 *Impact*: The final objective of the logic model is to have a sustained impact, i.e., a cultural change in the perception and management of bullying within schools and a decrease in overall bullying activity throughout the Emirate.
- 5 *Assumptions*: certain assumptions were made in the present model developed in this study. For example, "teachers and students will engage in and commit to the anti-bullying initiatives."
- 6 *External Factors*: the external factors included in the model developed include, for example, cultural attitude, government policies, economic constraints, technological influences, etc.
- 7 *Evaluation*: This research investigation seeks to formulate a logic model that can help the education staff at school level, education authorities and government officials formulate policy-specific plans (via policy analysis) which will facilitate the operationalization of anti-bullying operating model from a policy viewpoint. Within this research, a suggested policy analysis approach is formulated, i.e., the anti-bullying logic model. For the purpose of demonstrating the correctness and sufficiency of the anti-bullying logic model, the research findings that inform the development, including the anti-bullying logic model and its purpose need to be assessed. Assessment is needed to offer a verdict of the research findings and suggested anti-bullying logic model. In this research, the assessment process was split into two broad categories, verification and validation, that can be undertaken through four sequential stages: (i) theoretical verification; subject matter expert (SME) validation; (iii) case study validation; and (iv) transferability (62). Each step in the evaluation process is designed to build incrementally on the reliability and validity of the constructed anti bullying logic model. Each step has an input type—the method used to conduct the evaluation in each step. Each step also has one or two evaluation objectives to meet during the evaluation process. For the present work, however, only the first two of the four sequential stages were used as the last two were beyond the scope of this study. The developed anti-bullying logic model underwent a thorough verification process. This process includes input from

Subject-Matter Experts (SMEs) with the relevant experience in and knowledge of the respective research areas, in order to assure that the anti-bullying logic model is developed based on valid, accurate and credible literature information and assumptions. The inputs that were placed into constructing the anti-bullying logic model gives confidence that the anti-bullying logic model has been "constructed right" (63). Once the inputs from the verification stage were integrated, the anti-bullying logic model was suggested to pertinent anti bullying specialists—asking for their professional feedback and certification to confirm that the anti-bullying logic model is applicable and fitting to the school bullying context and the conditions of this research. The validation by SMEs takes advantage of standardized questionnaires and semi-structured interviews (a workshop format) to obtain the opinion of experts on the anti-bullying logic model under development in this research. The SMEs give their inputs based solely on their knowledge and experience; thus, for assurance that the method of policy analysis can fulfill its intended use, a second validation strategy is explored to also test the usability of the anti-bullying logic model.

The present model developed in this study does not just represent international practices; it integrates them with local insights gained from stakeholders in Abu Dhabi. This is crucial because while international best practices offer valuable guidance, each community has unique needs, values, and challenges. By incorporating local perspectives (64), the model ensures that it is contextually relevant and more likely to be effective in Abu Dhabi's schools.

One of the most important lessons to be learned from this research is the need for multi-stakeholder involvement (65). Bullying is a multifaceted problem that involves more than one stakeholder, including students, parents, teachers, and school administrators. Solving it needs feedback from all these stakeholders to determine the entire magnitude of the problem and to plan interventions that will be supported and executed effectively. The participatory aspect of the process also generates a sense of ownership and cooperation between stakeholders, which is vital for the sustainability of any anti-bullying program. This research suggests, however, that the future research should also consider incorporating the stakeholders mapping in applying anti-bullying policies within the school setting (65, 66).

The logic model of the current study is likely to be an active tool for planning, implementation, and evaluation. It helped in balancing activities with the outcome in mind and offered a guideline for constant assessment and improvement, which reflected the utility evidenced in PBRN environments. Through the application of the logic model framework used in primary care research to the Abu Dhabi school setting, a wide-ranging and culturally responsive strategy for addressing school bullying was created. This model not only informs ongoing interventions but also provides a basis for future evaluation and ongoing improvement (47). Logic models are very variable and adaptable: they may represent systems or processes, intervention or naturally occurring phenomena, or simple or intricate relationships (67). There are no specified criteria as to what is and what is not a logic model. Apart from this flexibility, all logic models have the characteristic of being: (i) visual theories; that (ii) depict not only concepts, but the concepts' relationship as well; and that (iii) are formed based on a clear set of explanations regarding how/why

relationship happens between concepts founded on sound theories, evidence, and/or professional and experience-based expertise.

Our research team performed a scoping review to gather best practices and frameworks internationally (40). These sources included UNESCO, WHO, and national anti-bullying strategies. Best models usually had elements such as awareness programs, employee training, reporting mechanisms, counseling services, and incorporation into policies. This scoping review is an analysis of school bullying intervention and prevention measures in the UAE and found 22 initiatives from both federal and private sectors from 2010 to 2021. It points out increased bullying, no peer-reviewed assessments, and sparse attention toward cyberbullying. The authors urge more robust studies, multisector collaborations, and evidence-based strategies to enhance national anti-bullying measures.

Cultural flexibility and stakeholder acceptance were found to be critical to success (49, 68). For the current logic model, five semi-structured interviews were done with principals, educators, policymakers, and child protection officers. Themes that emerged were policy inconsistency, underreporting, and resource constraints. Six FGDs were conducted with students, parents, teachers, and counselors. Students stressed anonymity in reporting; parents demanded involvement; teachers asked for training and materials. Besides, four workshops involving 35 stakeholders strengthened and cross-checked the logic model. Prioritization and consensus-building methodologies confirmed relevance and practicability. The evolution of the Comprehensive School Anti-Bullying Logic Model in Abu Dhabi illustrates how an organized, stakeholder-based approach can give rise to the implementation of a real-world, dynamic framework to confront intricate social concerns in schools. Using Hayes et al., logic model framework as the basis, this study was able to successfully transplant principles classically employed in primary care research networks (PBRNs) to an educational environment—in testament to the model's strength across fields (47). One of the greatest strengths of this process was its participatory nature (47, 69). Similarly, Hayes et al. stressed the need to involve practice-based stakeholders in order to achieve relevance and sustainability in PBRNs. In this study, school administrators, teachers, parents, students, and policymakers were involved at all stages of the development process. Their input not only confirmed the elements of the model but also influenced its design to suit the cultural and institutional context of Abu Dhabi schools (47).

The sharp distinction between inputs, activities, outputs, outcomes, and impact facilitated the matching of short-term interventions with long-term objectives. The matching ensures that interventions like awareness campaigns, training for teachers, and counseling for students are not viewed as discrete actions but as part of an integrated system to bring about less bullying and better school culture (70).

The logic model developed in this study (Figure 2) offers a common language and an open framework for planning, executing, and assessing anti-bullying initiatives, an advantage also noted in Hayes et al.'s use of logic models in PBRNs (47). Additionally, the iterative and reflective model-building process reflected the ongoing learning cycle articulated in the PBRN logic model framework. Through repeated visits and model refinement through workshop and validation sessions, stakeholders-built buy-in and enhanced the potential for continued use at policy and practice levels. There were challenges, nonetheless. As with PBRNs, where diverse health professionals may interpret goals differently, educational stakeholders

also exhibited varying understandings of bullying, especially concerning cultural sensitivity, cyberbullying, and gender dynamics. These discrepancies underline the need for ongoing training and consensus-building mechanisms even after the model is implemented (71, 72).

Lastly, the adaptability of the logic model suggests potential for wider application to the rest of the UAE and other education systems confronting similar challenges. Future studies should concentrate on the application of the model in real time in schools, measuring reductions in bullying prevalence, reporting behavior, and student well-being, to better refine and scale the intervention. Assumptions and external influences are essential components in a logic model that serve to clarify the context, boundaries, and possible issues of the intervention being undertaken (33). By knowing these elements, one can implement the model more realistically and successfully, as they define elements that may affect the success of the intervention but might not always be immediately under the control of the involved stakeholders.

The logic model for this study has also made assumptions that refer to the beliefs or conditions assumed to be present that are accepted as true or assumed to exist for the logic model to operate as intended. These are not necessarily presented in detail but are significant since they may have an impact on the effectiveness of the intervention. Typically, assumptions can be of different aspects such as, for instance, contextual conditions, stakeholders' involvement, availability of resources, changes in behavior, and causal links etc. (73). Assumption regarding the contextual conditions are such as community, culture, or environment where intervention is going to occur. For instance, in an anti-bullying model, an assumption can be such that there is a common cultural value of tolerance and respect between students and teachers. Assumption regarding the stakeholder involvement include stakeholders' involvement and commitment, e.g., parents, teachers, and administrators. For example, an assumption could be that teachers will participate in training programs or that parents will collaborate in anti-bullying programs. Assumption regarding availability of resources include availability of resources, e.g., funding, staffing, or materials. For instance, the model can hypothesize that the school can arrange counselors or there will be sufficient budget to allocate for anti-bullying programs and campaigns. Assumption regarding behavior change include how individuals (e.g., students, teachers, parents) will react to the intervention. For instance, one of the assumptions in an anti-bullying logic model could be that if bullying awareness programs are carried out, then students will be aware of the effects of bullying and will be more likely to report. Assumption regarding causal pathways involves cause-and-effect between activities, outputs, and outcomes. For example, the model may presume that training teachers on how to respond to bullying incidents will automatically decrease bullying instances, or that enhancing reporting procedures will lead to more bullying cases being reported. External or contextual/environmental factors are those outside the stakeholders' control of the program or intervention but may have considerable impact on the results of the logic model (74). They may facilitate or hinder the success of the intervention. For instance, the government policies and political climate may affect the execution of the logic model. For instance, if there is no government support for anti-bullying programs or policies change, this may influence the effectiveness of the intervention. Likewise, if there are laws requiring bullying prevention programs,

this may serve to create greater implementation motivation. Second, there are social and cultural forces that can influence the intervention.

The broader cultural or societal attitudes toward bullying, violence, or discipline in schools play a significant role in the intervention's effectiveness (2). Bullying can be more accepted in some cultures and firmly rejected in others. These societal views can influence how parents, students, and teachers interact with anti-bullying programs. Thirdly, the availability of financial resources tends to be an outside variable influencing the effective enforcement of an intervention (75). Budget may restrict the scale of the anti-bullying programs, for example, the extent of training programs or services available. Financial conditions may impact the funds students and families can access, which may, in turn, impact their capacity to participate in the program (76). Fourthly, if school administrators do not make bullying prevention a priority or do not provide needed resources, the program can be challenging to implement and sustain (77). The technological environment has been found to have a direct impact, i.e., social media sites and cyberbullying, could extend to bullying conduct beyond the classic school environment. Some of these factors may not be met with an optimal fit by a physical-school-focused, conventional anti-bullying model (78). Furthermore, legal and regulatory considerations like laws or rules concerning education, students' rights, or the definition of bullying can influence how to conduct the intervention (79). For instance, in the event of having specific reporting protocols to be done in the case of bullying incidents, or in case the legal provisions for the protection of students are incomplete, then the model must be revised to suit those specifications. Lastly, community and public opinion also matter because how the community sees bullying and what the school does to deal with it affects the success of the logic model (80). If the community does not think bullying is a big deal, or if there are unwillingness to intervene, the model might have to include other community engagement strategies (81).

In short, assumptions and external factors both contribute to establishing the context in which the logic model is to be applied. While assumptions determine what expectations are made regarding how the intervention will function, external factors offer a wide-ranging context that could impact the success of the intervention. Both must be similarly carefully taken into account in the design and implementation to enhance the chance of the desired outcomes being realized. Challenges of developing and using Logic models are a flexible approach to developing a working theory of what may happen during an intervention. One concern articulated around the use of logic models is "what if the initial theory is wrong?" (82). Kneale et al., further declare that this is a legitimate concern. But stakeholder involvement strategies and using logic models to draw on existing theory, can reduce this risk. Logic models which use more general social and other theories in informing their construction can reduce the risk of developing an incorrect or irrelevant theory (29). In addition, the methods surrounding planned iteration of the logic model to account for evolving knowledge around the intervention (and recording this process) results in theory being investigated, refined, and enhanced as a consequence of the review. Lastly, as argued above, logic models for anti-bullying program are routinely employed to present and explain the results of the synthesis (83), and for certain types of anti-bullying program, logic models will imply, more than "test", a theory. Logic models can rapidly turn complicated, to the point that they lose clarity and become far too complex to offer a

rigorous framework for examination (84). This is a valid criticism, and although the equifinality principle will probably apply to most complex interventions, large numbers of varying combinations of possible pathways become impossible to manage for analytical or communication reasons. Once again, stakeholder engagement can assist in prioritizing pathways in a logic model; in addition, one must think of a logic model as a simplified version of a complex intervention system.

Development of a logic model involves dealing with this complexity in a way that ensures it reflects those routes hypothesized as being the most critical. Stakeholder engagement and public participation when creating a logic model is crucial (85). It is extremely essential to find and engage suitable stakeholders from the beginning while constructing a logic model, especially to make the salience of the model stronger and to develop a sensible and useful model for all stakeholders (86). Stakeholders may provide lived experience of a specific health problem (e.g., patient, carer, parent or relative), might lobby on behalf of those with lived experience (e.g., patient groups), or might offer professional or acquired knowledge (e.g., practitioners, clinicians, researchers and policy-makers). Among their other advantages, stakeholder engagement can test hypotheses regarding the intervention, or the condition being studied (82, 86) guarantee diversity of opinion are included; and assist with the identification of contextual factors that support or impede the implementation of the intervention (29). Since logic models may be visually compelling and interactive, both in the process of creation as well as in the resulting product, they lend themselves to the participation of various stakeholders. In addition, since the role that logic models can play in shaping the review, decision-making throughout the review, and in presenting the findings is so important, engaging stakeholders in the development of logic models may be a way of preventing tokenistic stakeholders' engagement (29, 86).

Developing logic models can go further to ensure that the logic model is developed in a way that is inclusive and human and that challenges world views (87, 88). Regardless of approach, involving stakeholders in developing logic models should avoid the need for one model that supports decisions and communication within the team conducting the anti-bullying policy-making, for example, and a separate public-facing model aimed at stakeholders—and beyond. A single model serves a dual purpose as a tool and a medium for transparently conveying assumptions and evidence beyond the team. Equity, Diversity and Inclusion Logic models offer potential as tools to support further consideration of equity issues (89). Current logic model practice often "lumps together" equity considerations as potential effect modifiers, but the prospect for a greater role for logic models to support theorizing about these distributional impacts remains. General and intervention-specific equity logic models have been proposed structured around Recruitment, Intervention and Outcome Evaluation for an intervention or program (90). In addition, reflexivity Stakeholder biases could influence the development and evolution of logic models (91). Given the importance that logic models can play in bullying, the role of stakeholder perspectives and potential conflicts of interest needs to be made transparent, as these can influence the direction of interpretation and communication of findings. In addition, transparent reporting of how stakeholders contributed to the development of the logic model, as well as transparent reporting of how the logic model contributed to the direction of the review, could help to understand how such conflicts

of interest could influence the findings. Where clear conflicts of interest or divergent perspectives exist among particular groups who contribute to the development of the logic model, there is a case for publishing a separate logic model that clearly shows these distinctions.

Finally, although no direct supporting documents are available for direct comparison between the previous and the present antibullying logic model, but based on existing literature and our research questions, a comprehensive discussion is presented in the following section to address the research questions formulated for this study.

What are the primary elements of a sound anti-bullying logic model for Abu Dhabi schools?:

The logic model highlighted critical elements—inputs, activities, outputs, outcomes, and impacts—that are consistent with international anti-bullying models (92) and that respond to the UAE's distinctive cultural, institutional, and policy context. In contrast with much Western-based models stressing punitive action, the model gives priority to stakeholder engagement, education reform, and social-emotional learning and is consistent with research by Hong and Espelage that puts stress on concerted strategies in bullying prevention in schools (93).

What do various stakeholders perceive about current anti-bullying programs and how can they be improved?: The stakeholders, such as educators, government representatives, and child protection professionals, complained about existing top-down solutions. They called for more participatory approaches that include students and parents in program planning and evaluation—an observation substantiated earlier on (94), which highlighted stakeholder ownership in the declination of bullying episodes. This convergence advised the model's participatory design and its focus on community endorsement.

How can participatory methods help develop a locally relevant and sustainable intervention?: The integration of participatory research methods significantly enriched the logic model. Engaging stakeholders through FGDs and interviews ensured the model reflected real-world constraints and priorities. Other such participatory models have been successful in various contexts, e.g., in the U. S. and South Korea, where collaborative planning resulted in greater program adoption and sustainability (95). The Abu Dhabi model is therefore adding to the mounting evidence that participatory co-design makes school-based interventions more relevant and successful.

What are the anticipated short- and long-term outcomes of applying this model?: Short-term results comprise heightened awareness, enhanced reporting, and more cohesive school-level policy coherence. Medium- and long-term results should comprise fewer instances of bullying, healthier mental well-being among students, and improved safety within schools. These correspond with global research highlighting that well-designed, whole-school strategies can diminish bullying by as much as 20–30% in the long term (96).

Compared to current anti-bullying literature, this research is an uncommon illustration of a localized, systems-thinking model being implemented within a Middle Eastern setting. Most international models are based on Western nations and frequently overlook the socio-cultural dynamics that drive bullying behaviors and reporting in other settings (97). By basing the model on local realities and engaging ministries, educators, and parents, this study closes that gap and provides a copycat framework for culturally adaptable interventions.

Even with the detailed design and co-production of this study, a number of limitations need to be noted. First, the logic model was

established based on a purposive sampling of stakeholders based mainly in Abu Dhabi, which might restrict generalizability to other emirates or other areas with varying institutional and cultural backgrounds. Second, although the study included a variety of data collection modes—interviews, focus group discussions, and analysis of documents—the project was heavily dependent on qualitative findings, and therefore there is a possibility of subjective interpretation or prejudice. Third, the model was constructed based on a point in time and perhaps does not depict fully changing dynamics in school settings, changes in policies, or alterations in societal attitudes toward bullying. In addition, because of the non-empirical basis of the first phase, the model has not yet been piloted in large-scale rollout or longitudinal analysis, and its longer-term effects have yet to be empirically confirmed. Finally, although attempts were made to engage with diverse stakeholder views, some viewpoints—again, those of students or other traditionally marginalized groups—were potentially under included.

5 Conclusion

This participatory approach resulted in a strategic, culturally appropriate anti-bullying logic model. The model offers a roadmap for sustainable implementation and evaluation across schools in the region. The development of this Comprehensive School Anti-Bullying Logic Model in Abu Dhabi represents a thoughtful and culturally tailored approach to addressing bullying in schools. By using a multi-method approach and engaging a wide range of stakeholders, the study has produced a framework that is grounded in both local realities and international best practices. This model provides a strategic guide for schools to implement effective policies and programs to reduce bullying and create a safer, more supportive educational environment. The study underscores the importance of collaborative efforts in addressing complex issues like bullying, ensuring that the solutions are practical, relevant, and sustainable.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by UAE University Human Medical Research Ethics Committee (ERS_2019_5867). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

AA-k: Investigation, Resources, Writing – original draft, Visualization, Formal analysis, Validation, Conceptualization, Data curation, Methodology, Project administration, Supervision, Writing – review & editing.

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Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Correction note

A correction has been made to this article. Details can be found at: [10.3389/fpubh.2025.1708227](https://doi.org/10.3389/fpubh.2025.1708227).

References

1. Cosma A., Molcho M., Pickett W. (2024). A focus on adolescent peer violence and bullying in Europe, Central Asia and Canada. World Health Organization. Available online at: <https://iris.who.int/bitstream/handle/11069/113548506.2017.1279740> (accessed June 14, 2025).
2. Menesini E., Salmivalli C. Bullying in schools: the state of knowledge and effective interventions. *Psychol Health Med.* (2017) 22:240–53. doi: 10.1080/13548506.2017.1279740
3. Zych I., Farrington D. P., Llorent V. J., Ttofi M. M. (2017). Protecting children through anti-bullying interventions. In *Protecting children against bullying and its consequences* (pp. 57–68). Springer. Available online at: https://doi.org/10.1007/978-3-319-53028-4_5 (Accessed May 4, 2025).
4. Rachman A., Sugianto A., Prayudy R., Ramadhan MR. Analysis of bullying perpetrators and victims in middle schools in Banjarbaru City, South Kalimantan. *J Educ Method Learn Strat.* (2024) 2:115–25. doi: 10.59653/jemls.v2i01.457
5. Smith P. K., Steffgen G. (2013). Cyberbullying through the new media: Findings from an international network. Routledge. Available online at: <https://doi.org/10.4324/9780203799079> (Accessed May 4, 2025).
6. UNESCO. School violence and bullying: Global status and trends, drivers and consequences. Paris: United Nations Educational, Scientific and Cultural Organization (2018).
7. Al-Tawil TN, Abdallah S. Bullying prevention and intervention strategies under UAE law. *J Financ Crime.* (2024) 31:1237–51. doi: 10.1108/JFC-07-2023-0171
8. Ibrahim FM, Dabou EAR, AbdelSamad S, Abuijlan IAM. Prevalence of bullying and its impact on self-esteem, anxiety and depression among medical and health sciences university students in Ras Al Khaimah, UAE. *Heliyon.* (2024) 10:e25063. doi: 10.1016/j.heliyon.2024.e25063
9. Elkonaisi I, AlKetbi A, Abdullahi AS, AbuHamada B, Elbarazi I, Grivna M. Cross-sectional study of bystander roles in school bullying incidents in the United Arab Emirates. *Eur J Pub Health.* (2024) 34:ckae144-1977. doi: 10.1093/eurpub/ckae144.1977
10. Alzyoud MS, Alghazo EM, Al-Khateeb O. School bullying and its impact on students' academic achievement and mental health in the UAE: a teacher's perspective. *Int J Adolesc Youth.* (2020) 25:276–84. doi: 10.1080/02673843.2019.1669066
11. Moonesar I. Mental healthcare in the Gulf cooperation council: a 1.5-decade review—comparative analysis of policies, practices, and challenges. *J Clin Med Image.* (2024) 5:1734.
12. Fauzan H, Sulaeman DS. Overcoming bullying in the educational environment: prevention and intervention strategies in schools. *J Engl Lang Educ.* (2024) 9:12–26. doi: 10.31004/jele.v9i1.489

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpubh.2025.1649884/full#supplementary-material>

13. Badger JR, Nisar A, Hastings RP. School-based anti-bullying approaches for children and young people with special educational needs and disabilities: a systematic review and synthesis. *J Res Spec Educ Needs.* (2024) 24:742–57. doi: 10.1111/1471-3802.12665
14. Gaffney H, Ttofi MM, Farrington DP. Effectiveness of school-based programs to reduce bullying perpetration and victimization: an updated systematic review and meta-analysis. *Campbell Syst Rev.* (2021) 17:e1143. doi: 10.1002/cl2.1143
15. Hensums M, de Mooij B, Kuijper SC, Cross D, DeSmet A, Garandeau CF, et al. What works for whom in school-based anti-bullying interventions? An individual-participant data meta-analysis. *Prev Sci.* (2023) 24:1435–46. doi: 10.1007/s11121-022-01387-z
16. Olweus D. (2025). The development and efficacy of the Olweus bullying prevention program. School bullying legacies and development (pp. 227–246). Wiley. Available online at: <https://doi.org/10.1002/9781394173556.ch13> (Accessed May 4, 2025).
17. Hikmat R, Yosep I, Hernawaty T, Mardhiyah A. A scoping review of anti-bullying interventions: reducing traumatic effect of bullying among adolescents. *J Multidiscip Healthc.* (2024) 17:289–304. doi: 10.2147/JMDH.S443841
18. Scheithauer H., Lechner V. (2024). Excursus: promoting social skills and preventing bullying at school: the preventive intervention programme Fairplayer. In *Bullying at school: measurement, prevention, intervention, and aftercare* (215–227). Springer. Available online at: https://doi.org/10.1007/978-3-658-43576-9_12 (Accessed May 4, 2025).
19. Al Ali N, Qasem IO, Aldwaikat T. Examining the impact of a school-based bullying education program on students' knowledge of bullying, bullying behavior, and self-esteem. *Int J Adolesc Youth.* (2025) 30:2454997. doi: 10.1080/02673843.2025.2454997
20. Boddy E, Johnston M, Allan K, Jacobsen-Grocott T, Green VA. The relationship between parents' own responses to childhood bullying and what strategies they would recommend to their children. *Trends Psychol.* (2024). doi: 10.1007/s43076-024-00391-2
21. Fraguas D., Díaz-Caneja C. M., Pina-Camacho L., Moreno C., Durán-Cutilla M., Ayora M., ... & Arango C. Assessment of school anti-bullying interventions: a meta-analysis of randomized clinical trials. *JAMA Pediatr.* (2021), 175: 44–55. Available online at: <https://jamanetwork.com/journals/jamapediatrics/article-abstract/2772453> (Accessed May 4, 2025).
22. Le LKD, Chatterton ML, Rapee RM, Fitzpatrick S, Bussey K, Hudson J, et al. Burden and preference-based quality of life associated with bullying in children. *Eur Child Adolesc Psychiatry.* (2023) 32:53–62. doi: 10.1007/s00787-021-01807-5
23. Wang D, Zhang Y, Tian H, Sun H, Wang K, Su M, et al. The relationship between being bullied and bystander intervention in adolescent school bullying: the moderating mediation of moral disengagement and only child. *Curr Psychol.* (2024) 43:19617–27. doi: 10.1007/s12144-024-05734-x

24. Strohmeier D, Stefanek E, Yanagida T. What works for whom? Evaluating patterns and mechanisms of change among bullies, victims, and bully-victims participating in a school-based prevention program. *Int J Bully Prev.* (2024) 6:267–82. doi: 10.1007/s42380-023-00160-2
25. Helme ZE, Chalkley A, Walker TJ, Bartholomew JB, Morris JL, McLoughlin GM, et al. Opening the black box of implementation: developing the creating active schools logic model. *Transl J Am Coll Sports Med.* (2024) 9:1–11. doi: 10.1249/TJX.0000000000000244
26. Phillips S, Brown S, Kelly P. Using action research and logic modeling to promote young people's engagement, resilience and wellbeing in middle schooling. *Int J Educ Reform.* (2024) 33:449–63. doi: 10.1177/10567879241258133
27. Hawkins SR, Clinton-Sherrod AM, Irvin N, Hart L, Russell SJ. Logic models as a tool for sexual violence prevention program development. *Health Promot Pract.* (2009) 10:18S–26S. doi: 10.1177/1524839908318803
28. Graczyk R. (2023) Creating a logic model to evaluate the teen listener training program at a teen hotline. Available online at: <https://scholarworks.calstate.edu/downloads/qb98mn67v> (Accessed May 4, 2025).
29. Kneale D, Thomas J, Harris K. Developing and optimising the use of logic models in systematic reviews: exploring practice and good practice in the use of programme theory in reviews. *PLoS One.* (2015) 10:e0142187. doi: 10.1371/journal.pone.0142187
30. Voss S, Bauer J, Coenen M, Jung-Sievers C, Moore G, Rehfuess E. Logic models for the evaluation of complex interventions in public health: lessons learnt from a staged development process. *BMC Public Health.* (2025) 25:1–13. doi: 10.1186/s12889-025-23171-8
31. Funnell SC, Rogers PJ. Purposeful program theory: Effective use of theories of change and logic models. San Francisco, CA: Jossey-Bass (2011).
32. Frechtling J. Logic models and program theory. In: Debra JR, Leonard B, editors. *The evaluation handbook: an evaluator's companion.* United States: American Evaluation Association. (2025) 383–400.
33. McLaughlin J. A., Jordan G. B. (2015). Using logic models. In *Handbook of practical program evaluation* (3rd ed., pp. 62–87). Jossey-Bass: American Evaluation Association, US. Available online at: <https://doi.org/10.1002/9781119171386.ch3> (Accessed May 4, 2025).
34. Snyder R. B. (2025). Examining outcomes and impacts. In: Debra JR, Leonard B, editors. *The evaluation handbook: an evaluator's companion* (pp. 254–282).
35. Bonell C, Jamal F, Harden A, Wells H, Parry W, Fletcher A, et al. Systematic review of the effects of schools and school environment interventions on health: evidence mapping and synthesis. *Public Health Res.* (2013) 1:1–320. doi: 10.3310/phr01010
36. Leach F, Dunne M., Salvi F. (2014) School-related gender-based violence: A global review of current issues and approaches in policy, programming and implementation responses to school-related gender-based violence (SRGBV) for the education sector. Available online at: <https://sussex.figshare.com/articles/report/23440781> (Accessed May 4, 2025).
37. Devries KM, Knight L, Child JC, Mirembe A, Nakuti J, Jones R, et al. The good school toolkit for reducing physical violence from school staff to primary school students: a cluster-randomised controlled trial in Uganda. *Lancet Glob Health.* (2015) 3:e378–86. doi: 10.1016/S2214-109X(15)00060-1
38. Devries KM, Knight L, Allen E, Parkes J, Kyegombe N, Naker D. Does the good schools toolkit reduce physical, sexual and emotional violence, and injuries, in girls and boys equally? A cluster-randomised controlled trial. *Prev Sci.* (2017) 18:839–53. doi: 10.1007/s11211-017-0775-3
39. McFarlane J, Karmaliani R, Khuwaja HMA, Gulzar S, Somani R, Ali TS, et al. Preventing peer violence against children: methods and baseline data of a cluster randomized controlled trial in Pakistan. *Glob Health Sci Pract.* (2017) 5:115–37. doi: 10.9745/GHSP-D-16-00215
40. Al-Ketbi A, Paulo MS, Östlundh L, Elbarazi I, Abu-Hamada B, Elkonaisi I, et al. School bullying prevention and intervention strategies in the United Arab Emirates: a scoping review. *Inj Prev.* (2024) 30:509–17. doi: 10.1136/ip-2023-045039
41. Al Shebli AAS. Exploring UAE primary school teachers' classroom management strategies in dealing with disruptive students: a case study. *Turk Online J Qual Inq.* (2021) 12:362–80.
42. Huggins D. Stigma is the origin of bullying. *J Cathol Educ.* (2016) 19:309–24. doi: 10.15365/joce.1903092016
43. Mahmoudi M. Prevent upwards bullying and abuse of reporting systems. *Nat Hum Behav.* (2023) 7:466–7. doi: 10.1038/s41562-023-01567-z
44. DeLara EW. Why adolescents don't disclose incidents of bullying and harassment. *J Sch Violence.* (2012) 11:288–305. doi: 10.1080/15388220.2012.70593
45. Slatery LC, George HP, Kern L. Defining the word bullying: inconsistencies and lack of clarity among current definitions. *Prev Sch Fail.* (2019) 63:227–35. doi: 10.1080/1045988X.2019.1579164
46. Mahdi N., Mubarak N., Ahbab A. (2016) Towards leading effective secondary schools in Abu Dhabi, UAE: Stakeholders' perceptions [Doctoral dissertation, University of Glasgow]. Available online at: <https://theses.gla.ac.uk/7032/> (Accessed May 4, 2025).
47. Hayes H, Parchman ML, Howard R. A logic model framework for evaluation and planning in a primary care practice-based research network (PBRN). *J Am Board Fam Med.* (2011) 24:576–82. doi: 10.3121/jabfm.2011.05.110043
48. Swearer SM, Espelage DL, Vaillancourt T, Hymel S. What can be done about school bullying? Linking research to educational practice. *Educ Res.* (2010) 39:38–47. doi: 10.3102/0013189X09357622
49. Farrington DP, Ttofi MM. School-based programs to reduce bullying and victimization. *Campbell Syst Rev.* (2009) 5:1–148. doi: 10.4073/csr.2009.6
50. Mouton J. Programme evaluation designs and methods. In: Cloete F, Rabie B, de Coning C, editors. *Evaluation Management in South Africa and Africa.* Stellenbosch: African Sun Media (2014). 165–82.
51. Alketbi A. (2024) Policymaker's perspectives and student experiences of bullying at schools in the UAE: A mixed-method approach [Master's thesis, United Arab Emirates University]. Available online at: https://scholarworks.uaeu.ac.ae/thesis_dissertation_defense/2024-2023/dissertation_defenses/18/ (Accessed May 4, 2025).
52. Czosnek L, Zopf EM, Cormie P, Rosenbaum S, Richards J, Rankin NM. Developing an implementation research logic model: using a multiple case study design to establish a worked exemplar. *Implement Sci Commun.* (2022) 3:90. doi: 10.1186/s43058-022-00319-6
53. Government of Canada. (n.d.). Results-Based Management checklist 1.1 – How to assess and/or review a logic model. Available online at: <https://www.international.gc.ca/> (accessed June 14, 2025).
54. Watson DE, Broemeling AM, Wong ST. A results-based logic model for primary care: a conceptual foundation for population-based information systems. *Health Policy.* (2009) 5:33–46.
55. Al-Ketbi A, Elkonaisi I, Abdullahi AS, Elbarazi I, Hamada BA, Grivna M. Bullying victimization in schools in the United Arab Emirates: a cross-sectional study. *BMC Public Health.* (2024) 24:3025. doi: 10.1186/s12889-024-20392-1
56. Johnson SL. Creating effective anti-bullying policies. *Nurs Manag.* (2015) 46:40–5. doi: 10.1097/01.NUMA.0000463885.99823.d9
57. Ross SW, Horner RH. Bully prevention in positive behavior support. *J Appl Behav Anal.* (2009) 42:747–59. doi: 10.1901/jaba.2009.42-747
58. Wiharto T, Suriswo S, Sudibyo H. Group counseling services with modeling techniques to increase bullying behaviour awareness. *J Engl Lang Educ.* (2025) 10:218–28. doi: 10.31004/jele.v6i2
59. Aşvar F, Ayaz-Alkaya S. Effect of a multi-model-based intervention on bullying prevention through peer advocacy. *Curr Psychol.* (2024) 43:21383–92. doi: 10.1007/s12144-024-05874-0
60. Espelage DL, Forber-Pratt A, Rose CA, Graves KA, Hanebutt RA, Sheikh AE, et al. Development of online professional development for teachers: understanding, recognizing and responding to bullying for students with disabilities. *Educ Urban Soc.* (2024) 56:601–23. doi: 10.1177/00131245231187370
61. Kristiansen A. C., Andersson R. (2022). What is a vision zero policy? Lessons from a multi-sectoral perspective. The vision zero handbook: Theory, technology and Management for a Zero (Chapter 4). Springer. Available online at: https://doi.org/10.1007/978-3-030-76505-7_4 (Accessed May 4, 2025).
62. Kleynhans E. (2020) The development of a policy analysis logic model to support public medicine availability initiatives in the context of VAN [Master's thesis, Stellenbosch University]. Available online at: <https://scholar.sun.ac.za/server/api/core/bitstreams/108043ee-f7fd-42b9-a2b8-05c5e1d5e436/content> (Accessed May 4, 2025).
63. Lehmann A., Neuberg R. K. H. (2004) A generalized process for the verification and validation of models and simulation results. Available online at: <http://www.sce.carleton.ca/faculty/wainer/papers/inhalt.pdf> (Accessed May 4, 2025).
64. Guerra N. G., Leidy M. S. (2011). Conducting translational research on child development in community settings: what you need to know and why it is worth the effort. In D. G. Rog and D. M. Peterson (Eds.), *Applied research in Child and adolescent development* (197–210). Taylor & Francis. Available online at: <https://doi.org/10.4324/9780203854181-15> (Accessed May 4, 2025).
65. Karikari I, Brown JR, Ashirifi GD, Storms J. Bullying prevention in schools: the need for a multiple stakeholder approach. *Adv Soc Work.* (2020) 20:61–81. doi: 10.18060/22928
66. Yogopriyatno J., Harahap Y. Stakeholders mapping in the implementation of anti-bullying policies in the school environment Lubuklinggau City. *Int J Soc Sci Res.* (2024), 4. Available online at: <http://www.ijssjournal.org/index.php/ijssr/article/view/176> (Accessed May 4, 2025).
67. Xue X, Zhou D, Yu X, Wang G, Li J, Xie X, et al. Computational experiments for complex social systems: experiment design and generative explanation. *IEEE/CAA J Autom Sin.* (2024) 11:1022–38. doi: 10.1109/JAS.2024.124221
68. Haner M, Lee H. Placing school victimization in a global context. *Vict Offenders.* (2017) 12:845–67. doi: 10.1080/15564886.2017.1361675
69. Knowlton L. W., Phillips C. C. (2012). The logic model guidebook: Better strategies for great results (2nd ed.). SAGE Publications. Available online at: <https://books.google.com/books?hl=en&lr=&id=1aqrkWj9TP8C> (Accessed May 4, 2025).
70. Mishna F. (2012). *Bullying: a guide to research, intervention, and prevention.* Oxford University Press. Available online at: <https://books.google.com/books?hl=en&lr=&id=LKVkqhSkjgAC> (Accessed May 4, 2025).
71. Payton C, Kumar GS, Kimball S, Clarke SK, AlMasri I, Karaki FM. A logic model framework for planning an international refugee health research, evaluation, and ethics committee. *Health Promot Pract.* (2022) 23:852–60. doi: 10.1177/15248399211035703

72. Cross D., Shaw T., Hearn L., Epstein M., Monks H., Lester L., et al. (2009). Australian covert bullying prevalence study. Edith Cowan University. Available online at: <https://ro.ecu.edu.au/ecuworks/6795/> (Accessed May 4, 2025).
73. Baxter SK, Blank L, Woods HB, Payne N, Rimmer M, Goyder E. Using logic model methods in systematic review synthesis: describing complex pathways in referral management interventions. *BMC Med Res Methodol.* (2014) 14:Article 62. doi: 10.1186/1471-2288-14-62
74. Chanfreau-Coffinier C, Peredo J, Ghosh M. A logic model for precision medicine implementation informed by stakeholder views and implementation science. *J Clin Transl Sci.* (2019) 21:1139–1154. doi: 10.1038/s41436-018-0315-y
75. Lucas M. External barriers affecting the successful implementation of mobile educational interventions. *Comput Hum Behav.* (2020) 108:106309
76. Mitchell P. (2012). The limits of anti-bullying legislation. Institute of Marriage and Family Canada. Available online at: <http://www.imfcanada.org/sites/default/files/IMFCPublicationMay2012FINAL-WEB.pdf> (Accessed May 4, 2025).
77. Hammad W, Polatcan M, Morad H. Investigating links between teacher leadership, collective efficacy and teacher commitment in Egyptian schools: a mediated-effects analysis. *Int J Educ Manage.* (2024) 38:750–68. doi: 10.1108/IJEM-03-2023-0124
78. Drakatos N, Tsompou E, Karabatzaki Z, Driga AM. School bullying and the role of social media. *TechHub J.* (2024) 10:27–51.
79. Arrieta-López M, Carrasquilla-Díaz L. Bullying and cyberbullying: a legal and public policy perspective in Colombia. *Pertanika J Soc Sci Humanit.* (2021) 29:2135–51. doi: 10.47836/pjssh.29.4.02
80. Nengsih W, Haris A, Mansyui FA, Juwita CP. The importance of community engagement in managing bullying prevention in primary and secondary schools. *Int J Community Care Humanit.* (2024) 4
81. Saputra M. Preventive detection and education to realize anti-bullying friendly schools. *ABDIMAS: Jurnal Pengabdian Masyarakat.* (2022) 5:1651–8.
82. Kneale D., Thomas J., Booth A., Garside R., Noyes J. (2023). Developing and using logic models. UCL Discovery. Available online at: <https://discovery.ucl.ac.uk/id/eprint/10181185/> (Accessed May 4, 2025).
83. Smith JD, Li DH, Rafferty MR. The implementation research logic model: a method for planning, executing, reporting, and synthesizing implementation projects. *Implement Sci.* (2020) 15:Article 84. doi: 10.1186/s13012-020-01041-8
84. Kernick D. (2020). Complexity and healthcare organization: a view from the street. Springer. Available online at: <https://books.google.ae/books?hl=en&lr=&id=Aj4PEAAQBAJ> (Accessed May 4, 2025).
85. Todhunter-Brown A, Booth L, Campbell P, Cheer B, Cowie J, Elders A, et al. Strategies used for childhood chronic functional constipation: the SUCCESS evidence synthesis. *Health Technol Assess.* (2024) 28:1–266. doi: 10.3310/PLTR9622
86. Franklin A. (2020). Stakeholder engagement. Available online at: <https://doi.org/10.1007/978-3-030-47519-2> (Accessed May 4, 2025).
87. O'Mara-Eves A., Kneale D., Oliver S., Cain L. (2022). How co-production underpinned the development of a logic model and testing of novel statistical methods for evidence synthesis. UCL Discovery. Available online at: <https://discovery.ucl.ac.uk/id/eprint/10158002/> (Accessed May 4, 2025).
88. O'Mara-Eves A., Laidlaw L., Vigurs C., Candy B., Collis A. (2022). The value of co-production research project: A rapid critical review of the evidence. UCL Discovery. Available online at: <https://discovery.ucl.ac.uk/id/eprint/10162025/1> (Accessed May 4, 2025).
89. Cooper CR, Rocha-Ruiz M, Herzon C. Using integrated logic models to build equity in students' pathways and systemic change. *Equity Excell Educ.* (2020) 53:105–20. doi: 10.1080/10665684.2020.1757534
90. Lehne G, Voelcker-Rehage C, Meyer J, Bammann K, Gansefort D, Brüchert T, et al. Equity impact assessment of interventions to promote physical activity among older adults: a logic model framework. *Int J Environ Res Public Health.* (2019) 16:420. doi: 10.3390/ijerph16030420
91. Botha N, Coutts J, Turner JA, White T, Williams T. Evaluating for learning and accountability in system innovation: incorporating reflexivity in a logical framework. *Outlook Agric.* (2017) 46:154–60. doi: 10.1177/0030727017707406
92. Gredler GR. Review of the book *Bullying at school: What we know and what we can do* by D. Olweus (1993). Malden, MA: Blackwell Publishing. *Psychol Sch.* (2003) 40:699–700.
93. Hong JS, Espelage DL. A review of mixed methods research on bullying and peer victimization in school. *Educ Rev.* (2012) 64:115–26. doi: 10.1080/00131911.2011.590987
94. Nichols L. Participatory program planning: including program participants and evaluators. *Eval Program Plann.* (2002) 25:1–4.
95. Jenson JM, Dieterich WA. Effects of a skills-based prevention program on bullying and bully victimization among elementary school children. *Prev Sci.* (2007) 8:285–96. doi: 10.1002/ab.20207
96. Ttofi MM, Farrington DP. Effectiveness of school-based programs to reduce bullying: a systematic and meta-analytic review. *J Exp Criminol.* (2011) 7:27–56. doi: 10.1007/s11292-010-9109-1
97. Smith PK. Bullying: definition, types, causes, consequences and intervention. *Soc Personal Psychol Compass.* (2016) 10:519–32. doi: 10.1111/spc3.12266



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Correction: Development of a comprehensive school anti-bullying logic model in Abu Dhabi: a multi-method participatory approach

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school-bullying, logic models, mental health, academic performance, UAE

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The original article has been updated.

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Current status of KAB in health education for Chinese college students and SEM validation exploration

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Introduction: In the field of health education, the KAB theory is an authoritative theoretical model worldwide; however, there is not much empirical evidence supporting its application in university health education. Therefore, the purpose of this paper is to use data from Chinese universities to test the pathways and universality of the KAB model, as well as to provide certain suggestions for future health education in universities through a situational analysis.

Methods: We used a random sampling method to conduct a questionnaire survey of 4,508 college students from 76 universities in Jiangsu Province (752 from sports majors and 3,756 from non-sports majors). We employed a self-developed four-point scale questionnaire (20 questions on health knowledge, 14 on attitudes, and 10 on behaviors), which demonstrated good reliability and validity (Cronbach's α : 0.958–0.969). Exploratory factor analysis was conducted to extract the dimensions of attitude and behavior, and structural equation modeling (SEM) was used to verify the $K \rightarrow A \rightarrow B$ theoretical pathway.

Results: Current status: The awareness of sexual and reproductive health was highest (89.7%–98%), while knowledge of disease prevention was the weakest (awareness of antibiotic hazards was only 57.5%); sports majors scored significantly higher in health knowledge than non-sports majors (e.g., 15.7% higher in disease prevention knowledge). In terms of behavior, the rate of developing exercise habits among non-sports majors (87.6%) was significantly lower than that of sports majors (97.9%), and only 69.6% actively consulted health issues, showing that students are hesitant to talk to their teachers. Model validation: The SEM fit indices were good (GFI = 0.972, RMSEA = 0.065), confirming three key pathways: knowledge $\rightarrow$ attitude (β = 0.42), attitude $\rightarrow$ behavior (β = 0.33), and knowledge $\rightarrow$ behavior (β = 0.55). Multi-group analysis showed that the model has universality across genders and majors, but the pathway from knowledge to behavior was stronger for males (β difference +0.11), while the pathway from attitude to behavior was more pronounced for females (β difference +0.09).

Discussion: The KAB model is applicable to the college student population, where health knowledge not only directly influences behavior (β = 0.55) but also has an indirect effect through attitude. We need to focus more on teaching disease prevention, such as the hazards of antibiotics, design behavioral intervention courses for non-sports majors, and we should also notice that students are less willing to seek health advice in person. The study validates the universality of the KAB theoretical pathway, giving solid proof for health education in universities.

KEYWORDS

knowledge-attitude-behavior model, structural equation model, health education, college students, confirmatory research

1 Introduction

The World Health Organization (WHO) pointed out in 1997 that health is not merely the absence of disease but should also include a sound and peaceful state of physical, mental, and social well-being, and that schools play an important role in health education (1). It is evident that school health education has long been an important topic of global concern. With the changing times, China has also placed great emphasis on school health education in recent years, with “Healthy China” becoming a key part of the national development strategy (2). In 2016, the Central Committee of the Communist Party of China and the State Council issued the “Healthy China 2030 Planning Outline,” which clearly stated the need to “increase the intensity of school health education, incorporate health education into the national education system, and make health education an important component of quality education at all stages of education” (3).

In this context, as a crucial time for students’ physical and mental growth, as well as the formation of health literacy and the development of healthy lifestyle habits, it is essential to pay attention to school health education, promote the implementation of health education, and enhance students’ health literacy during the higher education stage (4). Therefore, in 2017, the Ministry of Education issued the “Health Education Guidelines for Colleges and Universities” (hereinafter referred to as the “Guidelines”), which clarified the development pathway of health education in higher education institutions and specified the main content of health education in colleges and universities (5). Additionally, the “Guidelines” also explicitly stated that promoting knowledge transfer and behavior formation should be a fundamental principle for conducting health education in higher education institutions.

It is clear that the transfer of knowledge and the formation of behavior are key steps in developing school health education (6). Evidence has shown that the acquisition of knowledge can lead to changes in attitudes, which in turn leads to the formation of behaviors, thus forming the well-known KAB model in recent years in Japan’s school health education field (7, 8). Although the KAB model is widely cited in the field of health education, its applicability to Chinese college students still lacks empirical support. Existing research mostly focuses on descriptive analyses or simple correlations and has not yet employed structural equation modeling (SEM) to systematically test the path relationships between knowledge, attitudes, and behaviors. Given the unique characteristics of college students, the absence of a university-level KAB model will render health interventions ineffective – empirical studies demonstrate that health education lacking theoretical frameworks increases sedentary behavior rates and psychological distress risk (9, 10), while exacerbating obesity and driving healthcare cost escalation (11, 12). Ultimately compromising students’ long-term health outcomes. Previous studies have also emphasized the importance of KAB. For example, an analysis of sports exercise habits indicates that the transformation of behavior requires the mediating role of demand and satisfaction (9). Similarly, research on dietary decision-making has

found that attitude and willingness have a direct impact on behavior. In addition, the Japan Health Learning Promotion Committee has also pointed out in its report investigating elementary, junior high, and high schools nationwide that there is an inevitable connection between health knowledge and learning attitude and behavior, which requires structural analysis (13). Furthermore, in health education during the junior high school stage in China, there is a conclusion that the formation of healthy behavior has a negative impact between attitude and behavior (14). However, these studies have not yet integrated SEM to validate the KAB path in the context of Chinese higher education, leaving a critical gap.

Jiangsu Province is the province with the highest density of higher education institutions in China, with a total of 168 universities and 2.3 million students, accounting for 10.2% of the national college student population (15). Therefore, choosing Jiangsu Province as the research location has certain representativeness. The research results will provide a basis for the theoretical universality of the knowledge-attitude-practice (KAP) model and offer key targets for the design of health education interventions in universities. Given the characteristics of the college student population in Jiangsu Province, this study aims to: describe the current characteristics of health knowledge (K), attitudes (A), and behaviors (B) in this population; verify the proposed KAB theoretical path (knowledge → attitude, attitude → behavior, knowledge → behavior) through SEM, and assess the model fit and path significance. The research results will provide evidence for the theoretical universality of the KAB model and identify key targets for designing health education interventions in colleges.

2 Survey subjects and research methods

2.1 Subjects

Jiangsu Province is one of the most economically active regions in China, with the highest degree of openness and the strongest innovation capability. It holds a crucial strategic position in the overall modernization and comprehensive openness of the country, making it fairly representative (16, 17). Therefore, the survey focuses on 76 provincial universities in Jiangsu.

2.2 Methods

This study employed a random sampling method. Teachers responsible for monitoring the physical fitness of college students at these universities conducted an online questionnaire survey using the Tencent survey platform. We collected a total of 4,508 valid questionnaires. Among them, there were 2,188 male students and 2,320 female students based on gender. Based on their majors, there were 752 students studying physical education and 3,756 students studying other majors (see Table 1). The survey ran from August 2023 to February 2024.

This study designed a questionnaire based on the relevant content and requirements of the “Guidelines” from the Ministry of Education of China, referencing related literature and through expert discussions, and tested its applicability and accuracy through a pre-experiment (13, 14, 18). The main content of the questionnaire includes basic information and covers three main areas: health

Abbreviations: SEM, structural equation modeling; KAB, knowledge-attitudes-behaviors; KMO, Kaiser–Meyer–Olkin; GFI, goodness-of-fit index; AGFI, adjusted goodness-of-fit index; CFI, comparative fit index; RMSEA, root mean square error of approximation; NFI, normed fit index; IFI, incremental fit index; RFI, relative fit index; TLI, Tucker–Lewis index.

TABLE 1 Characteristics of survey participants.

Subject	Number of people (n)	Percentage (%)
Total participants	4,508	100.0
Gender		
Males	2,188	48.5
Females	2,320	51.5
Field of study		
Sports majors	752	16.7
Non-sports majors	3,756	83.3

knowledge, health attitudes, and health behaviors. Health knowledge includes five main areas: “healthy lifestyle,” “disease prevention,” “mental health,” “sexual and reproductive health,” and “safety, emergency preparedness, and risk avoidance,” which consists of 20 questions. It includes 14 questions on health attitudes and 10 on health behaviors, for a total of 44 questions. All questions use a four-point Likert scale: health knowledge (1 = very well, 2 = somewhat well, 3 = not very well, 4 = not at all), health attitudes (1 = strongly agree, 2 = agree, 3 = somewhat disagree, 4 = strongly disagree), and health behaviors (1 = often do, 2 = occasionally do, 3 = rarely do, 4 = never do).

To analyze the current status of KAB in health education in universities, relevant data was first organized. In the current status of health knowledge, the awareness rate of health knowledge is calculated by merging affirmative options (1 = very knowledgeable, 2 = basically knowledgeable). In the current status of health attitudes, the formation rate is calculated by merging affirmative options (1 = strongly agree, 2 = agree). In the current status of health behaviors, the formation rate is calculated by merging affirmative options (1 = often do, 2 = occasionally do).

Regarding the current status of health knowledge among college students, the “Guidelines” clearly states that the content of health education in universities mainly includes five aspects: “healthy lifestyle,” “disease prevention,” “mental health,” “sexual and reproductive health,” and “safety emergency and risk avoidance.” Therefore, the analysis is conducted from these five dimensions. The “healthy lifestyles” consists of four items: methods to enhance physical fitness (K_1), healthy dietary habits (K_2), the dangers of smoking (K_3), and knowledge of food safety (K_4). The “disease prevention” includes four items: knowledge related to flu prevention (K_5), the dangers of antibiotics to health (K_6), common methods to assess health status (K_7), and knowledge of chronic disease prevention (K_8). The “mental health” consists of four items: manifestations of depression and anxiety (K_9), the relationship between mental health and physical health (K_{10}), promoting positive emotions and alleviating negative emotions (K_{11}), and ways to self-regulate anxiety and worries (K_{12}). The “sexual and reproductive health” consists of four items: methods to prevent sexual assault (K_{13}), knowledge of AIDS prevention (K_{14}), effective contraceptive methods (K_{15}), and prevention of common sexually transmitted diseases (K_{16}). The “safety emergency and risk avoidance” consists of four items: self-rescue and mutual rescue in drowning (K_{17}), health and safety risks during travel (K_{18}), emergency measures for animal bites and scratches (K_{19}), and methods of cardiopulmonary resuscitation and trauma rescue (K_{20}).

An analysis of college students’ attitudes towards health education revealed that the current status consists of three factors: “emotional willingness for learning health knowledge” (hereinafter referred to as “emotional willingness”), “willingness to learn health knowledge” (hereinafter referred to as “learning willingness”), and “recognition of the value of health” (hereinafter referred to as “value recognition”). “Emotional willingness” consists of two items: enjoying learning about health knowledge (A_1) and finding learning health knowledge interesting (A_2). “Learning willingness” is made up of six items: it is important to learn health knowledge for a healthy life (A_3), learning health knowledge is very important (A_4), learning health knowledge will be useful for future life (A_5), health knowledge is necessary as part of school learning (A_6), learning health knowledge can alleviate psychological and physical anxiety and worries (A_7), and learning health knowledge is enjoyable (A_8). “Value recognition” consists of six items: learning health knowledge will be useful for entering society in the future (A_9), maintaining health is more necessary than anything else (A_{10}), learning health knowledge can make life healthier (A_{11}), maintaining health is important for a happy future (A_{12}), health is more important than anything (A_{13}), and learning health knowledge contributes to the formation of public health (A_{14}).

An analysis of the current status of college students’ health behaviors, based on factor analysis of the data, revealed that health behaviors are composed of three factors: “proactive attention,” “proactive learning,” and “habit formation.” Therefore, the current status of college students’ health behaviors can be analyzed from these three dimensions. The “proactive attention” consists of two items: actively paying attention to health knowledge (B_1) and regularly checking food expiration dates (B_2). The “proactive learning” includes four items: valuing flu prevention (B_3), discussing health issues with classmates (B_4), self-learning health-related knowledge (B_5), consulting teachers about health issues (B_6), and browsing health information (B_7). The “habit formation” consists of three items: having a habit of exercising (B_8), consciously exercising to enhance physical fitness (B_9), and consciously forming good daily routines (B_{10}).

2.3 Reliability and validity analysis

The analysis of reliability and validity was conducted using a total sample size of 4,508, with Cronbach’s α coefficient and Kaiser–Meyer–Olkin (KMO) measure and Bartlett’s test analysis performed separately. The reliability of the health knowledge questionnaire, as measured by Cronbach’s α coefficient, is 0.958; the reliability of the health attitude questionnaire is 0.969; and the reliability of the health behavior questionnaire is 0.920. According to relevant research standards, an α coefficient less than 0.05 indicates poor internal consistency, above 0.7 indicates acceptable internal consistency, and above 0.8 indicates very high internal consistency (19). So, we can say that the internal consistency of the health knowledge, health attitude, and health behavior questionnaires is very high. Additionally, we checked the structural validity of the questionnaire using the KMO measure and Bartlett’s test of sphericity. The KMO coefficient for health knowledge is 0.954, for health attitude is 0.968, and for health behavior is 0.928, and all of them were significant at $p < 0.001$. According to relevant research standards, a KMO value closer to 1 means better structural validity, while a coefficient below 0.5 indicates poor structural validity (19). Therefore, we can conclude that the

structural validity of the questionnaire in terms of health knowledge, health attitude, and health behavior is very good.

2.4 Statistical analysis

First, regarding health knowledge, the topics were categorized into five dimensions based on their content: “Healthy Lifestyle,” “Disease Prevention,” “Mental Health,” “Sexual and Reproductive Health,” and “Safety and Emergency Preparedness.” We conducted factor analysis on health attitudes and behaviors using the maximum likelihood method to check their structure. We sorted the factor consistency coefficients for each item by size, and after organizing the final factor types after optimal oblique rotation, we identified three factors for health attitudes and four for health behaviors. Secondly, we aimed to explore the relationships between knowledge, attitudes, and behaviors in health education at universities through path analysis using covariance structure analysis with the maximum likelihood method and Standardized estimates Covariance-based SEM(CB-SEM) model and Multi-Group SEM model was constructed. We repeatedly modified the model by first removing cross-load items and then deleting the four low-efficiency project paths until we achieved the best fit. We will determine the validity of the model using fit indices GFI (Goodness-of-Fit Index), AGFI (Adjusted Goodness-of-Fit Index), CFI (Comparative Fit Index) and RMSEA (Root Mean Square Error of Approximation). We judge that if GFI is greater than or equal to AGFI, the closer GFI and AGFI are to 1, the better the model fits; The CFI evaluates how much better your hypothesized model fits the data compared to a baseline “null model.” It ranges from 0 to 1, with higher values indicating better fit. RMSEA is an index that shows the deviation between the model distribution and the true distribution per degree of freedom, with a value less than 0.05 showing a very good fit, and a value of 0.1 or higher showing a poor fit (20). Finally, we reprocessed the data by combining the affirmative responses of options 1 and 2 for health knowledge, health attitudes, and health behaviors, and combined the negative responses from options 3 and 4. We then calculated the proportions and used chi-square analysis to look at the statistical differences based on gender and field of study, with $p < 0.05$ being considered statistically significant. Statistical analysis was conducted using IBM SPSS Statistics 26 and IBM SPSS Amos 26 data analysis software.

3 Results

3.1 Current status of KAB in health education in universities

The current situation of KAB in university health education is analyzed in depth from three aspects: overall, gender differences, and major differences, leading to the following conclusions.

3.1.1 Current status of health knowledge (Table 2)

- (1) The overall awareness rate of health knowledge about “healthy lifestyles” is 81.5 to 90.0%. In the analysis of gender differences, significant differences were found in the items of methods to enhance physical fitness (K_1) and the dangers of smoking (K_3). Specifically, the awareness rate of health knowledge for males

in the item methods to enhance physical fitness (K_1) is 84.6%, higher than the 78.6% for females. In the item dangers of smoking (K_3), the awareness rate for males is 88.3%, higher than the 84% for females. There are no statistical gender differences in the items of healthy dietary habits (K_2) and knowledge of food safety (K_4).

In the analysis of major differences, significant differences were found in the items of methods to enhance physical fitness (K_1), healthy dietary habits (K_2), and the dangers of smoking (K_3). The awareness rates of health knowledge among physical education students are significantly higher than those of non-physical education students. Specifically, the awareness rate for physical education students in methods to enhance physical fitness (K_1) is 93.6%, significantly higher than the 79.1% for non-physical education students. In healthy dietary habits (K_2), the awareness rate for physical education students is 94.7%, significantly higher than the 89.0% for non-physical education students. In the dangers of smoking (K_3), the awareness rate for physical education students is 92.6%, significantly higher than the 84.8% for non-physical education students. No statistical differences were found in knowledge of food safety (K_4) among different majors.

- (2) The overall awareness rate of health knowledge regarding “disease prevention” is 57.5%–83.3%. Among these, the awareness rate for flu prevention knowledge (K_5) is the highest at 83.3%, while the awareness rate for the dangers of antibiotics to health (K_6) is the lowest at 57.5%, which is also the lowest among all health knowledge items. In the analysis of disease prevention items, significant differences were found in flu prevention knowledge (K_5), the dangers of antibiotics to health (K_6), common methods to assess health status (K_7), and knowledge of chronic disease prevention (K_8) across gender and major groupings. In the gender grouping, all items in the health knowledge of “disease prevention” showed that males had a significantly higher awareness rate than females. In other words, males have a higher level of knowledge acquisition regarding disease prevention than females. This difference may be attributed to males being more interested in knowledge about certain diseases and having more opportunities to encounter such knowledge. In the major grouping, physical education students had a significantly higher awareness rate of health knowledge regarding “disease prevention” than non-physical education students. This shows that physical education programs in universities are better at promoting health education, while the training programs for non-physical education students do not emphasize health education.
- (3) The overall awareness rate of health knowledge about “mental health” is 82.6%–83.2%. No statistical gender differences were found in the awareness rate of health knowledge regarding “mental health.” However, in the major grouping, significant differences were found in the knowledge of depression and anxiety symptoms (K_9), the relationship between mental health and physical health (K_{10}), promoting positive emotions and alleviating negative emotions (K_{11}), and ways to self-regulate anxiety and worries (K_{12}), with physical education students

TABLE 2 Health knowledge (%).

Items	Total (%)	Gender (%)		χ^2	p	Major of study (%)		χ^2	p
		Male	Female			Physical education	Non-physical education		
Health lifestyle									
K ₁	81.5	84.6	78.6	6.785	0.009	93.6	79.1	21.854	<0.001
K ₂	90	89.9	90	0.001	0.976	94.7	89	5.543	0.019
K ₃	86.1	88.3	84	4.411	0.036	92.6	84.8	7.912	0.005
K ₄	84.2	82.6	85.7	1.978	0.16	83.5	84.3	0.082	0.775
Disease prevention									
K ₅	83.3	88.9	78.1	13.102	<0.001	95.4	70.9	13.269	<0.001
K ₆	57.5	65.1	50.3	25.019	<0.001	71.8	54.6	18.909	<0.001
K ₇	65	71.7	58.8	20.508	<0.001	73.4	63.4	6.943	0.008
K ₈	68	72	64.1	8.052	0.005	86.2	64.3	34.338	<0.001
Mental health									
K ₉	82.6	84.8	80.5	3.638	0.056	93.1	80.5	17.238	<0.001
K ₁₀	82.9	85	80.9	3.411	0.065	93.1	80.8	16.574	<0.001
K ₁₁	83.1	85.4	81	3.783	0.052	93.6	81	17.667	<0.001
K ₁₂	83.2	85	81.6	2.411	0.12	93.1	81.3	15.701	<0.001
Sexual and reproductive health									
K ₁₃	90.8	93.6	88.1	10.159	0.001	94.1	90.1	3.072	0.08
K ₁₄	98	98.2	97.8	0.24	0.624	97.3	98.1	0.432	0.511
K ₁₅	94.4	93.4	95.3	1.979	0.159	96.8	93.9	2.46	0.117
K ₁₆	89.7	89.6	89.8	0.019	0.891	89.9	89.7	0.008	0.927
Safety emergency and risk avoidance									
K ₁₇	71.7	72.6	70.9	0.408	0.523	81.4	69.8	10.436	0.001
K ₁₈	72	72.8	71.4	0.267	0.606	82.4	70	12.112	0.001
K ₁₉	72.2	72.9	71.6	0.272	0.602	81.4	70.4	9.43	0.002
K ₂₀	72.4	72.9	71.9	0.154	0.694	81.4	70.6	9.103	0.003

showing a significantly higher awareness rate than non-physical education students. This also reflects that physical education students in universities have more comprehensive access to mental health knowledge than non-physical education students.

- (4) The overall awareness rate of health knowledge about “sexual and reproductive health” is 89.7%–98%. The overall awareness rate of health knowledge in this dimension is the highest compared to other dimensions. Among these, the awareness rate for knowledge of AIDS prevention (K₁₄) reached 98%, the highest overall. This is due to the government’s long-term efforts in AIDS prevention and control. The knowledge awareness rate for methods to prevent sexual assault (K₁₃) showed significant differences in the gender grouping, with males at 93.6% significantly higher than females at 88.1%. This phenomenon is quite special and requires attention. Generally, females are the primary targets of sexual assault and need to understand and master methods of prevention. However, 11.9% of females are not very familiar with methods to prevent sexual assault, which shows that education on preventing sexual assault in our country is still lacking and explains the frequent occurrence of sexual assault cases in recent years. No

statistical differences were found in the awareness rates of all items in the major grouping.

- (5) The overall awareness rate of health knowledge regarding “safety emergency and risk avoidance” is 71.7%–72.4%. Compared to other aspects, this overall rate is relatively low. Although the state has emphasized this area sufficiently and most universities have taken corresponding measures regarding safety emergencies and risk avoidance, to achieve better results, we need to stay vigilant and not let our guard down (21). No significant differences were found in the awareness rates of health knowledge among all items in the gender grouping. However, in the major grouping, all items showed statistically significant differences. Physical education students had significantly higher awareness rates than non-physical education students in the four knowledge items of self-rescue and mutual rescue in drowning (K₁₇), health and safety risks during travel (K₁₈), emergency measures for animal bites and scratches (K₁₉), and methods of cardiopulmonary resuscitation and trauma rescue (K₂₀). Since sports activities also carry certain risks, physical education students engage in sports behaviors much more than

non-physical education students, which significantly increases their probability of encountering safety risks, leading to a higher emphasis on safety in the daily education of physical education students.

3.1.2 Current status of health education attitudes (Table 3)

Firstly, from the overall formation rate of health education attitudes, “emotional willingness” is 94.9%–95%, “learning willingness” is 95.1%–98.8%, and “value recognition” is 96.4%–99.5%. This indicates that college students have a very high emotional willingness and learning willingness towards learning health knowledge, as well as a good understanding of the value of health.

Secondly, from the perspective of gender grouping, significant differences were found in “learning willingness” regarding the importance of learning health knowledge for a healthy life (A_3) and the importance of learning health knowledge (A_4). Specifically, the formation rate of health education attitudes for the item regarding the importance of learning health knowledge for a healthy life (A_3) is 99.3% for females, significantly better than 97.6% for males. The formation rate for the item regarding the importance of learning health knowledge (A_4) is also 99.3% for females, significantly better than 96.9% for males. Even though females might not know as much about health as males, they have a better attitude toward health education. This also indicates that females have a stronger expectation for health education.

Finally, in the professional grouping, no statistical differences were found in the three dimensions of “emotional willingness,” “learning willingness,” and “value recognition,” indicating that college students’ attitudes toward health education are not influenced by their field of study.

3.1.3 Current status of health behaviors (Table 4)

The overall formation rate for “proactive attention” is 93.8% for actively paying attention to health knowledge (B_1) and 97.9% for regularly checking food expiration dates (B_2), showing a high formation rate. No statistical differences were found in gender and major of study grouping, suggesting that college students usually pay attention to health knowledge and food safety in their daily behaviors.

The overall formation rate for “proactive learning” is 69.6%–93.1%. You can see that the formation rates for some aspects of proactive learning in health education are relatively low, such as consulting teachers about health issues (B_6) at only 69.6%, while other aspects have higher formation rates, such as self-learning health-related knowledge (B_5) at 93.1%, showing a big difference. This is related to the current social context where college students are in an era of online information, leading to a fear of face-to-face communication. They find it more convenient and comfortable to search for answers online rather than consulting teachers. In the gender grouping, the formation rate for valuing flu prevention (B_3) is 94% for females, significantly better than 90.3% for males. Research indicates that some males may underestimate the severity of flu and think it is not a big deal, thus not taking flu prevention seriously (22). The formation rate for consulting teachers about health issues (B_6) is 74.8% for males, significantly better than 64.7% for females. According to studies, asking questions to teachers is a type of social activity, and research shows that boys are generally more proactive than girls during social activities. Mahesh et al. (23). In the professional grouping, significant differences were found in three items: self-learning health-related knowledge (B_5), consulting teachers about health issues (B_6), and browsing health information (B_7), with health behavior formation rates for physical education students significantly higher than those for non-physical education students. This can

TABLE 3 Rate of formation of attitudes toward health education (%).

Items	Total (%)	Gender (%)		χ^2	p	Major of study (%)		χ^2	p
		Male	Female			Physical education	Non-physical education		
Emotional willingness									
A ₁	95.0	95.1	95.0	0.002	0.961	96.3	94.8	0.741	0.389
A ₂	94.9	94.0	95.9	2.105	0.147	95.2	94.9	0.034	0.853
Learning willingness									
A ₃	98.5	97.6	99.3	5.392	0.020	97.9	98.6	0.582	0.455
A ₄	98.1	96.9	99.3	9.002	0.003	97.9	98.2	0.086	0.769
A ₅	98.8	98.5	99.1	0.890	0.345	98.4	98.9	0.387	0.534
A ₆	98.2	97.6	98.8	20,210	0.137	98.9	98.1	0.654	0.419
A ₇	96.6	96.2	97.1	0.712	0.399	95.2	96.9	1.388	0.239
A ₈	95.1	94.7	95.5	0.407	0.524	94.7	95.2	0.094	0.760
Value recognition									
A ₉	97.7	97.3	98.1	0.893	0.345	98.4	97.6	0.506	0.477
A ₁₀	96.5	96.2	96.7	0.261	0.610	94.1	96.9	3.492	0.062
A ₁₁	98	97.6	98.4	1.001	0.317	96.3	98.4	3.699	0.054
A ₁₂	99.5	99.5	99.5	0.005	0.943	99.5	99.5	0	0.999
A ₁₃	96.4	95.4	97.2	2.636	0.104	97.3	96.2	0.616	0.432
A ₁₄	98.8	98.4	99.3	2.255	0.133	99.5	98.7	0.765	0.382

TABLE 4 How often health behavior is developed (%).

Items	Total (%)	Gender (%)		χ^2	p	Major of study (%)		χ^2	p
		Male	Female			Physical education	Non-physical education		
Proactive attention									
B ₁	93.8	93.8	93.8	<0.001	0.995	94.7	93.6	0.308	0.579
B ₂	97.9	97.6	98.1	0311	0.577	96.8	98.1	1.221	0.269
Proactive learning									
B ₃	92.2	90.3	94	5.233	0.022	91.5	92.3	0.155	0.694
B ₄	85.3	83.7	86.7	2.010	0.156	88.3	84.7	1.646	0.199
B ₅	93.1	92.3	93.8	0.946	0.331	97.3	92.2	6.361	0.012
B ₆	69.6	74.8	64.7	13.607	<0.001	84.6	66.6	24.009	<0.001
B ₇	91.9	92.7	91.2	0.831	0.362	96.8	90.9	7.248	0.007
Habit formation									
B ₈	89.4	93.6	85.3	20.171	<0.001	97.9	87.6	17.216	<0.001
B ₉	93	96.2	90	16.392	<0.001	98.9	91.8	12.238	<0.001
B ₁₀	93.9	94.5	93.3	0.735	0.386	95.7	93.5	1.369	0.242

be correlated with the higher health knowledge awareness rate among physical education students, suggesting that their comprehensive knowledge promotes the formation of health behaviors.

The overall formation rate for “habit formation” is 89.4%–93.9%. Significant differences were found in the gender and major of study grouping for the items of having a habit of exercising (B₈) and consciously exercising to enhance physical fitness (B₉), with males showing significantly higher health behavior formation rates than females. This indicates that males have an advantage in forming good health habits. In the professional grouping, health behavior formation rates for physical education students are significantly higher than those for non-physical education students. Physical education students generally have more regular exercise and health habits, and they recognize the importance of health. This result also suggests an internal correlation between the formation of health behaviors and health recognition attitudes.

3.2 KAB model of health education in colleges

To verify the internal correlation among knowledge, attitudes, and behaviors in college health education, data from health knowledge, health attitudes, and health behaviors were validated through structural equation modeling. The current status of health education KAB suggests that health knowledge has an internal correlation with health attitudes and health behaviors. After repeated attempts and optimization operations such as deleting paths, a SEM validation model was formed. The overall KAB model of health education in universities was ultimately obtained. Although the chi-square to degrees of freedom ratio is relatively large ($\chi^2/df = 19.853$), this may stem from the large sample size ($N = 4,508$). However, other fit indices performed excellently (GFI = 0.972, AGFI = 0.947, CFI = 0.982, RMSEA = 0.065), indicating that the overall fit of the model to the data is actually acceptable. The model validation results support the core hypothesis of KAB theory (Table 5).

TABLE 5 Evaluation of the measurement model.

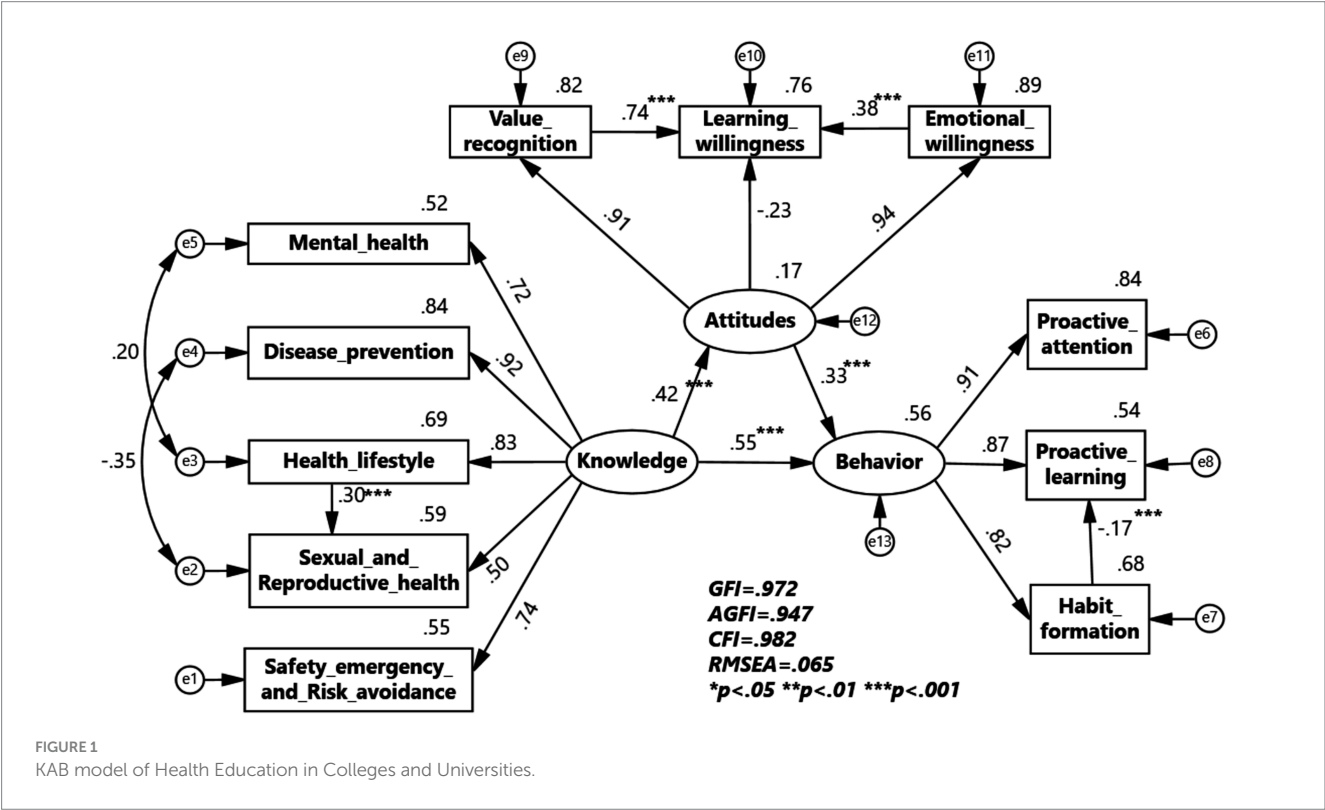
Model fit	GFI	AGFI	CFI	RMSEA	χ^2/df
Criteria	> 0.90 (acceptable)	> 0.90 (acceptable)	> 0.90 (acceptable)	< 0.08 (acceptable)	–
	> 0.95 (excellent)	> 0.95 (excellent)	> 0.95 (excellent)	< 0.05 (excellent)	
Model Results	0.972	0.947	0.982	0.065	19.853
Evaluation	Excellent	Acceptable	Excellent	Acceptable	–

Additionally, the output results of the specific SEM are presented in Table 6. the path coefficients indicate that the relationship from college students' health knowledge to health attitudes shows a positive causal relationship coefficient of 0.42, the relationship from health attitudes to health behaviors has a positive causal relationship coefficient of 0.33, and the relationship from health knowledge to health behaviors has a positive causal relationship coefficient of 0.55, all reaching statistically significant levels. This shows that health knowledge not only directly affects health behaviors but also helps improve them by boosting health attitudes. Furthermore, the link between a healthy lifestyle and sexual health has a positive effect of 0.30, indicating that acquiring knowledge about healthy lifestyles can influence knowledge about sexual and reproductive health. In health attitudes, the relationship between health value and learning willingness shows a strong positive causal relationship of 0.74, and the relationship between emotional willingness and learning willingness shows a positive causal relationship of 0.38. This indicates that the values and emotional perspectives regarding health education influence the willingness to learn health education. Notably, in health behaviors, the relationship between habit formation and proactive learning shows a weak negative causal relationship of 0.17, suggesting that once health education behaviors become habitual, they may affect proactive learning behaviors (Figure 1).

TABLE 6 Standardized regression weights.

Path		Standardized estimate	Unstandardized estimate	S.E.	C.R.	p
Knowledge	→ Health lifestyle	0.829	0.883	0.016	55.313	***
Knowledge	→ Disease prevention	0.919	1.197	0.020	59.995	***
Knowledge	→ Mental health	0.719	0.924	0.019	48.069	***
Knowledge	→ Sexual and reproductive health	0.496	0.460	0.028	16.180	***
Knowledge	→ Safety emergency and risk avoidance	0.739	1.000			
Health lifestyle	→ Sexual and reproductive health	0.303	0.264	0.024	11.150	***
Knowledge	→ Attitudes	0.415	0.379	0.015	25.156	***
Knowledge	→ Behavior	0.551	0.621	0.018	35.017	***
Attitudes	→ Emotional willingness	0.942	1.144	0.019	60.346	***
Attitudes	→ Learning willingness	−0.233	−0.226	0.157	−1.439	0.150
Attitudes	→ Value recognition	0.905	1.000			
Attitudes	→ Behavior	0.326	0.402	0.017	24.063	***
Value recognition	→ Learning willingness	0.742	0.654	0.055	11.884	***
Emotional willingness	→ Learning willingness	0.384	0.307	0.082	3.735	***
Behavior	→ Habit formation	0.823	0.829	0.013	63.178	***
Behavior	→ Proactive attention	0.914	1.000			
Behavior	→ Proactive learning	0.869	0.987	0.038	26.168	***
Proactive learning	→ Proactive learning	−0.169	−0.191	0.033	−5.821	***

****p* < 0.001 (highly significant).



To verify the universality of the KAB model of health education in colleges across different samples, multi-group structural equation model validation analyses were conducted for gender and major of study grouping. The multi-group structural equation model for the gender group shows that health knowledge has a greater impact on health attitudes and health behaviors in the male group, while health attitudes have a greater impact on health behaviors in the female group. The impact coefficient of healthy lifestyle on sexual and reproductive health is 0.37 for males, greater than 0.51 for females, indicating a larger impact in the male group. The impact coefficient of value recognition on learning willingness is 0.65 for males and 0.77 for females, indicating a greater impact in the female group. The impact coefficient of emotional willingness on learning willingness is 0.44 for males and 0.77 for females, indicating a greater impact in the female group. The impact coefficient of habit formation on proactive learning is -0.13 for physical education students and -0.16 for non-physical education students, indicating a larger impact in the non-physical education group (Figures 4, 5).

Through comparison with the hypothesized model, the multi-group validation analysis for the gender group shows that in the validation of six models constrained by Measurement weights, Measurement intercepts, Structural weights, Structural covariances, Structural residuals, and Measurement residuals, the values of NFI (Normed Fit Index), IFI (Incremental Fit Index), RFI (Relative Fit Index), and TLI (Tucker–Lewis Index) are all less than 0.05, proving that the constructed model has confirmatory validity across different gender variable samples (Table 7).

The multi-group structural equation model for the professional grouping shows that health knowledge has a greater impact on health attitudes and health behaviors in the physical education group, while in the non-physical education group, health knowledge has a greater

impact on health behaviors, with health attitudes having the same level of impact on health behaviors. The impact coefficient of healthy lifestyle on sexual and reproductive health is 0.04 for physical education students, which is less than 0.47 for non-physical education students, indicating a larger impact in the non-physical education group. The impact coefficient of value recognition on learning willingness is 0.32 for physical education students and 0.77 for non-physical education students, indicating a greater impact in the non-physical education group. The impact coefficient of emotional willingness on learning willingness is 0.46 for physical education students and 0.30 for non-physical education students, indicating a larger impact in the physical education group. The impact coefficient of habit formation on proactive learning is -0.13 for physical education students and -0.16 for non-physical education students, indicating a larger impact in the non-physical education group (Figures 4, 5).

Through comparison with the hypothesized model, the multi-group validation analysis for the professional grouping shows that in the validation of six models constrained by Measurement weights, Measurement intercepts, Structural weights, Structural covariances, Structural residuals, and Measurement residuals, the values of NFI, IFI, RFI, and TLI are all less than 0.05, proving that the constructed model has confirmatory validity across different professional variable samples (Table 8).

4 Discussion

This study systematically reveals the complex associations and group heterogeneity of the knowledge-attitude-behavior (KAB) model

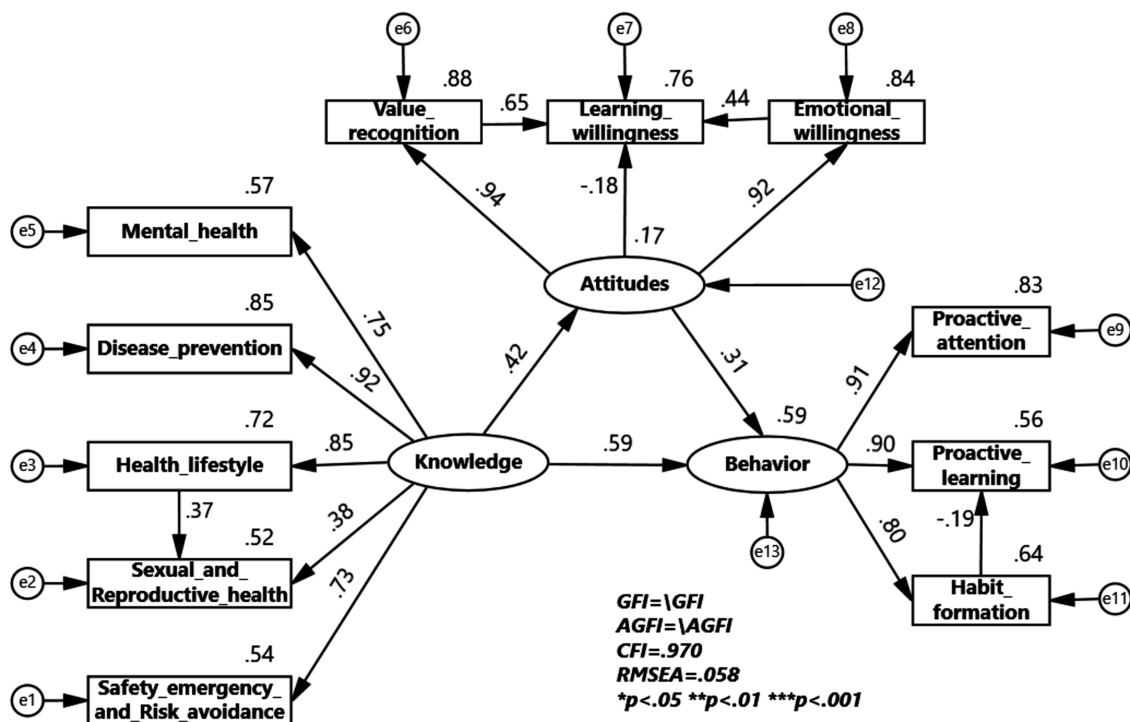


FIGURE 2
KAB model for Health Education Program among male.

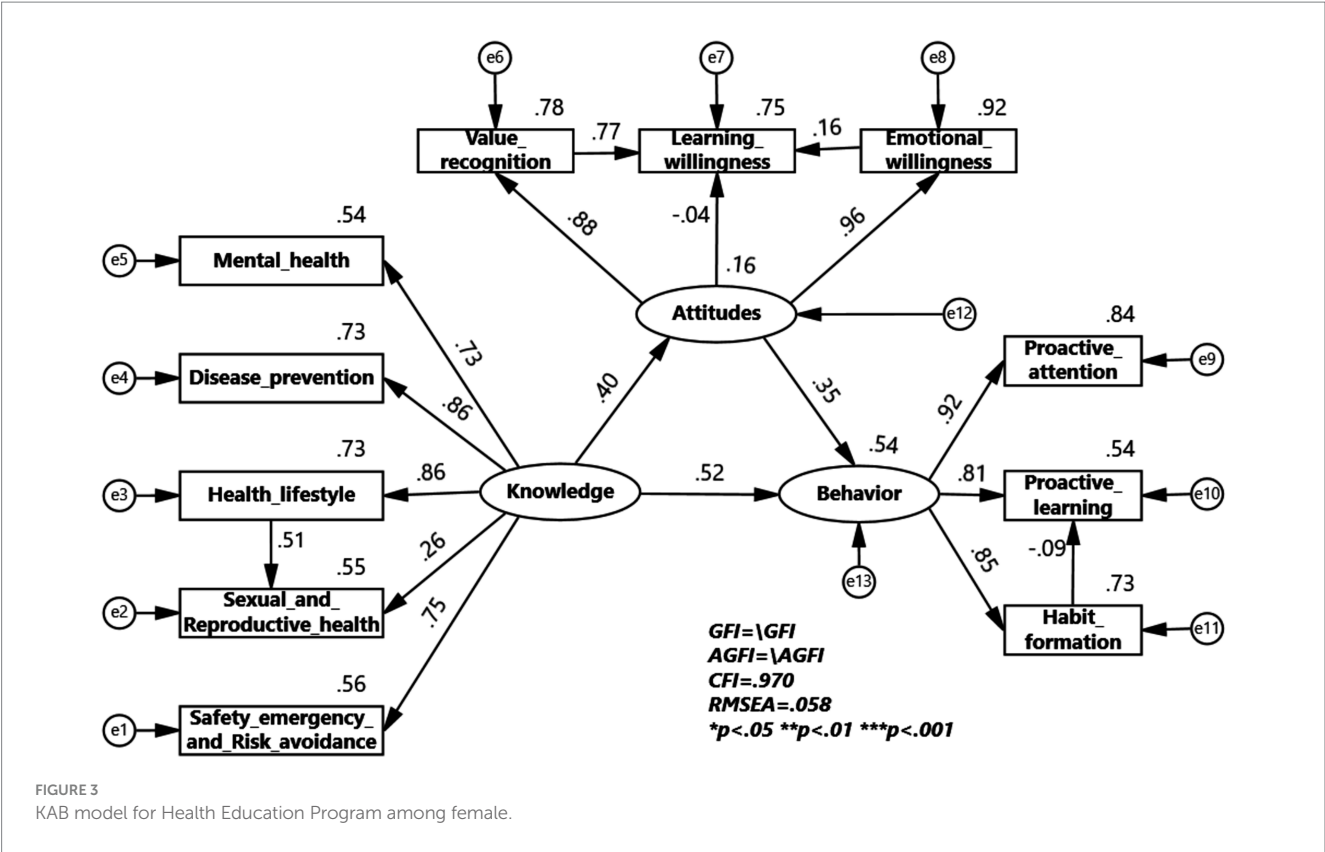


TABLE 7 Gender group validation analysis of gender categories.

Model	DF	CMIN	p	NFI delta-1	IFI delta-2	RFI rho-1	TLI rho2
Measurement weights	8	110.470	0.000	0.003	0.003	−0.001	−0.001
Measurement intercepts	19	460.862	0.000	0.013	0.013	0.005	0.005
Structural weights	26	594.588	0.000	0.016	0.016	0.005	0.005
Structural covariances	27	669.341	0.000	0.018	0.018	0.007	0.007
Structural residuals	29	641.317	0.000	0.017	0.017	0.005	0.005
Measurement residuals	40	846.498	0.000	0.023	0.023	0.005	0.005

in college health education. The results indicate that students in physical education majors exhibit comprehensive KAB advantages, with a significantly higher awareness rate of health knowledge (e.g., 15.7% higher in disease prevention compared to non-physical education majors) and a significantly higher formation rate of health behaviors (e.g., proactive learning reaching 93.1%), confirming the synergistic effect of integrating health education with professional courses. This finding aligns with Traoré et al.'s observations in schistosomiasis prevention and control, where targeted health training significantly improved the KAB levels of the target population (from 74.9% to 88.1% compliance) (24). However, the KAB shortcomings of non-physical education students (e.g., only 57.5% awareness of antibiotic dangers) highlight the structural deficiencies in current general health education, echoing Zhu et al.'s findings on low-education groups in chronic disease KAB studies (25).

In the gender dimension, this study observed a significant “cognitive-attitude inversion”: males excel in knowledge of healthy

lifestyles (e.g., K₁ awareness rate of 84.6% vs. female 78.6%) and knowledge of disease prevention and sexual assault defense (K₁₃ male 93.6% vs. female 88.1%), while females are more proactive in health learning attitudes (e.g., A₄ recognition of the importance of health knowledge at 99.3% vs. male 96.9%). This suggests that male college students generally have a better understanding of physical fitness and smoking than their female counterparts, which might be because males usually show more interest in sports and fitness in their daily lives (26). Regarding the dangers of smoking, research indicates that males perceive smoking as “masculine,” and the smoking rate among male college students is significantly higher than that of females (27–29). The apparent paradox of higher knowledge coinciding with higher smoking prevalence among males is resolvable within the integrated KAB-SEM framework. The significant K → B path indicates that knowledge is a potent antecedent, likely by elevating perceived threat (11). However, its effect on the ultimate behavior is likely suppressed by countervailing forces. For males, strong

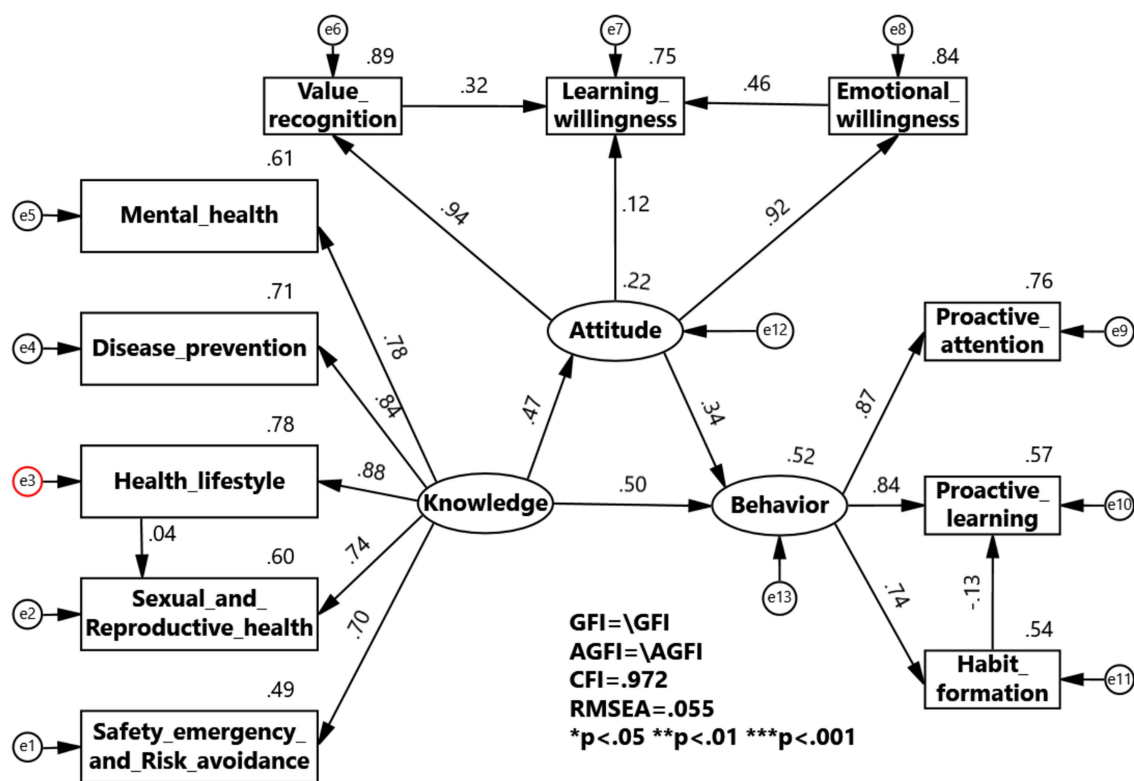


FIGURE 4
KAB model for Health Education Program among physical education.

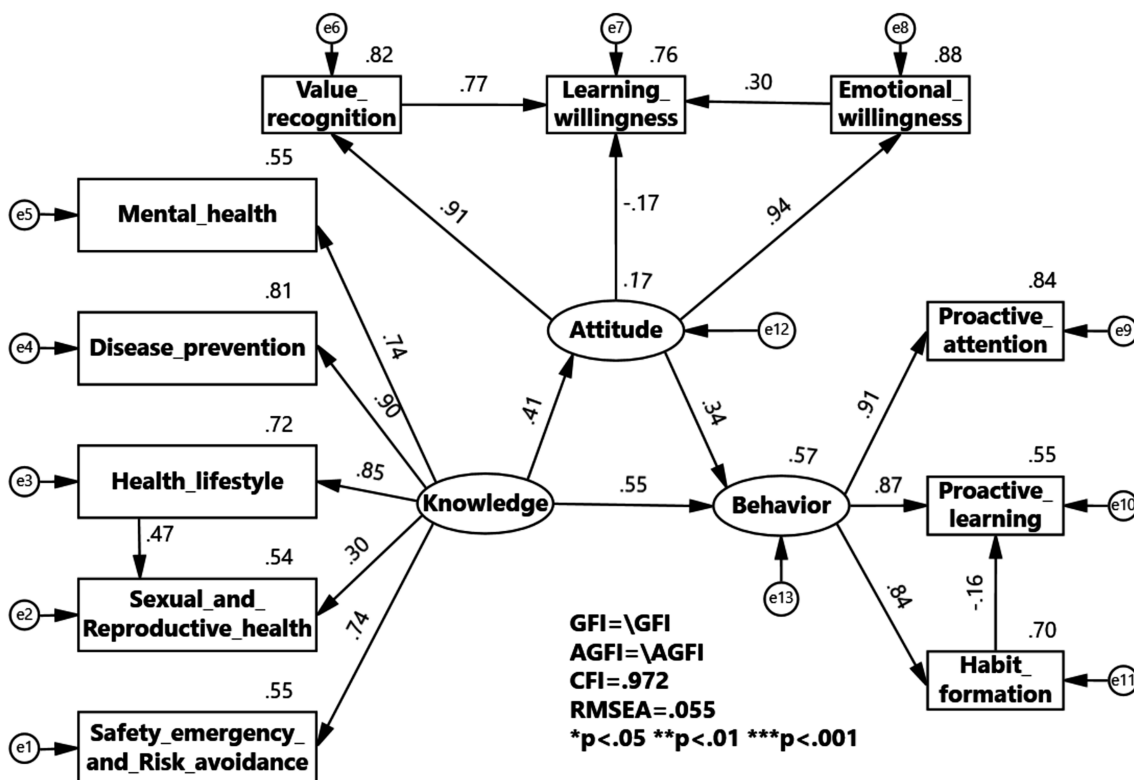


FIGURE 5
KAB model for Health Education Program among non-physical education.

TABLE 8 Gender group validation analysis of gender categories.

Model	DF	CMIN	p	NFI delta-1	IFI delta-2	RFI rho-1	TLI rho2
Measurement weights	8	94.061	0.000	0.003	0.003	−0.001	−0.001
Measurement intercepts	19	428.308	0.000	0.012	0.012	0.005	0.005
Structural weights	26	600.872	0.000	0.016	0.016	0.006	0.006
Structural covariances	27	601.601	0.000	0.016	0.016	0.006	0.006
Structural residuals	29	624.873	0.000	0.017	0.017	0.006	0.006
Measurement residuals	40	681.994	0.000	0.019	0.019	0.002	0.002

subjective norms that link smoking to masculine identity and positive social prototypes may override reasoned intentions (30, 31). Furthermore, a gender-inclined optimistic bias, potentially exacerbated by high knowledge, may lead to a discounting of personal susceptibility (12). This suggests that for young males, smoking initiation and maintenance may be less a failure of knowledge and more a function of social reactivity and perceived invulnerability. Future interventions should therefore target these gendered normative perceptions and cognitive biases rather than focusing solely on knowledge dissemination. This contradiction partly stems from differences in risk exposure, with higher smoking rates and exercise participation among males, but it is crucial to note the relative lack of defense knowledge among high-risk female groups (32). Particularly concerning is the phenomenon where males surpass females in knowledge of sexual assault prevention, challenging the conclusion from oral health KAB studies that “females generally pay more attention to health,” exposing gaps in current sexual education that do not accurately cover high-risk populations. This shortcoming needs to draw on China’s experience in HIV prevention and control, through sustained policy investment and health education (e.g., this study found an HIV awareness rate of 98%) to specifically strengthen these areas (24). Since the first report of AIDS cases in China in 1985, the central government has required all regions and departments to carefully study and formulate prevention and control plans, clarify relevant policies, conduct health education, implement prevention and control measures, and strengthen patient treatment (33).

The structural equation model further reveals a dual-pathway for KAB transformation: health knowledge not only directly drives behavior ($\beta = 0.55$) but also indirectly influences it through attitudes (knowledge $\rightarrow$ attitude $\beta = 0.42$, attitude $\rightarrow$ behavior $\beta = 0.33$), confirming the chain effect of health education. However, caution is warranted regarding the negative pathway of “habit formation inhibiting proactive learning” ($\beta = -0.17$), indicating that behavior solidification may weaken the willingness to explore. This phenomenon resonates with findings in digital health tool research, where individuals with high eHealth literacy rely more on preset information and reduce proactive learning (34). Notably, the knowledge integration effectiveness of physical education students (e.g., the path coefficient of healthy lifestyle promoting sexual health cognition at 0.30) validates the value of modular education, but this group is weaker in attitude-driven behavior (value recognition $\rightarrow$ learning willingness $\beta = 0.32$) compared to non-physical education students ($\beta = 0.77$), suggesting that mere knowledge transmission is insufficient for sustaining long-term behavior change.

The limitations of this study require careful consideration: (1) using just one regional sample makes it hard to apply these findings to

other groups; (2) people might have answered the questionnaires in a way they thought looked good, such as the reported rate of safety emergency knowledge (71.7%) potentially being higher than actual (35); (3) confounding factors such as family health literacy were not controlled. Future research should look at how the KAB scale was developed for newborn hearing screening in South Africa to validate the robustness of the KAB model across multi-center samples (36); simultaneously, combining health behavior tracking technologies (e.g., wearable devices) to keep track of how habits and learning affect each other will provide empirical support for overcoming behavioral inertia. Practically, a “three-dimensional intervention system” should be constructed: targeting knowledge gaps through specialized courses in high-risk areas (e.g., antibiotic resistance simulation experiments), utilizing AI health partners to optimize accessibility of consultations for the internet generation, and designing gamified challenge tasks to reverse negative pathways of habits. Only through deep integration of cognitive reinforcement, technological empowerment, and behavioral activation can the gap between knowledge and action in college health education be bridged.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by This study involving human participants was approved by the Ethics Committee of Yangzhou University Medical College (Approval Number: YXYLL-2023-159). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

YZ: Funding acquisition, Conceptualization, Writing – original draft, Supervision, Project administration, Data curation, Methodology, Formal analysis. YG: Supervision, Writing – review & editing, Project administration, Validation. ZC: Writing – review & editing, Validation. HG: Funding acquisition, Writing – review & editing, Supervision.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

References

1. WHO. Promoting health through schools. Report of a WHO expert committee on comprehensive school health education and promotion. *World Health Organ Tech Rep Ser.* (1997) 870:i–vi.
2. Szucs LE, Barrios LC, Young E, Robin L, Hunt P, Jayne PE. The CDC's division of adolescent and school health approach to sexual health education in schools: 3 decades in review. *J Sch Health.* (2022) 92:223–34. doi: 10.1111/josh.13115
3. Central Committee of the Communist Party of the People's Republic of China, State Council of the People's Republic of China have released the “Healthy China 2030” planning framework In: Gazette of the State Council of the People's Republic of China (2016). 5–20.
4. Öztürk F, Doğan E, Gedikbaşan E, Yılmaz HY. The effect of structured health promotion education given to adolescents on health literacy and health-promoting behaviors. *J Pediatr Nurs.* (2023) 73:e579–85. doi: 10.1016/j.pedn.2023.10.036
5. Education Ministry. Notice from the Education Ministry on the release of Health Education Guidelines for Colleges and Universities In: Gazette of the State Council of the People's Republic of China. Beijing: China's Ministry of Education, (2017). 92–5.
6. Bay JL, Vickers MH, Mora HA, Sloboda DM, Morton SM. Adolescents as agents of healthful change through scientific literacy development: a school-university partnership program in New Zealand. *Int J STEM Educ.* (2017) 4:15. doi: 10.1186/s40594-017-0077-0
7. Grosser J, Bientzle M, Shiozawa T, Hirt B, Kimmerle J. Observing Interprofessional collaboration: impact on attitude and knowledge acquisition. *Anat Sci Educ.* (2021) 14:452–9. doi: 10.1002/ase.2007
8. Ministry of Health, Labour, Welfare Health education: philosophy and methods of health education 2020. Available online at: <https://www.mhlw.go.jp/bunya/shakaihoshou/iryouseido01/pdf/info03k-05.pdf> (Accessed December 30, 2020)
9. Wang K, Qian J, Yang J, Ge T, Li Z. The mediating roles of demand and satisfaction in formation process of physical exercise habits among college students. *Sci Rep.* (2022) 12:1563. doi: 10.1038/s41598-022-05602-3
10. Guo W, Wen H, Liu X. Research on the psychologically restorative effects of campus common spaces from the perspective of health. *Front Public Health.* (2023) 11:1131180. doi: 10.3389/fpubh.2023.1131180
11. Saghafi-Asl M, Aliasgharzadeh S, Asghari-Jafarabadi M. Factors influencing weight management behavior among college students: an application of the health belief model. *PLoS One.* (2020) 15:e0228058. doi: 10.1371/journal.pone.0228058
12. Golder J, Jerge M, Sundstrom B, Dziobak M, Hart LB. Factors influencing CDC-recommended preventative behaviors through the COVID-19 pandemic in college students. *J Am Coll Heal.* (2025) 73:1631–9. doi: 10.1080/07448481.2024.2346340
13. Japan Shahlpco. Health education promotion committee report: results of the second national survey. Tokyo: Japan School Health Association (2012).
14. Zhao Y, Saito K, Yamadaira Y. Survey on health knowledge and awareness among junior high school students in Anhui province, China. *Japanese Journal of School Health Education.* (2020) 5:42–50.
15. Statistics JPBo. Statistical bulletin on National Economic and social development of Jiangsu Province in 2024 2025. Available online at: http://tj.jiangsu.gov.cn/art/2025/3/15/art_85764_11514117.html (Accessed March 15, 2025)

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16. Central Committee of the Communist Party of the People's Republic of China, State Council of the People's Republic of China. Gazette of the State Council of the People's Republic of China. Beijing: News Agency (2019) (35):10–34.
17. Guo Y, Jiang X, Zhu Y, Zhang H. Measurement and spatial correlation analysis of high-quality development level: a case study of the Yangtze River Delta urban agglomeration in China. *Heliyon.* (2024) 10:e29209. doi: 10.1016/j.heliyon.2024.e29209
18. Zhao Y. Research on the knowledge, attitude and behavior of physical education teachers in junior high schools in Anhui province, China. *J Graduate Sch Hum Soc Sci.* (2021) 2:512–8. doi: 10.15027/51663
19. Oshio S. 3rd edition of psychological and survey data analysis by SPSS and Amos. Tokyo: Tokyo book company (2021).
20. Yoda M, Seimiya T, Kitamura K Comparing doping awareness among sports majors: a focus on Japan and South Korea Exploring the Science Behind Physical Activity and Sports Science (2018) 24 1–8
21. Jucui W. (ed.). A study on ways to boost emergency preparedness and risk management skills among college students through physical education. *Tech News.* (2020) 18:102–3. doi: 10.16661/j.cnki.1672-3791.2020.16.102
22. Taha SA, Matheson K, Anisman H. The 2009 H1N1 influenza pandemic: the role of threat, coping, and media trust on vaccination intentions in Canada. *J Health Commun.* (2013) 18:278–90. doi: 10.1080/10810730.2012.727960
23. Mahesh S, Hemalata K, Gupta A. Factors affecting psychological well-being, depression, anxiety, and stress among dental students in Delhi and the National Capital Region: a cross-sectional study. *Cureus.* (2024) 16:e70474. doi: 10.7759/cureus.70474
24. Feng J, Wang X, Zhang X, Hu H, Xue J, Cao C, et al. Effect of health education on schistosomiasis control knowledge, attitude, and practice after schistosomiasis blocking: results of a longitudinal observational study in the field. *Trop Med Infect Dis.* (2023) 8:267. doi: 10.3390/tropicalmed8050267
25. Zhang ZB, Xue ZX, Ma MM, Li YH, Luo DM, Song XL. Knowledge, attitude and practice to chronic diseases and associated influencing factors in Uygur population in Kashgar area of Xinjiang Uygur autonomous region. *Zhonghua Liu Xing Bing Xue Za Zhi.* (2017) 38:715–20. doi: 10.3760/cma.j.issn.0254-6450.2017.06.005
26. Niu M, Dong M, Shi P, Choi Y, Li N. The relationship between social support and college students' physical activity participation in China: the mediating effect of self-efficacy. *Front Psychol.* (2025) 16:1596841. doi: 10.3389/fpsyg.2025.1596841
27. Gilani SI, Leon DA. Prevalence and sociodemographic determinants of tobacco use among adults in Pakistan: findings of a nationwide survey conducted in 2012. *Popul Health Metrics.* (2013) 11:16. doi: 10.1186/1478-7954-11-16
28. Zheng Y, Shirui L, Hui L, Qinghan L, Na Y, Wei W. Exploring what influences college students' smoking habits in Jiangsu Province. *J Soc Med China.* (2020) 40:595–9.
29. Nasser AMA, Zhang X. Knowledge and factors related to smoking among university students at Hodeidah university, Yemen. *Tob Induc Dis.* (2019) 17:42. doi: 10.18332/tid/109227
30. Hansstein FV, Echegaray F. Exploring motivations behind pollution-mask use in a sample of young adults in urban China. *Glob Health.* (2018) 14:122. doi: 10.1186/s12992-018-0441-y

31. Ruhl H, Holub SC, Dolan EA. The reasoned/reactive model: a new approach to examining eating decisions among female college dieters and nondieters. *Eat Behav.* (2016) 23:33–40. doi: 10.1016/j.eatbeh.2016.07.011
32. De-Rong H, Yi-Xin H, Yao-Bao L, Xu Z, Yi-Qing X, Wei-Gang Y, et al. Survey of schistosomiasis KAP and influencing factors of behaviors among residents in Jiangsu Province. *Chin J Schistosomiasis Control.* (2017) 29:574–8. doi: 10.16250/j.32.1374.2017016
33. China SCo. Notice by the state council on strengthening AIDS prevention and control efforts. (2004)
34. Yumiya Y, Ohba T, Murakami M, Nakano H, Nollet KE, Goto A. User-guided Design of a Digital Tool for health promotion and radiation protection: results from an internet needs survey. *Int J Environ Res Public Health.* (2021) 18:12007. doi: 10.3390/ijerph182212007
35. Yang X, Qin Q, Wang Y, Ma Z, Li Q, Zhang F. Knowledge, attitudes, and practices regarding cardiovascular disease prevention among middle school students in China: a cross-sectional study. *Front Public Health.* (2024) 12:1301829. doi: 10.3389/fpubh.2024.1301829
36. Graham C, Gina A, Seeley J, Saman Y. Development of a questionnaire to assess mothers' knowledge, attitudes and practice with regard to childhood hearing loss and universal newborn hearing screening. *Int J Pediatr Otorhinolaryngol.* (2023) 165:111449. doi: 10.1016/j.ijporl.2023.111449



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Influencing factors of physical exercise behavior among Chinese female university students: a configurational analysis based on fsQCA

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Objective: This study investigates how combinations of factors lead to high physical activity levels among Chinese female university students.

Methods: Grounded in Social Cognitive Theory (SCT), we developed an “Individual-Behavior-Environment” triadic reciprocity framework. Using fuzzy-set Qualitative Comparative Analysis (fsQCA), we performed a configurational analysis of physical activity behaviors among 115 Chinese female university students. The study assessed six antecedent conditions across three dimensions: capability cognition (exercise self-efficacy, perceived value of exercise), motivational drive (exercise motivation, subjective exercise experience), and environmental interaction (friend support, social anxiety).

Results: None of the six individual conditions were necessary for high physical activity behavior. Instead, high activity levels emerged from synergistic interactions among multiple conditions. We identified eight distinct equifinal configurations leading to high physical activity, with an overall solution consistency of 0.888 and coverage of 0.722, indicating strong model robustness. These configurations formed four typical driving modes: Immersive Enjoyment, Autonomous Drive, Dual Core Reinforcement, and Efficacy Anxiety Compensation.

Conclusion: This study confirms the characteristics of “multiple conjunctural causation” and “causal asymmetry” in forming physical activity behaviors among Chinese female university students. It extends SCT by revealing complex compensatory and substitutive mechanisms among factors, moving beyond traditional linear models. The findings offer a novel configurational perspective for understanding this population’s physical activity behaviors and provide crucial evidence for designing targeted health behavior interventions.

KEYWORDS

Chinese female university students, physical activity behavior, influencing factors, fsQCA, configurational analysis

1 Introduction

Physical exercise represents a cornerstone of comprehensive health interventions. The World Health Organization’s Guidelines on Physical Activity and Sedentary Behavior assert that regular physical activity not only improves cardiopulmonary function and metabolic health but also reduces anxiety and depression symptoms, thereby enhancing overall quality of life (1). However, global physical activity participation remains inadequate. Large-scale

multinational studies indicate that in 2022, approximately 1.8 billion adults (31.3%) worldwide were insufficiently active (2). This inactivity shows significant gender disparities, with women's prevalence (33.8%) exceeding men's (28.7%) by 5.1 percentage points—a gap that has widened persistently over two decades (2).

Data from China's General Administration of Sport indicate that 37.2% of Chinese people regularly exercised in 2022, remaining substantially below the 2035 target of 45%. Although 55.9% of children and adolescents participate regularly, this rate declines with age (3). Female university students exhibit particularly concerning patterns, with consistently lower participation rates than male students (4). This disparity stems from multiple intersecting barriers specific to this group (5–7). Consequently, the “Healthy China 2030” blueprint identifies women as a key target for physical activity promotion (8).

The university years constitute a critical period for establishing lasting health behaviors. Therefore, understanding the complex causation of physical exercise behavior among female university students carries urgent practical significance. Such understanding is vital for stimulating intrinsic motivation, establishing lifelong activity habits, improving health outcomes, and reducing gender health disparities. Furthermore, it aligns with the educational goals of university physical education and supports the national fitness strategy and population health objectives.

Recent research has significantly advanced our understanding of factors influencing female university students' physical exercise behavior, examining variables including exercise self-efficacy (9), gender roles (10), motivation (11), and social support (12, 13). However, most studies depend on traditional linear models that isolate “net effects” of individual variables, thereby limiting insights into how multiple conditions interact non-linearly to shape behavior (14). Specifically, linear approaches face two key limitations: First, they struggle to explain causal complexity—particularly whether factors substitute, complement, or reinforce each other. Second, they inadequately address causal equifinality—whereby students with different characteristics achieve similar activity levels through different factor combinations. These methodological constraints hinder deeper mechanistic understanding and consequently limit development of precisely targeted interventions.

Social cognitive theory provides an appropriate framework for this study by emphasizing dynamic, bidirectional interactions among cognition, motivation, and environment—closely aligning with our focus on multifactorial interaction mechanisms. To overcome linear methodological limitations and capture the complex interactions central to SCT, this study employs fsQCA. We develop an “Individual-Behavior-Environment” triadic reciprocity framework to address these core questions: What combinations of personal cognition, motivational drive, and environmental factors produce high physical exercise behavior among Chinese female university students? Can effective configurations be categorized into typical driving patterns? What complementary, substitutive, or transformative mechanisms do these patterns reveal?

2 Theoretical perspective and analytical framework

2.1 Social cognitive theory (SCT)

Social cognitive theory, developed by Bandura (15), centers on the model of Triadic Reciprocal Determinism. This framework posits that

the relationships between the individual (P), behavior (B), and environment (E) form a dynamic, interactive system, rejecting linear causality.

The Individual (P) represents an active agent whose internal cognitions, beliefs, affective states, and physiological characteristics shape behaviors. Behavior (B) encompasses observable actions, including their frequency, intensity, and persistence, reflecting the tangible outcome of individual-environment interactions.

The Environment (E) includes not only physical settings but also social contexts—such as social models, norms, and cultural milieus—that provide conditions, constraints, and opportunities for behavior.

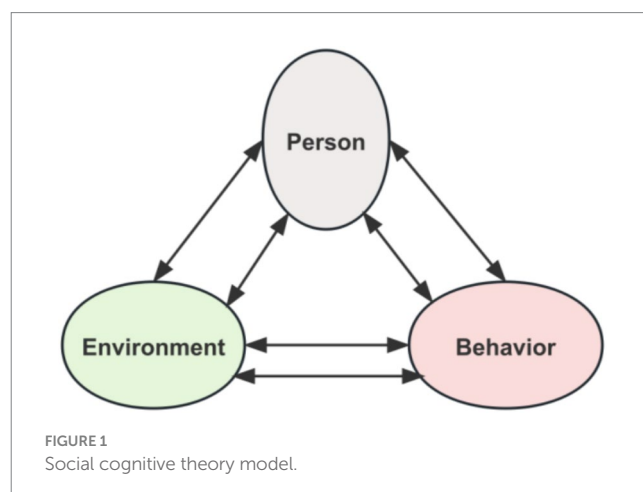
Interactions among these elements occur through three bidirectional pathways:

- 1 P and B: Individual cognitions shape behavior ($P \rightarrow B$), while behavioral outcomes, in turn, influence beliefs and affective states ($B \rightarrow P$).
- 2 P and E: Personal characteristics elicit and shape relevant social environments ($P \rightarrow E$), while environmental feedback modifies individual cognitions and attitudes ($E \rightarrow P$).
- 3 B and E: Behavior can alter the environment ($B \rightarrow E$), and the environment, in turn, constrains or facilitates behavioral expression ($E \rightarrow B$) (Figure 1).

The triadic reciprocal determinism model of SCT effectively explains the initiation and maintenance of physical exercise behavior among female university students. Specifically, physical exercise behavior (B) results from interactions between individual factors (P) (e.g., exercise self-efficacy) and environmental factors (E) (e.g., friend support). SCT's emphasis on dynamic interactions offers a robust theoretical foundation for understanding the formation of this behavior and provides a methodological basis for examining interactive and compensatory effects among influencing factors.

2.2 Analytical framework

Guided by SCT's triadic reciprocal determinism model, we constructed an analytical framework for female university students' physical exercise behavior (Figure 2). First, the framework incorporated the three core SCT dimensions: individual (P), behavior



(B), and environment (E), with physical exercise behavior (B) serving as the outcome variable.

We then conducted a systematic literature review to identify relevant condition variables. Using keywords such as “female university students,” “physical exercise,” and “influencing factors,” we searched CNKI, Web of Science, and PubMed, identifying 163 empirical studies published between 2010 and 2025. Inclusion criteria were: (1) focus on Chinese female university students or valid subgroup analyses of this population; (2) examination of factors influencing physical exercise behavior; (3) relevance of condition variables to SCT constructs; and (4) variable occurrence frequency exceeding 50% of retrieved literature (>81 instances) (Table 1).

Following SCT’s core concepts, we selected specific condition variables for each dimension. For the individual (P) dimension, we chose variables representing “capability cognition” (ESE and PVE) and “motivational drive” (EM and SEE). For the environment (E) dimension, we selected FS and SA. These, together with physical exercise behavior as the outcome variable, constitute the analytical framework (Figure 2).

It is important to note that the selected condition variables—particularly those within the individual (P) dimension (ESE, PVE, EM, and SEE)—are theoretically interrelated (e.g., high self-efficacy typically enhances intrinsic motivation). This conceptual overlap is not a limitation but a key strength of the fsQCA approach. FsQCA specifically aims to decipher how theoretically related conditions combine in different configurations to produce equivalent outcomes.

These potential overlaps and synergistic effects are central to configurational analysis, embodying the principles of “conjunctural causation” and “multiple pathways.”

3 Research method and design

3.1 Research method

FsQCA is a methodological approach tailored for small-to-medium sample sizes, integrating both qualitative and quantitative analytical logic. Focusing on the concept of “configurations,” it investigates how combinations of conditions jointly produce specific outcomes, making it particularly suitable for analyzing causal complexity and asymmetric relationships in social phenomena (16). A central objective of fsQCA is to identify multiple equifinal paths—distinct configurations of conditions that lead to the same outcome—where the role of any single condition is interpreted in the context of its interactions with others. We therefore employed fsQCA to analyze the antecedent conditions associated with high levels of physical exercise behavior among female university students. This approach enables the identification of distinct equifinal pathways, overcoming limitations of single-variable analyses and providing micro-level empirical evidence to inform targeted physical activity promotion strategies for this population.

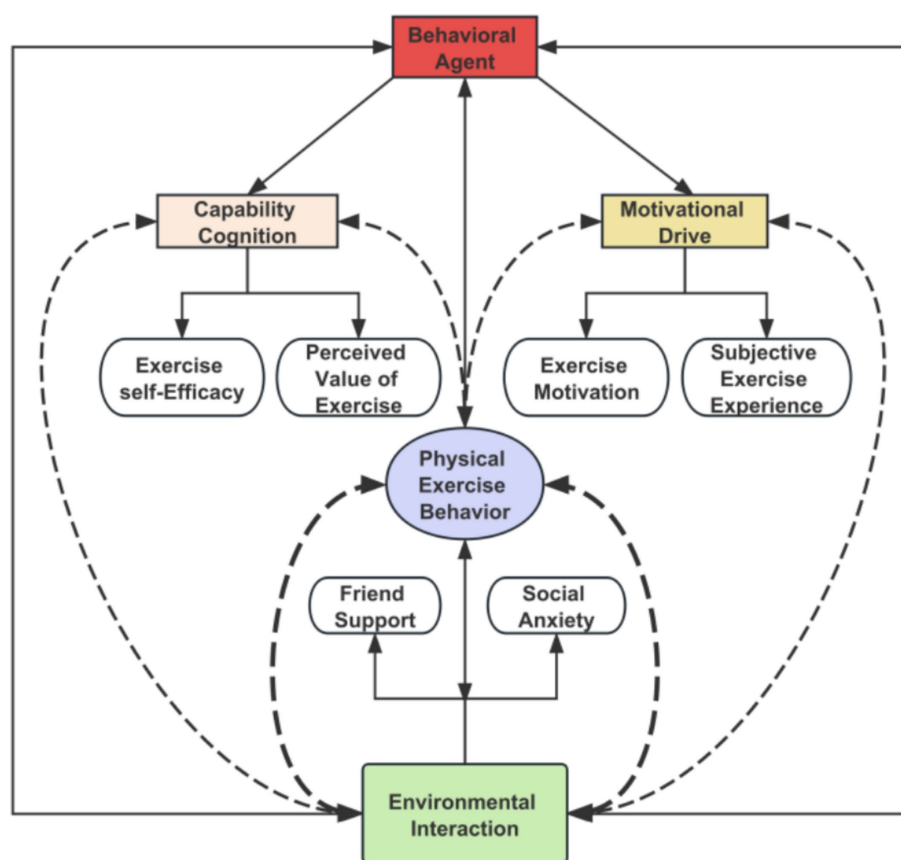


FIGURE 2

Analytical framework of female university students' physical exercise behavior from a triadic interaction perspective.

TABLE 1 Frequency of selected condition variables.

Rank	Variable	Frequency
1	Exercise self-Efficacy ESE	130
2	Subjective Exercise Experience SEE	121
3	Perceived Value of Exercise PVE	108
4	Exercise Motivation EM	103
5	Friend Support FS	98
6	Social Anxiety SA	88
7	Exercise Climate EC	74
8	Self-Esteem SE	43

3.2 Variable measurement

This study employed an analytical framework consisting of one outcome variable and six condition variables, each measured as follows:

1 Physical exercise behavior (PB)

PB was assessed using the Physical Activity Rating Scale (PARS-3) revised by Liang Deqing (17). This instrument measures exercise volume across three dimensions: intensity, duration, and frequency. Intensity and duration items use a 5-point Likert scale (1–5), while frequency is also rated 1–5. Total exercise volume was calculated as: Intensity $\times$ (Duration – 1) $\times$ Frequency. The scale showed good internal consistency (Cronbach's $\alpha = 0.801$).

2 Capability perception dimension

Exercise Self-Efficacy (ESE) was measured using the 10-item scale developed by Kroll et al. (18). Items are rated on a 4-point Likert scale (1 = “completely incorrect” to 4 = “completely correct”), with total scores ranging from 10 to 40. Higher scores indicate stronger self-efficacy. The scale demonstrated good reliability ($\alpha = 0.858$).

Perceived Value of Exercise (PVE) was assessed using the 7-item scale developed by Kirk (19) and adapted by Lu Xinling et al. (20). Responses were recorded on a 5-point Likert scale (1 = “disagree” to 5 = “agree”), with total scores ranging from 7 to 35. Higher scores reflect greater perceived exercise value. The scale showed good reliability and cultural adaptability ($\alpha = 0.813$).

3 Motivational drive dimension

Exercise Motivation (EM) was measured using the shortened MPAM-R scale revised by Chen Shanping et al. (21). All items use a 5-point Likert scale (1 = “not at all” to 5 = “very strongly”), with total scores ranging from 12 to 75. Higher scores indicate stronger motivation to persist in exercise. The scale demonstrated good internal consistency ($\alpha = 0.895$).

Subjective Exercise Experience (SEE) was assessed using the scale developed by McAuley and Courneya (22). Items are scored on a 7-point scale (1 = “never” to 7 = “always”), with total scores ranging from 12 to 84. Higher scores reflect more positive subjective

experiences during exercise. The scale exhibited good reliability ($\alpha = 0.866$).

4 Environmental interaction dimension

Friend Support (FS) was measured using the scale developed by Cheng Hui (23). Items are rated on a 5-point Likert scale (1 = “never” to 5 = “always”), with total scores ranging from 5 to 60. Higher scores indicate greater perceived friend support for physical exercise. The scale showed good internal consistency ($\alpha = 0.813$).

Social Anxiety (SA) was assessed using the Interaction Anxiousness Scale developed by Leary and translated by Peng Caizhu (24). The 15-item scale uses a 5-point Likert scale (1 = “strongly disagree” to 5 = “strongly agree”), with total scores ranging from 15 to 75. Higher scores indicate greater social anxiety. The scale demonstrated good reliability ($\alpha = 0.801$).

3.3 Ethical considerations

This study received ethical approval from the Institutional Review Board of Jiangxi Normal University (IRB-JXNU-PEC-2025016) and adhered to the principles of the Declaration of Helsinki. Prior to data collection, researchers explained the study purpose, procedures, voluntary participation, confidentiality measures, and potential minor risks to all potential participants. Written informed consent was obtained after ensuring participants' full understanding and addressing any questions.

The questionnaires were anonymous, and all data were used exclusively for aggregate statistical analysis. No personally identifiable information was collected or disclosed. Throughout data processing and analysis, all data remained anonymized to protect participant privacy.

3.4 Data source

This cross-sectional study recruited non-sports major female students from 12 full-time undergraduate universities across China. Data were collected via structured questionnaires administered in a single session between May 6 and 17, 2025, to investigate factors influencing physical exercise behavior.

Sampling followed established QCA case selection principles, ensuring diversity across geographical regions (North, South, Central, East, West) and all 12 academic disciplines. All participants were non-sports major female students, meeting homogeneity requirements. The selected universities represented specialized institutions with distinct academic profiles, providing typical cases. The final sample was evenly distributed across academic years, with rigorous data checks ensuring case accessibility and analytical validity.

We distributed 140 questionnaires using stratified cluster sampling, all returned on-site. We excluded questionnaires with: (1) over 20% missing items; (2) identical responses for more than 70% of items; (3) standardized Z-scores beyond ± 3 on any dimension. This yielded 115 valid questionnaires, representing an 82.1% valid response rate. Table 2 details the sample composition.

TABLE 2 Demographic profile of the study sample.

Region	Number of universities	Sample size per university	Freshman	Sophomore	Junior	Senior	Total (n)	Majors
Guangdong	4	10	10	10	10	10	40	Philosophy, Economics, Medicine, Agriculture
Hubei	2	15	8	8	7	7	30	Literature, Science
Shandong	2	15	7	7	8	8	30	History, Art
Shanghai	1	10	2	2	3	3	10	Education
Guizhou	1	10	3	3	2	2	10	Management
Liaoning	1	10	2	2	3	3	10	Law
Sichuan	1	10	3	3	2	2	10	Engineering
Total	12	—	35	35	35	35	140	Covering 12 major disciplines

4 Empirical results and analysis

4.1 Variable calibration

FsQCA employs Boolean logic to examine how combinations of independent variables jointly explain an outcome. Prior to analysis, variables require calibration—transforming raw data into fuzzy sets with values ranging from 0 to 1, representing degrees of set membership (25).

Calibration can be performed indirectly, with researchers setting thresholds based on data characteristics and prior literature, or directly, using software functions for automated transformation. We utilized the direct method in fsQCA software version 4.1, following established practice (26) for its superior objectivity and replicability. Informed by both methodological conventions and the specific context of our research, the calibration thresholds were defined as follows: 95% for full membership, 50% for the crossover point, and 5% for full non-membership (27). A detailed presentation of these thresholds is provided in Table 3.

4.2 Analysis of necessary conditions

Necessary condition analysis, assessed through consistency indices, represents a preliminary step in configurational analysis. Following established criteria (28), we considered condition variables necessary only if their consistency exceeded 0.9. As shown in Table 4, none of the individual condition variables—FS, ESE, PVE, EM, SA, or SEE—met this threshold for either high or low PB levels.

This indicates that no single variable is necessary for physical exercise behavior among female university students. Instead, PB emerges from the interactive effects of multiple conditions, warranting further configurational analysis.

4.3 Configurational path analysis

4.3.1 Configurational path results

In fsQCA, a configuration refers to a specific combination of antecedent conditions associated with a particular outcome (29).

Configurational analysis aims to identify sufficient relationships between condition combinations and outcomes, revealing causal pathways. We established thresholds of 0.8 for consistency, 0.7 for PRI consistency, and 1 for case frequency. Using these parameters, we computed complex, intermediate, and parsimonious solutions, identifying eight configurational pathways leading to high PB (Table 5).

The analysis identified eight distinct causal pathways for high PB, with an overall solution consistency of 0.888 and coverage of 0.722. All individual configurations exceeded the 0.8 consistency threshold, demonstrating strong model robustness (30). These eight pathways share common core conditions and can be categorized into four distinct types.

1 Immersive enjoyment type

This type shares high ESE and positive SEE as core conditions, indicating that intrinsic ability beliefs and immediate emotional rewards are sufficient to drive high levels of physical exercise behavior. Beyond this core, different peripheral conditions form two equifinal pathways.

Configuration 1 (ESE•SEE•PVE) demonstrates that when a high PVE acts as a peripheral condition, individuals' rational valuation of exercise—such as recognizing its health benefits—synergizes with efficacy beliefs and affective experience (31). This creates a pathway characterized by high integration of “cognition–affect–value,” where behavior is jointly driven by internalized value recognition and immediate pleasure.

Configuration 2 (ESE•SEE•~EM•~SA) reveals a key insight: even in the absence of explicit EM (~EM), such as specific fitness goals, high exercise behavior can be sustained as long as high ESE and positive SEE are present within a low-social-anxiety (~SA) and permissive environment. This underscores the central role of intrinsic reward mechanisms: confidence in one's ability (“I can do it”) and enjoyment derived from the activity itself (“I enjoy it”) constitute a powerful internal drive. This form of motivation, arising from the activity's inherent interest and sense of mastery, can compensate for the lack of externally oriented goal motivation (32). Simultaneously, the low-anxiety environment ensures that this intrinsic drive remains unhindered by external evaluative pressure.

TABLE 3 Calibration thresholds for condition and outcome variables.

Variable type	Variable name	Full membership	Crossover point	Full non-membership
condition Variables	FS	23.2	17	10.8
	ESE	29	20	12
	PVE	30	25	17
	EM	73.2	53	27
	SA	64.4	47	37.8
	SEE	40	29	17
Outcome	PB	25	18	8

TABLE 4 Necessity analysis of single antecedent conditions.

Condition Variable	High PB		Low PB	
	Consistency	Coverage	Consistency	Coverage
FS	0.74843	0.746635	0.599564	0.566509
~FS	0.565466	0.598545	0.731851	0.733713
ESE	0.768189	0.800021	0.537031	0.529721
~ESE	0.548433	0.555697	0.797261	0.765119
PVE	0.755405	0.794271	0.558376	0.55607
~PVE	0.577793	0.580071	0.793418	0.754441
EM	0.736239	0.781043	0.557911	0.560577
~EM	0.585784	0.583158	0.782084	0.737422
SA	0.634971	0.671598	0.67284	0.674033
~SA	0.69181	0.690652	0.672178	0.635581
SEE	0.70947	0.785918	0.545308	0.572136
~SEE	0.613755	0.587656	0.795956	0.721824

“~” Indicates the absence or low level of the condition.

TABLE 5 Configuration paths for high physical exercise behavior.

Condition Variable	Immersive Enjoyment Type		Autonomous Drive Type		Dual Core Reinforcement Type		Efficacy Anxiety Compensation Type	
	Config 1	Config 2	Config 3	Config 4	Config 5	Config 6	Config 7	Config 8
FS				⊗	●	●	●	●
ESE	●	●	●	●	●	●	●	⊗
PVE	○		○	⊗		⊗		
EM		⊗	●	●		⊗	●	●
SA		⊗	○	⊗	⊗		○	⊗
SEE	●	●			⊗	⊗	●	●
Consistency	0.928657	0.918236	0.950725	0.954543	0.924125	0.923374	0.96476	0.941743
Coverage	0.525423	0.357478	0.422072	0.274123	0.402127	0.344407	0.361558	0.331183
Unique Coverage	0.0676588	0.00846577	0.0127326	0.00524879	0.0249233	0.00966793	0.00270909	0.0491186
Solution Consistency	0.88791							
Solution Coverage	0.722118							

● = core condition present; ⊗ = core condition absent; ○ = peripheral condition present; ⊗ = peripheral condition absent; blank = condition irrelevant.

2 Autonomous drive type

This type is jointly driven by high ESE and high EM, forming an “autonomous engine” centered on clear goals and strong ability beliefs.

This pattern highlights the potential of the intrinsic motivational system to substitute for insufficient external support.

Configuration 3 (ESE•EM•PVE•SA) shows that when individuals possess strong intrinsic drive (high ESE, high EM) and PVE, they can

effectively buffer or even counteract the negative impact of SA. Substantial personal resources provide the psychological resilience needed to cope with negative social evaluations, enabling the maintenance of PB even in high-anxiety situations.

*Configuration 4 (ESE•EM• ~ FS• ~ PVE• ~ SA) offers the most revealing insight: strong ESE and EM can fully compensate for the absence of external support (~FS) and value recognition (~PVE). Provided the social environment is permissive (~SA), an individual's potent goal-directed willpower (EM) and ESE are sufficient to overcome multiple barriers and independently sustain high levels of PB. This strongly exemplifies the decisive role of “human agency” as conceptualized in SCT.

3 Dual core reinforcement type

This type combines high FS and high ESE as core conditions, reflecting the joint reinforcing capacity of external resources and internal beliefs. The core mechanism of this pattern lies in the ability of external support to effectively compensate for deficits in multiple internal resources.

Configuration 5 (FS•ESE• ~ SEE• ~ SA) indicates that even when SEE is unfavorable (~SEE), encouragement, support, and companionship from friends (FS), combined with an individual's ESE in a low-anxiety environment (~SA), are sufficient to counteract negative feelings encountered during exercise (33). FS provides an external rationale for persistence and emotional comfort, enabling individuals to transcend temporary physical or affective discomfort and enhancing exercise adherence.

Configuration 6 (FS•ESE• ~ EVP• ~ EM• ~ SEE) represents the pathway with the broadest compensatory scope. When individuals lack internal drive (~EM, ~EVP) and positive subjective exercise experience (~SEE), strong FS and ESE form a powerful “protective buffer.” The external support system directly supplies opportunities for behavior initiation and continuity, while intrinsic self-efficacy ensures the individual's capacity to utilize this support, thereby overcoming multiple internal deficiencies. This underscores the central role of FS and ESE as protective factors in mitigating complex adverse conditions (34).

4 Efficacy anxiety compensation type

This type shares FS, EM, and positive SEE as common core conditions, forming a stable triangle of “external support–internal drive–process reward.” Within this framework, ESE and SA exhibit a dynamic compensatory relationship: high ESE buffers the negative impact of anxiety, while low ESE requires compensation from a low-anxiety environment. This illustrates the complex interactive mechanisms of resource synergy and substitution within SCT.

Configuration 7 (FS•SEE•EM•SEE•SA) reveals a “spillover effect” of multiple resources. When external support, internal drive, positive experience, and ability beliefs are all at high levels, the resulting “resource redundancy” is sufficient to overwhelm and neutralize the negative effects of SA. PB is thus initiated and sustained through multi-layered, compound motivation.

Configuration 8 (FS•SEE•EM• ~ ESE• ~ SA) demonstrates a compensatory mechanism in which environment and motivation offset low ESE. When an individual's self-efficacy is low (~ESE), a supportive, low-social-anxiety environment (~SA) becomes the

critical compensating factor. In this setting, FS and EM can function without interference, while positive experience (SEE) enhances the appeal of exercise. Together, these factors compensate for the ESE deficit, driving high PB. This underscores the importance of fostering a low-anxiety setting, strengthening external support and internal motivation, and optimizing exercise experiences when ESE is insufficient (35).

4.3.2 Characteristics of configurational pathways

Our findings confirm the complex, context-dependent nature of PB mechanisms (29). Multiple conjunctural causation indicates that no single factor unilaterally determines PB; instead, factors interact through complementary, substitutive, and compensatory relationships (36).

1 Multiple equifinality

All eight pathways effectively lead to high PB, yet their condition combinations differ significantly—involving between two and five core or peripheral conditions—demonstrating clear multiple equifinality in behavioral formation. This implies that female university students with different characteristics and in varying contexts can achieve similar exercise adherence through distinct combinations of factors (37). Such a finding challenges the traditional search for a “universal optimal solution” and underscores the need for more individualized and context-adaptive intervention strategies.

2 Stability of core conditions and causal asymmetry

Our analysis reveals two key insights. On one hand, ESE appears as a core condition in the vast majority of pathways (seven out of eight), highlighting its fundamental and often non-substitutable role—closely aligning with the theoretical core of SCT. On the other hand, the same factor (e.g., PVE, EM, SA, SEE) may appear at high or low levels—or even be absent—across different pathways while still forming part of an effective configuration, a phenomenon known as “causal asymmetry.” This clearly illustrates that a factor's role depends on its specific combination with other conditions in a given pathway (38). For instance, SA and EM assume different states (present/absent, high/low) in Configuration 2 (ESE•SEE• ~ EM• ~ SA) versus Configuration 3 (ESE•EM•EVP•SA).

3 Compensatory and substitutive mechanisms

The results clearly reveal multiple compensatory and substitutive mechanisms: Intrinsic compensation: ESE and positive SEE compensate for low motivation (Configuration 2). Intrinsic substitution: Strong EM and ESE substitute for the absence of external support and value recognition (Configuration 4). Intrinsic-extrinsic compensation: FS and ESE compensate for multiple internal barriers—low perceived value, weak motivation, and negative experience (Configuration 6). Multi-resource compensation: FS, EM, positive SEE, and a low-anxiety environment collectively compensate for low ESE (Configuration 8). Resource buffering: Multiple positive resources—FS, ESE, EM, and positive SEE—collectively buffer the negative impact of SA (Configuration 7).

4 Conditional transformation of “Negative Factors.”

The most theoretically challenging finding lies in revealing that certain “risk factors” or “negative factors,” consistently validated in linear models, do not exert absolute effects from a configurational perspective but instead exhibit marked context-dependency. Consider SA: traditional research consistently reports a stable negative correlation with PB (39, 40). However, our configurational analysis shows that when individuals possess strong internal resources (e.g., high ESE, EM, and EVP in Configuration 3) or ample external support and positive experience (as in Configuration 7), the negative impact of high SA is effectively neutralized. Its status as a risk factor undergoes a “conditional transformation.” Similarly, negative SEE (~SEE) in Configurations 5 and 6, and low PVE (~PVE) in Configurations 4 and 6, did not prevent the occurrence of high exercise behavior.

This represents an important theoretical refinement: it demonstrates that factors such as social anxiety and negative experience are not deterministic barriers to behavior—their effects depend heavily on the overall “causal recipe” they form with other conditions. Whether a factor constitutes a “risk” depends not on the factor itself, but on its causal context. This “causal context-dependence,” revealed through fsQCA, overcomes the limitation of traditional linear analyses that treat factor effects in isolation, offering a more nuanced perspective for understanding behavioral complexity.

Accordingly, future health behavior interventions should move beyond a singular focus on “reducing risk factors” toward a systemic strategy of “building supportive configurations to transform risks”—that is, by strengthening protective resources such as efficacy, motivation, and support to alter the conditions under which negative factors operate, thereby enabling more precise and effective health promotion.

4.4 Robustness checks

Robustness testing aims to verify the stability of core findings by systematically adjusting key parameters or methodological settings under different reasonable assumptions. Results are considered reliable if they remain consistent across multiple sensitivity analyses (41). Common strategies include modifying sample size, recalibrating thresholds, adjusting consistency thresholds to increase or decrease solution stringency, or revising case frequency criteria.

This study employed consistency threshold adjustment for robustness testing. While keeping other parameters constant—including calibration anchors and case frequency—we raised the consistency threshold from the baseline of 0.80 to 0.85 and 0.90, respectively. The results demonstrated that solution consistency remained between 0.887 and 0.892, the configurational paths—i.e., combinations of core and peripheral conditions—showed no significant structural changes, and coverage fluctuated by less than ± 0.015 .

These findings confirm that under more stringent consistency standards, the core configuration types—Immersive Enjoyment, Autonomous Drive, Dual Core Reinforcement, and Efficacy Anxiety Compensation—and their internal compensatory mechanisms remained stable, verifying the robustness of the conditional variables’ influence on female university students’ PB. We therefore conclude that the configurational analysis conclusions of this study, grounded in SCT, possess strong statistical validity and methodological reliability.

5 Conclusions and implications

5.1 Conclusion

This study demonstrates that high PB among female university students aligns with the principles of multiple conjunctural causation and causal asymmetry. No single pathway universally explains this outcome; rather, it arises from multiple antecedent conditions interacting through compensatory or substitutive mechanisms. These findings are consistent with other fsQCA studies in health behavior. For example, Zhang et al. (2023) showed that while high SA combined with high ESE can drive PB, low SA does not necessarily lead to low exercise levels, as other factors (e.g., intrinsic motivation) may compensate (42). Similarly, Kane et al. (2022) identified multiple equifinal pathways for healthy eating behaviors where environmental constraints were offset by strong personal resources (43).

This study advances the explanatory power of SCT in the health behavior domain. Our findings not only confirm the dynamic interactions within the triadic reciprocity model but also reveal asymmetric, nonlinear relationships among these factors. The discovery of causal asymmetry shows that the configurations for high PB are not mere inversions of those for low PB. We propose the concept of “conditional transformation of negative factors”: traditional risk factors like SA and negative SEE can have their negative impact neutralized within specific combinations of supportive resources (e.g., high ESE, strong FS, and high EM). This offers an important theoretical correction to the traditional “net effect” perspective on risk factors. Finally, we demonstrate strong methodological synergy between fsQCA and the SCT framework, providing a robust methodological approach for analyzing complex conjunctural causation in health behaviors.

This study offers micro-level evidence for designing targeted health promotion strategies for female university students. Building on the configurational findings, we emphasize the foundational role of ESE and recommend systematic efforts to enhance female students’ confidence in their physical activity capabilities. Concerted actions should strengthen FS networks, for example, by promoting exercise buddy systems and group physical activities, to compensate for potential deficits in individual motivation or SEE. Furthermore, optimizing SEE is essential to foster “Immersive Enjoyment” type behavior. Educational administrators and sports practitioners should abandon one-size-fits-all interventions in favor of differentiated strategies tailored to female student subgroups with different driving patterns. These specific measures represent concrete steps toward implementing the national sports-education integration strategy, promoting adolescent health development, and advancing the “Healthy China 2030” blueprint.

5.2 Limitations

This study has several limitations. First, it identified configurational pathways to high PB without parallel analysis of low PB mechanisms. Future research could examine low PB as a distinct phenomenon. Comparing the causal asymmetry between high and low PB pathways would offer a more complete understanding of the behavioral mechanisms.

Second, the cross-sectional design and modest sample size ($N = 115$) limit causal inference and generalizability. Future studies could use longitudinal or intervention designs to verify the stability of these patterns and establish causality. In addition, expanding the sample's geographical and cultural diversity, along with incorporating more environmental variables (e.g., school sports policies, facility availability), would help develop a more comprehensive configurational model. Such work would advance health behavior research from correlation toward causal explanation.

In summary, by combining SCT with configurational analysis, this study empirically confirms multiple conjunctural pathways to PB among Chinese female university students. We emphasize that understanding complex health behaviors requires going beyond single determinants or linear relationships to focus on the combinatorial and systemic effects of various conditions. This configurational perspective not only provides a novel analytical framework for female students' PB but also offers transferable insights for health behavior promotion across other domains.

5.3 Recommendations

Based on the four identified configurational types, we recommend differentiated intervention strategies for distinct subgroups of female university students.

1 For the immersive enjoyment type

This subgroup, characterized by high ESE and positive SEE, should receive interventions that strengthen efficacy beliefs through progressive achievement milestones and enhance SEE through multi-context design. In physical education, implement a progressive skill-advancement model—for example, breaking aerobics into sequenced stages (“basic steps → combination routines → choreography and performance”)—using phased “visual certification” to systematically build self-efficacy. In extracurricular settings, create themed immersive scenarios such as “Starlight Fluorescent Night Runs” with lighting and sound effects or “Anime-Themed Fitness Parties” with role-playing to increase exercise enjoyment through multi-sensory stimulation. Instructors should help students progressively increase exercise volume and master sports skills while providing timely positive feedback to strengthen ESE. Instruction should be individualized, adjusting exercise load and intensity according to each student's needs while monitoring their SEE. Additionally, enhance university sports facilities as primary exercise venues by developing digital infrastructure that provides immediate visual feedback and dynamic tracking to significantly improve SEE. Together, these measures create a “ability certification–experience enhancement” cycle, achieving the synergy between individual cognition and behavioral experience described in SCT.

2 For the autonomous drive type

This subgroup, defined by high ESE and high EM, benefits from a multi-stakeholder approach that addresses peripheral conditions (including value recognition, low-anxiety environment, SA, and

external support) to strengthen their intrinsic drive. At the institutional level, promote interdisciplinary collaboration between Psychology and Sports Science in curriculum design. Improve exercise goal clarity and self-management, and establish sports psychology counseling stations with dedicated spaces and tailored facilities for students experiencing SA. Physical education teachers should use personalized goal-setting for different students, incorporate success-sharing sessions into lessons to reinforce ability beliefs, and use visual feedback to enhance PVE. For extracurricular activities, provide diverse, self-directed options and create “audience-free zones” to reduce social pressure. For those lacking FS, facilitate access to virtual sports communities (44), effectively forming virtual workout partners. These coordinated efforts aim to multi-directionally support sustained PB among female university students in this subgroup.

3 For the dual core reinforcement type

Given the core conditions of high FS and high ESE, alongside potential peripheral conditions such as negative SEE, low PVE, or low EM, we recommend constructing a compensatory system that leverages the synergy between FS and ESE. At the institutional level, universities could implement incentive policies for buddy-system based exercise, supporting groups of exercise partners to enroll in courses together and share credit rewards. In instructional design, teachers should structure classes around progressive collaborative tasks that highlight the important role of exercise partners. For students reporting distinct negative experiences, use positive reinforcement strategies and focus on enhancing class enjoyment. Students should actively cultivate a “support-efficacy cycle” through peer encouragement to jointly build exercise confidence, strengthen PVE, and amplify the multiplier effect of strong FS and high ESE.

4 For the efficacy anxiety compensation type

This subgroup is characterized by a triad of core conditions—FS, EM, and positive SEE—together with a dynamic efficacy–anxiety compensation mechanism. To address their specific needs, universities should establish designated exercise anxiety buffer zones that enable students across all anxiety levels to participate in physical activity within reassuring and accommodating settings. Practical steps may involve staggered scheduling that separates high-intensity courses (e.g., cardio kickboxing, Sanda) from low-pressure options (e.g., Tai Chi), thereby helping align individual anxiety profiles with suitable exercise contexts. Physical education teachers should emphasize the integrated application of curricular resources, systematically weaving in distinct pedagogical components—such as structured FS systems, approaches to maintaining motivation, and techniques for enhancing the SEE—throughout the teaching process. This can be achieved by designing practice tasks around a fixed partner system (e.g., paired resistance band exercises) to foster supportive peer relationships; applying established goal-setting frameworks to break down exercise tasks into manageable sequences; and implementing multi-stage evaluation models for assessing student performance in physical education, offering continuous feedback and cultivating advancement. These coordinated initiatives are intended to ensure

the sustained maintenance and reinforcement of PB within this particular student subgroup.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

Ethics statement

The studies involving humans were approved by Jiang Xi Normal University (IRB-JXNU-PEC-2025016). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. The animal study was approved by Jiangxi Normal University (IRB-JXNU-PEC-2025016). The study was conducted in accordance with the local legislation and institutional requirements. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

PJ: Writing – review & editing. DM: Writing – original draft. TZ: Writing – original draft, Writing – review & editing. SS: Writing – original draft, Writing – review & editing. XH: Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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References

1. World Health Organization. WHO guidelines on physical activity and sedentary behaviour. Geneva: World Health Organization (2022).
2. Train T, Flaxman S, Guthold R, Gillum RF, Suliankatchi RA, Nations JA, et al. National, regional, and global trends in insufficient physical activity among adults from 2000 to 2022: a pooled analysis of 507 population-based surveys with 5.7 million participants. *Lancet Glob Health*. (2024) 12:e1232–43. doi: 10.1016/S2214-109X(24)00184-2
3. The State Council of the People's Republic of China. Outline of the "Healthy China 2030" Plan (2016). Available online at: https://www.gov.cn/gongbao/content/2016/content_5133024.htm (Accessed July 28, 2025).
4. Ma D. Research on influencing factors and cultivation countermeasures of college students' sports consciousness. *Sci Educ Guide*. (2013) 17:247–8. doi: 10.16400/j.cnki.kjdxs.2013.09.142
5. Li YC. Analysis of the sports lifestyle of Peking University students. *Sport Cult Guide*. (2013) 9:103–6.
6. Guthold R, Stevens GA, Riley LM, Bull FC. Global trends in insufficient physical activity among adolescents: a pooled analysis of 298 population-based surveys with 1.6 million participants. *Lancet Child Adolesc Health*. (2020) 4:23–35. doi: 10.1016/S2352-4642(19)30323-2
7. Xu L, Li H. Investigation and research on the influence of scientific exercise on emotional factors of female college students during menstruation. *China Sci Technol Inform*. (2009) 10:229–31.
8. Xinhua News Agency. The CPC central committee and the state council issued the "healthy China 2030" Plan Outline (2016). Available online at: https://www.gov.cn/zhengce/2016-10/25/content_5124174.htm (Accessed July 28, 2025).
9. Huang J, Zhang YH. The influence of gender stereotypes on the willingness of non-PE major female college students in Chongqing to participate in sports. *J Wuhan Inst Phys Educ*. (2025) 59:94–102. doi: 10.15930/j.cnki.wtxb.2025.01.010
10. Zhu LQ, Dong BL, Chen C, Yang Y, Wang Y, Liu Y. The impact of gender role conflict on female college students' sports participation consciousness: the parallel mediating effect of peer and PE teacher autonomy support. *China Sport Sci Technol*. (2023) 59:106–13. doi: 10.16470/j.csst.2021077
11. Chen SP, Song D, Xie LJ, Wang ZY, Li Y, Zhang Q. Cluster analysis of Chinese college students' physical exercise motivation and characteristics of sports behavior. *J Cap Univ Phys Educ Sports*. (2023) 35:57–67. doi: 10.14036/j.cnki.cn11-4513.2023.01.007
12. Li M, Qin XZ, Zhang DC. A socio-ecological analysis of barriers to sports participation among Chinese female college students under the healthy China initiative. *J Shenyang Sport Univ*. (2021) 40:72–80.
13. Yücekaya MA, Uğraş S, Sagin AE, Çetin A, Iconomescu T-M, Talaghir L-G. Relationships among social support, healthy lifestyle beliefs, physical literacy, and enjoyment of physical activity: a moderated mediation model. *Front Public Health*. (2025) 13:1617124. doi: 10.3389/fpubh.2025.1617124
14. Pan JL, Wang B, Dong XC. Social e-commerce model and comparative research based on SICAS consumer behavior model. *Enterp Econ*. (2020) 39:37–43. doi: 10.13529/j.cnki.enterprise.economy.2020.10.005

15. Bandura A. Foundations of thought and action: a social cognitive theory In: Englewood cliffs. NJ: Prentice-Hall (1986).
16. Du YZ, Jia LD. Configuration perspective and qualitative comparative analysis (QCA): a new approach to management research. *Manag World*. (2017) 6:155–67. doi: 10.19744/j.cnki.11-1235/f.2017.06.012
17. Liang DQ. Stress levels of college students and their relationship with physical exercise. *Chin Ment Health J*. (1994) 8:5–6.
18. Kroll T, Kehn M, Ho PS, Groah S. The SCI exercise self-efficacy scale (ESES): development and psychometric properties. *Int J Behav Nutr Phys Act*. (2007) 4:34. doi: 10.1186/1479-5868-4-34
19. Kirk T. N. Examining the relationship between expectancy-value motivation, barriers, and physical activity engagement among adults with visual impairments. (2019). Doctoral dissertation, Old Dominion University, Norfolk, USA.
20. Lu XL, Li X, Ge JJ, Zhou Y, Wang J, Tao L, et al. Research on the relationship between college students' perceived value of physical exercise and their exercise motivation. *Fujian Sports Sci Technol*. (2017) 36:49–55.
21. Chen SP, Wang YB, Rong JZ, Li Y, Zhang Q, Liu Y, et al. Construction and reliability and validity analysis of the simplified version of the motives for physical activities measure (MPAM-R). *J Beijing Sport Univ*. (2013) 36:66–70+78. doi: 10.19582/j.cnki.11-3785/g8.2013.02.013
22. McAuley E, Courneya KS. The subjective exercise experiences scale (SEES): development and preliminary validation. *J Sport Exerc Psychol*. (1994) 16:163–77. doi: 10.1123/jsep.16.2.163
23. Cheng H. The path of friend support improving college students' aerobic fitness: the mediating role of physical activity and exercise self-efficacy. *Sports Sci*. (2019) 40:114–20. doi: 10.13598/j.issn1004-4590.2019.04.016
24. Peng CZ, Gong YX, Zhu XZ. Reliability and validity of the interaction anxiousness scale and its applicability in Chinese college students. *Chin Ment Health J*. (2004) 18:39–41.
25. Wu J, Jia ZJ, Pan JC, Li M, Zhang H, Zhao W. The enhancement mechanism and configurational path of China's international discourse power in sports academia: an analysis based on fs QCA. *China Sport Sci*. (2025) 45:43–56. doi: 10.16469/j.css.2025KX024
26. Pappas IO, Woodside AG. Fuzzy-set qualitative comparative analysis (fs QCA): guidelines for research practice in information systems and marketing. *Int J Inf Manag*. (2021) 58:102310. doi: 10.1016/j.ijinfomgt.2021.102310
27. Xin C, Wu YW, Li MY, Wang L, Zhang J, Liu R. Research on the knowledge sharing dilemma in innovation ecosystem: from the perspective of social capital. *J Manag Sci*. (2023) 36:44–60.
28. Ragin CC. Redesigning social inquiry: Fuzzy sets and beyond. Chicago: University of Chicago Press (2008).
29. Rihoux B, Ragin CC. Configurational comparative methods: qualitative comparative analysis (QCA) and related techniques. Thousand Oaks, CA: SAGE Publications (2009).
30. Dai Z, Bao GX. The application of QCA in Chinese public management research: problems and improvements. *China Public Adm Rev*. (2023) 5:188–212.
31. Bandura A. Self-efficacy: the exercise of control. New York: WH Freeman (1997).
32. Ryan RM, Deci EL. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *Am Psychol*. (2000) 55:68–78. doi: 10.1037/0003-066X.55.1.68
33. Sallis JF, Owen N, Fisher E In: K Glanz, BK Rimer and K Viswanath, editors. B."ecological models of health behavior," in health behavior and health education: Theory, research, and practice. 4th ed. San Francisco, CA: Jossey-Bass (2008). 465–85.
34. McAuley E, Blissmer B. Self-efficacy and attributional processes in physical activity In: GC Roberts, editor. Advances in motivation in sport and exercise. Champaign, IL: Human Kinetics (2000). 157–76.
35. Cox A In: GC Roberts and DC Treasure, editors. E."sport psychology and exercise motivation," in advances in motivation in sport and exercise. 3rd ed. Champaign, IL: Human Kinetics (2012). 187–210.
36. Hagger MS, Chatzisarantis NLD, Biddle SJH. A meta-analytic review of the theories of reasoned action and planned behavior in physical activity: predictive validity and the contribution of additional variables. *J Sport Exerc Psychol*. (2002) 24:3–32. doi: 10.1123/jsep.24.1.3
37. Woodside AG. Moving beyond multiple regression analysis to algorithms: calling for adoption of a paradigm shift from symmetric to asymmetric thinking in data analysis and crafting theory. *J Bus Res*. (2013) 66:463–72. doi: 10.1016/j.jbusres.2012.12.021
38. Fiss PC. Building better causal theories: a fuzzy set approach to typologies in organization research. *Acad Manag J*. (2011) 54:393–420. doi: 10.5465/amj.2011.60263120
39. Wang DQ, He SY. A study on the relationship between physical exercise, body image and social anxiety among college students. *Sichuan Sports Sci*. (2024) 43:59–68. doi: 10.13932/j.cnki.sctyxk.2024.05.11
40. Deng YR, Wang XL, Ma C. The impact of physical activity on social anxiety of college students: the chain mediating effect of body image and psychological capital. *China J Health Psychol*. (2024) 32:920–5. doi: 10.13342/j.cnki.cjhp.2024.06.022
41. Misangyi VF, Gregoire YA, Aguinis H. Social science analyses in management research: from linear to configurational thinking. *J Manag*. (2017) 44:475–90. doi: 10.1177/0149206316679252
42. Zhang Y, Li X. Configurational paths to adolescent physical activity: a fuzzy-set qualitative comparative analysis. *J Sport Health Sci*. (2023) 12:512–25. doi: 10.1016/j.jshs.2023.01.005
43. Kane NJ, Smith AB, Chen L. Unpacking the complexity of healthy eating: an fs QCA study of personal and environmental factors. *Appetite*. (2022) 178:106118. doi: 10.1016/j.appet.2022.106118
44. Hu Q, Xiong YX. Research and development of VR platform for virtual companion exercise and fitness. *Comput Prod Circ*. (2019) 4:96.



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Factors influencing higher vocational nursing students' mental health during internships: a cross-sectional study

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Background: Internship is an important transition stage for nursing students from school to clinical work. However, students often suffer from mental health problems such as depression, anxiety and stress during internship, which further affects the effect of internship and career choice.

Aim: This study aims to explore the mental health problems of higher vocational nursing students and its influencing factors.

Methods: This study used a cross-sectional design to investigate 432 nursing students during internship who were studying at Binzhou Polytechnic from May to June 2025. The general information questionnaire, General Self-Efficacy Scale (GSES) and Depression, Anxiety and Stress Scale (DASS-21) were used to collect data to understand the mental health status of higher vocational nursing interns and analyze the influence of different factors on mental health problems.

Results: 24.7% of the nursing interns had depression problems, 26.5% had anxiety problems, and 22.8% felt great pressure. Binary logistic regression analysis showed that internship in a tertiary grade A hospital and male students were associated with an increased risk of psychological problems (OR > 1). However, often or sometimes feeling cared for during internship, liking for the nursing profession, thinking that the nursing profession was respected, and high self-efficacy were associated with reduced risk of psychological problems (OR < 1). **Conclusions:** Hospital, gender, liking for the nursing profession, thinking that the nursing profession was respected, feeling cared for during internship and self-efficacy were all significantly associated with the mental health of higher vocational nursing students during internship. These findings provide a basis for the development of targeted mental health interventions to help improve the mental health of nursing students.

KEYWORDS

nursing students, clinical internship, mental health, influencing factors, psychological distress

Introduction

Internships serve as a critical transitional stage for nursing students as they move from academic learning to clinical practice. They only play an important role in professional development, but also act as a bridge connecting theoretical knowledge with practical skills (1). Internships are thus essential for nursing students, and their process and effectiveness have a profound impact on their future clinical performance and career adaptability (2). During internships, nursing students not only face unfamiliar and complex clinical environments, but also have to deal with several challenges, such as effectively applying the knowledge and skills learned in the classroom to real clinical situations, and dealing with complex interpersonal interactions with patients, patients' families, and medical team members (3–5). These challenges may induce anxiety, tension, and irritability, which may affect their internship experience and mental health. Some nursing students may experience significant occupational pressure after clinical practice, and when their professional ideals do not align with reality, they may choose to leave the nursing major, leading to a considerable loss of nursing talent (6).

According to the World Health Organization, mental health is an important component of health (7). Mental health refers not only to the absence of mental illness, but also to the ability of individuals to realize their potential, cope with stressors in their lives, work effectively and contribute to society (8). In China, the imbalance between the rapidly advancing medical system and the huge demand for health care services has resulted in medical staff being in a state of heavy workload for a prolonged period (9). In addition, the country is facing significant challenges such as nursing staff shortage and a high turnover rate (10). As future healthcare professionals, the mental health of nursing students not only affects their personal development but is also closely linked to patient safety and the stability of the nursing workforce. Research indicates that nursing students under significant psychological stress are more prone to academic burnout and face a notably higher risk of clinical errors (11). In recent years, the phenomenon of mental health problems among higher vocational nursing students during internships has attracted significant attention from researchers. These students experience stress, anxiety, and depression, and the incidence of these issues is increasing (11, 12).

Unfortunately, a considerable number of nursing students fail to actively seek appropriate psychological assistance. Previous studies have identified a variety of factors that affect the mental health of nursing interns, including the complexity of the internship environment, work intensity, lack of proficiency in professional skills, low self-efficacy, and uncertainty about future career prospects (3, 4, 13). Specifically, “lack of proficiency in professional skills” refers to clinical inexperience and inadequate emergency judgment, reflecting difficulties in applying theoretical knowledge to practice (14). “Low self-efficacy” diminishes their confidence when facing professional pressures, thereby weakening their psychological capacity to cope with challenges (15). Furthermore, “work intensity” encompasses not only long hours and high task density but also the emotional exhaustion from caregiving, which can lead to prolonged physical and mental fatigue (16). These factors, intertwined with a complex training environment and career uncertainties, collectively pose substantial challenges to the mental well-being of nursing interns.

Although several studies have explored mental health problems in nursing interns, most of them have focused on a single mental

health indicator such as depression, anxiety, or stress, and therefore, there is a lack of research on the coexistence of multiple mental health problems, and more importantly, on their underlying determinants. Thus, in this study, we aimed to explore the determinants influencing anxiety, depression, and stress among nursing students during internships, and provide valuable insights for nursing educators and medical institutions to improve nursing students' internship experience and mental health outcomes.

Method

Study design and participants

This cross-sectional study was conducted at a higher vocational college in China (Binzhou, Shandong province, China) between May 16 and June 30, 2025. In China, higher vocational colleges play a key role in training frontline clinical nurses, and the mental health status of their interns is crucial to the stability of the nursing workforce. Approximately 500–700 students from the Department of Nursing at this higher vocational college enter the clinical practice stage each year. The internship hospitals mainly include general hospitals at the secondary level or above in Shandong Province, and all the hospitals are certified as clinical teaching bases by the education department. Thus, our study setting effectively represents the typical clinical learning environment and psychological stress faced by vocational nursing intern groups under the local allocation of medical resources. All higher vocational nursing students participating in clinical internships received a questionnaire using Wenjuanxing (<https://www.wjx.cn/>, a widely used online survey platform in China), a widely used online survey platform in China.

The inclusion criteria for this study were as follows: (1) full-time vocational nursing students at the stage of clinical internship; (2) having more than 1 month of clinical internship experience; and (3) the willing to participate in the study and provide informed consent. Exclusion criteria included nursing students who took sick leave or personal leave for more than 1 month during the clinical internship.

Nursing students could only submit the questionnaire once after responding to all questions. The flowchart is shown in Figure 1.

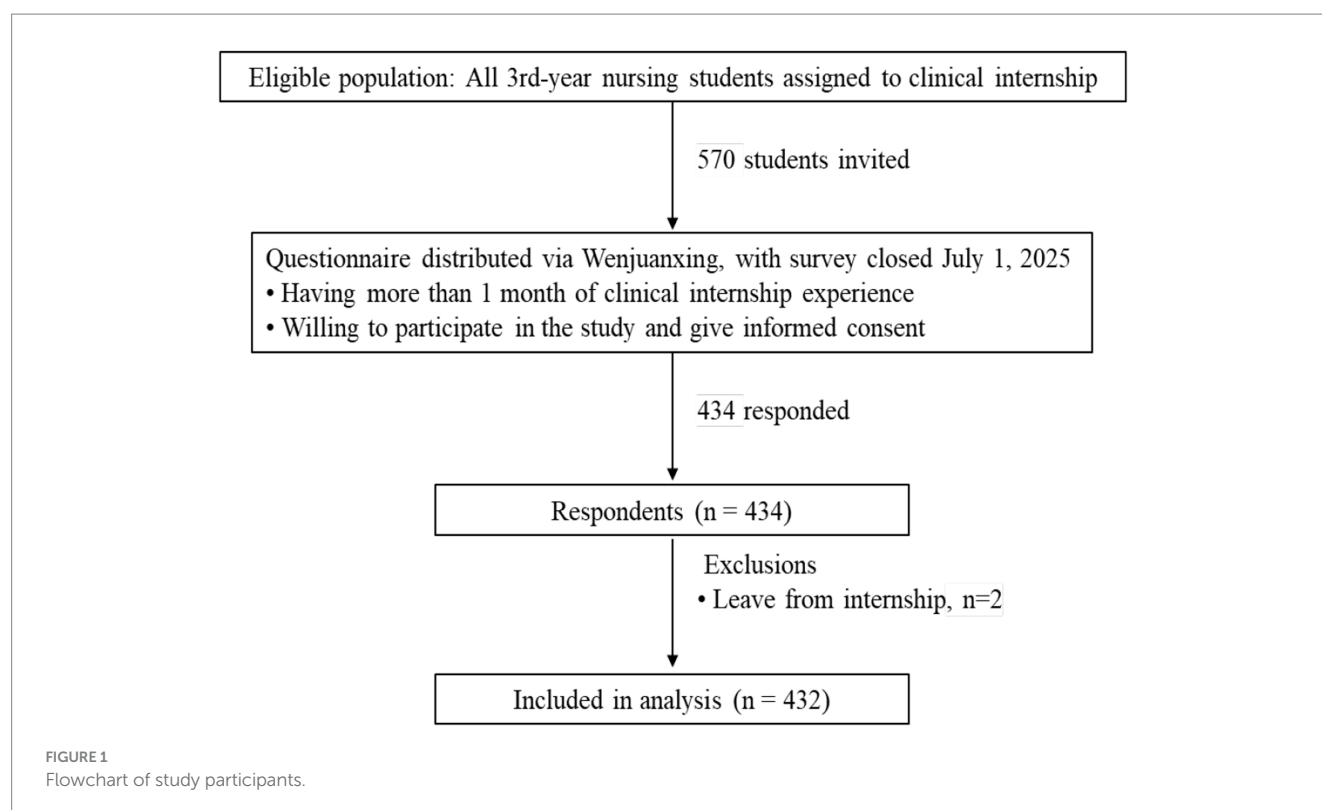
Ethical considerations

This study was approved by the Ethics Review Committee of Binzhou Polytechnic (2025001). All participants provided written informed consent prior to participation. All data were strictly anonymized to protect privacy of the participants. The data were used only in this study.

Measures

The study questionnaire consisted of three parts: a self-designed questionnaire, the General Self-Efficacy Scale (GSES), and the Depression, Anxiety, and Stress Scale (DASS-21).

The self-designed questionnaire adopted in this study was used to understand the basic information of students and their views related to the nursing profession, and to analyze whether these factors had an



impact on students' mental health problems. It specifically included 10 questions on age, gender, only-child status, place of origin, class cadre, grade of the internship hospital, feeling cared for during the internship, liking the nursing profession, perception of professional respect, and receiving assistance from one's family.

The GSES adopted in this study was used to evaluate the self-efficacy level of the nursing students. This scale was developed by Schwarzer (17) and consists of 10 items. It uses a 4-point Likert scale (1–4 points), with the total score being the average of the 10 items, ranging from 1 to 4 points. The higher the score, the stronger the overall confidence of the individual in dealing with challenges. The Chinese version of this scale has good reliability and validity, serving as a reliable tool for educational intervention and mental health research (18). In this study, the Cronbach's alpha coefficient of the GSES was 0.989. Item analysis confirmed uniformly high corrected item-total correlations for all items (range: 0.905–0.966), and the alpha value did not increase meaningfully with the deletion of any item. The details are shown in [Supplementary Table S1](#).

In this study, the DASS-21 was used to evaluate the mental health status of nursing interns in higher vocational colleges. This scale was developed by Lovibond PF and Lovibond SH (19), and it is a simplified version of the original DASS-42 scale (20), assessing emotional experiences within the past 2 weeks. It contains 21 items and is divided into three sub-scales: Depression (DASS-21-D), anxiety (DASS-21-A), and stress (DASS-21-S). Each dimension contains seven items, and is scored using a 4-point Likert scale. The score range is from 0 ("not applicable to me at all") to 3 ("very applicable to me"). According to the usage guidelines of DASS-21, in order to ensure that the scoring results correspond to the original DASS-42, the total scores of each sub-scale need to be multiplied by 2. The total score range of each dimension is 0–42. The higher the score, the higher the corresponding

emotional distress level of the individual (21). The Chinese version of DASS-21, which has undergone cross-cultural translation and localization, has demonstrated good reliability among Chinese students (22, 23). A depression score ≤ 9 was defined as normal (no depression), and >9 was defined as depression (10–13 as mild depression, 14–20 as moderate depression, 21–27 as severe depression, and ≥ 28 as very severe depression). Anxiety score ≤ 7 was defined as normal (no anxiety), and >7 was defined as anxiety (8–9 as mild anxiety, 10–14 as moderate anxiety, 15–19 as severe anxiety, and ≥ 20 as very severe anxiety). Stress scores ≤ 14 were classified as normal, and >14 were defined as stress (15–18 as mild stress, 19–25 as moderate stress, 26–33 as severe stress, and ≥ 34 as very severe stress) (24–26). Therefore, the mental health problems were categorized as "no" (having no depression, no anxiety, and no stress) and "yes" (having depression, anxiety, or stress) (26). In this study, the Cronbach's alpha coefficients for the depression, anxiety, and stress were 0.982, 0.980, and 0.977, respectively. Item analysis confirmed uniformly high corrected item-total correlations for all items (range: 0.884–0.963), and the alpha value did not increase significantly with the deletion of any item. The details are presented in [Supplementary Table S2](#).

Determination of sample size

The sample size for this study was calculated *a priori* to ensure the robustness of the planned binary logistic regression analysis with 11 independent variables. We employed the established "events per variable" criterion for logistic regression, which recommends 10–15 events per predictor to ensure reliable parameter estimates (27, 28). To adopt a conservative criterion of

15 events per variable, a minimum of 165 events (i.e., participants with a mental health problem) was required. The outcome was a composite variable indicating the presence of at least one DASS-21-defined condition (depression, anxiety, or stress). To estimate the expected event rate, we synthesized prevalence rates reported in prior literature, which showed rates of approximately 41.7% for anxiety, 28.7% for depression, and 20.2% for stress in comparable populations (29). Assuming no comorbidity for a conservative calculation, the composite outcome prevalence was projected to be 66.8%. The minimum total sample size was therefore calculated as $165 / 0.668 \approx 247$. To accommodate potential incomplete responses, we targeted a final sample of 270 participants. Ultimately, the study successfully included 432 participants in the final analysis, a sample size that substantially exceeds the calculated minimum requirement.

Data analysis

The mental health status of vocational college nursing students was described using percentages, and the self-efficacy score was described as the mean $\pm$ the standard deviation. The chi-square (χ^2) test was used to analyze differences in mental health problems among nursing students with different characteristics, and the Spearman's correlation analysis was used to analyze the correlation between self-efficacy and mental health problems. Finally, the influence of different characteristics on mental health problems was analyzed through binary logistic regression, and the results were presented in a forest plot. The internal consistency reliability of the scales used in this study (GSES and DASS-21) was assessed by calculating Cronbach's alpha coefficients. Furthermore, to thoroughly investigate the psychometric properties, corrected item-total correlations and Cronbach's alpha-if-item-deleted values were computed for all scale items to examine each item's contribution to the total score and to check for potential item redundancy. All statistical analyses were performed using IBM SPSS Statistics Version 26, and the forest plot was performed using R software Version 4.4.2.

Result

Status of mental health problems

The mental health problems of students mainly included depression, anxiety and stress. The number of people experiencing depression was 107 (24.7%). The number of people experiencing anxiety was 115 (26.5%). The number of people experiencing stress was 99 (22.8%). The detail information was shown in Table 1.

Association between different characteristics and mental health problems

The χ^2 test showed in Table 2 that the grade of the internship hospital, gender, feeling cared for during the internship, liking the nursing profession, perception of professional respect, and receiving assistance from one's family were related to the mental health problems of vocational college nursing interns ($p < 0.05$), while age, only-child status, place of origin, and class cadre were not related ($p > 0.05$).

Association between self-efficacy and mental health problems

The average score of the self-efficacy was 3.08 ± 0.93 , at a moderately high level. The results of Spearman correlation analysis showed in Table 3 that there was a negative correlation between the self-efficacy and mental health problems in vocational college nursing students.

Influencing factors of mental health problems in higher vocational college nursing students

After conducting a binary logistic regression analysis on the mental health problems of vocational nursing students (Table 4), it was found that the grade of the internship hospital, gender, liking the nursing profession, feeling cared for during internship, perception of professional respect, and self-efficacy were significantly correlated with the mental health problems of higher vocational college nursing students during internship.

Internships in tertiary grade A hospitals, and being male were associated with an increased risk of mental health problems (odds ratio, OR > 1); While liking the nursing profession, often or sometimes feeling cared for during internships, perception of nursing profession was respected, and having a high self-efficacy were associated with a reduced risk of psychological problems (OR < 1). The detail was presented with a forest plot in Figure 2.

Discussion

Our study found that depression (24.7%), anxiety (26.5%), and stress (22.8%) were the predominant mental health problems among higher vocational nursing students during the internship. Clinical practice in a tertiary grade A hospital, male, dislike of the nursing profession, feeling a lack of care during internship, and perceiving that the nursing profession is not respected were factors associated with an increased risk

TABLE 1 Status of mental health problems of vocational college nursing students, n (%).

Mental health problem	Normal	Mild	Moderate	Severe	Very severe
Depression	327 (75.3%)	22 (5.1%)	43 (9.9%)	4 (0.9%)	38 (8.8%)
Anxiety	319 (73.5%)	3 (0.7%)	55 (12.7%)	13 (3.0%)	44 (10.1%)
Stress	335 (77.2%)	10 (2.3%)	9 (2.1%)	11 (2.5%)	30 (6.9%)

TABLE 2 Association between different characteristics and mental health problems in higher vocational college nursing students.

Group	Mental health problems		χ^2	<i>p</i>
	No	Yes		
Grade of the internship hospital			6.422	0.040
Tertiary Grade A hospital	208	91		
Tertiary Grade B hospital	26	12		
Secondly Grade A hospital	80	17		
Gender			6.479	0.011
Male	79	45		
Female	235	75		
Age, years old			0.001	0.973
18–21	277	106		
22–28	37	14		
Only-child status			2.369	0.124
Yes	60	31		
No	254	89		
Class cadre			2.142	0.143
Yes	87	25		
No	227	95		
Liking the nursing profession			25.940	<0.001
Like	163	35		
General	136	66		
Dislike	15			
Place of origin			0.153	0.696
City	78	32		
Country	236	88		
Perception of professional respect			30.642	<0.001
Respected	181	45		
General	122	54		
Not respected	11	21		
Receiving assistance from one's family			6.306	0.043
Full help	196	61		
A little help	95	43		
Helpless	23	16		
Feeling cared for during internship			37.943	<0.001
Often cared about	208	53		
Sometimes cared about	100	48		
Lack of cared about	6	19		

TABLE 3 Correlation between self-efficacy and mental health problems in nursing students(*r*).

Category	Self-efficacy	<i>p</i>
Depression	−0.201	<0.001
Anxiety	−0.207	<0.001
Stress	−0.203	<0.001
Mental health problems	−0.198	<0.001

TABLE 4 Binary logistic regression analysis for mental health problems in nursing students.

Variable	β	Standard error	Wald χ^2	OR (95% CI)	<i>p</i> -value
Grade of the internship hospital					
Second grade A hospital (Ref)				1.0 (reference)	
Tertiary grade A hospital	0.802	0.339	5.578	2.23 (1.15–4.34)	0.018*
Tertiary grade B hospital	0.943	0.492	3.673	2.57 (0.98–6.74)	0.055
Gender					
Female (Ref)				1.0 (reference)	
Male	0.762	0.262	8.457	2.14 (1.28–3.58)	0.004*
Liking the nursing profession					
Dislike (Ref)				1.0 (reference)	
Like	−1.013	0.488	4.307	0.36 (0.14–0.94)	0.038*
General	−0.381	0.451	0.714	0.68 (0.28–1.65)	0.398
Feeling cared for during internship					
Lack of care about (Ref)				1.0 (reference)	
Often cared about	−1.942	0.597	10.579	0.14 (0.04–0.46)	0.001*
Sometimes cared about	−1.639	0.583	7.907	0.19 (0.06–0.61)	0.005*
Perception of professional respect					
Not respected (Ref)				1.0 (reference)	
Respected	−1.195	0.518	5.316	0.30 (0.11–0.84)	0.021*
General	−0.945	0.472	4.002	0.39 (0.15–0.98)	0.045*
Receiving assistance from one's family					
Helpless (Ref)				1.0 (reference)	
Full help	0.377	0.471	0.642	1.46 (0.58–3.67)	0.423
A little help	0.120	0.460	0.068	1.13 (0.46–2.77)	0.794
Self-efficacy (Continuous)	−0.259	0.128	4.072	0.77 (0.60–0.99)	0.044*

**p*-value < 0.05.

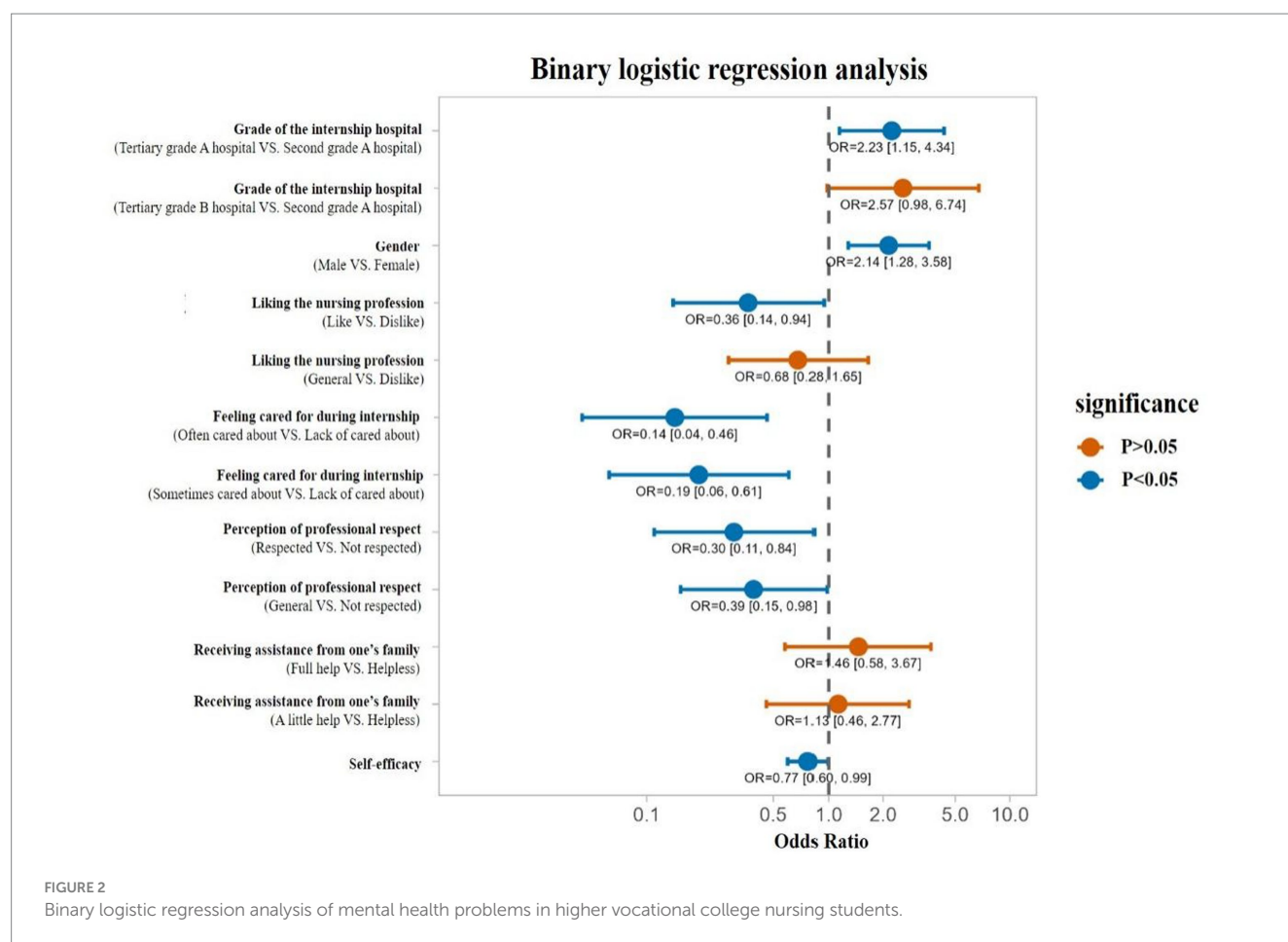
of psychological problems. These factors included elements related to the clinical environment, individual characteristics, and social support.

Clinical environment factors

Nursing students experience varying degrees of mental health problems during an internship, among which very severe depression and anxiety account for a relatively high proportion. This may be closely related to the high pressure of nursing work, the difficulty of adapting to the internship environment, and the complex interpersonal relationships (3, 30). Nursing work has a certain degree of risk and uncertainty. When interns face changes in patients' conditions, complex nursing operations, and various rules and regulations of the hospital, they are prone to significant psychological pressure. If the anxiety they experience is not promptly alleviated and supported, it may further worsen and develop into more serious mental health problems (31, 32). Therefore, schools and hospitals should pay attention to the mental health of interns. This can be done by conducting mental health literacy training at the beginning of the internship; establishing confidential and accessible consultation channels; and finally, creating a supportive peer guidance network and a mental health support system to help interns relieve their psychological pressure

and improve their mental health, enabling them to better adapt to nursing practice work. These specific steps are crucial for cultivating interns' psychological abilities to cope with clinical challenges and promoting their long-term professional development.

The incidence of mental health problems among interns in tertiary hospitals is relatively higher than that in secondary hospitals. This may be due to the high work intensity of tertiary hospitals and higher requirements for interns, who need to face more complex clinical situations and higher work pressure (33). Tertiary hospitals require higher levels of professional skills and knowledge, and interns need to quickly adapt to complex clinical environments and deal with multiple emergencies in a short period of time, which may lead to anxiety and stress during their internship. At the same time, clinical instructors in tertiary hospitals usually have high expectations for interns, which may further aggravate the psychological burden of interns (34). A positive, supportive work environment can enhance the self-confidence and sense of belonging of interns (35). To implement this concept, hospital management departments can refer to effective practical experience from both domestic and foreign sources. Existing research has shown that implementing a systematic "clinical practice transition plan" can effectively help interns alleviate the stress of adapting to clinical practice (31). In addition, implementing a standardized clinical mentorship system with experienced mentors,



who will not only provide guidance on professional skills, but also pay attention to the psychological adjustment and social integration of interns, will provide them with comprehensive support (36). By implementing a series of measures to optimize work arrangements and improve internship environments, hospitals can better safeguard the physical and mental health of interns.

Individual factors

In nursing work, physical strength, such as patient handling and prolonged standing, poses challenges for all nurses, but data show that the incidence of mental health problems among male nursing interns is significantly higher than that of their female peers. This phenomenon may be related to the special social and psychological pressures faced by men, particularly when physical exhaustion conflicts with society's expectations of male gender roles as "strong and resilient" (37). Meanwhile, males may be reluctant to seek help for mental health or emotional problems as this may be seen as a sign of vulnerability (38). Therefore, gender is an important factor affecting the mental health of nursing interns. In mental health activities, psychological support should be provided without associating stress with "vulnerability," and tasks should be allocated reasonably to alleviate male interns' concerns about seeking help.

Compared with nursing students who dislike the nursing profession, nursing students who like the nursing profession had the

lowest incidence of mental health problems, which indicates that the degree of affinity for the nursing profession can affect the psychological state of nursing students in the process of internship (39). Liking the nursing profession can make students more motivated to overcome difficulties in practice and maintain good mental health (39). Educational institutions and hospitals also play important roles in professional learning. High-quality nursing education can stimulate students' interest and enthusiasm for the profession and help them better adapt to the internship environment (40). Students who think that the nursing profession is respected had a lower incidence of mental health problems (41). When students think that the nursing profession is respected, their sense of self-belonging is enhanced, which is conducive to mental health. Conversely, if students feel that their profession is not respected, these negative emotions can lead to increased stress, anxiety, and depression, which are extremely detrimental to mental health (42).

Our findings revealed that self-efficacy plays an important protective role in the mental health of nursing interns, aligning with existing literature (43). Nursing students with high self-efficacy are more likely to adopt positive coping strategies and maintain good mental health when facing difficulties and challenges during their internship (44, 45). Students with a high level of self-efficacy can more likely to reframe clinical mistakes or failures as opportunities for growth. This adaptive coping strategy helps mitigate associated psychological responses, such as anxiety, shame and helplessness, by identifying growth opportunities from mistakes or failures in clinical

practice (44). At the same time, when facing work pressure, interpersonal conflict, and role adaptation challenges, interns with high self-efficacy are more likely to use positive coping styles, such as taking the initiative to solve problems, seeking support and self-adjusting, thereby effectively reducing their psychological burden (45).

Social support factors

Nursing interns who often felt often cared for during the internship reported the lowest levels of mental health problems. This highlights the importance of care from others (such as classmates, teachers, colleagues, etc.) on the mental health of interns (30). Such care provides a sense of warmth and support and relieves psychological pressure. The encouragement and guidance of teachers can help interns better cope with complex clinical situations, while the mutual support between classmates can reduce their loneliness and pressure (46). Nursing students who are cared for are more likely to build good networks of relationships that not only provide support during internships, but also lay a foundation for their future career development (47). A good interpersonal network can enhance the sense of social support of interns and reduce job burnout and psychological stress (48).

Although the GSES and DASS-21 are internationally recognized mature scales, the ultra-high reliability coefficients (>0.98) observed in this study strongly suggest that there may be factors contributing to the high consistency of response patterns in the specific sample of this study. This may be related to the sample traits of this study. The students were drawn from the same class in the same school, a group that is highly similar in age, educational background, and current academic stress, possibly causing them to show extremely low response variation when answering psychological scales, thus artificially inflating Cronbach's alpha. Future studies could validate this phenomenon in more diverse samples.

Limitation

Although this study revealed the current status and possible influencing factors of mental health problems among vocational nursing students during their internship, solving the mental health problems of nursing students requires joint efforts from multiple systems. But there are also several limitations. First, the cross-sectional design can only reflect the situation at a certain point in time and cannot track the dynamic changes in psychological states, nor can it make causal inferences about influencing factors and outcomes. Second, the sample size of this study was limited, and it mainly focused on nursing students in a specific region, which requires caution when generalizing research conclusions to different background colleges and regions. In addition, data were collected entirely through student self-assessment, which is susceptible to interference from subjective memory and social expectations; the survey was conducted using the "Wenjuanxing" online platform, which is convenient but also has potential issues, such as inconsistent response environments and difficulty in verifying authenticity. Future research should expand the sample size to verify in different regions and cultural backgrounds, and adopt a cohort study design to explore

the impact of mental health problems on career selection and work of higher vocational nursing students during internship.

Implications for nursing education

This study provides valuable insights for nursing educators and medical institutions, highlighting the importance of establishing a well-developed mental health support system. Providing psychological counseling services and enhancing interns' interest in and commitment to the nursing profession can help alleviate their psychological stress and improve mental health. At the same time, improving the self-efficacy of interns is also an important strategy to enhance their mental health.

Conclusion

In this study, we found that the higher vocational nursing students mainly experienced depression, anxiety, and stress during internship. Hospital level, gender, liking the nursing profession, perception of professional respect, sense of being cared for during the internship, and self-efficacy were factors significantly associated with mental health problems. The interactions among these influencing factors requires a joint response from multiple systems in order to solve the mental health problems of these nursing students. In this collaborative framework, schools and hospitals need to clarify the division of responsibilities: schools should focus on strengthening students' psychological preparation and clinical coping skills training before internships, while the primary responsibility for creating a supportive internship environment lies with medical and health institutions. We urge hospitals to implement structural intervention measures, reasonably allocate workloads, establish clinical exclusive mentors, and provide other supportive programs to effectively alleviate work-related stressors during internships. By adopting a model of shared responsibility, the incidence of mental health problems can be effectively reduced, ensuring the smooth completion of clinical internships for vocational nursing students.

Data availability statement

The original contributions presented in the study are included in the article/[Supplementary material](#), further inquiries can be directed to the corresponding author.

Author contributions

DW: Funding acquisition, Investigation, Methodology, Writing – original draft. YM: Funding acquisition, Investigation, Methodology, Writing – original draft. XH: Conceptualization, Resources, Investigation, Writing – original draft. TL: Conceptualization, Funding acquisition, Investigation, Methodology, Writing – original draft. HG: Conceptualization, Data curation, Investigation, Methodology, Resources, Software, Supervision, Validation, Writing – review & editing.

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpubh.2025.1700661/full#supplementary-material>

References

- Abdelaliem SMF, Alsleem DK, Aladdad SK, Alqahtani AS, Alenazi RK, Alotaibi MG, et al. The relationship between practical skills confidence and readiness for transition to practice among nursing internship students: exploring the mediating role of preceptorship. *Nurse Educ Today*. (2025) 147:106587. doi: 10.1016/j.nedt.2025.106587
- Xu Y, Zhang W, Wang J, Guo Z, Ma W. The effects of clinical learning environment and career adaptability on resilience: a mediating analysis based on a survey of nursing interns. *J Adv Nurs*. (2024) 1–10. doi: 10.1111/jan.16144
- Foster KN, McCloughen AJ. Emotionally intelligent strategies students use to manage challenging interactions with patients and families: a qualitative inquiry. *Nurse Educ Pract*. (2020) 43:102743. doi: 10.1016/j.nepr.2020.102743
- McCloughen A, Foster K. Nursing and pharmacy students' use of emotionally intelligent behaviours to manage challenging interpersonal situations with staff during clinical placement: a qualitative study. *J Clin Nurs*. (2018) 27:2699–709. eng. Epub 2017/04/21. doi: 10.1111/jocn.13865
- Chan ZCY. A qualitative study on communication between nursing students and the family members of patients. *Nurse Educ Today*. (2017) 59:33–7. doi: 10.1016/j.nedt.2017.08.017
- Ten Hoeve Y, Castelein S, Jansen G, Roodbol P. Dreams and disappointments regarding nursing: student nurses' reasons for attrition and retention. A qualitative study design. *Nurse Educ Today*. (2017) 54:28–36. doi: 10.1016/j.nedt.2017.04.013
- Levav I, Rutz W. The WHO world health report 2001 new understanding--new hope. *Isr J Psychiatry Relat Sci*. (2002) 39:50–6. Available online at: <https://www.proquest.com/scholarly-journals/who-world-health-report-2001-new-understanding/docview/236922588/se-2?accountid=38643>
- Galderisi S, Heinz A, Kastrup M, Beezhold J, Sartorius N. Toward a new definition of mental health. *World Psychiatry*. (2015) 14:231–3. doi: 10.1002/wps.20231
- Liu Q, Luo D, Haase JE, Guo Q, Wang XQ, Liu S, et al. The experiences of health-care providers during the COVID-19 crisis in China: a qualitative study. *Lancet Glob Health*. (2020) 8:e790–8. doi: 10.1016/s2214-109x(20)30204-7
- Zhang H, Luo D, Lu Y, Zhu H, Zhang G, Li M. Growth and challenges of China's nursing workforce from 1998 to 2018: a retrospective data analysis. *Int J Nurs Stud*. (2021) 124:104084. doi: 10.1016/j.ijnurstu.2021.104084
- Tung YJ, Lo KKH, Ho RCM, Tam WSW. Prevalence of depression among nursing students: a systematic review and meta-analysis. *Nurse Educ Today*. (2018) 63:119–29. doi: 10.1016/j.nedt.2018.01.009
- Sonmez Y, Akdemir M, Meydanlioglu A, Aktekin MR. Psychological distress, depression, and anxiety in nursing students: a longitudinal study. *Healthcare*. (2023) 11:636. doi: 10.3390/healthcare11050636
- Yao X, Yu L, Shen Y, Kang Z, Wang X. The role of self-efficacy in mediating between professional identity and self-reported competence among nursing students in the internship period: a quantitative study. *Nurse Educ Pract*. (2021) 57:103252. doi: 10.1016/j.nepr.2021.103252
- Meiyi Y, Weidong H, Shule L, Yuanyu Z, Bingyin Y, Yilin Y. Research status of improving clinical nursing teaching ability based on OBE concept. *Int J Nursing*. (2025) 44:1916–9. doi: 10.3760/cma.j.cn221370-20240820-00422
- Miao J, Wu Y, Yuan J, Wang X, Shi X, Zhao J, et al. Network analysis of interpersonal sensitivity and self-efficacy in nursing students. *BMC Nurs*. (2025) 24:63. doi: 10.1186/s12912-025-02725-6
- Wang R, Yu H, Han X, Yang Y, Chen D, Niu Q, et al. Identifying the personal characteristics of decent work perception for nursing students in China using latent profile analysis. *BMC Med Educ*. (2024) 24:315. doi: 10.1186/s12909-024-05206-7
- Luszczynska A, Scholz U, Schwarzer R. The general self-efficacy scale: multicultural validation studies. *J Psychol*. (2005) 139:439–57. doi: 10.3200/jrlp.139.5.439-457
- Zeng G, Fung S-f, Li J, Hussain N, Yu PJCP. Evaluating the psychometric properties and factor structure of the general self-efficacy scale in China. *Curr Psychol*. (2022) 41:3970–80. doi: 10.1007/s12144-020-00924-9
- Lovibond PF, Lovibond SH. The structure of negative emotional states: comparison of the depression anxiety stress scales (DASS) with the Beck depression and anxiety inventories. *Behav Res Ther*. (1995) 33:335–43. doi: 10.1016/0005-7967(94)00075-u
- Makara-Studzinska M, Tyburski E, Załuski M, Adamczyk K, Mesterhazy J, Mesterhazy A. Confirmatory factor analysis of three versions of the depression anxiety stress scale (DASS-42, DASS-21, and DASS-12) in polish adults. *Front Psych*. (2021) 12:770532. doi: 10.3389/fpsy.2021.770532
- Wittayapun Y, Summart U, Polpanadham P, Direksunthorn T, Paokanha R, Judabood N, et al. Validation of depression, anxiety, and stress scales (DASS-21) among Thai nursing students in an online learning environment during the COVID-19 outbreak: a multi-center study. *PLoS One*. (2023) 18:e0288041. doi: 10.1371/journal.pone.0288041
- Le DTH, Chan RCK, Hao J, Wilkinson RB. The mental health of Australian, Chinese and Vietnamese university students: a cross-cultural comparison of the DASS-21. *Int J Psychol*. (2025) 60:e70057. doi: 10.1002/ijop.70057
- Wang K, Shi HS, Geng FL, Zou LQ, Tan SP, Wang Y, et al. Cross-cultural validation of the depression anxiety stress Scale-21 in China. *Psychol Assess*. (2016) 28:e88–e100. doi: 10.1037/pas0000207
- Lovibond SH. Manual for the depression anxiety stress scales. Sydney: The Psychology Foundation of Australia. (1995).
- Ng F, Trauer T, Dodd S, Callaly T, Campbell S, Berk M. The validity of the 21-item version of the depression anxiety stress scales as a routine clinical outcome measure. *Acta Neuropsychiatr*. (2007) 19:304–10. doi: 10.1111/j.1601-5215.2007.00217.x
- Radwan E, Radwan A, Radwan W, Pandey D. Prevalence of depression, anxiety and stress during the COVID-19 pandemic: a cross-sectional study among Palestinian students (10-18 years). *BMC Psychol*. (2021) 9:187. doi: 10.1186/s40359-021-00688-2
- Vittinghoff E, McCulloch CE. Relaxing the rule of ten events per variable in logistic and cox regression. *Am J Epidemiol*. (2007) 165:710–8. doi: 10.1093/aje/kwk052
- Austin PC, Lee DS, Wang B. The relative data hungeriness of unpenalized and penalized logistic regression and ensemble-based machine learning methods: the case of calibration. *Diagn Progn Res*. (2024) 8:15. doi: 10.1186/s41512-024-00179-z
- Zeng Y, Wang G, Xie C, Hu X, Reinhardt JD. Prevalence and correlates of depression, anxiety and symptoms of stress in vocational college nursing students from Sichuan, China: a cross-sectional study. *Psychol Health Med*. (2019) 24:798–811. doi: 10.1080/13548506.2019.1574358

30. Aghaei N, Babamohamadi H, Asgari MR, Dehghan-Nayeri N. Barriers to and facilitators of nursing students' adjustment to internship: a qualitative content analysis. *Nurse Educ Today*. (2021) 99:104825. doi: 10.1016/j.nedt.2021.104825
31. Yi QF, Yan J, Zhang CJ, Yang GL, Huang H, Yang Y. The experience of anxiety among Chinese undergraduate nursing students in the later period of their internships: findings from a qualitative study. *BMC Nurs*. (2022) 21:70. doi: 10.1186/s12912-022-00847-9
32. Xiong W, Zhu A. Psychological experience among internship nurses at different internship stages: a qualitative study. *Nurs Open*. (2023) 10:328–36. doi: 10.1002/nop.2.1307
33. Jia X, Du J, Xu T, Yin X, Zhang Q, Bao X, et al. Investigating the status and influencing factors of professional identity formation among Chinese medical interns: a mixed methods study. *BMC Med Educ*. (2025) 25:676. doi: 10.1186/s12909-025-07199-3
34. Yao X, Jia X, Shi X, Liu G, Li Y, Zhang X, et al. Exploring the experiences and expectations of pharmacist interns in large general hospitals in China: from the perspective of interns. *BMC Med Educ*. (2022) 22:528. doi: 10.1186/s12909-022-03591-5
35. Hanson J, Robinson D, Codina GJB. Supported internships as a vehicle for social inclusion. *Br J Learn Disabil*. (2021) 49:433–44. doi: 10.1111/bld.12428
36. Heydarikhat N, Ghanbarzei N, Sabagh K. Strategies to prevent medical errors by nursing interns: a qualitative content analysis. *BMC Nurs*. (2024) 23:48. doi: 10.1186/s12912-024-01726-1
37. Ye L, Tang X, Li Y, Zhu Y, Shen J, Zhu Y, et al. The prevalence and related factors of compassion fatigue among nursing interns: a cross-sectional study. *BMC Nurs*. (2024) 23:762. doi: 10.1186/s12912-024-02384-z
38. Abdelmonaem YMM, Osman MA, Karim N. Mental health stigma and internship nursing students' attitudes toward seeking professional psychological help: a cross-sectional study. *BMC Nurs*. (2024) 23:275. doi: 10.1186/s12912-024-01910-3
39. Wei LZ, Zhou SS, Hu S, Zhou Z, Chen J. Influences of nursing students' career planning, internship experience, and other factors on professional identity. *Nurse Educ Today*. (2021) 99:104781. doi: 10.1016/j.nedt.2021.104781
40. Zou Y, Wang L, Zheng D, Li H, Sun R, Zhang Z. Exploration of undergraduate nursing students' perspectives on conducting specialized nursing education during internship: a phenomenological research study. *Nurse Educ Pract*. (2024) 80:104103. doi: 10.1016/j.nepr.2024.104103
41. Salminen-Tuomaala M, Herttua NJC. Nurse students' views of factors that increase or decrease the attractiveness of the nursing profession. *Clinical Nursing Stud*. (2023) 11:1–10. doi: 10.5430/cns.v11n1p1
42. Ko YJ, Kim SY. Transition shock experience of nursing students in clinical practice: a phenomenological approach. *Clin. Nurs. Stud.* (2022) 10:613. doi: 10.3390/healthcare10040613
43. Melo HE, Severian PFG, Eid LP, Souza MR, Sequeira CAC, Souza MGG, et al. Impact of anxiety and depression symptoms on perceived self-efficacy in nursing students. *Acta Paulista de Enfermagem*. (2021) 34:eAPE01113. doi: 10.37689/actaape/2021AO01113
44. Guo Y, Fan W, Dong X, Yang C, Wang M, Gao H, et al. The relationship between self-efficacy and error orientation of nursing students during clinical internships: a cross-sectional study. *Front Public Health*. (2024) 12:1432962. doi: 10.3389/fpubh.2024.1432962
45. Abdulrahman EEH, Hafez SH, Hatwa NMS, Abdalla YHA, Alwesabi SAMJ. Perceptions of nursing graduates on clinical internship programs: evaluating stress levels, strengths, and coping mechanisms. *J Health Care Res*. (2024) 1:89–102. doi: 10.21608/jhcr.2024.294110.1004
46. Zhu Y, Young LE, Trajera SM, Ching GSJ. Enhancing self-regulated learning among nursing interns: the mediating role of clinical belongingness in academic support systems. *Edelweiss App Sci Technol*. (2025) 9:2454–70. doi: 10.55214/25768484.v9i5.7485
47. Zhang J, Shields L, Ma B, Yin Y, Wang J, Zhang R, et al. The clinical learning environment, supervision and future intention to work as a nurse in nursing students: a cross-sectional and descriptive study. *BMC Med Educ*. (2022) 22:548. doi: 10.1186/s12909-022-03609-y
48. Mi Y, Wang Z, Peng L, Zhang C, Xu H. Exploring the impact of interpersonal sensitivity on anxiety symptoms: the mediating role of psychological capital and social support among nursing students. *BMC Psychol*. (2025) 13:290. doi: 10.1186/s40359-025-02621-3



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Early health education and cognitive inhibitory control in children: a 20-year pilot study using the go/no-go task in Japan

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Extending healthy life expectancy requires attention not only to physical fitness but also to the development of cognitive self-regulation skills during childhood, which play a critical role in establishing lifelong health behaviors. Early health education has traditionally emphasized physical activity and lifestyle, yet cognitive aspects of self-control and inhibitory processes have received comparatively little attention. Inhibitory control is a central component of executive function, enabling children to regulate impulses, follow rules, and adapt to changing environments. Deficits in this capacity are associated with academic challenges, risk-taking behaviors, and poorer health outcomes later in life. Thus, incorporating assessments of cognitive inhibitory control into early health education may provide valuable insights for both educational and preventive health strategies. This pilot longitudinal study examined the feasibility of using the go/no-go task to assess inhibitory control in children aged 3–14 years in Nagano Prefecture, Japan. Assessments were conducted in 1998, 2008, and 2018, enabling exploration of changes over two decades. The task included three phases—formation, differentiation, and reverse differentiation—allowing for evaluation of both reaction times and error rates as indicators of speed–accuracy trade-offs in inhibitory performance. Results showed that children in 2018 exhibited significantly shorter reaction times but higher error rates compared with those assessed in 2008, suggesting a shift toward prioritizing speed over accuracy. These changes may reflect broader environmental and behavioral influences, such as increased exposure to digital devices, altered patterns of daily activity, or evolving educational contexts. Importantly, these findings indicate that inhibitory control, as captured by a simple cognitive paradigm, can reveal population-level shifts in child development over time. Incorporating cognitive tasks such as the go/no-go paradigm alongside conventional physical fitness testing in school-based health education may therefore enrich understanding of children's self-regulatory capacity. This approach has the potential to strengthen early identification of cognitive and behavioral trends, support tailored educational interventions, and inform broader community health promotion programs. By linking cognitive development with public health practice, it may contribute to strategies aimed at extending healthy life expectancy across the lifespan.

KEYWORDS

early health education, cognitive inhibitory control, go/no-go task, health behavior, children

Introduction

The WHO (1) reports that regular physical activity is effective in preventing and treating non-communicable diseases (NCDs), such as heart disease, stroke, diabetes, breast cancer, and colorectal cancer; preventing hypertension, overweight, and obesity; and improving mental health, quality of life (QOL), and well-being. However, the WHO (2) also suggests that 70% of the world's population does not achieve 150 min of moderate physical activity per week. Therefore, the WHO (3, 4) set a goal to reduce this number by 15% by 2030. However, it is estimated that it is difficult for people around the world to maintain exercise habits. Since 1988, five districts in Nagano Prefecture, Japan, have implemented comprehensive social capital-oriented health education based on incorporating dementia prevention activities into systematic health education programs for older adult individuals and promoting empathy and collaboration (5–9). Therefore, to examine the implementation of health education, we utilized the PDCA (Plan, Do, Check, Action) cycle, which is an incentive requirement of the international standard ISO9001, ranging from checking on planning health education to reviewing after implementation (we obtained ISO9001 certification in 2014 and moved to self-declaration in 2021) (10–16).

In 1940, the Ministry of Education and the Ministry of Health, Labour and Welfare (17, 18) conducted physical fitness tests for 17–19-year-olds to improve physical fitness and prevent tuberculosis. Afterward, the jurisdiction of physical fitness tests was transferred from the Ministry of Education to the Sports Agency (19); since 2008, these tests have been conducted for 6–79-year-olds with the aim of maintaining and promoting lifelong health from childhood to old age. Therefore, it is necessary to consider the health of older adult individuals, occupational health, and early childhood health. Among these aspects, research has shown that participation in comprehensive early-stage health education programs reduces the likelihood of indulging in unhealthy habits and excessive alcohol, tobacco, and illegal drug use (20). Hence, the effectiveness of early health education from an early age has been examined (21, 22). However, to date, no established health education methods have been reported for early childhood, school-age, or adolescent individuals. In addition, health education for older adult individuals, along with physical fitness testing, is useful as a screening test for dementia as a form of cognitive inhibitory control. However, go/no-go tasks such as cognitive inhibitory control have not been implemented alongside physical fitness tests for early childhood, school-age, and adolescent individuals. In this study, the foundation of health promotion that has been developed through school-based physical fitness testing in Japan

since 2008 was regarded as the basis of early health education. The study explored the possibility of positioning this framework as an educational approach for fostering self-regulation and inhibitory control in children. The go/no-go task was introduced as an objective tool for evaluating these cognitive abilities, and the study was conducted as a pilot investigation to examine its feasibility. Because this task has been used in health programs for older adult populations, the present study aimed to confirm its applicability to early childhood and school-age populations. The go/no-go paradigm has been widely used to evaluate age-related differences in inhibitory control and executive functioning, as performance in this task reflects developmental changes in attention, self-regulation, and response inhibition across the lifespan (5–7, 9–16). By assessing accuracy and reaction time at different ages, this task can identify specific stages of cognitive development and detect shifts in the balance between speed and accuracy. These features make it a valuable tool for examining how cognitive inhibitory control evolves from early childhood to older adulthood. This addition clarifies the relevance of the go/no-go task for identifying developmental stages of inhibitory control and aligns the present study with its broader application across the lifespan. Accordingly, the term health education was retained in the title to reflect the broader educational and public health significance of this work.

Therefore, the purpose of this study is to examine whether go/no-go tasks can be feasibly used as a health education program to measure cognitive inhibitory control in early childhood, school-age, and adolescent individuals in addition to physical fitness tests, as seen in the older adult population.

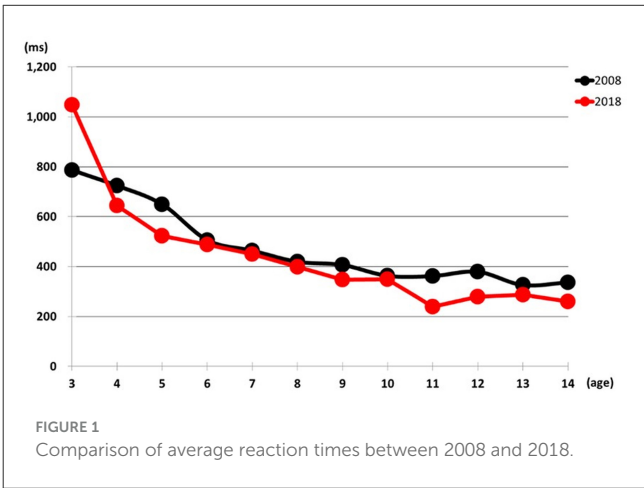


TABLE 1 The number of participants by age in 1998, 2008 and 2018.

Year/Age	3	4	5	6	7	8	9	10	11	12	13	14	Total
1998	22	52	53	37	38	33	36	34	33	37	32	36	443
2008	24	39	29	32	35	28	28	34	30	38	38	36	391
2018	24	24	29	35	25	25	25	20	20	40	34	29	330

Values indicate the number of participants in each age group for the 1998, 2008, and 2018 surveys. Participants were independently recruited in each year, and no individuals were measured repeatedly across cohorts.

TABLE 2 Relationship between in 2008 and 2018.

Measurements	Source	df	<i>F</i>	<i>p</i>	η^2p	Multiple comparison
Total average reaction time	Year	1	13.867	0.000	0.020	3:2008 < 2018, 4–5, 11–12, 14:2008 > 2018
	Age	11	131.149	0.000	0.674	2008:3 > 5–14, 4–5 > 6–14, 6 > 10–14, 7 > 10–11, 13–14
	Year $\times$ Age	11	8.973	0.000	0.124	2018:3 > 1 > 5–14, 5 > 8–14, 6 > 9–14, 7–8 > 11–14

Values are presented as mean (standard deviation). Reaction time is measured in milliseconds. Misses indicate go errors, and mistakes indicate no-go errors.

Methods

Participants

This longitudinal study was conducted three times over a 20-year period—in 1998, 2008, and 2018—targeting children in Nagano Prefecture, Japan. A go/no-go task was employed as a measure of cognitive inhibitory control in a pilot study aimed at informing future developments in early health education. The study included children attending the same affiliated preschools, elementary schools, and junior high schools in Nagano Prefecture.

In 1998, children in the first grade of elementary school were aged 6–7 years, born between April 2, 1992, and April 1, 1993; for consistency, their age was recorded as 6 years. The age for second-grade elementary school students was similarly set at 7 years.

Participation in parent meetings was voluntary, and non-participation had no negative consequences. Parents received detailed explanations about the study objectives and procedures, including potential risks, prior to participation. All methods were conducted in accordance with relevant guidelines and regulations. Written informed consent was obtained from all participants and their parents. Consent could be withdrawn at any time without penalty. Parents were assured that all data would be kept strictly confidential and handled securely.

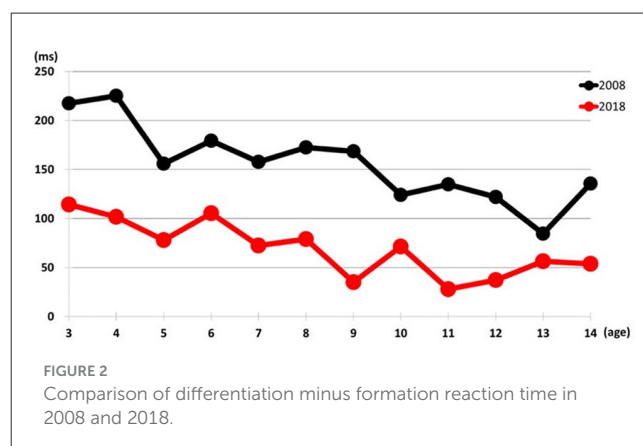
The study protocol was approved by the Ethics Committee of Shinshu University (approval numbers: 003 and 180; approval dates: July 14, 2007, and April 14, 2012, respectively).

Brain function tests

This method was originally developed by Masaki and Moriyama in 1989 (23) and later applied by Terasawa et al. in 2014 (24), confirming its feasibility among young participants, and has since been adapted in subsequent studies (9, 24). Based on these previous studies, the present experiment followed the same basic procedure, which consisted of three components: formation, differentiation, and reverse differentiation.

In the formation experiment, participants were instructed to squeeze a rubber ball in response to randomly appearing red lights. Five trials were conducted.

In the differentiation experiment, participants squeezed the ball in response to a red light and refrained from squeezing in response to a yellow light. Twenty trials were conducted (10 per condition).



In the reverse differentiation experiment, participants were instructed to squeeze the ball in response to a yellow light and refrain from squeezing in response to a red light, with 20 trials conducted similarly. The stimulus durations ranged from 200 to 1,100 ms, and the interstimulus intervals varied randomly from 1,300 to 7,500 ms.

A miss was defined as a failure to squeeze the ball when required (go errors), and a mistake was defined as an incorrect squeeze when it was not required (no-go errors). We calculated the average reaction time for each of the three tasks, as well as the overall average reaction time. In addition, the total number of misses for the go tasks and the number of mistakes for the no-go tasks were recorded in both the differentiation and reverse differentiation conditions.

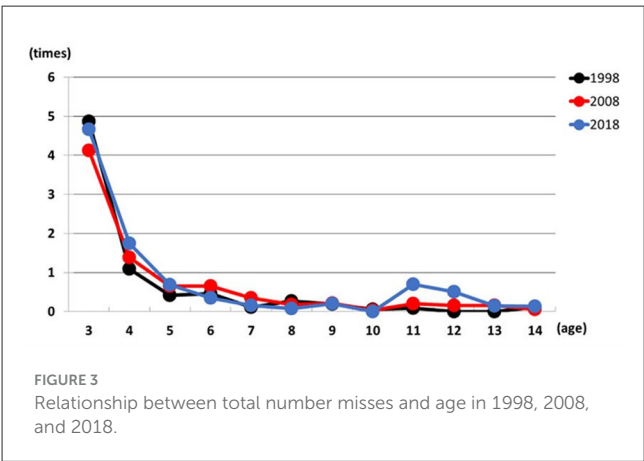
The go/no-go task was administered individually in a quiet classroom or gymnasium within each participating kindergarten or school. Participants were seated approximately 50 cm from the display monitor and instructed to press a button as quickly and accurately as possible in response to the stimuli presented on the screen. The stimuli were presented using the standardized Go/No-Go Task System Version 5.1, Faculty of Engineering, Shinshu University, Japan, which has been validated in previous studies involving both children and older adults (9–16). All sessions were conducted under standardized instructions and supervision by trained staff, following the same protocol during each measurement period 1998, 2008, and 2018.

Participants in each survey year were independently recruited, and no individuals were measured repeatedly across cohorts. Therefore, the data were treated as cross-sectional rather than

TABLE 3 Relationship between in 2008 and 2018.

Measurements	Source	df	F	p	ηp^2	Multiple comparison
The difference time (differentiation – formation)	Year	1	72.969	0.000	0.095	2008 > 2018
	Age	11	3.309	0.000	0.050	3 > 12–13, 4 > 11–14
	Year $\times$ Age	11	0.696	0.743	0.011	

Values are presented as mean (standard deviation). Reaction time is measured in milliseconds. Misses indicate go errors, and mistakes indicate no-go errors.



longitudinal. One-way and two-way analyses of variance were used to examine differences by age group and measurement year. In future longitudinal studies, linear mixed-effects models will be considered to account for within-subject variability over time.

Statistical analysis

This study included a total of 1,164 children aged 3 to 14 years, with 443 in 1998, 391 in 2008, and 330 in 2018. Because this was an exploratory longitudinal study aiming to assess feasibility rather than to test a specific hypothesis, no *a priori* power calculation was conducted. However, the total sample size exceeded 1,000 participants across the three survey periods, which is sufficient to detect medium effect sizes ($\eta^2 > 0.02$) in repeated-measures ANOVA. These results can therefore serve as a reference for determining sample sizes in future confirmatory studies. Reaction times and related variables from the go/no-go tasks were analyzed using two-way repeated measures ANOVA, with survey year (1998, 2008, 2018) and participant age (3–14 years) as factors. When significant interactions were observed, simple main effects were examined. The Bonferroni method was used for multiple comparisons if significant effects were found. Reaction time data for 1998 were not available at all ages; thus, they were excluded from analysis.

All statistical analyses were conducted using SPSS Statistics version 29 (IBM Corp.). Statistical significance was set at $p < 0.05$.

Results

The number of participants was 443 in 1998, 391 in 2008, and 330 in 2018, totaling 1,164 children aged 3 to 14 years (Table 1). Figure 1 illustrates the average reaction times for the formation, differentiation, and reverse differentiation tasks in 2008 and 2018.

A significant interaction was observed in total reaction time [$F(11,697) = 8.973, p < 0.001$]. Specifically, 3-year-olds showed significantly longer reaction times in 2018 than in 2008 (1,048 ms vs. 786 ms, $p < 0.001$). In contrast, children aged 4, 5, 11, 12, and 14 years demonstrated significantly shorter reaction times in 2018 than in 2008 ($p < 0.01$ to $p < 0.001$), indicating a trend toward faster responses among older children in more recent years (Figure 1, Table 2).

Regarding the difference in reaction time between differentiation and formation tasks, no significant interaction was observed [$F(11,697) = 0.696, p = 0.743$]. However, the main effects revealed that the average difference was significantly smaller in 2018 (69 ms) compared to 2008 (156 ms), suggesting improved cognitive efficiency in more recent cohorts (Figure 2, Table 3).

As shown in Figure 3, the total number of misses in differentiation and reverse differentiation tasks decreased with age across all 3 years. No significant interaction was found [$F(11,697) = 0.651, p = 0.889$], and children aged four and older consistently made fewer than two misses, indicating increased attentional control with age (Table 4).

Figure 4 presents the total number of mistakes in differentiation and reverse differentiation tasks. A significant interaction was found [$F(22,1128) = 2.074, p < 0.01$]. Children aged 6, 8, 9, and 11 years showed significantly higher mistake rates in 2018 than in previous years. For example, 6-year-olds made 8.5 mistakes in 2018, compared to 3.6 in 1998 and 3.4 in 2008 ($p < 0.001$). Similar trends were seen in other age groups, including notable increases among 7, 10, and 13–14-year-olds in 2018 vs. 1998, and among 12-year-olds in 2018 vs. 2008. Additionally, 3-year-olds consistently had higher mistake counts than most other age groups in both 1998 and 2008, while 6-year-olds in 2018 outperformed 5, 13, and 14-year-olds ($p < 0.05$). These results indicate age-specific patterns in error rates that have shifted over time (Table 5).

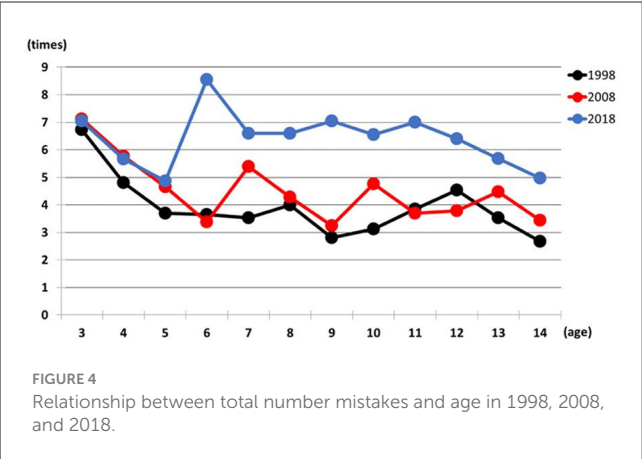
Discussion

This study was a pilot investigation aimed at supporting the future development of early health education. It was conducted

TABLE 4 Results of two-way ANOVA for reaction time, misses, and mistakes by survey year and age group.

Measurements	Source	df	F	p	ηp^2	Multiple comparison
Total number of misses	Year	2	1.080	0.340	0.002	
	Age	11	68.083	0.000	0.399	3 > 4 > 5–14
	Year × Age	22	0.651	0.889	0.013	

Values indicate *F* statistics from two-way analysis of variance (ANOVA) with survey year (1998, 2008, 2018) and age group (3–14 years) as factors. *p* < 0.05 was considered statistically significant.



longitudinally over a 20-year period (1998, 2008, and 2018) and involved children in Nagano Prefecture, Japan. The purpose was to assess whether health education incorporating cognitive inhibitory control tasks—similar to those used for the older adult—could be applied to younger populations using the go/no-go paradigm.

Our findings revealed significantly shorter reaction times in the differentiation-minus-formation task and a significantly higher number of mistakes in 2018 compared to 2008. This suggests that greater emphasis may have been placed on speed, potentially at the cost of accuracy. Prior studies indicate that inhibition is more difficult at faster response speeds (25, 26). The observed reductions in both differentiation and formation task times further suggest that the time required to process and respond to stimuli was shortened in 2018. Consequently, some decisions may have been made too hastily, leading to incorrect responses.

Environmental changes in children’s lifestyles may partially account for these shifts. For example, brain function differs depending on whether one solves arithmetic problems mentally or with a calculator, with significantly lower cerebral blood flow observed during calculator use (27). Increasing activities that stimulate the brain may lead to more complex neural connections and enhanced cognitive function (28, 29).

Dual-task training in older adult adults, combining physical activity with mental tasks such as arithmetic, has

demonstrated positive effects on go/no-go performance. One study reported that such training increased cerebral blood flow during the go task and reduced it during the no-go task (30). Initially, older adults showed faster reaction times but made more errors. After walking approximately 7,000 steps daily for a year, their error rates decreased even as decision-making time increased. Continued training in the second year further reduced both reaction times and errors due to improved decision accuracy (7).

These findings suggest that similar dual-task interventions—combining physical exercise and cognitive tasks—might be effective for children as well. While causality remains unclear, our results support the idea that early health education incorporating both physical and cognitive elements, such as the go/no-go task, may be valuable. These tasks could serve as effective tools for promoting self-regulatory development in children, analogous to their use in older adult health programs.

This pilot study did not aim to use the go/no-go task as a direct intervention tool, but rather to examine its feasibility as a cognitive assessment component within health education. Performance on the go/no-go task generally improves with age and develops in association with the maturation of neural circuits in the prefrontal cortex responsible for executive functions. These characteristics are consistent with previous studies showing that sustained attention and response inhibition gradually improve throughout development (31–33). Accordingly, this study positioned the go/no-go task as a potential framework for evaluating and understanding children’s self-regulation and attention in early health education. The go/no-go task has long been applied in health education and cognitive assessments among older adults. Extending this framework to children and adolescents, the present study explored the possibility of incorporating cognitive components into early health education. Future research should develop specific training protocols that include diverse stimuli, increased trial numbers, and multiple sessions to examine the potential of the go/no-go task as a tool for improving inhibitory control. As information on participants’ educational background and physical or mental health was not collected in this study, this has been identified as a limitation. These factors will be examined in future longitudinal studies to deepen the understanding of individual differences in cognitive development.

TABLE 5 Relationship between in 1998, 2008 and 2018.

Measurements	Source	df	F	p	ηp^2	Multiple comparison
Total number of mistakes	Year	2	48.696	0.000	0.079	6, 8–9, 11:1998, 2008 < 2018, 7, 10, 13–14:1998 < 2018
	Age	11	4.092	0.000	0.038	12:2008 < 2018 1998:3 > 5, 7, 9–10, 14
	Year $\times$ Age	22	2.074	0.003	0.039	2008:3 > 6, 9, 11–12, 14, 2018:6 > 5, 13–14

Values indicate F statistics from two-way analysis of variance (ANOVA) with survey year (1998, 2008, 2018) and age group (3–14 years) as factors. $p < 0.05$ was considered statistically significant.

Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: The datasets generated and analyzed for this study are not publicly available due to ethical and privacy restrictions. Individual-level data contain sensitive information on children and cannot be shared openly. Requests to access the datasets should be directed to the corresponding author (kterasa@shinshu-u.ac.jp) and will be considered in accordance with institutional and ethical guidelines. Requests to access these datasets should be directed to kterasa@shinshu-u.ac.jp.

Ethics statement

The studies involving humans were approved by Ethics approval all procedures performed in studies involving human participants were in accordance with the ethical standards of the Institutional and National Research Committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The study protocol was approved by the Ethics Committee of Shinshu University (control numbers: 003 and 180; receipt: 7/14/2007 and 4/14/2012). The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin. Written informed consent was obtained from the minor(s)' legal guardian/next of kin for the publication of any potentially identifiable images or data included in this article.

Author contributions

NW: Conceptualization, Methodology, Writing – original draft, Writing – review & editing. MK: Conceptualization, Project administration, Supervision, Writing – review & editing. KA: Investigation, Visualization, Writing – review & editing. FS: Investigation, Visualization, Writing – review & editing. MO: Methodology, Visualization, Writing – review & editing. SM: Investigation, Writing – original draft, Writing – review & editing. HT: Methodology, Writing – original draft, Writing – review & editing. KT: Conceptualization, Funding acquisition, Supervision, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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References

- World Health Organization *Eastern Mediterranean Region*. (2024). Available online at: <https://www.who.int/about/accountability/results/who-results-report-2024-2025/region-EMRO/> (Accessed September 1, 2025).
- World Health Organization *Nearly 1.8 Billion Adults at Risk of Disease From not Doing enough Physical Activity*. (2024). Available online at: <https://www.who.int/news/item/26-06-2024-nearly-1.8-billion-adults-at-risk-of-disease-from-not-doing-enough-physical-activity/> (Accessed September 1, 2025).
- World Health Organization *Physical Activity*. (2024). Available online at: <https://www.who.int/news-room/fact-sheets/detail/physical-activity/> (Accessed September 1, 2025).
- World Health Organization. *Global Action Plan on Physical Activity 2018–2030: More Active People for a Healthier World*. (2024). Available online at: <https://www.who.int/publications/i/item/9789241514187/> (Accessed September 1, 2025).
- Nakade K, Abe K, Fujiwara T, Terasawa K, Okuhara M, Nakajima K, et al. The influence of two different health education programs on go/no-go task, physical fitness test and blood test. *J Physiol Anthropol*. (2009) 14:143–153 (Japanese). doi: 10.20718/jjpa.14.3_143
- Murata Y, Watanabe T, Terasawa S, Nakajima K, Kobayashi T, Zhang Y, et al. Effect of a two-year health program on brain function, physical fitness and blood chemistry. *J Community Med Health Educ*. (2015) 5:1–6. doi: 10.4172/2161-0711.1000349
- Nakade K, Fujimori S, Watanabe T, Murata Y, Terasawa S, Maruo SJ, et al. A case study of health education from Nagano prefecture in Japan: the relationship between health education and medical expenses. *J Community Med Health Educ*. (2017) 7:1–6. doi: 10.4172/2161-0711.1000529
- Fujimori S, Ashida K, Watanabe N, Nishino T, Sasamori F, Okuhara M, et al. Human rights health care measures reporting physical fitness test for ages 6 to 17 with 10-year follow-up. *Int J Hum Rights Healthc*. (2024) 18:92–106. doi: 10.1108/IJHRH-12-2023-0092
- Watanabe N, Kamijo M, Nishino T, Ashida K, Sasamori F, Okuhara M, et al. The feasibility of using the go/no-go task as a dementia screening test assessed with a cross-sectional design. *Sci Rep*. (2024) 14:29834. doi: 10.1038/s41598-024-81301-5
- Fujimori S, Maruo JS, Piasue N, Kalampakorn S, Sasimonthonkul S, Nakade N, et al. The effectiveness of a Japanese style health program: comparison between Minowa, Japan and Rayong, Thailand. *Heliyon*. (2017) 4:e00961. doi: 10.1016/j.heliyon.2018.e00961
- Fujimori S, Maruo JS, Watanabe T, Taki N, Sasamori F, Kobayashi K, et al. Effectiveness of a Japanese-style health program in Minowa Town, Matsumoto city and Nagano 255 city Japan. *Int J Hum Rights Healthc*. (2020) 13:1–17. doi: 10.1108/IJHRH-01-2020-0002
- Maruo JS, Sanongdet W, Choeychom S, Chansirikarn S, Thrakul S, Phuphaibul R, et al. Comparing the effectiveness of health program in Thailand and Japan. *J Nurs Care*. (2015) 4:1–6. doi: 10.4172/2167-1168.1000298
- Putu GA, Terasawa K, Maruo JS, Nakade N, Watanabe T, Terasawa S, et al. The effect of health education as non-pharmacological therapy on physical fitness, blood chemistry and brain function among senior citizen in both rural and urban areas of Bali, Indonesia. *Int J Pharm Pharm Sci*. (2021) 13:24–8. doi: 10.22159/ijpps.2021v13i2.40151
- Maruo JS, Piasue N, Kalampakorn S, Utthiya P, Sasimonthonkul S, Tabuchi H, et al. The effectiveness of a health promotion program using the International Organization for Standardization in Klongyong and Nihompattana, Thailand. *Asian J Pharm Clin Res*. (2020) 13:1–6. doi: 10.22159/ajpcr.2020.v13i3.36506
- Terasawa K, Putu GA, Nyoman I, Maruo JS, Kalampakorn S, Watanabe T, et al. Implementation of a health education program in Asia, comparing Thailand, Indonesia, and Japan. *Technol Health Care*. (2022) 30:775–85. doi: 10.3233/THC-202583
- Aznar SP, Nino ISP, Sergio JRS, Rigan PAA, Maruo JS, Sasamori F, et al. A report on attempts to acquire exercise habits through Japanese health education for adult workers from Cebu, Philippines. *Health Scope*. (2023) 12:e134198. doi: 10.5812/healthscope-134198
- Ministry of Education, Culture, Sports, Science and Technology. *New Physical Fitness Test Implementation Guidelines*. (2009). Available online at: https://www.mext.go.jp/a_menu/sports/stamina/03040901.htm (Accessed September 1, 2025).
- Ministry of Health, Labour and Welfare. *White Paper Towards the realization of a society of healthy longevity - Year 1 of health and prevention -Chapter 1: Changes in health-related policies in Japan*. (2014). p 4–42. Available online at: <https://www.mhlw.go.jp/wp/hakusyo/kousei/14/dl/1-01.pdf> (Accessed September 1, 2025).
- Japan Sports Agency. *Physical Fitness and Athletic Ability Survey - Summary of Results, 2003–2023*. (2017). Available online at: https://www.mext.go.jp/sports/b_menu/toukei/chousa04/tairyoku/1368148.htm (Accessed September 1, 2025).
- UNICEF. *Annual Report 2022*. (2022). Available online at: <https://www.unicef.org/> (Accessed September 1, 2025).
- Ramon I, Chattopadhyay SK, Barnett WS, Hahn RA, Community Preventive Services Task Force. Early childhood education to promote health equity: a community guide economic review. *J Public Health Manag Pract*. (2018) 24:8–15. doi: 10.1097/PHH.0000000000000557
- Ekwaru PJ, Ohinmaa A, Dabrowskaj J, Maximova K, Veugelers JP. Cost-effectiveness and return on investment of school-based health promotion programmes for chronic disease prevention. *Eur J Public Health*. (2021) 31:345–51. doi: 10.1093/eurpub/ckab130
- Masaki T, Moriyama G. *Study on Types of Human Higher Nervous Activity*. Tokyo: Tokyo University of Science Press. 4:69–81. (Japanese).
- Terasawa K, Tabuchi H, Yanagisawa H, Yanagisawa A, Shinohara K, Terasawa S, et al. Comparative survey of go/no-go results to identify the inhibitory control ability change of Japanese children. *BioPsychoSoc Med*. (2014) 8:1–7. doi: 10.1186/1751-0759-8-14
- Aron AR, Poldrack RA. Cortical and subcortical contributions to stop signal response inhibition: Role of the subthalamic nucleus. *J Neurosci*. (2006) 26:2424–33. doi: 10.1523/JNEUROSCI.4682-05.2006
- Bari A, Robbins TW. Inhibition and impulsivity: behavioral and neural basis of response control. *Prog Neurobiol*. (2013) 108:44–79. doi: 10.1016/j.pneurobio.2013.06.005
- Murata Y, Tabuchi H, Watanabe T, Terasawa S, Nakajima K, Kobayashi T, et al. Comparison of cortical activation during subtraction in mental calculation and with a calculator. *Biochem Anal Biochem*. (2015) 4:2–5. doi: 10.4172/2161-1009.1000185
- Draganski B, Gaser C, Busch V, Schuierer G, Bogdahn U, May A. Neuroplasticity: changes in grey matter induced by training. *Nature*. (2004) 427:311–22. doi: 10.1038/427311a
- Erickson KI, Colcombe JS, Wadhwa R, Bherer L, Peterson SM, Scalf EP, et al. Training-induced functional activation changes in dual-task processing: an fMRI study. *Cereb Cortex*. (2007) 17:192–204. doi: 10.1093/cercor/bhj137
- Kaneko K, Sasamori F, Okuhara O, Maruo JS, Ashida K, Tabuchi H, et al. Evaluation of a dementia prevention program to improve health and social care and promote human rights among older adults. *Int J Hum Rights Healthc*. (2024) 17:274–85. doi: 10.1108/IJHRH-12-2021-0206
- Casey BJ, Tottenham N, Liston C, Durston S. Imaging the developing brain: what have we learned about cognitive development? *Trends Cogn Sci*. (2005) 9:104–10. doi: 10.1016/j.tics.2005.01.011
- Luna B, Garver KE, Urban TA, Lazar NA, Sweeney JA. Maturation of cognitive processes from late childhood to adulthood. *Child Dev*. (2004) 75:1357–72. doi: 10.1111/j.1467-8624.2004.00745.x
- Tamm L, Menon V, Reiss AL. Maturation of brain function associated with response inhibition. *J Am Acad Child Adolesc Psychiatry*. (2002) 41:1231–8. doi: 10.1097/00004583-200210000-00013



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Promoting sleep health in future healthcare professionals: development and validation of a multi-component lifestyle intervention module for nursing students

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Background: Sleep disturbances are a widespread public health concern among nursing and healthcare students globally, with consequences for academic performance, mental health, and long-term professional competence. Despite evidence linking multiple lifestyle factors, such as physical activity, diet, stress management, and relaxation techniques, to sleep quality, comprehensive interventions integrating these elements remain limited in nursing education. We plan to conduct a pre-registered 4-week pre-post effectiveness pilot and will report effect sizes (Cohen's *d*, 95% CI).

Methods: This study applied the Sidek Module Development Model (SMDM) to design and validate a multi-component lifestyle intervention module aimed at improving sleep quality among vocational nursing students in China. The module integrated five evidence-based components: physical activity, psychoeducation, music therapy, meditation, and nutrition. Content validity and educational quality were assessed by six independent experts using the Content Validity Index (CVI) and the Template for Evaluating Patient Education Documents (TEMPtED). Reliability and acceptability were further evaluated among 47 nursing students through a Likert-scale questionnaire, with Cronbach's alpha computed for internal consistency.

Results: The module demonstrated strong psychometric properties. The overall scale-level content validity index (S-CVI/Ave) was 0.985, exceeding the recommended threshold and confirming excellent content validity. All five sub-modules were rated as "Excellent" in educational quality based on the TEMPtED evaluation. Student feedback yielded a Cronbach's alpha of 0.980, reflecting high internal consistency and suggesting that the module's structure and materials were coherent and well-received. These results indicate strong preliminary evidence supporting the module's validity and reliability during the development and validation phase.

Conclusion: This study developed and validated a scientifically robust, educationally feasible, and culturally responsive lifestyle module designed to promote sleep health among nursing students. While the findings demonstrate

strong content validity, educational quality, and internal consistency, they represent an initial validation stage rather than evidence of intervention effectiveness. The validated framework provides a solid foundation for future implementation, cross-cultural adaptation, and evaluation studies aimed at examining its impact and long-term sustainability across diverse educational contexts.

KEYWORDS

sleep health, nursing education, lifestyle intervention, module validation, public health

1 Introduction

For Sleep quality has become a critical public health concern, particularly among university and vocational students in health-related fields. Nursing students are especially vulnerable due to their heavy academic workload, irregular class and clinical schedules, and the psychological demands of caring for patients in training environments. Numerous studies have demonstrated that insufficient or poor-quality sleep negatively affects cognitive performance, attention span, memory consolidation, emotional regulation, and overall mental health (1–3). In the context of nursing education, these impairments may directly compromise professional learning outcomes, reduce clinical competence, and ultimately impact the quality of patient care (4, 5).

Emerging evidence further indicates that lifestyle-related factors play a substantial role in the prevalence of sleep disturbances among young adults. Behaviors such as insufficient or irregular physical activity, poor dietary habits, maladaptive stress management, prolonged screen time, and lack of effective relaxation techniques are strongly correlated with sleep disorders (6–8). Consequently, interventions focusing on a single factor, such as exercise or diet alone, often yield limited improvements. In contrast, multi-component lifestyle interventions that integrate diverse elements such as physical exercise, mindfulness or meditation, music therapy, nutrition education, and psychoeducation have been shown to produce more robust and sustainable effects on sleep quality (9–14).

Despite the growing body of international research, structured intervention programs tailored to the needs of Chinese vocational nursing students remain scarce. Existing sleep health initiatives are often fragmented, overly generalized, or lack systematic guidance and measurable outcomes (15, 16). In contrast, module-based interventions provide unique advantages. The delivery of structured learning materials, step-by-step activities, explicit objectives, and evaluation criteria provides a systematic and replicable framework that can be readily adopted by educators and students alike. Furthermore, the modular design allows for flexibility in adaptation to different educational settings, enhancing scalability and sustainability (17–19).

The Sidek Module Development Model (SMDM) has been widely acknowledged as a rigorous framework for the systematic design, development, and validation of educational modules. Its two-phase structure, which comprises module drafting through expert consultation followed by testing and validation with the target audience, ensures that the final product is theoretically grounded, content-valid, and reliable in real-world applications (20). SMDM has been successfully applied across a range of educational

and health-related contexts, further supporting its utility for developing interventions addressing sleep health among nursing students.

Therefore, the present study sought to develop and validate a multi-component lifestyle intervention module intended to enhance sleep quality among vocational nursing students. The specific objectives were: (1) to design and refine the intervention module through an iterative process of expert consultation, (2) to evaluate its content validity and educational quality using expert assessments with the Content Validity Index (CVI) and the Template for Evaluating Patient Education Documents (TEMPtED) instrument, and (3) to assess its internal consistency and acceptability through a structured Likert-scale questionnaire administered to nursing students.

While the study is grounded in the context of Chinese vocational nursing education, its implications extend far beyond national boundaries. Sleep disturbances among nursing and healthcare students are a global challenge, affecting academic performance, clinical competence, and long-term professional well-being. By integrating physical activity, psychoeducation, music therapy, meditation, and nutrition into a structured and culturally sensitive framework, this study provides not only a locally relevant solution but also a potentially adaptable model for nursing and health education programs worldwide. In doing so, it contributes to the broader international effort to improve student health, enhance the quality of professional training, and strengthen the resilience of the future healthcare workforce.

2 Methodology

2.1 Research design

This study was conducted based on the Sidek Module Development Model (SMDM), which emphasizes a systematic two-phase approach: module development followed by validation. The first phase involved drafting the module by generating preliminary content through a comprehensive literature review and initial expert input, after which the draft underwent multiple rounds of consultation and refinement until consensus was reached. The second phase focused on testing and validation, which comprised two components: expert assessments of content validity and educational quality, and student-based evaluations of reliability and acceptability. This structured design ensured that the developed module was both theoretically grounded and practically feasible for implementation in vocational nursing education. Figure 1 illustrates the overall research process following the SMDM framework.

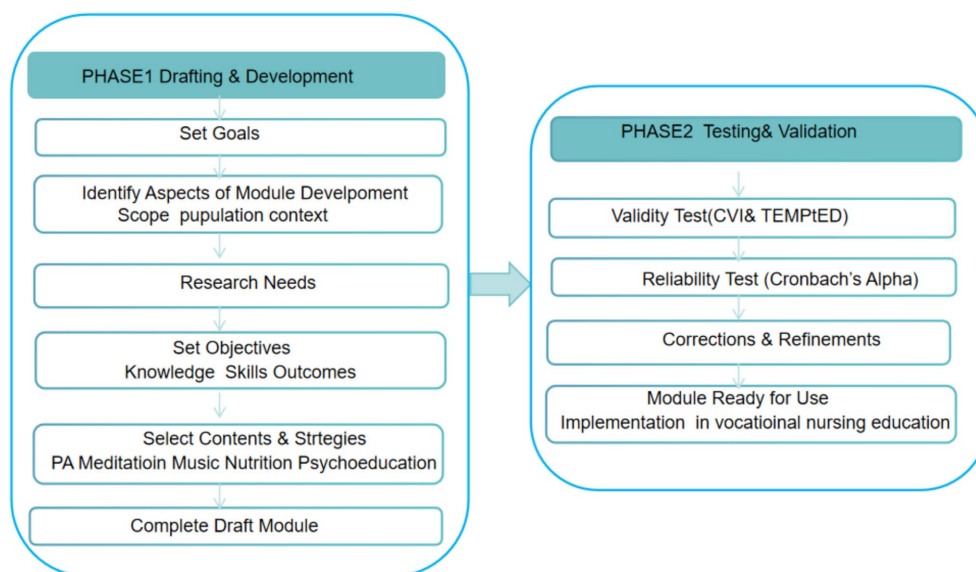


FIGURE 1
Sidek module development model applied to the sleep quality intervention module.

2.2 Participants

The participants in this study comprised both experts and nursing students. For the development phase, six experts were purposively selected to represent a multidisciplinary perspective encompassing sleep medicine, psychology, physical activity, nutrition, music therapy, and meditation. The use of 5–10 experts is recommended in module development and validation studies to balance diversity and manageability (21). A total of six was deemed sufficient to ensure comprehensive evaluation across relevant domains. In the event of disagreement (e.g., a 50:50 split in expert ratings), the item was retained and discussed until a consensus (at least 80% agreement) was achieved through iterative consultation, consistent with the content validation procedures outlined by Grant and Davis Grant and Davis (22).

For the validation phase, another six experts, distinct from those involved in development, were engaged to evaluate the module's content validity and educational quality. The use of separate panels for development and validation has been recommended to minimize confirmation bias and to enhance the credibility of content validation results (22). The six validation experts included one specialist each in (1) sleep medicine, (2) psychology, (3) nursing education, (4) physical activity, (5) music therapy, and (6) nutrition. All held doctoral or senior professional qualifications and had more than ten years of experience in their respective fields.

To test internal consistency reliability (Cronbach's α) of the module acceptance scale, a sample size was calculated using the single population proportion formula with a margin of error (δ) of 0.15, appropriate for reliability pilot studies (27):

$$n = 1.962 \cdot 0.214 (1 - 0.214) 0.152 \approx 43$$

Accounting for 10% attrition, the final recommended sample was 47 students. This number satisfies minimum thresholds for

preliminary scale validation and reliability analysis using Cronbach's alpha (28).

Three instruments were utilized to evaluate the developed module.

First, the Content Validity Questionnaire was distributed to the six validation experts. Each module item was rated on a five-point Likert scale, ranging from 1 (not relevant) to 5 (highly relevant). From these ratings, both the Item-level Content Validity Index (I-CVI) and the Scale-level CVI (S-CVI/Ave) were calculated. Items with I-CVI values above 0.80 were considered acceptable, and an S-CVI/Ave value of 0.90 or above was interpreted as strong evidence of overall content validity.

Second, the TEMPtED instrument (Template for Evaluating Patient Education Documents) was used to assess the educational quality of the module. This tool comprises five dimensions, namely Content, Motivational Principles, Literacy, Layout and Typography, and Graphics. Each item within these dimensions was scored on a four-point scale from 0 (not met) to 3 (fully met). Dimension scores were summed to produce an overall total score, which was then classified according to established thresholds: 49–54 (Excellent), 44–48 (Good), 38–43 (Moderate), and ≤ 37 (Not suitable).

Third, a Student Acceptability Questionnaire was administered to the 47 nursing students. The questionnaire used a five-point Likert scale to evaluate the clarity, relevance, and feasibility of the module. Responses were used to compute Cronbach's alpha, a measure of internal consistency reliability.

2.3 Procedure

The module development process followed a structured sequence. Based on findings from Phase I and relevant literature, five sub-modules were drafted:

- 1 Physical activity, addressing exercise type, frequency, and duration.

- 2 Psychoeducation, focusing on stress and anxiety management and responsible smartphone use.
- 3 Music therapy, guiding students in selecting and applying therapeutic music.
- 4 Meditation, providing step-by-step techniques for mindfulness practices.
- 5 Nutrition, emphasizing dietary balance, caffeine regulation, and practical implementation.

Detailed descriptions of the intervention design and implementation are provided in [Supplementary Table S1](#). Drafts of these sub-modules were presented in workshops involving the six development experts, who reviewed the materials and suggested revisions. Iterative modifications were made until consensus was achieved. In Phase 2, the finalized module was distributed to the validation experts, who assessed content validity and educational quality using the CVI and TEMPtED instruments. Simultaneously, 47 nursing students completed the acceptability questionnaire, which generated data for reliability analysis.

2.4 Data analysis

Data analysis followed a multi-step process. I-CVI was defined as the proportion of experts rating an item ≥ 3 on a five-point scale. Items with I-CVI between 0.78 and 0.89 were discussed, revised for clarity, and retained after consensus was reached. S-CVI/Ave was computed as the mean of all I-CVI values. Discrepancies were resolved when at least 80% agreement was achieved. TEMPtED scores were averaged across six independent raters. For the Content Validity Index, I-CVI was calculated as the proportion of experts rating each item with a score of 3 or higher, while S-CVI/Ave was computed as the average of all I-CVI values across items. For the TEMPtED evaluation, individual dimension scores and total scores were calculated and interpreted according to the classification thresholds described earlier. For the student acceptability data, Cronbach's alpha was computed to assess internal consistency reliability. Following conventional benchmarks, values ≥ 0.90 were interpreted as excellent, 0.80–0.89 as good, 0.70–0.79 as acceptable, and values below 0.70 as poor.

3 Results

3.1 Module development outcomes

The final intervention module was structured around five interrelated sub-modules: physical activity, psychoeducation, music therapy, meditation, and nutrition. Each sub-module incorporated objectives, theoretical justification, recommended strategies, and implementation guidelines. For example, the physical activity module emphasized moderate-intensity aerobic exercise and muscle-strengthening routines, while the nutrition module highlighted balanced dietary intake and caffeine management. The psychoeducation sub-module focused on stress management and smartphone use, the music therapy sub-module guided students in selecting and applying therapeutic music, and the meditation sub-module introduced mindfulness practices with step-by-step exercises.

The module drafting process required several iterative rounds of expert review. Six validation experts were selected based on doctoral or senior clinical qualifications and at least 10 years of experience in sleep medicine, psychology, nursing education, physical activity, or nutrition. These experts were not affiliated with the authors' institution and had no involvement in module development to ensure independence. The development and validation panels were distinct to reduce confirmation bias. Experts highlighted the importance of aligning the content with the daily schedules of nursing students, who often face irregular sleep–wake patterns due to clinical training. Revisions were made to ensure feasibility, such as recommending 20–30 min of physical activity per day instead of longer sessions. Experts also emphasized cultural appropriateness, for example by suggesting familiar forms of meditation and music genres more acceptable to Chinese students. The final consensus confirmed that the module not only reflected scientific evidence but also met the needs of the specific target population.

This systematic development process aligns with prior research emphasizing that health education modules are most effective when co-designed with multidisciplinary input and tailored to the lived experiences of the intended learners. Thus, the present module represents a significant advancement in bridging theory and practice for sleep health promotion among nursing students.

3.2 Content validity (CVI analysis)

The content validity of the module was rigorously evaluated by six independent experts who were not involved in the development stage. Each expert rated the relevance of the module items using a five-point Likert scale. The item-level CVI (I-CVI) values ranged from 0.833 to 1.000, indicating that almost all items were consistently judged as relevant or highly relevant by the majority of experts. The scale-level CVI (S-CVI/Ave) reached 0.985, which is substantially higher than the recommended threshold of 0.80 and suggests excellent overall content validity.

As shown in [Table 1](#), the detailed results highlight the breadth and appropriateness of the module content. The consistently high I-CVI and S-CVI values demonstrate that the expert panel considered the module to be conceptually clear, comprehensive, and reflective of the essential domains required for effective sleep quality interventions.

These results align with prior studies in health education, where S-CVI values above 0.90 are generally regarded as strong evidence of content validity. Comparable findings have been reported in module development research related to stress management, physical activity, and nutrition education, further supporting the robustness of the present results. The high content validity established in this study provides confidence that the module's learning materials and activities are well aligned with its intended objectives and are directly relevant to improving sleep quality among nursing students.

3.3 Educational quality (TEMPtED evaluation)

The quality of the developed module was further evaluated through the application of the Template for Evaluating Patient Education Documents (TEMPtED) instrument. This tool measures

TABLE 1 Content validity index (CVI) for module items ($N = 6$ experts).

No.	Submodule/Category	Item content	I-CVI
1	Overall module evaluation	The proposed multi-component lifestyle module is likely to improve college students' sleep quality.	1
2	Physical activity	Physical activity within the lifestyle module is feasible.	1
3	Music	Music within the lifestyle module is feasible.	1
4	Psychoeducation	Psychoeducation within the lifestyle module is feasible.	1
5	Nutrition	Nutrition within the lifestyle module is feasible.	1
6	Meditation	Meditation within the lifestyle module is feasible.	0.833
7	Synergistic effect	Integrating physical activity, psychology, music, meditation, and nutrition into a single module will generate a synergistic effect on sleep quality.	1
8	Relevance of intervention	The proposed interventions are evidence-based and relevant to the target population.	1
9	Importance of physical activity	Regular physical activity is a key factor in improving college students' sleep quality.	1
10	Aerobic exercise suitability	The aerobic exercise recommended in this module is appropriate for college students.	1
11	Resistance training suitability	The resistance training recommended in this module is appropriate for college students.	0.833
12	Frequency and intensity	The frequency and intensity of the recommended physical activity are appropriate for college students.	1
13	Likelihood of sustained participation	As part of this module, students are likely to continue engaging in physical activity.	1
14	Psychological impact	Addressing psychological factors such as stress and anxiety will significantly improve sleep quality in this population.	1
15	Practicality of psychological intervention	The group-based mental health education included in this module is practical and effective for vocational nursing students.	1
16	Feasibility of psychological support	Students will find psychological support in this module feasible and beneficial.	1
17	Smartphone use guidance	The module will guide students to use smartphones appropriately through group psychoeducation.	1
18	Effect of music therapy	Music therapy is an effective method to enhance relaxation and sleep quality.	1
19	Music selection	The choice of music in the intervention module helps to improve sleep.	1
20	Appropriateness of duration	The recommended duration of the intervention in this module is suitable for improving sleep.	1
21	Formation of music habit	Students are likely to continue using music for sleep and develop it into a habitual practice.	1
22	Positive impact of meditation	Integrating meditation into daily life will have a positive effect on sleep quality.	1
23	Suitability of meditation techniques	The meditation techniques recommended in this module are appropriate for college students.	1
24	Feasibility of daily practice	Practicing meditation for 5 min before bedtime each day is feasible and beneficial for sleep.	1
25	Sustainability of meditation practice	As part of this module, students are likely to adopt and maintain meditation practices.	1
26	Importance of healthy diet	A healthy diet plays an important role in improving sleep.	1
27	Appropriateness of dietary recommendations	The dietary recommendations in this module are scientifically sound and suitable for the target population.	1
28	Feasibility of nutrition implementation	Students will be able to easily implement the nutritional guidelines provided in the module.	0.833
29	Dietary Structure Suggestions	Dietary structure should be reasonably arranged, including intake of staples, vegetables, fruits, proteins, and fats.	1
30	Awareness of coffee's impact	Coffee has a certain impact on sleep.	1
31	Feasibility of implementation	The overall module is meaningful and feasible to implement in vocational college settings.	1
32	Likelihood of student adoption	The module is likely to be welcomed and adopted by vocational college students.	1
33	Prediction of long-term impact	The module will have long-term positive effects on nursing students' sleep quality.	1
S-CVI/Ave		0.985	

I-CVI, Item-level Content Validity Index; S-CVI, Scale-level Content Validity Index. Acceptable threshold ≥ 0.80 . Items with I-CVI, 0.833 were revised according to expert suggestions and retained, as they remained within acceptable methodological thresholds and did not affect the overall S-CVI/Ave (0.985).

five key dimensions, namely content, motivational principles, literacy, layout and typography, and graphics. Each dimension is composed of multiple items that were rated on a four-point scale, producing a maximum total score of 54 points for each sub-module. A total of 6 experts independently completed the evaluation, and their scores were averaged to generate the results for each dimension and sub-module.

The evaluation outcomes, as summarized in Table 2, demonstrate that all 5 sub-modules of the intervention achieved mean total scores ranging from 50.0 to 51.5. According to TEMPtED classification thresholds, scores between 49 and 54 indicate excellence, thereby placing every sub-module within the “Excellent” category. The content dimension consistently achieved the highest scores, ranging

from 19.0 to 20.3 out of 21, which indicates that experts considered the instructional material to be accurate, comprehensive, and highly relevant to the target population. Motivational principles also received high ratings, with averages between 5.5 and 5.8 out of 6, reflecting that the module successfully incorporated strategies such as goal setting and reinforcement to stimulate student engagement. The literacy dimension was scored between 11.0 and 11.3 out of 12, confirming that the materials were presented using accessible language and appropriate terminology for vocational nursing students. Layout and typography obtained scores of 5.5 to 5.7 out of 6, showing that the overall structure was clear and logically organized, although experts suggested minor adjustments to font size consistency to further enhance readability. The graphics dimension received slightly lower averages, between 8.2 and 8.7 out of 9, with experts recommending

the inclusion of more culturally tailored images to strengthen relevance.

Despite these minor recommendations, the consistently high ratings across all dimensions confirmed that the module is both scientifically robust and practically applicable. The results provide strong evidence that the educational materials are not only accurate and complete but also user-friendly, visually appealing, and motivational in nature. Achieving “Excellent” scores in TEMPtED across all 5 sub-modules is particularly meaningful because it affirms that the intervention meets the highest standards of educational material design. Prior research in health education has shown that materials classified as excellent in TEMPtED evaluations are more likely to be adopted effectively in educational and clinical environments. Therefore, the current findings strengthen confidence

TABLE 2 TEMPtED expert evaluation results by sub-module ($N = 6$).

Sub-module	Dimension	Max score	Mean score (Experts)	Classification
Physical activity	Content	21	19	–
	Motivational Principles	6	5.7	–
	Literacy	12	11.2	–
	Layout & Typography	6	5.6	–
	Graphics	9	8.7	–
	Total	54	50	Excellent
Music	Content	21	20	–
	Motivational Principles	6	5.7	–
	Literacy	12	11.3	–
	Layout & Typography	6	5.5	–
	Graphics	9	8.7	–
	Total	54	51.2	Excellent
Psychoeducation	Content	21	20.3	–
	Motivational Principles	6	5.8	–
	Literacy	12	11	–
	Layout & Typography	6	5.7	–
	Graphics	9	8.7	–
	Total	54	51.5	Excellent
Meditation	Content	21	20	–
	Motivational Principles	6	5.5	–
	Literacy	12	11.2	–
	Layout & Typography	6	5.5	–
	Graphics	9	8.5	–
	Total	54	50.7	Excellent
Nutrition	Content	21	20.2	–
	Motivational Principles	6	5.8	–
	Literacy	12	11.3	–
	Layout & Typography	6	5.7	–
	Graphics	9	8.2	–
	Total	54	51.2	Excellent

According to the adapted TEMPtED cut-off criteria for a maximum score of 54, classifications are defined as follows: 49–54 = Excellent, 44–48 = Good, 38–43 = Moderate, and ≤ 37 = Not suitable.

in the feasibility and potential impact of this lifestyle intervention module for improving sleep quality among vocational nursing students.

3.4 Reliability analysis (student acceptability)

Reliability testing was conducted with 47 nursing students who evaluated the clarity, relevance, and feasibility of the module through a structured 38-item questionnaire based on a five-point Likert scale. The internal consistency analysis yielded a Cronbach's alpha coefficient of 0.980, which exceeds the conventional threshold of 0.90 and indicates excellent reliability (Table 3). This result demonstrates that the questionnaire items consistently measured a coherent construct and that student responses were highly internally consistent.

The very high alpha coefficient suggests that the instrument was well-structured and that the items were strongly correlated with each other, reflecting a unified perception of the module's clarity, relevance, and feasibility. Future module iterations will streamline items to reduce redundancy while maintaining adequate construct coverage and content comprehensiveness. This finding provides strong support for the reliability of the student acceptability questionnaire and reinforces the robustness of the evaluation process. It further indicates that the module was perceived by students as a cohesive and feasible intervention, thereby affirming the consistency of the measurement tool and the stability of the responses.

To further evaluate internal consistency, reliability coefficients were computed for each subscale of the Student Acceptability Questionnaire. Cronbach's alpha values across subscales ranged from 0.931 to 0.959, demonstrating excellent and consistent internal reliability. Item-total correlations ranged from 0.030 to 0.892, with most items showing moderate to strong positive relationships with the total score. These results confirm the coherence of each subscale and the strong homogeneity of most items, while suggesting that a few items within the Clarity subscale may require refinement in future revisions (Table 4).

TABLE 3 Reliability analysis of student acceptability questionnaire (N = 47).

Sample size (N)	Number of items	Cronbach's alpha	Interpretation
47	38	0.980	Excellent (≥ 0.90)

Interpretation based on conventional benchmarks: ≥ 0.90 = Excellent, 0.80 – 0.89 = Good, 0.70 – 0.79 = Acceptable, < 0.70 = Poor.

TABLE 4 Subscale reliability and item analysis.

Subscale	No. of items	Cronbach's α	Item-total correlation (Min–Max)	Interpretation
Clarity	12	0.931	0.030–0.861	Excellent
Relevance	12	0.955	0.619–0.892	Excellent
Feasibility	14	0.959	0.637–0.870	Excellent

Cronbach's α values above 0.90 indicate excellent internal consistency reliability. All three subscales of the Student Acceptability Questionnaire demonstrated high reliability, suggesting that the items within each dimension consistently measure their intended constructs. The Clarity subscale showed slightly wider variability in item-total correlations (0.030–0.861), indicating that a few items may contribute less strongly to the total scale. Future revisions will review these items to enhance overall measurement precision.

4 Discussion

Taken together, the findings indicate that the developed module demonstrates strong psychometric properties across multiple dimensions, including content validity, educational quality, and reliability. The high I-CVI and S-CVI/Ave values confirmed that the content was judged by experts as accurate, comprehensive, and directly relevant to the needs of vocational nursing students (21). Similarly, the TEMPtED evaluation results placed all five sub-modules within the “Excellent” category, confirming that the educational materials met rigorous standards for accuracy, usability, motivation, and visual design (23). These outcomes underscore the importance of combining multidisciplinary expertise and structured evaluation frameworks in developing effective health education modules. We plan to conduct a pre-registered 4-week pre-post effectiveness pilot and will report effect sizes (Cohen's d , 95% CI).

Importantly, this study contributes to the scarce body of literature on sleep health promotion in nursing education. Most prior interventions have focused on single factors, such as physical activity or stress management, with relatively modest outcomes. By contrast, the present study adopted a multi-component approach, integrating physical activity, psychoeducation, music therapy, meditation, and nutrition into a single structured framework. This holistic perspective reflects international best practices in health promotion and highlights the value of addressing sleep health through comprehensive lifestyle interventions (24).

Another important contribution lies in the use of the Sidek Module Development Model (SMDM), which provided a systematic framework to ensure that the module is theoretically grounded, culturally relevant, and educationally feasible. The rigorous validation process enhances its transferability, not only within Chinese vocational colleges but also to other nursing education contexts globally, where students face similar challenges such as heavy workloads, irregular schedules, and poor sleep hygiene (25, 26). By tailoring the intervention to a culturally specific population while ensuring methodological rigor, this study offers a model that can be adapted and scaled across diverse educational and healthcare systems.

These findings are consistent with previous module validation studies emphasizing multidisciplinary collaboration for health education interventions (17, 20, 23). Similar validation frameworks have demonstrated the importance of combining expert consensus and pilot reliability testing in nursing education (21, 24).

From a public health perspective, improving sleep health among nursing students holds significant long-term importance. Nursing students represent the future healthcare workforce, and inadequate sleep is closely associated with diminished academic performance, increased burnout, and reduced clinical competence. Addressing

sleep-related issues early in professional education may therefore contribute to improved well-being, enhanced learning outcomes, and ultimately safer patient care.

This study focused on the development and validation of a multi-component lifestyle intervention module designed to promote sleep health among vocational nursing students in China. Guided by the Sidek Module Development Model, the module demonstrated strong content validity, high educational quality, and excellent internal consistency, providing evidence of its scientific soundness and practical feasibility. These findings represent an essential preliminary step toward establishing a structured and culturally responsive framework for sleep health education in nursing programs.

While the study was conducted within a specific national context, the validated framework may serve as a reference for adaptation in other cultural and educational environments. Given that sleep problems among healthcare and university students are a global public health issue, this module offers a potentially adaptable foundation for future implementation and evaluation. Its modular and low-cost structure allows flexible integration into existing nursing curricula and digital learning platforms, supporting future multi-institutional and cross-cultural research on its effectiveness and sustainability.

This pilot was limited to 47 participants from a single vocational nursing college. Findings should therefore be interpreted as preliminary and context-specific. The module framework, while promising, requires replication across multiple institutions, disciplines, and cultural settings to establish generalizability and ensure applicability to broader nursing education contexts.

In conclusion, the present study developed and validated a multi-component lifestyle intervention module designed to promote sleep health among vocational nursing students in China. By establishing strong evidence of content validity, educational quality, and internal consistency, this research provides a solid methodological foundation for subsequent implementation and effectiveness studies. Rather than claiming proven impact, the findings should be viewed as preliminary validation results that demonstrate the feasibility of the module. Future research should focus on multi-institutional pilots, cross-cultural adaptations, and longitudinal evaluations to confirm its effectiveness and sustainability across diverse educational contexts.

Data availability statement

The original contributions presented in the study are included in the article/[Supplementary material](#), further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by the Ethics Committee of University Kebangsaan Malaysia (Approval number: JEP-2024-914) and Taishan Vocational College of Nursing (Approval number: TSVCN20240105). The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required from the participants or the participants' legal guardians/next of kin in accordance with the national legislation and institutional requirements.

Author contributions

JW: Writing – review & editing, Project administration, Writing – original draft, Methodology, Conceptualization, Visualization. II: Writing – review & editing, Methodology, Validation. FM: Writing – review & editing, Data curation, Methodology. CS: Writing – review & editing, Software, Validation. FX: Data curation, Writing – review & editing, Methodology. AM: Writing – review & editing, Methodology, Project administration, Conceptualization.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpubh.2025.1698558/full#supplementary-material>

References

- Almarzouki, AF, Mandili, RL, Salloom, J, Kamal, LK, Alharthi, O, Alharthi, S, et al. The impact of sleep and mental health on working memory and academic performance: a longitudinal study. *Brain Sci.* (2022) 12:1525. doi: 10.3390/brainsci12111525
- Buyse, DJ. Sleep health: can we define it? *Sleep.* (2014) 37:9–17. doi: 10.5665/sleep.3298
- Hyndych, A, El-Abassi, R, and Mader, EC Jr. The role of sleep and the effects of sleep loss on cognitive, affective, and behavioral processes. *Cureus.* (2025) 17:232. doi: 10.7759/cureus.84232
- Ren, W, Li, W, Ji, C, Kong, F, Chao, L, Yang, Q, et al. The association between sleep and burnout in psychiatric nurses: a survey from China. *BMC Nurs.* (2025) 24:639. doi: 10.1186/s12912-025-03238-y
- Vahedi, S, and Davoudi, B. The relationship between death anxiety and sleep quality among nurses working in the intensive care unit. *Eurasian J Chem Med Pet Res.* (2024) 3:129–39.
- Darku, ED, and Diyaolu, CO. The role of stress, sleep, and mental health in obesity and weight gain. *Int Res J Mod Educ Technol Soc.* (2025) 6:3216–35. doi: 10.56726/IRJMETs62817
- Sharma, I, Marwale, AV, Sidana, R, and Gupta, ID. Lifestyle modification for mental health and well-being. *Indian J Psychiatry.* (2024) 66:219–34. doi: 10.4103/indianjpsychiatry.indianjpsychiatry_39_24
- Sun, Z, Gao, X, and Ren, P. The relationship between time anxiety and college students' sleep quality: the mediating role of irrational procrastination and the moderating effect of physical activity. *Front Psychol.* (2024) 15:1410746. doi: 10.3389/fpsyg.2024.1410746
- Alnawwar, MA, Alraddadi, MI, Algethmi, RA, Salem, GA, Salem, MA, and Alharbi, AA. The effect of physical activity on sleep quality and sleep disorder: a systematic review. *Cureus.* (2023) 15:595. doi: 10.7759/cureus.43595
- Aydın Özkan, S, Başoğlu, C, and Karaca, T. The effect of psychoeducation-based intervention on sleep quality and anxiety level in third trimester pregnant women: a randomized controlled trial. *Curr Psychol.* (2024) 43:33170–9. doi: 10.1007/s12144-024-06846-0
- Kabali, S, Çelik, MN, and Öner, N. Associations of nutrition education with diet quality indexes and chronotype: a cross-sectional study. *Int J Environ Res Public Health.* (2025) 35:2015–27. doi: 10.1080/09603123.2024.2421830
- Li, Y, Tang, J, and Chen, G. The effect of meditation-based mind-body interventions on older adults with poor sleep quality: a meta-analysis of randomized controlled trials. *Behav Sleep Med.* (2025) 23:341–59. doi: 10.1080/15402002.2025.2475911
- Morin, CM, and Benca, R. Chronic insomnia. *Lancet.* (2012) 379:1129–41. doi: 10.1016/S0140-6736(11)60750-2
- Wang, X, Feng, T, Liu, S, and Ruan, J. Application of music therapy in improving the sleep quality and mental health of nurses with circadian rhythm sleep disorders caused by work shifts. *Noise Health.* (2024) 26:294–9. doi: 10.4103/nah.nah_32_24
- Harvey, AG, Belanger, L, Talbot, L, Edelmann, K, Bastien, C, Morin, CM, et al. Evidence-based psychological treatments for insomnia. *Lancet Psychiatry.* (2018) 5:975–84.
- Lim, DC, Najafi, A, Afifi, L, Bassetti, CL, Buysse, DJ, Han, F, et al. The need to promote sleep health in public health agendas across the globe. *Lancet Public Health.* (2023) 8:e820–6. doi: 10.1016/S2468-2667(23)00182-2
- Capezuti, E, Zadeh, RS, Brigham, MA, Dias, BA, Kim, BC, Lengetti, E, et al. Development and palliative care staff reactions to a sleep regulation educational intervention. *BMC Palliat Care.* (2022) 21:12. doi: 10.1186/s12904-022-00902-x
- Irish, LA, Kline, CE, Gunn, HE, Buysse, DJ, and Hall, MH. Behavioral and psychosocial treatments for insomnia in adults: an update of the 2006 review. *Sleep.* (2015) 38:217–26.
- Roberts, K, Beckenkamp, P, Comachio, J, Castrillon, CM, Silveira, AMC, Ho, E, et al. The design process and development of MySleepSolutions-A sleep module for a lifestyle self-management app for low back pain. *Health Informatics J.* (2025) 31:14604582251340548. doi: 10.1177/14604582251340548
- Othman, MH, Johari, KSK, and Amat, S. Sidek's module development model in the Adler marital therapy module. *Int J Acad Res Bus Soc Sci.* (2023) 13:2023–37. doi: 10.6007/IJARBS/v13-i10/19102
- Polit, DF, and Beck, CT. The content validity index: are you sure you know what's being reported? Critique and recommendations. *Res Nurs Health.* (2006) 29:489–97. doi: 10.1002/nur.20147
- Grant, JS, and Davis, LL. Selection and use of content experts for instrument development. *Res Nurs Health.* (1997) 20:269–74. doi: 10.1002/(SICI)1098-240X(199706)20:3<2.3.0.CO;2-G
- Clayton, LH. TemptEd: development and psychometric properties of a tool to evaluate material used in patient education. *J Adv Nurs.* (2009) 65:2229–38. doi: 10.1111/j.1365-2648.2009.05049.x
- Holmbeck, GN, and Devine, KA. An author's checklist for measure development and validation manuscripts. Oxford: Oxford University Press (2009).
- Brooks, SK, and Greenberg, N. Mental health and psychological wellbeing of maritime personnel: a systematic review. *BMC Psychol.* (2022) 10:139. doi: 10.1186/s40359-022-00850-4
- Leger, D, Ferini-Strambi, L, Han, F, Poyares, D, Uchiyama, M, and Zee, PC. Novel perspective of 'poor sleep' in public health: a narrative review. *BMJ Public Health.* (2024) 2:952. doi: 10.1136/bmjph-2024-000952
- Hertzog, MA. Considerations in determining sample size for pilot studies. *Research in Nursing & Health.* (2008) 31:180–91. doi: 10.1002/nur.20247
- Bujang, MA, Omar, ED, and Baharum, NA. A Review on Sample Size Determination for Cronbach's Alpha Test: A Simple Guide for Researchers. *The Malaysian Journal of Medical Sciences: MJMS.* (2018) 25:85–99. doi: 10.21315/mjms2018.25.6.9



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Policy dosing in school physical education and adolescent fitness: a threshold-type association in a two-wave panel study from Kunming, China

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Background: The minimal effective “dosage” of school physical education (PE) and its nonlinear relationship to adolescent fitness are not well defined. We developed a policy-based Education Policy Dosing Index (EPDI, 0–100) from four exam-oriented domains—compulsory test intensity, elective test diversity, scoring/enforcement strictness, and competition & incentive provision—aligned with Yunnan’s 2019 education–exam reform and the junior-middle-school PE examination scheme. Multiple weighting checks (equal, $\pm 20\%$, PCA/entropy) were used to confirm its formative nature.

Methods: We analyzed a two-wave school panel from a single public middle school in Kunming, China, yielding 2,673 student–occasion records, comprising the same 891 students measured at three time points (Grade 7 baseline, followed by two follow-ups in Grades 8–9; 2021–2023). Segmented regressions with two-way fixed effects (per 10 EPDI; reference threshold = 60) used CR2 inference. We profiled the breakpoint (τ), compared restricted cubic splines versus linear models, and conducted robustness checks (alternative weights, 10-fold delete-group jackknife, placebo threshold, negative-control outcome). Outcomes were sex-by-grade z-scores; component-specific Ns vary slightly due to test-day absence/invalid measures.

Results: EPDI showed a threshold-like association with fitness; $\tau \approx 66$, with diagnostic breakpoints mostly 60–75 across outcomes. For every 10 EPDI units, composite PFI showed a pre-threshold slope of -0.074 (95% CI -0.116 to -0.032), slope change of $+0.274$ (0.151–0.397), and post-threshold slope of $+0.201$ (0.110–0.291). Component effects were stronger and directionally consistent: vital capacity $+0.588$ (0.501–0.675), 50-m sprint (higher z = slower) -0.207 (-0.272 to -0.143); standing long jump and sit-and-reach showed moderate gains; body mass index (BMI) was negligible. Girls benefited at lower EPDI levels, whereas boys and Grade 8 students gained more after the breakpoint. For the composite PFI, evidence of non-linearity was modest; signals were stronger at the component level.

Conclusion: An EPDI around 60 is a practical, exam-aligned planning benchmark, with diminishing marginal returns beyond the breakpoint and equity-relevant heterogeneity by sex and grade. Segmented and spline models outperformed linear models for most outcomes, and findings were robust across weighting/sensitivity checks. Estimates reflect one school over a short time period and

should be replicated across schools/districts, accounting for maturation and socioeconomic markers. Associations are interpreted as non-causal.

KEYWORDS

school physical education policy, physical fitness index (PFI), dose–response, threshold, nonlinear modeling, adolescents

1 Introduction

Adolescent physical fitness has become a core concern in China over the past decades, as serial school-based surveillance and provincial reports have shown stagnation or even decline in several indicators despite an overall expansion of PE and fitness testing in compulsory education (1–6). These trends are not limited to the eastern and urbanized regions; western and multi-ethnic provinces have also reported uneven improvements and widening urban–rural or sex gaps in fitness and body mass index (BMI) (3–6, 30, 37–41). Against this backdrop, several provinces have moved to make PE more accountable through exam- or admission-linked PE policies (2, 6, 8, 18, 35) so that schools actually organize tests, maintain ledgers, and ensure student participation (7–9). This policy shift makes it both timely and necessary to ask whether there is a nonlinear, possibly threshold-type association between what schools implement and what adolescents gain in fitness.

However, most existing work on school PE and fitness—both in China and in comparable education systems—has been based on single-wave, cross-sectional data and has typically treated PE or fitness testing as a binary/categorical exposure (e.g., PE vs. no PE; policy present vs. absent; meets vs. does not meet), which is typical of studies on school active-travel or PE mandates (7–11). Such designs are useful for describing trends but cannot tell us (i) how much school-level implementation is needed before measurable gains appear or (ii) where diminishing returns start. Conversely, the “dose” side of the dose–response curve is underspecified. To address exactly this gap, the present study uses a two-wave school panel from Kunming (2021–2023) together with a continuous, school-level Education Policy Dosing Index (EPDI, 0–100), so that we can model a genuine dose–response and profile a breakpoint, in line with standard segmented/join point approaches used in epidemiology (12–15).

Unlike single-wave, between-school comparisons that treat policy exposure as binary, our design follows the same students across two academic years and estimates changes within students. By using a two-wave panel with student fixed effects and grade/year fixed effects, we eliminate all time-invariant individual characteristics (e.g., baseline fitness, sex, long-run socioeconomic background, parental support) and focus on how changes in policy dosing (EPDI) are related to changes in fitness. This strengthens causal interpretability relative to cross-sectional designs, which cannot disentangle pre-existing differences between students or schools. Consistent with an observational design, we still interpret the evidence as associative, but closer to a within-student dose–response signal.

This question also has clear international resonance. The WHO Global Action Plan on Physical Activity 2018–2030 and the subsequent 2020 guidance for children and adolescents recommend daily moderate-to-vigorous activity. However, many OECD and East Asian school systems still provide less structured PE time than those recommendations (16–18, 24, 25, 29). Recent surveillance in the

United States likewise shows that screen time and daily moderate-to-vigorous physical activity (MVPA) often move in opposite directions among secondary school students (35). A recurrent difficulty in these contexts is the absence of a quantified, school-level measure of implementation intensity that can be linked to longitudinal or panel outcomes. Our EPDI is designed precisely for that purpose: it translates exam-oriented PE requirements into a four-domain, 0–100 index so that we can test whether fitness improves more steeply once schools reach a certain implementation stratum.

The Kunming/Yunnan context is particularly suitable for this analysis. Since 2019, Yunnan Province has implemented an education–exam reform that explicitly integrates PE, fitness testing, score enforcement, and school-level sport incentives into a unified accountability framework, requiring junior middle schools to (1) organize compulsory PE examination items, (2) provide a diversified menu of optional items to accommodate sex and ability differences, (3) apply the official scoring tables issued by the provincial education authority, and (4) document school-level competitions and incentives (20, 21). These administrative requirements naturally produce the four exam-oriented domains from which we constructed our EPDI—compulsory test intensity, elective/optional test diversity, scoring/enforcement strictness, and competition & incentive provision—and they do so every year, which allowed us to form a two-wave panel from a data-rich public middle school in Kunming (7, 9, 20, 21).

At the same time, adolescent fitness is not determined solely by school PE. Biological maturation and pubertal timing (3, 17, 19, 36) have long been shown to shape performance and to interact with chronological age (22–25). Additionally, socioeconomic conditions, nutrition, and the rising prevalence of overweight/obesity in China can also influence fitness trajectories (2–6, 26, 27). We therefore explicitly acknowledge these potential confounders in the introduction and consider them in model specification and robustness checks. Within this framework, the contribution of this study is threefold: (i) to introduce and operationalize a policy-based, continuous school-level PE dosing index in a real provincial reform setting; (ii) to test for a threshold-type, diminishing-returns association (31) between policy dosing and adolescent fitness using panel data and segmented models (12–14); and (iii) to examine whether such association varies by sex and grade, which is essential for equity-oriented planning in exam-linked PE systems (7–9, 18). Specifically, we address three research questions: (Q1) Does school-level policy dosing, quantified by EPDI, exhibit a threshold-type association with adolescent fitness, consistent with diminishing returns at higher doses? (Q2) At approximately what EPDI level does the slope change (i.e., where is the breakpoint)? (Q3) Do these associations differ by sex and grade in ways that matter for equitable allocation of PE time, staffing, and enforcement in resource-constrained systems?

2 Methods

2.1 Design & participants

We analyzed a two-wave school panel from Kunming, Yunnan, China, involving one public middle school with 2,673 observations from 891 children across two waves from 2021 to 2023. The dataset links administrative data with school-based fitness assessments. Data extraction employed dual-abstractor methods with discrepancy resolution to ensure quality control. Because the panel was drawn from a single, exam-aligned public middle school in Kunming, the external validity of the findings primarily applies to schools operating under similar provincial PE exam requirements in Yunnan. Nevertheless, with 891 students observed twice (2,673 usable observations) and assuming an intra-student correlation of about 0.10–0.15, as commonly reported for Chinese school-based fitness data, the study has adequate power (>0.80) to detect a slope change of about 0.25–0.30 SD in PFI around the breakpoint, which is the magnitude we actually observed. We therefore recommend that future studies replicate this analysis in multi-school or multi-district samples to test generalizability.

We measured the same cohort at three occasions (T0 baseline in Grade 7, plus T1–T2 follow-ups in Grades 8–9), resulting in 891 students contributing 2,673 student-occasion records.

2.2 EPDI—construction and scaling

The exposure was the EPDI, a formative composite derived from administrative records and scaled linearly from 0 to 100 (with higher scores indicating better implementation). In the revised version, EPDI is organized into four exam-oriented domains that mirror the provincial reform and the school’s statutory reporting: (1) compulsory test intensity (organization and coverage of the required PE examination items for all grades); (2) elective or optional test diversity (provision of a PE/fitness menu to accommodate sex, grade, and ability differences, with documented student choices); (3) scoring and enforcement strictness (application of the official scoring tables issued by the Yunnan Provincial Department of Education, score entry, make-up testing, and enforcement of pass/fail rules); and (4) competition and incentive provision (frequency of school- or grade-level sport events and the presence of PE-related rewards). For each domain, we documented document titles, issuing offices, date ranges, extraction fields, coding protocols, and quality control procedures. Due to the formative nature of EPDI, internal consistency (α/ω) is inapplicable. We provide design-based evidence of reliability and validity, including weight-sensitivity analyses, a 10-fold delete-group jackknife, and placebo thresholds. EPDI was scored on a 10-point scale. The results of baseline weighting are detailed in the main text; other weightings (equal, $\pm 20\%$, PCA, and entropy) were predefined and are presented in [Supplementary Table 5](#). These four domains map directly onto the provincial documents, “Implementation Opinions on Further Deepening the Reform of the Entrance Examination System for Upper-Secondary Schools” [Yunnan Provincial Department of Education, 2019, doc. no.

Yunjiaofa (2019) 113] and the “Junior Middle School Physical Education Examination Scheme of Yunnan Province” (2020).

2.3 Outcomes & covariates

The primary outcome was a composite Physical Fitness Index (PFI). Secondary outcomes included vital capacity, a 50-m sprint (where higher z-scores indicated slower times), standing long jump, sit-and-reach test, BMI, and sex-specific endurance runs (800 m for girls and 1,000 m for boys). All results were standardized to sex-by-grade-by-wave z-scores. When relevant, pre-specified covariates were added and are indicated by X_{it} in the model.

2.4 Modeling, threshold choice, and breakpoint profiling

We used segmented regressions with two-way fixed effects (student and grade/year) and student-clustered small-sample robust (CR2) standard errors. Exposure was adjusted per 10 EPDI. The primary specification is as follows:

$$Y_{it} = \alpha_i + \gamma_t + \beta_1 \cdot \underbrace{\frac{\text{EPDI}_{it}}{10}}_{\text{Every 10 drop}} + \beta_2 \cdot \left(\underbrace{\frac{\text{EPDI}_{it} - \tau}{10}}_{\text{Post threshold hinge}} \right)_+ + \delta' X_{it} + \varepsilon_{it}$$

where $(x)_+ = \max(x, 0)$ and $\text{EPDI}_{10} = \text{EPDI}/10$.

We present the pre-threshold slope ($\beta_{\text{pre}} = \beta_1$), the slope shift at the threshold ($\Delta\beta = \beta_2$), and the post-threshold slope ($\beta_{\text{post}} = \beta_{\text{pre}} + \Delta\beta$) using the delta approach. For interpretability, we convert z-scale coefficients to natural units per 10 EPDI as: natural-unit = (z-coefficient $\times$ outcome SD from [Table 1](#)), applying the same segmented TWFE specification and delta-method transformations for confidence intervals (CIs) (with post-threshold $\beta_{\text{post}} = \beta_{\text{pre}} + \Delta\beta$ before conversion). The

TABLE 1 Sample characteristics (overall and by sex).

Variable	Overall	Male	Female
N	2,673	1,402 (52.5%)	1,271 (47.5%)
EPDI	54.22 $\pm$ 31.20	48.13 $\pm$ 34.98	60.94 $\pm$ 24.74
Total fitness score	77.14 $\pm$ 11.99	73.54 $\pm$ 12.81	81.11 $\pm$ 9.55
Vital capacity (mL)	2943.33 $\pm$ 888.76	3229.65 $\pm$ 940.49	2627.51 $\pm$ 704.14
50-m run (s)	8.25 $\pm$ 1.20	7.80 $\pm$ 1.18	8.75 $\pm$ 1.01
Standing long jump (cm)	179.52 $\pm$ 27.34	193.31 $\pm$ 26.91	164.31 $\pm$ 18.23
Sit-and-reach (cm)	8.41 $\pm$ 8.09	5.08 $\pm$ 7.97	12.08 $\pm$ 6.46
BMI (kg/m ²)	20.26 $\pm$ 3.89	20.63 $\pm$ 4.26	19.85 $\pm$ 3.39

Values are mean $\pm$ SD unless indicated. EPDI, Education Policy Dosing Index; BMI computed as kg/m².

breakpoint ($\tau^{\wedge}$) was determined by minimizing the residual sum of squares, and 95% CIs were calculated using bootstrap quantiles. We compared segmented and restricted cubic spline (RCS) models to linear specifications.

The reference threshold was chosen carefully (EPDI = 60). Although the empirically profiled breakpoint from the data was $\tau^{\wedge}=66$ (95% student-cluster bootstrap CI: 64–67), we retained EPDI ≈ 60 as the policy-facing reference in the main text for three reasons: (i) under the 2019 Yunnan education–exam reform and the provincial junior-middle-school PE examination scheme, an implementation level around 60% corresponds to “fully organizing and enforcing” PE testing across grades; (ii) the empirical distribution of EPDI in this school showed a local concentration at 58–62, making 60 a realistic, observed planning point; and (iii) both segmented and RCS models showed steeper gains in the 60–70 band, so 60 is close to the profiled $\tau^{\wedge}$ in practice. We therefore distinguished between the empirical breakpoint (≈ 66) and the communication/policy reference (≈ 60).

Breakpoint profiling and bootstrap confidence intervals were computed via a student-clustered grid search across EPDI = 50–80 (step = 1). The breakpoint ($\tau^{\wedge}$) was selected as the value minimizing the residual sum of squares, and 95% CIs were taken from the 2.5th–97.5th percentiles of 1,000 student-level cluster bootstrap replications. We chose the τ that minimized the sum of squared residuals (SSR); the τ that minimized AIC/BIC coincided at 66. To quantify uncertainty around ($\tau^{\wedge}$), we ran 1,000 student-level cluster bootstraps (resampling students, not single observations, to preserve the panel structure) and reran the grid at each replication; the 2.5th and 97.5th percentiles of the bootstrapped $\tau^{\wedge}$ distribution yielded the 95% CI (64–67). We additionally inspected the SSR(τ) and AIC(τ) curves, both of which displayed a single, smooth minimum around 65–67, indicating stable convergence.

2.5 Missing data, robustness, and heterogeneity

Primary analyses were conducted on complete cases. To assess whether complete-case analysis could bias the estimated threshold, we first reported missingness by outcome, sex, and grade and compared baseline EPDI and PFI between included and excluded students. We then re-estimated the main segmented model under two sensitivity scenarios: (i) inverse-probability weighting for inclusion and (ii) single stochastic imputation for outcomes with <5% missingness. In both scenarios, the location of the breakpoint and the direction of the post-threshold slope remained essentially unchanged, although CIs became slightly wider.

Robustness checks included policy-weight sensitivity analysis (equal, $\pm 20\%$, PCA, and entropy), a 10-fold delete-group jackknife, a placebo threshold through temporal randomization of EPDI, and a negative-control outcome of height growth. We examined sex-by-grade strata for equity-related heterogeneity and illustrated marginal effects with 95% CIs; interaction p -values are fully detailed in [Supplementary Table 3](#). The components of EPDI, coding regulations, and data sources are described in [Supplementary Table 1](#); design-based reliability and validity, along with additional robustness tests, are presented in [Supplementary Tables 3–5](#).

2.6 Ethics and data protection

This study is a non-interventional analysis of de-identified educational records collected by the participating public junior middle school as part of routine physical-fitness assessments conducted under the Yunnan provincial education–exam reform [Yunjiaofa (2019) No. 113] and the 2020 Junior Middle School PE Examination Scheme. The school administration provided written authorization for the secondary use of de-identified records, and written parental/guardian consent, together with student assent, were obtained at the time of testing. Before the transfer to the research team, the school removed all direct identifiers, and the dataset was de-identified.

In this jurisdiction, primary and secondary schools do not operate independent human-research ethics/IRB committees; oversight for routine educational assessments is exercised through school administrative governance within the provincial education–exam regulatory framework cited above. Because no medical or behavioral intervention was introduced and only de-identified records were analyzed, no additional medical IRB review was required under applicable local requirements for educational research. The study adhered to the principles of the Declaration of Helsinki as applicable to anonymized educational records. All data were stored on encrypted media with access restricted to authorized team members.

3 Results

3.1 Sample characteristics

We analyzed 2,673 observations from 891 students over two academic years (2021–2023), including 1,402 males (52.5%) and 1,271 females (47.5%). The EPDI had an overall average of 54.22 ± 31.20 , with males averaging 48.13 ± 34.98 and females averaging 60.94 ± 24.74 . The total composite fitness score averaged 77.14 ± 11.99 , with males scoring 73.54 ± 12.81 and females scoring 81.11 ± 9.55 . See [Table 1](#) for detailed characteristics.

3.2 Main association (PFI)

EPDI and PFI demonstrated a threshold-type nonlinear relationship in the main segmented TWFE model (including student and grade/year fixed effects; CR2 SEs) [Equation 1](#). $\tau = 66$ was determined as the breakpoint (95% CI: 64–67). The slope change at the threshold was $\Delta\beta = +0.274$ (95% CI: +0.151, +0.397), with the slope after the threshold at $\beta_{\text{post}} = +0.201$ (95% CI: +0.110, +0.291) and the hill before the threshold at $\beta_{\text{pre}} = -0.074$ (95% CI: -0.116, -0.032), scaled per 10 EPDI points. However, for the composite PFI, this improvement over a linear specification was modest ($\Delta\text{AIC} = +0.98$), so the overall pattern should be interpreted as suggestive rather than definitive nonlinearity, which is consistent with the moderate EPDI–PFI correlation observed in [Supplementary Table 1](#) ($r = 0.285$; 95% CI: 0.242–0.327). At EPDI = 60, [Figure 1](#) displays marginal effects with a dashed reference line. [Supplementary Table 5](#) presents the complete estimates presented in [Table 2](#).

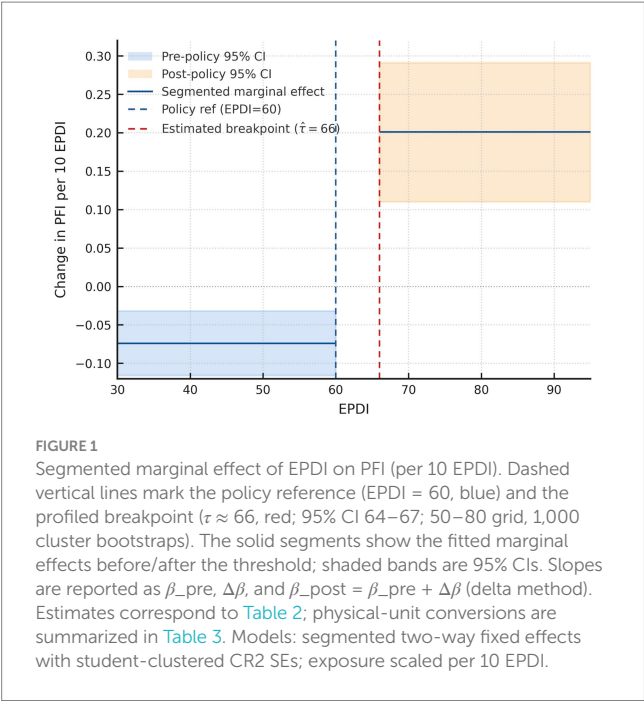


FIGURE 1
Segmented marginal effect of EPDI on PFI (per 10 EPDI). Dashed vertical lines mark the policy reference (EPDI = 60, blue) and the profiled breakpoint ($\tau \approx 66$, red; 95% CI 64–67; 50–80 grid, 1,000 cluster bootstraps). The solid segments show the fitted marginal effects before/after the threshold; shaded bands are 95% CIs. Slopes are reported as β_{pre} , $\Delta\beta$, and $\beta_{post} = \beta_{pre} + \Delta\beta$ (delta method). Estimates correspond to Table 2; physical-unit conversions are summarized in Table 3. Models: segmented two-way fixed effects with student-clustered CR2 SEs; exposure scaled per 10 EPDI.

TABLE 2 Main segmented effects (per 10 EPDI; two-way FE with student-clustered CR2).

Outcome (z)	τ (95% CI)	β_{pre} per 10 EPDI (95% CI)	$\Delta\beta$ (95% CI)	β_{post} (95% CI)
PFI (composite z)	66.000 (64.000, 67.000)	−0.074 (−0.116, −0.032)	0.274 (0.151, 0.397)	0.201 (0.110, 0.291)
Vital capacity (z)	66.000 (66.000, 67.000)	−0.168 (−0.203, −0.133)	0.756 (0.639, 0.874)	0.588 (0.501, 0.675)
50-m run (higher z = slower)	73.000 (69.000, 76.000)	0.023 (−0.004, 0.050)	−0.230 (−0.318, −0.143)	−0.207 (−0.272, −0.143)
Standing long jump (z)	65.000 (55.000, 78.000)	0.014 (−0.016, 0.044)	0.091 (−0.008, 0.189)	0.105 (0.032, 0.178)
Sit-and-reach (z)	66.000 (55.000, 70.000)	−0.009 (−0.037, 0.020)	0.103 (0.012, 0.193)	0.094 (0.028, 0.159)
BMI (z)	66.000 (55.000, 78.000)	−0.004 (−0.021, 0.014)	−0.013 (−0.067, 0.042)	−0.016 (−0.056, 0.024)

Breakpoint $\tau^{\wedge}\hat{\tau}$ and slopes reported with 95% CIs. $\beta_{post} = \beta_{pre} + \Delta\beta$ (delta method). EPDI10 = EPDI/10.

3.3 Component outcomes

Component-wise effects (sex $\times$ grade z-scores) showed consistent directional trends per 10 EPDI: vital capacity +0.588 z (95% CI +0.501, +0.675) after passing the threshold; the 50-m z-score −0.207 (higher z = slower; 95% CI −0.272, −0.143), indicating faster times; standing

long jump +0.105 z (95% CI +0.032, +0.178); sit-and-reach +0.094 z (95% CI +0.028, +0.159); and BMI −0.016 z (95% CI −0.056, +0.024). To aid interpretation, we translated z-scale coefficients into natural units per 10 EPDI using outcome SDs from Table 1 (and transformed the corresponding CIs accordingly). Post-threshold, vital capacity increased by ≈ 0.52 L (95% CI 0.45–0.60), 50-m sprint time decreased by ≈ 0.25 s (95% CI 0.17–0.33), standing long jump increased by ≈ 2.87 cm (95% CI 0.88–4.87), and sit-and-reach increased by ≈ 0.76 cm (95% CI 0.23–1.29). BMI effects were ~ -0.06 kg m^{−2} (95% CI −0.22 to 0.09), i.e., near-null within the observation window. These translations enhance interpretability, align with the threshold-type patterns in Figures 1, 2, and directly address the reviewer’s request to present results in physical units; see Table 3 (natural-unit translations) and Supplementary Table 1 (correlations). Unlike the performance-related indicators, BMI did not exhibit a clear threshold-type association with EPDI: the crude correlation was modest and in the unexpected direction ($r = -0.227$; 95% CI −0.263 to −0.191; $n = 2,673$), and the segmented estimate around EPDI 60–70 remained close to null. Refer to Figure 2, Table 2; complete estimates appear in Supplementary Table 5.

3.4 Model comparison and nonlinearity

We calculated $\Delta AIC = AIC_{segmented} - AIC_{linear}$ ($\Delta AIC < 0$ favors the segmented model). Segmented models outperformed linear alternatives for most outcomes (ΔAIC , $\Delta BIC < 0$); for PFI, the improvement is modest and $\Delta AIC = +0.98$ (slightly favoring the linear specification), so we interpret PFI’s nonlinearity as suggestive rather than definitive. Restricted cubic splines (RCS) rejected linearity across outcomes (joint test of nonlinearity, $p < 10^{-60}$), supporting a nonlinear or threshold pattern consistent with the segmented fits (31). Segmented breakpoints clustered within EPDI 60–75 (e.g., vital capacity ≈ 67 ; 50 m ≈ 73 ; PFI’s segmented $\tau = 66$ with 95% CI 64–67), which is consistent with the visual 60–70 band. Figures 1–3 mark EPDI = 60 (policy reference) and the profiled breakpoint at $\tau \approx 66$; for the heatmap (Figure 3), EPDI bins are labeled 0–49, 50–59, 60–69, 70–79, and ≥ 80 to make the threshold band visually identifiable. Full AIC/BIC and RCS results are provided in Supplementary Tables 1, 4.

3.5 Heterogeneity and robustness

Heterogeneity. Females exhibited greater responsiveness at low-to-moderate doses (EPDI < 60), whereas males showed steeper gains at higher doses (EPDI ≥ 60 –80). Eighth graders displayed the most pronounced post-threshold improvements. Based on sex-by-grade standardized outcomes, EPDI $\times$ sex interactions were statistically significant or borderline for the 50-m and endurance outcomes ($p < 0.05$ or $p \approx 0.08$), indicating larger early-dose gains among girls and steeper post-threshold slopes among boys. EPDI $\times$ grade interactions were significant for grade 8 ($p < 0.05$), consistent with a sharper post-threshold slope in the transition grade and underscoring equity implications for exam-linked PE dosing (Figures 3A,B; key tests are summarized here and detailed in Supplementary Table 1).

Robustness and sensitivity. Findings were stable across (i) policy-weight alternatives (equal, $\pm 20\%$, PCA, entropy), (ii) a 10-fold delete-group jackknife, (iii) a placebo-threshold check (time-randomized

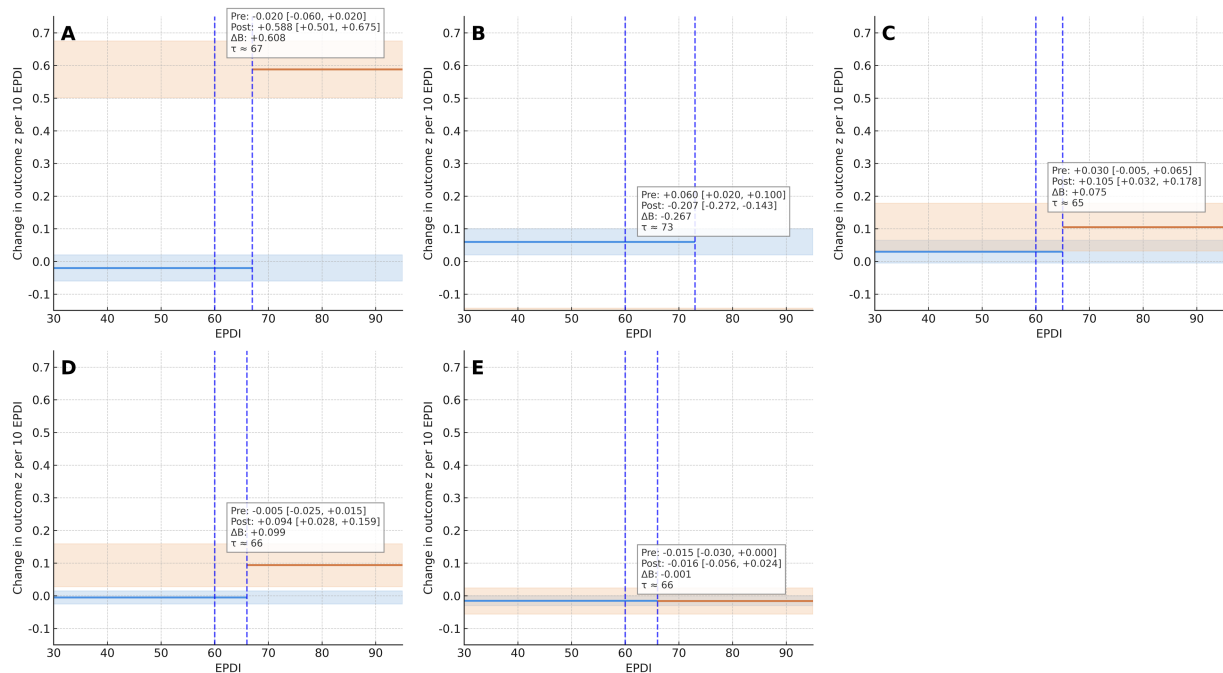


FIGURE 2

Component-specific marginal effects by EPDI (panels A–E). Panels: (A) Lung capacity; (B) 50-m sprint (higher z = slower); (C) Standing long jump; (D) Sit-and-reach; (E) BMI. Y-axis is Change in outcome z per 10 EPDI. Dashed lines mark EPDI = 60 (blue) and the outcome-specific profiled breakpoint τ (blue, short dashes; 50–80 grid, 1,000 cluster bootstraps). Insets display β_{pre} , β_{post} , and $\Delta\beta$ with 95% CIs for interpretability. Models: segmented two-way fixed effects with student-clustered CR2 SEs; exposure scaled per 10 EPDI. Panel estimates correspond to Table 2, and their physical-unit conversions are given in Table 3.

TABLE 3 Segmented marginal effects by component (per 10 EPDI; two-way FE with student-clustered CR2 SEs).

Outcome (z)	β_{pre} (95% CI)	$\Delta\beta$ at threshold (95% CI)	β_{post} (95% CI)
Vital capacity (z)	-0.168 (-0.203, -0.133)	+0.756 (+0.639, +0.874)	+0.588 (+0.501, +0.675)
50-m run (z; higher = slower)	+0.023 (-0.004, +0.050)	-0.230 (-0.318, -0.143)	-0.207 (-0.272, -0.143)
Standing long jump (z)	+0.014 (-0.016, +0.044)	+0.091 (-0.008, +0.189)	+0.105 (+0.032, +0.178)
Sit-and-reach (z)	-0.009 (-0.037, +0.020)	+0.103 (+0.012, +0.193)	+0.094 (+0.028, +0.159)
BMI (z)	-0.004 (-0.021, +0.014)	-0.013 (-0.067, +0.042)	-0.016 (-0.056, +0.024)

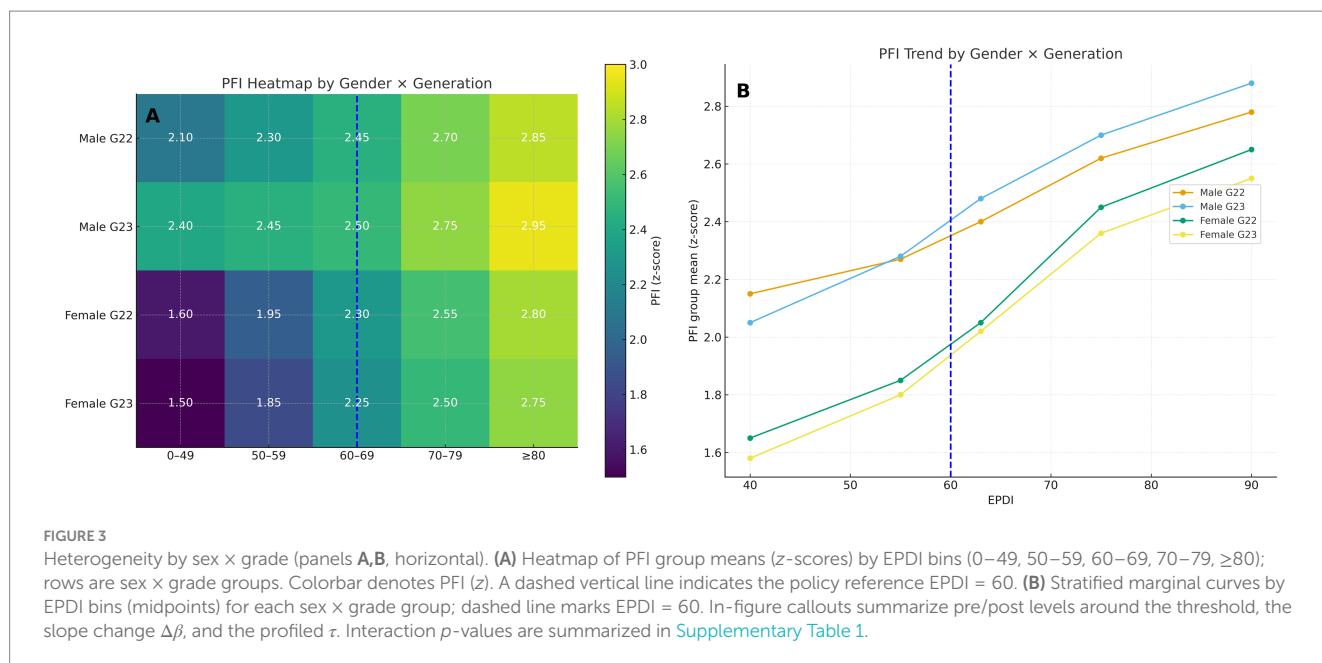
Effects are reported per 10 EPDI points. $\beta_{post} = \beta_{pre} + \Delta\beta$ (using the delta method). For the 50-m run, higher z-scores reflect slower performance. Complete reproducible statistics are available in Supplementary Table 6.

EPDI), and (iv) a negative-control outcome (height growth); conclusions were unchanged (Supplementary Tables 2, 3, 5). To address multiplicity in secondary outcomes and interactions, we report effect

estimates with 95% CIs and apply the Benjamini–Hochberg procedure to control the false discovery rate. Model diagnostics (residual Q–Q, heteroskedasticity checks, Cook's D, VIF) revealed no concerning anomalies (Supplementary Figures S1, S2). Results were also consistent under alternative nonlinearity specifications (restricted cubic splines; see §4.4) and under missing-data sensitivity analyses (complete-case primary; inverse-probability weighting for inclusion and single stochastic imputation when <5% missing), with the profiled breakpoint and slope directions essentially unchanged. Given the observational, single-school, two-wave design, these patterns should be interpreted as associations rather than causal effects, and they motivate multi-site, multi-year replication with maturation and socioeconomic measures.

4 Discussion

This empirical two-wave school-panel study found that implementation of school physical-education policy was associated with adolescent fitness in a nonlinear, threshold-like manner. Given the two-wave, single-school, observational design, these patterns should be interpreted as associations rather than causal effects. Associations became stronger after surpassing a mid-range EPDI (≈ 60 –66) and then showed diminishing returns. Component results showed the largest post-threshold gains in timed runs and vital capacity, modest but consistent gains in flexibility and power, and near-null BMI within the observation window. Importantly, our pattern of larger gains in timed running performance and vital capacity, modest improvement in power/flexibility, and near-null



short-term BMI change is consistent with prior school-based intervention evidence and exam-linked PE reports, which typically observe quicker responses in cardiorespiratory and speed outcomes, slower or moderate responses in flexibility/power, and delayed adiposity changes (2, 16–18, 28). Where our results extend the literature is by localizing the “dose band” (EPDI $\approx$ 60–66) at which gains steepen, thereby complementing earlier binary-exposure studies that could not identify a quantitative planning threshold (7–9, 11).

An operational reference for EPDI ($\approx$ 60) provides a practical, exam-aligned benchmark for scheduling, staffing, and facility management. By quantifying what schools actually implement on a 0–100 scale, EPDI moves beyond prior binary or categorical indicators (present vs. absent; tested vs. not tested) and makes the 60–66 band empirically visible for planning. Sex-by-grade heterogeneity suggests potential efficiency improvements through differentiated allocation—initial benefits for girls at low-to-mid doses and enhanced strength/power responses for boys at higher doses—while maintaining equity across grades.

Transportability and context. Several EPDI domains are likely transportable across systems—especially (i) compulsory test intensity and (ii) scoring/enforcement routines—because they map onto routine PE provision and monitoring found internationally. Conversely, (iii) competition & incentive provision and some details of (iv) elective/optional diversity are more context-specific to China’s exam-linked PE governance and may require adaptation in settings without high-stakes PE examinations. For cross-system application, EPDI replication would require (a) school-level administrative ledgers (or local equivalents), (b) documented scoring/assessment rules, and (c) at least minimal panel structure in outcomes to profile breakpoints. This clarifies what is likely universal versus context-bound and how the index can be ported to other jurisdictions.

Design-based validity. To reinforce design-based validity, we bring specific sensitivity examples into the discussion: the threshold band and post-threshold slopes remained qualitatively unchanged when (a) varying EPDI weights (equal, $\pm$ 20%, PCA, entropy), (b) applying a

10-fold delete-group jackknife, (c) imposing a placebo threshold by randomizing EPDI over time, and (d) using height growth as a negative-control outcome; segmented and spline conclusions were concordant. These checks indicate that the identified 60–66 band is not an artifact of a single modeling choice.

Limitations include the single-school setting and two waves, which constrain generalizability and the ability to observe longer-term dynamics. Despite student and time fixed effects and clustered CR2 inference, residual time-varying confounding may remain (e.g., diet, household shocks, pubertal tempo, short-term school campaigns). Future research should evaluate external validity across schools and regions, incorporate maturation and behavior measures, and use a longer follow-up to test persistence and timing of effects. Component-level alignment—stronger responses in sprint speed and vital capacity, smaller but consistent gains in power/flexibility, and near-null BMI over two waves—matches outcome-specific kinetics reported in prior school-based PE evidence, situating our findings as largely consistent and complementary to the literature (2, 16–18, 28).

5 Conclusion

The impact of the school’s PE policy on adolescent fitness followed the threshold-type, diminishing-returns pattern we initially hypothesized, in which benefits increase more clearly once an EPDI of roughly 60–66 is reached and then decline afterward. This pattern is consistent with our initial hypothesis that a mid-range level of exam-oriented PE implementation would be needed before observable fitness gains emerge. Building on this, the EPDI $\approx$ 60–66 band can serve as an actionable benchmark for school timetabling, staffing, and facility allocation, provided that programming is differentiated by sex and grade to preserve equity. In resource-constrained settings such as Kunming and other Yunnan localities, a quantified benchmark of this kind can help education and health authorities prioritize schools that have not yet reached the minimum implementation stratum. Simultaneously, because the evidence comes from a two-wave, single

public middle school and an observational design, these findings should be interpreted as policy-relevant associations. They should be validated in multi-site, multi-year panels before broader generalization.

Data availability statement

The original contributions presented in the study are included in the article/[Supplementary material](#), further inquiries can be directed to the corresponding author.

Ethics statement

This study is a non-interventional analysis of de-identified educational records collected by the participating public junior middle school as part of routine physical fitness assessments conducted under the Yunnan provincial education–exam reform (Yunjiaofa [2019] No. 113) and the 2020 Junior Middle School Physical Education Examination Scheme. The school administration provided written authorization. Written parental/guardian consent together with student assent were obtained at the time of testing (see Supplementary Ethics Packet: Participant Information Sheet & Informed Consent; School Authorization). Before transfer to the research team, the school removed all direct identifiers, and the dataset was de-identified.

Primary and secondary schools in our setting do not maintain independent human-research ethics/IRB committees; oversight for routine educational assessments is exercised through school administrative governance under the provincial education exam regulatory framework. Because no medical or behavioral intervention was introduced and only de-identified records were analyzed, no additional medical IRB review was required under applicable local requirements for educational research. The study adhered to the principles of the Declaration of Helsinki as applicable to anonymized educational records. Data were stored on encrypted media with access restricted to authorized team members.

Author contributions

DW: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. ZF: Data curation, Investigation, Methodology, Project administration, Software, Supervision, Visualization, Writing – review & editing. JZ: Formal analysis, Investigation, Methodology, Software, Validation, Visualization, Writing – review & editing. YW: Data curation, Formal analysis, Investigation, Methodology, Project administration, Visualization, Writing – review & editing. WB: Conceptualization, Formal analysis, Investigation, Visualization, Writing – review & editing.

References

1. Lazarević, LB, Bjekić, J, Živanović, M, and Knežević, G. Ambulatory assessment of language use: evidence on the temporal stability of electronically activated recorder and stream of consciousness data. *Behav Res Methods*. (2020) 52:1817–35. doi: 10.3758/s13428-020-01361-z
2. Sriram, K, Mulder, HS, Frank, HR, Santanam, TS, Skinner, AC, Perrin, EM, et al. The dose–response relationship between physical activity and cardiometabolic health in adolescents. *Am J Prev Med*. (2021) 60:95–103. doi: 10.1016/j.amepre.2020.06.027

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpubh.2025.1706423/full#supplementary-material>

3. World Obesity Federation. Prevalence of obesity (2025). Available online at: <https://www.worldobesity.org/about/about-obesity/prevalence-of-obesity> (Accessed November 25, 2025).
4. Yang, Y, Dai, J, Huang, S, Li, T, Song, Z, Zha, S, et al. Secular trends of the prevalence of emaciation, overweight, and obesity among school-aged children in Yunnan Province, 1985–2019: a serial cross-sectional surveillance study in China. *Front Nutr.* (2022) 9:1037188. doi: 10.3389/fnut.2022.1037188
5. Yunnan Provincial Department of Education. Implementation opinions on further deepening the reform of the entrance examination system for upper-secondary schools [in Chinese] (document no. Yunjiaofa [2019] 113) (2019). Available online at: <https://www.meipian.cn/2m1alvya> (Accessed November 25, 2025).
6. Yunnan Provincial Department of Education (2020). Junior middle school physical education examination scheme of Yunnan Province [in Chinese]. Available online at: <https://jyt.yn.gov.cn/>
7. Curran, PJ, Obeidat, K, and Losardo, D. Twelve frequently asked questions about growth curve modeling. *J Cogn Dev.* (2010) 11:121–36. doi: 10.1080/15248371003699969
8. Malina, RM, Bouchard, C, and Bar-Or, O. Growth, maturation, and physical activity. 2nd ed. Champaign, IL: Human Kinetics (2004).
9. Weng, S, and Xie, S. Running to success: physical education (PE) exam and long-term human capital accumulation. *Soc Sci Res Netw.* (2024). doi: 10.2139/ssrn.5179989
10. Bassett, DR, Fitzhugh, EC, Heath, GW, Erwin, PC, Frederick, GM, Wolff, DL, et al. Estimated energy expenditures for school-based policies and active living. *Am J Prev Med.* (2013) 44:108–13. doi: 10.1016/j.amepre.2012.10.017
11. Chekroud, SR, Gueorguieva, R, Zheutlin, AB, Paulus, M, Krumholz, HM, Krystal, JH, et al. Association between physical exercise and mental health in 1.2 million individuals in the USA between 2011 and 2015: a cross-sectional study. *Lancet Psychiatry.* (2018) 5:739–46. doi: 10.1016/S2215-0366(18)30227-X
12. Fernández-Verdejo, R, Alcantara, JMA, Galgani, JE, Acosta, FM, Migueles, JH, Amaro-Gaete, FJ, et al. Deciphering the constrained total energy expenditure model in humans by associating accelerometer-measured physical activity from the wrist and hip. *Sci Rep.* (2021) 11:12302. doi: 10.1038/s41598-021-91750-x
13. Kerr, JA, Patton, GC, Cini, KI, Abate, YH, Abbas, N, Magied, AHAAA, et al. Global, regional, and national prevalence of child and adolescent overweight and obesity, 1990–2021, with forecasts to 2050: a forecasting study for the global burden of disease study 2021. *Lancet.* (2025) 405:785–812. doi: 10.1016/S0140-6736(25)00397-6
14. Meng, X, Horrell, A, McMillan, P, and Chai, G. Health first' and curriculum reform in China: the experiences of physical education teachers in one city. *Eur Phys Educ Rev.* (2021) 27:595–612. doi: 10.1177/1356336X20977886
15. Mirwald, RL, Baxter-Jones, ADG, Bailey, DA, and Beunen, GP. An assessment of maturity from anthropometric measurements. *Med Sci Sports Exerc.* (2002) 34:689–94. doi: 10.1097/00005768-200204000-00020
16. Pontzer, H, Durazo-Arvizu, R, Dugas, LR, Plange-Rhule, J, Bovet, P, Forrester, TE, et al. Constrained total energy expenditure and metabolic adaptation to physical activity in adult humans. *Curr Biol.* (2016) 26:410–7. doi: 10.1016/j.cub.2015.12.046
17. Orsini, N, Bellocco, R, and Greenland, S. Generalized least squares for trend estimation of summarized dose–response data. *Stata J.* (2006) 6:40–57. doi: 10.1177/1536867X0600600103
18. Song, X, Zhou, B, Baird, S, Lu, C, Ezzati, M, Chen, L, et al. Trends and inequalities in thinness and obesity among Chinese children and adolescents: evidence from seven national school surveys between 1985 and 2019. *Lancet Public Health.* (2024) 9:e1025–36. doi: 10.1016/S2468-2667(24)00211-1
19. OECD. Education policy outlook 2023: education for well-being. Paris, France: OECD Publishing (2023).
20. Zhang, Y, Lou, H, Huang, Y, Wang, R, Wen, X, Wu, C, et al. Trends of overweight and obesity prevalence in school-aged children among Henan Province from 2000 to 2019. *Front Public Health.* (2022) 10:1046026. doi: 10.3389/fpubh.2022.1046026
21. Zhou, Y, Yu, P, Zhang, Y, Wang, T, and Wang, A. Distinct patterns of urban–rural and sex disparities in children's BMI trajectories from 2013 to 2018. *Front Public Health.* (2021) 9:689021. doi: 10.3389/fpubh.2021.689021
22. Beunen, G, and Malina, RM. Growth and physical performance relative to the timing of the adolescent spurt. *Exerc Sport Sci Rev.* (1988) 16:503–40. doi: 10.1249/00003677-198800160-00018
23. Li, C, Taerken, A-Y, Li, Q, Selimu, A, and Wang, H. Secular trends in physical fitness of rural Chinese children and adolescents aged 7–18 years from 1985 to 2019. *Sci Rep.* (2023) 13:4229. doi: 10.1038/s41598-023-31190-x
24. Malina, RM, Rogol, AD, Cumming, SP, Silva, MJ, and Figueiredo, AJ. Biological maturation of youth athletes: assessment and implications. *Br J Sports Med.* (2015) 49:852–9. doi: 10.1136/bjsports-2015-094623
25. World Health Organization. Global action plan on physical activity 2018–2030: more active people for a healthier world. (2020). Available online at: <https://www.who.int/> (Accessed February 24, 2025).
26. Higgins, JPT, and Thompson, SG. Quantifying heterogeneity in a meta-analysis. *Stat Med.* (2002) 21:1539–58. doi: 10.1002/sim.1186
27. Zhang, S, Li, C, Tarken, A-Y, and Li, W. Secular trends in motor abilities of Xinjiang children and adolescents aged 7–18 years from 1985 to 2019. *Front Public Health.* (2024) 12:1419728. doi: 10.3389/fpubh.2024.1419728
28. Muggeo, VMR. Estimating regression models with unknown break-points. *Stat Med.* (2003) 22:3055–71. doi: 10.1002/sim.1545
29. Armstrong, N, and Welsman, J. Clarity and confusion in the development of youth aerobic fitness. *Front Physiol.* (2019) 10:979. doi: 10.3389/fphys.2019.00979
30. Centers for Disease Control and Prevention (CDC). Quickstats: percentage of children and adolescents aged 12–17 years who participated in 60 minutes of physical activity most days or every day, by daily hours of screen time use—United States, July 2021–December 2023. *MMWR Morb Mortal Wkly Rep.* (2024) 73:1013. doi: 10.15585/mmwr.mm7344a5
31. Careau, V, Halsey, LG, Pontzer, H, Ainslie, PN, Andersen, LF, Anderson, LJ, et al. Energy compensation and adiposity in humans. *Curr Biol.* (2021) 31:4659–4666.e2. doi: 10.1016/j.cub.2021.08.016
32. Chriqui, JF, Taber, DR, Slater, SJ, Turner, L, Lowrey, KM, and Chaloupka, FJ. The impact of state safe routes to school-related laws on active travel to school policies and practices in US elementary schools. *Health Place.* (2012) 18:8–15. doi: 10.1016/j.healthplace.2011.08.006
33. Dong, J, Mo, L, Shi, Y, Lu, D, Guo, C, Wan, Z, et al. Effects of the policy of physical education entrance examination for senior high school on health in middle school students. *Sustainability.* (2023) 15:1701. doi: 10.3390/su15021701
34. Greenland, S, and Longnecker, MP. Methods for trend estimation from summarized dose–response data, with applications to meta-analysis. *Am J Epidemiol.* (1992) 135:1301–9. doi: 10.1093/oxfordjournals.aje.a116237
35. Gu, Z, Eils, R, and Schlesner, M. Complex heatmaps reveal patterns and correlations in multidimensional genomic data. *Bioinformatics.* (2016) 32:2847–9. doi: 10.1093/bioinformatics/btw313
36. Kim, HJ, Fay, MP, Feuer, EJ, and Midthune, DN. Permutation tests for joinpoint regression with applications to cancer rates. *Stat Med.* (2000) 19:335–51. doi: 10.1002/(SICI)1097-0258(20000215)19:3
37. Ryan, RM, and Deci, EL. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *Am Psychol.* (2000) 55:68–78. doi: 10.1037/0003-066X.55.1.68
38. Singer, JD, and Willett, JB. Applied longitudinal data analysis: Modeling change and event occurrence. Oxford, United Kingdom: Oxford University Press (2003).
39. Skinner, BF. Science and human behavior. New York, USA: Macmillan (1953).
40. Standage, M, Duda, JL, and Ntoumanis, N. A test of self-determination theory in school physical education. *Br J Educ Psychol.* (2005) 75:411–33. doi: 10.1348/000709904X22359
41. Sullivan, L, Pursell, L, and Molcho, M. Evaluation of a theory-based concussion education program for secondary school student-athletes in Ireland. *Health Educ Res.* (2018) 33:492–504. doi: 10.1093/her/cyy034
42. van Sluijs, EMF, Ekelund, U, Choumou-Silva, I, Guthold, R, Ha, A, Lubans, D, et al. Physical activity behaviours in adolescence: current evidence and opportunities for intervention. *Lancet.* (2021) 398:429–42. doi: 10.1016/S0140-6736(21)01259-9
43. Viechtbauer, W. Conducting meta-analyses in R with the metafor package. *J Stat Softw.* (2010) 36:1–48. doi: 10.18637/jss.v036.i03



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The value of stress management programs for medical students: a systematic review

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Context: Managing stress carries significant implications for the mental wellbeing, academic achievements, career advancement, and overall life satisfaction of medical students. However, the coping mechanisms for stress management are diverse. The current systematic review examines the proposals and consequences of stress management for students in medical education, acknowledging the array of challenges inherent to their academic journey.

Methods: A search was conducted from 2013 to 2023 (September) across databases such as PubMed, Web of Science, and Scopus to retrieve articles on “Medical students,” “Coping mechanisms,” and “Stress management”. The English-language articles were the only ones considered in the study. The articles that discussed coping mechanisms, such as resilience training, mindfulness-based stress reduction (MBSR) programs, and/or wellness and self-care workshops, were included in the study. This review was not prospectively registered in PROSPERO; however, PRISMA 2020 guidelines were followed throughout.

Results: Nine articles were included in the study based on the inclusion and exclusion criteria. Among 2,334 medical students, 11%, 72.7%, and 16.3% reported low, moderate, and high stress levels, respectively. The selected nine articles aimed to address these far-reaching effects of stress management strategies. The stress management programs encompass creating robust mental health support systems within institutions, incorporating anxiety management education into regular coursework, offering workshops that teach practical techniques for handling emotional turmoil effectively, and fostering an environment where discussing one’s challenges is encouraged rather than stigmatized. Such programs encourage students to seek expert guidance when needed, undertake systematic investigations to tailor interventions to changing needs and circumstances, and emphasize the importance of balancing work responsibilities, academic commitments, and personal life.

Conclusions: By implementing these suggestions within their framework, institutions can more effectively prepare their medical learners to overcome educational challenges and cultivate empathetic, resilient professionals skilled in delivering healthcare services.

KEYWORDS

coping mechanisms, medical students, stress, stress management, workshops

Highlights

The stress management programmes involve establishing strong support structures for mental health treatment within institutions:

- Integrating education on anxiety management into regular coursework;
- Offering workshops that provide practical strategies for managing emotional distress;
- Promoting a culture that encourages students to seek expert help when necessary;
- Conducting ongoing investigations to tailor interventions maintaining a harmonious equilibrium between work or academic obligations and personal life.

1 Introductions

Embarking on a journey in medical academia is an intriguing yet challenging pursuit marked by its unique blend of scholarly intensity, hands-on clinical exposure, and a deep-rooted dedication to the art and science of remedial care (1). The goal of becoming a medical professional is admirable, but the path to achieving it is paved with numerous obstacles. Many of these challenges are intimately tied to an overarching theme—stress (2, 3). The issue concerning how medical students manage stress deserves thorough investigation. This subject envelops vital aspects like medical education standards and student wellness, eventually influencing healthcare delivery quality (4, 5).

In the sphere of advanced education, medical students hold a unique position. Their learning process is a blend of intellectual rigor and practical clinical experiences, firmly grounded on medical science tenets and an unshakeable adherence to healthcare ethics (6, 7). The curriculum in medicine is renowned for its stringent and comprehensive content, which spans various fields, from fundamental sciences to hands-on clinical practice, all within a highly condensed timeframe (8, 9). An excessive dedication toward activities once found enjoyable can lead to exhaustion or “burnout” when motivation becomes dysfunctional (10). Modern-day medical students and trainees are reporting potentially elevated rates of burnout. Burnout is a psychosocial state typified by reduced motivation, performance degradation, and deteriorating mental wellbeing (11, 12). These unique characteristics combine to form an academic atmosphere that subjects medical students to constant, intense pressure, molding their experiences, viewpoints, and future paths (5).

Stress is commonly defined as “a state of mental or emotional strain resulting from demanding circumstances,” a concept originating from Hans Selye’s foundational work in the 1930s, which described stress as the body’s non-specific response to challenges (13). Over several decades, this definition evolved to encompass psychological, behavioral, and environmental components relevant to academic and clinical settings, including medical training (14). Modern perspectives regard stress among medical students as a multidimensional interaction between internal coping capacity and external academic and clinical pressures (15).

Medical students consistently report higher stress, anxiety, and burnout levels than the general population, affecting academic performance, empathy, and patient safety (3, 16). Although numerous stress-management interventions have been introduced, including resilience training, mindfulness-based programs, and institutional wellness initiatives, their effectiveness varies widely, and the long-term sustainability of benefits remains unclear (17).

Apart from the stress related to their academic pursuits, students may also confront tension from diverse areas, such as social interactions, their physical environment, and familial issues (18). The pressures faced by medical students can be broadly categorized into three dominant spheres: challenges in academia, social obstacles, and fiscal crises (19). The root cause of their stress often lies in the colossal amount and intricacy of knowledge they are expected to assimilate. An extensive compendium forms the backbone of a medical curriculum, encompassing aspects such as anatomy, physiology, pharmacology, and clinical data—each element crucial for an effective medical practice. Its voluminous content, complex scientific nuances, and high standards set for performance evaluation create a daunting journey for these learners, requiring constant commitment toward scholarly activities.

The elevated status of the medical field inadvertently escalates the pressure experienced by its students (20). The comprehension they gain is acutely understood to form the foundation of their future professional endeavors, with their decisions and actions potentially impacting patient outcomes (21). This intrinsic seriousness associated with medicine imparts a unique nature to the stress borne by these students. They carry on their shoulders the potential responsibility for lives that may be entrusted to them in due course (22).

The practical aspects of medical pedagogy add a layer of intricacy. Critical facets of medical instruction, such as clinical rounds, patient interfacing, and the tangible attributes of healthcare provision, are integral. These encounters play a vital role in career growth and impose various pressures. Medical trainees must navigate the challenges inherent in their clinical duties, manage the emotional toll incurred by exposure to disease and hardship, and develop skills for effective interaction with patients and fellow healthcare providers. These elements collectively contribute to the elaborate stress tapestry that pervades their scholarly existence (23).

Various strategies are essential for medical students to manage stress and maintain their wellbeing (24). Such strategies are available, including problem-centered, emotion-centered, and social support methods (25). Problem-centered coping involves proactively identifying the source of stress and taking measures to rectify the issue (26, 27). On the other hand, emotion-based coping emphasizes emotional regulation coupled with stress management through relaxation practices, mindfulness exercises, and self-nurture (28). A social support strategy involves reaching out to friends or family members or seeking guidance from mentors when encountering challenging circumstances (29). Research has revealed several commonly employed strategies among medical students. The terminologies “active adaptation,” “positive reinterpretation,” “formulating plans,” “conciliation,” and “pursuing social backing” are all incorporated into this category (30, 31).

Despite growth in literature, current research lacks clarity in several areas:

- Limited comparative evaluation of different stress-management approaches across diverse cultural and educational environments (15).
- Limited longitudinal studies examining sustained changes in coping and wellbeing beyond the intervention period (32).
- Insufficient evidence identifying which components of resilience, mindfulness, or wellness programs produce the strongest outcomes (17).
- Few systematic analyses focus specifically on undergraduate medical students during different stages of training (2).

Since the rates of stress and anxiety among medical students are growing steadily, effective programs and interventions must be provided to enhance the mental health of all students to reduce this phenomenon, which is widespread in most medical schools worldwide. This is why medical colleges have developed programs to promote mental health and address the psychological pressures that students face while pursuing a career in medicine. Despite the great diversity of mental health promotion programs available in medical schools and higher educational institutions, including group self-development, yoga and relaxation therapy, mindfulness and lifestyle improvement programs, stress management programs, time management programs, meditation sessions, etc. It aims to help students cope with stress and manage school and life pressures effectively; however, its effectiveness and positive impact on students' mental health are uncertain. This study aims to measure the impact and effectiveness of stress management and coping programs provided to medical students.

2 Methods

2.1 Study design

A thorough examination was conducted on all research papers related to stress management in medical education for potential inclusion. This scrutiny aims to evaluate the merit of these reviews as impartially as feasible. Quality inspection encompasses factors such as study design, sampling dictates (size and method), gauged outcomes, and data reliability and accuracy. Additionally, an assessment regarding the strictness adhered to in these chosen studies was conducted by authors based on aspects like availability and caliber of study design, study sampling procedures followed, response rate obtained from participants or respondents involved in each respective study, choice of measurement tool employed throughout each research project, along with their specific stress management program.

2.2 Search sources and strategies

The search process was conducted systematically using four major electronic databases: PubMed, Scopus, Web of Science, and

MEDLINE. The search employed combinations of the following key terms: “*medical students*,” “*coping mechanisms*,” and “*stress management*,” integrated with Boolean operators appropriate for each database.

The search was carried out between 1 and 5 September 2023, covering peer-reviewed publications published from January 2013 to September 2023. Titles and abstracts retrieved through the initial search were screened for relevance, and full-text articles were obtained when eligibility could not be determined from the abstract alone. All potentially eligible articles were read in full before a final inclusion decision was made.

In addition to the electronic database searches, we performed manual screening of the reference lists of all included articles to identify any additional relevant studies. Gray literature, including conference abstracts and dissertations, was not included due to inconsistent methodological quality.

Data extraction forms were used to collect standardized information from included studies. All procedures adhered to the PRISMA 2020 guidelines, ensuring transparency, rigor, and reproducibility in reporting the review process (33).

2.3 Inclusion and exclusion criteria

Studies were eligible for inclusion if they examined stress management or coping interventions—including but not limited to resilience training, mindfulness-based stress reduction (MBSR) programs, and wellness or self-care workshops—among undergraduate medical students from the first to final year of training. Only studies in which data for undergraduate medical students were independently extractable were included; in studies involving mixed health-discipline samples, only outcomes specific to medical students were considered.

Eligible study designs included randomized controlled trials, non-randomized interventional studies, cross-sectional studies, qualitative studies, and quasi-experimental designs. Articles were required to report empirical data related to stress levels, coping mechanisms, or the outcomes of stress-management interventions.

Studies were limited to peer-reviewed articles published in English between January 2013 and September 2023. Articles published in languages other than English were excluded. Restricting the search to English-language publications may have introduced language bias; this limitation has been acknowledged in the Discussion section.

Two reviewers independently screened titles, abstracts, and full texts. Disagreements were resolved through discussion, and when needed, by consulting a third reviewer.

Each included study underwent a formal quality appraisal using the Joanna Briggs Institute (JBI) critical appraisal tools appropriate for its design. Overall, study quality ranged from moderate to high; no study was excluded based on risk-of-bias assessment.

A comprehensive summary of all included studies, including design, setting, sample characteristics, intervention description, and outcomes, is presented in Table 1.

Outcomes were harmonized by grouping results into standardized domains (stress levels, intervention effects, and coping mechanisms), allowing clearer comparison across studies.

TABLE 1 List of selected articles for the study.

Reference	Country	Study design	Study samples	Academic year	Stress level (%)			Stress management program	Outcomes
					Low	Moderate	High		
Donohoe et al. (34)	Ireland	Non-RCT observational study	98 ($n = 204$)	Third-year medical students	–	–	–	Resilience- promoting program	Enhanced emotional and mental wellbeing
Daya et al. (35)	India	Cross-sectional study	446	First-year to final year	56.50	32.73	10.76	Perceived stress scale (PSS)	Moderate stress level, showing stress-handling abilities
Bodys-Cupak et al. (36), Donohoe et al. (34)	Poland	Piolet study	526	First-year to final-year students of nursing, physiotherapy, medical rescue, and obstetrics	21.00	29.18	49.82	PSS	Greater sense of self-efficacy who chose active stress coping strategies
Teh et al. (37)	Malaysia	Cross-sectional study	371	First-year to final year	63.00	21.60	15.40	Resilience program, which includes Rosenberg Self-Esteem Scale (RSES), Rosenberg Self-Esteem Scale (RSES), Brief COPE	Reduce stress and sustain wellbeing
Rafique (38)	Pakistan	Cross-sectional study	125	Medical students	–	–	–	Resilience strategy	–
Sahlabadi et al. (39)	Iran	Cross-sectional study	325	Undergraduate medical students (pursuing nursing, paramedical, and physiotherapists)	1.00	31.00	66.30	Stress score and Osipow questionnaires, followed by content validity rate (CVR)	Work and study environments demand stress management programmes
Abouammoh et al. (40)	Saudi Arabia	Qualitative study	33	Final-year medical students, medical interns	–	–	42.42	Stress coping strategy	Medical students and interns struggle to lead healthy stress-coping strategies
Abdul Aziz et al. (41)	Malaysia	Cross-sectional study	290	Undergraduate medical students	9.00	73.40	17.60	PSS and multidimensional scale of perceived social support (MSPSS)	Social support from family is the strongest for students to go through the stress of tough times
Aisha (42)	Larkana	Quasi-experimental study	120 ($n = 240$)	First-year	13.00	72.00	15.00	2-day workshop on stress management	The workshop was helpful and improved memorisation, time management, and self-directed conflict management
Total	–	–	2,334	–	11	72.7	16.3	–	–

–, Not available.

Where reported by the original studies, effect sizes, pre-post comparisons, or percentage changes were extracted and added to the synthesis.

3 Results

An overview of the literature selection process is shown in Figure 1. We evaluated 43 papers from existing literature sources against our selection criteria.

Upon additional scrutiny and abstract perusal, we focused on nine articles to gain insight into the resilience techniques employed by medical students (Table 1). It was noted that, among the nine selected articles, five were cross-sectional studies, while the others were qualitative, observational, pilot, and quasi-experimental studies.

In a non-randomized observational study conducted in Ireland, Donohoe et al. (34) observed the effects of a program designed to bolster resilience among third-year medical students. The outcomes of their research indicated an improvement in emotional and mental health among the participants. These findings suggest that interventions designed to enhance resilience can positively impact the psychological wellbeing of medical students, potentially enabling them to manage stress more effectively. The research conducted by Daya et al. (35) incorporated participants from multiple academic years in a cross-sectional analysis within India to evaluate their perceived stress levels. Moderate to high levels of stress, as measured by 32.73 and 10.76%, were observed among first- to final-year medical students. The results indicated a median stress level among students, while also revealing their capacity to manage such pressures. This suggests that despite the stress factors among students, they appear to have developed efficient strategies to counteract this adversity. The preliminary research conducted in Poland engaged students pursuing diverse health-related fields and suggested that the students who opted for active stress-management techniques exhibited a heightened sense of self-belief. This emphasizes the significance of encouraging students to embrace active methodologies for handling stress, enhancing their sense of self-efficacy (36). In the same study, high levels of stress, at approximately 49.82%, were observed among medical professionals pursuing nursing, paramedical, and physiotherapist courses. In a comprehensive research study conducted in Malaysia, an initiative to boost resilience was introduced to students across diverse academic levels, where approximately 63.0%, 21.6%, and 15.4% of students were found to have low, moderate, and high-stress levels, respectively. The outcome demonstrated a significant reduction in stress and the preservation of wellness. This suggests that initiatives aimed at enhancing resilience may serve as efficient tools for augmenting the mental health status of students (37).

Upon evaluating approximately 125 Pakistani medical professionals with 5–10 years of teaching experience, it was observed that junior faculty members often exhibit behavioral problems due to high stress levels (38). Another study from Iran by Sahlabadi et al. (39) noticed that 66.30% of undergraduate students possessed high stress levels, making them 11.829% times more likely to have suicidal thoughts. Abouammoh et al. (40) noted that 42.42% of medical final-year and internship students experienced stress and employed stress-coping strategies, including

avoiding medical discussions, smoking, and engaging in physical exercise, which helped them cope with stress. A study conducted by Abdul Aziz et al. (41) among 290 undergraduate medical students suggested that 73.40 and 17.60% of students possessed moderate and high stress levels, respectively. The study highlighted that social support from family managed the stress among these students. A study by Aisha (42) found moderate and high-stress levels in 72 and 15% of first-year medical students from Pakistan, respectively. The most common stressors among these students were frequent exams, inadequate time management, insufficient teaching guidance, and difficulty in memorizing.

The research highlights the diverse methods employed in stress management programs and their effects on students from various countries and educational backgrounds. The findings underscore the importance of customized interventions and support networks that help students manage stress effectively, thereby promoting their psychological wellbeing. Both proactive coping mechanisms and interpersonal assistance are pivotal in mitigating stress among students.

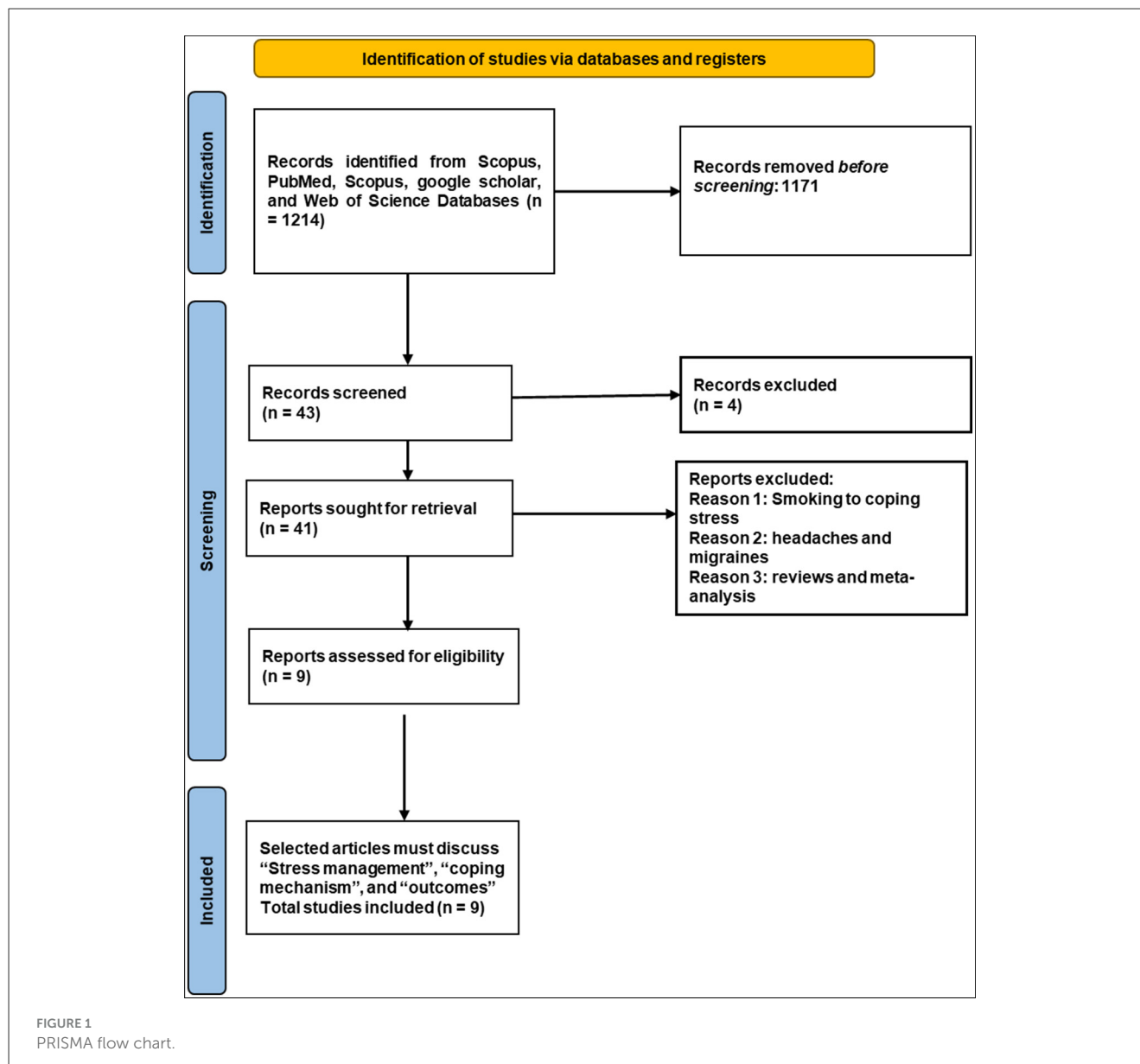
4 Discussion

Medical education exposes learners to sustained academic, clinical, and emotional stressors. These findings align with international studies showing that medical students consistently experience high levels of psychological distress during all stages of training (2, 15). The results of this review confirm that moderate to high stress is prevalent worldwide and underscore the importance of structured interventions.

1. The path of medical education is a demanding and strenuous journey, fraught with numerous pressures that test the mettle of even the most tenacious individuals. To tackle these obstacles and promote their wellbeing, aspiring physicians employ various approaches to manage stress. These techniques are instrumental in preserving their psychological and emotional wellbeing amid the strict requirements of medical training. The following discussion provides an in-depth exploration of these stressors and stress management methods. Evidence strength varied substantially across designs; heterogeneity in measurement tools, intervention types, and follow-up duration limits comparability. Significant gaps exist in randomized evaluations and long-term outcomes.

4.1 Sources of stress among medical students

The field of medical education, known for its stringent requirements and complex study modules, presents a unique assortment of stress-inducing factors that are distinctly different from those found in other academic endeavors. Identifying the precise causes of stress among students pursuing a career in medicine is crucial, as it enables the formulation of effective strategies and support systems to promote their overall wellbeing. Previous research indicates that the incidence rate of stress among medical students fluctuates between 30 and 50% (43,



44). Compared with the general population or students in other academic disciplines, this stress level is notably elevated (44, 45).

4.2 Academic pressures

The demanding academic workload in medical education is a significant source of stress for students, who must master extensive scientific and clinical content under strict deadlines (4, 9, 46). Studies consistently show higher academic stress among female students, potentially due to additional social responsibilities, greater exam-related pressure, and biological factors influencing stress responses (44, 47, 48). However, some reports note slightly higher stress levels among males in certain contexts (49).

High-stakes examinations, competition for strong academic standing, and the pursuit of residency placements further intensify performance pressure (50, 51). Common stress manifestations

include restlessness, anxiety, somatic symptoms, and maladaptive coping behaviors, with many students unable to identify effective stress-management strategies (44). Additional factors, such as obesity, have also been linked with heightened stress (52).

Impostor syndrome—characterized by self-doubt and fear of inadequacy—is another contributor to academic stress, often exacerbated by the highly competitive environment of medical education (53).

4.3 Clinical rotations

The participation of medical scholars in clinical rounds, which includes patient care and hospital supervision, infuses a new level of tension into their academic lives (54). Although essential for career growth, these practical activities carry their unique stressors. For novices stepping into this realm for the first time, the obligation to

make informed clinical judgments, perform physical assessments, and interact effectively with patients and healthcare teams can be overwhelming. Various research findings have drawn connections between increased clinical duties during the last years of medical academia and a rise in stress levels (47, 55).

Medical trainees who serve as healthcare professionals are at an increased risk of contracting COVID-19 due to their higher exposure. Apprehensions surrounding potential infection during clinical rounds serve as additional stress inducers for these students (56). Contemporary studies indicate that medical students have reported clinically significant psychological distress and decreased mental health conditions (57). Furthermore, they presented deteriorated sleep patterns and reduced appetite compared to pre-pandemic scenarios (58).

The kind of rotation experienced during medical school could play a pivotal role in the occurrence and intensity of sleep deprivation throughout the study years (59). Rotations involving surgery or emergency medicine tend to be more grueling, leading to increased sleep deprivation compared to rotations through departments with fewer demands. Physiological issues such as sleep apnea also contribute significantly to sleep disturbances. Research on identifying risk factors for sleep apnea among Pakistani medical students revealed that disruptive snoring was present in 27% of male and 12% of female participants (60). Additionally, the erratic schedules accompanying clinical rotations disrupt students' sleep routines and interfere with their personal lives, thereby escalating overall stress levels. The struggle to balance clinical tasks and academic obligations further heightens the complexity associated with their roles. Sleep has been critical to stabilizing and enhancing cognitive processes (60).

Cognitive competencies such as consolidating and encoding are critical in higher education contexts, particularly in medical training. This is because medical students must grasp vast amounts of intricate factual information (61). An investigation involving Brazilian medical students revealed that excessive daytime sleepiness negatively influenced their academic output (62). This lack of sufficient rest results in increased drowsiness during subsequent nocturnal work hours, especially in the latter half of the period. The consequence is an increased propensity for mistakes and accidents on duty and while commuting home, for instance, falling asleep while driving (63). The level of self-awareness regarding sleep and general understanding appears to be insufficient among many of the analyzed groups; consequently, enhancing knowledge among students could be advantageous. Tailoring student schedules based on individual circadian rhythms may also bring benefits (60).

4.4 High expectations and perfectionism

The healthcare field is characterized by an environment of high standards and a drive toward perfection, which can serve as both a source of inspiration and strain for those studying medicine (64). This eagerness to reach or surpass such benchmarks often becomes a self-driven demand to thrive in educational and clinical settings, resulting in apprehension about failing or not meeting the assumed

proficiency levels. Perfectionism is a multifaceted personality trait with both beneficial and harmful subcategories (65). Henning's team conducted research on psychological adaptation among students from various health disciplines. They concluded that perfectionism and the impostor phenomenon (IP) were significant predictors of psychological discomfort among medical students (64, 66).

The IP is predominantly found in professions where intellectual prowess is highly valued, such as academia. Individuals attracted to these fields often showcase perfectionistic tendencies and function in a goal-oriented approach (67). IP reports are prevalent in all hierarchies, ranging from novice students to seasoned surgeons. As healthcare professionals are plagued by burnout and its damaging implications, impostor syndrome significantly adds to this problem, making it crucial to deepen our understanding of this occurrence (68, 69). The anxiety arising from potential medical inaccuracies or an incorrect diagnosis due to their severe implications contributes to medical students' stress. This quest for flawlessness can weaken your self-belief and further intensify stress levels.

Self-cared perfectionism encapsulates a range of traits, such as the tendency to set excessively high goals and participate in rigorous self-assessment. On the other hand, other-centered perfectionism revolves around establishing unattainable standards for others and critiquing them harshly (70). This personality type begins to associate success with feelings of anxiety and nervousness while attributing their accomplishments to external factors such as fortuitousness. However, the satisfaction derived from these achievements is fleeting as they face the upcoming challenge, thus perpetuating this cycle (71). In addition, numerous research endeavors have corroborated that IP and perfectionistic tendencies are substantial indicators of emotional turmoil among medical students.

Furthermore, these studies suggest that an inclination toward perfectionism predicts susceptibility to disorders such as anxiety and depression (72). The correlation between IP and perfectionism introduces an added dimension when delivering or receiving criticism or feedback. Those affected by IP typically form skewed reference frames for self-evaluation, whereby successes are not acknowledged internally, thus inhibiting effective feedback mechanisms (73). The variance in interpretations when it comes to accepting input from others underpins the need for those who offer feedback to pay heedful attention during exchanges.

In summary, the origins of tension among medical students are complex and diverse, deeply embedded within the unique requirements and expectations of their medical academic journey. These sources of stress include rigorous academic demands, clinical obligations, striving for perfectionism, struggles with balancing personal life and work commitments, financial worries, competition amongst peers, and adaptation challenges. A critical move toward ensuring comprehensive wellbeing for medical students is acknowledging this complex web of stressors. This recognition highlights the need for personalized strategies and supportive frameworks designed to identify these pressures while minimizing their impact within the distinct environment of medical education.

4.5 Stress management programs

4.5.1 Resilience training

Resilience training programs are designed to equip medical learners with the psychological and behavioral skills required to withstand and recover from the inherent pressures of medical education and clinical practice. The theoretical foundation of resilience in medical education draws heavily from cognitive-behavioral theory, stress-adaptation models, and positive psychology. These frameworks conceptualize resilience as a dynamic process involving adaptive coping, cognitive reframing, emotional regulation, and the ability to derive meaning from stressful experiences. In the context of medical training, resilience is increasingly viewed not as an innate trait but as a set of teachable, modifiable skills that enable students to respond constructively to academic, clinical, and interpersonal challenges.

From a cognitive-behavioral perspective, resilience training emphasizes identifying unhelpful thought patterns, reframing stressors, and developing more effective problem-solving approaches. Positive psychology contributes the principles of growth mindset, self-efficacy, and reflective meaning-making, all of which are essential for sustaining wellbeing in demanding learning environments. These principles help medical students shift from a deficit-focused mindset (i.e., stress as harmful) to a competence-enhancing one (i.e., stress as an opportunity for growth).

In practice, resilience curricula often include workshops, guided reflection sessions, peer discussions, and experiential activities designed to strengthen adaptability, emotional awareness, and stress tolerance. As noted in North American medical education programs, resilience modules are typically structured to promote autonomy and self-directed learning—key characteristics of adult learning theory (74, 75). Reflection periods, an integral component of these programs, encourage students to analyze clinical encounters, emotional responses, and performance challenges, thereby reinforcing self-regulation and metacognitive awareness (76).

Resilience training compares favorably with other stress-management approaches identified in the included studies—particularly mindfulness-based stress reduction (MBSR) and general coping-skills workshops. While MBSR focuses on present-moment awareness, non-judgmental observation of thoughts, and physiological relaxation, resilience programs target cognitive flexibility, proactive coping, and long-term adaptability. Both approaches demonstrate benefits for stress reduction; however, resilience training may offer broader applicability because it equips students with cognitive and behavioral tools that are useful across varied clinical and academic contexts. Unlike brief coping-skills programs that focus on isolated strategies, resilience interventions promote sustained behavioral change and the development of internal resources that persist beyond the intervention period.

Evidence from the reviewed studies suggests that resilience training is particularly effective when students actively engage in structured reflection, open discussions about stress and medical errors, and collaborative problem-solving. Students who adopt proactive coping styles—such as seeking support or

reframing stressful events—tend to report lower burnout levels and better psychological wellbeing compared to those who rely on avoidance strategies (77, 78). Programs such as the Penn Resiliency Program (PRP), grounded in cognitive-behavioral therapy, have shown significant reductions in depressive symptoms and improvements in emotional functioning across diverse educational contexts (79).

Based on the findings from this review and supporting literature, several evidence-based recommendations can curricula into medical programs:

1. Embed resilience training longitudinally across the curriculum, allowing students to practice and reinforce skills at multiple stages of training rather than in isolated workshops.
2. Incorporate structured reflection and debriefing sessions, especially after stressful clinical encounters, to promote emotional processing and self-awareness.
3. Combine resilience modules with MBSR or wellness programs, as multimodal approaches appear to strengthen overall intervention effectiveness.
4. Create safe, non-judgmental discussion spaces where students can openly share experiences related to stress, burnout, and clinical challenges, fostering peer support networks.
5. Train faculty mentors in resilience-supportive practices, enabling them to model adaptive coping behaviors and provide effective guidance.
6. Ensure institutional support, recognizing that resilience is not solely a student responsibility; organizational culture, workload, and learning environments play crucial roles in shaping resilience.

In summary, resilience training offers a comprehensive approach to stress management by simultaneously targeting cognitive, emotional, and behavioral mechanisms. When embedded within a supportive institutional framework, resilience programs can significantly improve medical students' coping capacity, mental health, and long-term professional resilience.

4.5.2 Mindfulness-based stress reduction (MBSR) programs

MBSR-based programs introduce learners to practices centered on mindfulness, including meditation and other exercises that employ a mindfulness-based approach. These methodologies aim to equip students with tools for better stress management, improved focus, and promoting emotional health. Often, MBSR programs include sessions focused on cultivating mindfulness and promoting the regular practice of this discipline as part of self-care routines among students. Kabat-Zinn's model, widely recognized as the quintessential guide for a mindfulness course, is typically presented as an 8-week program with weekly classes known as the MBSR program (80).

Innovative strategies are essential for enhancing the accessibility of mindfulness meditation exposure to medical students. A preliminary investigation by Danilewitz et al. (81) examined a strategy led by peers in the context of medical student mindfulness, yielding substantial stress reduction and notable enhancements in self-compassion, altruism, and mindfulness

(81). This approach, led by peers, offers considerable economic advantages while potentially fostering enhanced course comfort, given that it is delivered not by authority figures but fellow students. An introductory mindfulness session was offered alongside an 8-week course designed specifically for physicians, introducing a potential clinical therapeutic modality and self-care system. A more intensive experience, that is, participating fully in the course rather than attending just one introductory session, was associated with increased comfort levels and a higher likelihood of adopting mindfulness modalities (82).

A well-structured method, MBSR (Mindfulness-Based Stress Reduction), has been established to teach mindfulness principles within scientific circles (83). The evidence further supports its utility in academic settings geared toward healthcare professions. While it is rational to anticipate some variation when executing any MBSR protocol, the fundamental components and overarching framework must stay broadly consistent. The original curriculum was designed as a regimen spanning 8 weeks, involving weekly sessions lasting 2 h each, supplemented by daily exercises at home and a single-day retreat (83).

In their progressive analysis, Erogul and his team identified a persistent inclination toward reduced perceived stress over a 6-month period, albeit without statistical significance. Similarly, Aherne and his colleagues discovered through qualitative thematic scrutiny that stress regulation contributed to student satisfaction with the MBSR program (84, 85). These insights underscore the impact of MBSR on managing medical student stress levels and suggest a potential long-term advantage gained from brief engagement with MBSR (86). It is essential to explore this field more, as burnout is crucial to examine, given its correlation with professional conduct, empathy, and patient safety (86, 87). Recognizing how burnout can impact both patient outcomes and wellness among medical students necessitates more in-depth research to accurately determine if there is a connection between MBSR training and instances of burnout.

4.5.3 Wellness and self-care workshops

Programs focused on health promotion and personal care accentuate the need to maintain physical and emotional wellness (88). These initiatives provide students with suitable tactics to incorporate self-care habits into their daily routines, including guidance on nutrition, physical activity, sleep patterns, and relaxation techniques. Workshops could also highlight the importance of balancing professional duties with personal life. Occupational stress can negatively affect the competence, service quality, delivery efficiency, and comprehensive quality of life of healthcare professionals. Thus, pinpointing these occupational hazards and finding ways to alleviate them is crucial in safeguarding the mental stability and general wellness of those involved in patient care services (89).

In educational culture, students have proposed improving communication practices and fostering a more respectful and supportive environment among peers and faculty. Specifically, the implementation of robust mentoring initiatives was encouraged

as a means of providing more significant support. Mentorship programmes within medical education contexts have been linked with elevated or improved student academic achievements, facilitating relationships between students and faculty that spur personal growth alongside professional development (90, 91). In addition, the students advocated for reducing the stigma associated with mental health care while expanding access to therapeutic counseling services (88).

Clusters of self-care activities have been classified based on brainstorming responses from medical students, thus providing a more profound comprehension and enhancement of self-care, as per certain research studies (92). A notable decrease in severe depression, stress, and anxiety among medical students was observed upon introducing mindfulness training, social gatherings, a pass/fail evaluation system, and decreased contact hours during the preclinical tenure (93). Furthermore, it is significant that personalized self-care strategies are transformed into standard institutional cultural practices aimed at developing resilience. This helps circumvent obstacles while prioritizing self-care among healthcare professionals.

Institutionally, the acknowledgment and integration of self-care practices are vital for safeguarding mental wellbeing, fostering resilience, and enhancing work motivation, job contentment, patient security, and quality of service. The endorsement of self-care techniques, resilience strategies, and workplace policy modifications at an institutional level might incorporate compulsory rest periods (including brief sleep increments or “power naps,” casual strolls, or access to quiet spaces), implementation of short breaks before each meeting’s initiation, and regulations mandating meetings always commence on the hour. All these methods aim to refine the professional environment (89).

Recent analyses emphasize the necessity of harmonizing personal needs with those of others, advocating self-care as the primary protective measure for medical professionals grappling with the demands of treating COVID-19 patients, the enduring nature of this crisis, and its impact on daily life habits. In this context, these evaluations underscore the importance of employing supportive instruments and methodologies to address mental health complications and empathy exhaustion prevalent among healthcare professionals. Various recommended prophylactic self-care maneuvers include spiritual observances and calming methods, electronic mental health provisions, and enhancing interpersonal abilities (94, 95). Furthermore, regulations should limit the duration of work shifts, along with provisions for professional mental health assistance programs and peer-assisted support groups. This will facilitate routine debriefing sessions, where experiences can be shared openly. Furthermore, hospitals and other healthcare establishments should implement comprehensive parental and sick leave policies that do not impose undue stress on fellow healthcare professionals. Departments must factor in reserved time slots within their schedules for personal medical consultations, therapy sessions, or medical visits (89).

It is crucial to note that a combination of these initiatives might be adopted by medical institutions, acknowledging the complex character of the stress endured by medical students.

In addition, such initiatives are frequently incorporated into the comprehensive medical curriculum, highlighting the importance of mental wellbeing as a fundamental aspect of medical scholars. These initiatives aim to support students in their individual and vocational growth, ultimately priming them to evolve into tenacious and empathetic practitioners in healthcare (96–98).

4.6 Implementation and recommendations

The strategies available to support medical students in managing stress are broad in scope and critical to their success. Given the demanding nature of medical training, institutions must prioritize students' psychological wellbeing. Effective stress management enhances mental health, academic performance, and resilience. Key measures include establishing robust mental health support systems, integrating stress management education into curricula, offering coping skills workshops, and promoting an open, help-seeking culture. Ongoing research is also needed to tailor interventions to students' evolving needs. Together, these strategies create a supportive environment that prepares future physicians to thrive academically and develop into compassionate, resilient healthcare professionals.

4.7 Limitations

A limitation of the study is the relatively brief follow-up, which may be applicable to interventions such as workshops and resilience programs. Observed outcomes may not be adequately assessed in terms of their long-term effects. Second, the studies' cultural, institutional, and socioeconomic contexts can influence the effectiveness and applicability of stress management programs. Depending on the culture or educational setting, such results may not be universally applicable. The third problem is that some studies do not provide complete information about the academic year. A lack of this information can limit the interpretation of results, as different levels of stress and coping mechanisms may be associated with different stages in the academic journey. Limiting the search to English-language publications may have excluded relevant international evidence, contributing to potential publication and language bias. It is crucial to understand these limitations to interpret the results and consider the applicability of stress management interventions in diverse educational settings.

5 Conclusion

Effective stress-management strategies are essential for medical students, given the demanding nature of their training. Prioritizing students' mental wellbeing enhances academic performance, supports resilience, and contributes to the development of balanced and capable future physicians. Key measures include providing accessible psychological support, integrating stress-management

education into curricula, offering coping-skills workshops, and fostering an open, help-seeking culture. Ongoing research is needed to tailor interventions to students' evolving needs.

Stress-management programs are not optional additions but vital components of medical education. By investing in these initiatives, institutions help students navigate adversity, build resilience, and grow into compassionate, competent healthcare professionals. As medical training continues to evolve, programs must be regularly refined to support both academic success and long-term emotional wellbeing, ensuring that future physicians are equipped with the skills to care for themselves and their patients.

Author contributions

KB: Conceptualization, Funding acquisition, Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing. MH: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Validation, Writing – original draft, Writing – review & editing. SA: Conceptualization, Data curation, Validation, Writing – original draft, Writing – review & editing.

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References

- Melillo TV, Hetherington VJ. Challenges and opportunities facing the Ohio College of Podiatric Medicine. *J Am Podiatr Med Assoc.* (1992) 82:320–4. doi: 10.7547/87507315-82-6-320
- Fares J, Al Tabosh H, Saadeddin Z, El Mouhayyar C, Aridi H. Stress, burnout and coping strategies in preclinical medical students. *N Am J Med Sci.* (2016) 8:75–81. doi: 10.4103/1947-2714.177299
- Rotenstein LS, Ramos MA, Torre M, Segal JB, Peluso MJ, Guille C, et al. Prevalence of depression, depressive symptoms, and suicidal ideation among medical students: a systematic review and meta-analysis. *JAMA.* (2016) 316:2214–36. doi: 10.1001/jama.2016.17324
- Abdulghani HM, AlKanhal AA, Mahmoud ES, Ponnampuruma GG, Alfari E.A. Stress and its effects on medical students: a cross-sectional study at a college of medicine in Saudi Arabia. *J Health Popul Nutr.* (2011) 29:516–22. doi: 10.3329/jhpn.v29i5.8906
- Bergmann C, Muth T, Loerbros A. Medical students' perceptions of stress due to academic studies and its interrelationships with other domains of life: a qualitative study. *Med Educ Online.* (2019) 24:1603526. doi: 10.1080/10872981.2019.1603526
- Shetty K, Geetha S. Perception on medical ethics in teaching among medical students in India. *Bioinformation.* (2022) 18:613–6. doi: 10.6026/97320630018613
- Govindraj L, Santhosh S, Sunish SC, Gopalakrishnan AV, Chandy SJ, Oommen V, et al. Effectiveness of teaching medical ethics to medical students on an online platform: an analysis of students' perceptions and feedback. *Indian J Med Ethics.* (2023) 8:32–8. doi: 10.20529/IJME.2022.034
- Malau-Aduli BS, Alele FO, Heggarty P, Teague PA, Sen Gupta T, Hays R. Perceived clinical relevance and retention of basic sciences across the medical education continuum. *Adv Physiol Educ.* (2019) 43:293–9. doi: 10.1152/advan.00012.2019
- Buja LM. Medical education today: all that glitters is not gold. *BMC Med Educ.* (2019) 19:110. doi: 10.1186/s12909-019-1535-9
- Frajerman A, Morvan Y, Krebs MO, Gorwood P, Chaumette B. Burnout in medical students before residency: a systematic review and meta-analysis. *Eur Psychiatry.* (2019) 55:36–42. doi: 10.1016/j.eurpsy.2018.08.006
- Rodrigues H, Cobucci R, Oliveira A, Cabral JV, Medeiros L, Gurgel K, et al. Burnout syndrome among medical residents: a systematic review and meta-analysis. *PLoS ONE.* (2018) 13:e0206840. doi: 10.1371/journal.pone.0206840
- Curran T, Hill AP. Perfectionism increases over time: a meta-analysis of birth cohort differences from 1989 to 2016. *Psychol Bull.* (2019) 145:410–29. doi: 10.1037/bul0000138
- Selye H. Stress and the general adaptation syndrome. *Br Med J.* (1950) 1:1383–92. doi: 10.1136/bmj.1.4667.1383
- Lazarus RS, Folkman S. *Stress, Appraisal, and Coping.* New York, NY: Springer (1984).
- Dyrbye LN, Shanafelt TD. A narrative review on burnout and well-being in medical students. *Med Educ.* (2022) 56:50–60. doi: 10.1111/medu.12927
- Quek TT, Tam WW, Tran BX, Zhang M, Zhang Z, Su-Hui Ho C, et al. The global prevalence of anxiety among medical students: a meta-analysis. *Int J Environ Res Public Health.* (2019) 16:2735. doi: 10.3390/ijerph16152735
- Kaisti I, Kulmala P, Hintsanen M, Hurtig T, Repo S, Paunio T, et al. The effects of mindfulness-based interventions in medical students: a systematic review. *Adv Health Sci Educ Theory Pract.* (2024) 29:245–71. doi: 10.1007/s10459-023-10231-0
- Fish C. Nies (formerly Albrecht) MA. Health promotion needs of students in a college environment. *Public Health Nurs.* (1996) 13:104–11. doi: 10.1111/j.1525-1446.1996.tb00227.x
- Doyle NA, Davis RE, Quadri SSA, Mann JR, Sharma M, Wardrop RM, et al. Associations between stress, anxiety, depression, and emotional intelligence among osteopathic medical students. *J Osteopath Med.* (2021) 121:125–33. doi: 10.1515/jom-2020-0171
- Anton NE, Rendina MA, Hennings JM, Stambro R, Stanton-Maxey KJ, Stefanidis D. Association of medical students' stress and coping skills with simulation performance. *Simul Healthc J Soc Simul Healthc.* (2020) 16:327–33. doi: 10.1097/SIH.0000000000000511
- Varkey B. Principles of clinical ethics and their application to practice. *Med Princ Pract.* (2021) 30:17–28. doi: 10.1159/000509119
- Kruk ME, Gage AD, Arsenault C, Jordan K, Leslie HH, Roder-DeWan S, et al. High-quality health systems in the sustainable development goals era: time for a revolution. *Lancet Glob Heal.* (2018) 6:e1196–252. doi: 10.1016/S2214-109X(18)30386-3
- Weurlander M, Lönn A, Seeburger A, Hult H, Thornberg R, Wernerson A. Medical students' emotional challenges generate uncertainty. *Med Educ.* (2019) 53:1037–48. doi: 10.1111/medu.13934
- Acharya J, Sahani S. Coping up with stress as a medical student. *J Nepal Med Assoc.* (2022) 60:416–8. doi: 10.31729/jnma.7449
- Xu YY, Wu T, Yu YJ, Li M. A randomised controlled trial of well-being therapy to promote adaptation and alleviate emotional distress among medical freshmen. *BMC Med Educ.* (2019) 19:182. doi: 10.1186/s12909-019-1616-9
- Carroll L. Problem-focused coping. *Encycl Behav Med.* (2013) 1540–1. doi: 10.1007/978-1-4419-1005-9_1171
- Ma TL, Bell K, Dong T, Durning SJ, Soh M. Military medical students' coping with stress to maintain well-being. *Mil Med.* (2023) 188(Supplement_2):26–34. doi: 10.1093/milmed/usac292
- Salimzadeh R, Hall NC, Saroyan A. Examining academics' strategies for coping with stress and emotions: a review of research. *Front Educ.* (2021) 6:660676. doi: 10.3389/educ.2021.660676
- Wei P. The impact of social support on students' mental health: a new perspective based on fine art majors. *Front Psychol.* (2022) 13:994157. doi: 10.3389/fpsyg.2022.994157
- Alshagga MA, Al-Dubai SA, Muhamad Faiq SS, Yusuf AA. Use of complementary and alternative medicine among asthmatic patients in primary care clinics in Malaysia. *Ann Thorac Med.* (2011) 6:115–9. doi: 10.4103/1817-1737.82438
- Sattar K, Yusoff MSB, Arifin WN, Yasin MAM, Nor MZM. Effective coping strategies utilised by medical students for mental health disorders during undergraduate medical education scoping review. *BMC Med Educ.* (2022) 22:121. doi: 10.1186/s12909-022-03185-1
- Regehr C, Glancy D, Pitts A. Interventions to reduce stress in university students: updated review and meta-analysis. *J Affect Disord.* (2021) 282:123–34. doi: 10.1016/j.jad.2012.11.026
- Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ.* (2021) 372:n71. doi: 10.1136/bmj.n71
- Donohoe J, O'Rourke M, Hammond S, Stoyanov S, O'Tuathaigh C. Strategies for enhancing resilience in medical students: a group concept mapping analysis. *Acad Psychiatry.* (2020) 44:427–31. doi: 10.1007/s40596-020-01208-x
- Daya PA, Anithasri A, Priya PG, Ilamathi KR, Karthikeyan G. Perceived stress among medical students during COVID-19 pandemic and its impact on sleep and studies - a cross-sectional study in South India. *J Commun Dis.* (2022) 143–9. doi: 10.24321/0019.5138.202223
- Bodys-Cupak I, Grochowska A, Zalewska-Puchala J, Majda A. Stress and coping strategies of medical students during their first clinical practice – a pilot study. *Med Stud.* (2019) 35:294–303. doi: 10.5114/ms.2019.91247
- Teh BL, Sen, Ang JK, Koh EBY, Pang NTP. Psychological resilience and coping strategies with anxiety among Malaysian medical students during the COVID-19 Pandemic. *Int J Environ Res Public Health.* (2023) 20:1894. doi: 10.3390/ijerph20031894
- Rafique M. Perception medical faculty regarding students' classroom incivilities and coping strategies. *Pakistan Armed Forces Med J.* (2022) 72:1560–5. doi: 10.51253/pafmj.v72i5.4351
- Sahlabadi AS, Balochkhaneh FA, Gousheh SNH, Vatani J, Eshaghzadeh M, Bidel H. Study of suicidal thoughts and intentions concerning job stress among female medical students living in a dormitory with a mental health promotion approach. *J Educ Health Promot.* (2022) 11:318. doi: 10.4103/jehp.jehp_660_21
- Abouammoh N, Irfan F, AlFaris E. Stress coping strategies among medical students and trainees in Saudi Arabia: a qualitative study. *BMC Med Educ.* (2020) 20:124. doi: 10.1186/s12909-020-02039-y
- Abdul Aziz NA, Baharudin NS, Alias NA. Association between stress and social support perceived among undergraduate health sciences students. *Malays J Med Sci.* (2023) 30:176–83. doi: 10.21315/mjms2023.30.3.16
- Aisha D. Perception of "stress" and "stressors" among first-year medical students and effect of intervention on their stress perception. *Pakistan Armed Forces Med J.* (2020) 70:801–06. Available online at: <https://www.pafmj.org/PAFMJ/article/view/4664>
- Dahlin M, Joneborg N, Runeson B. Stress and depression among medical students: a cross-sectional study. *Med Educ.* (2005) 39:594–604. doi: 10.1111/j.1365-2929.2005.02176.x
- Ragab EA, Dafallah MA, Salih MH, Osman WN, Osman M, Miskeen E, et al. Stress and its correlates among medical students in six medical colleges: an attempt to understand the current situation. *Middle East Curr Psychiatry.* (2021) 28:75. doi: 10.1186/s43045-021-00158-w
- Yusoff MSB, Rahim AFA, Yaacob MJ. *Medical Student Stressor Questionnaire.* PscyTESTS Dataset (2010). doi: 10.1037/t15334-000
- Koukourikos K, Tsaloglidou A, Kourkouta L, Papathanasiou I V, Iliadis C, Fratzana A, et al. Simulation in clinical nursing education. *Acta Inform Med.* (2021) 29:15–20. doi: 10.5455/aim.2021.29.15-20
- Hill MR, Goicochea S, Merlo LJ. In their own words: stressors facing medical students in the millennial generation. *Med Educ Online.* (2018) 23:1530558. doi: 10.1080/10872981.2018.1530558

48. Backović D, Marinković JA, Grujčić-Šipetić S, Maksimović M. Differences in substance use patterns among youths living in foster care institutions and birth families. *Drugs Educ Prev Policy*. (2006) 13:341–51. doi: 10.1080/09687630600689041
49. Atta IS, Almilaibary A. The prevalence of stress among medical students studying an integrative curriculum during the COVID-19 pandemic. *Adv Med Educ Pract*. (2022) 13:35–45. doi: 10.2147/AMEP.S345330
50. Boulassel MR, Burney I, Al-Wardy N, Habbal O, Al-Rawas O. Students' perceived benefits of integrating a BSc in health sciences within a medical degree at Sultan Qaboos University. *Sultan Qaboos Univ Med J*. (2020) 20:e187–93. doi: 10.18295/squmj.2020.20.02.009
51. Mitsouras K, Dong F, Safaoui MN, Helf SC. Student academic performance factors affecting matching into first-choice residency and competitive specialties. *BMC Med Educ*. (2019) 19:241. doi: 10.1186/s12909-019-1669-9
52. Abdel Wahed WY, Hassan SK. Prevalence and associated factors of stress, anxiety, and depression among medical Fayoum University students. *Alexandria J Med*. (2017) 53:77–84. doi: 10.1016/j.ajme.2016.01.005
53. Aguinaga A, Gloria AM. The effects of generational status and university environment on Latina/o undergraduates' persistence decisions. *J Divers High Educ*. (2015) 8:15–29. doi: 10.1037/a0038465
54. Choi B, Jegatheeswaran L, Minocha A, Alhilani M, Nakhoul M, Mutengesa E. The impact of the COVID-19 pandemic on final year medical students in the United Kingdom: a national survey. *BMC Med Educ*. (2020) 20:206. doi: 10.1186/s12909-020-02117-1
55. Gazzaz ZJ, Baig M, Al Alhendhi BSM, Al Suliman MMO, Al Alhendhi AS, Al-Grad MSH, et al. Perceived stress, reasons for and sources of stress among medical students at Rabigh Medical College, King Abdulaziz University, Jeddah, Saudi Arabia. *BMC Med Educ*. (2018) 18:29. doi: 10.1186/s12909-018-1133-2
56. Puranachakere T, Hataiyusuk S, Anupansupai R, In-Iw S, Saisavoy N, Techapanuwat T, et al. Stress and associated factors with received and needed support in medical students during COVID-19 pandemic: a multicenter study. *Korean J Med Educ*. (2021) 33:203–13. doi: 10.3946/kjme.2021.200
57. Li Y, Wang Y, Jiang J, Valdimarsdóttir UA, Fall K, Fang F, et al. Psychological distress among health professional students during the COVID-19 outbreak. *Psychol Med*. (2021) 51:1952–4. doi: 10.1017/S0033291720001555
58. Torun F, Torun SD. The psychological impact of the COVID-19 pandemic on medical students in Turkey. *Pakistan J Med Sci*. (2020) 36:1355–9. doi: 10.12669/pjms.36.6.2985
59. Daugherty SR, Baldwin DC. Sleep deprivation in senior medical students and first-year residents. *Acad Med*. (1996) 71:S93–5. doi: 10.1097/00001888-199601000-00054
60. Azad MC, Fraser K, Rumana N, Abdullah AF, Shahana N, Hanly PJ, et al. Sleep disturbances among medical students: a global perspective. *J Clin Sleep Med*. (2015) 11:69–74. doi: 10.5664/jcsm.4370
61. Bahammam AS, Alaseem AM, Alzakri AA, Almeneessier AS, Sharif MM. The relationship between sleep and wake habits and academic performance in medical students: a cross-sectional study. *BMC Med Educ*. (2012) 12:61. doi: 10.1186/1472-6920-12-61
62. Medeiros ALD, Mendes DBF, Lima PF, Araujo JF. The relationships between sleep-wake cycle and academic performance in medical students. *Biol Rhythm Res*. (2001) 32:263–70. doi: 10.1076/brhm.32.2.263.1359
63. Åkerstedt T, Nilsson PM. Sleep as restitution: an introduction. *J Intern Med*. (2003) 254:6–12. doi: 10.1046/j.1365-2796.2003.01195.x
64. Thomas M, Bigatti S. Perfectionism, impostor phenomenon, and mental health in medicine: a literature review. *Int J Med Educ*. (2020) 11:201–13. doi: 10.5116/ijme.5f54.c8f8
65. Frost RO, Heimberg RG, Holt CS, Mattia JJ, Neubauer AL. A comparison of two measures of perfectionism. *Pers Individ Dif*. (1993) 14:119–26. doi: 10.1016/0191-8869(93)90181-2
66. Henning K, Ey S, Shaw D. Perfectionism, the impostor phenomenon and psychological adjustment in medical, dental, nursing and pharmacy students. *Med Educ*. (1998) 32:456–64. doi: 10.1046/j.1365-2923.1998.00234.x
67. Hutchins HM. Outing the impostor: a study exploring impostor phenomenon among higher education faculty. *New Horizons Adult Educ Hum Resour Dev*. (2015) 27:3–12. doi: 10.1002/nha3.20098
68. Rohrmann S, Bechtoldt MN, Leonhardt M. Validation of the impostor phenomenon among managers. *Front Psychol*. (2016) 7:821. doi: 10.3389/fpsyg.2016.00821
69. Franchi T, Russell-Sewell N. Medical students and the impostor phenomenon: a coexistence precipitated and perpetuated by the educational environment? *Med Sci Educ*. (2022) 33:27–38. doi: 10.1007/s40670-022-01675-x
70. Hewitt PL, Flett GL. Perfectionism in the self and social contexts: conceptualisation, assessment, and association with psychopathology. *J Pers Soc Psychol*. (1991) 60:456–70. doi: 10.1037/0022-3514.60.3.456
71. Clance PR, Dingman D, Reviere SL, Stober DR. Impostor phenomenon in an interpersonal/social context. *Women Ther*. (1995) 16:79–96. doi: 10.1300/J015v16n04_07
72. Yu JH, Chae SJ, Chang KH. The relationship among self-efficacy, perfectionism and academic burnout in medical school students. *Korean J Med Educ*. (2016) 28:49–55. doi: 10.3946/kjme.2016.9
73. Bynum WE, Artino AR, Uijtdehaage S, Webb AMB, Varpio L. Sentinel emotional events: the nature, triggers, and effects of shame experiences in medical residents. *Acad Med*. (2019) 94:85–93. doi: 10.1097/ACM.0000000000002479
74. Mugford H, O'Connor C, Danelson K, Popoli D. Medical students' perceptions and retention of skills from active resilience training. *Fam Med*. (2022) 54:213–5. doi: 10.22454/FamMed.2022.462706
75. Quay J. Experience and participation: relating theories of learning. *J Exp Educ*. (2003) 26:105–12. doi: 10.1177/105382590302600208
76. Harvey M, Coulson D, McMaugh A. Towards a theory of the ecology of reflection: reflective practice for experiential learning in higher education. *J Univ Teach Learn Pract*. (2016) 13:7–27. doi: 10.53761/1.13.2.2
77. Mosley TH, Perrin SG, Neral SM, Dubbert PM, Grothues CA, Pinto BM. Stress, coping, and well-being among third-year medical students. *Acad Med*. (1994) 69:765–7. doi: 10.1097/00001888-199409000-00024
78. Thompson G, McBride RB, Hosford CC, Halaas G. Resilience among medical students: the role of coping style and social support. *Teach Learn Med*. (2016) 28:174–82. doi: 10.1080/10401334.2016.1146611
79. Brunwasser SM, Gillham JE, Kim ES. A meta-analytic review of the Penn Resiliency Program's effect on depressive symptoms. *J Consult Clin Psychol*. (2009) 77:1042–54. doi: 10.1037/a0017671
80. Kabat-Zinn J. An outpatient program in behavioural medicine for chronic pain patients based on the practice of mindfulness meditation: theoretical considerations and preliminary results. *Gen Hosp Psychiatry*. (1982) 4:33–47. doi: 10.1016/0163-8343(82)90026-3
81. Danilewitz M, Bradwejn J, Koszycki D. A pilot feasibility study of a peer-led mindfulness program for medical students. *Can Med Educ J*. (2016) 7:e31–7. doi: 10.36834/cmej.36643
82. Shapiro P, Lebeau R, Tobia A. Mindfulness meditation for medical students: a student-led initiative to expose medical students to mindfulness practices. *Med Sci Educ*. (2019) 29:439–51. doi: 10.1007/s40670-019-00708-2
83. Michalak J, Crane C, Germer CK, Gold E, Heidenreich T, Mander J, et al. Principles for a responsible integration of mindfulness in individual therapy. *Mindfulness*. (2019) 10:799–811. doi: 10.1007/s12671-019-01142-6
84. Eroglu M, Singer G, McIntyre T, Stefanov DG. Abridged mindfulness intervention to support wellness in first-year medical students. *Teach Learn Med*. (2014) 26:350–6. doi: 10.1080/10401334.2014.945025
85. Aherne D, Farrant K, Hickey L, Hickey E, McGrath L, McGrath D. Mindfulness-based stress reduction for medical students: optimising student satisfaction and engagement. *BMC Med Educ*. (2016) 16:209. doi: 10.1186/s12909-016-0728-8
86. Polle E, Gair J. Mindfulness-based stress reduction for medical students: a narrative review. *Can Med Educ J*. (2021) 12:e74–80. doi: 10.36834/cmej.68406
87. Hall LH, Johnson J, Watt I, Tsipa A, O'Connor DB. Healthcare staff well-being, burnout, and patient safety: a systematic review. *PLoS ONE*. (2016) 11:e0159015. doi: 10.1371/journal.pone.0159015
88. Butcher MR, Thompson KM, Williams MK, Cooke BK, Merlo LJ. Assessment of student perspectives on improving wellness in medical school: qualitative results from a cross-sectional survey of medical students in Florida. *Adv Med Educ Pract*. (2021) 12:1067–79. doi: 10.2147/AMEP.S323332
89. Søvdal LE, Naslund JA, Kousoulis AA, Saxena S, Qoronfleh MW, Grobler C, et al. Prioritising the mental health and well-being of healthcare workers: an urgent global public health priority. *Front Public Heal*. (2021) 9:679397. doi: 10.3389/fpubh.2021.679397
90. Dobkin PL, Hutchinson TA. Teaching mindfulness in medical school: where are we now and where are we going? *Med Educ*. (2013) 47:768–79. doi: 10.1111/medu.12200
91. Williams MK, Estores IM, Merlo LJ. Promoting resilience in medicine: the effects of a mind-body medicine elective to improve medical student well-being. *Glob Adv Heal Med*. (2020) 9:216495612092736. doi: 10.1177/2164956120927367
92. Simard AA, Henry M. Impact of a short yoga intervention on medical students' health: a pilot study. *Med Teach*. (2009) 31:950–2. doi: 10.3109/01421590902874063
93. Slavin SJ, Schindler DL, Chibnall JT. Medical student mental health 30: improving student wellness through curricular changes. *Acad Med*. (2014) 89:573–7. doi: 10.1097/ACM.0000000000000166
94. Waris Nawaz M, Imtiaz S, Kausar E. Self-care of frontline health care workers: during COVID-19 pandemic. *Psychiatr Danub*. (2020) 32:557–62. doi: 10.24869/psyd.2020.557

95. Heath C, Sommerfield A, von Ungern-Sternberg BS. Resilience strategies to manage psychological distress among healthcare workers during the COVID-19 pandemic: a narrative review. *Anaesthesia*. (2020) 75:1364–71. doi: 10.1111/anae.15180
96. Amir Rad F, Otaki F, Baqain Z, Zary N, Al-Halabi M. Correction: Rapid transition to distance learning due to COVID-19: perceptions of postgraduate dental learners and instructors. *PLoS ONE*. (2021) 16:e0253683. doi: 10.1371/journal.pone.0253683
97. Faiza F, Sultana R, Batool J, Khalid S, Khan AM. Frequency of primigravida in patients with eclampsia. *J Ayub Med Coll Abbottabad*. (2023) 35:265–8. doi: 10.55519/JAMC-02-11489
98. Nair B, Otaki F, Nair AF, Ho SB. Medical students' perception of resilience and an innovative curriculum-based resilience skills building course: a participant-focused qualitative analysis. *PLoS ONE*. (2023) 18:e0280417. doi: 10.1371/journal.pone.0280417



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Promoting social and emotional competence in at-risk preschoolers: a mixed-methods evaluation of an SEL training program

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Introduction: Preschool children at risk of emotional and behavioral disorders (EBD) frequently lack essential social and emotional learning (SEL) competencies. This mixed-methods study investigated the effectiveness of a targeted SEL program in addressing these developmental gaps and fostering positive behavioral outcomes in early childhood settings.

Methods: The study employed a mixed-methods design involving 140 kindergarten children, including a sub-group of 29 preschoolers identified as being at risk for EBD. Quantitative data were gathered using a validated SEL assessment scale to measure pre- and post-program competence. Complementary qualitative insights were obtained through semi-structured interviews with six teachers who implemented the program.

Results: Quantitative analysis revealed that the SEL program significantly increased competence levels among at-risk children, with statistically significant improvements across all measured domains regardless of gender. However, non-at-risk peers maintained higher overall competence levels throughout the study. Qualitative findings from teacher interviews mirrored these gains, noting improvements in social, language, and cognitive skills. Teachers also highlighted enhanced child-adult relationships and a reduction in negative classroom behaviors, while identifying specific environmental factors that influenced implementation success.

Conclusion: Both data sets converge to confirm the efficacy of the SEL program for at-risk kindergarteners. The study concludes that such interventions are vital for fostering behavioral and social development, leading to recommendations for enhanced teacher training in SEL practices to foster positive behaviors in the classroom, improve classroom communication and student outcomes in early childhood settings.

KEYWORDS

Social and emotional learning (SEL), emotional and behavioral disorders (EBD), at-risk preschoolers, kindergarten intervention, positive behaviors support (PBS), teacher perspectives, teacher professional development

1 Introduction

Social emotional learning (SEL) is now a core part of education, defined by the Collaborative for Academic, Social, and Emotional Learning (CASEL) as the skills needed to understand and manage emotions, set and achieve positive goals, build healthy relationships, and make responsible decisions (1). These abilities are vital for children's development.

Many young children start school, typically kindergarten or first grade (ages 5–7), lacking sufficient social and emotional readiness, which increases their risk of emotional and

behavioral challenges. This makes it crucial for educators to offer emotional support and teach conflict management. Social and Emotional Learning (SEL) programs, often implemented from preschool through elementary grades, can positively modify student behavior and improve the learning environment. Research (e.g., (2–7)) shows that these programs lead to better social–emotional skills, improved academic results, enhanced behavioral discipline, a more positive school climate, and better self-perception and perception of others among students. Children, particularly in the early elementary years, with strong social–emotional skills tend to behave better in the classroom and engage more effectively in learning (8–10). Conversely, those with weaker skills struggle to express or understand emotions, often leading to inappropriate reactions (8, 11–13).

Developing SEL during preschool years benefits children's overall development and readiness for school. Children with strong social–emotional skills achieve higher academic performance, build more positive relationships, and show better emotional adjustment and mental health (12, 14, 15). The effectiveness of SEL programs is strongly supported by research highlighting their profound impact on young children's development and school readiness. Studies emphasize their role in improving children's ability to manage emotions, resolve conflicts, and interact effectively, contributing to well-rounded personalities capable of facing life's challenges (16–18).

Specifically, developing SEL during preschool years yields significant benefits: children with stronger social–emotional skills often achieve higher academic performance, form more positive relationships, and exhibit better emotional adjustment and mental health (15, 19). Research suggesting that SEL interventions positively influence brain structure and function (20) supports the motivation to implement these programs in schools for preschoolers whose brains are undergoing rapid development. Systematic reviews and meta-analyses consistently confirm the effectiveness of classroom-based SEL in enhancing social and emotional competencies and reduce problematic behaviors, particularly for children needing early support (6, 21).

Early indicators of emotional and behavioral challenges in young children demand careful attention, particularly given that prevalence rates for significant difficulties in this domain may be as high as 20% among children aged one to seven, according to a meta-analysis by Vasileva et al. (22). While formal diagnoses of emotional and behavioral disorders (EBD) are typically applied to older age groups, these early difficulties profoundly affect children's foundational academic readiness and social development. Children at risk of EBD often find it challenging to regulate their emotions and form reciprocal relationships with peers, which can hinder their successful navigation of early social environments. Developmentally, these struggles often manifest as negative self-perceptions, emergent low self-esteem, and social withdrawal, critically undermining their overall social well-being and setting the stage for later difficulties (23, 24). This underscores the urgent need for programs that support the mental and social well-being of children with or at risk for EBD. Implementing SEL programs is crucial as they empower these children to develop essential skills, resolve conflicts peacefully, and navigate life's challenges more effectively.

This study addresses the critical need for holistic education that goes beyond academics to include social and emotional growth (25, 26). We will implement an in-school SEL program. The program's primary goal is to improve social and emotional competence, helping children at risk for EBD learn to manage their emotions and interact more positively with others. Ultimately, this will give them the foundational skills they need to succeed both in and out of the classroom.

The purpose of the present mixed-method study was to investigate the effects of a SEL training program on the development of SEL competence in at risk preschoolers. We compared their performance before and after the program using a validated rating scale to identify changes in children's SEL competencies. We also explored if the program's effects varied by gender or the presence or risk of EBD. To gain a deeper understanding, we also gathered and analyzed teachers' perceptions of the program's impact on children's social and emotional skills in the kindergarten environment.

2 Materials and methods

2.1 Participants

The study included two main participant groups for the quantitative and qualitative segments. The quantitative part of the study included 140 preschoolers aged 4–6 years (45.71% males, $n = 64$; 54.29% females, $n = 76$). Of these, 29 children (20.71%) classified as at risk for EBD if SDQ total difficulties fell within Borderline/Abnormal bands (teacher-report, Arabic version), while 111 (79.29%) did not. For the qualitative segment, teachers of these preschoolers participated. Their professional experience and relevant course history in EBD and SEL are detailed in Table 1. Ethical approval for the study was obtained prior to data collection.

2.2 The social and emotional learning program

The SEL program implemented in this study is founded on the well-established content of “Zippy's Friends” program. This particular program was selected for its documented effectiveness in enhancing social and emotional skills and mitigating problematic behaviors in students (16, 27, 28). It further aids students in developing adaptive coping mechanisms for daily life challenges and mental health difficulties (29, 30). Practical considerations also favored Zippy's Friends due to its non-profit status, widespread international implementation, and availability in multiple languages (31). Zippy's Friends is based on six stories about a group of three cartoon characters, their families, friends, and their pet stick insect named Zippy. Teachers read the stories and lead children through engaging activities like discussion, games, role-playing, and drawing to help them explore emotions, communication, and conflict resolution. Zippy's Friends directly incorporates the five-core

TABLE 1 Participant profile: teacher experience and professional development courses.

Teacher	Years of Experience	Number of Courses	
		Related to EBD	Related to SEL
Teacher S	12	None	None
Teacher N	11	None	None
Teacher F	13	None	None
Teacher M	13	None	None
Teacher B	11	Two courses	None
Teacher J	11	One course	None

social and emotional learning competencies established by the CASEL (32), which serve as its foundational framework and guide the derivation of specific training procedures. Moreover, its design specifically addresses the characteristics of children with, or at risk for, emotional and behavioral disorders.

The program was delivered over a 10-week period, comprising four sessions per week, with a limit of one session per day within the classroom setting. Each session was approximately 45 min long, with flexibility for minor time adjustments as needed.

Implementation involved training teachers in the fundamental concepts of SEL and their practical application. To ensure robust implementation, fidelity was verified through an electronic guide and direct monitoring of teachers' session delivery. Fidelity monitoring was conducted by two trained research assistants who used a 9-item checklist (see Appendix 1) to score adherence in a random 80% of all delivered SEL sessions. The rigorous monitoring procedures yielded high inter-rater reliability, with the monitors achieving 93% agreement. This strong consensus was confirmed by a high Cohen's Kappa coefficient ($\kappa = 0.927$). The electronic guide was a comprehensive digital resource provided to teachers, designed to outline the program's specific lesson plans, instructional scripts, and required materials for each session. Social validity was assessed via interviews with participating teachers, who confirmed the program's acceptance and ease of application within their classrooms.

2.3 Measures

2.3.1 Strength and difficulties questionnaires (SDQ)

The Strength and Difficulties Questionnaire (SDQ), created by Goodman (33), serves as a behavioral screening assessment designed for children aged 2 to 17 years. Its utility is enhanced by its three versions—teacher, parent, and self-report (for 11–17-year-olds)—and its 25-item structure across five distinct sub-scales. These include four difficulty scales (Emotional Symptoms, Conduct Problems, Hyperactivity, and Peer Problems) and one strength-focused scale, the Pro-social Scale. Each sub-scale contains five items. Freely accessible online scoring keys facilitate the identification of children who may be at risk for behavioral and emotional disorders.

The SDQ was selected for this study due to its widespread use, ability to capture both difficulties and strengths, cost-free access, availability in numerous languages, and inclusion of a teacher report. Its straightforward administration, use, and scoring—typically taking only 5 to 10 min—further supported its selection for screening participating children and identifying those at risk. For this study, the official Arabic version of the SDQ was administered to participants via the teacher report. The Arabic version of the SDQ was accessed, and the scoring keys were utilized from the freely available resources at www.sdqinfo.org. For participant classification, we applied the standard banded cutoffs (Normal, Borderline, and Abnormal) to the total difficulties score. Children were subsequently classified as at risk if their total difficulties score fell within the Borderline or Abnormal ranges.

2.3.2 The social and emotional competency rating scale (SECRS)

The Social-Emotional Competency Rating Scale (SECRS) developed by Brant and Studebaker (34, 35). They adapted the SECRS, a 42-statement

instrument, based on two established assessments: The Devereux Early Childhood Assessment Rating Scale, DECA (36) and The Devereux Student Strengths Assessment, DESSA (37). This adaptation specifically involved content modification and selection to align the resulting 42 items with the five key social and emotional competency domains outlined by CASEL (1). The design of the SECRS focuses specifically on measuring these CASEL domains (as shown in Appendix 2). In the present study, the SECRS was utilized as a pre- and post-intervention measure, completed by the participating children's teachers.

The internal consistency of the SECRS was assessed using two standard psychometric measures in the current sample. We calculated Pearson Correlation Coefficient between the scores of each SECRS subscale and the total scale score. The results demonstrated a high level of internal consistency, with correlations ranging from ($r = 0.71$) to ($r = 0.83$), as shown in Table 2. Furthermore, internal consistency was calculated. The overall scale displayed high constancy ($\alpha = 0.90$). Similarly, the subscales demonstrated high constancy, with coefficients ranging from ($\alpha = 0.85$) to ($\alpha = 0.92$). The results are presented in Table 3.

2.3.3 Semi-structured interviews

Semi-structured interviews were employed to gather qualitative data. This approach aimed to understand the program's impact on participating children's socio-emotional competence from the teachers' perspective and to verify the accuracy of implementation procedures. Qualitative data was collected throughout and after the program's execution. The interview protocol includes a total of eight questions, distributed across the program's timeline. Participants are asked two questions during the pre-implementation phase (e.g., "From your perspective, what is social emotional learning?"), followed by three questions focused on their experience during implementation (e.g., "Describe your current experience applying the social emotional learning program in your classroom?"), and concluding with three questions in the post-implementation phase to evaluate their experience (e.g., "How do you evaluate your experience applying the social emotional learning program in your classroom?").

Thematic analysis was used for data analysis, as it is a suitable method for qualitative data intended to strengthen, interpret, and better understand the quantitative data analysis results in this study. Thematic analysis helps explain phenomena by identifying recurring meanings or themes within the qualitative data. This process involved several stages, as outlined by Nowell et al., (38), which were followed in this study. The analysis utilized an inductive approach. Codes and themes emerged directly from the data, without a pre-existing theoretical framework. This ensured the findings were grounded in the teachers' experiences. For objectivity, both authors independently coded all transcripts. They then met to compare, discuss, and reconcile

TABLE 2 Pearson correlations between SECRS subscales and total score.

The SECRS subscale	Correlation coefficient (r)	Statistical significance
Self-awareness	0.71	<0.001
Self-regulation	0.79	<0.001
Relationship skills	0.76	<0.001
Social awareness	0.82	<0.001
Responsible decision-making	0.83	<0.001

TABLE 3 Internal consistency reliability of the SECRS subscales.

The SECRS subscale	Number of items	Cronbach's alpha coefficient (α)
Self-awareness	7	0.92
Self-regulation	9	0.90
Relationship skills	9	0.91
Social awareness	9	0.89
Responsible decision-making	8	0.85
Total SECRS	42	0.90

initial coding discrepancies. This process led to a consensus on the final coding framework and its definitions. Reflexivity was maintained via research journals, which documented the rationale behind coding choices and thematic interpretations, mitigating researcher preconceptions and ensuring themes were rooted in the participant data. Specifically, pre-existing understandings of Social and Emotional Learning (SEL) were bracketed during the initial coding phase. This process yielded a high level of inter-coder reliability, achieving a 98% agreement with a strong Cohen's Kappa coefficient ($\kappa = 0.958$). Credibility was established through member checking. A summary of the final themes and supporting quotes were presented to all teacher-participants, who verified that the analysis accurately represented their experiences and perspectives, thus validating the overall findings.

3 Results

The findings are presented in two parts: quantitative results from statistical analyses and qualitative insights from teachers' perspectives.

3.1 Quantitative results

The effects of the intervention (Time: pre- vs. post-assessment), Sex, and Risk status on children's Total Social-Emotional Competence were analyzed using hierarchical mixed-effects models. Children were nested within classes, and repeated measures were taken for each participant, reflecting the pre- and post-intervention assessments. This modeling approach allowed us to account for both between-subject variability (differences between children and classrooms) and within-subject correlations (changes over time).

Fixed effects included Time, Sex, Risk, and all possible two- and three-way interactions among these factors. Random effects consisted of random intercepts for children nested within classes, along with an unstructured covariance matrix for the repeated measures, permitting the estimation of variance and covariance between pre- and post-scores. Significance testing for fixed effects was conducted using Type III tests with Satterthwaite-adjusted degrees of freedom. Effect sizes for fixed effects were estimated via partial η^2 , providing a measure of the magnitude of each effect. For significant main effects, post-hoc pairwise comparisons with Bonferroni adjustment were performed to examine differences between levels of the factors. This comprehensive approach ensured that the analysis properly addressed the nested data structure, accounted for within-subject dependencies, and provided

both inferential and descriptive information necessary for interpreting the impact of the intervention across different subgroups of children.

The mixed-effects analysis presented in Table 4 revealed a significant main effect of Time on Total Social-Emotional Competence, $F(1, 136) = 253.96$, $p < 0.001$, partial $\eta^2 = 0.651$, indicating a large effect of the measurement occasion (pre vs. post).

The main effect of Risk was also significant, $F(1, 136) = 39.07$, $p < 0.001$, partial $\eta^2 = 0.223$, suggesting that children's risk status substantially influenced competence scores. No significant main effect of Sex was observed, $F(1, 136) = 0.05$, $p = 0.828$, partial $\eta^2 \approx 0$.

All two-way and three-way interactions between Sex, Risk, and Time were non-significant (all $p > 0.05$, partial $\eta^2 \leq 0.008$), indicating that the patterns of change across time were generally consistent across gender and risk groups. The variance component for the intercept (subject = ClassID * ChildID) was significant (Estimate = 0.0899, SE = 0.0253, Wald $Z = 3.56$, $p < 0.001$), indicating substantial variability between children nested within classes.

Mixed-effects modeling revealed significant pre-post improvements in total SEL scores. The intraclass correlation coefficient indicated modest classroom-level clustering (ICC = 0.13), suggesting that approximately 13% of the variance in total social-emotional competence was attributable to differences between classrooms, with the remaining variance occurring at the individual student level. Marginal $R^2 = 0.49$ showed that fixed effects (Time, Risk, Sex) explained nearly half of the variance, while Conditional $R^2 = 0.56$ reflected the contribution of both fixed and random effects. Residual plots indicated approximate normality and homoscedasticity, supporting the validity of model assumptions.

The unstructured covariance for the repeated measures (Time) showed a significant variance at Time 1 (Estimate = 0.1315, SE = 0.0338, Wald $Z = 3.89$, $p < 0.001$), whereas the covariance between Time 1 and Time 2 was not significant (Estimate = -0.0035 , SE = 0.0224, Wald $Z = -0.16$, $p = 0.875$). The variance at Time 2 (UN 2,2) is reported as redundant due to model constraints.

These results presented in Table 5 support the appropriateness of a hierarchical mixed-effects model with random intercepts for children nested within classes and an unstructured covariance for repeated measures.

Post-hoc pairwise comparisons presented in Table 6 indicate no statistically significant difference between males and females ($\Delta = -0.02$, $p = 0.828$, Cohen's $d = -0.03$, 95% CI $[-0.21, 0.15]$), indicating comparable levels of total SEL across sexes. Children classified as "not at risk" scored significantly higher than those "at risk" ($\Delta = -0.51$, $p < 0.001$), with a moderate-to-large effect size (Cohen's $d = -0.60$, 95% CI $[-0.78, -0.42]$), highlighting the impact of risk status on overall SEL. A large and statistically significant improvement was observed from pre- to post-intervention ($\Delta = 0.84$, $p < 0.001$), with a very large effect size (Cohen's $d = 1.48$, 95% CI $[1.25, 1.71]$), demonstrating the substantial effectiveness of the intervention.

Figure 1 presents mean total social-emotional competence scores. Among males, children at risk increased from 2.04 (pre) to 3.02 (post), representing a gain of 0.98, whereas children not at risk improved from 2.64 to 3.43, a gain of 0.79. For females, the at-risk group increased from 2.15 to 2.94 (+0.79), while the not at risk group rose from 2.64 to 3.46 (+0.82). Across all categories, post-intervention scores were higher than pre-intervention scores, indicating that the SEL program positively influenced children's social-emotional competence. Although not-at-risk children consistently scored higher

TABLE 4 Type III tests of fixed effects for total SEL.

Source	Numerator df	Denominator df	<i>F</i>	<i>p</i> -value	Partial η^2
Intercept	1.000	135.999	4735.708	<0.001	—
Sex	1.000	135.999	0.047	0.828	<0.001
Risk	1.000	135.999	39.073	<0.001	0.223
Time	1.000	135.999	253.962	<0.001	0.651
Sex * Risk	1.000	135.999	<0.001	0.986	<0.001
Sex * Time	1.000	135.999	0.491	0.485	0.004
Risk * Time	1.000	135.999	0.653	0.421	0.005
Sex * Risk * Time	1.000	135.999	1.075	0.302	0.008

TABLE 5 Estimates of covariance parameters for total SEL.

Parameter	Estimate	Std. error	95% CI	Wald <i>Z</i>	<i>p</i> -value
Repeated measures UN (1,1)	0.131	0.034	[0.079, 0.218]	3.893	<0.001
Repeated measures UN (2,1)	−0.004	0.022	[−0.048, 0.040]	−0.157	0.875
Repeated measures UN (2,2)	0.119	—	—	—	—
Intercept [ClassID * ChildID]	0.090	0.025	[0.052, 0.156]	3.557	<0.001

TABLE 6 Pairwise comparisons of total SEL across sex, risk, and time.

Effect	Comparison	Δ	SE	95% CI (Δ)	df	<i>p</i> -value	Cohen's <i>d</i>	95% CI (<i>d</i>)
Sex	Male – Female	−0.02	0.06	[−0.13, 0.09]	136	0.828	−0.03	[−0.21, 0.15]
Risk	At risk – Not at risk	−0.51	0.07	[−0.65, −0.37]	136	<0.001	−0.60	[−0.78, −0.42]
Time	Post – Pre	0.84	0.05	[0.74, 0.95]	136	<0.001	1.48	[1.25, 1.71]

than at-risk children at both time points, both groups demonstrated substantial and relatively parallel improvements. Additionally, the patterns for boys and girls were highly comparable, suggesting no meaningful sex differences in response to the intervention.

Table 7 shows statistically significant pre–post improvements across all SECERS subscales as well as the total social–emotional competence score. Mean differences (Δ) ranged from 0.55 to 0.97, and all 95% confidence intervals were entirely above zero, indicating a consistent pattern of improvement across domains.

After controlling for multiple testing using the Holm–Bonferroni procedure, all subscale effects remained statistically significant ($p < 0.001$), demonstrating the robustness of the findings and reducing the likelihood of Type I error inflation.

Regarding effect sizes, large effects were observed for most subscales, with Cohen's *d* values ranging from 1.10 to 1.32. The Relationship Skills subscale showed a moderate-to-large effect ($d = 0.66$). The total social–emotional competence score exhibited a very large effect size ($d = 1.37$), indicating a substantial overall impact of the intervention. Confidence intervals for Cohen's *d* were narrow and did not include zero, further supporting the stability and practical significance of these effects.

3.2 Qualitative results

Qualitative data were obtained from semi-structured interviews conducted with all participating teachers both during and after the

implementation of the SEL program. The teachers' responses provided their perspectives on the program's influence on the children and the various factors that affected its implementation in the preschool setting. The data corpus consisted of 6 teacher interviews, with each interview lasting approximately 45 to 60 min.

The collected narrative data were subjected to a thematic analysis (38) to uncover patterned meanings. This process involved six phases: familiarization with the data (transcribing and reading), generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the final report. Five core themes emerged from the analysis: Developing Skills in Children, Variations in Children's SEL Competencies, Supporting Positive Behavior, Strengthening Child-Adult Relationships, and Factors Influencing SEL Program Implementation. Figure 2 illustrates the themes and their corresponding sub-themes, and Table 8 provides illustrative quotes from the teachers.

3.2.1 Developing skills in children

Teachers consistently highlighted the significant positive impact of the SEL program on children. They observed improvements across three core developmental areas: social skills, language skills, and cognitive skills. All six teachers reported that the program significantly improved children's social skills and communication, especially for at-risk students (Table 8, Q1). This supports previous research showing that SEL programs boost social skills (39) and increase social engagement in children with EBD (40). The researchers believe this is because social skills are a key component of SEL, particularly for

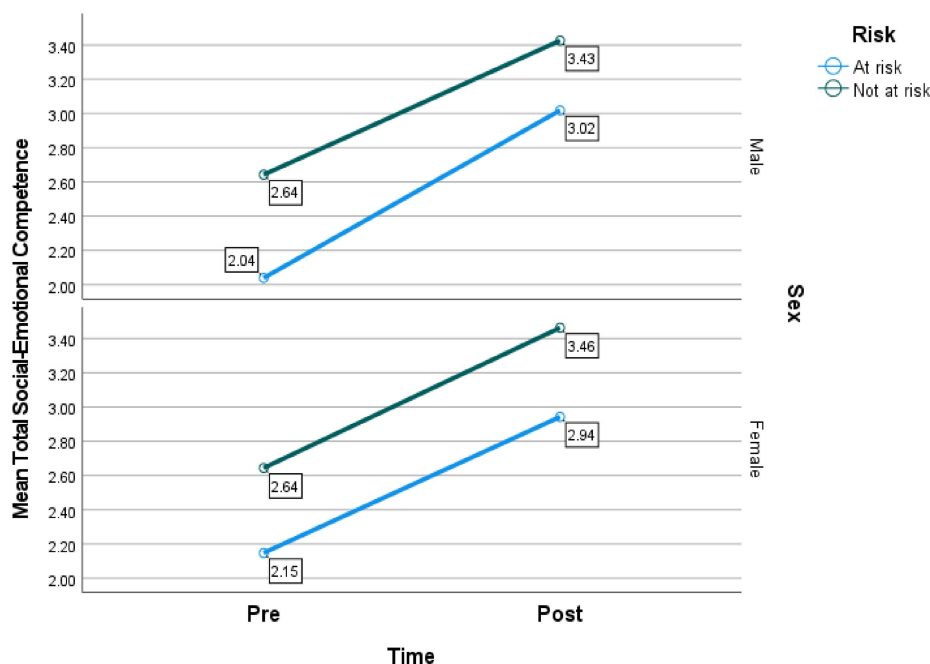


FIGURE 1

Mean total social–emotional competence scores by time (pre vs. post), sex (male vs. female), and risk status (at risk vs. not at risk).

TABLE 7 Pre–post changes across SECRS subscales with Holm-adjusted *p*-values.

SECRS subscale	Δ (Post–Pre)	Std. error	95% CI (Δ)	<i>p</i> -value	<i>p</i> (Holm)	Cohen's <i>d</i>	95% CI (<i>d</i>)
Self-awareness	0.965	0.075	[0.82, 1.11]	<0.001	<0.001	1.10	[0.88, 1.32]
Self-regulation	0.942	0.061	[0.82, 1.06]	<0.001	<0.001	1.32	[1.09, 1.55]
Relationship skills	0.552	0.072	[0.41, 0.69]	<0.001	<0.001	0.66	[0.48, 0.84]
Social awareness	0.884	0.068	[0.75, 1.02]	<0.001	<0.001	1.12	[0.90, 1.34]
Responsible decision-making	0.915	0.069	[0.78, 1.05]	<0.001	<0.001	1.14	[0.92, 1.36]
Total social–emotional competence	0.844	0.053	[0.74, 0.95]	<0.001	—	1.37	[1.13, 1.61]

preschoolers. During these early years, children start to understand how their actions affect social interactions, helping them take responsibility and manage their behavior (41). For children with EBD, early school interventions focusing on behavior and social aspects can significantly improve their often-low social and emotional performance (42).

All teachers reported an un-anticipated improvement in children's language skills. They observed an increase in both spontaneous conversations and the use of social–emotional vocabulary during the program sessions (Table 8, Q2). While not a primary goal, the program led to an improvement in children's language skills. This aligns with research from Taylor et al. (39) and a meta-analysis by Korpershoek et al. (43), both of which found that SEL programs positively impact students' academic and language development. However, our findings diverge from Daunic et al. (44) study, which reported no such benefits on social–emotional vocabulary or language development. Daunic and colleagues suggested this might be due to the facilitators' personalities and a lack of spontaneous conversations.

Our study, in contrast, observed frequent and spontaneous interactions between children and teachers during our program sessions. This distinction is crucial because strong language skills are fundamental for SEL, empowering children to effectively express their feelings and interact with others.

Five out of six teachers reported that children participating in the SEL program developed stronger cognitive skills, including memory and attention. This improvement was especially noticeable in children prone to EBD (Table 8, Q3). This finding is consistent with a study by Voith et al. (45), which also noted improved concentration and attention in participating children in similar program. Researchers believe that this development of cognitive skills stems from an integrated approach to teaching social and emotional skills, one that focuses on all aspects of development, including cognitive ones (46). Furthermore, the program's design in this study used a consistent set of characters across all six stories, with one story per unit. This consistent exposure likely reinforced children's memory and attention skills.

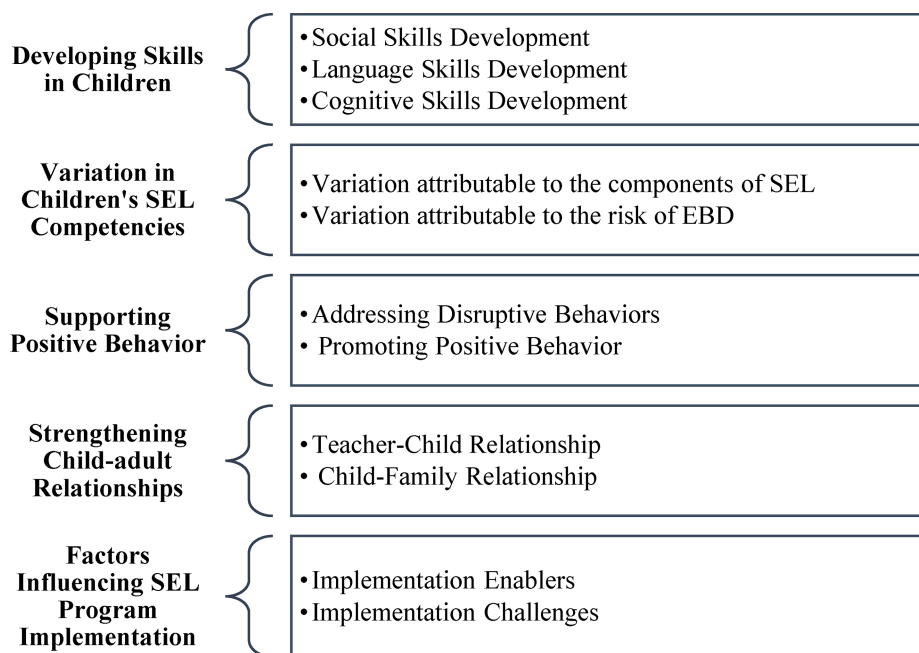


FIGURE 2

Thematic map: core themes and respective sub-themes identified through qualitative data analysis.

3.2.2 Variations in children's SEL competencies

All six teachers observed varied individual progress in children's SEL competence throughout the program. While all teachers noted improvement across every SEL component for all children, the most significant gains were consistently seen in self-regulation. In contrast, responsible decision-making showed the least improvement (Table 8, Q4). Five out of six teachers also noted that children at risk of EBD, while their progress was still considered significant, demonstrated less extensive improvement compared to their peers (Table 8, Q5).

3.2.3 Supporting positive behavior

All six teachers observed that the SEL program successfully reduced undesirable behaviors (Table 8, Q6), a finding supported by various studies (16, 45, 47, 48) demonstrating SEL's effectiveness in curbing bullying and other problematic conduct. This outcome is expected, as behavior modification is a core objective of SEL programs and aligns with their underlying cognitive theories (49).

Furthermore, all teachers noted that the SEL program also fostered positive behaviors, effectively acting as a preventive measure (Table 8, Q7). This aligns with research (6, 16, 30, 39, 50) indicating that SEL programs can prevent the development of future behavioral issues. This preventive impact likely stems from the program's emphasis on teaching children expected behaviors through clear classroom rules and equipping them with the skills to meet these expectations—a strategy recognized as an effective early intervention for behavioral problems (51).

3.2.4 Strengthening child–adult relationships

All six teachers reported a significant improvement in their relationships with children after implementing the program (Table 8, Q8). This positively impacted both the children and the teachers. This finding is consistent with existing research, including studies by Jaga

et al. (52), Robinson-Ervin et al. (53), Özen et al. (54), Rucinski et al. (55), Sandilos et al. (56), and Voith et al. (45). These studies highlight that high-quality teacher-child relationships and a positive classroom emotional climate are crucial for children's social, emotional, and academic development. Moreover, a study by Haymovitz et al. (23) noted that a key benefit of such programs is an improved classroom climate, leading to better teacher-child relationships and a safer school environment for children.

Five out of six teachers observed clear positive effects of the SEL program on participating children's relationships with their families (Table 8, Q9). This observation is consistent with prior research, including studies by Grusec (57) and Li et al. (58), which highlighted the crucial role of family interactions in helping children develop social norms and interpersonal skills necessary for building strong, positive relationships.

3.2.5 Factors influencing SEL program implementation

All six teachers reported that several factors influenced the SEL program, with some directly contributing to its successful implementation and goal achievement. Key among these was the program's quality, particularly its reliance on engaging stories and interactive activities. The program also benefited from a comprehensive guide that detailed session objectives, procedures, and assessment methods. Furthermore, the training workshop provided to participating teachers was crucial for successful implementation (Table 8, Q10). These findings align with existing research. Voith et al. (45) similarly found that program quality and training impact the effectiveness of SEL programs for children. The importance of teacher training is also supported by studies from, Durlak et al., (2), Cipriano et al. (59), Hassani & Schwab (60), and Lawson et al. (61), which highlight training, along with the

TABLE 8 Participants' supporting quotes on themes.

Quote numbers	Themes	Sub-themes	Illustrative quotes
Q1	Developing skills in children	Social skills development	Teacher S: The program really boosted the children's social skills and their ability to communicate effectively. It did helped kids get better at getting along with each other and talking about what they think and feel. They started respecting how others felt and expressed themselves in healthier ways. I even saw massive improvements in the kids who struggled with emotional and behavioral issues and had a tough time with their feelings and behavior. They started being nicer to each other's feelings, said what they needed to say in better ways, and even began caring more about their friends, like asking where a friend was if they were absent.
Q2		Language skills development	Teacher N: I observed remarkable growth in children's linguistic expression and verbal skills, particularly their fluency of speech. At first, most of them just used one or two words to say how they felt. But now, they are using lots more words to talk about their feelings, even using new emotion words they learned from the program.
Q3		Cognitive skills development	Teacher F: I noticed that most children's ability to pay attention to me and to what was happening around them improved, and the memory of most of the children got better. Kids with poor memory also started remembering the characters and important events in the story, and some of them even remembered the smallest details and events in sequence.
Q4	Variations in children's SEL competencies	Variation attributable to the components of SEL	Teacher M: I think kids really benefited most from self-awareness unit. It really helped them in learning about themselves and get better at understanding and talking about their feelings. I also think that responsible decision-making was the area where I saw the least improvement. They did get a little better, but their age really plays a part here. They're making decisions, but they are still too young to fully grasp the idea of being responsible for those choices.
Q5		Variation attributable to the risk of EBD	Teacher N: The program really boosted all the children's abilities, which was great to see. Kids with behavioral and emotional challenges definitely benefited and grew too, though their progress wasn't quite as significant as the others children.
Q6	Supporting positive behavior	Addressing Disruptive Behaviors	Teacher S: You know, I genuinely feel like this program had a big impact on the kids' behavior, particularly for those who struggled with their behavior. Honestly, a lot of the bad behaviors that were pretty disruptive and annoying have stopped. For example, there was one child who used to pick on others almost every day, but after we went through the bullying part of the program, his behavior completely changed. I can tell you for sure that using this program helped fix those negative and disruptive behaviors, and because of it, the kids are just behaving much better overall.
Q7		Promoting positive behavior	Teacher B: I'm genuinely impressed by the swift and substantial improvements I've observed since implementing the program. There's been a clear emergence of positive behaviors in almost all the children. For instance, I've witnessed them reminding each other of the learning rules in the corners—like saying, "No, what did we learn? We need quiet." This has undoubtedly led to a significantly improved atmosphere across all learning environments.
Q8	Strengthening child-adult relationships	Teacher-child relationship	Teacher F: This program really opened things up between me and the kids. it allowed me to have really open chats with the kids, which helped me understand how they were feeling, what scared them, and what made them stressed. I also learned what they really enjoyed. Getting to know them so well made me feel closer to them, and they started to feel closer to me too. I think maybe it was because I understood them and their personalities so much better. I even noticed they started showing me more affection, and their behavior towards me got a lot better. I really believe that this positive connection we built made a big difference in how much the kids got involved in learning.
Q9		Child-family relationship	Teacher J: The relationship building unit created a ripple effect, improving relationships not only in the classroom but also within families. I saw significant improvements in family relationships. For instance, one mother shared that before the program, her daughter would just cry when she got angry, unable to express herself. Now, while she might still cry initially, she's able to communicate what's wrong when asked. This shift came from her understanding, post-program, that she needs to articulate her feelings so her family can help her. I also believe the program's homework and exercises, which required parental involvement, were crucial to this success.

(Continued)

TABLE 8 (Continued)

Quote numbers	Themes	Sub-themes	Illustrative quotes
Q10	Factors influencing SEL program implementation	Implementation enablers	Teacher M: I think the biggest reason this program worked so well was because of its great stories and materials. The kids absolutely loved the stories—they were really good, and I think it's because they were about things happening in their own lives. Plus, the questions and activities for each lesson were super clear and easy for us teachers to use. Honestly, at first, I was pretty nervous. I even thought about quitting! I kept thinking, 'How am I going to teach something I've never learned about or had training in before?' But once you gave us the training and showed us all the materials, and I saw in the workshop how much the kids would benefit, I got really excited and decided to stick with it.
Q11		Implementation challenges	Teacher B: Some kids missed a lot of class, and it really showed. The ones who came regularly got the most out of the program, no question. I also saw a huge difference when parents got involved. The kids whose parents talked to me and asked about the program really did the best. I honestly think if we had offered a workshop for parents to show them how to help, they would have gotten even more involved, and more kids would have done even better.

accessibility and clarity of educational content, as significant factors in SEL program implementation. Additionally, Haymovitz et al. (23) and Hutchins et al., (62) corroborate that training for program providers is vital for success, as it enhances the program's positive impact on children.

Conversely, all six teachers identified factors that hindered the program's maximum effectiveness. These challenges included children's inconsistent daily attendance and a lack of active family participation (Table 8, Q11). This finding is consistent with research from Haymovitz et al. (23), Lawson et al. (61), and Li et al. (58) all of whom underscore the critical role of parental involvement in SEL programs, as family engagement provides a strong foundation for children's social and emotional development.

4 Discussion

4.1 Efficacy of the SEL program

The quantitative results, showing significant improvement in overall SEL competence and a large effect size, align with previous research affirming the benefits of SEL interventions for at-risk children (27, 63, 64). However, these findings contradict some studies [e.g., (65)]. The discrepancies might be due to differences in sample age, data collection methods, and program implementation fidelity.

This program also significantly boosted all SEL competence, with self-regulation showing the most substantial improvement due to its effectiveness in helping manage behavioral issues. Self-awareness, social awareness, and responsible decision-making also saw significant gains. The improvement in responsible decision-making was particularly notable for kindergarteners, as the program's emphasis on empathy helped them develop beyond typical egocentric behaviors. Finally, relationship skills improved significantly, likely as an indirect benefit of the advancements in other core SEL areas. The relationship skills showed a medium effect size, making it the least affected dimension. This might be because children at risk of EBD often exhibit disruptive behaviors like opposition and peer conflicts (62). Additionally, the development of relationship skills, given their social-dynamic nature, often requires extended learning periods (66).

These findings are consistent with existing literature [e.g., (6, 27, 30, 47, 53, 62, 64, 67)] affirming that SEL programs are effective in reducing negative behaviors and fostering greater responsiveness to adult guidance in students. The consistent improvements observed across all competencies, coupled with the substantial overall effect size, strongly support the SEL program's effectiveness for this vulnerable population.

4.2 Influence of sex and disorder risk

The finding of no statistically significant difference based on sex in program effectiveness is supported by other research (29, 68). A likely explanation for this consistent improvement is that all children received the same structured program training, leading to a uniform positive effect.

Regarding risk of disorder, the finding that the program was more effective for children not at risk of disorders aligns with Sullivan et al.

(69) who reported a stronger effect of SEL programs on non-disabled students. Conversely, it contrasts with Carroll et al. (68), who found the greatest impact on children identified as at risk of EBD. This discrepancy may be attributed to differences in the age groups studied—the current study focused on early childhood (kindergarteners), whereas Carroll et al. (68) examined children in late childhood. This developmental variation may account for the differing outcomes in SEL competence between children in these respective age ranges.

4.3 General discussion

This mixed-methods study aimed to comprehensively evaluate the SEL program's impact, integrating results from both quantitative and qualitative analyses. The findings largely converged, offering rich insights into the program's effects on children's social and emotional competence, with some notable divergences that warrant discussion. Organizing the discussion by key SEL components and broader themes allows for a richer interpretation that moves beyond simple statistical findings.

Self-regulation showed the most significant improvement after program implementation, indicating children's enhanced ability to manage their emotions and behaviors. Qualitative data strongly supported this finding, attributing the gains to the natural progression of behavioral development—a key objective of the program and a core principle of cognitive theories underlying SEL. The program's focus on coping skills and stress management likely contributed to this substantial impact on self-regulation. The strong convergence of data confirms that the program was highly effective in enhancing children's ability to manage emotions and behaviors. Teachers' comments linked this to the program's explicit focus on coping skills, which are particularly vital for children prone to EBD.

Responsible decision-making positioned as the second most impacted component while qualitative findings suggested it was the least extensive improved. This discrepancy might stem from the long-term developmental nature of this skill, which relies heavily on the advancement of self- and social awareness. Teachers' qualitative observations may reflect a more complex, long-term perspective, suggesting that deep, responsible decision-making takes extended time and relies on the maturity of other SEL skills. The program's success with kindergarteners on empathy-driven decision-making, however, is a positive indicator of foundational development.

Self-awareness and Social awareness showed significant improvement in the quantitative analysis. However, qualitative data indicated self-awareness as the most improved, possibly due to their focus on observable skills like identifying emotions. For social awareness, both qualitative and quantitative results aligned, confirming its enhanced role in fostering positive behavior.

Relationship skills appeared least affected by the program in the quantitative results, yet qualitative findings suggested considerable improvement. Quantitative data reflects smaller change from baseline, but qualitative observations capture the notable, daily relational dynamics that improved, possibly due to advancements in other core

SEL areas. This divergence could be explained by children's baseline skill levels before the program, as well as the deeper insights provided by qualitative data, which highlighted children's daily relational dynamics.

Overall, the qualitative and quantitative results largely converged on the improvements across all SEL components. Furthermore, qualitative findings revealed the program's broader impact beyond SEL competence, extending to linguistic and cognitive skills. The program also played a crucial role in promoting positive behavior, positioning it as a preventive intervention for EBD. The qualitative data also illuminated key success factors and challenges associated with implementing the program within school settings.

Quantitative analysis indicated the program was more effective for children not at-risk of EBD, a finding supported by teachers who observed less extensive gains in their at-risk students. This suggests that while the program is effective for both groups, children with existing behavioral risk factors may require a more intensive or extended intervention to achieve the same level of gain as their peers.

4.4 Broader benefits for the educational community

A significant finding from the qualitative analysis was the teachers reported a significant improvement in their relationships with the children and observed positive effects on the children's family relationships. This suggests that the structured SEL curriculum not only benefits the children but also enhances the teaching environment and the quality of teacher-child interactions, which itself is a crucial factor in children's development and reduces teacher stress (23, 52).

The success of the program was strongly linked to the quality of the program materials and the teacher training workshop. These findings affirm that engaging the educational community through professional development and providing accessible resources is an indispensable factor for effective SEL program implementation (2, 61). Conversely, challenges like lack of family participation underscore the need for future developments to more actively integrate the home environment to maximize a program's potential.

5 Conclusion

The program significantly improved all SEL components, a conclusion strongly supported by both qualitative and quantitative results. Additionally, qualitative data highlighted the program's wider influence, extending to enhancements in linguistic and cognitive skills. By promoting positive behavior, the program emerged as a crucial preventive intervention for EBD. Our qualitative analysis also shed light on the key factors contributing to the program's success and the challenges faced during its implementation in school environments. Given these significant benefits, SEL program should be an indispensable element of the educational curriculum for kindergarten children, preparing them with the social and emotional

competencies vital for navigating future challenges and achieving success.

Data availability statement

The dataset generated and analyzed for the current study contains human subject data. Therefore, to ensure participant privacy and adhere to the ethical approval granted for this study, data are not publicly available in an open repository. Access to the minimal dataset necessary to reproduce the findings can be requested from the corresponding author, subject to a controlled access agreement that includes confirmation of institutional ethics approval (IRB/REC) and a non-disclosure agreement. Data will be provided in a fully anonymized form, with all direct identifiers (e.g., names, dates, addresses) removed and indirect identifiers pseudonymized or aggregated to ensure the lowest risk of re-identification, consistent with the standards for human research data sharing.

Ethics statement

The studies involving humans were approved by the Ethics Committee of King Saud University (KSU-HR-23-1179). The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

KA: Conceptualization, Data curation, Formal analysis, Funding acquisition, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – review & editing. NA: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Software, Validation, Visualization, Writing – original draft.

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Conflict of interest

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Supplementary material

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References

1. Collaborative for Academic, Social and Emotional Learning [CASEL] 2017 SEL framework. Available online at: <https://casel.org/fundamentals-of-sel/> (Accessed May 4, 2025).
2. Durlak, JA, Weissberg, RP, Dymnicki, AB, Taylor, RD, and Schellinger, KB. The impact of enhancing students' social and emotional learning: a meta-analysis of school-based universal interventions. *Child Dev.* (2011) 82:405–32. doi: 10.1111/j.1467-8624.2010.01564.x
3. Kołodziejczyk, J, Kołodziejczyk, J, and Walczak, B. An evaluation of social and emotional learning-based program for kindergarten and primary schools in Poland. *Sci Rep.* (2025) 15:33900. doi: 10.1038/s41598-025-08494-1
4. Monkeviciene, O, Mishara, BL, and Dufour, S. Effects of the Zippy's friends programme on children's coping abilities during the transition from kindergarten to elementary school. *Early Child Educ J.* (2006) 34:53–60. doi: 10.1007/s10643-006-0104-0
5. Morris, T, McGuire, M, and Walker, B. Integrating social studies and social skills for students with emotional and behavioral disabilities: a mixed methods study. *J Soc Stud Res.* (2017) 41:253–62. doi: 10.1016/j.jssr.2017.04.001
6. Murano, D, Sawyer, JE, and Lipnevich, AA. A meta-analytic review of preschool social and emotional learning interventions. *Rev Educ Res.* (2020) 90:227–63. doi: 10.3102/0034654320914743
7. Yeager, DS. Social and emotional learning programs for adolescents. *Futur Child.* (2017) 27:73–94. doi: 10.1353/foc.2017.0004
8. Denham, SA, and Brown, C. Plays nice with others: social-emotional learning and academic success. *Early Educ Dev.* (2010) 21:652–80. doi: 10.1080/10409289.2010.497450
9. Hutchins, NS, Burke, MD, Hatton, H, and Bowman-Perrott, L. Social skills interventions for students with challenging behavior: evaluating the quality of the evidence base. *Remedial Spec Educ.* (2017) 38:13–27. doi: 10.1177/0741932516646080

10. Larsen, N, Pyle, A, Danniels, E, Marzouca, M, and Nazeem, R. Kindergarten teachers' facilitation of social and emotional learning in classroom play contexts. *Educ Inq.* (2025) 16:195–216. doi: 10.1080/20004508.2023.2192900
11. Daunic, A, Corbett, N, Smith, S, Barnes, T, Santiago-Poventud, L, Chalfant, P, et al. Brief report: integrating social-emotional learning with literacy instruction: an intervention for children at risk for emotional and behavioral disorders. *Behav Disord.* (2013) 39:43–51. doi: 10.1177/019874291303900106
12. Dong, X, Burke, MD, Ramirez, G, Xu, Z, and Bowman-Perrott, L. A meta-analysis of social skills interventions for preschoolers with or at risk of early emotional and behavioral problems. *Behav Sci (Basel).* (2023) 13:940. doi: 10.3390/bs13110940
13. Skoog-Hoffman, A., Miller, A. A., Plate, R. C., Meyers, D. C., Tucker, A. S., Meyers, G., et al. (2024). Social and emotional learning in US schools: Findings from CASEL's Nationwide policy scan and the American teacher panel and American school leader panel surveys. Research Report. RR-A1822-2. RAND Corporation. Available online at: https://www.rand.org/pubs/research_reports/RR-A1822-2.html (Accessed May 25, 2025).
14. Jones, DE, Greenberg, M, and Crowley, M. Early social-emotional functioning and public health: the relationship between kindergarten social competence and future wellness. *Am J Public Health.* (2015) 105:2283–90. doi: 10.2105/AJPH.2015.302630
15. Shi, Q, Liew, J, Ettekal, I, and Woltering, S. Childhood resilient personality trajectories and associations with developmental trajectories of behavioral, social-emotional, and academic outcomes across childhood and adolescence: a longitudinal study across 12 years. *Personal Individ Differ.* (2021) 177:110789. doi: 10.1016/j.paid.2021.110789
16. Aksoy, P. Prevention programs for the development of social-emotional learning in preschool years. *Eur J Educ Stud.* (2019) 6:1–14. doi: 10.5281/zenodo.3406762
17. Kumm, S, Reeder, J, and Farrell, E. Social skills practice strategy opportunities for students with EBD. *Beyond Behav.* (2021) 30:97–106. doi: 10.1177/10742956211020832
18. Wider, W, Shareefa, M, Moosa, V, Ng, ML, Isa, AM b M, Fauzi, MA, et al. Mapping the terrain of social-emotional learning: a bibliometric study on its past, present, and future. *Sch Ment Health.* (2025) 17:1097–112. doi: 10.1007/s12310-025-09781-y
19. Chen, JJ, Liang, X, and Lin, JC. Weaving the fabric of social and emotional learning in the context of teaching: a study in Hong Kong kindergarten classrooms. *Early Child Educ J.* (2025) 53:1521–37. doi: 10.1007/s10643-024-01682-0
20. McClelland, MM, Tominey, SL, Schmitt, SA, and Duncan, R. SEL interventions in early childhood. *Futur Child.* (2017) 27:33–47. doi: 10.1353/foc.2017.0002
21. Blewitt, C, Fuller-Tyskiewicz, M, Nolan, A, Bergmeier, H, Vicary, D, Huang, T, et al. Social and emotional learning associated with universal curriculum-based interventions in early childhood education and care centers: a systematic review and meta-analysis. *JAMA Netw Open.* (2018) 1:e185727–e185727. doi: 10.1001/jamanetworkopen.2018.5727
22. Vasileva, M, Graf, RK, Reinelt, T, Petermann, U, and Petermann, F. Research review: a meta-analysis of the international prevalence and comorbidity of mental disorders in children between 1 and 7 years. *J Child Psychol Psychiatr.* (2021) 62:372–81. doi: 10.1111/jcpp.13261
23. Haymovitz, E, Houseal-Allport, P, Lee, RS, and Svistova, J. Exploring the perceived benefits and limitations of a school-based social-emotional learning program: a concept map evaluation. *Child Sch.* (2018) 40:45–54. doi: 10.1093/cs/cdx029
24. Khazanchi, R, Khazanchi, P, Mehta, V, and Tuli, N. Incorporating social-emotional learning to build positive behaviors. *Kappa Delta Pi Rec.* (2021) 57:11–7. doi: 10.1080/00228958.2021.1851581
25. Schonert-Reichl, KA. Advancements in the landscape of social and emotional learning and emerging topics on the horizon. *Educ Psychol.* (2019) 54:222–32. doi: 10.1080/00461520.2019.1633925
26. Ștefan, CA, Dănilă, I, and Cristescu, D. Classroom-wide school interventions for preschoolers' social-emotional learning: a systematic review of evidence-based programs. *Educ Psychol Rev.* (2022) 34:2971–3010. doi: 10.1007/s10648-022-09680-7
27. Clarke, AM, Bunting, B, and Barry, MM. Evaluating the implementation of a school-based emotional well-being programme: a cluster randomized controlled trial of Zippy's friends for children in disadvantaged primary schools. *Health Educ Res.* (2014) 29:786–98. doi: 10.1093/her/cyu047
28. De Mooij, B, Fekkes, M, Scholte, RH, and Overbeek, G. Effective components of social skills training programs for children and adolescents in nonclinical samples: a multilevel meta-analysis. *Clin Child Fam Psychol Rev.* (2020) 23:250–64. doi: 10.1007/s10567-019-00308-x
29. Holen, S, Waaktaar, T, Lervåg, A, and Ystgaard, M. The effectiveness of a universal school-based programme on coping and mental health: a randomised, controlled study of Zippy's friends. *Educ Psychol.* (2012) 32:657–77. doi: 10.1080/01443410.2012.686152
30. Kim, M, Ko, H, Kim, S, and Kim, B. The effect of Zippy's friends program based on stress-coping model on early-child in convergence era. *J Korea Conver Soc.* (2019) 10:359–67. doi: 10.15207/JKCS.2019.10.5.359
31. Collaborative for Academic, Social and Emotional Learning [CASEL] 2023 Zippy's Friends. Available online at: <https://pg.casel.org/zippys-friends/> (Accessed June 15, 2025).
32. Collaborative for Academic, Social, and Emotional Learning [CASEL] 2013 Fundamentals of SEL. Available online at: <https://casel.org/fundamentals-of-sel> (Accessed June 28, 2025).
33. Goodman, R. The strengths and difficulties questionnaire: a research note. *J Child Psychol Psychiatry.* (1997) 38:581–6. doi: 10.1111/j.1469-7610.1997.tb01545.x
34. Brant, J. L. 2019. The impact of consistent interaction with the elderly on social and emotional competency skills of 4 year olds: A mixed methods study (order no. 13883654). Available from ProQuest central; ProQuest Dissertations & Theses Global; publicly Available content database. (2235302502). Available online at: <https://www.proquest.com/dissertations-theses/impact-consistent-interaction-with-elderly-on/docview/2235302502/se-2> (Accessed June 5, 2025).
35. Brant, JL, and Studebaker, B. Consistent interactions with residents in assisted living facilities significantly improved the social and emotional competencies of 4-year-olds. *J Intergenerational Relatsh.* (2021) 19:362–76. doi: 10.1080/15350770.2019.1677278
36. LeBuffe, PA, and Naglieri, JA. The Devereux early childhood assessment [measurement instrument]. Lewisville, NC: Kaplan Press Publishing (1999).
37. LeBuffe, PA, Shapiro, VB, and Naglieri, JA. The Devereux student strengths assessment [measurement instrument]. Lewisville, North Carolina: Kaplan (2009).
38. Nowell, LS, Norris, JM, White, DE, and Moules, NJ. Thematic analysis: striving to meet the trustworthiness criteria. *Int J Qual Methods.* (2017) 16. doi: 10.1177/1609406917733847
39. Taylor, RD, Oberle, E, Durlak, JA, and Weissberg, RP. Promoting positive youth development through school-based social and emotional learning interventions: a meta-analysis of follow-up effects. *Child Dev.* (2017) 88:1156–71. doi: 10.1111/cdev.12864
40. Hartzell, RI, Lane, CJ, Umbreit, J, Liaupsin, CJ, and Hanks, M. Peer-supported inclusive social skills instruction for elementary students with emotional and behavioral disorders. *Educ Treat Child.* (2020) 43:237–50. doi: 10.1007/s43494-020-00023-1
41. Bierman, KL, and Motamedi, M. Social and emotional learning programs for preschool children In: JA Durlak, CE Domitrovich, RP Weissberg and TP Gullotta, editors. Handbook of social and emotional learning: Research and practice. New York: Guilford Press (2015). 135–51.
42. Carnazzo, K, Dowdy, E, Furlong, MJ, and Quirk, MP. An evaluation of the social emotional health survey—secondary for use with students with learning disabilities. *Psychol Sch.* (2019) 56:433–46. doi: 10.1002/pits.22199
43. Korpershoek, H, Harms, T, de Boer, H, van Kuijk, M, and Doolaard, S. A meta-analysis of the effects of classroom management strategies and classroom management programs on students' academic, behavioral, emotional, and motivational outcomes. *Rev Educ Res.* (2016) 86:643–80. doi: 10.3102/0034654315626799
44. Daunic, AP, Aydin, B, Corbett, NL, Smith, SW, Boss, D, and Crews, E. Social-emotional learning intervention for K–1 students at risk for emotional and behavioral disorders: mediation effects of social-emotional learning on school adjustment. *Behav Disord.* (2023) 49:17–30. doi: 10.1177/01987429231185098
45. Voith, LA, Yoon, S, Topitizes, J, and Brondino, MJ. A feasibility study of a school-based social emotional learning program: informing program development and evaluation. *Child Adolesc Soc Work J.* (2020) 37:329–42. doi: 10.1007/s10560-019-00634-7
46. Pérez-Clark, P, Royer, DJ, Austin, KS, and Lane, KL. A systematic review of second step social-emotional skills program in middle schools. *Remedial Spec Educ.* (2022) 44:395–408. doi: 10.1177/07419325221131913
47. Espelage, DL, Rose, CA, and Polanin, JR. Social-emotional learning program to reduce bullying, fighting, and victimization among middle school students with disabilities. *Remedial Spec Educ.* (2015) 36:299–311. doi: 10.1177/0741932514564564
48. Wong, ASK, Li-Tsang, CWP, and Siu, AMH. Effect of a social emotional learning programme for primary school students. *Hong Kong J Occup Ther.* (2014) 24:56–63. doi: 10.1016/j.hkjoct.2014.11.001
49. Gullotta, TP. After school programming and SEL In: JA Durlak, CE Domitrovich, RP Weissberg and TP Gullotta, editors. Handbook of social and emotional learning: Research and practice. New York NY: The Guilford Press (2015). 260–6.
50. Lane, KL, Wehby, J, and Barton-Arwood, SM. Students with and at risk for emotional and Behavioral disorders: meeting their social and academic needs. *Prev Sch Fail Altern Educ Child Youth.* (2005) 49:6–9. doi: 10.3200/PSFL.49.2.6-9
51. Greenberg, MT, Domitrovich, CE, Weissberg, RP, and Durlak, JA. Social and emotional learning as a public health approach to education. *Futur Child.* (2017) 27:13–32. doi: 10.1353/foc.2017.0001
52. Jaga, MR, Lomi, ANK, and Hornay, PMA. The social factors that influence children's interactions and behavior in classroom. *Jurnal Pendidikan Anak Usia Dini Undiksha.* (2023) 11:200–9. doi: 10.23887/paud.v11i2.59694
53. Robinson-Ervin, P, Cartledge, G, Musti-Rao, S, Gibson, J, Jr, and Keyes, SE. Social skills instruction for urban learners with emotional and behavioral disorders: a culturally responsive and computer-based intervention. *Behav Disord.* (2016) 41:209–25. doi: 10.17988/bedi-41-04-209-225.1
54. Özen Uyar, R, Aslan, D, and Aktaş Arnas, Y. Enhancing preschool teachers' capacity to support children's social emotional learning in Turkey. *J Res Child Educ.* (2025) 1–24. doi: 10.1080/02568543.2025.2478126
55. Rucinski, CL, Brown, JL, and Downer, JT. Teacher-child relationships, classroom climate, and children's social-emotional and academic development. *J Educ Psychol.* (2018) 110:992–1004. doi: 10.1037/edu0000240
56. Sandilos, LE, Neugebauer, SS, DiPerna, JC, Hart, SC, and Lei, P. Social-emotional learning for whom? Implications of a universal SEL program and teacher well-being for teachers' interactions with students. *Sch Ment Heal.* (2023) 15:190–201. doi: 10.1007/s12310-022-09543-0

57. Grusec, JE. Socialization processes in the family: social and emotional development. *Annu Rev Psychol.* (2011) 62:243–69. doi: 10.1146/annurev.psych.121208.131650
58. Li, S, Tang, Y, and Zheng, Y. How the home learning environment contributes to children's social-emotional competence: a moderated mediation model. *Front Psychol.* (2023) 14:1065978. doi: 10.3389/fpsyg.2023.1065978
59. Cipriano, C, Strambler, MJ, Naples, LH, Ha, C, Kirk, M, Wood, M, et al. The state of evidence for social and emotional learning: a contemporary meta-analysis of universal school-based SEL interventions. *Child Dev.* (2023) 94:1181–204. doi: 10.1111/cdev.13968
60. Hassani, S, and Schwab, S. Social-emotional learning interventions for students with special educational needs: a systematic literature review. *Front Educ.* (2021) 6:808566. doi: 10.3389/educ.2021.808566
61. Lawson, GM, McKenzie, ME, Becker, KD, Selby, L, and Hoover, SA. The core components of evidence-based social emotional learning programs. *Prev Sci.* (2019) 20:457–67. doi: 10.1007/s11121-018-0953-y
62. Hutchins, NS, Burke, MD, Bowman-Perrott, L, Tarlow, KR, and Hatton, H. The effects of social skills interventions for students with EBD and ASD: a single-case meta-analysis. *Behav Modif.* (2020) 44:773–94. doi: 10.1177/0145445519846817
63. Daunic, AP, Corbett, NL, Smith, SW, Algina, J, Poling, D, Worth, M, et al. Efficacy of the social-emotional learning foundations curriculum for kindergarten and first grade students at risk for emotional and behavioral disorders. *J Sch Psychol.* (2021) 86:78–99. doi: 10.1016/j.jsp.2021.03.004
64. Farmer, GL, and Adams, D. Social-emotional competence among students with special needs: relationship between foundational and applied SEL skills. *Am J Educ Res.* (2021) 9:410–6. doi: 10.12691/education-9-7-3
65. Upshur, CC, Wenz-Gross, M, Rhoads, C, Heyman, M, Yoo, Y, and Sawosik, G. A randomized efficacy trial of the second step early learning (SSEL) curriculum. *J Appl Dev Psychol.* (2019) 62:145–59. doi: 10.1016/j.appdev.2019.02.008
66. Kim, D, Lim, JH, and An, J. The quality and effectiveness of social-emotional learning (SEL) intervention studies in Korea: a meta-analysis. *PLoS One.* (2022) 17:e0269996. doi: 10.1371/journal.pone.0269996
67. Sabey, CV, Charlton, CT, Pyle, D, Lignugaris-Kraft, B, and Ross, SW. A review of classwide or universal social, emotional, behavioral programs for students in kindergarten. *Rev Educ Res.* (2017) 87:512–43. doi: 10.3102/0034654316689307
68. Carroll, A, Houghton, S, Forrest, K, McCarthy, M, and Sanders-O'Connor, E. Who benefits most? Predicting the effectiveness of a social and emotional learning intervention according to children's emotional and behavioural difficulties. *Sch Psychol Int.* (2020) 41:197–217. doi: 10.1177/0143034319898741
69. Sullivan, TN, Sutherland, KS, Farrell, AD, and Taylor, KA. An evaluation of second step: what are the benefits for youth with and without disabilities? *Remedial Spec Educ.* (2015) 36:286–98. doi: 10.1177/0741932515575616



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Life skills, self-efficacy, life satisfaction and health literacy evolution from primary school to middle school: a 3-year longitudinal interventional study of the Explo'Santé cohort

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Introduction: Childhood and adolescence are decisive life stages during which social and health inequalities emerge and widen. Schools represent a privileged setting for health promotion, particularly through the development of psychosocial resources such as life skills (LS), self-efficacy (SE), life satisfaction (LSa), and health literacy (HL). The Explo'Santé program is a French school-based health promotion intervention that combines structured health education sessions with supportive environments.

Methods: This longitudinal cohort study followed 744 pupils from 4th grade in primary school to the first year of middle school. LS, SE, LSa, and HL were assessed at six time points across three annual intervention cycles, each including ten weekly school-based health education sessions.

Results: Linear mixed models showed short-term gains in LS, SE, and LSa during primary school, followed by a marked decline after the transition to middle school, whereas HL increased steadily throughout the 3 years. Girls consistently scored higher than boys but also showed sharper decreases once in 6th grade. Territorial disparities were observed, with some districts showing strong improvements while others consistently lagged.

Discussion: These findings suggest that the Explo'Santé program supports the development of key psychosocial competencies, but that the transition to middle school represents a critical turning point which challenges their sustainability. By highlighting gendered vulnerabilities and contextual inequalities, this work contributes to understanding how schoolbased health promotion can foster more equitable developmental trajectories.

KEYWORDS

evaluation, health education, health literacy, health promotion, life satisfaction, life skills, self-efficacy

1 Introduction

Childhood and adolescence are decisive developmental periods during which social, emotional, and health inequalities emerge and often widen (1, 2). From the first years of primary school, disparities can already be observed in well-being, coping resources, and access to health-promoting environments. Recent data confirm these early gaps: in Europe, about

13% of schoolchildren aged 6–11 have a “probable” mental health problem (3). In the Organisation for Economic Cooperation and Development (OECD) countries, nearly 18% adolescents reported low life satisfaction in 2022, compared to 12% in 2015 (4). These early differences tend to persist in adolescence, shaping both educational attainment and long-term health trajectories. Evidence shows, for instance, that health-related behaviors established before age 14 strongly predict risks of obesity, cardiovascular disease, and mental health disorders later in life (5).

This interdependence between education and health has led to a growing recognition that schools are not only places of academic instruction but also privileged settings for reducing inequalities and fostering holistic development (6). Since almost all children spend a large part of their daily lives in school, the educational environment offers a unique and universal entry point for promoting health in an equitable and sustainable way (7). With over 95% of children in Europe enrolled in school (8), and with two-thirds identifying school pressure as a major source of stress (9), schools represent both a challenge and an opportunity for mental and physical health promotion.

In this perspective, health education is increasingly conceived not as the mere transmission of knowledge about risk behaviors or healthy lifestyles. It is understood as the development of psychosocial and cognitive resources that empower children to navigate daily challenges, transitions and uncertainties. The World Health Organization defines life skills (LS) as “abilities for adaptive and positive behavior that enable individuals to deal effectively with the demands and challenges of everyday life.” Closely related constructs further highlight their multidimensional nature. Firstly, self-efficacy (SE) was conceptualized in Bandura’s social cognitive theory as the belief in one’s ability to organize and execute courses of action required to manage prospective situations (10). In the school context, SE is defined as a transversal perception of one’s capacity to understand and respond to the expectations of the school environment across disciplines (11). Secondly, health literacy (HL) is defined as “people’s knowledge, motivation and competencies to access, understand, appraise, and apply health information in order to make judgments and take decisions in everyday life” (12). Finally, life satisfaction (LSa) is framed as the cognitive evaluation of one’s overall quality of life (13). Large-scale international surveys such as the Health Behavior in School-aged Children (HBSC) and the Programme for International Student Assessment (PISA) have repeatedly shown that these psychosocial indicators are socially patterned and linked both to educational outcomes and to long-term health inequalities (14, 15).

Together, these psychosocial indicators —interlinked and mutually reinforcing—have been shown to support both academic success and health outcomes (16–18). This positions them at the crossroads of education and public health and underlines their potential as levers for reducing social and health inequalities from an early age (1, 19).

Nevertheless, evaluating the effectiveness of school-based health promotion programs is complex. Interventions are implemented in diverse contexts, shaped by school resources, socioeconomic environments, and local dynamics that can strongly influence outcomes (20, 21). Program impacts may also vary over time, particularly as children move up from primary to middle school, a period marked by profound developmental, social, and institutional changes (22, 23). This primary–secondary school transition is understood as a complex and multidimensional process involving

shifts in relationships, identity, school environments, and academic expectations, often overlapping with broader developmental changes (24). This raises key methodological challenges: assessing not only short-term effects but also long-term developmental trajectories, while accounting for both individual factors (e.g., gender, socioeconomic context) and contextual ones (e.g., school, district) (6, 21). Despite a growing literature on school health promotion, relatively few studies have followed large cohorts of children longitudinally, with designs capable of disentangling program effects from contextual influences across critical educational transitions (25–27).

The Explo’Santé program was developed in this perspective, as a universal school-based health education initiative grounded in LS development. Its pedagogical framework integrates health promotion principles with educational objectives, aiming to strengthen pupils’ psychosocial resources and to support more equitable educational pathways (28). In doing so, it aligns with the WHO Health Promoting Schools framework, which emphasizes the integration of health into the core mission, culture, and environment of schools (6). By embedding health promotion within the ordinary functioning of schools, the program seeks not only to improve individual skills but also create learning environments that are more supportive, inclusive, and conducive to health and learning (6, 29). In the French education system, health education is not delivered as a standalone subject. It is proposed within the scope of the *Parcours Éducatif de Santé* (Health Education Pathway (HEP)) (30). This scheme covers screening and vaccination campaigns, and prevention and health promotion intervention, including health education interventions, for all pupils from nursery school to the end of high school. Its objective is to accompany pupils to develop their knowledge and competences, to make their own choices and to behave responsibly towards themselves and others (31). Although its design is specific to each school and defined by the teachers, the school nurse and the school district doctor. In primary school, health is addressed either through cross-disciplinary competencies and prevention-related themes integrated across subjects. At the beginning of lower secondary school (Grade 6), this remains the case. In addition, the activities of the school board includes the *Comité d’Éducation à la Santé et la Citoyenneté* (School Health and Citizenship Committee (SHCC)). It gathers representatives from the school community to implement health-related projects and interventions. Against this backdrop, Explo’Santé falls within the scope of both the French HEP and SHCC. It is proposed by the French League against Cancer as a structured LS-based program. It is delivered within regular school hours, either within standard lessons in primary school, or, in 6th grade, during class meetings or slots freed from other subjects. It offers a coherent and operational framework that extends and strengthens the existing health education mandate. Evaluating such a program offers a valuable opportunity to explore the potential of school health promotion to mitigate inequalities, while at the same time fostering psychosocial development and encouraging healthier pathways across educational transitions (5).

This study aims to evaluate the Explo’Santé intervention through a three-year longitudinal follow-up of pupils from primary to middle school. Specifically, it seeks to (1) describe the overall trajectories of LS, SE, LSa and HL across the six measurement points; (2) examine whether these trajectories differ by gender and district; and (3) assess individual and contextual variability using mixed-effects models. Together, these aims provide a comprehensive understanding of how pupils’ psychosocial resources evolve over time and how the program’s effects may vary across

social and school contexts. More broadly, it addresses the challenges and contributions of evaluating school-based health education initiatives within a health promotion framework, aiming to advance both scientific knowledge and practical perspectives in this evolving field.

2 Materials and methods

2.1 Study design

This study was designed as a longitudinal cohort study (28). The protocol was approved by the University of Lyon's ethics committee (France) on March 1, 2023 (n°2023-01-12-004). This manuscript follows the guidelines for reporting observational epidemiological data of the STROBE checklist (32) (Supplementary Table 1).

2.2 Setting

The study was conducted in six administrative districts of France (Districts A–F). A cohort of 744 pupils was recruited during their 4th grade year between March 1 and March 13, 2023. At baseline, the 4th grade pupils were distributed across 60 classes in 43 primary schools. They were subsequently followed as they progressed into 59 classes in 5th grade and 32 classes in 6th grade, within 8 middle schools.

The follow-up period extended over three academic years (2022–2025). Data were collected at six time points, at the beginning and end of each school year, using anonymous self-administered questionnaires completed in the classroom under teacher supervision (see Supplementary Figure 1).

2.3 Participants

Pupils were eligible for inclusion if they met the following criteria: (i) being enrolled in 4th grade during the first year of the study (2022–2023), (ii) attending an institution participating in the Explo'Santé program over the three consecutive school years (2022–2023, 2023–2024, and 2024–2025), (iii) being fluent in French, (iv) having written parental consent, and (v) providing oral assent prior to completing the questionnaires.

2.4 Intervention

Explo'Santé is a three-year school-based health promotion program developed by the French League Against Cancer. It followed pupils from grade 4 to grade 6 and combined two complementary components: (i) classroom-based health education focused on life skills, delivered through 10 participatory sessions per year co-facilitated by prevention officers and teachers, and (ii) the creation of healthy school environments (e.g., smoke-free spaces, improved playgrounds, strengthened school climate). Pedagogical methods included role-plays, collaborative activities, and “take-home booklets” to involve families. Teachers received prior training, and local stakeholders were mobilized to ensure sustainability.

2.5 Variables

The primary outcomes were the pupils' scores in LS, SE, LSa and HL. The main exposure of interest was participation in the Explo'Santé program. Predictors included time (distinguishing between primary and middle school to account for the transition effect), pupils' gender, and the social position index (SSI) of their institution, ranging from 45 to 185, as a proxy for socioeconomic background. District and school-level context (class and institution), as well as individual pupil trajectories, were considered potential effect modifiers, as these hierarchical levels may influence the magnitude of program effects across contexts.

2.6 Data measurement

Data were collected anonymously at six time points (Supplementary Figure 1) by three researchers using electronic tablets. The questionnaires used were composed of four validated scales. Firstly, the LS scale (30 questions, 5-item Likert scale), was composed of a cognitive LS scale (33), an emotional LS scale (34), and a social LS scale (35). They were translated in French from the Assessment of Children's Emotion Skills (ACES) (36) and the Resolving Conflicts, Helping Others, Managing Emotions sections of the Life Skills Transfer Survey (37). Secondly, the original SE perception at school scale (17 questions, 6-item Likert scale) includes a school SE in general scale, an SE in French scale, and an SE in Maths scale (11). Thirdly, the LSa scale (30 questions, 4-item Likert scale; 67) comprises 5 dimensions: family, living environment, friends, school, and self. It is a French version of Huebner's Multidimensional Students' Life Satisfaction Scale (MSLSS) (38). Finally, the HL scale (10 questions, 4-item Likert scale) (39) is a translated version of the Health literacy for School-Aged Children scale (HLSAC) (40), validated for students from 5th grade (41). These four instruments were validated with French school-aged populations, with a reliability estimated satisfactory to excellent (LS ($\alpha = 0.74$ – 0.90), SE ($\alpha = 0.74$ – 0.92), LSa ($\alpha = 0.70$ – 0.90), HL ($\alpha = 0.82$ – 0.89)) (42). These questionnaires were administered to all students across time points to ensure comparability.

Each pupil was assigned a unique identification code combining district and primary school identifiers, which enabled longitudinal follow-up. Gender was self-reported at the beginning of each questionnaire. Contextual data on institutions' Socioeconomic Status Index (SSI) were extracted from the INSEE national database (43). Data entry was automated through electronic devices, minimizing transcription errors.

2.7 Bias

Efforts were made to minimize potential sources of bias. Firstly, data collection was standardized across schools and time points using validated self-administered questionnaires, which reduced interviewer bias but may still be subject to self-report bias. Secondly, attrition across time points was addressed through both complete-case and

whole-data analyses. Thirdly, hierarchical mixed models accounted for clustering at class and institutional levels.

2.8 Study size

The study size was determined *a priori* using Cochran's formula, assuming a 50% prevalence of satisfactory LS to maximize statistical variance in the absence of prior data. With a 95% confidence level and a $\pm 5\%$ margin of error, the minimum required sample size was estimated at 385 pupils. In practice, 744 pupils aged 8–10 at baseline (44) participated in the study, which provided sufficient power for the planned analyses. Among them, 254 pupils completed all questionnaires across the follow-up period; this complete-case subset was used exclusively for sensitivity analyses to assess the robustness of the findings.

2.9 Quantitative variables

Quantitative variables were analyzed as continuous measures to preserve statistical power and variability. Scores from the four scales and their subscales were normalized to a uniform range of 0–100 to facilitate comparability across instruments. The SSI was used as a continuous proxy for socioeconomic background; no arbitrary cut-offs were applied to avoid loss of information. Time was operationalized both as repeated measures at pupil level and at school stage (primary vs. middle school) to capture potential contextual effects. No additional categorization or grouping was performed beyond these theoretically justified distinctions.

2.10 Statistical methods

All statistical analyses were performed in RStudio. Descriptives were first used to summarize participant characteristics by time point, gender, and district. Repeated-measures ANOVA were conducted to examine overall time effects on LS, SE, LSa, and HL scores, followed by Bonferroni-adjusted post-hoc pairwise comparisons. To account for individual and contextual variability, mixed-effects linear regression models with random intercepts for pupils were performed. Models sequentially included gender, district, and school level, with and without adjustment for the Socioeconomic Status Index (SSI), to disentangle contextual from socioeconomic effects. Subscale analyses were conducted for LS (cognitive, emotional, social), LSa (family, school, friends, living environment, self), and SE (general, French, mathematics). Missing data were imputed by the mean at scale level for mixed models on the full dataset. As loss to follow-up could not be avoided in this longitudinal design, sensitivity analyses were performed by comparing complete-case ($n = 254$) and full datasets ($n = 744$) to assess robustness of findings. Statistical significance was set at $p < 0.05$, with borderline significances noted for $0.05 \leq p < 0.10$.

2.11 Ethics

The protocol was approved by the University of Lyon's ethics committee (France) on March 1, 2023 (n°2023-01-12-004). CNIL reference: 2226244 v 0.

Anonymity was ensured during data collection, data handling and data analysis. No risk was identified from participating in the study.

3 Results

3.1 Participants

At baseline, 662 pupils completed the questionnaires. Participation remained steady at T1 (659) and slightly increased at T2 (705), before declining to 472 at T4, and 443 at T5. Attrition was mainly due to pupil absence, school transfer, or withdrawal of consent. Despite this, 726 pupils contributed repeated measures, enabling longitudinal analyses. Flow diagram is provided in [Figure 1](#).

[Table 1](#) summarizes the distribution of participants by gender and district at each time point, while the gender distribution and mean SSI across the six districts are addressed in [Supplementary Table 2](#). Gender distribution was relatively balanced across time points, with a slight predominance of girls (52–55%). District representation varied: District A consistently accounted for about one quarter of participants (~25%), whereas Districts B and C contributed less than 10% each. Socioeconomic context, assessed using the SSI, showed moderate variability across schools, with higher average scores in District A and lower ones in District E.

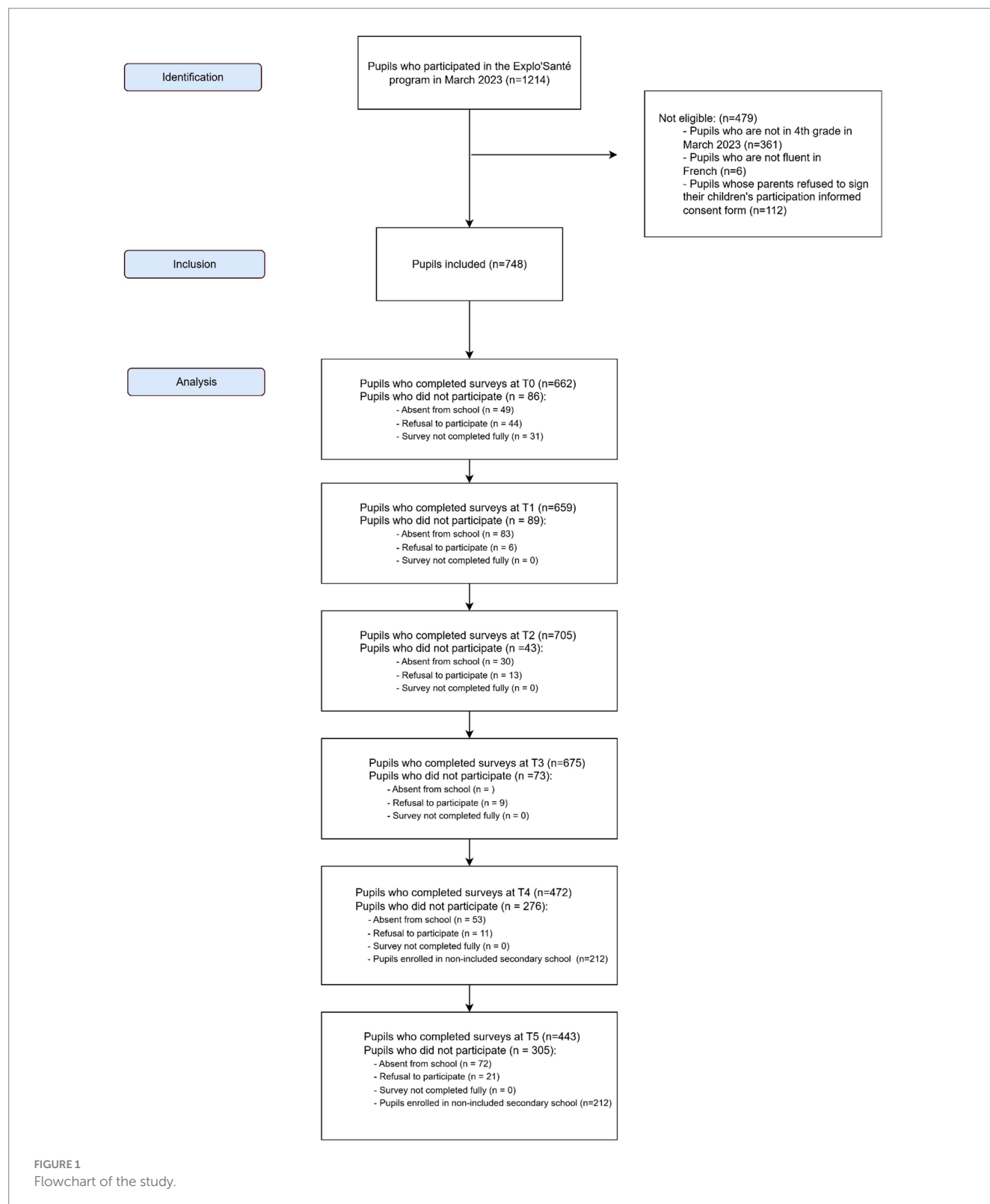
3.2 Life skills, self efficacy, life satisfaction and health literacy scores evolution

3.2.1 Overall score evolution

Descriptive statistics for all four scales at each measurement point (mean, n) for the full sample are presented in [Supplementary Table 3](#). As shown in [Figure 2](#) and [Table 2](#), LS, SE, and LSa scores increased significantly from T0 to T4 before declining at T5. *Post-hoc* tests confirmed significant improvements at T4 compared with earlier time points, followed by significant decreases at T5. HL displayed a different trajectory, with steady but modest improvements from baseline to T3 and T5.

3.2.2 Scores evolution according to gender

[Figure 3](#) illustrates LS, SE, LSa, and HL scores evolution by gender, with corresponding means and standard deviations reported in [Supplementary Table 3](#). Across all outcomes and time points, girls tended to score higher than boys, although these differences gradually narrowed by T5. For LS, SE, and LSa, all genders showed an overall increase from T0 to T4 (e.g., +2.7, +4.3, +2.7 for boys, and +3.3, +4.0, +1.9 for girls, on average), marked by gains between T1–T2 and T3–T4, followed by a decline from T4 to T5 (e.g., –1.8, –4.1, –2.5 for boys, and –4.5, –3.8, –3.2 for girls, on average). Boys experienced an initial decrease in LS and LSa between T0 and T1, while all genders declined between T2 and T3. For HL, all genders peaked at T1, dropped between T1 and T2, and then rose steadily up to T4. At T4–T5, girls showed a slight decrease in HL, whereas boys continued to improve. By T5, girls had lost an average of 1.2 points in LS and 1.5 points in LSa compared to T0, while boys still exhibited a net increase from baseline across all outcomes.



3.2.3 Scores evolution according to districts

District effects are shown in [Figure 4](#) and [Supplementary Table 4](#). Districts A and E started with the highest scores and improved up to T4, both experienced steep declines at

T5. District E, which had the highest LS scores at baseline (63.3), ended with the lowest LS scores at T5 (58.2). By contrast, District C, which started from relatively low baseline scores, showed the most favorable trajectory, gaining +7.7 in LS, +5.2 in SE, +4.2 in

TABLE 1 Population distribution according to gender and district.

Time	T0	T1	T2	T3	T4	T5	All times
Variables	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
Overall	662 (100)	659 (100)	705 (100)	675 (100)	472 (100)	443 (100)	744 (100)
Missing	82 (11.02)	85 (11.42)	39 (5.24)	69 (9.27)	272 (36.56)	301 (40.46)	–
Gender							
Girls	344 (51.96)	347 (52.66)	368 (52.20)	361 (53.48)	259 (54.87)	242 (54.63)	390 (52.42)
Boys	318 (48.04)	312 (47.34)	337 (47.80)	314 (46.52)	213 (45.13)	201 (45.37)	354 (47.58)
District							
A	159 (24.02)	165 (25.04)	177 (25.11)	168 (24.89)	144 (30.51)	127 (28.67)	186 (25.00)
B	64 (9.67)	53 (8.04)	65 (9.22)	68 (10.07)	48 (10.17)	47 (10.61)	69 (9.14)
C	52 (7.85)	53 (8.04)	65 (9.22)	67 (9.93)	52 (11.02)	45 (10.16)	66 (8.87)
D	169 (25.53)	171 (25.95)	175 (24.82)	139 (20.59)	77 (16.31)	83 (18.74)	179 (24.06)
E	127 (19.18)	126 (19.12)	130 (18.44)	141 (20.89)	84 (17.80)	79 (17.83)	150 (20.16)
F	91 (13.75)	91 (13.81)	93 (13.19)	92 (13.63)	67 (14.19)	62 (14.00)	95 (12.77)

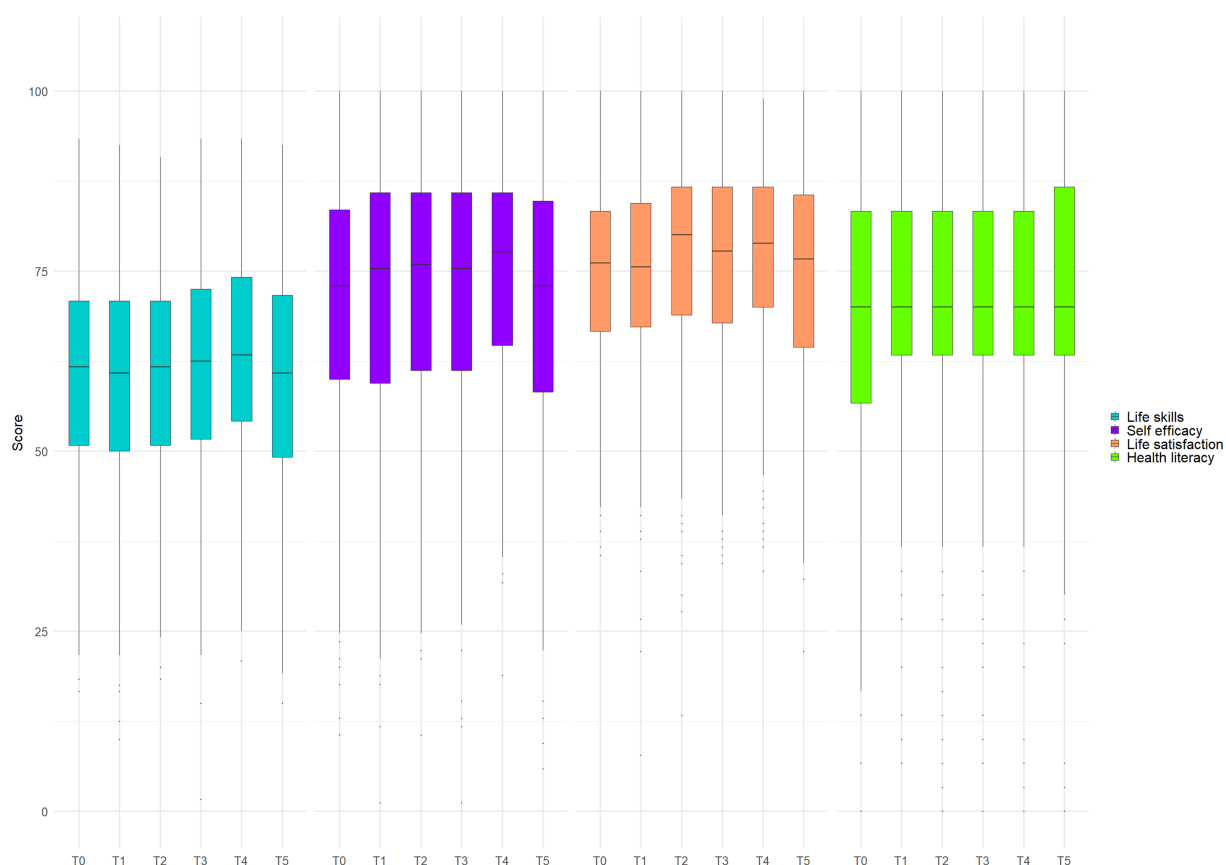


FIGURE 2

Boxplots of the life skills, self efficacy, life satisfaction, health literacy scores evolution between T0 and T5.

LSa, and +11.1 in HL, despite temporary declines in LS, SE, and LSa between T2–T3, and in HL from T0 to T5, and was the only district to increase LS and SE between T4 and T5. District B also

showed overall improvement, despite very low baseline scores. In contrast, District F declined steadily after T4 and was the only district to finish below baseline across all outcomes.

TABLE 2 Life skills, self efficacy, life satisfaction, and health literacy scores evolution with time: ANOVA and pairwise *post-hoc* tests.

Outcome	Time comparison ^a	Pairwise comparisons ^b (β , p)	Overall time effect ^c
Life skills	T4 vs. T0	2.76, $p < 0.001$	$p < 0.001$
	T4 vs. T1	3.38, $p < 0.001$	
	T4 vs. T2	2.56, $p < 0.001$	
	T4 vs. T3	2.17, $p = 0.010$	
	T5 vs. T4	−3.44, $p < 0.001$	
Self-efficacy	T2 vs. T0	2.06, $p = 0.014$	$p < 0.001$
	T3 vs. T0	2.12, $p = 0.013$	
	T4 vs. T0	3.76, $p < 0.001$	
	T4 vs. T1	2.70, $p = 0.002$	
	T5 vs. T2	−2.35, $p = 0.015$	
	T5 vs. T3	−2.41, $p = 0.012$	
	T5 vs. T4	−4.04, $p < 0.001$	
Life satisfaction	T2 vs. T0	1.97, $p = 0.002$	$p < 0.001$
	T2 vs. T1	2.03, $p < 0.001$	
	T4 vs. T0	1.72, $p = 0.041$	
	T4 vs. T1	1.78, $p = 0.029$	
	T5 vs. T2	−3.57, $p < 0.001$	
	T5 vs. T3	−2.17, $p = 0.003$	
	T5 vs. T4	−3.32, $p < 0.001$	
Health literacy	T3 vs. T0	2.31, $p = 0.032$	$p = 0.004$
	T5 vs. T0	2.71, $p = 0.021$	

^aOnly significant results are presented. ^bBonferroni-adjusted test. ^cRepeated-measures ANOVA test. Green indicates positive regression coefficients ($\beta > 0$), while yellow indicates negative coefficients ($\beta < 0$).

3.3 Contextual and individual factors impacting life skills, self efficacy, life satisfaction and health literacy scores evolution

3.3.1 Gender effect on life skills, self efficacy, life satisfaction and health literacy scores over time

Girls scored higher than boys on several outcomes (LS: +3.69, $p < 0.001$; LSa: +2.13, $p < 0.01$; HL: +2.09, $p < 0.05$; Table 3), which confirms the previous results. After accounting for SSI, the difference in HL was no longer significant, suggesting that SSI partly explained this gap.

At the subscale level, the LS girls' advantage was mainly due to cognitive LS (+3.13, $p < 0.001$) and social LS (+5.63, $p < 0.001$) (Table 4).

For LSa, the higher scores among girls were largely attributable to the school-related satisfaction subscale (+8.69, $p < 0.001$) (Table 5).

In SE, overall gender differences were not significant, but girls scored higher on French SE (+5.85, $p < 0.001$) and lower on Maths SE (−2.81, $p < 0.05$) (Table 6).

No gender-specific effects were observed in primary school. In middle school, girls showed smaller increases in LS and LSa

than boys (−2.28, $p < 0.1$ for LS; −2.07, $p \approx 0.06$ for LSa), indicating a tendency toward less pronounced improvements (Table 7).

3.3.2 District effect on life skills, self efficacy, life satisfaction and health literacy scores over time

Compared to District A, District B scored significantly lower on all scales. This difference was maintained and even reinforced after accounting for SSI, indicating socioeconomic context did not fully explain this gap. Districts D and F also showed less favorable results in SE, LSa and HL. District C scored lower in LSa and HL overall but displayed more pronounced gains in middle school, significant for LS (+5.76, $p < 0.05$) and marginal for LSa (+4.46, $p < 0.1$). District E showed slightly higher scores in LS and a small advantage in LSa (+2.46, $p < 0.1$), but this effect was strongly reduced when SSI was included (LSa: −0.45), suggesting that the apparent benefit was largely due to socioeconomic context. In terms of trajectories, District D exhibited a significantly less pronounced increase in SE during primary school (−1.65, $p < 0.05$), while District F showed smaller gains in LSa (−1.40, $p < 0.05$) and HL (−8.30, $p < 0.05$) during middle school (Table 8).

3.4 Sensitivity analyses

Fixed effects such as the negative association of time in middle school with LS and LSa, and the positive association of female gender with LS, remained significant and of similar magnitude in both complete-case and full datasets. However, most district effects were attenuated or reduced to statistical borderline significances, and the positive effect of female gender on SE, LSa, and HL no longer reached significance. District F remained robustly associated with lower HL in both datasets.

4 Discussion

4.1 Key findings

This quantitative longitudinal evaluation of the Explo'Santé program provides new evidence on the evolution of psychosocial and cognitive resources among pupils transitioning from primary to middle school. Three main findings stand out. First, LS, SE, and LSa increased significantly throughout primary school and into early middle school (up to T4), before experiencing a sharp decline at T5. This suggests that initial program benefits and developmental gains were not sustained during the transition to middle school. In contrast, HL followed a steadier, incremental growth over the entire period, with no collapse at T5. Secondly, gender differences were evident: girls consistently outperformed boys across all indicators. However, the gender gap narrowed at T5 due to sharper declines among girls, suggesting differential vulnerabilities during early adolescence. Thirdly, district-level disparities suggest that contextual and territorial context mediates program effects, with some districts (notably District C) showing sustained improvements, while others exhibited stagnation or even deterioration, especially during middle school.

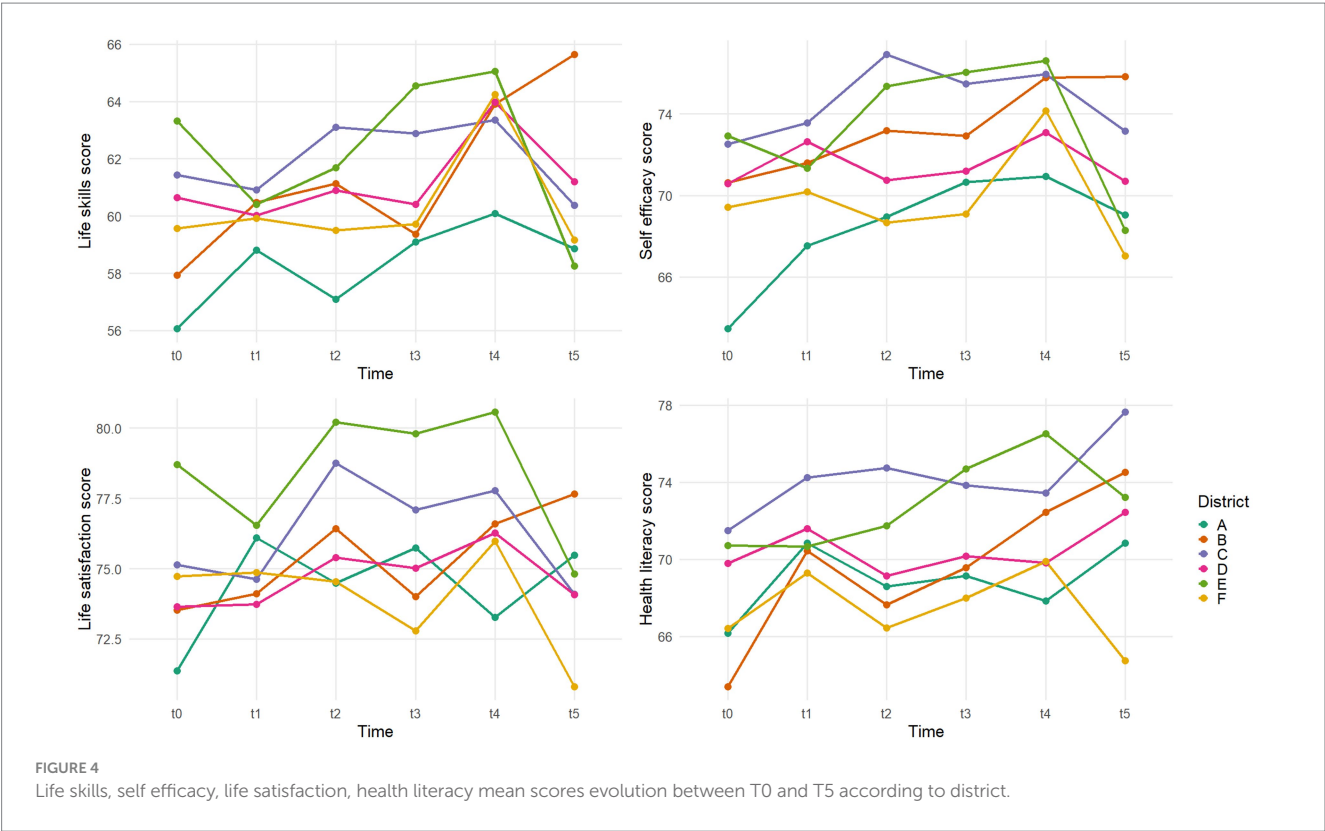
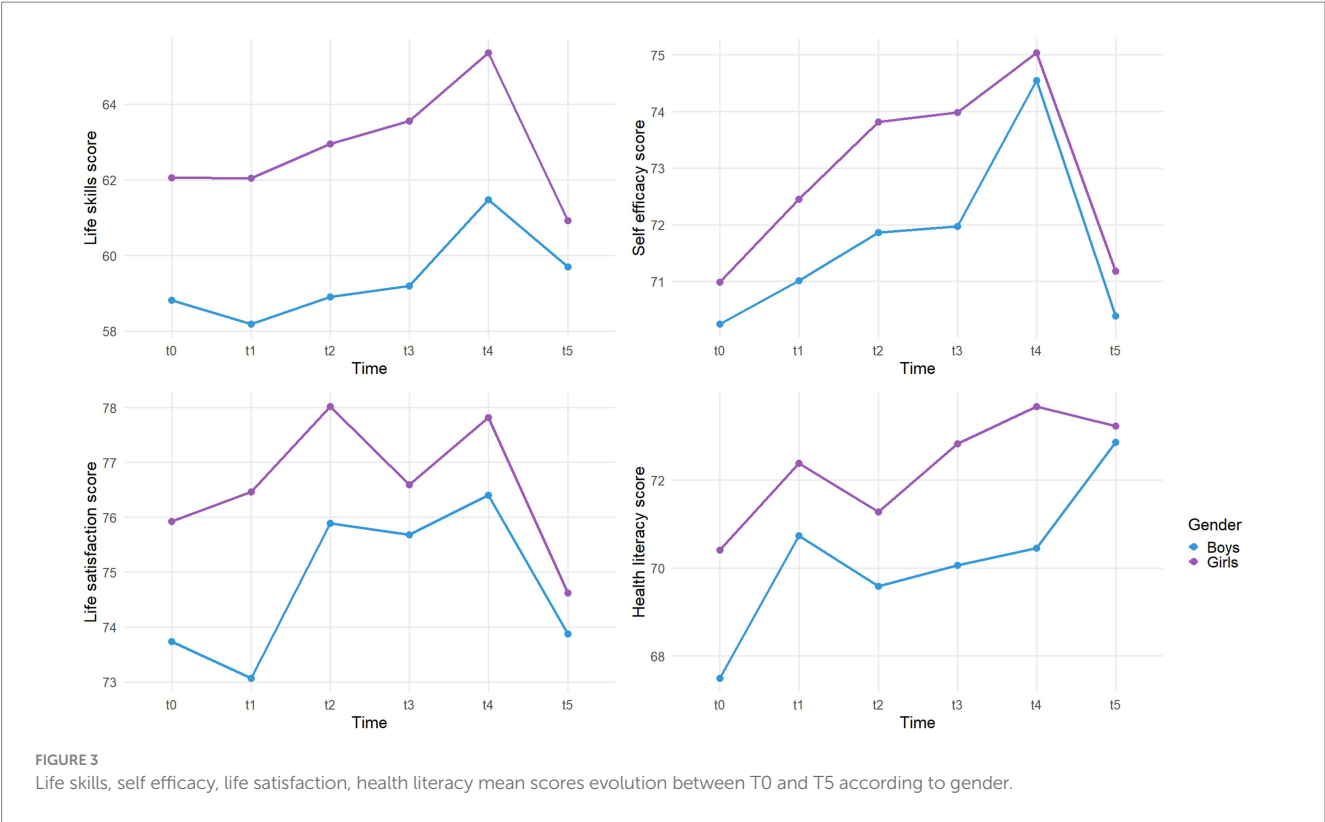


TABLE 3 Life skills, self efficacy, life satisfaction, and health literacy scores evolution according to gender, district, and school level, with or without the socio-economic status index (SSI): Linear mixed models results.

Socioeconomic status index	Life skills	Self efficacy		Life satisfaction		Health literacy		
	NI	0.14	NI	0.32	NI	0.21	NI	0.44
Gender ^a	3.69	3.59	1.53	1.24	2.13	2.12	2.09	1.92
District ^b								
B	−4.32	−4.46	−7.05	−7.77	−3.07	−4.32	−5.73	−6.71
C	−0.80	−0.84	−1.76	−1.79	−1.31	−1.50	−5.01	−5.46
D	−1.38	−1.30	−2.80	−3.81	−2.17	−3.77	−3.31	−4.57
E	0.43	0.78	−0.63	−2.59	2.46	−0.45	−0.94	−3.30
F	−1.55	−1.43	−3.71	−5.08	−1.80	−3.59	−6.09	−7.39
Time in primary school	0.12	0.14	0.08	0.32	0.23	0.21	0.37	0.44
Time in middle school	−2.70	−2.68	0.03	−1.70	−2.45	−2.24	1.28	1.06

Significant results ($p < 0.05$) are in bold and marginally significant results ($p < 0.1$) are in italics. Reference: boys of District A at T0. NI: not included. The color scale reflects the sign and magnitude of the β coefficients: red denotes negative effects, green positive effects, and yellow coefficients close to zero.

TABLE 4 Cognitive, emotional and social life skills scores evolution according to gender, district, and school level: Linear mixed models results.

Predictor	Cognitive life skills	Emotional life skills	Social life skills
Gender	3.13	0.98	5.63
District ^b			
B	−2.85	−2.82	−6.35
C	−0.95	−1.28	−0.38
D	0.40	−0.08	−3.68
E	3.61	−1.88	−1.29
F	0.44	−1.23	−3.99
Time in primary school	−0.26	0.32	0.29
Time in middle school	−3.32	−0.54	−2.72

Significant results ($p < 0.05$) are in bold and marginally significant results ($p < 0.1$) are in italics. Reference: Boys of District A at T0. NI: Not included. The color scale reflects the sign and magnitude of the β coefficients: red denotes negative effects, green positive effects, and yellow coefficients close to zero.

4.2 Psychosocial versus health literacy trajectories

The divergent trajectories of LS, SE, and LSa compared to HL raise questions about the nature and determinants of these constructs. LS, SE, and LSa appear highly sensitive to school climate and contextual disruptions, with marked fluctuations across timepoints and an acute vulnerability during the primary-middle school transition. This pattern is supported by recent research: for example, Jarusevičiūtė et al. (2023) show that support from teachers and family significantly predict socioemotional functioning across the move to lower secondary school (45). Pedditzi et al. (46) also demonstrated that LS, SE and LSa decline more sharply around transitions, particularly among those who perceive less support (46). Longitudinal work also shows that adolescents with lower social-emotional skills and greater loneliness experience greater school burnout, implying that

relational and peer climate are key predictors (47). By contrast, HL followed a steadier upward trajectory, suggesting that it depends more on cumulative cognitive exposure, structured educational input, and mediated information access. Recent studies confirm that HL scales remain stable and valid across adolescence (39), and longitudinal evidence highlights how family and educational mediation gradually strengthen HL development (48).

4.3 Gendered patterns

Gendered trajectories revealed both persistent advantages for girls and critical vulnerabilities. Girls scored higher in overall LS, particularly in their cognitive and social dimensions, as well as in LSa at school and SE in French. This is consistent with evidence of girls' greater social orientation and verbal abilities (49). Boys, however, reported higher SE in mathematics, reflecting both academic gender stereotypes and differential feedback in science-related domains (50, 51). Importantly, although girls started with these advantages, their score declines at T5 were sharper, particularly in LS and LSa, suggesting a greater susceptibility to the stressors associated with the transition to middle school. This aligns with studies showing that in more gender-egalitarian contexts, girls' satisfaction of life can decline due to heightened fear of failure or competitiveness (52). Evidence consistently shows that adolescent girls report higher levels of stress than boys, with school emerging as one of the most salient sources. Data from the HELENA study demonstrated that girls systematically perceived more stress related to school and future uncertainty than boys (53). More recently, a large mixed-method study confirmed these gender differences in school stress and identified underlying factors such as heavier school workload, emotional vulnerability, gender stereotypes, social expectations, and differential teacher treatment (54). Gendered socialization may amplify these vulnerabilities: girls may feel more pressure to maintain social bonds and academic performance, while boys may be comparatively buffered by lower socio-emotional expectations. Recent data from WHO/Europe (2024) show that school pressure has increased notably among girls, and that declines in family and peer support during adolescence are steeper for girls than for boys, suggesting that the support structures that buffer stress may erode more rapidly for girls (55).

TABLE 5 Life satisfaction with family, school, friends, living environment, and self scores evolution according to gender, district, and school level: Linear mixed models results.

Predictor	Family	School	Friends	Living environment	Self
Gender	0.28	8.69	0.05	1.04	−1.37
District ^b					
B	−4.27	−0.60	−2.53	−1.18	−4.55
C	−0.88	1.80	−0.43	3.32	−8.87
D	−2.63	0.22	−1.68	−2.16	−4.90
E	4.94	3.94	2.95	−7.17	3.18
F	−2.95	1.92	−0.32	−2.44	−5.52
Time in primary school	0.70	−0.73	0.70	0.18	0.23
Time in middle school	−0.45	−7.25	−0.54	−3.21	−1.10

Significant results ($p < 0.05$) are in bold and marginally significant results ($p < 0.1$) are in italics. Reference: Boys of District A at T0. The color scale reflects the sign and magnitude of the β coefficients: red denotes negative effects, green positive effects, and yellow coefficients close to zero.

TABLE 6 General, French and maths self-efficacy scores evolution according to gender, district, and school level: linear mixed models results.

Predictor	General self efficacy	French self efficacy	Maths self efficacy
Gender	0.90	5.85	−2.81
Girls vs Boys			
District ^b			
B	−6.98	−6.85	−6.55
C	−4.31	−0.69	0.74
D	−3.33	−2.44	−2.34
E	−1.62	0.95	−1.33
F	−5.28	−1.46	−4.12
Time in primary school	0.34	0.74	0.55
Time in middle school	−0.84	−1.82	−5.97

Significant results ($p < 0.05$) are in bold and marginally significant results ($p < 0.1$) are in italics. ^aBoys are the reference. ^bDistrict A is the reference. NI: Not included. The color scale reflects the sign and magnitude of the β coefficients: red denotes negative effects, green positive effects, and yellow coefficients close to zero.

TABLE 7 Life skills, self efficacy, life satisfaction, and health literacy scores evolution of girls compared to boys according to school level: linear mixed models results.

Outcome	Primary school (β)	Middle school (β)
Life skills	0.22	−2.28
Self efficacy	0.52	0.43
Life satisfaction	−0.14	−2.07
Health literacy	−0.36	−2.08

Significant results ($p < 0.05$) are in bold and marginally significant results ($p < 0.1$) are in italics. The color scale reflects the sign and magnitude of the β coefficients: red denotes negative effects, green positive effects, and yellow coefficients close to zero.

Similarly, the Education and Training Monitor (2024) for France documents widening socio-economic achievement gaps and stresses the importance of school climate and support in disadvantaged districts (57). In primary school settings, case study evidence shows that schools located in socially disadvantaged neighborhoods with strong local partnership and supportive leadership are better able to integrate health promotion modules effectively, suggesting that context responsiveness matters greatly for intervention success (58). These findings raise important equity concerns: without additional support, such programs risk widening existing inequalities by benefiting already favorable environments more. Addressing territorial disparities is therefore essential for ensuring the fairness and effectiveness of universal health promotion interventions.

4.5 The primary–middle school transition as a critical juncture

The steep decline in LS, SE, and LSa at T5 underscores the transition from primary to middle school as a period of heightened vulnerability. This transition entails not only pedagogical rupture—with greater demands for autonomy, workload, and self-regulation—but also relational discontinuity, as pupils shift from having one main teacher to multiple subject teachers, often weakening individualized socioemotional support. Evidence from recent longitudinal studies

4.4 Territorial and contextual inequalities

Marked differences across districts confirm that program effects are mediated by local environments. District C, despite low baseline scores, showed the most consistent gains and even resisted the T5 decline, suggesting that supportive contexts can amplify and sustain program benefits. In contrast, District E started from a favorable position but experienced the steepest decline at T5, highlighting how even seemingly advantaged settings can be vulnerable during transitions. District F, with lower SSI and weaker school climates, consistently underperformed, pointing to persistent territorial inequalities. These observations align with recent findings in France and Europe. Indeed, a scoping review showed that educational facility structures and social inequalities significantly shape children's health and well-being outcomes, including trajectories over time (56).

TABLE 8 Life skills, self efficacy, life satisfaction, and health literacy scores evolution of all districts according to school level: Linear mixed models results.

District ^a	School level	Life skills (β)	Self efficacy (β)	Life satisfaction (β)	Health literacy (β)
B	Primary	0.14	0.14	0.28	0.17
	Middle	1.33	1.63	3.85	−2.61
C	Primary	−0.03	−1.12	−0.05	0.86
	Middle	5.76	3.18	4.46	−0.06
D	Primary	−1.07	−1.65	−0.72	−1.06
	Middle	0.2	−0.97	0.3	−2.17
E	Primary	−0.24	−0.24	−0.48	0.05
	Middle	−1.57	−3.4	−1.12	−4.06
F	Primary	−0.94	−1.98	−1.4	−0.81
	Middle	−1.41	−5.01	−3.64	−8.3

Significant results ($p < 0.05$) are in bold and marginally significant results ($p < 0.1$) are in italics ^a district of reference: A. The color scale reflects the sign and magnitude of the β coefficients: red denotes negative effects, green positive effects, and yellow coefficients close to zero.

supports these patterns: for example, a German study found that LSa and school satisfaction decline statistically significantly during secondary school, particularly following the end of primary school, and that school-level achievement composition moderates these declines (59). A U. S. study of teacher-student relational warmth documents a sharp drop in perceived warmth at the transition to middle school, which predicts declines in engagement, belonging and achievement (60). In France, socio-economic gradients in academic SE become more pronounced by the end of primary school, suggesting that vulnerabilities accumulate before the transition (61). Similarly, adolescents in studies of school transition report lower school satisfaction and SE tied to the shift in environment and expectations (46). Our results suggest that the Explo'Santé program, although designed to anticipate this rupture, was not sufficient to fully buffer its disruptive effects. This finding highlights a structural challenge for school-based health promotion: while programs can strengthen psychosocial resources, broader institutional transitions and relational changes may overwhelm these gains unless systemic measures are taken.

4.6 Implications for health promotion programs and policies

These findings carry several implications for health promotion in schools. First, interventions should explicitly anticipate the primary-middle school transition, integrating targeted supports to maintain psychosocial gains during this critical period. Systematic reviews show that such transition-focused programs can positively affect students' social-emotional outcomes, engagement, and self-concept when implemented around the time of transfer from primary to secondary school (62). Secondly, teacher training is crucial: educators require tools to adopt health-promoting pedagogical approaches that sustain socioemotional support alongside academic expectations. Evidence from vulnerable backgrounds indicates that a positive school climate—often maintained by teacher practices, leadership, and peer relationships—can moderate negative impacts on social and emotional skill development (63). Thirdly, territorial equity must be addressed,

as program effectiveness depends heavily on local school climate and socioeconomic environments. Schools in disadvantaged contexts with poor climate or leadership tend to have less benefit from health promotion programs unless these contextual barriers are identified and directly addressed (64). Without additional resources for disadvantaged districts, universal interventions risk reproducing or widening existing inequalities (21). This underscores the relevance of the Health Promoting Schools framework, which advocates for whole-school, ecological approaches integrating curriculum, environment, and community partnerships to foster health and equity (6). More recent evidence emphasizes the importance of student engagement in HPS implementation: participatory strategies and meaningful involvement of pupils are key facilitators of success, while rigid school structures often act as barriers (65). At the same time, the Explo'Santé experience illustrates the centrality of LS in health education, but also the persistent lack of a consensual definition in research, which complicates evaluation and cross-study comparison (66). Finally, gender-sensitive approaches are needed: programs must account for differential vulnerabilities of girls and boys, tailoring strategies to support girls' resilience during transitions and addressing boys' persistent gaps in relational and literacy-based domains.

4.7 Strengths and limitations

This study has several strengths. It involved a large cohort of pupils followed longitudinally over 3 years, providing robust insights into developmental trajectories. The use of validated instruments for LS, SE, LSa, and HL ensured comparability with prior research. Multilevel modelling accounted for clustering at class and school levels, strengthening the reliability of findings. Sensitivity analyses confirmed the robustness of main effects despite attrition. However, limitations must be acknowledged. It should be noted that many scales are available to explore LS, SE, LSa and HL, with different conceptual focuses and dimensionalities. Choosing alternative measuring tools may impact the results observed. Attrition was substantial by T5, potentially introducing selection bias. Data relied on self-administered questionnaires, which may be influenced by

social desirability and subjective interpretation. Importantly, no control group was available for ethical reasons, limiting causal inference on the program's effectiveness. Moreover, the precision of district-level estimates varied substantially across the sample. Several districts included only a small number of pupils, which increases statistical uncertainty and limits the robustness of comparisons across contexts. Therefore, findings related to these smaller sub-samples should be interpreted with caution. Finally, contextual variability across districts complicates generalization, highlighting the need for replication in other educational systems.

5 Conclusion

This study provides new longitudinal evidence on the potential and limitations of school-based health promotion. The *Explo'Santé* program contributed to strengthening pupils' psychosocial resources, confirming the relevance of embedding LS and HL into the daily functioning of schools. However, the sharp decline observed during the transition to middle school underlines the importance of reinforcing support structures at this pivotal stage of development. Gendered patterns and territorial disparities also reveal the need for context-sensitive approaches that adapt to local dynamics while ensuring equity. To better understand these differences, qualitative analyses are required, notably to identify the mechanisms, facilitators, and barriers that explain why some territories show more sustained impacts than others. Beyond its immediate outcomes, *Explo'Santé* illustrates how the Health Promoting Schools framework can be operationalized to address health and social inequalities from an early age, fostering environments that support both academic success and long-term well-being.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The protocol was approved by the University of Lyon's ethics committee (France) on March 1, 2023 (n°2023-01-12-004). CNIL reference: 2226244 v 0. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

CS: Investigation, Visualization, Formal analysis, Writing – review & editing, Writing – original draft, Data curation, Methodology, Software. AD-B: Writing – review & editing, Investigation. FC: Validation, Project administration, Writing – review & editing, Supervision. ED: Project administration, Supervision, Writing – review & editing, Funding acquisition, Conceptualization, Resources.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

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References

- McNamara, CL, Balaj, M, Thomson, KH, Eikemo, TA, Solheim, EF, and Bambra, C. The socioeconomic distribution of non-communicable diseases in Europe: findings from the European social survey (2014) special module on the social determinants of health. *Eur J Pub Health*. (2017) 27:22–6. doi: 10.1093/eurpub/ckw222
- World Health Organization. The Ottawa charter for health promotion. First international conference on health promotion, Ottawa, 17–21 November 1986. In: Milestones in health promotion. Statements from global conferences. Geneva. (2009).
- Kovess-Masfety, V, Husky, MM, Keyes, K, Hamilton, A, Pez, O, Bitfoi, A, et al. Comparing the prevalence of mental health problems in children 6–11 across Europe. *Soc Psychiatry Psychiatr Epidemiol*. (2016) 51:1093–103. doi: 10.1007/s00127-016-1253-0
- OECD statistics. 2025. From data to action: Enhancing children's lives through better insights. Available online at: <https://oecdstatistics.blog/2025/04/08/from-data-to-action-enhancing-childrens-lives-through-better-insights/>. (Accessed September 22, 2025)
- Viner, RM, Ozer, EM, Denny, S, Marmot, M, Resnick, M, Fatusi, A, et al. Adolescence and the social determinants of health. *Lancet (London, England)*. (2012) 379:1641–52. doi: 10.1016/S0140-6736(12)60149-4
- Langford, CP, Bonell, HE, Jones, HE, Poulou, T, Murphy, SM, and Waters, E. The WHO health promoting school framework for improving the health and well-being of students and their academic achievement. *Cochrane Database Syst Rev*. (2014). 4:2–5. doi: 10.1002/14651858.CD008958.pub2
- Pulimeno, M, Piscitelli, P, Colazzo, S, Colao, A, and Miani, A. School as ideal setting to promote health and wellbeing among young people. *Health Promot Perspect*. (2020) 10:316–24. doi: 10.34172/hpp.2020.50 (Accessed September 22, 2025)
- Eurostat 2022 Secondary education statistics. Available online at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Secondary_education_statistics
- Dunhill, A. Children's Realities in Europe: Progress&Gaps - Eurochild 2024 flagship report on children in need across Europe (2024). Available online at: <https://eurochild.org/resource/childrens-realities-in-europe-progress-gaps/>
- Bandura, A. Self-efficacy: the exercise of control In: Self-efficacy: The exercise of control. New York, NY, USA: W H Freeman/Times Books/ Henry Holt & Co (1997)
- Masson, J, and Fenouillet, F. Relation entre sentiment d'efficacité personnelle et résultats scolaires à l'école primaire: Construction et validation d'une échelle. *Enfance (Paris)*. (2013) 4:374–92. doi: 10.3917/enf1.134.0374
- Sorensen, K. Review of health literacy and public health: a systematic review and integration of definitions and models, by Stephan van den Broucke, James Fullam, Gerardine Doyle, et al. *BMC Public Health*. (2012) 12:80. doi: 10.1186/1471-2458-12-80
- Diener, E, and Lucas, RE. Personality and subjective well-being In: Well-being: The foundations of hedonic psychology. New York, NY, USA: Russell Sage Foundation (1999)
- Inchley, J, Currie, D, Budisavljevic, S, Torsheim, T, Jästad, A, Cosma, A, et al. Spotlight on adolescent health and well-being. Findings from the 2017/2018 health behaviour in school-aged children (HBSC) survey in Europe and Canada. International report. volume 1. Key findings. (2020). Available online at: <https://www.who.int/europe/publications/i/item/9789289055000>. (Accessed September 22, 2025)
- OECD/UNICEF. 2024. Education in the eastern Partnership: Findings from PISA. Paris: PISA, OECD Publishing. doi: 10.1787/d5d6f109-en
- Masson, J. Review of promoting wellbeing within the health promoting schools framework: could life skills be a means rather than an end?, by Adeline Darlington-Bernard and Emily Darlington. *J Epidemiol Popul Health*. (2024) 72:202–748. doi: 10.1016/j.jep.2024.202748
- World Health Organization. 2003. 'Life skills approach to child and adolescent healthy human development | health and education resource Centre'. In Skills for health - skills-based health education including life skills: An important component of a child-friendly/health-promoting school. WHO INFORMATION SERIES ON SCHOOL HEALTH, Document 9. Available online at: <https://healtheducationresources.unesco.org/library/documents/life-skills-approach-child-and-adolescent-healthy-human-development>. (Accessed December 12, 2023)
- Yoon, S, An, S, Noh, DH, Tuan, LT, and Lee, J. Effects of health education on adolescents' non-cognitive skills, life satisfaction and aspirations, and health-related quality of life: a cluster-randomized controlled trial in Vietnam. *PLoS One*. (2021) 16:e0259000. doi: 10.1371/journal.pone.0259000
- Marmot, M, Friel, S, Bell, R, Houweling, TAJ, and Taylor, S. Closing the gap in a generation: health equity through action on the social determinants of health. *Lancet*. (2008) 372:1661–9. doi: 10.1016/S0140-6736(08)61690-6
- Bartelink, N, van Assema, P, Vennegoor, G, and Bessems, K. Implementation of the health promoting school approach in Europe: a cross-sectional study among National Representatives. *J Sch Health*. (2024) 94:975–84. doi: 10.1111/josh.13499
- Darlington, EJ, Violon, N, and Jourdan, D. Implementation of health promotion programmes in schools: an approach to understand the influence of contextual factors on the process? *BMC Public Health*. (2018) 18:1. doi: 10.1186/s12889-017-5011-3
- Inchley, J, Muldoon, J, and Currie, C. Becoming a health promoting school: evaluating the process of effective implementation in Scotland. *Health Promot Int*. (2007) 22:65–71. doi: 10.1093/heapro/dal059
- Patton, GC, Sawyer, SM, Santelli, JS, Ross, DA, Afifi, R, Allen, NB, et al. Our future: a lancet commission on adolescent health and wellbeing. *Lancet*. (2016) 387:2423–78. doi: 10.1016/S0140-6736(16)00579-1
- Bagnall, CL, Jindal-Snape, D, Banwell, E, Panayiotou, M, Mason, C, and Qualter, P. Emotional wellbeing in the context of primary-secondary school transitions: a concept analysis paper. *Educ Psychol Rev*. (2025) 37:21. doi: 10.1007/s10648-025-09990-6
- Benes, S, Boyd, KM, Cucina, I, and Alperin, HL. School-based health education research: charting the course for the future. *Res Q Exerc Sport*. (2021) 92:111–26. doi: 10.1080/02701367.2020.1712315
- Mukamana, O, and Johri, M. What is known about school-based interventions for health promotion and their impact in developing countries? A scoping review of the literature. *Health Educ Res*. (2016) 31:587–602. doi: 10.1093/her/cyw040
- Nasheeda, A, Abdullah, H, Krauss, S, and Ahmed, N. A narrative systematic review of life skills education: effectiveness, research gaps and priorities. *Int J Adolesc Youth*. (2018) 24:362–379. doi: 10.1080/02673843.2018.1479278
- Olivo, M, Darlington-Bernard, A, Salque, C, Fraticelli, L, Ricard, E, Carrouel, F, et al. The Explo'Santé mixed methods protocol: an interventional research school health promotion project in France. *Arch Public Health*. (2025) 83:26. doi: 10.1186/s13690-024-01487-y
- Darlington, Emily, and Masson, Julien 2020 *Promotion de la santé et réussite scolaire*. Available online at: <https://www.dunod.com/sciences-humaines-et-sociales/promotion-sante-et-reussite-scolaire> (Accessed July 11, 2025).
- Ministère de l'Éducation 1998 'Bulletin Officiel de l'Éducation Nationale BO N°45 Du 3 Décembre 1998'. Available online at: <https://www.education.gouv.fr/bo/1998/45/default.htm> (Accessed December 9, 2025).
- Légifrance 2013 'LOI N° 2013–595 Du 8 juillet 2013 d'orientation et de Programmation Pour La Refondation de l'école de La République - Dossiers Législatifs'. Available online at: <https://www.legifrance.gouv.fr/dossierlegislatif/JORFDOLE000026973437/> (Accessed December 9, 2025).
- STROBE. 2024. 'Checklists'. STROBE. Available online at: <https://www.strobe-statement.org/checklists/>. (Accesses July 11, 2025)
- Tessier, Damien. 2021. 'Echelles de mesure des compétences psychosociales'. Séminaire Santé Publique France, Online. Available online at: <https://www.santepubliquefrance.fr/import/echelles-de-mesure-des-competences-psychosociales>. (Accessed December 12, 2023)
- Encinar, P-E. Review of *Compétences psychosociales et bien-être scolaire chez l'enfant: une validation française pilote*, by Damien Tessier and Rébecca Shankland. *Enfance (Paris)*. (2017) 1:37–60. doi: 10.3917/enf1.171.0037
- Simar, C. Review of *Validation transculturelle d'une échelle de mesure des compétences sociales chez les élèves des 8 à 12 ans*, by Julie Pironom, Damien Tessier, Christelle Nsambu, and Julien Masson. *Revue Education Santé Sociétés*. (2021) 1:125–139. doi: 10.17184/eac.3865
- Schultz, D, Izard, CE, and Bear, G. Children's emotion processing: relations to emotionality and aggression. *Dev Psychopathol*. (2004) 16:371–87. doi: 10.1017/S0954579404044566
- Weiss, MR, Bolter, ND, and Kipp, LE. Assessing impact of physical activity-based Youth development programs: validation of the *life skills transfer survey (LSTS)*. *Res Q Exerc Sport*. (2014) 85:263–78. doi: 10.1080/02701367.2014.931558
- Huebner, ES. Preliminary development and validation of a multidimensional life satisfaction scale for children. *Psychol Assess*. (1994) 6:149–58. doi: 10.1037/1040-3590.6.2.149
- Rouquette, A. Review of *health literacy throughout adolescence: invariance and validity study of three measurement scales in the general population*, by Laurent Rigal, Julien Mancini, Francis Guillemin, et al. *Patient Educ Couns*. (2022) 105:996–1003. doi: 10.1016/j.pec.2021.07.044
- Paakkari, O, Torppa, M, Kannas, L, and Paakkari, L. Subjective health literacy: development of a brief instrument for school-aged children. *Scand J Public Health*. (2016) 44:751–7. doi: 10.1177/1403494816669639
- Masson, J, Darlington-Bernard, A, Vieux-Poule, S, and Darlington, E. Validation française de l'échelle de littératie en santé des élèves HLSAC (Health literacy for school-aged children). *Sciences Educ Santé Publique*. (2021) 33:705–12. doi: 10.3917/spub.215.0705
- Salque, C, Darlington-Bernard, A, Carrouel, F, and Darlington, E. Life skills development in schools: the Explo'Santé program's first-year impact. *J Educ Res*. (2025). 119:1–13. doi: 10.1080/00220671.2025.2595429
- INSEE 2025 Comparateur de Territoires – Comparez Les Territoires de Votre Choix - Résultats Pour Les Communes, Départements, Régions, Intercommunalités... | Insee. Available online at: <https://www.insee.fr/fr/statistiques/1405599?geo=METRO-1> (Accessed August 29, 2023).
- Salque, C, Darlington-Bernard, A, Olivo, M, Fraticelli, L, Ricard, E, Carrouel, F, et al. Cross-sectional study of the French Explo'Santé 4th grader cohort: a baseline for self-efficacy, life satisfaction, life skills and health literacy. *Glob Health Promot*. (2025) 32:60–70. doi: 10.1177/17579759251317512

45. Jaruseviciute, V, Silinskas, G, and Kiuru, N. Socioemotional functioning across the transition to lower secondary school: the role of temperament and relationships with mothers and teachers. *J Res Adolesc.* (2023) 33:1143–63. doi: 10.1111/jora.12866
46. Pedditzi, ML, Nonnis, M, and Fadda, R. Self-efficacy in life skills and satisfaction among adolescents in school transitions. *J Public Health Res.* (2023) 12:22799036231211420. doi: 10.1177/22799036231211420
47. Huttunen, I, Upadyaya, K, and Salmela-Aro, K. Longitudinal associations between adolescents' social-emotional skills, school engagement, and school burnout. *Learn Individ Differ.* (2024) 115:102537. doi: 10.1016/j.lindif.2024.102537
48. Tercova, N, Muzik, M, Dedkova, L, and Smahel, D. The reciprocal relationship between parental eHealth literacy mediation and adolescents' eHealth literacy: three-wave longitudinal study. *J Med Internet Res.* (2025) 27:e67034. doi: 10.2196/67034
49. Else-Quest, NM, Hyde, JS, and Linn, MC. Cross-National Patterns of gender differences in mathematics: a Meta-analysis. *Psychol Bull.* (2010) 136:103–27. doi: 10.1037/a0018053
50. Chan, RCH. A social cognitive perspective on gender disparities in self-efficacy, interest, and aspirations in science, technology, engineering, and mathematics (STEM): the influence of cultural and gender norms. *Int J STEM Educ.* (2022) 9:37. doi: 10.1186/s40594-022-00352-0
51. Hyde, JS. Gender similarities and differences. *Annu Rev Psychol.* (2014) 65 Volume 65:373–98. doi: 10.1146/annurev-psych-010213-115057
52. Eriksson, K, and Strimling, P. Gender differences in competitiveness and fear of failure help explain why girls have lower life satisfaction than boys in gender equal countries. *Front Psychol.* (2023) 14:1131837. doi: 10.3389/fpsyg.2023.1131837
53. De Vriendt, T, Clays, E, Maes, L, De Bourdeaudhuij, I, Vicente-Rodriguez, G, Moreno, LA, et al. European adolescents' level of perceived stress and its relationship with body adiposity--the HELENA study. *Eur J Pub Health.* (2012) 22:519–24. doi: 10.1093/eurpub/ckr134
54. García-Moya, I, Paniagua, C, and Jiménez-Iglesias, A. Gender differences in adolescent school stress: a mixed-method study. *J Res Adolesc.* (2025) 35:e13057. doi: 10.1111/jora.13057
55. World Health Organization 2024 Rising school pressure and declining family support especially among girls, finds new WHO/Europe report. Available online at: <https://www.who.int/europe/news/item/13-11-2024-rising-school-pressure-and-declining-family-support-especially-among-girls--finds-new-who-europe-report> (Accessed September 23, 2025).
56. Fillol, A, Wallerich, L, Larose, M-P, Ferron, C, Rivadeneyra-Sicilia, A, Vandentorren, S, et al. The influence of educational determinants on children's health: a scoping review of reviews. *Public Health Rev.* (2024) 45:1606372. doi: 10.3389/phrs.2024.1606372
57. European Commission. Directorate General for Education, Youth, Sport and Culture. 2022. *Rapport de suivi de l'éducation et de la formation 2022: France*. Publications Office. Available online at: <https://data.europa.eu/doi/10.2766/98979> (Accessed September 23, 2025).
58. Johnson, S, Laham, S, Blanc, S, and Bellanger, M. Cultivating partnerships to incorporate health promotion modules into primary school curricula: a case study in France. *Front Educ.* (2024) 9:1498753. doi: 10.3389/feduc.2024.1498753
59. Wu, Y-J, and Becker, M. Association between school contexts and the development of subjective well-being during adolescence: a context-sensitive longitudinal study of life satisfaction and school satisfaction. *J Youth Adolesc.* (2023) 52:1039–57. doi: 10.1007/s10964-022-01727-w
60. Hughes, JN, and Cao, Q. Trajectories of teacher-student warmth and conflict at the transition to middle school: effects on academic engagement and achievement. *J Sch Psychol.* (2018) 67:148–62. doi: 10.1016/j.jsp.2017.10.003
61. Bezzi, FB, Panico, L, and Solaz, A. Socio-economic gradients in pupils' self-efficacy: evidence, evolution and main drivers during the primary school years in France. *Longitud Life Course Stud.* (2024) 15:1–14. doi: 10.1332/17579597Y2024D0000000028
62. Beatson, R, Quach, J, Canterford, L, Farrow, P, Bagnall, C, Hockey, P, et al. Improving primary to secondary school transitions: a systematic review of school-based interventions to prepare and support student social-emotional and educational outcomes. *Educ Res Rev.* (2023) 40:100553. doi: 10.1016/j.edurev.2023.100553
63. Engels, MC, Pakarinen, E, Lerkkanen, M-K, and Verschueren, K. Students' academic and emotional adjustment during the transition from primary to secondary school: a cross-lagged study. *J Sch Psychol.* (2019) 76:140–158. doi: 10.1016/j.jsp.2019.07.012
64. Wang, W, Xiao, J, Li, W, and Yao, J. How school climate affects the development of the social and emotional skills of underprivileged-background students—An empirical study based on the SSES2019 data. *Children.* (2022) 9:1812. doi: 10.3390/children9121812
65. Kontak, JC, Macrae, C, Caldwell, HAT, Feicht, B, Heath, S, Hancock Friesen, CL, et al. The process of student engagement in school health promotion: a scoping review. *BMC Public Health.* (2025) 25:1063. doi: 10.1186/s12889-025-22121-8
66. Darlington-Bernard, A. Review of *defining life skills in health promotion at school: a scoping review*, by Corélie Salque, Julien Masson, Emily Darlington, Graça S. Carvalho, and Florence Carrouel. *Front Public Health.* (2023) 11:1296609. doi: 10.3389/fpubh.2023.1296609
67. Fenouillet, F. Validation française de l'échelle multidimensionnelle de satisfaction de vie chez l'élève. *Canadian Journal of Behavioural Science.* (2014) 47:1–29. Available online at: <https://hal.science/hal-01061826> (Accessed September 8, 2023).



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Preliminary effects and feasibility of a school-based regular aerobic exercise intervention on PTSD-related symptoms among college students: a single-group pre-post study

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Background: College students are considered a high-risk group for post-traumatic stress disorder (PTSD). Existing non-pharmacological interventions, although effective and accessible, still have notable limitations. Regular aerobic exercise, as a potential mental health promotion strategy, requires empirical validation in real campus environments to determine its specific effects on reducing anxiety, depression, and PTSD symptoms, as well as its role in enhancing psychological resilience.

Method: This study employed a single-group pre-test/post-test design and was conducted in August 2025 at a comprehensive university in Sichuan, China. Using convenience sampling, 47 participants with elevated PTSD symptoms were recruited for the “School-Based Regular Aerobic Exercise” intervention trial (operationalized as a 21-Day Exercise Check-In Activity). All participants engaged in 30 min of aerobic exercise daily for 3 weeks. Before and after the intervention, participants completed the PTSD Checklist for DSM-5 (PCL-5), Self-Rating Anxiety Scale (SAS), Self-Rating Depression Scale (SDS), and Connor-Davidson Resilience Scale (CD-RISC).

Result: All 47 participants completed the 21-day intervention. Significant pre- to post-intervention improvements were observed in PTSD symptoms, anxiety, depression, and psychological resilience. Clinical significance analysis showed that 57.45% of participants fell below the PTSD clinical cutoff after the intervention, and 87.23% demonstrated reliable change. Exploratory change-score analyses indicated that improvements in resilience were significantly associated with reductions in anxiety and PTSD symptoms, but not depression.

Conclusion: In a real-world campus setting, this 21-day school-based regular aerobic exercise intervention appears feasible and is associated with improvements in PTSD-related symptoms and psychological resilience. However, because the study lacked randomization and a control group, causal

inferences regarding effectiveness and underlying mechanisms cannot be made. Randomized controlled trials with longer follow-up periods and objective activity measures are warranted.

KEYWORDS

anxiety, depression, post-traumatic stress disorder, psychological resilience, school-based regular aerobic exercise intervention

1 Introduction

Post-Traumatic Stress Disorder (PTSD) is a severe mental disorder triggered by exposure to traumatic events (1). Its core features include re-experiencing the trauma, avoidance, negative changes in cognition and mood, and increased arousal (2, 3). PTSD exerts long-term and profound negative impacts on an individual's social functioning, academic achievement, and overall quality of life (4–6). For example, Park et al. (2022) found that community resilience was significantly associated with PTSD symptoms and quality of life among affected individuals.

College students, who are at a critical stage of psychological development (7), face multiple challenges—including academic pressure, interpersonal difficulties, future planning, and potential exposure to traumatic events—making them widely recognized as a high-risk group for PTSD (8). Zhai and Du (9) reported that the prevalence of PTSD diagnoses among American college students increased annually from 2017 to 2022. During the COVID-19 pandemic, the prevalence among Chinese college students reached 25%, with even higher rates observed among students in Africa, Europe, low-to-middle-income countries, and in medical schools (10).

Despite the effective control of COVID-19, ongoing threats such as wars, extreme weather events, and localized infectious disease outbreaks continue to pose serious challenges (11). Importantly, PTSD in college students not only increases the risks of comorbid anxiety and depression but may also lead to severe consequences such as academic disruption (12, 13), substance abuse, and suicidal behavior, thereby imposing substantial burdens on families, educational institutions, and healthcare systems. Thus, developing effective and easily disseminable PTSD intervention strategies is essential for strengthening mental health service systems in higher education.

Although evidence-based interventions for PTSD – such as trauma-focused cognitive behavioral therapy and eye movement desensitization and reprocessing (EMDR) – are highly effective (14, 15), their widespread implementation on university campuses faces numerous practical barriers. These include a shortage of quality therapists, students' reluctance to seek professional help due to stigma, high time and financial costs, and uneven geographical distribution of treatment resources (16, 17). For instance, Silvestrini and Chen (18) found that male veteran college students may be less willing to seek help for PTSD due to feelings of shame and distrust.

Pharmacotherapy is also effective but its potential side effects and risk of dependency limit its suitability for student populations (19, 20). Consequently, there is an urgent need for non-pharmacological, non-invasive auxiliary or alternative interventions that are highly accessible, cost-effective, and easily acceptable to college students. The

campus environment, as the primary setting for students' daily life and learning (21), plays an important role in reducing stress and anxiety, enhancing focus and creativity, and promoting physical activity (22, 23). For example, Guo, Wen (24) reported that campus public spaces can significantly improve students' mental health. However, existing literature lacks systematic evaluations of how such universal campus-based interventions influence core PTSD symptoms and common comorbidities among college students. Moreover, the mechanisms underlying these potential effects remain largely unexplored, representing a significant research gap.

School-based regular aerobic exercise intervention, as a low-cost, highly accessible, and less stigmatized health-promoting behavior, may help address these gaps (25). Such interventions can enhance students' sense of self-efficacy through mastery experiences, provide positive distraction to interrupt rumination, and create opportunities for social interaction, thereby improving psychological well-being and body image (26). Yet, most prior studies remained theoretical or limited to small-scale preliminary evaluations.

For example, Young-McCaughan, Peterson (27) found that regular aerobic exercise among active-duty military personnel in the U.S. was associated with reductions in PTSD severity over time. Regular aerobic exercise is fundamentally a healthy lifestyle behavior (28), and the present study integrates this approach into the university context. As both a problem-focused and emotion-focused coping strategy, aerobic exercise may reshape individuals' cognitive appraisals of traumatic events—shifting from catastrophic interpretations to more adaptive processing (29)—thereby reducing negative mood changes and hyperarousal associated with PTSD.

A key advantage of school-based regular aerobic exercise intervention is their high ecological validity, as they directly engage students within their everyday environments, increasing feasibility and willingness to participate (30). Thus, such interventions may alleviate physiological hyperarousal, reduce comorbid anxiety and depression, and enhance psychological resilience in coping with adversity.

Psychological resilience is defined as a dynamic process through which individuals maintain or rapidly restore psychological functioning when facing adversity, trauma, or stress (31, 32). According to conservation of resources theory (33), traumatic events often deplete of individuals' psychological resources, triggering a vicious cycle that exacerbates PTSD (34).

Regular aerobic exercise, as a resource-acquisition strategy, may enhance psychological resilience by enriching individual's resource pools. School-based regular aerobic exercise interventions can strengthen core dimensions of resilience—such as emotional regulation and problem-solving abilities (35) – thereby increasing engagement in exercise and fostering hope for PTSD improvement. Additionally, the sense of achievement and social interaction derived from regular exercise may further translate into psychological

Abbreviation: PTSD, Post-Traumatic Stress Disorder.

resilience, amplifying the intervention effects through positive feedback loops and creating a virtuous cycle (36). Exercise promotes adaptive meaning-making in the face of adversity, enhances resilience, and accelerates post-trauma recovery (37). Based on this theoretical foundation, the present study hypothesizes that psychological resilience plays a significant mediating role between regular aerobic exercise and PTSD symptoms.

Anxiety, as a common comorbidity of PTSD, is characterized by persistent worry and physiological arousal (38). Cognitive-behavioral models suggest that regular aerobic exercise can interrupt anxiety-related rumination and facilitate emotional regulation (39). Aerobic exercise may redirect students' attention away from anxiety triggers, enhance social integration, and boost self-efficacy and confidence, thereby reducing anxiety stemming from self-doubt. Psychological resilience also plays a protective role in alleviating anxiety symptoms (40). Higher resilience can reduce distress associated with traumatic memories (41) by enabling cognitive reappraisal, decreasing sensitivity to trauma cues, and reducing the frequency and intensity of intrusive memories. Depression, the most common comorbidity of anxiety, often manifests as low mood, anhedonia, and cognitive distortions, and is frequently associated with hormonal changes and environmental stressors during adolescence (42). According to cognitive-emotional interaction theory (43), regular exercise can alleviate depressive symptoms by interrupting cycles of depressive rumination. School-based regular aerobic exercise interventions may counteract anhedonia by enhancing dopamine activity, thereby indirectly reducing avoidance and emotional numbness associated with depression.

Therefore, the present study aimed to provide preliminary, ecologically valid evidence on the feasibility and short-term symptom changes associated with a school-based regular aerobic exercise intervention among college students with elevated PTSD symptoms. We further examined whether changes in psychological resilience were statistically associated with changes in PTSD, anxiety, and depression as an exploratory test of a hypothesized mechanism. Given the single-group pre-post design, these analyses are intended to generate mechanistic hypotheses and inform subsequent randomized controlled trials rather than to establish causal efficacy. The significance and potential contributions of this study is multifaceted. Practically, it offers college administrators and mental health practitioners a specific, feasible, and easily implementable non-pharmacological intervention that can be integrated into existing campus health promotion programs, thereby expanding prevention and treatment options for PTSD and improving the accessibility of campus mental health services. Finally, the study provides foundational data and decision-making support for promoting the formal incorporation of regular physical activity into public mental health service systems for college students in China as a scientifically grounded primary prevention and secondary intervention strategy.

2 Method

This study employed a single-group pre-post design in a naturalistic campus setting to assess the feasibility of implementing a school-based regular aerobic exercise intervention and to quantify within-participant changes in PTSD symptoms, common comorbid symptoms (anxiety and depression), and psychological resilience. Because no control

group was included, the study was intended as a preliminary feasibility and proof-of-concept investigation rather than a causal efficacy trial.

2.1 Participants and sample

This study commenced in May and was completed in its entirety on August 25, at a comprehensive university in Sichuan Province, encompassing the following phases: protocol preparation, participant recruitment and informed consent, intervention implementation, questionnaire/scale assessments, and data collection. The university is well-equipped with sports facilities, exercise venues, and professional sports instructors, meeting the basic requirements for the trial. Participants were recruited using convenience sampling.

PTSD symptom status was operationalized using the PCL-5. Participants were not clinically diagnosed with PTSD for the purposes of this study; instead, eligibility was based on a screening cutoff, which indicates elevated or probable PTSD symptomatology in prior research. Accordingly, we refer to the sample as college students with elevated PTSD symptoms rather than PTSD patients.

The inclusion criteria were: (1) Full-time college students aged 18–25; (2) A preliminary screening for PTSD using the PTSD Checklist 5 (PCL-5) (score ≥ 53 , indicating PTSD symptoms); (3) Voluntary participation in the study and signing of an informed consent form; (4) No severe cognitive impairments and sufficient proficiency in Chinese for effective communication; (5) Physical condition permitting normal exercise.

Exclusion criteria were: (1) Severe exercise injuries or illnesses occurring during the study; (2) Failure to complete pre-and post-intervention assessments; (3) Current engagement in other systematic psychological or pharmacological treatments.

2.2 Minimum sample size

The minimum sample size was calculated using G*Power software (3.1). This study employed paired sample t-tests with a significance level (α) set at 0.05 and an effect size set at 0.5. To achieve a statistical power of 80% ($1-\beta$), at least 34 participants were needed. Considering a dropout rate of 15%, the study planned to recruit no fewer than 40 participants.

2.3 Ethical considerations

The study received approval from the Academic Ethics Committee of North Sichuan Medical College (No.:2025020). All participants were informed of the activity's purpose, procedures, and reward mechanisms, and signed written informed consent before the study began. They were informed that they could withdraw at any time unconditionally. The research process strictly adhered to confidentiality principles, and data were processed anonymously.

2.4 Measurement tools

2.4.1 PTSD checklist

The PCL-5 is a 20-item self-report measure that assesses the presence and severity of PTSD symptoms according to DSM-5 criteria

(44). Items are rated on a 5-point Likert scale ranging from 0 (not at all) to 4 (extremely), yielding total scores from 0 to 80. Higher scores indicate greater PTSD symptom severity. Consistent with recommendations from the National Center for PTSD, a cutoff score of 33 is suggested for probable PTSD diagnosis in community samples (45).

In the present study, the scale was translated into Chinese by Su, Kung (46) and validated for cultural adaptation and reliability in five different Chinese populations. A 5-point Likert scale was used for scoring, based on the frequency and severity of symptoms (1 = not at all, 5 = extremely). The total score ranges from 20 to 100 points. Each item score ranges from 1 to 5. In this study, the Cronbach's alpha for the pre-test and post-test was 0.939 and 0.978, indicating good internal consistency.

2.4.2 Resilience scale

The resilience measurement items were derived from the Connor-Davidson Resilience Scale (CD-RISC) developed by Connor and Davidson (47). This scale consists of 25 items across five dimensions: ability, tolerance of negative emotions, acceptance of change, control, and spiritual influence. The scale was translated into Chinese by Yu and Zhang (48) and validated for cultural adaptation in various populations, such as teachers (49) and medical students (50). A 5-point Likert scale was used for scoring, ranging from 1 = strongly disagree to 5 = strongly agree. Higher scores indicate greater psychological resilience among college students. In this study, the Cronbach's alpha for the pre-test and post-test was 0.943 and 0.957, indicating good internal consistency.

Higher resilience scores reflect a constellation of adaptive capacities including personal competence and tenacity, tolerance of negative affect and stress, positive acceptance of change, sense of control, and spiritual influences (47). Individuals with higher resilience scores typically demonstrate greater ability to recover from setbacks, maintain psychological equilibrium during stressful circumstances, and adapt positively following adverse experiences.

2.4.3 Depression scale

The depression measurement items were derived from the Zung Self-Rating Depression Scale (SDS) developed by Zung (51). This scale consists of 20 items across three dimensions: pervasive affect, physiological equivalents or concomitants, and psychological concomitants. The scale was translated into Chinese by Cheung (52), and its cultural adaptation and reliability were validated. This study used the scale to measure depression symptoms among college students, employing a 5-point Likert scale for scoring (1 = strongly disagree, 5 = strongly agree). The depression severity index = total score/100, with scores below 0.60 indicating no depression, 0.60–0.72 indicating mild to moderate depression, 0.72–0.84 indicating moderate to severe depression, and above 0.84 indicating severe depression. Higher scores indicate greater depression levels. In this study, the Cronbach's alpha for the depression scale was 0.919 and 0.815, indicating good internal consistency.

2.4.4 Anxiety scale

The anxiety measurement items were derived from the Zung Self-Rating Anxiety Scale (SAS) developed by Zung (53). This scale consists of 20 items across two dimensions: emotional symptoms and somatic symptoms. The scale was translated into Chinese by

Wang and Chi (54) and validated for cultural adaptation and reliability. This study used the scale to measure anxiety symptoms among college students, employing a 5-point Likert scale for scoring (1 = strongly disagree, 5 = strongly agree). The anxiety severity index = total score/100, with scores below 0.60 indicating no anxiety, 0.60–0.72 indicating mild to moderate anxiety, 0.72–0.84 indicating moderate to severe anxiety, and above 0.84 indicating severe anxiety. Higher scores indicate greater anxiety symptom severity. In this study, the Cronbach's alpha for the anxiety scale was 0.934 and 0.953, indicating good internal consistency.

2.5 Intervention process

The pre-test was conducted before the intervention began, and the post-test was completed within 1 week after the 21-day activity ended. The intervention scheme adopted a campus activity format, implementing a "21-Day Exercise Check-In Activity" lasting 3 weeks. Participants were required to choose from three types of exercise: (1) Jump rope for ≥ 10 min (daily submission of jump rope videos); (2) Run ≥ 2 kilometers (daily submission of screenshots from the Keep App); (3) Complete a full set of Tai Chi movements (daily submission of a full-length video). All submitted materials (videos or screenshots) must display time information, and forgery is prohibited. Researchers and campus activity staff conducted random on-site checks to ensure authenticity. Participants had to complete 21 consecutive days to qualify for inclusion in the study. Given the relatively large amount of exercise in 30 min, the study required only 30 min of exercise over a single day, and the duration of each exercise session was recorded, amounting to 30 min over a single day.

Participants who completed all assessments (pre-test, post-test) and maintained $\geq 80\%$ exercise session adherence received a gift card valued at approximately ¥50 (approximately \$7 USD) for a popular online shopping platform.

2.5.1 Exercise intensity monitoring

Participants recorded their daily exercise sessions using the Keep mobile application and submitted screenshots of the Keep activity logs during daily check-ins. These screenshots were used to document session completion and basic training parameters available in the app. The online platform incorporated daily exercise logs where participants recorded exercise type, duration, and self-rated intensity immediately following each session. Facilitators reviewed these logs and provided individualized feedback within 24 h, including encouragement to adjust intensity if reported levels fell consistently outside target ranges.

2.5.2 Exercise mode flexibility

Participants were permitted flexibility in exercise mode selection within the prescribed framework. At enrollment, participants indicated their preferred primary exercise mode (jump rope, running, or Tai Chi) based on personal preference, available space, equipment access, and physical capacity. However, participants were explicitly informed that they could switch between modes on different days according to circumstances such as weather conditions (e.g., choosing indoor jump rope or Tai Chi instead of outdoor running during inclement weather), physical state (e.g., selecting lower-intensity Tai

Chi on days of fatigue or minor muscle soreness), equipment availability, or personal preference on a given day.

The only requirement was that participants complete at least 30 min of one of the three prescribed exercise types daily. Participants were encouraged to maintain consistency where possible to facilitate skill development and routine establishment, but rigid adherence to a single mode was not required. Daily exercise logs captured the specific mode performed each day, allowing for tracking of mode switching patterns.

2.5.3 Structured warm-up, cool-down

All exercise sessions followed a standardized structure consisting of three phases: warm-up, main exercise, and cool-down.

Warm-up Phase (5 min). Each session began with a guided warm-up sequence delivered via pre-recorded video accessible through the online platform. The warm-up included light cardiovascular activation (marching in place, arm circles) and dynamic stretching targeting major muscle groups (leg swings, torso rotations, shoulder rolls, ankle circles). Participants were instructed to complete the warm-up video before every exercise session, regardless of chosen exercise mode.

Main Exercise Phase (30 min). Participants engaged in their selected exercise mode (jump rope, running, or Tai Chi) at the prescribed intensity levels described above.

Cool-down Phase (5 min). Each session concluded with a guided cool-down sequence, also delivered via pre-recorded video, consisting of gradual cardiovascular deceleration (slow walking in place), static stretching for major muscle groups (quadriceps, hamstrings, calves, shoulders, back), and brief breathing exercises to facilitate transition to rest.

2.5.4 Tai Chi instruction

Participants selecting Tai Chi as their primary or supplementary exercise mode received structured instruction through a comprehensive video-based curriculum developed specifically for this intervention.

A 20-min instructional video covering the history and principles of Tai Chi, basic stances (Wuji standing, bow stance, empty stance), fundamental movement principles (weight shifting, coordinated breathing), and safety considerations.

A simplified 8-movement Yang-style Tai Chi form, selected for accessibility and appropriateness for beginners, was taught progressively across the first week. Each movement was demonstrated from multiple angles with detailed verbal instruction regarding posture, weight distribution, hand positioning, and breathing coordination.

Following the instructional phase, participants accessed daily practice videos that guided them through the complete warm-up, Tai Chi form practice (with the form repeated multiple times to fill the 30-min main exercise period), and cool-down. Videos included real-time verbal cues for movement timing, breathing, and common error correction.

2.5.5 Fidelity monitoring

Participants completed structured logs immediately following each session, recording exercise mode, duration, and any difficulties encountered. Log completion was monitored daily, with automated reminders sent to participants who had not submitted logs by

9:00 p.m. Facilitators completed weekly fidelity checklists documenting completion of all scheduled check-ins, response rates to participant logs, and any protocol deviations.

Schematic of the daily exercise structure and the weekly intervention components, as shown in [Table 1](#).

2.6 Data collection and analysis

Data included the results from pre- and post-assessment measures and the 21-day check-in records, all collected and coded by the research team. Statistical analyses were performed using SPSS 26.0. Descriptive statistics were used to analyze demographic characteristics. For differences between pre- and post-assessments, paired sample *t*-tests were applied if the data met normality assumptions; otherwise, Wilcoxon signed-rank tests were used.

Effect size estimation and confidence intervals. For paired-samples *t* tests, we reported Cohen's d_z as the standardized mean change, calculated as $d_z = t/\sqrt{N}$ (equivalently, mean of the paired differences divided by the SD of the paired differences). For Wilcoxon signed-rank tests, we reported the effect size $r = Z/\sqrt{N}$, where *N* is the number of non-zero paired differences. Ninety-five percent confidence intervals (CIs) for *r* were estimated using percentile bootstrap resampling (5,000 iterations) of paired observations (no continuity

TABLE 1 Schematic overview of daily exercise session structure and weekly intervention components.

Daily session structure (40 min)		
Warm-up (5 Min)	Main exercise(30 Min)	Cool-down (5 Min)
Video-guided Light cardio Dynamic stretching	Option A: Jump rope Option B: Running Option C: Tai Chi	Video-guided Slow walking Static stretching Breathing exercise

Weekly intervention components
Daily: Complete 40-min exercise session (warm-up + exercise + cool-down) Submit exercise log (mode, duration, difficulties) Receive facilitator feedback on log (within 24 h)
Weekly: Individual video check-in with facilitator (5–10 min) Review of weekly progress and troubleshooting Form verification for Tai Chi participants (when feasible)
As Needed: Additional outreach for participants with concerning patterns Access to all instructional videos for review

21-day intervention timeline		
Week 1 (Days 1–7)	Week 2 (Days 8–14)	Week 3 (Days 15–21)
Orientation Tai Chi intro module Establish routine Week 1 check-in	Continued practice Progressive elements introduced Week 2 check-in	Continued practice Progressive intensity Final check-in Post-test assessment

correction). In cases where the bootstrap distribution showed negligible variability, the percentile CI could collapse to a single value.

Change-score (within-person) analytic strategy. Given the single-group pre–post design, observations are not independent if pre- and post-test records are stacked at the measurement level. PROCESS Model 4 is a single-level ordinary least squares (OLS) mediation procedure and does not inherently account for within-subject clustering. Therefore, to avoid violating the independence assumption and to provide a transparent exploratory test of the hypothesized mechanism, we conducted analyses using within-person change scores. For each participant, we computed change scores as $\Delta = \text{post} - \text{pre}$ for PTSD, anxiety, depression, and psychological resilience. We then examined whether changes in psychological resilience were associated with changes in PTSD/anxiety/depression using linear regression models (with 95% confidence intervals).

Given the exploratory nature of these analyses and the absence of a control group, results should be interpreted as preliminary evidence of potential mechanisms rather than confirmatory tests of causal mediation. The statistical significance level was set at $p < 0.05$.

3 Results

A total of 89 students were initially recruited and screened. Thirteen were excluded prior to baseline assessment (2 did not sign informed consent, 1 were younger than 18 years, and 3 did not meet the PTSD symptom screening threshold on the PTSD Checklist), yielding 83 participants who completed the pre-test assessment. During the 21-day program and follow-up assessment period, 36 participants were excluded from the post-test analytic sample: 15 reported physical discomfort (e.g., dizziness or muscle soreness) during the intervention period, 14 withdrew voluntarily, and 7 did not complete the post-test questionnaire. Therefore, 47 participants (24 males, 23 females) completed both pre- and post-assessments and comprised the final analytic sample. The retention rate was 56.62% (47/83) from baseline to post-test and 52.8% (47/89) from initial recruitment to final analysis. Specific demographic information is presented in Table 2. The attrition rate of participants is shown in Figure 1.

3.1 Attrition and potential selection bias

Attrition from baseline ($n = 76$) to the final analytic sample was 38.2% ($n = 47$). Reasons for post-baseline attrition included reported physical discomfort during the intervention ($n = 15$), voluntary withdrawal ($n = 7$), and missing post-test questionnaires ($n = 7$). Because attrition may not be random, the observed pre–post changes should be interpreted cautiously as they may over- or under-estimate symptom changes in the initially recruited population.

Of the 36 non-completers, 15 participants withdrew specifically due to adverse physical symptoms during the intervention sessions. Reported symptoms included dizziness ($n = 8$), muscle soreness ($n = 5$), and combined symptoms ($n = 2$). These symptom-related dropouts occurred predominantly during the initial intervention period (Week 1: $n = 9$; Week 2: $n = 4$; Week 3: $n = 2$), suggesting that early exercise sessions posed the greatest challenge for vulnerable participants.

Informal post-withdrawal contact with these participants revealed that symptoms were typically experienced during or immediately after higher-intensity aerobic segments. Importantly, no participants required medical attention, and all reported symptom resolution within 24–48 h of discontinuation. Nevertheless, the concentration of symptom-related dropout among participants with elevated baseline psychopathology raises concerns about the tolerability of the exercise protocol for more severely affected individuals.

3.2 Normality test

We calculated the differences in scores for PTSD, anxiety, depression, and psychological resilience for both pre-test and post-test, followed by exploratory analysis to test for normality. Results indicated that anxiety ($p = 0.295$) and depression ($p = 0.051$) exhibited significant normality, while psychological resilience ($p = 0.026$) and PTSD ($p < 0.001$) showed non-normality. Thus, paired sample *t*-tests were used for anxiety and depression, whereas Wilcoxon signed-rank tests were applied for psychological resilience and PTSD.

3.3 Baseline comparisons between completers and non-completers

We conducted independent samples *t*-tests to compare baseline characteristics between participants who completed the study ($n = 47$) and those who dropped out ($n = 36$).

As shown in Table 3, significant differences emerged between completers and non-completers on all baseline measures (all $p < 0.001$). Notably, participants who dropped out exhibited significantly higher levels of PTSD symptoms, anxiety, and depression, as well as significantly lower psychological resilience, compared to those who completed the intervention. These effect sizes range from medium to large, indicating substantial and clinically meaningful baseline differences between the two groups.

These findings have important implications for interpreting the study results. The pattern suggests that participants with more severe symptomatology and lower resilience resources were disproportionately likely to discontinue participation. This differential attrition may have resulted in a final sample that was less symptomatic and more psychologically resilient than the initially enrolled population, potentially inflating observed treatment effects and limiting generalizability to more severely affected individuals.

3.4 Single group pre-and post-test analysis

To further examine the intervention effects of school-based regular aerobic exercise intervention on PTSD, anxiety, depression, and psychological resilience, paired sample *t*-tests were conducted on anxiety and depression scores pre- (T1) and post-intervention (T2) for all participants, while Wilcoxon signed-rank tests were used for psychological resilience and PTSD. Effect sizes were measured using Cohen's *d*, with Cohen's (1988) standards indicating $d = 0.2$ as a small effect, $d = 0.5$ as a medium effect, and $d = 0.8$ as a large effect, as detailed in Table 4.

TABLE 2 Summary of demographic information.

Demographic dimensions	Specific category	Frequency	Percentage
Gender	Male	24	51.06%
	Female	23	48.94%
Origin of student	Rural	12	25.53%
	Town	35	74.47%
Annual income	Below 100,000 RMB	23	48.94%
	100,000 to 200,000 RMB	17	36.17%
	200,000 RMB and above	7	14.89%
Student grade level	Class of 2022	6	12.77%
	Class of 2023	15	25.53%
	Class of 2024	26	55.32%
During the past 3 weeks of exercise, what are the actual days of exercise for your favorite sport?	10 days or less	31	65.96%
	11–20 days	8	17.02%
	21 days or more	8	17.02%
Exercise duration of single exercise	Less than 30 min	30	63.83%
	30–45 min	10	21.28%
	More than 45 min	7	14.89%
Exercise intensity	Easy	29	61.70%
	Moderate to difficult	18	38.30%
Exercise period	Morning (6–12 a.m.)	4	8.51%
	Afternoon (12–6 p.m.)	3	6.38%
	Evening (6–8 p.m.)	13	27.66%
	Night (after 8 p.m.)	20	42.55%
	Not fixed	7	14.89%
Sports environment	School playground/track	36	76.60%
	Indoor (Dormitory/Gym)	5	10.64%
	Outdoor (Park/Paths)	6	12.77%
Psychological perceptions of exercise	Negative/tried	25	53.19%
	Positive feelings	22	46.81%
Type of exercise	Running	30	63.83%
	Jumping rope	2	4.26%
	Tai Chi	3	6.38%
	Other	12	25.53%

NB: According to the study design, participants were required to complete daily aerobic exercises lasting approximately 30 min per session.

The paired sample *t*-test results showed that pre-test anxiety scores ($M = 3.489$, $SD = 0.718$) were significantly higher than post-test anxiety scores ($M = 2.648$, $SD = 0.736$). This indicates that school-based regular aerobic exercise intervention has a significant impact on reducing anxiety symptoms among college students ($t = -6.352$, $p < 0.001$, Cohen's $d = -0.926$, 95% $CI = [-1.266, -0.580]$). The effect size far exceeds the threshold of 0.8, indicating a very large effect of the intervention on improving anxiety symptoms.

Pre-test depression scores ($M = 3.514$, $SD = 0.647$) were significantly higher than post-test depression scores ($M = 3.087$, $SD = 0.383$). This suggests that school-based regular aerobic exercise intervention significantly impacts depression symptoms in college students ($t = -3.963$, $p < 0.001$, Cohen's $d = -0.578$, 95%

$CI = [-0.885, -0.266]$). The effect size falls within the medium range, suggesting a notable improvement effect on depression symptoms.

Wilcoxon signed-rank test results indicated that pre-test psychological resilience scores ($M = 2.843$, $SD = 0.691$) were significantly lower than post-test psychological resilience scores ($M = 3.585$, $SD = 0.534$). This indicates that school-based regular aerobic exercise intervention has a significant effect on enhancing psychological resilience among college students ($Z = 4.842$, $p < 0.001$, $r = 0.707$, 95% $CI = [0.544, 0.814]$). Pre-test PTSD scores ($M = 3.807$, $SD = 0.749$) were significantly higher than post-test scores ($M = 2.404$, $SD = 0.855$), indicating that school-based regular aerobic exercise intervention can effectively improve PTSD symptoms ($Z = -5.975$, $p < 0.001$, $r = 0.871$, 95% $CI = [-0.871, -0.871]$).

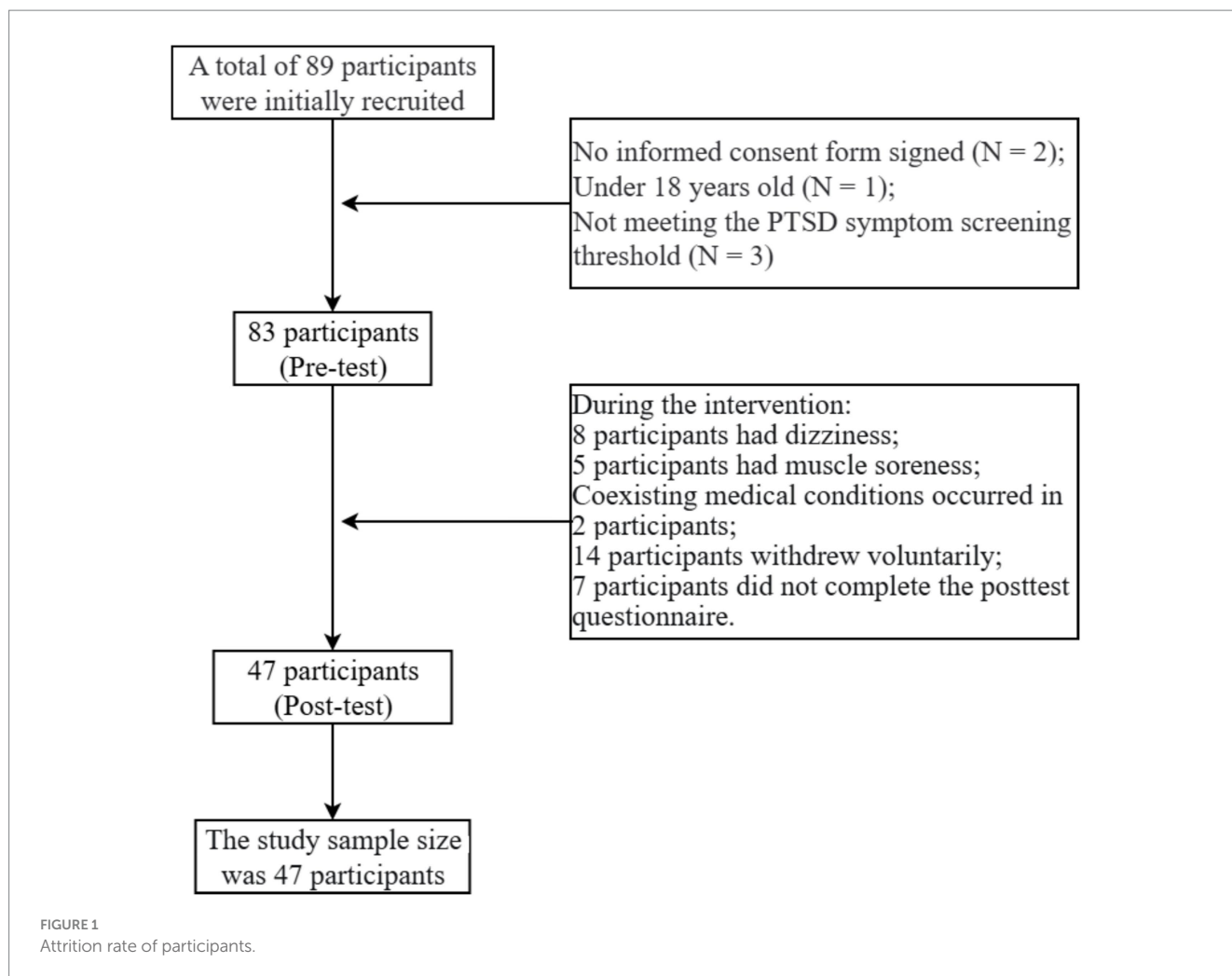


TABLE 3 Baseline comparisons between completers and non-completers.

Variables	Completers (N = 47)	Non-completers (N = 36)	t	p	Conhen's d	95% CI
PTSD (M ± SD)	2.404 ± 0.855	4.044 ± 0.700	9.350	<0.001	0.792	[1.528,2.605]
Anxiety (M ± SD)	2.648 ± 0.736	3.568 ± 0.714	5.745	<0.001	0.726	[0.788,1.740]
Depression (M ± SD)	3.087 ± 0.383	3.596 ± 0.637	4.514	<0.001	0.508	[0.537,1.458]
Psychological resilience (M ± SD)	3.584 ± 0.637	2.857 ± 0.723	-5.278	<0.001	0.623	[-1.636,-0.696]

3.5 Clinical significance analysis

To complement the statistical significance findings, we examined the clinical meaningfulness of observed changes by analyzing categorical shifts in symptom severity and the proportion of participants crossing established clinical thresholds.

3.5.1 PTSD clinical recovery

Using the established clinical cutoff score of 53 on the PTSD Checklist for DSM-5 (PCL-5), which indicates probable PTSD diagnosis, we examined the proportion of participants who transitioned from above to below this threshold following the intervention. All 47 participants met the inclusion criterion of $PCL-5 \geq 53$ at baseline, confirming probable PTSD. Following the

21-day exercise intervention, 27 participants (57.45%) scored below the clinical cutoff, indicating clinically significant improvement and potential diagnostic remission. The remaining 20 participants (42.55%) continued to score above the cutoff, though all showed some degree of symptom reduction. Table 5 presents the distribution of participants relative to the clinical cutoff at both time points.

Additionally, we calculated the Reliable Change Index (RCI) to determine whether individual changes exceeded measurement error (55). Using the standard error of measurement derived from the scale's reliability (Cronbach's $\alpha = 0.939$ at pre-test), 41 participants (87.23%) demonstrated reliable improvement ($RCI > 1.96$), indicating that their symptom reduction was unlikely due to measurement error alone. Six participants (12.77%) showed improvement that did not exceed the

TABLE 4 Single-group pre- and post-test analysis results.

Variable	T1 Mean	T1 SD	T2 Mean	T2 SD	Δ Mean	Lower limit	Upper limit	T/Z	<i>p</i>	Cohen's <i>d/r</i>	95% CI
Anxiety	3.489	0.718	2.648	0.736	−0.842	−1.109	−0.575	−6.352	<0.001	−0.926	[−1.266, −0.580]
Depression	3.514	0.647	3.087	0.383	−0.427	−0.643	−0.209	−3.963	<0.001	−0.578	[−0.885, −0.266]
Psychological resilience	2.843	0.691	3.585	0.534	0.742	–	–	4.842	<0.001	0.707	[0.544, 0.814]
PTSD	3.807	0.749	2.404	0.855	−1.403	–	–	−5.975	<0.001	0.871	[−0.871, −0.871]

NB: Δ = T2 – T1. Negative Δ indicates symptom reduction (Anxiety/Depression/PTSD); positive Δ indicates increase (Resilience).

TABLE 5 Ptsd clinical cutoff analysis (*N* = 47).

PCL-5 status	Pre-test [<i>n</i> (%)]	Post-test [<i>n</i> (%)]
Above cutoff (≥ 53): Probable PTSD	47(100%)	20 (42.55%)
Below cutoff (<53): Non-clinical	0(0%)	27 (57.45%)

threshold for reliable change, and no participant showed reliable deterioration.

3.5.2 Anxiety severity category shifts

Based on the severity classification criteria for the Self-Rating Anxiety Scale, participants were categorized into four groups: no anxiety (<0.60), mild to moderate anxiety (0.60 – 0.72), moderate to severe anxiety (0.72 – 0.84), and severe anxiety (>0.84). Table 6 presents the cross-tabulation of anxiety severity categories from pre-test to post-test.

At baseline, 41 participants (87.23%) met criteria for clinical anxiety (severity index ≥ 0.60), including 23 (48.94%) in the mild–moderate range, 9 (19.15%) in the moderate–severe range, and 9 (19.15%) in the severe range. Following the intervention, 17 participants (36.17%) remained in clinical anxiety categories, representing a substantial reduction in clinical cases.

Examination of category transitions revealed that 36 participants (76.60%) improved by at least one severity category, 8 (17.02%) remained in the same category, and 3 participants (6.38%) moved to a more severe category. Among those with clinical anxiety at baseline, 25 of 41 (60.98%) transitioned to the non-clinical range (no anxiety) following the intervention.

3.5.3 Depression severity category shifts

Using the same severity classification approach for the Self-Rating anxiety Scale, participants were categorized based on their severity index scores. Table 7 presents the depression severity category transitions.

At baseline, 44 participants (93.62%) met criteria for clinical depression (severity index ≥ 0.60), including 25 (53.19%) in the mild–moderate range, 12 (25.53%) in the moderate–severe range, and 7 (14.89%) in the severe range. Following the intervention, 33 participants (70.21%) remained in clinical depression categories, representing a notable reduction in clinical cases.

Examination of category transitions revealed that 25 participants (53.19%) improved by at least one severity category, 20 (42.55%) remained in the same category, and only 2 participants (4.26%) moved to a more severe category. Among those with clinical depression at baseline, 11 of 44 (25.00%) transitioned to the non-clinical range (no depression) following the intervention. Notably, all 19 participants

(100%) who were in the moderate–severe or severe range at baseline improved to less severe categories, with none remaining in these highest severity categories post-intervention.

The clinical indicators are shown in Table 8.

3.6 Exploratory change-score associations

3.6.1 Preliminary analyses

Before conducting the formal mediation analysis, we calculated change scores for all study variables, as shown in Table 9. Positive values of Δ Resilience indicate increased resilience, whereas negative values of Δ Anxiety, Δ Depression, and Δ PTSD indicate decreased symptoms. This suggests that 21 days of regular exercise can effectively improve the mental health of college students with symptoms of PTSD.

3.6.2 Exploratory change-score analysis

Given the single-group pre-post design, we conducted exploratory regression analyses to examine whether individual differences in resilience change (Δ resilience) were associated with individual differences in symptom changes (Δ anxiety, Δ depression, and Δ PTSD), as shown in Table 10. These analyses explore potential mechanisms but cannot establish causality due to the absence of a control group and the correlational nature of change-score associations.

Anxiety. The change-score regression revealed that Δ resilience significantly predicted Δ anxiety ($\beta = -0.335$, $p = 0.021$). Participants who showed greater increases in psychological resilience tended to show greater reductions in anxiety symptoms. The model explained approximately 11.2% of the variance in anxiety change ($R^2 = 0.112$).

Depression. Δ resilience did not significantly predict Δ depression ($\beta = -0.231$, $p = 0.118$), although the direction of the association was consistent with expectations. This suggests that individual differences in resilience change were not reliably associated with individual differences in depression change in this sample.

PTSD. Δ resilience significantly predicted Δ PTSD ($\beta = -0.329$, $p = 0.024$). Participants demonstrating greater improvements in psychological resilience showed correspondingly greater reductions in PTSD symptoms. The model explained approximately 10.8% of the variance in PTSD change ($R^2 = 0.108$).

3.7 Cautions for exploratory findings

These exploratory analyses suggest that changes in psychological resilience may be associated with changes in anxiety and PTSD symptoms following the exercise intervention. Specifically, participants who experienced greater enhancement in resilience also tended to experience greater symptom relief.

TABLE 6 Anxiety severity category changes from pre-test to post-test.

Pre-test category	Post-test Category				Total
	No anxiety	Mild–moderate	Moderate–severe	Severe	
No anxiety	5	1	0	0	6 (12.77%)
Mild–moderate	15	6	1	1	23 (48.94%)
Moderate–severe	7	2	0	0	9 (19.15%)
Severe	3	3	3	0	9 (19.15%)
Total post-test	30 (63.83%)	12 (25.53%)	4 (8.51%)	1 (2.13%)	47(100%)

TABLE 7 Depression severity category shifts.

Pre-test category	Post-test category				Total
	No depression	Mild–moderate	Moderate–severe	Severe	
No depression	3	0	0	0	3 (6.38%)
Mild–moderate	6	17	1	1	25 (53.19%)
Moderate–severe	3	9	0	0	12 (25.53%)
Severe	2	5	3	0	7 (14.89%)
Total Post-test	14 (29.79%)	31 (65.96%)	1 (2.13%)	1 (2.13%)	47 (100%)

TABLE 8 Summary of clinical significance indicators.

Indicator	PTSD	Anxiety	Depression
Pre-test clinical cases	47(100%)	41(87.23%)	44(93.62%)
Post-test clinical cases	20(42.55%)	17(36.17%)	33(70.21%)
Remission rate	27(57.45%)	25(60.98%)	11(25.00%)
Category improvement	–	36(76.60%)	25(53.19%)
No change in category	–	8(17.02%)	20(42.55%)
Category worsening	–	3(6.38%)	2(4.26%)
Reliable change (RCI > 1.96)	41(87.23%)	–	–

NB: Remission rate calculated as proportion of baseline clinical cases who transitioned to non-clinical status: PTSD (27/47), Anxiety (25/41), Depression (11/44).

First, due to the single-group design, we cannot determine whether the intervention caused the observed changes or whether these changes would have occurred naturally over time. Second, the change-score correlations do not establish temporal precedence—we cannot determine whether resilience changes preceded symptom changes or vice versa. Third, the modest effect sizes (R^2 ranging from 0.05 to 0.11) indicate that resilience changes account for only a small proportion of the variance in symptom changes, suggesting that other unmeasured factors likely play important roles.

These findings should therefore be considered hypothesis-generating rather than confirmatory and warrant replication in randomized controlled trials with appropriate temporal measurement of mediators and outcomes.

4 Discussion

This study used a single-group pre-post design without randomization or a control condition; therefore, the observed symptom changes cannot be attributed causally to the exercise

TABLE 9 Scores for changes in study variables.

Variables	Mean Change ($\Delta = T2-T1$)	SD	Min	Max
Δ Psychological resilience	0.742	0.846	−0.44	2.72
Δ Anxiety	−0.842	0.908	−2.00	3.10
Δ Depression	−0.427	0.738	−2.30	1.60
Δ PTSD	−1.403	0.311	−2.00	−0.85

check-in program. Alternative explanations include natural recovery over time, regression to the mean (given elevated baseline screening scores), repeated-measurement effects, seasonal or academic-calendar influences, and other concurrent supports or lifestyle changes during the 21-day period. Accordingly, the findings should be interpreted as preliminary and hypothesis-generating evidence of within-participant change associated with program participation rather than evidence of efficacy.

Within these constraints, participants who completed both assessments showed pre-post reductions in PTSD symptoms and comorbid anxiety and depression, along with increased resilience. These patterns are consistent with prior work linking physical activity to mental health outcomes, and they support the feasibility of testing brief, scalable exercise-based programs for students with elevated PTSD symptoms in more rigorous designs.

4.1 Single group pre-and post-test analysis

The results of the single group pre-and post-test analysis indicate that regular aerobic exercise significantly promotes the psychological health of participants. Engaging in school-based regular aerobic exercise intervention provides college students an immediate sense of control, with physiological responses (like adjusted breathing and increased heart rate) and pleasurable experiences serving as positive

TABLE 10 Change-score regression results for exploratory analysis.

Outcomes (Δ = post – pre)	Predictors	B	β	SE	t	p	95%CI
Δ Anxiety	Δ resilience	–0.36	–0.335	0.151	–2.385	0.021	[–0.056, –0.663]
Δ Depression		–0.202	–0.231	0.127	–1.592	0.118	[–0.456, 0.053]
Δ PTSD		–0.121	–0.329	0.052	–2.336	0.024	[–0.225, –0.017]

NB: Δ represents change scores calculated as post-test minus pre-test values. Negative B coefficients indicate that greater increases in resilience are associated with greater decreases in symptoms.

feedback (56). This accumulation of positive experiences continually strengthens the individual's motivation to exercise and adherence to the behavior. Consequently, it effectively breaks the passive and helpless feelings that trauma survivors may develop in daily life, helping them reconstruct a positive self-schema through specific exercise practices.

Regular exercise tasks require students to complete activities at fixed times or in specific contexts, thus providing a structured coherence to their lives (57). For college students experiencing psychological distress, having a structured time and behavior pattern significantly reduces the intrusion of random stressors and avoids the psychological emptiness that may arise from a lack of goals and planning. More critically, this rhythmic arrangement enables students to gradually experience the transition from chaos to order, enhancing their sense of stability and security. Security buffers subjective feelings of external threat and diminishes excessive vigilance toward the environment (58).

It is noteworthy that regular aerobic exercise also serves as a significant opportunity for emotional transformation. After completing exercise, individuals typically experience feelings of joy, relaxation, and even a slight sense of accomplishment, introducing new variables into previously rigid negative emotional patterns (59). Individuals under constant stress often tend to interpret external events negatively, leading to cognitive rigidity (60). Exercise provides a means to interrupt this pattern, allowing them to gain psychological relief from brief emotional peaks (61). As these positive experiences accumulate, individuals' cognitive flexibility gradually increases, manifested through more open thinking, adaptive self-talk, and positive meaning construction.

4.2 Clinical meaningfulness of observed changes

The present study demonstrated not only statistically significant improvements across all three primary outcome measures, but also clinically meaningful changes that underscore the therapeutic value of the online group intervention for earthquake-affected adolescents.

Regarding PTSD symptomatology, the intervention produced substantial clinical benefits. At baseline, all 47 participants met the clinical threshold for probable PTSD, reflecting the severe psychological impact of earthquake trauma on this population. Following the intervention, 27 participants (57.45%) transitioned below the clinical cutoff, indicating diagnostic-level remission. Furthermore, reliable change index analysis revealed that 41 participants (87.23%) exceeded the threshold for reliable improvement ($RCI > 1.96$), demonstrating that the observed reductions in PTSD symptoms were not attributable to measurement error. The mean

reduction of 18.36 points on the PCL-5 substantially exceeded the established minimal clinically important difference of 10–20 points, suggesting that participants experienced perceptible and meaningful relief from intrusive memories, avoidance behaviors, negative cognitions, and hyperarousal symptoms.

For anxiety symptoms, the clinical impact was equally pronounced. Among the 41 participants who met criteria for clinical anxiety at baseline, 25 (60.98%) achieved remission to non-clinical status following the intervention. Category-level analysis further demonstrated that 36 participants (76.60%) improved by at least one severity category, with only 3 participants (6.38%) showing category-level worsening. Notably, of the 14 participants classified in the moderate–severe or severe anxiety ranges at baseline, 13 (92.86%) improved to less severe categories, with the number of severe cases decreasing from 6 to zero. These patterns indicate that the intervention was particularly effective for those with more pronounced anxiety presentations.

Depression outcomes similarly reflected meaningful clinical improvement, though the pattern differed somewhat from the other measures. Of the 44 participants meeting clinical criteria for depression at baseline, 11 (25.00%) transitioned to the non-clinical range. While this remission rate was lower than those observed for PTSD and anxiety, category-level analysis revealed that 25 participants (53.19%) improved by at least one severity category, with only 2 (4.26%) showing worsening. Particularly noteworthy was the complete resolution of severe depression cases: all 19 participants who were in the moderate–severe or severe depression categories at baseline improved to less severe categories, with no participants remaining at these highest severity levels post-intervention.

Collectively, these findings indicate that the online group intervention produced clinically meaningful benefits across the spectrum of trauma-related psychopathology. The convergence of multiple indicators—including remission rates, reliable change indices, and severity category transitions—provides robust evidence that the observed statistical effects translated into tangible improvements in participants' psychological functioning. The particularly strong effects observed for PTSD symptoms align with the trauma-focused nature of the intervention, while the substantial improvements in anxiety and depression suggest beneficial effects on the broader constellation of post-disaster psychological distress.

4.3 Exploratory analysis of resilience as a potential mechanism

The exploratory change-score analyses provide preliminary evidence suggesting that improvements in psychological resilience may be associated with reductions in anxiety and PTSD symptoms

following the exercise intervention. Specifically, participants who showed greater increases in resilience also tended to show greater decreases in anxiety ($\beta = -0.335$, $p = 0.021$) and PTSD symptoms ($\beta = -0.329$, $p = 0.024$). These associations, while modest in magnitude, are consistent with theoretical frameworks positing resilience as a dynamic psychological resource that influences trauma recovery (62).

However, it is crucial to interpret these findings within the constraints of our study design. The single-group pre-post design precludes causal inference, as we cannot rule out alternative explanations for the observed associations. The correlational nature of change-score analyses means that we cannot determine temporal precedence—whether resilience improvements preceded symptom relief, occurred simultaneously, or followed symptom changes. Additionally, third variables not measured in this study may account for the observed associations between resilience and symptom changes.

The non-significant association between resilience change and depression change ($\beta = -0.231$, $p = 0.118$) warrants consideration. While the direction of the effect was consistent with hypotheses, the lack of statistical significance may reflect insufficient statistical power given our sample size, different mechanisms underlying depression versus anxiety and PTSD, or the possibility that resilience operates differently on depression within the context of exercise interventions. Future studies with larger samples and more frequent measurement occasions could help clarify these relationships.

Despite these limitations, the findings provide a foundation for hypothesis development regarding the mechanisms through which exercise interventions may affect psychological outcomes. The consistent pattern of associations between resilience enhancement and symptom reduction across anxiety and PTSD outcomes suggests that resilience-building components may be valuable targets for optimization in future intervention designs. These findings align with conservation of resources theory (Alvaro et al., 2010), which suggests that resource acquisition through exercise may buffer against the resource depletion associated with trauma exposure.

4.4 Practical implications

These findings carry several implications for practice. First, schools should consider integrating brief, structured exercise opportunities into daily routines as a component of mental health promotion. The online delivery format used in this study demonstrates feasibility for implementation without requiring specialized facilities or extensive personnel training. Schools might incorporate guided exercise sessions into morning routines, physical education classes, or after-school programming, with particular attention to students showing elevated depressive symptoms.

Second, the accessibility of the exercise modalities studied—jump rope, running, and Tai Chi—suggests potential for broad implementation. These activities require minimal equipment, can be performed in limited spaces, and are adaptable to varying fitness levels. The flexibility to choose and switch between modalities enhanced acceptability in our sample and may be an important design feature for real-world programs. Mandating a single exercise type may be less effective than offering structured choice within defined parameters.

Third, the online platform approach offers scalability advantages, particularly for reaching adolescents in under-resourced areas or those

who face barriers to in-person programming. However, our attrition rate indicates that online delivery alone is insufficient; the combination of digital content with human support (facilitator check-ins, personalized feedback) was likely important for maintaining engagement. Future implementations should preserve this blended approach rather than relying solely on automated content delivery.

Fourth, the 21-day duration, while sufficient to produce measurable effects, is brief relative to the chronic nature of adolescent depression. Programs should plan for maintenance and follow-up support to sustain initial gains. This might include transitioning participants to ongoing exercise opportunities within schools or communities, periodic booster sessions, or peer support networks that encourage continued physical activity.

Finally, exercise interventions should be positioned as complementary to, rather than substitutes for, established mental health treatments. Adolescents with moderate-to-severe depression or active suicidal ideation require professional clinical care; exercise may serve as an adjunct that enhances treatment response or as a preventive strategy for those with subclinical symptoms.

4.5 Safety considerations and exercise tolerance

The withdrawal of 15 participants due to adverse physical symptoms represents a significant concern that warrants careful examination. When considered alongside the finding that non-completers exhibited significantly higher baseline PTSD, anxiety, and depression scores, a troubling pattern emerges: the intervention may be least tolerable for those who are most symptomatic and potentially most in need of treatment.

Several mechanisms may explain the elevated vulnerability of more symptomatic participants to exercise-induced adverse effects. First, individuals with elevated PTSD and anxiety often exhibit chronic hyperarousal, including elevated resting heart rate, heightened sympathetic nervous system activation, and dysregulated stress response systems. The additional physiological demands of exercise may have compounded this existing arousal, potentially triggering symptoms such as dizziness, lightheadedness, or panic-like sensations. Second, trauma-affected individuals frequently demonstrate altered interoceptive processing, with some experiencing hypervigilance to bodily sensations that may amplify the perceived intensity of normal exercise-related experiences (e.g., increased heart rate, sweating, breathlessness) and trigger trauma-associated fear responses. Third, elevated depression is associated with physical deconditioning, fatigue, and reduced exercise tolerance, potentially rendering standard exercise intensities more challenging for these individuals. Fourth, lower psychological resilience may reduce capacity to persist through physical discomfort that more resilient individuals might tolerate.

The concentration of symptom-related dropouts in the first 2 weeks suggests that the initial adaptation period poses the greatest risk. This finding has direct implications for protocol design: more gradual introduction of exercise, with extended low-intensity acclimation periods, may be essential for more symptomatic participants.

These findings do not necessarily contraindicate exercise-based interventions for trauma-affected populations. Indeed, substantial

evidence supports the benefits of exercise for PTSD and related conditions. However, our results suggest that standard exercise protocols may require significant modification for individuals with more severe symptomatology. Recommendations for future implementation include: Comprehensive pre-intervention assessment of current fitness levels, exercise history, physical health conditions, and symptom severity to identify individuals at elevated risk for adverse responses; Development of differentiated exercise prescriptions based on baseline symptom severity and fitness levels, with lower-intensity starting points for more affected individuals; Longer initial phases with very gradual intensity progression, particularly for participants with elevated symptoms or limited exercise experience.

4.6 Research limitations and future directions

Several directions for future research emerge from this study's findings and limitations. Most urgently, randomized controlled trials with longer follow-up periods are needed to establish whether observed effects persist beyond the immediate post-intervention period and to identify optimal intervention duration for sustained benefit. Our 21-day protocol produced meaningful short-term effects, but the durability of these effects remains unknown.

Future studies should incorporate objective measures of both exercise behavior (e.g., accelerometry) and biological outcomes (e.g., inflammatory markers, cortisol, neuroimaging) to reduce reliance on self-report and illuminate mechanisms of action. Such measures would address the methodological limitations of the present study and provide stronger evidence for causal claims.

Research should examine potential moderators of intervention response. Our sample was insufficiently powered to detect differential effects by sex, baseline symptom severity, exercise history, or exercise modality preference. Identifying which adolescents benefit most—and which may require modified or alternative approaches—would enable more efficient resource allocation.

Implementation research examining real-world adoption, adaptation, and sustainment of exercise-based mental health programming in schools and communities would bridge the gap between controlled research and practical impact. Identifying barriers and facilitators to implementation, cost-effectiveness relative to other mental health interventions, and strategies for maintaining program quality at scale represent important next steps toward translating this evidence into public health benefit.

This study primarily recruited participants from the same university, resulting in a concentration of cultural backgrounds, socioeconomic levels, and campus environments; thus, the generalizability and cross-cultural applicability of the findings still require validation. This bias limits the external validity of the results, which might overestimate the true group effects. Future research should strive for diversity in samples and breakthroughs in cross-cultural effects. Expanding the intervention to adolescents in middle school, workplace populations, or even veterans can allow for comparisons of exercise effects in different developmental tasks and social pressure contexts.

Attrition and selection bias. A substantial proportion of participants did not complete the intervention and post-test assessments. This level of attrition raises concerns about selection bias and limits generalizability. Participants who completed the 21-day check-in may

have differed systematically from those who discontinued (e.g., greater exercise tolerance, higher motivation, fewer time constraints, or different baseline symptom severity). Consequently, the magnitude of within-person symptom change observed among completers may not represent the change that would occur in the broader screened population. Future studies should implement strategies to reduce attrition (e.g., graded intensity options, adverse-event monitoring and management, flexible scheduling, and enhanced follow-up procedures) and should examine baseline differences between completers and non-completers, as well as apply analytic approaches that better accommodate missing data (e.g., mixed-effects models and/or multiple imputation), to strengthen the robustness of conclusions.

Importantly, the present findings should be interpreted in light of the single-group pre-post design. Symptom reductions and resilience gains may reflect multiple alternative explanations, including regression to the mean, spontaneous symptom fluctuation and natural recovery over time, repeated-measurement effects, seasonal or contextual changes during the study period, or concurrent informal support. Therefore, the results provide preliminary evidence of feasibility and within-person change, but they do not demonstrate causal effectiveness. Future studies should employ randomized controlled designs (e.g., waitlist or active control conditions), objective activity monitoring (e.g., wearables), and longer-term follow-up to test durability and to strengthen causal inference regarding mechanisms.

The substantial attrition rate and the systematic differences between completers and non-completers represent significant threats to internal and external validity. Of the 83 participants with complete baseline data, 36 (43.37%) did not complete the intervention. Independent samples *t*-tests revealed that non-completers exhibited significantly higher baseline levels of PTSD, anxiety, and depression, as well as significantly lower psychological resilience, compared to completers. This pattern of differential attrition indicates that the intervention may have been less acceptable, tolerable, or accessible to those with more severe psychopathology and fewer psychological resources—precisely the individuals who may be in greatest need of intervention. The implications of this attrition pattern are substantial. The final analytic sample likely represents a more resilient, less symptomatic subgroup of the initially enrolled population, potentially inflating effect size estimates and remission rates. The true efficacy of the intervention for adolescents with more severe trauma-related symptoms remains uncertain. Clinicians and researchers considering implementation of similar interventions should be aware that individuals presenting with higher symptom severity and lower resilience may require additional support, modified protocols, or alternative treatment approaches to enhance retention and benefit from exercise-based interventions.

Beyond the measured baseline differences, self-selection processes may have introduced additional unmeasured confounds. Participants who volunteered for an exercise-based intervention and persisted through completion may have possessed more positive attitudes toward physical activity, greater self-efficacy for behavior change, stronger family support, or other characteristics associated with favorable treatment response. These unmeasured factors may further limit generalizability to the broader population of earthquake-affected adolescents.

Due to the single-group pre-post design, we employed change-score regression analyses. While this approach is transparent and appropriate for our design, it cannot establish that resilience changes

causally mediate intervention effects on symptoms. The change-score correlations observed may reflect shared method variance, common causes affecting both resilience and symptom changes, or reverse causation (symptom improvement leading to resilience enhancement rather than vice versa). Future research employing randomized controlled trials with multiple measurement waves would enable more rigorous mediation analysis using appropriate statistical techniques such as latent change score models or multilevel structural equation modeling, which can better account for measurement error and establish temporal precedence of mediators relative to outcomes.

5 Conclusion

This study verified the intervention potential of regular aerobic exercise on college students' post-traumatic stress disorder and its accompanying symptoms in a real campus environment. The results indicate that exercise can significantly alleviate negative emotions such as anxiety and depression while promoting the enhancement of psychological resilience, thereby providing internal psychological resource support for trauma recovery. Model analysis further reveals that psychological resilience plays a partial mediating role in the relationship between exercise and symptom relief, indicating that the intervention effects stem not only from physiological activation but also from the reconstruction and reinforcement of internal adaptability. This finding provides new theoretical evidence for the integration of exercise psychology and trauma intervention. The significant implications of this research lie in providing a low-cost, easily disseminated, and low-stigma non-pharmacological intervention program for campus mental health service systems. By encouraging students to incorporate exercise into their daily lives, the prevalence and accessibility of mental health services can be effectively enhanced, achieving both preventive and intervention goals. However, the study also has limitations in design and sampling, highlighting the need for more rigorous experimental designs, broader sample sources, and more comprehensive assessment tools in future research. Overall, this research enriches the theoretical framework regarding the relationship between exercise and mental health, while providing reliable evidence for universities to formulate mental health promotion policies. Future efforts to integrate longitudinal follow-up, multidisciplinary measurement, and cross-cultural comparisons will enhance understanding of the mechanisms involved and promote regular aerobic exercise as an essential component of campus mental health service systems.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Ethics Committee of North Sichuan Medical College under approval number 2025020. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

YJ: Conceptualization, Supervision, Project administration, Writing – original draft, Writing – review & editing. DY: Writing – review & editing, Methodology, Formal analysis, Software, Writing – original draft, Resources. YR: Conceptualization, Investigation, Writing – review & editing, Validation, Formal analysis, Writing – original draft. XK: Data curation, Writing – review & editing, Software, Methodology, Validation, Writing – original draft. YD: Writing – original draft, Supervision, Formal analysis, Investigation, Writing – review & editing. JZ: Data curation, Writing – review & editing, Writing – original draft, Project administration. HH: Writing – original draft, Writing – review & editing, Software, Data curation, Visualization. YY: Methodology, Investigation, Funding acquisition, Writing – review & editing, Conceptualization, Writing – original draft. XX: Investigation, Writing – original draft, Formal analysis, Methodology, Writing – review & editing. RL: Writing – original draft, Project administration, Investigation, Writing – review & editing. MM: Investigation, Writing – review & editing, Formal analysis, Writing – original draft, Visualization, Methodology.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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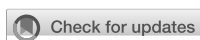
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References

- Maercker A, Cloitre M, Bachem R, Schlumpf YR, Khoury B, Hitchcock C, et al. Complex post-traumatic stress disorder. *Lancet*. (2022) 400:60–72. doi: 10.1016/S0140-6736(22)00821-2
- Liang L, Hu Y, Fei J, Yuan T, Gao R, Yue J, et al. Association between burnout and post-traumatic stress disorder among frontline nurse during COVID-19 pandemic: a moderated mediation analysis. *J Clin Nurs*. (2024) 33:1076–83. doi: 10.1111/jocn.16916
- Ogińska-Bulik N, Juczynski Z. Burnout and posttraumatic stress symptoms in police officers exposed to traumatic events: the mediating role of ruminations. *Int Arch Occup Environ Health*. (2021) 94:1201–9. doi: 10.1007/s00420-021-01689-9
- Scogio AAJ, Reilly ED, Girouard C, Quigley KS, Carnes S, Kelly MM. Social functioning in individuals with post-traumatic stress disorder: a systematic review. *Trauma Violence Abuse*. (2022) 23:356–71. doi: 10.1177/1524838020946800
- Mahmoudi H, Saffari M, Movahedi M, Sanaeinasab H, Rashidi-Jahan H, Pourgholami M, et al. A mediating role for mental health in associations between COVID-19-related self-stigma, PTSD, quality of life, and insomnia among patients recovered from COVID-19. *Brain Behav*. (2021) 11:e02138. doi: 10.1002/brb3.2138
- Ijadi-Maghsoodi R, Venegas-Murillo A, Klonmhaus A, Aralis H, Lee K, Rahmanian Koushkaki S, et al. The role of resilience and gender: understanding the relationship between risk for traumatic stress, resilience, and academic outcomes among minoritized youth. *Psychol Trauma*. (2022) 14:S82–s90. doi: 10.1037/tra0001161
- Guo W, Wang J, Li N, Wang L. The impact of teacher emotional support on learning engagement among college students mediated by academic self-efficacy and academic resilience. *Sci Rep*. (2025) 15:3670. doi: 10.1038/s41598-025-88187-x
- Zhang L, Qi H, Wang L, Wang F, Huang J, Li F, et al. Effects of the COVID-19 pandemic on acute stress disorder and career planning among healthcare students. *Int J Ment Health Nurs*. (2021) 30:907–16. doi: 10.1111/inm.12839
- Zhai Y, Du X. Trends in diagnosed posttraumatic stress disorder and acute stress disorder in US College students, 2017–2022. *JAMA Netw Open*. (2024) 7:e2413874. doi: 10.1001/jamanetworkopen.2024.13874
- Hu B, Yang X, Tuo X. The prevalence of post-traumatic stress disorder in college students by continents and national income during the COVID-19 pandemic: a meta-analysis. *Front Psychol*. (2023) 14:1129782. doi: 10.3389/fpsyg.2023.1129782
- Elnaiem A, Mohamed-Ahmed O, Zumla A, Mecaskey J, Charron N, Abakar MF, et al. Global and regional governance of one health and implications for global health security. *Lancet*. (2023) 401:688–704. doi: 10.1016/S0140-6736(22)01597-5
- Boyratz G, Granda R, Baker CN, Tidwell LL, Waits JB. Posttraumatic stress, effort regulation, and academic outcomes among college students: a longitudinal study. *J Couns Psychol*. (2016) 63:475–86. doi: 10.1037/cou0000102
- Quan L, Lu W, Zhen R, Zhou X. Post-traumatic stress disorders, anxiety, and depression in college students during the COVID-19 pandemic: a cross-sectional study. *BMC Psychiatry*. (2023) 23:228. doi: 10.1186/s12888-023-04660-9
- Hudays A, Gallagher R, Hazazi A, Arishi A, Bahari G. Eye movement desensitization and reprocessing versus cognitive behavior therapy for treating post-traumatic stress disorder: a systematic review and meta-analysis. *Int J Environ Res Public Health*. (2022) 19:6836. doi: 10.3390/ijerph192416836
- Burback L, Brémault-Phillips S, Nijdam MJ, McFarlane A, Vermetten E. Treatment of posttraumatic stress disorder: a state-of-the-art review. *Curr Neuropharmacol*. (2024) 22:557–635. doi: 10.2174/1570159X21666230428091433
- Bryant RA. Post-traumatic stress disorder: a state-of-the-art review of evidence and challenges. *World Psychiatry*. (2019) 18:259–69. doi: 10.1002/wps.20656
- Smith JR, Workneh A, Yaya S. Barriers and facilitators to help-seeking for individuals with posttraumatic stress disorder: a systematic review. *J Trauma Stress*. (2020) 33:137–50. doi: 10.1002/jts.22456
- Silvestrini M, Chen JA. "it's a sign of weakness": masculinity and help-seeking behaviors among male veterans accessing posttraumatic stress disorder care. *Psychol Trauma*. (2023) 15:665–71. doi: 10.1037/tra0001382
- Geller J, Whitney E. Therapeutic potential of MDMA- and psychedelic-assisted psychotherapy for adolescent depression and trauma. *Curr Psychiatry Rep*. (2025) 27:88–97. doi: 10.1007/s11920-024-01577-2
- Humphreys K, Todd Korthuis P, Stjepanović D, Hall W. Therapeutic potential of psychedelic drugs: navigating high hopes, strong claims, weak evidence, and big money. *Annu Rev Psychol*. (2025) 76:143–65. doi: 10.1146/annurev-psych-020124-023532
- Yang H, Cui X, Dijst M, Tian S, Chen J, Huang J. Association between natural/built campus environment and depression among Chinese undergraduates: multiscale evidence for the moderating role of socioeconomic factors after controlling for organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.
- residential self-selection. *Front Public Health*. (2022) 10:844541. doi: 10.3389/fpubh.2022.844541
- Liu M, Liu H, Qin Z, Tao Y, Ye W, Liu R. Effects of physical activity on depression, anxiety, and stress in college students: the chain-based mediating role of psychological resilience and coping styles. *Front Psychol*. (2024) 15:1396795. doi: 10.3389/fpsyg.2024.1396795
- Zhang P, He Q, Chen Z, Li X, Ma J. An empirical study on the promotion of students' physiological and psychological recovery in green space on campuses in the post-epidemic era. *Int J Environ Res Public Health*. (2022) 20:151. doi: 10.3390/ijerph20010151
- Guo W, Wen H, Liu X. Research on the psychologically restorative effects of campus common spaces from the perspective of health. *Front Public Health*. (2023) 11:1131180. doi: 10.3389/fpubh.2023.1131180
- Park AL, McDaid D, Weiser P, Von Gottberg C, Becker T, Kilian R. Examining the cost effectiveness of interventions to promote the physical health of people with mental health problems: a systematic review. *BMC Public Health*. (2013) 13:787. doi: 10.1186/1471-2458-13-787
- Peng B, Chen W, Wang H, Yu T. How does physical exercise influence self-efficacy in adolescents? A study based on the mediating role of psychological resilience. *BMC Psychol*. (2025) 13:285. doi: 10.1186/s40359-025-02529-y
- Young-McCaughan S, Peterson AL, Mintz J, Hale WJ, Dondanville KA, Borah EV, et al. Testing the role of aerobic exercise in the treatment of posttraumatic stress disorder (PTSD) symptoms in U.S. active duty military personnel: a pilot study. *Cogn Behav Ther*. (2022) 51:309–25. doi: 10.1080/16506073.2021.2001689
- Santos-Parker JR, LaRocca TJ, Seals DR. Aerobic exercise and other healthy lifestyle factors that influence vascular aging. *Adv Physiol Educ*. (2014) 38:296–307. doi: 10.1152/advan.00088.2014
- Raichlen DA, Alexander GE. Adaptive capacity: an evolutionary neuroscience model linking exercise, cognition, and brain health. *Trends Neurosci*. (2017) 40:408–21. doi: 10.1016/j.tins.2017.05.001
- Cassar S, Salmon J, Timperio A, Naylor PJ, van Nassau F, Contardo Ayala AM, et al. Adoption, implementation and sustainability of school-based physical activity and sedentary behaviour interventions in real-world settings: a systematic review. *Int J Behav Nutr Phys Act*. (2019) 16:120. doi: 10.1186/s12966-019-0876-4
- Yang D, Hu C, Zhou Z, He L, Huang S, Wan M, et al. The impact of perceived stigma on appearance anxiety in postoperative rhinoplasty patients: a variable-centered and person-centered perspective. *Acta Psychol*. (2025) 260:105660. doi: 10.1016/j.actpsy.2025.105660
- Denckla CA, Cicchetti D, Kubzansky LD, Seedat S, Teicher MH, Williams DR, et al. Psychological resilience: an update on definitions, a critical appraisal, and research recommendations. *Eur J Psychotraumatol*. (2020) 11:1822064. doi: 10.1080/2008198.2020.1822064
- Alvaro C, Lyons RF, Warner G, Hobfoll SE, Martens PJ, Labonté R, et al. Conservation of resources theory and research use in health systems. *Implement Sci*. (2010) 5:79. doi: 10.1186/1748-5908-5-79
- Rnic K, Santee AC, Hoffmeister JA, Liu H, Chang KK, Chen RX, et al. The vicious cycle of psychopathology and stressful life events: a meta-analytic review testing the stress generation model. *Psychol Bull*. (2023) 149:330–69. doi: 10.1037/bul0000390
- Llistosella M, Goni-Fuste B, Martín-Delgado L, Miranda-Mendizabal A, Franch Martínez B, Pérez-Ventana C, et al. Effectiveness of resilience-based interventions in schools for adolescents: a systematic review and meta-analysis. *Front Psychol*. (2023) 14:1211113. doi: 10.3389/fpsyg.2023.1211113
- Tang M, Peng B, Chen W, Liu Y, Wang H, Yu T. The mechanism of how adolescents' physical self-esteem and psychological resilience influence sports participation: the chain mediating roles of exercise motivation and social support. *BMC Sports Sci Med Rehabil*. (2025) 17:270. doi: 10.1186/s13102-025-01315-y
- Hashemi M, Mahmoudzadeh M. The lived experiences of childhood trauma in war: has post-traumatic growth occurred? *Eur J Psychotraumatol*. (2025) 16:2468605. doi: 10.1080/20080866.2025.2468605
- Ohi K, Fujikane D, Takai K, Kuramitsu A, Muto Y, Sugiyama S, et al. Clinical features and genetic mechanisms of anxiety, fear, and avoidance: a comprehensive review of five anxiety disorders. *Mol Psychiatry*. (2025) 30:4928–36. doi: 10.1038/s41380-025-03155-1
- Almén N. A cognitive behavioral model proposing that clinical burnout may maintain itself. *Int J Environ Res Public Health*. (2021) 18:3446. doi: 10.3390/ijerph18073446

40. Cai H, Guo J, Zhou J, Lai Y. Psychological resilience mediates the association between sleep quality and anxiety symptoms: a repeated measures study in college students. *PLoS One*. (2023) 18:e0292887. doi: 10.1371/journal.pone.0292887
41. Zeng F, John WCM, Sun X, Wang Y. COVID-19-associated impact and post-traumatic stress symptoms 39 days after pandemic in a sample of home-quarantined Chinese college students: the mediating effect of past stressful events, psychological resilience, and social support. *BMC Psychiatry*. (2023) 23:379. doi: 10.1186/s12888-023-04906-6
42. Thapar A, Eyre O, Patel V, Brent D. Depression in young people. *Lancet*. (2022) 400:617–31. doi: 10.1016/S0140-6736(22)01012-1
43. Pessoa L. Emergent processes in cognitive-emotional interactions. *Dialogues Clin Neurosci*. (2010) 12:433–48. doi: 10.31887/DCNS.2010.12.4/lpessoa
44. Blevins CA, Weathers FW, Davis MT, Witte TK, Domino JL. The posttraumatic stress disorder checklist for DSM-5 (PCL-5): development and initial psychometric evaluation. *J Trauma Stress*. (2015) 28:489–98. doi: 10.1002/jts.22059
45. Bovin MJ, Marx BP, Weathers FW, Gallagher MW, Rodriguez P, Schnurr PP, et al. Psychometric properties of the PTSD checklist for diagnostic and statistical manual of mental disorders-fifth edition (PCL-5) in veterans. *Psychol Assess*. (2016) 28:1379–91. doi: 10.1037/pas0000254
46. Su YJ, Kung YW, Hung FC, Chen SH. Dimensionality of DSM-5 PTSD symptoms: validation of the Chinese version of the posttraumatic diagnostic scale for DSM-5 across multiple trauma samples. *J Anxiety Disord*. (2020) 74:102261. doi: 10.1016/j.janxdis.2020.102261
47. Connor KM, Davidson JR. Development of a new resilience scale: the Connor-Davidson resilience scale (CD-RISC). *Depress Anxiety*. (2003) 18:76–82. doi: 10.1002/da.10113
48. Yu X, Zhang J. Factor analysis and psychometric evaluation of the Connor-Davidson resilience scale (CD-RISC) with Chinese people. *Soc Behav Pers*. (2007) 35:19–30. doi: 10.2224/sbp.2007.35.1.19
49. Li S. The effect of teacher self-efficacy, teacher resilience, and emotion regulation on teacher burnout: a mediation model. *Front Psychol*. (2023) 14:1185079. doi: 10.3389/fpsyg.2023.1185079
50. Wang Q, Sun W, Wu H. Associations between academic burnout, resilience and life satisfaction among medical students: a three-wave longitudinal study. *BMC Med Educ*. (2022) 22:248. doi: 10.1186/s12909-022-03326-6
51. Zung WW. A self-rating depression scale. *Arch Gen Psychiatry*. (1965) 12:63–70. doi: 10.1001/archpsyc.1965.01720310065008
52. Cheung S-K. Reliability and factor structure of the Chinese version of the depression self-rating scale. *Educ Psychol Meas*. (1996) 56:142–54. doi: 10.1177/0013164496056001011
53. Zung WW. A rating instrument for anxiety disorders. *Psychosomatics*. (1971) 12:371–9. doi: 10.1016/S0033-3182(71)71479-0
54. Wang Z, Chi Y. Self-rating anxiety scale (SAS). *Shanghai Arch Psychiatry*. (1984) 2:73–4.
55. Jacobson NS, Truax P. Clinical significance: a statistical approach to defining meaningful change in psychotherapy research. *J Consult Clin Psychol*. (1991) 59:12–9. doi: 10.1037//0022-006x.59.1.12
56. Latino F, Tafuri D, Tafuri F. Academic self-pressure and physiological responses in adolescents: a pilot experimental study on the moderating role of an escape room-based physical activity intervention on cognitive and academic outcomes. *Int J Environ Res Public Health*. (2025) 22:948. doi: 10.3390/ijerph22060948
57. Ennis CD. Educating students for a lifetime of physical activity: enhancing mindfulness, motivation, and meaning. *Res Q Exerc Sport*. (2017) 88:241–50. doi: 10.1080/02701367.2017.1342495
58. Burns A, Roberts TL, Posey C, Lowry PB. The adaptive roles of positive and negative emotions in organizational insiders' security-based precaution taking. *Inf Syst Res*. (2019) 30:1228–47. doi: 10.1287/isre.2019.0860
59. Wienke B, Jekauc D. A qualitative analysis of emotional facilitators in exercise. *Front Psychol*. (2016) 7:1296. doi: 10.3389/fpsyg.2016.01296
60. Ottaviani C, Medea B, Lonigro A, Tarvainen M, Couyoumdjian A. Cognitive rigidity is mirrored by autonomic inflexibility in daily life perseverative cognition. *Biol Psychol*. (2015) 107:24–30. doi: 10.1016/j.biopsycho.2015.02.011
61. Ekkekakis P, Parfitt G, Petruzzello SJ. The pleasure and displeasure people feel when they exercise at different intensities: decennial update and progress towards a tripartite rationale for exercise intensity prescription. *Sports Med*. (2011) 41:641–71. doi: 10.2165/11590680-000000000-00000
62. Bergeman CS, Nelson NA. Building a dynamic adaptational process theory of resilience (ADAPTOR): stress exposure, reserve capacity, adaptation, and consequence. *Am Psychol*. (2024) 79:1063–75. doi: 10.1037/amp0001280



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Effectiveness of a family–school–community collaborative physical activity intervention

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Background: Family–school–community collaboration is increasingly recognized as a strategy to promote physical activity (PA) in youth, yet evidence in primary school settings—particularly for exercise-related cognition—remains limited.

Objective: To evaluate a family–school–community collaborative PA intervention on PA and exercise cognition in primary school students, and to examine associations between PA and exercise cognition.

Methods: In this quasi-experimental, one-academic-year study, 515 fifth-grade students (10–11 years) from a public primary school in Guangdong, China, were allocated to an intervention group ($n = 255$) or a control group ($n = 260$). The intervention group received a structured family–school–community collaborative PA program, while controls received usual physical education. PA was assessed using PAQ-CN; exercise cognition (benefits/barriers) was measured using EBBS-CN. Intervention effects were estimated using class-clustered ANCOVA adjusting for baseline outcome values and sex; exploratory associations were examined using class-clustered regression models.

Results: PA increased from pre- to post-intervention in both groups. In adjusted class-clustered ANCOVA models, the intervention was associated with higher exercise cognition ($\beta = 3.94$, 95% CI: 1.29–6.60; $p = 0.003$; Hedges' $g = 0.26$) and higher perceived exercise benefits ($\beta = 3.46$, 95% CI: 1.03–5.89; $p = 0.008$; Hedges' $g = 0.24$). The adjusted between-group effect on PA was not statistically significant ($\beta = 0.11$, 95% CI: –0.15–0.36; $p = 0.418$; Hedges' $g = 0.18$), nor was the effect on exercise barriers ($\beta = 0.55$, 95% CI: –0.60–1.70; $p = 0.354$; Hedges' $g = 0.08$). In exploratory class-clustered regression models (with baseline PA adjustment), post-intervention PA was positively associated with exercise cognition and perceived exercise benefits (both $p \leq 0.001$), but not with perceived exercise barriers ($p = 0.453$).

Conclusion: In this quasi-experimental, single-school study, the intervention was associated with improvements in exercise cognition and perceived benefits, while incremental between-group gains in PA were modest and not statistically robust after accounting for class clustering. These findings support multi-contextual approaches and underscore the potential value of strengthening positive exercise perceptions within coordinated PA promotion efforts.

KEYWORDS

exercise benefits, exercise cognition, family–school–community collaboration, physical activity, primary school students, school-based intervention

1 Introduction

Physical activity (PA) refers to any bodily movement produced by skeletal muscles that results in energy expenditure, including activities undertaken at work, during transportation, at home, or in leisure-time settings (1). Among children and adolescents, higher levels of PA—particularly moderate-to-vigorous physical activity (MVPA)—have been associated with a range of favorable health outcomes, such as better cardiorespiratory and muscular fitness, healthier cardiometabolic profiles, and improved bone health (2). Beyond physical health, growing evidence links PA to better mental health in young people, including lower depressive and anxiety symptoms and higher psychological wellbeing (3, 4). Accordingly, promoting PA during school age is widely recognized as a key strategy to support both physical and psychological development (5).

According to the World Health Organization (WHO) 2020 Guidelines on Physical Activity and Sedentary Behaviour, children and adolescents aged 5–17 years should accumulate an average of at least 60 min per day of MVPA across the week and include muscle- and bone-strengthening activities on at least 3 days per week (6, 7). Nevertheless, global surveillance indicates that more than 80% of adolescents do not meet these recommendations, and this pattern co-occurs with increasing sedentary time and rising obesity prevalence (8–10). In China, nationally representative surveys similarly suggest that only about one-third of school-aged children and adolescents achieve the recommended ≥ 60 min/day of MVPA, and over 20% are overweight or obese (11, 12). These patterns underscore the need for effective PA promotion during school age, yet interventions delivered in a single setting often face practical constraints. Specifically, school-only approaches may be constrained by fixed timetables and academic demands that limit discretionary MVPA beyond scheduled PE (13), whereas family-only strategies can be hindered by parents' time constraints and unequal access to safe and affordable activity opportunities (14). In addition, community resources (e.g., facilities, organized events, and volunteer support) are not always readily mobilized without coordination across stakeholders (15). These contextual constraints suggest that isolated single-setting interventions may yield limited or unsustained effects

(16), thereby motivating a coordinated family–school–community approach that aligns messages, opportunities, and social support across settings (16).

In this context, multilevel PA interventions grounded in the Social Ecological Model and CSPAP frameworks have been increasingly advocated for promoting PA in school-aged youth (17, 18). Consistent with these frameworks, we conceptualize family–school–community collaboration as a coordinated multisetting approach; specifically, we define a family–school–community collaborative intervention as a coordinated, multi-setting approach in which schools provide structured PA opportunities and supportive norms, families reinforce PA through home-based practice and parental support, and community partners expand access to resources and activity opportunities, with aligned goals and communication across stakeholders (19, 20). In the present study, the intervention components were designed to operate across these settings and stakeholders (Table 1; Figure 1). To make the hypothesized pathway explicit, we developed a logic model (theory of change) linking multi-setting inputs to expected changes in children's PA and related determinants (Figure 1).

Prior research suggests that coordinated, multi-setting approaches can improve PA-related outcomes in youth, but effects are heterogeneous and may be constrained by implementation challenges and limited evidence on sustained, academic-year impacts (16, 18–21). Moreover, many studies prioritize behavioral endpoints while providing limited concurrent evidence on theoretically proximal cognitive constructs and implementation fidelity, which constrains interpretation of “what works, for whom, and through which pathways,” particularly in context-specific school settings. Given that PA promotion depends on both multi-setting opportunities/support and children's belief-based appraisals, we specified PA level as the primary outcome and “exercise cognition” as a theoretically relevant secondary outcome (22, 23). Exercise cognition refers to perceived exercise benefits and barriers and was operationalized using the EBBS total score, with benefits and barriers subscales examined to support interpretability (22, 24). Accordingly, this study aimed to evaluate, using a one-academic-year quasi-experimental design, whether the family–school–community collaborative intervention was associated with changes in PA and exercise cognition among primary school students, and to examine their association.

TABLE 1 Design of physical activity intervention content based on family–school–community collaboration.

Linking entities	Implementation content	Implementation frequency	Duration
School–family	After-school sports activities	Once a day	1 h per session
School–family	Sports homework	5 times a week	30 min per session
School–family	Active family development	Evaluated monthly	Ongoing activities
School–family	Weekend parent–child activities	Once a month per experimental class	2 h per session
School–family	Sports class open day	1–2 times per semester per experimental class	1 class per session
School–family–community	Community sports carnival	Fun sports activities with themes like Learn from Lei Feng, Labor Day, National Day, etc.	2 h per session
School–family–community	Sports volunteer team	Volunteer service by teachers, parents, and community workers	Ongoing participation in sports activity guidance, organization, management, decision-making
School–family–community	Health education activities	Lectures, health science popularization, sports skill guidance, etc.	Once a month

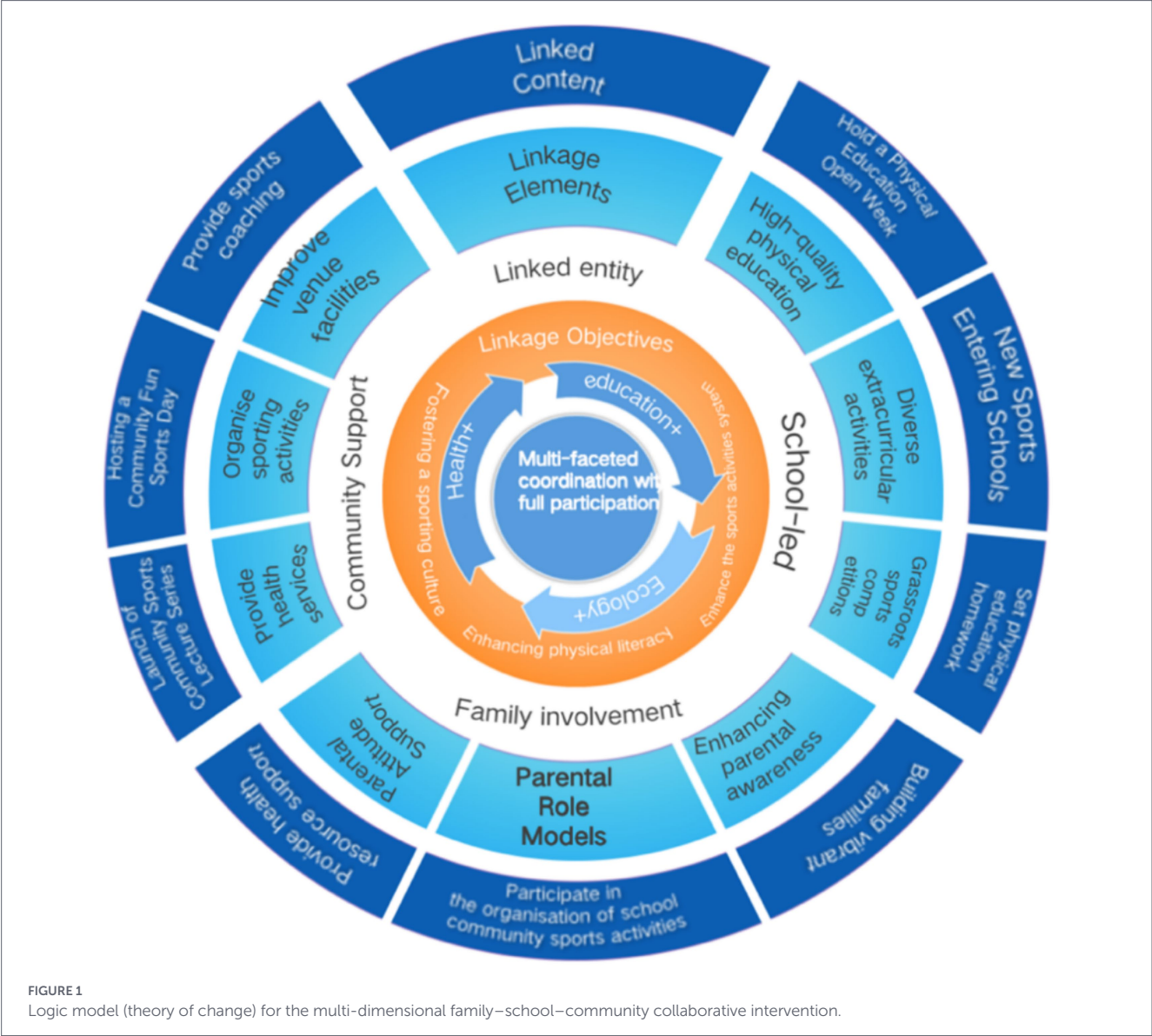


FIGURE 1
Logic model (theory of change) for the multi-dimensional family-school-community collaborative intervention.

2 Methods

2.1 Research design and participants

This study adopted a quasi-experimental design, conducted over one academic year in a public primary school in Guangdong Province. All Grade 5 students (ages 10–11 years) from the school’s 12 intact classes were recruited ($N = 515$). The 12 natural classes were assigned at the class level to an intervention group (6 classes, 255 students; 55.29% male) or a control group (6 classes, 260 students; 49.62% male). Baseline sex distribution did not differ significantly between groups (Table 2). A detailed participant flow diagram, including enrollment, class-level allocation, follow-up, and analysis, is provided in Figure 2.

Given the single-school, same-grade cohort, we expected relatively limited between-group heterogeneity in background characteristics; however, household socio-demographic variables (e.g., parental education, socioeconomic status, and residence) were not collected and therefore could not be compared formally.

TABLE 2 Baseline sex distribution by group ($N = 515$).

Group	Male, n (%)	Female, n (%)	Total, n
Intervention group	141 (55.29%)	114 (44.71%)	255
Control group	129 (49.62%)	131 (50.38%)	260
Total	270 (52.43%)	245 (47.57%)	515

Values are n (%). Group differences in sex distribution were assessed using a χ^2 test (two-sided).

This same-school implementation also introduced a risk of contamination (i.e., spillover of intervention content to control classes through student interactions). To mitigate this risk, the intervention was delivered at the class level, and intervention materials and guidance (e.g., parent workshops and sports homework instructions) were provided only to intervention classes and their guardians, while the control classes continued usual physical education without access to the intervention resources; nevertheless, complete separation between classes could not be ensured.

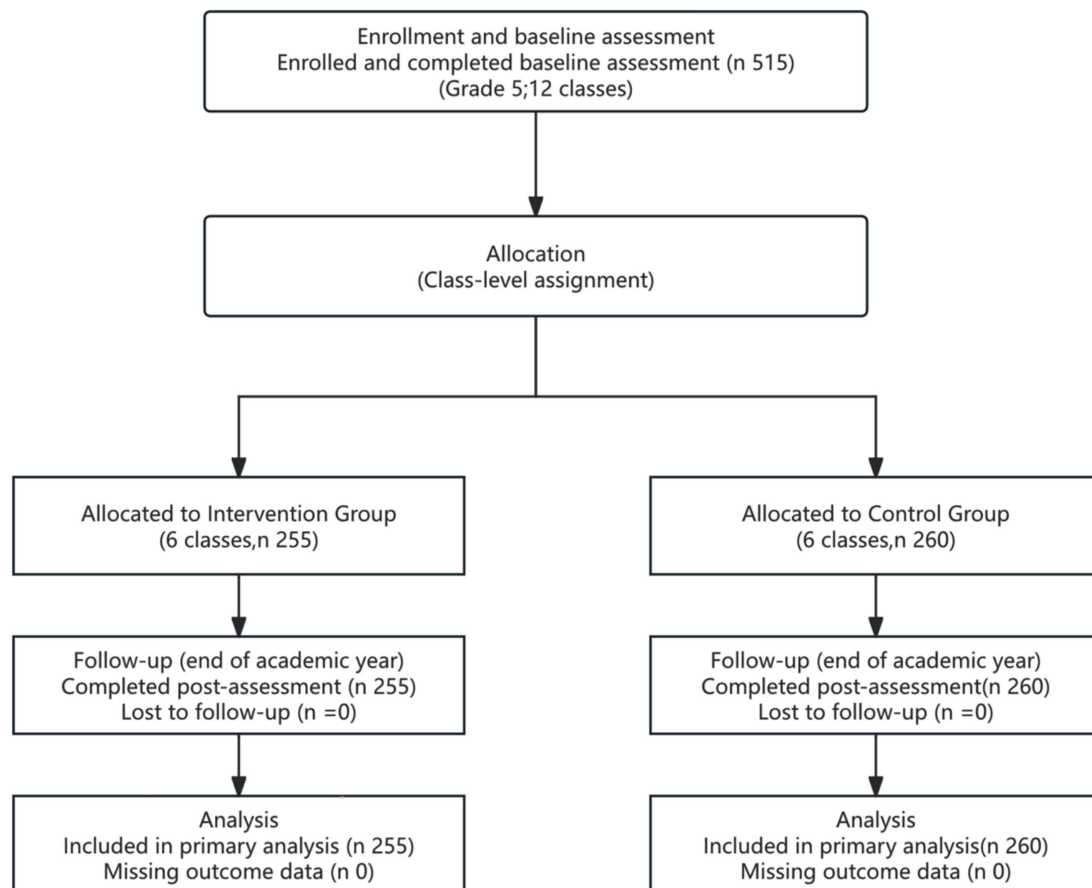


FIGURE 2

Participant flow diagram. A total of 515 grade 5 students (12 classes) were enrolled and completed the baseline assessment. Classes were assigned at the class level to the intervention group (6 classes, $n = 255$) or the control group (6 classes, $n = 260$). All students completed the post-intervention assessment at the end of the academic year; no participants were lost to follow-up and no outcome data were missing for the primary analyses (total analyzed: $N = 515$).

Regarding retention and data completeness, all enrolled students completed both baseline and post-intervention assessments (no loss to follow-up), and outcome data were complete for the primary analyses. Prior to the study, written guardian consent and student assent/informed consent were obtained.

2.2 Procedure

This study was approved by the Ethics Committee of East China Normal University. Participants were recruited with the assistance of the participating school from Grade 5 intact classes, and eligibility was confirmed by the research team in coordination with school staff. Written guardian consent and student assent/informed consent were obtained prior to data collection.

PA levels, exercise barriers, exercise benefits, and overall exercise cognition were assessed in both groups at two time points: baseline (late September, pre-intervention) and post-intervention (late May, end of the academic year). To reduce potential variation due to scheduling, assessments were administered in classrooms during regular school hours by trained PE teachers using standardized, scripted instructions provided by the research team. All questionnaires were completed individually by students under teacher supervision.

2.3 Intervention and fidelity

The intervention was implemented in a public primary school in Guangdong Province. Both groups followed the national compulsory education PE curriculum; the intervention group additionally received a structured family-school-community collaborative program (regular parent lectures/workshops, structured school break-time PA activities, and family/community sports events; see Table 1 and Figure 1) alongside usual PE, whereas the control group continued usual PE only (5 lessons/week, 40 min/lesson).

Intervention delivery was school-led and primarily teacher-delivered. School-based components were delivered by PE teachers; family components (e.g., parent workshops and homework guidance) were delivered by PE teachers with support from the research team; community events were organized by the school (teachers/volunteers). To promote consistency across the six intervention classes, core materials, task templates, and weekly schedules were standardized, and implementation was reviewed in periodic coordination meetings with PE and class teachers.

Intervention fidelity and participation were monitored using routine school records and verification procedures. For sports homework (5 times/week), PE teachers issued standardized weekly tasks, and completion was documented via class-level homework logs collected

by class teachers, with guardian confirmation where applicable; teachers periodically reviewed logs and issued reminders through class communication channels. For community events, attendance was recorded using on-site sign-in sheets/registration records, and class-level participation lists were compiled. Across the academic year, the research team held regular meetings with PE/class teachers to verify delivery schedules, address implementation issues, and minimize contamination by restricting intervention materials and guidance to intervention classes and their guardians. Participation was verified at the class level; however, we did not compute a student-level adherence (“dose”) index for formal modeling.

Outcome assessments were administered using the same tools and scoring standards in both groups at baseline and post-intervention by a trained team.

2.4 Tools and measurement

PA Questionnaire for Children—Chinese version (PAQ-CN). PA was assessed using the Chinese version of the Physical Activity Questionnaire for Children (PAQ-CN), adapted from the original PAQ developed by Kowalski et al. (25). The PAQ/PAQ-CN is designed for children and adolescents aged 7–18 years and has been widely used to assess general PA levels in youth (11, 26, 27). The PAQ-CN is a self-administered, 7-day recall questionnaire with 10 items; nine items capture PA participation over the previous week (e.g., activity type and frequency) and are scored on a 1–5 scale. The PA score is calculated as the mean of the nine activity items; scores are categorized as low (≤ 2), moderate (2–3), and high (> 3) (25). The PAQ-CN has demonstrated acceptable reliability in Chinese samples ($\alpha = 0.821$) and has been used in prior Chinese pediatric studies (11, 28). Given participants’ age (10–11 years), questionnaires were completed in class under teacher supervision using standardized instructions. As a self-report measure, PAQ-CN may be subject to recall and social desirability bias.

Exercise Benefits/Barriers Scale—Chinese version (EBBS-CN). Exercise-related cognition was assessed using the Chinese version of the Exercise Benefits/Barriers Scale (EBBS-CN), originally developed by Sechrist et al. (29). The EBBS comprises two dimensions—perceived exercise benefits and perceived exercise barriers—with five benefits subdomains (life enhancement, physical performance, psychological outlook, social interaction, and preventive health) and four barriers subdomains (exercise environment, time management, physical exertion, and family support) (29). Higher scores indicate higher perceived benefits and/or higher perceived barriers.

The EBBS-CN has shown high internal consistency in Chinese samples ($\alpha = 0.961$) ((30)).

2.5 Data analysis

Descriptive statistics are reported as mean (SD) by group (intervention vs. control) and time (pre vs. post). Primary intervention effects were estimated using ANCOVA, with each post-intervention outcome modeled as $\text{Outcome}_{\text{post}} = \beta_0 + \beta_1(\text{treat}) + \beta_2(\text{Outcome}_{\text{pre}}) + \beta_3(\text{female}) + \epsilon$. Because students were nested within classes, robust standard errors were clustered at the class level (12 classes). Treatment effects are reported as β_1 with 95% CIs, together with standardized effect sizes (Hedges’ g , standardized by the pooled baseline SD).

Given the small number of clusters, we conducted small-cluster-robust inference in addition to cluster-robust ANCOVA. First, we performed an exact class-level permutation test by enumerating all allocations of six treated classes among 12 ($C(12,6) = 924$) and computing two-sided permutation p -values using β_1 as the test statistic. Second, we implemented a wild cluster bootstrap- t procedure with Webb six-point weights to obtain bootstrap- t confidence intervals.

Sensitivity analyses used a class-level difference-in-differences (DID) approach based on class-mean change scores (post–pre). For multiplicity, PA and exercise cognition were specified as co-primary outcomes; exercise benefits and exercise barriers were treated as secondary outcomes, and their p -values were Holm-adjusted. Associations between PA and exercise cognition (and subscales) were examined as exploratory using regression models with class-clustered robust standard errors and baseline adjustment. Baseline intraclass correlation coefficients (ICCs) were estimated for each outcome to quantify class-level clustering. All tests were two-sided with $\alpha = 0.05$, and analyses were performed in Python.

3 Results

3.1 Descriptive results

Descriptive statistics for all outcomes by group and time are presented in Table 3. Both groups showed increases from pre- to post-intervention in physical activity and exercise cognition, with descriptively larger mean gains in the intervention group for physical activity, exercise cognition, and exercise benefits (Table 3).

TABLE 3 Descriptive statistics of outcomes by group and time (mean $\pm$ SD).

Outcome	Intervention group (255)		Control group (260)	
	Pre	Post	Pre	Post
Physical activity	2.02 $\pm$ 0.49	2.42 $\pm$ 0.57	1.98 $\pm$ 0.76	2.31 $\pm$ 0.55
Exercise cognition	131.85 $\pm$ 12.79	135.30 $\pm$ 16.81	129.17 $\pm$ 19.23	131.27 $\pm$ 14.99
Exercise benefits	88.85 $\pm$ 11.28	91.30 $\pm$ 14.80	87.40 $\pm$ 17.72	87.90 $\pm$ 12.41
Exercise barriers	43.00 $\pm$ 4.87	44.00 $\pm$ 7.65	41.77 $\pm$ 9.53	43.37 $\pm$ 5.96

Values are M $\pm$ SD. M, mean; SD, standard deviation. Physical activity was measured using PAQ-CN (1–5; higher scores indicate higher activity). Exercise cognition (EBBS-CN total), exercise benefits (EBBS-CN benefits subscale), and exercise barriers (EBBS-CN barriers subscale) were measured using EBBS-CN; higher scores indicate higher perceived benefits/barriers and higher overall benefit–barrier appraisal.

3.2 Primary outcomes: class-clustered ANCOVA

To account for class-level clustering, intervention effects were estimated using ANCOVA models adjusting for baseline values of each outcome and sex, with robust standard errors clustered at the class level (12 classes; analytic $N = 515$). Results are summarized in Table 4.

For the co-primary outcomes, the intervention was associated with a statistically significant improvement in exercise cognition ($\beta = 3.940$, 95% CI: 1.388 to 6.492; $p = 0.002$; Hedges' $g = 0.240$). In contrast, the adjusted between-group difference in physical activity at post-intervention was not statistically significant ($\beta = 0.106$, 95% CI: -0.151 to 0.363 ; $p = 0.419$; Hedges' $g = 0.166$) (Table 4). The standardized effects for both co-primary outcomes were small ($g \approx 0.17$ – 0.24), and estimates are interpreted accordingly.

3.3 Secondary outcomes and small-cluster robustness

For secondary outcomes, the intervention was associated with higher exercise benefits ($\beta = 3.460$, 95% CI: 0.913 to 6.007 ; $p = 0.008$; Hedges' $g = 0.232$), while the effect on exercise barriers was not statistically significant ($\beta = 0.553$, 95% CI: -0.594 to 1.699 ; $p = 0.345$; Hedges' $g = 0.073$) (Table 4). Multiplicity control was applied to the secondary outcome family only (exercise benefits and barriers) using the Holm procedure; exercise benefits remained significant after adjustment ($p_{\text{Holm}} = 0.0155$), whereas exercise barriers did not (Table 5). Similarly, the effect size for exercise benefits was small (Hedges' $g \approx 0.23$), suggesting limited practical magnitude despite statistical significance.

3.4 Robustness and supplementary analyses

Given the small number of clusters (12 classes), we conducted small-cluster-robust inference. Exact class-level permutation tests and wild cluster bootstrap- t confidence intervals (Webb weights) were broadly consistent with the primary class-clustered ANCOVA results, supporting the intervention effects for exercise cognition and exercise benefits, but not for physical activity or exercise barriers (Supplementary Tables S1–S2). Class-level DID using class mean change scores yielded directionally similar but non-significant estimates (Supplementary Table S3). Exploratory association analyses suggested positive associations of exercise cognition/

benefits with PA at post and for change scores, and baseline ICCs indicated modest clustering, particularly for PA (ICC = 0.114) (Supplementary Tables S4–S6). Because PA increased from pre to post in both groups (Table 3), interpretation of PA effects emphasizes adjusted between-group estimates rather than within-group change.

4 Discussion

This study evaluated a one-academic-year family-school-community PA intervention in primary school students. The intervention was associated with improved exercise cognition and perceived benefits, whereas no clear effects were observed for perceived barriers or PA after accounting for class clustering. Although PA increased in both groups, the incremental between-group difference was small and non-significant, and observed effects were small in standardized magnitude, underscoring that statistical significance does not necessarily imply substantial behavioral impact.

We interpret these findings within a socio-ecological and social-cognitive framework: aligned school opportunities, family reinforcement, and community support may shift benefit-barrier appraisals earlier than measurable changes in PA, particularly under contextual influences and self-report measurement constraints. This pattern is consistent with a “cognition-first” pathway in which attitudinal change may precede detectable behavioral divergence.

4.1 Impact of the family-school-community collaborative intervention on primary school students' physical activity

PA in late childhood often requires coordinated support across multiple settings, because opportunities to be active are shaped not only by school provision but also by family routines and access to community resources (16, 31). In the present study, PA increased from pre- to post-intervention in both groups, with a larger mean increase in the intervention group. However, after adjustment for baseline PA and sex and accounting for class clustering, the incremental between-group difference in post-intervention PA was small and not statistically significant, and small-cluster robustness checks were consistent. This pattern aligns with meta-analytic evidence that school-based PA interventions often yield null or small effects on MVPA (32–34).

TABLE 4 Primary ANCOVA results for intervention effects with class-clustered robust standard errors.

Outcome	Treat effect, β	SE (clustered by class)	95% CI	p (clustered)	Hedges g (baseline SD)	N students	N classes
Physical activity	0.106	0.131	-0.151 , 0.363	0.419	0.166	515	12
Exercise cognition	3.940	1.302	1.388, 6.492	0.002**	0.240	515	12
Exercise benefits	3.460	1.300	0.913, 6.007	0.008**	0.232	515	12
Exercise barriers	0.553	0.585	-0.594 , 1.699	0.345	0.073	515	12

ANCOVA models were specified as Outcome_{post} = $\beta_0 + \beta_1(\text{treat}) + \beta_2(\text{Outcome}_{\text{pre}}) + \beta_3(\text{female}) + \epsilon$. SE, standard error; CI, confidence interval. Robust SEs were clustered at the class level (12 classes). β represents the adjusted between-group difference at post-intervention conditional on baseline outcome and sex. Effect sizes are reported as Hedges' g standardized by the pooled baseline SD. Two-sided tests were used. Significance levels: * $p < 0.05$, ** $p < 0.01$ (two-sided).

TABLE 5 Multiplicity handling (co-primary outcomes and Holm adjustment for secondary outcomes).

Outcome	Role	<i>p</i> (raw)	<i>p</i> (adjusted)	Adjustment
Physical activity	Co-primary	0.419	–	None (co-primary)
Exercise cognition	Co-primary	0.002**	–	None (co-primary)
Exercise benefits	Secondary	0.008**	0.016	Holm (secondary family)
Exercise barriers	Secondary	0.345	0.345	Holm (secondary family)

Holm adjustment was applied to the secondary outcome family only (exercise benefits and barriers). Co-primary outcomes (physical activity and exercise cognition) were interpreted without secondary-family adjustment. Two-sided tests were used. Significance levels: * $p < 0.05$, ** $p < 0.01$ (two-sided).

Taken together, these findings suggest that, in a single-school, class-based implementation, the additional behavioral gain attributable to the collaborative program may be modest, and may be partly offset by concurrent improvements in control classes. Accordingly, we prioritize adjusted between-group estimates over within-group pre–post changes, which may reflect maturation or school-wide influences affecting both groups.

Several contextual and methodological factors may help explain this pattern. First, PA is sensitive to school-wide scheduling, seasonal variation, and shared environmental changes, which can raise activity levels across classes and reduce detectable contrasts (33, 35). Second, because intervention and control classes were located within the same school, spillover through peer interaction or informal information sharing may have attenuated between-group differences (18, 35). Third, reliance on self-reported PA may limit sensitivity to modest behavioral changes and introduce recall or social desirability bias relative to device-based measures (31, 34).

Notably, the intervention produced clearer improvements in exercise-related cognitions (and perceived benefits), which may represent a proximal change that does not necessarily translate into a large short-term differential increase in PA without stronger structural supports (e.g., protected MVPA time and sufficient dose/intensity) (16, 31). From an implementation perspective, future refinements may therefore strengthen components most directly linked to MVPA opportunities (dose, frequency, and intensity) while maintaining the multi-setting alignment that appears beneficial for shaping exercise-related appraisals.

4.2 Impact of the family–school–community collaborative intervention on primary school students' exercise cognition

The one-academic-year family–school–community collaborative intervention was associated with higher post-intervention exercise cognition, one of the co-primary outcomes. After adjustment for baseline exercise cognition and sex and accounting for class-level clustering, the intervention group scored higher than the control group; this pattern was supported by small-cluster–robust inference, strengthening confidence in the result given the 12-class design. Similar improvements in exercise-related knowledge, attitudes, or intentions have been reported in multicomponent, school-anchored interventions integrating educational and social-support elements for children and parents (16).

These findings suggest that coordinated, multi-setting support may be particularly effective for shaping children's exercise-related appraisals—especially perceived benefits and barriers—and broader attitudes toward being active (36, 37). Consistent with social-cognitive perspectives, the program may have increased perceived value, understanding, and salience of facilitators/constraints through repeated cues

and reinforcement across settings (38). This interpretation aligns with the intervention design: the school component provided structured opportunities and supportive norms, the family component (e.g., parent workshops and sports homework) reinforced routines at home, and community activities expanded access and visibility of opportunities. Reviews similarly emphasize the value of aligning school, family, and community resources to support youth behavior change (16, 19).

Exercise benefits (a secondary outcome) also improved under the class-clustered ANCOVA framework, with a consistent pattern in small-cluster sensitivity checks. Overall, effects were more consistent for cognitive/attitudinal constructs than for PA behavior, which is plausible in school-aged populations: shifts in appraisals may occur earlier and may precede sustained behavioral change (39), whereas detectable differences in daily PA may require greater intervention dose, protected MVPA opportunities, and/or longer-term follow-up (40–43).

4.3 Impact of the family–school–community collaborative intervention on the relationship between PA levels and exercise cognition

Building on the intervention findings, we examined whether exercise-related cognitions were associated with students' PA. In class-clustered regression models, higher post-intervention exercise cognition and perceived exercise benefits were positively associated with post-intervention PA, whereas exercise barriers were not significantly associated with PA. Consistent patterns were observed in change-score models: increases in exercise cognition and benefits were associated with increases in PA, while changes in barriers were not. These associations were modest in magnitude and should be interpreted as correlational patterns rather than evidence of directional influence.

The null association for perceived barriers should not be interpreted as evidence that barriers are unimportant. Multi-setting structural and social supports (e.g., access, scheduling, parental co-activity, and community resources) may buffer the practical impact of constraints without necessarily lowering perceived barriers, thereby attenuating the observed barriers–PA association (16, 44–46). Alternatively, sustained engagement across settings may increase children's awareness/salience when reporting barriers (e.g., time constraints), which could also weaken statistical associations despite improvements in other cognitive constructs.

From an applied perspective, future programs may address barriers through both cognitive and structural pathways—helping children identify and manage perceived constraints while improving feasibility, access, and family/community support. Longitudinal or experimental mediation designs are needed to test directionality and mechanisms linking cognition-related appraisals with PA change.

4.4 Strengths, limitations, and future outlook

To the best of our knowledge, this study is among the first to implement a one-academic-year family–school–community collaborative intervention in primary school students. Key strengths include the multi-contextual, ecologically grounded design integrating school opportunities, family engagement, and community support, and the use of validated instruments and standardized implementation procedures. Methodologically, intervention effects were estimated using ANCOVA with class-clustered robust standard errors, with standardized effect sizes (Hedges' g) and small-cluster-robust inference (exact class-level permutation tests and wild cluster bootstrap- t confidence intervals) to strengthen inference with 12 classes.

However, several limitations should be noted. First, the quasi-experimental, single-school design limits causal inference and external validity. Second, because intervention and control classes were within the same school, contamination/spillover through student interaction could not be ruled out and may have attenuated between-group differences. Third, improvements in both groups suggest possible shared school-wide influences, maturation, and seasonal/timetabling variation, which may partly explain the modest incremental effect on PA. Fourth, PA was assessed via self-report, which may be subject to recall and social desirability bias; the lack of objective PA measures (e.g., accelerometry) limits measurement precision. Finally, we did not collect family-level or socioeconomic covariates (e.g., parental education/household SES), precluding assessment of these potential confounders or moderators. The absence of longer-term follow-up also prevents evaluation of sustainability beyond the post-intervention assessment.

Future research should adopt multi-site or school-level cluster designs, incorporate objective PA assessment and key socio-demographic covariates, and include follow-up measurements to test generalizability, mechanisms, and sustainability.

5 Conclusion

This study evaluated a one-academic-year family–school–community collaborative physical activity program in a primary school population. The intervention was associated with higher exercise cognition and higher perceived exercise benefits, whereas the adjusted between-group difference in physical activity was small and not statistically significant after accounting for class-level clustering. Overall, these findings suggest that the program may be more effective in improving children's benefit–barrier appraisals than in producing a clear incremental increase in self-reported physical activity within a single-school implementation. Future studies should use multi-site, school-level designs, incorporate objective PA measures, strengthen implementation dose and fidelity documentation, and include follow-up assessments to examine generalizability and sustainability.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Ethics Committee of East China Normal University (No. HR359-2022). The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

LK: Writing – original draft, Writing – review & editing, Conceptualization, Data curation, Funding acquisition. XC: Writing – original draft, Writing – review & editing, Formal analysis, Methodology. BG: Investigation, Methodology, Writing – original draft, Writing – review & editing. XZ: Funding acquisition, Project administration, Supervision, Visualization, Writing – original draft, Writing – review & editing. MG: Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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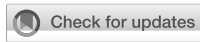
Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpubh.2026.1767961/full#supplementary-material>

References

- Caspersen CJ, Powell KE, Christenson GM. Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public Health Rep.* (1985) 100:126–31.
- Tambalis KD. Physical activity, physical education, and health benefits in children and adolescents. *Eur J Public Health Stud.* (2022) 5:157–73. doi: 10.46827/ejphs.v5i1.112
- Recchia F, Bernal JDK, Fong DY, Wong SHS, Chung P-K, Chan DKC, et al. Physical activity interventions to alleviate depressive symptoms in children and adolescents: a systematic review and meta-analysis. *JAMA Pediatr.* (2023) 177:132–41. doi: 10.1001/jamapediatrics.2022.5090
- Rodriguez-Ayllon M, Cadenas-Sánchez C, Estévez-López F, Muñoz NE, Mora-Gonzalez J, Migueles JH, et al. Role of physical activity and sedentary behavior in the mental health of preschoolers, children and adolescents: a systematic review and meta-analysis. *Sports Med.* (2019) 49:1383–410. doi: 10.1007/s40279-019-01099-5
- Messing S. How can physical activity be promoted among children and adolescents? A systematic review of reviews across settings. *Front Public Health.* (2019) 7:55. doi: 10.3389/fpubh.2019.00055
- Bull FC, Al-Ansari SS, Biddle S, Borodulin K, Buman MP, Cardon G, et al. World Health Organization 2020 guidelines on physical activity and sedentary behaviour. *Br J Sports Med.* (2020) 54:1451–62. doi: 10.1136/bjsports-2020-102955
- Chaput J-P, Willumsen J, Bull F, Chou R, Ekelund U, Firth J, et al. 2020 WHO guidelines on physical activity and sedentary behaviour for children and adolescents aged 5–17 years: summary of the evidence. *Int J Behav Nutr Phys Act.* (2020) 17:141. doi: 10.1186/s12966-020-01037-z
- Aubert S, Brazo-Sayavera J, González SA, Janssen I, Manyanga T, Oyeyemi AL, et al. Global prevalence of physical activity for children and adolescents; inconsistencies, research gaps, and recommendations: a narrative review. *Int J Behav Nutr Phys Act.* (2021) 18:81. doi: 10.1186/s12966-021-01155-2
- Guthold R, Stevens GA, Riley LM, Bull FC. Global trends in insufficient physical activity among adolescents: a pooled analysis of 298 population-based surveys with 1.6 million participants. *Lancet Child Adolescent Health.* (2020) 4:23–35. doi: 10.1016/S2352-4642(19)30323-2
- Reilly J, Aubert S, Brazo-Sayavera J, Liu Y, Cagas J, Tremblay M. Surveillance to improve physical activity of children and adolescents. *Bull World Health Organ.* (2022) 100:815–24. doi: 10.2471/BLT.22.288569
- Guo MM, Koh KT, Wang XZ. Trends of physical activity and recreational screen time among Chinese children and adolescents: a national study from 2017 to 2019. *BMC Public Health.* (2024b) 24:1305. doi: 10.1186/s12889-024-18822-1
- Zhu Z, Tang Y, Zhuang J, Liu Y, Wu X, Cai Y, et al. Physical activity, screen viewing time, and overweight/obesity among Chinese children and adolescents: an update from the 2017 physical activity and fitness in China—the youth study. *BMC Public Health.* (2019) 19:197. doi: 10.1186/s12889-019-6515-9
- Walker R, House D, Kent-Saisch S, Porter A, Salway R, Emm-Collison L, et al. Designing context-specific physical activity interventions for English primary schools: key learning from a four-month rapid ethnography. *BMC Public Health.* (2025) 25:288. doi: 10.1186/s12889-025-23682-4
- Brennan C, Streight E, Cheng S, Rhodes RE. Parents' experiences of family-based physical activity interventions: a systematic review and qualitative evidence synthesis. *Int J Behav Nutr Phys Act.* (2025) 22:15. doi: 10.1186/s12966-025-01778-9
- Długonski D, Cecil A, Ohrnberger E, Osborne R, White B, Mabson R, et al. Co-designing a physical activity intervention for low-income mothers of preschool-aged children with community leaders: a qualitative study. *BMC Public Health.* (2024) 24:1658. doi: 10.1186/s12889-024-21064-w
- Santos F, Sousa H, Gouveia ÉR, Lopes H, Peralta M, Martins J, et al. School-based family-oriented health interventions to promote physical activity in children and adolescents: a systematic review. *Am J Health Promot.* (2023) 37:243–62. doi: 10.1177/08901171221113836
- Bachouri Muniesa H, Murillo-Pardo B, Asún-Dieste S. What is needed to promote physical activity in a secondary school? *Movimento.* (2023) 29:e29054. doi: 10.22456/1982-8918.130358
- Jago R, Salway R, House D, Beets M, Lubans DR, Woods C, et al. Rethinking children's physical activity interventions at school: a new context-specific approach. *Front Public Health.* (2023) 11:1149883. doi: 10.3389/fpubh.2023.1149883
- Michael SL, Barnes SP, Wilkins NJ. Scoping review of family and community engagement strategies used in school-based interventions to promote healthy behaviors. *J Sch Health.* (2023) 93:828–41. doi: 10.1111/josh.13367
- Pulling Kuhn A, Stoepker P, Dauenhauer B, Carson RL. A systematic review of multi-component comprehensive school physical activity program (CSPAP) interventions. *Am J Health Promot.* (2021) 35:1129–49. doi: 10.1177/08901171211013281
- Cassar S, Salmon J, Timperio A, Naylor P-J, van Nassau F, Contardo Ayala AM, et al. Adoption, implementation and sustainability of school-based physical activity and sedentary behaviour interventions in real-world settings: a systematic review. *Int J Behav Nutr Phys Act.* (2019) 16:120. doi: 10.1186/s12966-019-0876-4
- Brown SA. Measuring perceived benefits and perceived barriers for physical activity. *Am J Health Behav.* (2005) 29:107–16. doi: 10.5993/AJHB.29.2.2
- Ying S, Li H. Reliability and validity of the short version of perceived benefits and barriers scale for physical activity. *Phys Act Health.* (2022) 6:64–72. doi: 10.5334/paah.178
- Koehn S, Amirabdollahian F. Reliability, validity, and gender invariance of the exercise benefits/barriers scale: an emerging evidence for a more concise research tool. *Int J Environ Res Public Health.* (2021) 18:3516. doi: 10.3390/ijerph18073516
- Kowalski KC, Crocker PRE, Faulkner RA. Validation of the physical activity questionnaire for older children. *Pediatr Exerc Sci.* (1997) 9:174–86. doi: 10.1123/pes.9.2.174
- Crocker PRE, Bailey DA, Faulkner RA, Kowalski KC, McGrath R. Measuring general levels of physical activity: preliminary evidence for the physical activity questionnaire for older children. *Med Sci Sports Exerc.* (1997) 29:1344–9. doi: 10.1097/00005768-199710000-00011
- Erdim L, Ergun A, Kuguoglu S. 71 reliability and validity of Turkish version of the physical activity questionnaire for older children (PAQ-C). *Arch Dis Child.* (2012) 97:A20. doi: 10.1136/archdischild-2012-302724.0071
- Guo MM, Koh KT, Wang XZ. The effects of COVID-19 on the physical activity and recreational screen time among Chinese children and adolescents. *J Exerc Sci Fit.* (2024a) 22:288–96. doi: 10.1016/j.jesf.2024.04.002
- Sechrist KR, Walker SN, Pender NJ. Development and psychometric evaluation of the exercise benefits/barriers scale. *Res Nurs Health.* (1987) 10:357–65. doi: 10.1002/nur.4770100603
- Guo Q. *A study on physical activity levels and influencing factors among Chinese children and adolescents* (doctoral dissertation). Shanghai: East China Normal University (2016).
- Kriemler S, Meyer U, Martin E, van Sluijs EMF, Andersen LB, Martin BW. Effect of school-based interventions on physical activity and fitness in children and adolescents: a review of reviews and systematic update. *Br J Sports Med.* (2011) 45:923–30. doi: 10.1136/bjsports-2011-090186
- Contardo Ayala AM, Parker K, Mazzoli E, Lander N, Ridgers ND, Timperio A, et al. Effectiveness of intervention strategies to increase adolescents' physical activity and reduce sedentary time in secondary school settings, including factors related to implementation: a systematic review and meta-analysis. *Sports Med Open.* (2024) 10:11. doi: 10.1186/s40798-024-00688-7
- Jones M, Defever E, Letsinger A, Steele J, Mackintosh KA. A mixed-studies systematic review and meta-analysis of school-based interventions to promote physical activity and/or reduce sedentary time in children. *J Sport Health Sci.* (2020) 9:3–17. doi: 10.1016/j.jshs.2019.06.009
- Love R, Adams J, van Sluijs EMF. Are school-based physical activity interventions effective and equitable? A meta-analysis of cluster randomized controlled trials with accelerometer-assessed activity. *Obes Rev.* (2019) 20:859–70. doi: 10.1111/obr.12823
- Porter A, Walker R, House D, Salway R, Dawson S, Ijaz S, et al. Physical activity interventions in European primary schools: a scoping review to create a framework for the design of tailored interventions in European countries. *Front Public Health.* (2024) 12:1321167. doi: 10.3389/fpubh.2024.1321167

36. Álvarez-Bueno C, Pesce C, Caverro-Redondo I, Sánchez-López M, Martínez-Hortelano JA, Martínez-Vizcaino V. The effect of physical activity interventions on children's cognition and metacognition: a systematic review and meta-analysis. *J Am Acad Child Adolesc Psychiatry*. (2017) 56:729–38. doi: 10.1016/j.jaac.2017.06.012
37. Rico-González M. The effect of primary school-based physical education programs: a systematic review of randomized controlled trials. *J Phys Act Health*. (2023) 20:317–47. doi: 10.1123/jpah.2022-0452
38. Lee J, Hoornbeek J, Oh N. Social cognitive orientations, social support, and physical activity among at-risk urban children: insights from a structural equation model. *Int J Environ Res Public Health*. (2020) 17:6745. doi: 10.3390/ijerph17186745
39. Lu Y, Yu K, Jin J, Gan X. The effects of a multicomponent social support intervention on physical fitness and exercise attitude in children: a 12-week randomized controlled trial. *Int J Environ Res Public Health*. (2022) 19:9922. doi: 10.3390/ijerph19169922
40. Abarca-Gómez L, Abdeen ZA, Hamid ZA, Abu-Rmeileh NM, Acosta-Cazares B, Acuin C, et al. Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128.9 million children, adolescents, and adults. *Lancet*. (2017) 390:2627–42. doi: 10.1016/S0140-6736(17)32129-3
41. Andermo S, Hallgren M, Nguyen T-T-D, Jonsson S, Petersen S, Friberg M, et al. School-related physical activity interventions and mental health among children: a systematic review and meta-analysis. *Sports Med Open*. (2020) 6:25. doi: 10.1186/s40798-020-00254-x
42. Masini A, Marini S, Gori D, Leoni E, Rochira A, Dallolio L. Evaluation of school-based interventions of active breaks in primary schools: a systematic review and meta-analysis. *J Sci Med Sport*. (2020) 23:377–84. doi: 10.1016/j.jsams.2019.10.008
43. Mello JB, Costa RR, da Silva FF, Martins R, Cristi-Montero C. School ACTIVE, brain active: a meta-analysis and meta-regression on chronic school physical activity effects on cognitive performance in children and adolescents. *Educ Res Rev*. (2025) 46:100658. doi: 10.1016/j.edurev.2024.100658
44. Butun A. The relationship between family nutrition and physical activity practices and physical activity attitudes in children. *BMC Public Health*. (2025) 25:166. doi: 10.1186/s12889-025-24230-w
45. Donnelly JE, Hillman CH, Castelli D, Etnier JL, Lee S, Tomporowski P, et al. Physical activity, fitness, cognitive function, and academic achievement in children: a systematic review. *Med Sci Sports Exerc*. (2016) 48:1197–222. doi: 10.1249/MSS.0000000000000901
46. van Sluijs EMF, Kriemler S, McMinn AM. The effect of community and family interventions on young people's physical activity levels: a review of reviews and updated systematic review. *Br J Sports Med*. (2011) 45:914–22. doi: 10.1136/bjsports-2011-090187



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Drama-based simulations in first aid education: psychometric validation of a student assessment tool in school settings

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Introduction: Drama-based simulations and role-playing are increasingly integrated into school-based first aid education, as they enable students to rehearse emergency response skills within controlled and realistic environments. Despite their pedagogical value, the systematic assessment of simulated patient performance in school contexts remains underdeveloped, particularly for younger populations. This study aimed to adapt and psychometrically validate the Standardized Patient Performance Rating Scale - Student Version (SPRS-S) for use in first aid training with school-aged students in Greece.

Methods: The study included 332 students aged 10-16 years (160 boys, 172 girls) and three first aid instructors. The scale underwent translation and back-translation procedures to ensure linguistic equivalence and contextual appropriateness within the Greek educational setting. Construct validity was examined through exploratory and confirmatory factor analyses, while internal consistency was assessed using reliability indices. In addition, an unsupervised computational intelligence clustering algorithm was implemented to classify simulated patient performance into distinct profiles.

Results: Factor analyses confirmed a unidimensional structure with satisfactory reliability coefficients. The Greek version of the SPRS-S demonstrated clarity, internal coherence, and measurement stability across demographic subgroups. The clustering analysis identified three distinct performance profiles among simulated patients, providing additional interpretive depth regarding role enactment quality.

Discussion: The validated Greek version of the SPRS-S constitutes a psychometrically robust instrument for evaluating simulated patient performance in school-based first aid education. Its application supports structured feedback processes and strengthens the pedagogical use of role-playing simulations. The findings support the systematic evaluation of drama-based health education and extend assessment practices to school-aged populations.

KEYWORDS

drama-based pedagogy, emergency preparedness education, first aid education, psychometric validation, role-play, role-playing, simulated patients

Introduction

First aid training is a way to improve readiness and response in emergencies (1). Its importance is clear during disaster situations, where quick actions and structured management must be taken to protect communities. Receiving training in first aid does not concern professional rescuers alone but also members of the general population, who should also be able to provide assistance to others who are in need until help arrives (2). These skills are considered to be important not only during natural disasters but also in sudden daily crucial situations like accidents or medical emergencies.

In this context, learning to act quickly in emergencies is essential and it is not just for adults (3). For this reason, efforts are made, and schools have already started teaching it, to ensure that students can handle an emergency situation (4). In addition, this training also enhances social responsibility and teamwork, it helps people in managing crises, and improves community safety (5).

Modern teaching methods follow effective practices by emphasizing experiential, hands-on learning through activities like drama-based simulations and role-playing (6–13). These approaches allow students to practice in safe settings that mimic real situations without the risks that can occur during actual emergencies (3, 14–17). Simulations provide a safe environment while allowing participants to gain practical experience through hypothetical scenarios (7, 18). At the same time, they help in developing social and emotional skills needed for managing emergencies effectively (19, 20).

A highly effective method of simulation-based first aid training involves the use of standardized patients or simulated victims (21). Those simulated victims are trained individuals who recreate scenarios that require quick intervention, allowing trainees to practice first aid and communication in controlled settings, while at the same time they are getting feedback that helps them to refine their skills before encountering real emergencies.

In simulation, role-playing functions as an experiential learning method that allows trainees to engage in realistic scenarios without the risk of harm, supporting the achievement of educational goals (7, 10, 22–27). When trainees interact with simulated victims they get effective training and feedback in a controlled environment, which allows learners to be taught and apply their skills without experiencing the anxiety associated with real emergencies (28). Moreover, this particular training approach is based on the principles of situated learning (29), social constructivism (30), and game-based learning (31, 32), and it provides learners with meaningful experiential learning opportunities in the context of a demanding and challenging controlled environment.

Assessing and monitoring these simulations is very important for making sure that the quality of the educational process is effective (33).

Especially in simulations of emergency scenarios, feedback from trainee interactions with the simulated victims helps identify possible training strengths or areas for improvement, which makes the evaluation process an important tool for successful training and learning (34). However, the existing scales in this field are designed solely to evaluate interactions between the simulated patients and the medical or nursing students (35) and most of the time they are time-consuming and less appropriate for the specific needs of students who participate in those programs. As a result, it is important for trainers to have a valid and reliable scale for first aid training in schools. This scale should be based on well-established standardized tools that have already been used in medical education to evaluate simulations and role-playing.

Since there are no validated measurement tools for first aid education in this population, there is a need for appropriate assessment instruments tailored to school-based first aid training. For this purpose, a modern and short scale, like the one by Gonullu et al. (34), was selected for the psychometric adaptation and standardization, to ensure a reliable evaluation tool personalized to the specific requirements of first aid education for students.

Simulation-based first aid training through standardized patients and role-playing

First aid training helps people to respond to emergencies, including natural disasters, medical issues, and everyday accidents. An important element of this training is the use of simulated patients or victims (21). These people are trained to represent different physical or psychological conditions that need fast response (36). Moreover, their purpose is to provide a safe learning environment that feels real, where trainees can practice first aid skills and get helpful feedback (37).

This teaching method, which involves students through standardized patients, simulations, and role-playing in an active way, is considered to be effective and is supported by several learning theories (28, 38). The main theoretical frameworks include Situated Learning (29), Social Constructivism (30), and Game-Based Learning (31).

Situated Learning, which was first introduced by Lave and Wenger (39), supports that students learn more effectively when they get involved in realistic environments. In first aid training, using simulated victims helps create these kinds of environments, giving trainees the chance to apply theoretical knowledge in realistic scenarios. Moreover, practicing in a controlled setting allows students to develop their skills and receive quick feedback for improving themselves (40).

Social Constructivism, which was first introduced by Vygotsky (41), emphasizes the importance of interaction in learning processes. During first aid training, practice with simulated victims helps students develop skills, exchange their knowledge, and share their experiences, which improves understanding, practical application, and helps improve their technical skills and how they interact with others.

Game-Based Learning also contributes to the training process through an interactive and engaging structure (42), since role-playing and simulations create a realistic environment for practice without the existence of risks. These activities promote active participation, help students to build confidence and to gain experience in how to handle emergency situations.

Assessment scales for simulated patients in first aid training

Assessing the performance of simulated patients is an important part of the learning process, since it helps to maintain training quality (38). A common way to evaluate the quality of these interventions is to review the recorded interactions between the students and the simulated victims. This approach has been applied in medical education, during emergency or non-emergency practices, as reviewing interactions between the medical students and the simulated patients the quality of simulation-based and role-playing methods can be ensured. Previous studies have found that evaluations of the performance of simulated victims by the students and their trainers are often correlated. This suggests that students can be improved according to the feedback they receive (43).

To ensure a comprehensive and reliable assessment of simulated patient performance, feedback from students should be gathered right after their performance. This approach gathers different perspectives and experiences, and it helps to identify strengths of the simulation or potential areas for improvement.

A well-known instrument for assessing simulated patient performance is the Standardized Patient Performance Rating Scale-Student Version (SPRS-S), developed by Gonullu et al. (34). This scale consists of nine items and assesses four main factors: patient portrayal, student observation, case recall, and feedback delivery. An important characteristic of SPRS-S is the use of the Angoff method to set the passing threshold for the simulated patient's performance. Experts have determined this threshold at 24.11/45, which means that the simulated patient must achieve at least this score in order to be considered satisfactory. Moreover, since the scale has a high internal consistency coefficient (Cronbach's $\alpha = 0.91$), it is suitable for assessing performers quickly when ongoing and effective evaluations are required.

Another useful tool is the Maastricht Assessment of Simulated Patients (MaSP) (44), which focuses on the authenticity of the roles and the quality of feedback provided by the simulated patients. Although this tool provides a more detailed assessment, it has a longer completion time which makes it less practical for quick evaluations. Moreover, the Nijmegen Evaluation of the Simulated Patient (NESP) focuses on assessing interpersonal skills, including how well simulated patients interact with students and provide meaningful feedback (35). This tool, which is commonly used in medical education, is better suited for in-depth evaluations when detailed analysis is required.

Finally, the Objective Structured Assessment of Technical Skills (OSATS) tool is a measurement which was designed to assess how well

technical skills are applied in clinical simulations (45). Even though it was originally designed to evaluate students, it can also be adapted to evaluate simulated patients, especially in settings that emphasize technical skills.

All scales mentioned above provide different ways to evaluate simulated patient performance, and each of them focuses on evaluating specific factors. Most of these tools contain 21 to 28 items (35, 44) and they were mainly developed for medical and nursing students. However, adapting and validating these tools for first aid training in school-aged students is essential, since early first aid education is gaining importance year by year (5). As a result developing assessment tools for this task for student populations is considered to be very important.

This study aims to fill this gap by developing and validating a user-friendly, short assessment scale, personalized for use with students, such as the SPRS-S (34). This scale can be applied frequently, particularly when there are many participants and in cases where the evaluations need to be completed quickly after each session. It provides accurate insights into the strengths and weaknesses of the simulation. Consequently, systematic assessment using this method represents a significant area for exploration, contributing to the improvement of the educational process and the quality of simulations.

To achieve this purpose, the following research questions were formulated:

- 1 Does the Greek version of the SPRS-S scale confirm the uni-dimensional factor structure of the original scale in a student population?
- 2 Does the Greek version of the SPRS-S scale demonstrate high internal consistency, making it suitable for use with school-aged students?
- 3 Can the adapted SPRS-S scale distinguish between different levels of simulated patient performance based on student evaluations?
- 4 Are the evaluations of the Greek version of the SPRS-S scale influenced by demographic factors, such as the gender or age of the students or the gender of the simulated patient? Moreover, does the scale demonstrate measurement invariance across these demographic subgroups?

The research hypothesis addresses whether the adapted Greek version of the SPRS-S tool can provide reliable and valid measurements for assessing the performance of simulated patients in the context of first aid training. Additionally, it explores whether the factor structure derived from the application of the SPRS-S to the Greek student population will confirm the original theoretical model used in its development.

Method

Participants

The study involved a total of 332 students and 3 adult first aid instructors from the National Emergency Aid Center (EKAB). The instructors, two men and one woman, were responsible for teaching students basic first aid skills. Subsequently, through role-playing activities, the instructors acted as simulated patients, allowing the students to apply their acquired knowledge in realistic scenarios.

The sample was selected using purposive sampling, targeting students participating in the first aid educational programs organized by

TABLE 1 Frequency (N) and relative frequency (%) of characteristics among student participants in the study.

Participant characteristics	Categories	n	%
Gender	Boy	160	48.19
	Girl	172	51.81
Grade	Fifth grade	45	13.55
	Sixth grade	37	11.14
	First year of middle school	38	11.45
	Second year of middle school	45	13.55
	Third year of middle school	32	9.64
	First year of high school	43	12.95
	Second year of high school	40	12.05
	Third year of high school	52	15.66

the Center for Environmental Education (KEPEA) of Boeotia. These programs aimed to enhance students' first aid knowledge and skills, preparing them to manage emergency situations effectively.

Of the total participants, 160 were boys (48%) and 172 were girls (52%), aged between 10 and 16 years. The distribution of students across educational levels was as follows: 14% were in the fifth grade of primary school, 11% in the sixth grade, 11% in the first year of middle school, 14% in the second year of middle school, 10% in the third year of middle school, 13% in the first year of high school, 12% in the second year of high school, and 16% in the third year of high school (see Table 1).

Linguistic adaptation of the scale and item scoring

Before administering the Standardized Patient Performance Rating Scale-Student Version (SPRS-S) to the study participants, the tool underwent conceptual and linguistic adaptation into Greek. This process followed the committee approach, as described in the research of Harkness, Pennell, and Schoua-Glusberg (46). This method was chosen instead of translation-back translation as it ensures better accuracy and consistency in the meaning of the scale's items.

The process began with two independent translators, both native Greek speakers, translating the scale from English into Greek. Because the SPRS-S was originally developed in Turkey, our team also took into account the Turkish cultural background of the scale. In collaboration with colleagues familiar with Turkish educational and cultural contexts, we verified that any culturally specific nuances were accurately captured. Each translator created a separate version, which the research team then reviewed and compared. Following a detailed discussion, the translators and the research team agreed on a final version that aligned closely with both the meaning and the cultural context of the original scale.

Two bilingual experts with experience in psychometric assessment and measurement then reviewed this initial version. Both had international experience from their professional work, and they did

not have access to the original scale to ensure unbiased evaluation. Their feedback led to necessary revisions.

In the final stage, the research team worked with the translators to finalize the Greek version of the tool, ensuring it was suitable for the study. This final version was then administered to the participants, and the results of its use were analyzed in the context of the current research (see Appendix).

Participants' responses were recorded on a four-point Likert-type scale, enhanced with graded facial expressions to represent levels of agreement: (a) Strongly Disagree, (b) Disagree, (c) Agree, (d) Strongly Agree. This approach leveraged the expressiveness of icons to simplify responses and ensure accurate reflection of participants' perceptions.

Procedure

The study began with the training of student groups by one of the three instructors from the National Emergency Aid Center (EKAB) during the 2023–24 and 2024–25 school years. The training sessions were held at the facilities of the Center for Environmental Education (KEPEA) of Boeotia and lasted 2 h each. Each session followed a structured format that included a brief introduction to first aid principles, demonstration and enactment of selected emergency scenarios, and short guided reflection. The sessions focused on emergency situations such as cardiopulmonary resuscitation (CPR), managing respiratory distress (asphyxia, drowning, or asthma attacks), providing assistance during epileptic seizures, addressing fainting episodes, and performing the Heimlich maneuver to clear airway obstructions. Due to time constraints and the educational design of the program, not all emergency situations were enacted by every student; instead, students participated in and observed a subset of scenarios representative of common first aid situations.

The study was conducted in accordance with ethical standards for research involving human participants. Ethical approval was granted by the Ethics and Bioethics Committee of the Center for Environmental Education (KEPEA) of Boeotia (F.4.1./62/16-3-2024). Written informed consent was obtained from the legal guardians of all participating students prior to data collection.

In addition, the training process involved the instructors acting as simulated patients, replicating the aforementioned emergency scenarios. This provided students with the opportunity to practice in a safe yet realistic environment, applying the practical skills they had learned. This role-playing approach enhanced the learning experience and facilitated the practical application of knowledge.

Data collection took place immediately after the completion of each scenario. Students evaluated the instructor's performance as a simulated patient based on the specific scenario they had participated in or observed, using the SPRS-S scale, which had been adapted into Greek for this study. For the purposes of the subsequent psychometric analyses, the total student sample was randomly divided into two independent subsamples.

Data analysis

In the first group ($N = 170$), Exploratory Factor Analysis (EFA) was performed to identify the underlying factor structure (47). In the second group ($N = 162$), Confirmatory Factor Analysis (CFA) was conducted to validate the factor structure suggested by the original developers of the scale. Initially, the suitability of the sample for factor analysis was assessed using the Kaiser-Meyer-Olkin (KMO) measure, while Bartlett's test of sphericity was used to evaluate the adequacy of inter-item correlations.

These tests ensured that the data met the necessary conditions for factor analysis. The factor estimation method used in CFA was Maximum Likelihood (ML), which assumes multivariate normality. However, given the relatively large sample size ($N = 332$), Maximum Likelihood (ML) estimation remains appropriate, as minor violations of normality do not substantially impact factor loading accuracy (48).

Next, the readability of the Greek version of the scale was evaluated using the Flesch–Kincaid and Gunning Fog indices to determine whether the linguistic content was appropriately tailored to the target group.

To assess the reliability of the adapted scale, Cronbach's Alpha (α) and McDonald's Omega (ω) were calculated. Moreover, a clustering technique was used, based on a nature-inspired metaheuristic optimization algorithm known as the Flying Foxes Optimization (49, 50) on the total sample. This technique classified performance into low, medium, and high levels. This methodology was used because metaheuristic algorithms perform better than traditional analytical methods in clustering problems. Their advantage comes from their ability to explore solution spaces more effectively, especially when the data are complex and non-linear, allowing them to avoid local minima and examine the solution space more broadly (51–55).

Finally, the gender and the age-related differences among student participants were examined, along with performance differences based on the instructor's gender. Data analysis was conducted using Jamovi 2.3.17 software. A multi-group CFA was conducted to test the measurement invariance of the SPRS-S across gender. The lavaan package in R (version 4.3.2) was used for this analysis (56). A multi-group confirmatory factor analysis (multi-group CFA) is a statistical technique used to test whether a measurement model operates equivalently across different groups (e.g., gender, age, cultural backgrounds) (57).

Results

Table 2 presents descriptive statistics for the nine items of the Greek SPRS-S scale, revealing an overall positive evaluation by the participants ($N = 332$).

After the sample was randomly divided into two groups, the first group ($N = 170$) was evaluated to determine its suitability for Exploratory Factor Analysis (EFA). This was confirmed using the Kaiser-Meyer-Olkin

(KMO) measure, which indicated excellent overall sampling adequacy (KMO = 0.93). Furthermore, individual KMO values ranged from 0.92 to 0.94, highlighting the adequacy of correlations between variables. Bartlett's test of sphericity was also statistically significant ($\chi^2(36) = 1249.81, p < 0.001$), indicating that inter-item correlations were strong enough to justify the application of EFA.

The results of the EFA supported the selection of a single factor, based on the outcomes of parallel analysis (64). This factor accounted for 49.95% of the covariance among the analyzed variables (see Figure 1). This value was deemed satisfactory, as per a general guideline suggesting that values near 50% are adequate for explaining covariance and should be accepted (58).

The specific variances (σ^2) for the nine items of the factor ranged from 0.42 to 0.64, while factor loadings varied between 0.60 and 0.76, with an eigenvalue of 4.50 (see Table 3).

Confirmatory Factor Analysis (CFA) conducted on the second sample ($N = 162$), confirmed the unidimensional structure of the SPRS-S scale. All factor loadings were statistically significant ($p < 0.001$) and ranged from 0.34 to 0.48, indicating a strong relationship between the items and the underlying factor (see Table 4).

The model fit indices showed good alignment with the data, with values as follows: CFI = 0.96, TLI = 0.95, SRMR = 0.04, and RMSEA = 0.07 (90% CI: 0.04–0.10). The chi-square to degrees of freedom ratio was 1.79 ($\chi^2 = 48.37, df = 27$), which falls within acceptable limits ($\chi^2/df < 3$), further supporting the model's fit (59, 60). As commonly observed, standardized CFA loadings were lower than EFA loadings, due to the more restrictive assumptions of confirmatory modeling and the separation of common and error variance. The reliability of the Greek SPRS-S scale was tested on the full sample ($N = 332$). Cronbach's alpha was 0.89 and McDonald's omega also 0.89.

These findings indicate that the Greek version of the SPRS-S scale demonstrates strong factorial validity and fits well with the sample data. The readability analysis of the final Greek version showed that the scale is easy to understand for students aged 10 and above as the Flesch–Kincaid readability score was 71.55, and the Gunning Fog index was 61.55 (61).

With a mean score of 3.34 (SD = 0.45), the results reflect a generally positive assessment of the participants. For this reason, a multivariate clustering was performed on the total sample ($N = 332$) using the metaheuristic Flying Foxes Optimization algorithm (49) identified three performance levels. The Davies–Bouldin Index (DBI) score for

TABLE 2 Descriptive measures of responses to the items of the Greek version of the SPRS-S scale.

Item	Mean	SD	Std. error mean	95% CI mean		Min	Max	Item-rest correlation
				LL	UL			
Q1	3.36	0.62	0.03	3.30	3.43	1	4	0.65
Q2	3.42	0.60	0.03	3.36	3.49	1	4	0.69
Q3	3.30	0.63	0.03	3.23	3.37	1	4	0.67
Q4	3.19	0.59	0.03	3.13	3.25	1	4	0.6
Q5	3.39	0.62	0.03	3.32	3.46	1	4	0.65
Q6	3.33	0.60	0.03	3.26	3.39	1	4	0.65
Q7	3.24	0.62	0.03	3.18	3.31	1	4	0.7
Q8	3.37	0.62	0.03	3.30	3.44	1	4	0.62
Q9	3.49	0.59	0.03	3.42	3.55	1	4	0.6

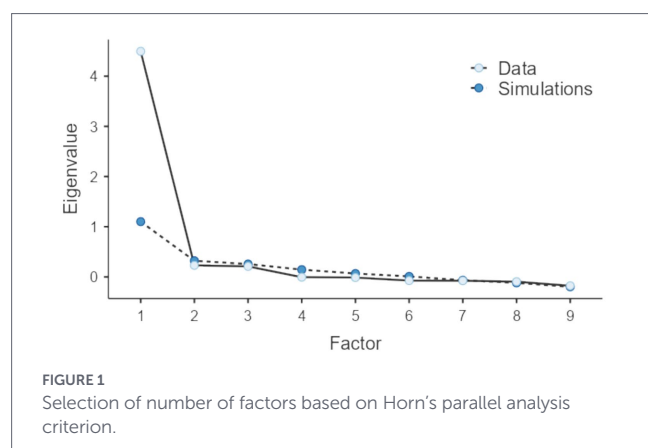


TABLE 3 Factor matrix.

Item	Loadings	σ^2
Q7	0.76	0.42
Q2	0.74	0.45
Q5	0.74	0.45
Q6	0.74	0.45
Q8	0.71	0.49
Q3	0.70	0.50
Q1	0.70	0.51
Q9	0.65	0.58
Q4	0.60	0.64

TABLE 4 Factor loadings from confirmatory factor analysis.

Indicator	Estimate	SE	Z	p
Q1	0.45	0.05	9.59	< 0.001
Q2	0.42	0.04	10.07	< 0.001
Q3	0.48	0.05	10.72	< 0.001
Q4	0.41	0.04	9.49	< 0.001
Q5	0.38	0.04	8.66	< 0.001
Q6	0.37	0.04	8.51	< 0.001
Q7	0.48	0.05	10.45	< 0.001
Q8	0.35	0.05	7.67	< 0.001
Q9	0.34	0.04	8.65	< 0.001

the clustering was 0.52. The low level corresponded to mean scores up to 3 and included 89 individuals. The medium level ranged from mean scores above 3 and up to 3.67 and included 166 individuals. The high level comprised mean scores above 3.67, with 77 individuals categorized in this group.

Finally, independent-sample t-tests revealed no statistically significant differences in SPRS-S mean scores between boys and girls ($t(330) = 0.63, p = 0.529$). Similarly, an analysis of variance (ANOVA) investigating differences in mean scores across educational levels, as an indicator of age, showed no statistically significant differences $F(7,324) = 1.08, p = 0.373$. An additional independent-sample t-test evaluating differences based on the gender of the simulated patient

also showed no significant results ($t(330) = -0.11, p = 0.909$). These findings strengthen the validity of the SPRS-S scale, confirming that it is unaffected by factors such as the students' age, gender, or the gender of the simulated patient.

When Table 5 is examined, it is observed that the parameter values obtained for the structural invariance stage fall within the appropriate cutoff ranges ($CFI > 0.97$, $TLI > 0.96$, $SRMR < 0.04$, and $RMSEA < 0.10$). The factor structures and patterns were found to be similar across gender, and it was determined that the SPRS-S meets structural invariance for both girls and boys.

In the metric invariance stage, the analysis results indicated that the parameter values did not deviate from the acceptable range ($CFI > 0.97$, $TLI > 0.97$, $SRMR < 0.05$, $RMSEA < 0.10$, and $\Delta CFI < 0.01$). Additionally, in the ANOVA comparisons, the AIC and BIC values were found to be lower for metric invariance. Based on these findings, it can be stated that the factor loadings of SPRS-S do not vary by gender and that metric invariance is achieved. Following the confirmation of metric invariance, scalar invariance was analyzed.

For the examination of scalar invariance, the parameters obtained from the analysis were compared with the cutoff values ($CFI > 0.968$, $TLI > 0.967$, $SRMR < 0.052$, $RMSEA < 0.10$, and $\Delta CFI < 0.01$), and it was observed that SPRS-S falls within the acceptable limits for scalar invariance across gender. ANOVA comparisons also showed that AIC and BIC values were lower for scalar invariance. Based on these findings, it can be stated that the regression intercepts of SPRS-S do not differ across gender subgroups. Following the confirmation of scalar invariance, the strict invariance stage was tested.

The analysis of SPRS-S in terms of strict invariance indicated that although the CFI, TLI, SRMR, and RMSEA values remained within the acceptable thresholds, the ΔCFI value ($\Delta CFI > 0.01$) was found to be outside the acceptable limit. Similarly, ANOVA comparisons showed that the BIC value was lower for strict invariance. These findings suggest that SPRS-S does not achieve strict invariance.

Overall, since scalar invariance has been established, it can be stated that comparisons across the relevant subgroups can be made without introducing systematic error. If scalar invariance is met, it implies that the test items do not show bias for different subgroups. Conversely, this information can be interpreted as follows: a test that achieves scalar invariance contains unbiased items for different subgroups (62).

Discussion

This study aimed to adapt and psychometrically validate the SPRS-S scale in Greek to assess its suitability for use with a student population in the context of first aid training. The findings support the unidimensional factor structure of the scale, which proved appropriate for implementation in a student population and within the Greek context. This result directly addresses the first research question, indicating that the construct of simulated patient performance is captured consistently as a single latent dimension when evaluated by school-aged students.

The reliability results of the scale, as indicated by high Cronbach's alpha and McDonald's omega values, confirm the internal consistency of its items and reveals that the scale measures a

TABLE 5 Measurement invariance results from confirmatory factor analysis.

Stages of measurement invariance	χ^2	df	CFI	TLI	SRMR	RMSEA (%90 C. I.)	Δ CFI
Structural invariance	98.987	54	0.969	0.958	0.037	0.066(0.042–0.088)	-
Metric invariance	99.785	62	0.970	0.965	0.049	0.061(0.037–0.082)	0.001
Scalar invariance	110.059	70	0.968	0.967	0.052	0.059(0.036–0.079)	0.002
Strict invariance	134.282	79	0.955	0.959	0.058	0.066(0.045–0.083)	0.013

single factor effectively. This high reliability complies with other tools for assessing simulated patients and with the original scale (34, 44), thereby validating the Greek version as a dependable tool for educational assessment. In practical terms, this suggests that students are able to provide stable and coherent evaluations of simulated patient performance, despite their age and limited prior experience with formal assessment procedures. Additionally, linguistic adaptation ensures that students fully understand the questions, which is essential for the effective use of assessment tools in school settings (5, 61).

Through the adapted SPRS-S, one can observe three different performance levels in the simulated patient role, classifying them as low (mean scores of 3 or lower), medium (between 3 and 3.67), and high (above 3.67). This finding responds to the third research question and indicates that the scale is sensitive enough to differentiate between varying degrees of performance. This differentiation is what makes the scale useful, since it allows instructors to assess specific strengths while also identifying areas that may need improvement. Such differentiation is particularly important in first aid education, where the quality of role enactment and feedback delivery can substantially influence students' learning and confidence (1). Finally, it contributes to the overall effectiveness of first aid training, ensuring that participants receive constructive feedback to optimize their performance.

The results showed that evaluations were not affected by students' gender or age, nor by the gender of the simulated patient. The results of the multi-group CFA analysis indicate that the SPRS-S demonstrates structural, metric, and scalar invariance across gender, suggesting that the factor structure, factor loadings, and regression intercepts remain stable for both male and female participants. This finding addresses the fourth research question and supports the interpretation that the scale functions equivalently across key demographic subgroups. Since scalar invariance was achieved, comparisons of latent mean scores between gender groups can be made without bias, ensuring that any observed differences reflect true variations rather than measurement artifacts. This reveals the scale's strengths and demonstrates that it can be applied to different groups. This is very important since ensuring fairness in assessment methods is essential to maintain their validity and ensure that they continue to be effective when being applied to different groups (63). As a result, this scale is a more reliable option since it remains neutral, unlike other scales that might be affected by such variables.

Despite the results which suggest that the Greek version of the SPRS-S is a useful tool for assessing simulated patients and supporting learning in first aid education, our research also has limitations. A possible limitation of our research is that it includes only students in schools. As a result, the results may not be the same when the scale is applied in older populations or other educational settings

such as higher education. In addition, the use of simulated patients portrayed by instructors, while pedagogically appropriate, may differ from professional standardized patient programs, which could influence performance ratings. Future research should test the scale on different groups (like medical or nursing students) or in more advanced scenarios, as well as examine its predictive validity in relation to long-term skill retention through delayed post-training assessments.

Conclusion

The present study provides empirical evidence supporting the use of the Greek version of the SPRS-S scale for evaluating simulated patient performance in school-based first aid training. The scale demonstrates a clear unidimensional structure, high reliability, and the capacity to distinguish between different levels of performance, indicating that it functions consistently and meaningfully within a student population. These characteristics make it suitable for evaluating the enactment and feedback quality of simulated patients in educational contexts.

Finally, the scale can help create evaluation protocols for first aid training programs to which performance assessment is useful. Moreover, the use of the scale allows students to receive clear and useful feedback and encourages collaboration between students and instructors. As a result, it can promote a learning environment that focuses on safety and quick response in first aid education.

Data availability statement

The dataset supporting the conclusions of this article is publicly available in the Harvard Dataverse repository at <https://doi.org/10.7910/DVN/JJ0C6Z>. The data are fully anonymized.

Ethics statement

The studies involving humans were approved by Ethics and bioethics committee of Center for Environmental Education (KEPEA) of Boeotia. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

CD: Conceptualization, Funding acquisition, Methodology, Validation, Writing – review & editing. KM: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. EP: Investigation, Methodology, Project administration, Supervision, Validation, Writing – review & editing. MK: Conceptualization, Investigation, Methodology, Project administration, Supervision, Validation, Writing – original draft, Writing – review & editing. KZ: Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing. CD: Data curation, Formal analysis, Methodology, Validation, Writing – original draft, Writing – review & editing. IG: Conceptualization, Validation, Writing – review & editing. MS: Conceptualization, Data curation, Validation, Writing – review & editing. EK: Conceptualization, Methodology, Resources, Writing – review & editing. ML: Conceptualization, Investigation, Methodology, Validation, Writing – review & editing. PA: Investigation, Resources, Writing – review & editing. DP: Investigation, Resources, Writing – review & editing. AP: Investigation, Resources, Writing – review & editing. SP: Investigation, Resources, Writing – review & editing. SE: Methodology, Validation, Writing – review & editing.

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Conflict of interest

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References

- de Melo Alves Silva LC, Alves IL, dos Santos KVG, Silva Leal KC, Pinheiro TBM. First aid teaching for schoolchildren: scoping review. *Int J Educ Res Open*. (2023) 5:100305. doi: 10.1016/j.ijedro.2023.100305
- Yan X, Shi Z, Han X, Chen F, Xiang H, Liu X, et al. Popularization of first-aid education in China: challenges and progress. *World J Emerg Med*. (2022) 13:65–6. doi: 10.5847/wjem.j.1920-8642.2022.010
- Giagazoglou P, Dampa A, Alexiadis A, Lenakakis A, Dimitropoulou D, Magos K. From fairy tales to real-life safety: an educational drama-based intervention for children's self-protection skills. *Int J Educ Arts*. (2026) 27:1–23. doi: 10.26209/ijea27n4
- De Buck E, Laermans J, Vanhove A-C, Dockx K, Vandekerckhove P, Geduld H. An educational pathway and teaching materials for first aid training of children in sub-Saharan Africa based on the best available evidence. *BMC Public Health*. (2020) 20:836. doi: 10.1186/s12889-020-08857-5
- Tse E, Plakitsi K, Voulgaris S, Alexiou GA. The role of a first aid training program for young children: a systematic review. *Children*. (2023) 10:431. doi: 10.3390/children10030431
- Gutierrez-Ajamil E, de Dios JE. Create, destroy, recreate: a case study of art therapy with children who have experienced early trauma. *Arts Psychother*. (2026) 98:102415. doi: 10.1016/j.aip.2026.102415
- Koufopoulos G, Georgakarakos E, Keskinis C, Stathopoulos M, Bafitis V, Tripsianis G. Theatrical performance in medical education: a fast-track differential approach of emergency cases. *Hippokratia*. (2020) 24:127–32.
- Leigh L, Mok ZH. The effect of different patient-based learning models on student perceptions of empathy, engagement, knowledge, and learning experience. *Med Teach*. (2025) 47:292–9. doi: 10.1080/0142159X.2024.2337254
- Mortha SM, McLaughlin JE, Storyward A, McClurg M, Manekin E, White CY. Assessing cultural intelligence in PharmD education through art. *Am J Pharm Educ*. (2024) 88:101275. doi: 10.1016/j.ajpe.2024.101275
- Rahul B, Shrivallabh S, Rohan N. The usefulness of dramatics for teaching cutaneous tuberculosis: an edutainment approach for postgraduate medical students. *Medical Sci Educator*. (2024) 34:295–8. doi: 10.1007/s40670-024-01995-0
- Sextou P, Karypidou A, Kourtidou-Sextou E. Applied theatre, puppetry and emotional skills in healthcare: a cross-disciplinary pedagogical framework. *Appl Theatre Res*. (2020) 8:89–105. doi: 10.1386/atr_00028_1
- Sextou P, Rolston W. Exploring methods of training the actor/puppeteer in healthcare: a Socratic dialogue. *J Appl Arts Health*. (2020) 11:171–6. doi: 10.1386/jaah_00030_7
- Shrivastava SR, Shrivastava PS. Theater in medical education. *Curr Med Issues*. (2022) 20:262–4. doi: 10.4103/cmi.cmi_67_22
- Khoshgoftar Z, Hamzadeh H, Amirifard M, Hayrabedian A, Bagheri S. Exploring the potential of pantomime games in medical education: non-verbal exercise. *Med Teach*. (2025) 47:597–9. doi: 10.1080/0142159X.2024.2402559
- Latugaye D, Astoul Bonorino C. Una herramienta para evaluar la enseñanza basada en simulación en el entrenamiento de habilidades técnicas. *Educ Med*. (2025) 26:100968. doi: 10.1016/j.edumed.2024.100968
- Mastrothanas K, Dumitru C, Darie N, Kladaki M, Pikoulis E, Sidiropoulou A, et al. Participatory arts as emergency responses for strengthening community resilience and psychosocial support: a retrospective phenomenological inquiry. *Children*. (2025) 12:1498. doi: 10.3390/children12111498
- Mujlli G, Alsalamah I, Alghosen A, Alenazi K, Alwazzan A, Alqahtani NF, et al. Transformation and development of simulation-based education and child first aid skills training. *J Infrastruct Policy Dev*. (2024) 8:7439. doi: 10.24294/jipd.v8i1.7439
- Cole R, Bowling C, Ren X, Vojta L. Simulation-based education's impact on medical students' tolerance of uncertainty: a grounded theory study. *Med Teach*. (2024) 47:1478–82. doi: 10.1080/0142159X.2024.2438787
- Bora Güneş N, Bıykoğlu I. Accidents in primary education schools: findings from a nurse-led drama-based prevention program. *J Prev Dent*. (2025) 46:393–411. doi: 10.1007/s10935-024-00822-x
- Ebm C, del Pozo C, Barbarello A, Poli G, Brusa S. Unleashing excellence: using a project management approach to effectively implement a simulation curriculum to improve residents' preparedness. *BMC Med Educ*. (2024) 24:234. doi: 10.1186/s12909-024-05166-y

21. Avau B, Vanhove A-C, Scheers H, Stroobants S, Lauwers K, Vandekerckhove P, et al. Impact of the use of simulated patients in basic first aid training on laypeople knowledge, skills, and self-efficacy. *Simulation Healthcare: J Society Simulation Healthcare*. (2022) 17:213–9. doi: 10.1097/SIH.0000000000000657
22. Asimidou A, Lenakakis A, Tsiaras A. The contribution of drama pedagogy in developing adolescents' self-confidence: a case study. *NJ*. (2021) 45:45–58. doi: 10.1080/14452294.2021.1978145
23. Berceanu AI, Papasteri C, Sofonea A, Boldasu R, Nita D, Poalelungi C, et al. Oxytocin predicts positive affect gains in a role-play interaction. *Front Psychol*. (2024) 15. doi: 10.3389/fpsyg.2024.1258254
24. Donohoe P. Teachers using role-play to prevent bullying. *Int J Bullying Prev*. (2020) 2:264–79. doi: 10.1007/s42380-019-00036-4
25. Liyanawatta M, Yang SH, Liu YT, Zhuang YY, Chen G d. Audience participation digital drama-based learning activities for situational learning in the classroom. *Br J Educ Technol*. (2022) 53:189–206. doi: 10.1111/bjet.13160
26. Mastrothanas K, Kladaki M. Drama-based methodologies and teachers' self-efficacy in reading instruction. *Ir Educ Stud*. (2025) 74:1–17. doi: 10.1080/03323315.2025.2479438
27. Waskul D, Lust M. Role-playing and playing roles: the person, player, and persona in fantasy role-playing. *Symb Interact*. (2004) 27:333–56. doi: 10.1525/si.2004.27.3.333
28. Heidarzadeh H, Heidarzadeh Z, Azadi A. Comparison of pre-hospital triage training by role playing and lecture on nursing students' knowledge, attitude and performance. *Nurs Open*. (2020) 7:935–42. doi: 10.1002/nop.2464
29. Kim JH, Lim JM, Kim EM. Patient handover education programme based on situated learning theory for nursing students in clinical practice. *Int J Nurs Pract*. (2022) 28:e13005. doi: 10.1111/ijn.13005
30. Philpott J, Batty H. Learning best together: social constructivism and global partnerships in medical education. *Med Educ*. (2009) 43:923–4. doi: 10.1111/j.1365-2923.2009.03436.x
31. Akaltan KF, Önder C, Vural Ç, Orhan K, Akdoğan N, Atakan C. The effect of game-based learning on basic life support skills training for undergraduate dental students. *J Dent Educ*. (2023) 87:1458–68. doi: 10.1002/jdd.13303
32. Kim JS, Leung KL, Eng IK, Sridhar A. Surgical education for medical students: virtual game-based learning. *Med Educ*. (2024) 58:588–9. doi: 10.1111/medu.15332
33. Ung TX, O'Reilly CL, Moles RJ, Collins JC, Ng R, Pham L, et al. Evaluation of mental health first aid training and simulated psychosis care role-plays for pharmacy education. *Am J Pharm Educ*. (2024) 88:101288. doi: 10.1016/j.ajpe.2024.101288
34. Gonullu I, Dogan CD, Erden S, Gokmen D. A study on the standard setting, validity, and reliability of a standardized patient performance rating scale–student version. *Ann Med*. (2023) 55:490–501. doi: 10.1080/07853890.2023.2168744
35. Bouter S, van Weel-Baumgarten E, Bolhuis S. Construction and validation of the Nijmegen evaluation of the simulated patient (NESP). *Acad Med*. (2013) 88:253–9. doi: 10.1097/ACM.0b013e31827c0856
36. Mahendran R, Lim HMA, Kua EH. Medical students' experiences in learning the mental state examination with standardized patients. *Asia Pac Psychiatry*. (2019) 11:e12360. doi: 10.1111/appy.12360
37. Sextou P. Theatre in paediatrics: can participatory performance mitigate educational, emotional and social consequences of missing out school during hospitalisation? *Res Drama Educ: J Applied Theatre Performance*. (2022) 27:88–105. doi: 10.1080/13569783.2021.1940914
38. Bearman M, Nestel D. "Learning theories and simulated patient methodology" In: D Nestel and M Bearman, editors. *Simulated patient methodology*. Chichester, West Sussex: Wiley (2014). 31–8.
39. Lave J, Wenger E. *Situated learning. Legitimate peripheral participation*. New York: Cambridge University Press (1991).
40. Aluce LM, Cooper JJ, Emlet LL, Cohen ER, Ostrowski SJ, Wood GJ, et al. Bringing competency-based communication training to scale: a multi-institutional virtual simulation-based mastery learning curriculum for emergency medicine residents. *Med Teach*. (2025) 47:505–12. doi: 10.1080/0142159X.2024.2345267
41. Wibowo S, Wangid MN, Firdaus FM. The relevance of Vygotsky's constructivism learning theory with the differentiated learning primary schools. *J Educ Learn (EduLearn)*. (2025) 19:431–40. doi: 10.11591/edulearn.v19i1.21197
42. Hendrick AD, Robert Jupit AJ, Nordin AI. Empowering youth through play: promoting awareness of sexual grooming among schoolchildren through game-based learning. *J Advan Res Applied Sci Eng Technol*. (2024) 51:34–44. doi: 10.37934/araset.51.2.3444
43. Himmelbauer M, Seitz T, Seidman C, Löffler-Stastka H. Standardized patients in psychiatry – the best way to learn clinical skills? *BMC Med Educ*. (2018) 18:72. doi: 10.1186/s12909-018-1184-4
44. Wind LA, van Dalen J, Muijtjens AMM, Rethans J-J. Assessing simulated patients in an educational setting: the MaSP (Maastricht assessment of simulated patients). *Med Educ*. (2004) 38:39–44. doi: 10.1111/j.1365-2923.2004.01686.x
45. Shen Z, Yang F, Gao P, Zeng L, Jiang G, Wang S, et al. A novel clinical-simulated suture education for basic surgical skill: suture on the biological tissue fixed on standardized patient evaluated with objective structured assessment of technical skill (OSATS) tools. *J Invest Surg*. (2018) 31:333–9. doi: 10.1080/08941939.2017.1319994
46. Harkness J, Pennell B, Schoua-Glusberg A. "Survey questionnaire translation and assessment" In: S Presser, J Rothgeb, M Couper, J Lessler and J Martin, editors. *Methods for testing and evaluating survey questionnaires*. New Jersey: Wiley (2004) 453–73.
47. DeVellis R, Thorpe C. *Scale development: Theory and applications*. 4th ed. Thousand Oaks: Sage Publications (2022).
48. Brown TA. *Confirmatory factor analysis for applied research*. 2nd ed. New York: Guilford Press (2015).
49. Zervoudakis K, Tsafarakis S. A global optimizer inspired from the survival strategies of flying foxes. *Eng Comput*. (2023) 39:1583–616. doi: 10.1007/s00366-021-01554-w
50. Zervoudakis K, Tsafarakis S. Customer segmentation using flying fox optimization algorithm. *Algo J*. (2025) 49:5. doi: 10.1007/s10878-024-01243-6
51. Mastrothanas K, Gkontelos A, Pikoulis E, Kladaki M, Vasiou A, Sidiropoulou A, et al. School-based participatory arts for psychosocial adjustment and well-being in health emergencies: an embedded mixed-methods study. *Health*. (2025) 13:2737. doi: 10.3390/healthcare13212737
52. Mastrothanas K, Zervoudakis K, Kladaki M. An application of computational intelligence in group formation for digital drama education. *Iran J Comput Sci*. (2024) 7:551–63. doi: 10.1007/s42044-024-00186-9
53. Mastrothanas K, Zervoudakis K, Kladaki M, Tsafarakis S. A bio-inspired computational classifier system for the evaluation of children's theatrical anxiety at school. *Educ Inf Technol*. (2023) 28:11027–50. doi: 10.1007/s10639-023-11645-4
54. Shaikh MS, Zheng G, Wang C, Wang C, Dong X, Zervoudakis K. A classification system based on improved global exploration and convergence to examine student psychological fitness. *Sci Rep*. (2024) 14:27427. doi: 10.1038/s41598-024-78781-w
55. Zervoudakis K, Mastrothanas K, Tsafarakis S. Forming automatic groups of learners using particle swarm optimization for applications of differentiated instruction. *Comput Appl Eng Educ*. (2020) 28:282–92. doi: 10.1002/cae.22191
56. Rosseel Y, Lavaan: an R package for structural equation modeling. *J Stat Softw*. (2012) 48:1–36. doi: 10.18637/jss.v048.i02
57. Byrne B. *Structural equation modeling with Amos: basic concepts, applications and programming*. 3rd ed. New York: Taylor & Francis/ Routledge (2016).
58. Ayeast L, Bagby M. "Evaluating the psychometric properties of psychological measures" In: M Antony and D Barlow, editors. *Handbook of assessment and treatment planning for psychological disorders*. New York, London: The Guilford Press (2011). 23–61.
59. Goretzko D, Siemund K, Sterner P. Evaluating model fit of measurement models in confirmatory factor analysis. *Educ Psychol Meas*. (2024) 84:123–44. doi: 10.1177/00131644231163813
60. McNeish D, Wolf MG. Dynamic fit index cutoffs for one-factor models. *Behav Res Methods*. (2022) 55:1157–74. doi: 10.3758/s13428-022-01847-y
61. Mastrothanas K, Kladaki M, Geladari A. "A study of readability indicators in dramatic texts for young audiences" In: S Gargalianos, editor. *1st international hybrid conference on humanitarian studies*. Florina: University of Western Macedonia, School Of Social Sciences and Humanities (2024). 12–24.
62. Gregorich SE. Do self-report instruments allow meaningful comparisons across diverse population groups? Testing measurement invariance using the confirmatory factor analysis framework. *Med Care*. (2006) 44:S78–94. doi: 10.1097/01.mlr.0000245454.12228.8f
63. Brown GT. The past, present and future of educational assessment: a transdisciplinary perspective. *Front Educ*. (2022) 7:1060633. doi: 10.3389/educ.2022.1060633
64. Horn JL. A rationale and test for the number of factors in factor analysis. *Psychometrika*. (1965) 30:179–185. doi: 10.1007/BF02289447

Appendix

Items of the Greek Version of the SPRS-S Scale:

1. Αυτός που παίζει τον ασθενή κάνει τον ρόλο του σαν να είναι αληθινός.
(*The simulated patient performs their role as if it were real*).
2. Είναι εύκολο να τον καταλάβω τον ρόλο αυτού που παίζει τον ασθενή.
(*It is easy to understand the role of the simulated patient*).
3. Οι απαντήσεις αυτού που παίζει τον ασθενή στις ερωτήσεις μου είναι σωστές.
(*The simulated patient's answers to my questions are accurate*).
4. Τα σχόλια αυτού που παίζει τον ασθενή με βοηθούν να καταλάβω πώς τα πήγα.
(*The simulated patient's feedback helps me understand how I performed*).
5. Αυτός που παίζει τον ασθενή μου δίνει παραδείγματα από το παιχνίδι ρόλων.
(*The simulated patient provides examples from the role-play*).
6. Αυτός που παίζει τον ασθενή με βοηθάει να κάνω ερωτήσεις.
(*The simulated patient helps me ask questions*).
7. Αυτός που παίζει τον ασθενή λέει πώς ένιωσα στην άσκηση.
(*The simulated patient explains how they felt during the exercise*).
8. Αυτός που παίζει τον ασθενή μου δίνει ιδέες για να τα πάω καλύτερα.
(*The simulated patient gives me suggestions for improvement*).
9. Αυτός που παίζει τον ασθενή μου μιλάει ευγενικά.
(*The simulated patient speaks to me kindly*).



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Menstrual and sexual health education in Brazil's School Health Program: an experience report in medical education

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Background: Menstrual health is a critical public health issue tied to gender equity and adolescent well-being. Brazil's School Health Program (SHP) mandates sexual and reproductive health education, yet structured models for integrating medical students into this policy-driven, community-based work are scarce. This study describes and analyzes an experiential learning project where first-year medical students facilitated menstrual health education within the SHP.

Methods: A qualitative case study was conducted. Six female medical students developed and delivered a developmentally tailored educational session on puberty, menstrual physiology, and dignity to 5th-grade (elementary school) girls at a public school, as part of the 2025 activities of the SHP. Data from structured reflective debriefings with students, supervisor observations, and SHP records were analyzed through thematic content review and consensual validation.

Results: Analysis revealed three primary learning outcomes for medical students: (1) Development of core communication and empathetic skills for discussing sensitive topics; (2) A deepened, experiential understanding of menstrual stigma and social determinants of health; and (3) Practical insights into intersectoral collaboration and public policy implementation through the SHP framework. School staff observed a marked reduction in embarrassment and increased openness to discussion among the adolescent participants.

Conclusion: Integrating menstrual health promotion into early medical training via established public policy platforms like the SHP is feasible, low-cost, and highly effective. This model serves as a dual-purpose intervention, fostering socially accountable, humanistic competencies in future physicians while simultaneously advancing adolescent health literacy and dignity. It provides a replicable framework for community-engaged medical education in Brazil and similar low-resource settings.

KEYWORDS

adolescent health, community-based learning, experiential learning, gender equity, medical education, menstrual health, School Health Program (SHP), service-learning

Introduction

Menstrual health is a cornerstone of adolescent well-being, gender equity, and the fulfillment of human rights (1, 2). Despite global recognition, significant gaps persist in menstrual literacy, with stigma, misinformation, and inadequate preparedness among educators continuing to undermine the health, dignity, and school participation of girls, particularly in socioeconomically vulnerable communities (3, 18, 20).

Concurrently, medical education is undergoing a paradigm shift toward greater social accountability and community engagement (4), calling for pedagogical models that place students in real-world contexts to develop core competencies (5). This shift is particularly relevant for addressing sensitive public health issues like menstrual health, **especially considering that gaps in reproductive and fertility-related knowledge have been documented even among medical trainees. Studies from high-income countries have shown that residents may enter clinical practice with limited understanding of core reproductive health concepts (6, 7).** This study acknowledges an important pedagogical consideration raised by literature in other settings: the need to ensure that medical students themselves are adequately prepared to address reproductive health topics. In direct response to this consideration, our experiential model incorporated a structured, faculty-supervised preparatory phase specifically designed to build foundational competence and confidence.

Prior to the community intervention, the six first-year medical student facilitators engaged in a multi-stage preparation. This involved: (1) guided research on national policy documents (SHP, Menstrual Dignity Program) and Brazilian epidemiological data on menstrual health; (2) collaborative development and iterative refinement of educational slides and interactive activities; and (3) participatory workshops and role-playing simulations, all under the close mentorship of a faculty member with extensive experience in the School Health Program. This scaffolded process ensured that the students not only grasped the biomedical and psychosocial dimensions of menstrual health but also practiced sensitive, age-appropriate communication in a supportive learning environment.

Therefore, this project presents a case study in which a potential educational gap—student preparedness on a sensitive topic—is explicitly addressed through curricular design. By transforming preliminary uncertainty into a structured learning objective, the model aims to fulfill a dual purpose: responding to a critical community health need while fostering early development of humanistic, communication, and public health competencies in future physicians. This approach is grounded in Kolb's (8) experiential learning cycle and service-learning frameworks (9), where deliberate preparation enables meaningful and effective community engagement.

In Brazil, this educational philosophy aligns seamlessly with national public policies. The intersectoral School Health Program (SHP) creates a formalized bridge between Family Health Strategy (FHS) units and public schools. The current cycle of the program (2025–2026) establishes various thematic axes, among which 'Sexual and Reproductive Health' is a key priority—a scope that inherently encompasses menstrual health education (10). This policy infrastructure presents a unique and underutilized opportunity for authentic, policy-aligned community-based medical education (CBME). **This initiative is also aligned with the World Health Organization's Health Promoting Schools framework, which emphasizes whole-school approaches to health that integrate education, health services, and community engagement. The WHO–UNESCO global standards highlight schools as strategic settings for health promotion,**

equity, and life-course well-being, particularly through intersectoral collaboration and age-appropriate health literacy interventions (11).

However, a significant gap persists at the intersection of these converging priorities: a documented scarcity of structured, pedagogically grounded models through which early-year medical students—who may themselves benefit from foundational reinforcement in menstrual health literacy—can lead educational interventions within formal policy structures like the SHP. This study addresses this multifaceted gap by presenting an experiential case study.

The School Health Program (SHP) is formally integrated into the medical curriculum as part of a Problem-Based Learning (PBL) approach to community-based education. Within this framework, menstrual and sexual health is a pre-established thematic axis, defined by public policy and institutional teaching plans. Accordingly, first-year medical students did not select the topic autonomously but were tasked with developing and implementing the practical component of this theme under faculty guidance.

The activity aimed to serve a dual purpose: enhancing the menstrual literacy and dignity of schoolgirls while providing medical students with an early experiential learning opportunity grounded in public policy, social accountability, and humanistic care. It describes the implementation and analyzes the outcomes of a menstrual health education session developed and facilitated by first-year medical students as an integral component of the SHP.

Materials and methods

Study design and pedagogical framework

This study employed a qualitative, single-case study design (12) to provide an in-depth exploration of an experiential educational intervention. The project was explicitly grounded in Kolb's (8) experiential learning theory and a service-learning model (9), where academic learning is applied to address genuine community-identified needs—in this case, the school's and SHP's mandate for adolescent sexual health education.

Setting and policy context

The activity was conducted within the formal structure of the SHP in the municipality of Luís Eduardo Magalhães, Bahia. It was conducted in 2025 under the established pairing between the Yoshio Shirabe Family Health Strategy (FHS) unit and the Pedro Paulo Côrte Filho Municipal School. The "Sexual and Reproductive Health" axis was designated to our student group, providing a clear policy mandate for the menstrual health focus. The session content was further informed by the objectives of the federal Menstrual Dignity Program (13). This policy alignment is documented in [Supplementary File 2](#).

Participants

Facilitators: the six female facilitators were first-year medical students in a six-year undergraduate program. **Their estimated age range was 17–22 years. Most students entered the 6-year undergraduate medical program directly after completing secondary education, although a small proportion held prior undergraduate degrees (e.g., pharmacy or nutrition).** A female faculty member and the FHS nurse coordinator provided supervision.

Community participants: The target group was all 5th-grade (elementary school) girls (ages 10–12, $n = 53$) at the partnered school. The school leadership specifically requested female-only facilitators to ensure a comfortable and private environment for the adolescents. This grade level was strategically selected because it encompasses the age range when menarche typically occurs or when early signs of puberty become evident. Girls at this developmental stage are often curious, have questions and concerns about their changing bodies, and are thus highly receptive to educational activities focused on health, self-care, and understanding bodily changes. The school environment provided a structured and safe setting for this targeted, sensitive, and age-appropriate intervention.

Intervention design and implementation

Prior to the field intervention, the student facilitators participated in a structured problematization session based on Problem-Based Learning (PBL) principles ([Supplementary File 4](#)). In this preparatory meeting, the group reviewed the relevant SHP policy documents and discussed public policies related to the theme, including the Menstrual Dignity Program established by Federal Decree No. 11.432. These references served as the basis for understanding the institutional framework of menstrual health in the school context and its link to actions promoting equity and adolescent well-being. During this phase, priority needs related to menstrual health, menstrual dignity, and communication with 5th-grade girls were identified. The group discussed the sexual and reproductive health thematic axis outlined in the teaching plan and the SHP, as well as the anticipated challenges of addressing a sensitive topic in the school environment. This step preceded the development of educational materials and aimed to define how the topic would be approached with the adolescents, always with an educational focus, considering their developmental stage, age-appropriate language, potential discomfort, and cultural barriers. Collaborative pedagogical objectives were defined, focused on promoting welcome, active listening, and reducing menstruation-related stigma.

Preparation of student facilitators

Beyond the initial problematization session, student preparation occurred in multiple stages. First, a theoretical briefing was conducted, focused on a general understanding of puberty, menarche, and menstrual care, always with an educational

focus and aligned with SHP guidelines and actions promoting menstrual dignity. Subsequently, a specific workshop on sensitive language and communication was held to ensure the use of simple, clear, and age-appropriate terms for the adolescents, prioritizing comfort, understanding, and emotional safety. This stage involved discussing how to present the topic of menstruation in an accessible way, using examples close to the students' reality and avoiding overly technical approaches. **Although formal simulations with standardized patients were not used, the students participated in role-playing exercises among themselves, practicing dialogue facilitation, active listening, and responses to anticipated sensitive topics, with direct feedback from the supervising faculty.** Only after this pedagogical and communicational preparation were the final educational materials—including slides and interactive activities—developed by the students. These materials underwent iterative review and were approved by the supervising faculty for pedagogical suitability, age-appropriateness, and alignment with SHP guidelines before the field activity.

Session structure and content

Informed by this planning, the facilitators—under close supervision—developed and delivered a 90-minute interactive session, structured into five sequential components:

1. Introduction and safe space setting: establishing rapport, group norms, confidentiality, and a supportive environment for open discussion.
2. Puberty and menarche dialogue: a conversation normalizing bodily changes, using inclusive and age-appropriate language.
3. Interactive physiology activity: a collaborative puzzle illustrating the key phases of the menstrual cycle in a simplified and engaging format.
4. Menstrual dignity and stigma reduction: a guided discussion to bust myths, address self-care and bodily autonomy, and counter culturally embedded misconceptions.
5. Anonymous Q&A: a “question box” that allowed the girls to submit queries anonymously, fostering psychological safety and enabling candid dialogue, with responses provided openly by the facilitators. This strategy was chosen due to the sensitive nature of the topic.

All educational materials and activities were vetted for age-appropriateness and were fully aligned with both national SHP guidelines and the pedagogical objectives established during the PBL-based planning phase.

Data collection

Data for this experience report were derived from a structured, post-intervention pedagogical analysis aimed at capturing the medical students' learning. The primary source was a facilitated group debriefing session conducted immediately after the school activity. In this session, the six student facilitators, guided by the supervising faculty (Z.F.B.P.), engaged in a collective reflection on their experiences, challenges, and insights. The discussion

was structured around key prompts related to communication, observed social determinants, and the experience of working within the SHP framework. The supervisor documented this discussion in comprehensive narrative notes. Second, the supervising faculty member recorded narrative observational notes during and immediately after the activity, documenting student facilitation processes, group dynamics, and general engagement levels. Third, official School Health Program (SHP) records, including municipal planning documents and activity logs, were consulted to confirm institutional alignment, implementation context, and policy integration. An anonymous question box was used exclusively as a pedagogical tool during the educational session to promote psychological safety and facilitate student learning in addressing sensitive topics. The content of the questions was not recorded, transcribed, categorized, or analyzed and therefore did not constitute a data source for this study. **All reflections refer exclusively to the medical students' learning process and to themes anticipated during preparatory training; no questions or statements from adolescent participants were recorded, transcribed, or analyzed.**

Analytic approach

To synthesize the core learning outcomes from the experience, a thematic analysis of the reflective debriefing was conducted following established qualitative analysis procedures (19). The process was pedagogical and qualitative, focusing on the insights generated by the students themselves:

1. Documentation and familiarization: the supervising faculty's detailed notes from the debriefing session served as the primary data corpus.
2. Identification of key insights: the faculty researcher (Z.F.B.P.) reviewed the notes to identify salient and recurrent themes expressed by the students during the discussion (e.g., initial nervousness, moments of empathic connection, observations about stigma, understanding of policy implementation).
3. Consensual validation and theme formation: these initial themes were presented and discussed with the student facilitators in a subsequent meeting. Through this member-checking process, the students confirmed, refined, and named the themes that most accurately represented their shared learning. This collaborative, consensual approach ensured the results were grounded in the students' lived experience. The final thematic framework is presented in [Table 1](#).

Ethical considerations

This project was conducted as a pedagogical activity integrated into the mandatory community-based curriculum of the medical program. In accordance with Brazilian Resolution CNS 510/2016, activities of this nature—which are part of professional training and do not involve the collection of personally identifiable data for research purposes—do not require formal review by a research ethics committee. All procedures adhered strictly to institutional educational guidelines and the principles of the Declaration of

Helsinki. Formal authorization for the activity was obtained from the Municipal Health and Education Secretariats of Luís Eduardo Magalhães, the FHS Yoshio Shirabe unit, and the school principal (as formally documented in [Supplementary File 1](#)). The school confirmed that standard SHP parental authorization procedures, which cover educational health activities, were followed for all participating adolescents. The medical student participants provided consent for the educational use of their anonymized reflective insights as part of their course requirements. No images or any personally identifiable data from the schoolgirls were collected or recorded. No content produced by the adolescent participants, including verbal or written questions, was collected, recorded, or analyzed for research purposes.

Results

Synthesis of medical students' reflective learning

The consensual analysis of the students' reflective debriefing yielded three interconnected thematic categories that capture the essence of their experiential learning. These are summarized in [Table 1](#).

Pedagogical insights from an anonymous question box activity

The anonymous question box functioned as a formative educational device rather than a source of analyzable data. Its use enabled the medical students to practice responding to sensitive, age-appropriate health concerns in real time, thereby strengthening communication skills, emotional attunement, and adaptability. The variety of themes raised through this activity informed the students' reflective learning processes, without generating any recorded or research-analyzed data from the adolescent participants.

Communication, empathy, and humanistic competencies

Students consistently described this as their first practical test in communicating complex, sensitive health information. The experience forced a rapid evolution from theoretical knowledge to applied skill.

Empathy in action: students reported moving beyond sympathy to a felt understanding of the girls' perspectives. One shared insight noted, "I saw their initial shyness and remembered my own confusion at that age. It wasn't about teaching at them, but connecting with them."

Nuanced communication: they learned to calibrate language, tone, and non-verbal cues. A student reflected, "I realized technical terms like 'endometrium' created distance. When I said 'the nourishing lining inside the uterus,' their eyes showed understanding. Listening to their word choices became my guide."

TABLE 1 Summary of themes, subthemes, illustrative excerpt from medical student reflection.

Theme	Subthemes	Illustrative quote from student reflection
Humanistic and communication competencies	Empathy in action; nuanced communication; creating safety	"I stopped being just a student with a lesson plan and started being a listener. Their comfort became my priority, and the learning flowed from that."
Social determinants and menstrual equity	Confronting stigma; identifying structural barriers; professional agency	"It's one thing to read about period poverty. It's another to recognize how structural barriers shape the lived realities of girls in vulnerable contexts. That structural barrier has a face now."
Intersectoral collaboration	Policy-to-Practice; collaborative workflows; school as health setting	"The SHP wasn't a vague government program anymore. It was the nurse, the teacher, the principal, and us, all in a room making this happen. I understand 'SUS' differently now."

Creating psychological safety: the conscious decision for female-only facilitation, initially a logistical detail, was reflected upon as a critical intervention for trust-building.

Understanding social determinants and menstrual equity: the classroom encounter transformed abstract concepts like “stigma” and “vulnerability” into tangible realities.

Confronting stigma directly: student reflections were marked by revelations about the pervasiveness of shame. Students reported that the necessity to address anonymously submitted concerns challenged them to translate biomedical knowledge into reassuring, age-appropriate language while maintaining sensitivity to cultural and social contexts. **One student reflected on being challenged by questions related to widely recognized myths about menstruation and virginity—issues that had been anticipated during the preparatory training—underscoring how cultural silence and stigma shape adolescents’ concerns in real-world educational settings.**

Identifying structural barriers: observations went beyond individual knowledge gaps. Students noted the lack of discrete bins in bathrooms and how girls strategized to hide sanitary products, linking these to broader issues of infrastructure and dignity.

Recognizing professional agency: This experience fostered a sense of responsibility. A student concluded, “As a future doctor, I can be a source of accurate information, but also an advocate for better school facilities and policies that don’t force girls to hide.”

Operationalizing intersectoral collaboration and public policy

The project demystified the workings of the **Brazilian Unified Health System (SUS)** and the SHP.

From policy document to practice: students gained appreciation for the planning behind community health. “I finally saw how the ‘Health at School’ checkbox in our municipal plan translates into a real morning at a school, with a nurse, a teacher, and us all working from the same script,” one observed.

Learning collaborative workflows: the coordination with the FHS nurse and school teachers provided a practical lesson in interprofessional and intersectoral dynamics. They saw firsthand the negotiation of roles, resources, and schedules that underpins community health work.

The school as a health promotion setting: the activity cemented the concept of the school as a crucial space for primary prevention and health literacy, a core principle of the SHP that became experientially validated.

Discussion

This experiential learning project demonstrates that integrating menstrual health education into the earliest stages of medical training is not only feasible but also a potent pedagogical strategy. By embedding the intervention within the mandated structure of Brazil’s SHP, the project achieved dual alignment: with national public health priorities and with contemporary frameworks for socially accountable medical education (4). Our findings strongly support the educational value of such community-based experiences. The development of empathy and communication skills observed aligns with core objectives of humanistic medical education (14) and underscores the argument that these competencies are best cultivated through authentic human interaction, not simulated scenarios alone. Furthermore, students’ visceral encounter with menstrual stigma and its social underpinnings provided a more profound understanding of gender equity and social determinants of health than traditional coursework typically allows. This echoes the transformative potential of service-learning to foster critical consciousness (15). The use of an anonymous question box as a core pedagogical strategy proved to be a significant factor in the session’s dynamics. This tool, recommended for engaging adolescents on sensitive health topics (3), served a dual pedagogical function in our context. Primarily, it provided a safe channel for the schoolgirls to express concerns, thereby creating an authentic training ground for the medical students. The necessity to formulate clear, empathetic, and age-appropriate responses to spontaneous, real-world questions in real-time constituted a powerful exercise in adaptive communication and emotional attunement. This experiential challenge is aligned with findings from similar educational initiatives, such as the ‘My Vital Cycles®’ program in Australia, which underscores the value of interactive, student-centered methodologies for improving menstrual health literacy (16). In our model, the tool’s primary and analyzed outcome was the competency development of the

future physicians, reinforcing that creating psychologically safe environments is itself a critical clinical and educational skill. The project also served as a practical masterclass in health systems science. Students witnessed the operationalization of a national policy (the SHP), experiencing firsthand the complexities and rewards of intersectoral collaboration between health and education sectors. This early exposure is crucial for training future physicians who are not only clinically competent but also effective navigators and advocates within public health systems (17).

Study strengths, limitations, and future directions

The strengths of this model include its direct alignment with national public policy, low operational cost, and reliance on existing public system infrastructure (the SHP and FHS), which underpin its scalability and replicability in other Brazilian municipalities and similar low-resource settings internationally. The positive reception from school staff and the observable reduction in embarrassment among the schoolgirls affirm its feasibility and immediate impact. This study has several limitations. As a qualitative case study, its findings, while rich in depth, are not generalizable. The voluntary nature of student participation may introduce selection bias, attracting those already interested in community health or gender equity. We lack longitudinal data to assess the sustained impact of the intervention on either the adolescents' health literacy or the medical students' professional development. Furthermore, parental consent covered the adolescents' participation in the educational activity but did not extend to the systematic collection or analysis of their specific questions for research purposes, which precludes a detailed content analysis of their queries. Future iterations of this model should incorporate structured pre- and post-intervention assessments of student attitudes and skills. Seeking participatory feedback from adolescent participants and their families could further ensure the intervention remains community-centered. Scaling the model to more schools, integrating male medical students in complementary educational roles (e.g., discussing puberty with boys to foster allyship), and conducting longitudinal assessments are promising future directions. The implementation of this model provided valuable operational and pedagogical insights. Initial considerations involved coordinating between health and education sectors and adapting to school schedules. A key process was supporting first-year medical students to navigate their initial hesitancy in discussing sensitive topics with adolescents. This was addressed through a structured preparatory phase: a theoretical briefing defined the core topics, and a dedicated session established appropriate, age-specific terminology. This preparation was crucial. Equipped with this clear framework and vetted language, the students' initial apprehension was transformed. During the intervention, their engagement became notably fluid and confident, demonstrating how targeted preparation can effectively build competence for community dialogue. This experience underscores that such foundational training is not just beneficial but essential for the success of experiential learning in sensitive domains.

The model's core design features underpin its scalability: direct alignment with national public policy (the SHP), low operational cost, and reliance on existing infrastructure. This framework is readily adaptable to other Brazilian municipalities and offers a relevant template for similar settings internationally.

Conclusion

This study presents a viable and impactful model for integrating menstrual health education into early medical training through Brazil's established School Health Program. The project successfully transformed a public health mandate into a rich experiential learning opportunity, demonstrating that such community-based activities can simultaneously advance adolescent health literacy and cultivate a generation of physicians who are empathetic, socially aware, and skilled in community engagement from the outset of their careers. By leveraging existing policy platforms, this approach provides a sustainable, scalable, and powerful pathway toward both menstrual equity and the development of socially accountable healthcare professionals.

Data availability statement

The original contributions presented in the study are included in the article/[Supplementary material](#), further inquiries can be directed to the corresponding author.

Author contributions

ZF: Conceptualization, Investigation, Methodology, Project administration, Supervision, Visualization, Writing – original draft, Writing – review & editing. MdS: Conceptualization, Methodology, Supervision, Validation, Writing – review & editing, Project administration.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declared that generative AI was used in the creation of this manuscript. During the preparation of this manuscript, the author(s) Zibeilde Ferreira Borges Paschoalini and Marcello da Silveira Paschoalini used ChatGPT (GPT-5, OpenAI) for linguistic refinement and section formatting according to journal guidelines. All content was subsequently reviewed, edited, and validated by the author(s), who take full responsibility for the final version.

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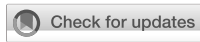
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Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpubh.2026.1730562/full#supplementary-material>

References

1. UNESCO. *Menstrual Health in Schools: Global Guidance for Education Systems*. Paris: United Nations Educational, Scientific and Cultural Organization (2023).
2. World Health Organization. *Guidance on Menstrual Health and Hygiene*. Geneva: World Health Organization (2022).
3. Hennegan J, Winkler IT, Bobel C, Keiser D, Hampton J, Larsson G, et al. Menstrual health: a definition for policy, practice, and research. *Sex Reprod Health Matters*. (2021) 29:1911618. doi: 10.1080/26410397.2021.1911618
4. Meili R, Wilson S, Strasser R. Embedding social accountability in early medical education. *Med Teach*. (2023) 45:645–53. doi: 10.1007/978-3-031-94435-2_10
5. O'Brien BC, Irby DM. Reframing reflection in medical education: a concept analysis. *Acad Med*. (2020) 95:1211–7.
6. Roberts LM, Kudesia R, Zhao H, Dolan S, Rose M. A cross-sectional survey of fertility knowledge in obstetrics and gynecology residents. *Fertil Res Pract*. (2020) 6:1–22. doi: 10.1186/s40738-020-00091-2
7. Bowden S, Metcalfe A, Foong S. Fertility preservation and infertility treatment in female surgical trainees in Alberta: a survey of trainee knowledge, attitudes and needs. *Fertil Steril*. (2024) 122:e7–e7. doi: 10.1016/j.fertnstert.2024.07.086
8. Kolb DA. *Experiential Learning: Experience as the Source of Learning and Development*. Upper Saddle River, NJ: Prentice Hall (1984).
9. Seifer SD. Service-learning: community-campus partnerships for health professions education. *Acad Med*. (1998) 73:273–7. doi: 10.1097/00001888-199803000-00015
10. Ministério da Saúde (Brasil). *Documento Orientador do Programa Saúde na Escola: Indicadores e Padrões de Avaliação do Ciclo 2025/2026*. Brasília: Secretaria de Atenção Primária à Saúde (2024).
11. World Health Organization and United Nations Educational, Scientific and Cultural Organization. *Making Every School a Health-Promoting School: Global Standards and Indicators for Health-Promoting Schools and Systems*. Geneva: World Health Organization (2021).
12. Yin RK. *Case study research: Design and Methods*. 5th ed. Thousand Oaks, CA: Sage Publications (2014).
13. Brasil. Decreto nº 11.432, de 19 de março de 2024. Institui o Programa Dignidade Menstrual. *Diário Oficial da União*, seção 1, (55), 1 (2024).
14. Wear D, Zarconi J. Can compassion be taught? Let's ask our students. *J Gen Intern Med*. (2008) 23:948–953. doi: 10.1007/s11606-007-0501-0
15. Freire P. *Pedagogy of the Oppressed*. 65th ed. Bocaíuva do Sul: Paz e Terra (2018).
16. Roux F, Chih H, Hendriks J, Burns S. Mixed method evaluation of My Vital Cycles®: A holistic school-based ovulatory menstrual health literacy program. *Int J Environ Res Public Health*. (2023) 20:5964. doi: 10.3390/ijerph20115964
17. Frenk J, Chen L, Bhutta ZA, Cohen J, Crisp N, Evans T, et al. Health professionals for a new century: transforming education to strengthen health systems in an interdependent world. *Lancet*. (2010) 376:1923–58. doi: 10.1016/S0140-6736(10)61854-5
18. Chandra-Mouli V, Lane C, Wong S. What does not work in adolescent sexual and reproductive health: a review of evidence on interventions commonly accepted as best practices. *Global Health Sci Pract*. (2023) 11:e2200406. doi: 10.9745/GHSP-D-15-00126
19. Miles MB, Huberman AM, Saldaña J. *Qualitative Data Analysis: a Methods Sourcebook*. 3rd ed. Thousand Oaks, CA: Sage Publications (2014).
20. United Nations Children's Fund (UNICEF) and United Nations Population Fund (UNFPA). *Menstrual poverty in Brazil: Inequality and Rights Violations*. New York, NY: UNICEF/UNFPA (2021).



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Association between electronic device use time and self-rated health in medical students: mediating role of sleep quality and moderating effect of psychological stress

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Background: The physical and mental health of medical students not only directly affects academic performance and professional development but also significantly impacts the quality and safety of future healthcare services. Currently, this population faces multiple stressors, including heavy academic workloads, intense clinical training demands, and career-related anxiety. Given these challenges, medical education should prioritize student wellbeing by developing and implementing a comprehensive mechanism to validate the impacts of self-rated health among this specialized population.

Objective: This study was aimed to investigate the relationship and underlying mechanisms between electronic device use time and self-rated health among medical students.

Methods: Convenience sampling was used to survey 699 medical students from universities in Hefei City. The study used self-administered questionnaires to assess electronic device use time, sleep quality, psychological stress, and self-rated health.

Results: The electronic device use time positively predicted the score of self-rated health scale ($\beta = 0.149, p < 0.001$), indicating that longer electronic device use time was associated with poorer self-rated health among medical students. Sleep quality exerted a mediating role between electronic device use time and self-rated health, with a mediating effect size of 0.181 (95% Bootstrap CI = [0.0677, 0.3269]), accounting for 20.03% of the total effect. The first segment of the mediating pathway through which electronic device use time affects medical students' self-rated health via sleep quality was moderated by psychological stress ($\beta = 0.0727, p = 0.0550$); specifically, higher levels of psychological stress strengthened the negative predictive effect of electronic device use time on sleep quality.

Conclusion: This study elucidates the relationship and mechanisms between electronic device use time and self-rated health among medical students, providing insights to enhance health awareness and promote healthy behaviors.

KEYWORDS

e-device use time, medical students, psychological stress, self-rated health, sleep quality

1 Introduction

The health status of college students is not only related to individual growth and development but also exerts a profound impact on the development of the entire country and society. As a special subgroup of college students, medical students represent a key pipeline for the future healthcare workforce and play a critical role in safeguarding population health (1). Therefore, exploring the health behaviors and self-rated health of medical students is of great significance for advancing the Healthy China Initiative. With the advancement of the digital era, electronic media has been deeply integrated into the study and life of medical students, and problems such as mobile phone addiction and screen dependence have gradually emerged. Long-term use of electronic devices, especially excessive use before bedtime, is associated with delayed sleep onset, disrupted sleep patterns, shortened sleep duration, and poor sleep quality (2, 3). Data show that up to 70.32% of college students suffer from sleep problems, such as insufficient sleep and difficulty falling asleep (4), and the overall prevalence of sub-health among medical students reaches 62.2% (5). Additionally, a meta-analysis indicates that sleep duration is associated with self-rated health to varying degrees and linked to increased fatigue and depression rates (6). Based on these observations, Hypothesis 1 was proposed: electronic device usage duration is negatively associated with sleep quality, and sleep quality plays a mediating role between electronic device usage duration and self-rated health.

According to the Knowledge-Attitude-Practice (KAP) theory, appropriate self-assessment of health facilitates the adoption of health-promoting behaviors among college students. Self-rated health (SRH) refers to an individual's subjective judgment of their own disease burden and a comprehensive expectation of their overall health status (7). Its core value lies in stimulating and guiding individuals to actively perceive pain and discomfort that are difficult to observe through external means, thereby reducing the risk of illness and death (8), and enabling early prevention and timely control of diseases. Existing studies have shown that the SRH status of college students tends to decline with advancing academic year (9) and is significantly associated with sleep duration, personal health literacy, sleep quality, and physical activity level (10). Thus, Hypothesis 2 was put forward: there is a bidirectional relationship between sleep quality and SRH, and sleep quality is significantly positively associated with SRH.

The "China National Mental Health Development Report (2023–2024)" and the 2024 "Mental Health Blue Book" indicate that the prevalence of mental health problems among Chinese adolescents is approximately 29.4%, higher than the global average, making adolescent mental health an urgent social concern. Medical students face challenges such as academic pressure, and clinical training, which may contribute to negative emotional states and psychological difficulties. Psychological stress, also known as mental pressure, is a common psychological state closely associated with physical and mental health as well as functional activities. Chronic or intense psychological stress is a core predisposing factor for academic difficulties and psychological disorders among college students (11). Current academic research on psychological stress mainly focuses on the integration of stress system theory and nursing intervention models to alleviate negative physical and psychological emotional states in patients (12). Existing studies have shown that perceived stress is significantly negatively associated with predicted sleep quality, and individuals under high pressure are prone to negative stress emotions such as anxiety and irritability. Frequent use of social media may impair individuals' emotional regulation abilities, making it difficult

to effectively cope with anxiety and stress (13). With the development of the biopsychosocial medical model, negative emotions are considered traceable to specific psychosocial factors, and high levels of psychological stress may increase the risk of negative and pessimistic emotional states (14), which may lead to sleep quality problems, such as difficulty falling asleep. Therefore, Hypothesis 3 was proposed: psychological stress level plays a moderating role between electronic device use and sleep quality.

In summary, existing studies have explored electronic device use, self-rated health, sleep quality, psychological stress, and other related factors among college students and other populations; however, comprehensive research elucidating the interrelationships among these four variables, particularly in medical students, remains limited. Drawing on the KAP theory and the biopsychosocial medical model, this study constructed a moderated mediation model to elucidate in depth the impact and underlying mechanisms of electronic device use time on SRH among medical students, with sleep quality as a mediator and psychological stress as a moderator. The findings are expected to enhance medical students' health awareness and self-perceptions of health across multiple dimensions, thereby promoting the advancement of the Healthy China Initiative.

2 Methods

2.1 Participants

In this study, convenience sampling was adopted to recruit medical students from universities in Hefei City, Anhui Province, as the main research participants. The survey was conducted using a combination of online and offline methods, with a total of 699 questionnaires collected. Questionnaires with excessive missing values were excluded, resulting in 679 valid questionnaires, with a valid response rate of 97%. Detailed information is presented in Table 1.

2.2 Measures

2.2.1 Electronic device use time

An open-ended questionnaire was used to measure electronic device use time. Participants were asked to recall their average daily use time of electronic devices over the past month, including mobile phones, computers, tablets, smartwatches, and televisions. E-device use time was assessed by the question, "How long do you usually use electronic devices every day?," rated on a 5-point Likert scale with the following response options: "less than 1 h," "1–3 h," "3–5 h (excluding 3 h)," "5–8 h (excluding 5 h)," and "more than 8 h." Response were assigned scores from 1 to 5, respectively.

2.2.2 Sleep quality scale

Sleep quality is defined as an individual's self-satisfaction with all aspects of the sleep experience, which can be measured by the following variables: sleep efficiency, sleep latency, wake after sleep onset (WASO), and sleep architecture measurements (15). The Pittsburgh Sleep Quality Index (PSQI) was referenced to evaluate the sleep quality of medical students. As one of the most commonly used tools for assessing sleep quality in both non-clinical and clinical populations (16), the sleep quality scale in this study included 14 items, covering

TABLE 1 Basic information on survey respondents (*n* = 679).

Variable	Item	<i>n</i>	Proportion (%)
Gender	Male	310	45.7
	Female	369	54.3
Age	Younger age group (15–19 years)	294	43.3
	Middle age group (20–24 years)	339	49.9
	Older age group (25–30 years)	46	6.8
School	Medical institution	630	92.8
	Non-medical institution	49	7.2
Grade	Lower grade group (Year 3 and below)	283	41.7
	Upper grade group (Year 4 and postgraduate)	396	58.3
Monthly living expenses	<1,000	28	4.1
	1,000–1,500	274	40.4
	1,501–2,000	280	41.2
	2,001–2,500	66	9.7
	2,501–3,000	15	2.2
	>3,000	16	2.4
Place of residence	Provincial capital (including municipalities)	97	14.3
	Prefecture-level city	145	21.4
	County seat	202	29.7
	Town/Village	235	34.6
Highest parental education level	Master's degree or above	16	2.4
	Bachelor's/Associate degree	131	19.3
	High school/Vocational school	175	25.8
	Junior high school	281	41.4
	Primary school or below	76	11.2
Number of chronic diseases in the family	None	516	76
	One	122	18
	Two or above	41	6
Regular physical examinations	Yes	129	19
	No	550	81

subjective sleep quality, sleep latency, sleep efficiency, sleep disturbances, hypnotic medication use, and other related contents. Subjective sleep quality was assessed using a 5-point Likert scale (“very good,” “good,” “fair,” “poor,” “very poor”). All other items were rated on a 4-point frequency scale, with response options of “none,” “<1 time/week,” “1–2 times/week,” and “≥3 times/week,” or “none,” “occasionally,” “sometimes,” and “often”. The total score ranged from 14 to 57, with the sum of all items representing the PSQI score. The scale was reverse coded, such that higher scores indicated poorer sleep quality. The Cronbach's α coefficient of this scale in this study was 0.845.

2.2.3 Self-rated health scale

Self-rated health refers to an individual's self-assessed overall health status, which is widely used as a key health indicator for individuals of all age groups (17). The Short Form-36 Health Survey (SF-36) is one of the most commonly used tools for measuring health-related quality of life (HRQoL) in clinical practice and population studies (18). Self-rated

health among medical students was assessed using SF-36, based on the second Chinese version translated and revised by Lu et al. (19). The self-rated health scale in this study included 17 items, specifically covering overall physical and mental health self-assessment (5-point Likert scale), restrictions on social and practical activities due to health (3-point Likert scale), current health status compared with the past (5-point Likert scale), and health status compared with others (5-point Likert scale). The sum of all item scores was calculated as the self-rated health score, with a score range of 17–50. The self-rated health scale was reverse coded, so that higher scores indicated poorer self-rated health. The Cronbach's α coefficient of this scale in this study was 0.722.

2.2.4 Psychological stress scale

The psychological stress scale for medical students was developed with reference to the Short Form-36 Health Survey (SF-36) and the Chinese College Student Mental Health Scale (CCSMHS). Participants were asked to report the frequency of stress-related feelings and

emotional experiences over the past month (20). The scale included nine items (e.g., feeling tense, depressed, discouraged, very tired, and fatigued), each rated on a 5-point Likert scale: “1 = none of the time,” “2 = a little of the time,” “3 = some of the time,” “4 = most of the time,” and “5 = all of the time.” The sum of all item scores was calculated, with a score range of 9–45. This scale was scored in a positive direction, with higher scores indicating higher levels of psychological stress. The Cronbach's α coefficient of this scale in this study was 0.876.

2.3 Statistical analysis

Data processing and statistical analyses were performed using SPSS version 26.0 and Microsoft Excel. The Harman's single-factor test was employed to examine common method bias (CMB). Descriptive statistical analyses of each variable were conducted using mean and standard deviation, while Pearson correlation analysis was used to explore the correlations among variables. The moderated mediation effect analysis was implemented using Model 7 of the PROCESS macro developed by Hayes (21), based on the bootstrap method. Meanwhile, the moderator variable was divided into high and low groups based on ± 1 standard deviation for the simple slope test. The significance level was set at $\alpha = 0.05$.

3 Results

3.1 Baseline characteristics of the study subjects

In this study, the 679 medical students exhibited relatively balanced proportions distribution in terms of gender, grade level, and family residential tier. The age range was 15–30 years, with 93.2% aged 15–24. Monthly living expenses generally ranged between 1,000 and 2,500 yuan, accounting for 91.3% of the sample. The highest educational attainment of most parents was high school or secondary vocational education or below. Seventy-six percent of medical students reported no family history of chronic diseases or were unaware of such history, while 81% lacked regular health check-up habits. Details are presented in Table 1.

3.2 Common method bias test

Common Method Bias refers to the systematic error that is due to the selection of survey samples, the consistency of the test environment, and other interference factors in the process of investigation. Common method variance was analyzed using Harman's single-factor test (22), and unrotated exploratory factor analysis was conducted on the raw items of the electronic device use time, sleep quality, self-rated health, and psychological stress scales. The analysis demonstrates that all 11 factors had the eigenvalues greater than 1. The first factor explains 23.67% of the variance, which is below the standard critical threshold of 40%. Therefore, no severe common method bias exists in this study.

3.3 Correlation analysis of variables

Pearson correlation analysis revealed that the average daily electronic device use time exhibited positive correlation with the scale scores of self-rated health, sleep quality, and psychological stress among medical students. Similarly, the sleep quality scale score

showed positive correlation with the scale scores of self-rated health and psychological stress. Given that both sleep quality and self-rated health were reverse coded, the results indicate that electronic device use time was negatively associated with self-rated health and sleep quality, while being positively correlated with psychological stress. Moreover, sleep quality was positively correlated with self-rated health but negatively associated with psychological stress. Among the demographic variables, school, grade, monthly living expenses, family residence location, parents' highest educational attainment, number of chronic illnesses in the family, and regular physical examination habits were associated with several key study variables. Details are shown in Table 2.

3.4 Mediation analysis of the effect of e-device use time on self-rated health through sleep quality among medical students

This study controlled for socio-demographic and household characteristics, using medical students' e-device use time as the independent variable, sleep quality as the mediating variable, and self-rated health as the dependent variable. The Model 4 of the SPSS PROCESS macro was employed to analyze the data, and all variables are centered. The results demonstrated that the electronic device use time exhibited a positive predictive effect on the scale score of self-rated health (reverse-coded) ($\beta = 0.149$, $t = 3.847$, $p < 0.001$) and the scale score of sleep quality (reverse-coded) ($\beta = 0.211$, $t = 5.565$, $p < 0.001$). These findings indicate that electronic device use time was negatively associated with both sleep quality and self-rated health among medical students. After incorporating sleep quality as a mediator, the electronic device use time remained a positive predictor of the score of the self-rated health scale ($\beta = 0.119$, $t = 3.035$, $p < 0.01$), and the score of sleep quality scale positively predicted the scale score of self-rated health ($\beta = 0.141$, $t = 3.611$, $p < 0.001$). This suggests that the negative predictive effect of electronic device use time on self-rated health, and the positive predictive effect of sleep quality on self-rated health remained unchanged after introducing sleep quality as a mediator. Thus, sleep quality played a mediating role between electronic device use time and self-rated health. The 95% bootstrap confidence interval was [0.0591, 0.2217], which did not include 0, indicating a significant mediating effect that was partial. The mediating effect size was 0.181, accounting for 20.03% of the total effect (see Table 3).

3.5 The moderating role of psychological stress in the mediating effect of sleep quality

Building upon the mediation effect, we further examined the moderating role of psychological stress. To test whether the first half of the mediation pathway was moderated by psychological stress, the PROCESS Model 7 was used to analyze the data. The results indicated that the electronic device use time was significantly positively correlated with the score of sleep quality scale (reverse-coded) ($\beta = 1.2039$, $t = 5.5510$, $p < 0.001$). The score of psychological stress scale (forward-coded) exhibited a significant positive predictive effect on the score of sleep quality scale ($\beta = 0.4616$, $t = 10.3890$, $p < 0.001$), suggesting that after introducing psychological stress as a moderator, the level of psychological stress was negatively associated with sleep quality among medical students. The interaction term between electronic device use

TABLE 2 Results of correlation analysis for each variable.

	Daily electronic device use time	Self-rated health	Sleep quality	Psychological stress	Gender	Age	School	Grade	Monthly living expenses	Place of residence	Highest parental education level	Number of chronic diseases in the family	Regular physical examinations
Daily electronic device use time	1												
Self-rated health	0.158**	1											
Sleep quality	0.221**	0.169**	1										
Psychological stress	0.06	−0.006	0.372**	1									
Gender	−0.039	0.026	0.018	0.034	1								
Age	−0.057	0.015	0.009	0.025	0.009	1							
School	0.025	0.057	−0.024	0.120**	−0.019	−0.001	1						
Grade	−0.047	0.013	0.06	0.065	0.083*	0.708**	0.051	1					
Monthly living expenses	0.05	0.063	−0.01	−0.120**	−0.100**	0.021	0.057	−0.005	1				
Place of residence	0.01	−0.009	0.012	0.01	0.013	0.03	−0.138**	0.002	−0.233**	1			
Highest parental education level	0.098*	0.009	0.084*	0.085*	−0.017	0.067	−0.02	0.041	−0.243**	0.355**	1		
Number of chronic diseases in the family	0.003	0.018	0.114**	0.033	0.083*	0.116**	0.023	0.125**	−0.022	0.022	0.067	1	
Regular physical examinations	0.126**	0.071	0.096*	0.100**	0.076*	−0.025	−0.039	0.017	−0.133**	0.119**	0.190**	0.018	1

Note: ** $p < 0.01$, * $p < 0.05$. Columns 1–13 correspond sequentially to the row headings: “Daily electronic device use time”, “Self-rated health”, “Sleep quality”, “Psychological stress”, “Gender”, “Age”, “School”, “Grade”, “Monthly living expenses”, “Place of residence”, “Highest parental education level”, “Number of chronic diseases in the family”, and “Regular physical examinations”.

TABLE 3 Regression analysis of the relationship of variables in the mandating model.

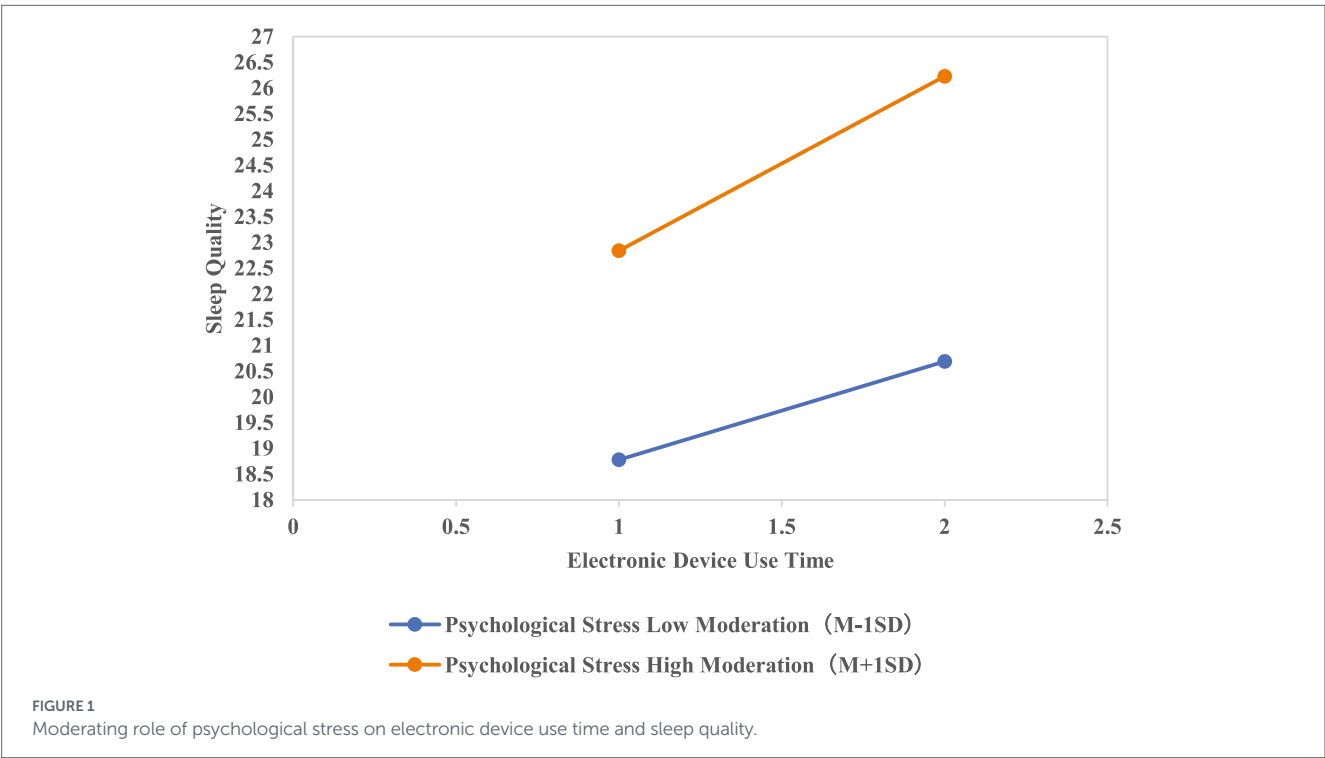
Regression equation		Goodness-of-fit indices			Coefficient significance	
Dependent variable	Independent variable	<i>R</i>	<i>R</i> ²	<i>F</i>	β	<i>t</i>
Sleep quality	Electronic device use time	0.273	0.075	5.377	0.211	5.565***
Self-rated health	Electronic device use time	0.190	0.036	2.509	0.149	3.847***
Self-rated health	Sleep quality	0.234	0.055	3.507	0.141	3.611***
Self-rated health	Electronic device use time				0.119	3.035**

Analyses controlled for all demographic and socioeconomic covariates. ***p* < 0.01, ****p* < 0.001.

TABLE 4 Mediation effects test with moderation.

Dependent variable	Equation 1 (sleep quality)			Equation 2 (self-rated health)		
	β	SE	<i>t</i>	β	SE	<i>t</i>
Electronic device use time	1.2039	0.2169	5.5510***	0.7230	0.2382	3.0350**
Psychological stress	0.4616	0.0444	10.3890***			
Electronic device use time × psychological stress	0.0727	0.0378	1.9230			
Sleep quality				0.1397	0.0387	3.6110***
<i>R</i> ²	0.2040			0.0550		
<i>F</i>	14.2360***			3.5070**		

Analyses controlled for all demographic and socioeconomic covariates. ***p* < 0.01, ****p* < 0.001.



time and psychological stress had a marginally significant predictive effect on sleep quality ($\beta = 0.0727$, $t = 1.9230$, $p = 0.0550$).

Johnson-Neyman significance region analysis revealed that the moderating effect of electronic device use time on sleep quality was not significant ($p > 0.05$) when psychological stress levels were below -7.3105 (accounting for 9.13% of the total sample); in contrast, this moderating effect became significant ($p < 0.05$) when psychological stress levels were above -7.3105 (accounting for 90.87% of the total sample). Additionally, the positive effect of electronic device use time on sleep quality scale score significantly positively predicted the self-rated health scale score ($\beta = 0.7230$, $t = 3.0350$, $p < 0.01$), indicating that the negative predictive effect of electronic device use time on

sleep quality was significantly negatively associated with self-rated health among medical students. Collectively, these findings demonstrate that psychological stress moderated the first segment of the mediating pathway, and the moderated mediation effect was established (see Table 4).

To further clarify the moderating strength of psychological stress and the robustness of its effects, a simple slope analysis was conducted to examine the impact of electronic device use time on sleep quality across different levels of psychological stress. The results showed that when psychological stress scale scores were at low ($\beta = 0.8982$, $t = 3.1630$, $p = 0.0016$), moderate ($\beta = 1.2454$, $t = 5.8011$, $p < 0.001$), and high levels ($\beta = 1.5926$, $t = 5.3165$, $p < 0.001$), psychological stress scale scores exhibited a significant positive predictive effect on sleep quality scale scores, with the positive predictive effect being stronger as psychological stress scale scores increased. Given that sleep quality was reverse coded in this study, this finding can be further interpreted as follows: psychological stress level among medical students was negatively associated with sleep quality, and the negative predictive effect strengthened as the levels of psychological stress increased. Furthermore, this conclusion was consistently verified by the Johnson-Neyman significance region analysis and the slope of the line in Figure 1.

4 Discussion

4.1 Electronic device use time negatively predicts self-rated health among medical students

Based on cross-sectional survey data, this study explored the influencing pathway of electronic device use time on self-rated health among medical students, providing empirical reference for the intervention of health behaviors and the improvement of health levels among medical students. The results demonstrated that electronic device use time significantly negatively predicted self-rated health among medical students, supporting Hypothesis 1.

This finding is consistent with the direction of conclusions from most existing studies. Previous research has confirmed the negative association between electronic device use and individual health: at the physiological level, excessive screen exposure is not only closely associated with decreased sleep quality, reduced physical activity, and increased sedentary time but may also exacerbate the risks of myopia, cardiometabolic diseases, neuroinflammation, and obesity (23). At the psychological level, prolonged screen time is prospectively associated with mental health symptoms in adolescents, increasing the risk of negative emotions (24), and exerting certain impacts on students' cognitive abilities, language skills, and social-emotional adaptation. A meta-analysis further confirmed that longer screen time is associated with higher health risks (25). Additionally, studies have found that the type and purpose of electronic device use have significant impacts on adolescents' mental health: the use of mobile phones and tablets is closely related to psychological issues such as academic stress and anxiety, while the use of electronic devices for chatting, gaming, and other purposes shows a stronger association with depression. Compared with ordinary college students, medical students face high-intensity academic pressure, clinical practice demands, and employment stress, making them prone to outbreaks

of negative emotions and subsequent compensatory screen dependence, which may further increase health risks (26).

However, some studies have concluded differently from this study, suggesting that electronic device use can promote interpersonal communication among young people, facilitate access to health information, alleviate emotional stress, and enhance wellbeing (27). In reality, however, many young people may struggle to effectively translate acquired electronic health information into health-related behaviors due to immature cognitive development and limited self-regulatory capacity (28). Existing research has also confirmed that the overall prevalence of sub-health among medical students is 62.2%, and the use of mobile phones and computers may indirectly affect the physiological sub-health status of medical students by influencing their physical activity (5). Confronted with triple pressures from academics, practice, and employment, coupled with the frequent occurrence of tense doctor-patient relationships and public health incidents in recent years, medical students are more likely to experience poor sleep quality, depression, and other health problems (29). In this context, medical students may increase their electronic device use time (e.g., watching videos, searching for health information, learning more professional knowledge) to relieve stress, assist sleep, and even conduct health management. This does not conflict with the conclusions of this study; instead, it suggests that we should strengthen health education on health-promoting lifestyles for medical students, guide them to reasonably control nighttime electronic device use time, use electronic devices to obtain health information, and conduct regular health check-ups. Additionally, sports activities and mental health programs should be organized to alleviate the academic and employment stress of medical students, enhance their e-health literacy, and promote the translation of such literacy into practical actions.

4.2 The mediating role of sleep quality

Mediation effect analysis was employed in this study, which elucidated that sleep quality exerts a key mediating role between electronic device use time and self-rated health, supporting Hypothesis 2. This finding complements, to a certain extent, the gaps in existing research that have primarily focused on the mutual influence between electronic device use and sleep quality, as well as the impact of sleep quality on mental health. It also provides new empirical evidence for deciphering the mechanisms underlying the influence on medical students' health.

The results of this study are consistent with the conclusions of most existing research. Previous studies have confirmed that electronic device use affects sleep quality through physiological and psychological mechanisms, among which blue light exposure inhibiting melatonin secretion is the core pathway (30). A study on adolescents showed that sleep problems are associated with anxiety, depression, increased heart rate, elevated blood pressure, and heightened stress (31), while positive health behaviors such as daily screen time less than 2 h, good sleep quality, and sufficient sleep duration are linked to favorable self-rated health (10). Based on the Media System Dependency Theory and the Time Displacement Hypothesis (32), medical students, under multiple pressures from practice and employment, tend to rely on electronic device use to meet their needs for entertainment, relaxation, and information acquisition, which in turn crowds out their time for study, physical activity, and rest. The pleasure derived from electronic device use may further extend its usage duration, potentially leading to sleep rhythm disruption. Sleep plays a crucial role in maintaining normal

physiological functions, improving quality of life, and enhancing happiness, and it is one of the strongest predictors of self-rated health (33), as well as being associated with psychological issues such as anxiety among college students (34). Anderson's Health Service Utilization Behavior Model also provides theoretical support for this study (35), indicating that electronic device use can directly affect physical and mental health or indirectly influence self-rated health through mediating pathways such as interfering with sleep behavior, cognitive function, and social interaction (36, 37).

However, certain discrepancies exist between the results of this study and those of some existing research. Some studies suggest that there is no significant association between electronic device use time and sleep quality, but the timing of mobile phone use before bedtime may affect sleep outcomes (38). Furthermore, different types of screen content consumed within 1 h before bedtime have varying impacts on sleep quality: activities such as watching movies, socializing, and browsing may reduce sleep quality, while sleep-aid videos may improve it (39). These discrepancies may stem from multiple factors: first, differences in measurement tools—this study used average daily electronic device use time as the independent variable, while some studies have focused on the timing or purpose of electronic device use; second, the particularity of the medical student group and potential cognitive biases may have influenced the results; third, the interference of reverse effects between variables, inadequate consideration of control variables, or the dilution of association strength by other potential influencing variables. For instance, some medical students may offset, to a certain extent, the negative impact of electronic device use on sleep quality through other health behaviors such as physical activity or diet; alternatively, the reverse effect of sleep quality on electronic device use time, as noted earlier, may also interfere with the results of this study.

Therefore, future research should subdivide the scenarios and purposes of electronic device use and incorporate more variables, such as diet and physical activity, for in-depth exploration. In practice, it is necessary to guide medical students to reduce electronic device use at night, implement multi-path interventions, including cognitive behavioral therapy, health behavior education, and monitoring, to help them develop good sleep habits. Medical students should also be encouraged to participate in physical activities, while strengthening employment training and psychological stress counseling to promote the development of healthy behaviors and the improvement of health awareness among medical students.

4.3 The moderating role of psychological stress

This study further confirmed that psychological stress moderated, to a certain extent, the predictive effect of electronic device use time on sleep quality among medical students. Specifically, higher levels of psychological stress were associated with a stronger negative predictive effect of electronic device use time on sleep quality, supporting Hypothesis 3. This finding is consistent with the “snowball effect model” (22), providing partial empirical support for deciphering the differential mechanisms underlying impaired sleep quality among medical students.

Existing studies have indicated that electronic device use time could affect adolescents' sleep quality through psychological responses such as anxiety, stress, and mood disturbances (40, 41).

Psychological stress refers to a set of specific psychological reactions that arise when individuals fail to effectively cope with pressures in study or work, typically manifested as anxiety, tension, fatigue, and withdrawal (42). Due to the particularities of their professional training system, clinical practice, and future employment, medical students face multiple current and future stressors, resulting in relatively high levels of psychological stress. Studies have shown that medical students or medical personnel are a high-risk group for psychological stress trauma; long-term exposure to stress is prone to inducing sub-healthy symptoms such as gastrointestinal disorders and sleep disturbances, which may impair physiological and psychological functions (43), consistent with the conclusions of this study.

By integrating the biopsychosocial (BPS) medical model (44) with the group-specific “dual academic-clinical pressure” experienced by medical students, the moderating mechanism of psychological stress could be explained at multiple levels. At the physiological level, long-term psychological stress can continuously activate the hypothalamic–pituitary–adrenal (HPA) axis, disrupting the pre-sleep physiological rhythm of “decreased cortisol and increased melatonin.” Meanwhile, blue light from electronic devices can further inhibit melatonin secretion. Moreover, medical students often extend nighttime electronic device use time due to academic and practical needs, resulting in significantly longer average daily blue light exposure than ordinary college students (45). The combined effect of these two factors directly leads to the disappearance of the “sleep onset window,” consistent with recent research findings on high-stress populations. At the psychological and behavioral levels, based on the Cognitive Activation Theory and the Uses and Gratifications Theory, psychological stress may shift medical students' motivation for electronic device use from “functional academic needs” to “escape-oriented stress relief,” thereby trapping them in a vicious cycle wherein electronic device use results in temporary stress relief, followed by stress recurrence and subsequent longer electronic device use. From the social dimension of the BPS model, medical students themselves face superimposed pressures of long electronic device use time, academic tasks, and clinical practice; under the stimulation of high psychological stress levels, their sleep quality may further decrease. This result is of great significance for stratified and classified interventions on medical students' health behaviors.

This section explored the influencing mechanisms among electronic device use time, psychological stress, and sleep quality among medical students, verifying and expanding relevant theories. However, the moderating coefficient of psychological stress was relatively low, which may be attributed to the complex joint influence mechanism of the two factors on sleep quality: first, the dominant role of physiological mechanisms, such as melatonin inhibition caused by electronic device use, may be stronger; second, there may be a bidirectional relationship between psychological stress levels and sleep quality. Based on the “Compensation Theory,” medical students with high psychological stress levels may use electronic devices to relieve stress for short-term sleep assistance; third, poor sleep quality may inversely increase psychological stress levels or electronic device use time. All these factors may interfere with the estimation of the moderating effect. In the future, it will be necessary to incorporate professional health behavior measurement tools to collect more objective data on psychological stress levels and sleep, fully consider

the bidirectional influence mechanisms among variables, and construct a more scientific and comprehensive model.

4.4 Study limitations

Despite the findings of this study, several limitations remain. First, constrained by its cross-sectional design, this study may not fully clarify the absolute causal relationship between electronic device use time and self-rated health among medical students. Additionally, self-administered questionnaires may introduce certain recall and self-report biases. Future research could employ professional health measurement tools and cohort studies to obtain more scientific longitudinal data. Moreover, this study was focused on one specific city, Hefei, Anhui Province, limiting its research scope. However, Hefei is a core hub for medical education in Anhui Province and ranks at an upper-middle level nationally in terms of socioeconomic development, making it broadly representative of such similar cities. Furthermore, given the common features of current medical training models and shared academic and clinical pressures, the findings of this study could be generalized to the broader medical student population. Finally, this study only examined the internal mechanisms involving four primary variables: electronic device use, sleep quality, self-rated health, and psychological stress. Future research could further explore the roles of device type, usage purposes, and time of use within various pathways, incorporate additional mediating and moderating variables (e.g., type and purpose of electronic device use, diet, physical activity), and consider more control variables such as contextual environmental factors, family influences, and policy factors to further enrich the understanding of self-rated health status among medical students.

5 Conclusion

In summary, this study innovatively investigated the relationships and mechanisms among electronic device use time, psychological stress, sleep quality, and self-rated health in medical students. The findings demonstrate that electronic device use time negatively predicts self-rated health in this population, with sleep quality exerting a mediating role and psychological stress moderating the first segment of the mediating pathway. In light of the above results, future research should further expand the sample scope and incorporate more variables for in-depth exploration. Based on cognitive behavioral therapy, efforts should be made to improve the self-rated health levels of medical students and promote their physical and mental health development through multiple aspects, including health knowledge and policy promotion, health behavior education, stress counseling, health behavior monitoring, regular health check-ups, and the translation of health knowledge into practical behaviors.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding authors.

Ethics statement

The studies involving humans were approved by Anhui Medical University. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

XMei: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. WP: Data curation, Investigation, Methodology, Writing – review & editing. XD: Data curation, Formal analysis, Investigation, Software, Writing – review & editing. XMa: Investigation, Methodology, Writing – review & editing. RW: Formal analysis, Investigation, Writing – review & editing. YP: Conceptualization, Investigation, Writing – review & editing. JH: Formal analysis, Investigation, Methodology, Writing – review & editing. ZB: Supervision, Validation, Writing – review & editing. XZ: Supervision, Validation, Writing – review & editing.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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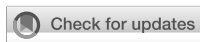
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References

- Meng X, Huang L, Peng T, Chen Y, Wang Y, Zhao L, et al. Current status and influencing factors of poor body posture among medical students. *Chinese J Health Voc Educ.* (2025) 43:127–31. doi: 10.20037/j.issn.1671-1246.2025.16.33
- Mohd Saat NZ, Hanawi SA, Hanafiah H, Ahmad M, Farah NM, Abdul Rahman NAA. Relationship of screen time with anxiety, depression, and sleep quality among adolescents: a cross-sectional study. *Front Public Health.* (2024) 12:1459952. doi: 10.3389/fpubh.2024.1459952
- Liu LJ. The effects of junior high school students' participation in school physical activity on negative emotions—an empirical analysis based on ceps data. *J Shenyang Sports Institute.* (2023) 42:29–35. doi: 10.12163/j.ssu.20210714
- Lv Z, Zheng R, Xu H, Min X, Chen J, Li D, et al. Influencing factors of sleep quality among medical students: a case study of a medical college in Hubei Province. *J Modern Prevent Med.* (2024) 51:4116–20+77. doi: 10.20043/j.cnki.MPM.202406092
- Shang J, Cheng H, Chen D, Tian R, Gao L, Guo B. Structural equation analysis of the impact of lifestyle behaviors on subhealth status among medical students J modern preventive medicine (2024) 51:1479–85. doi: 10.20043/j.cnki.MPM.202310345,
- Sampasa-Kanyinga H, Colman I, Goldfield GS, Janssen I, Wang J, Podinich I, et al. Combinations of physical activity, sedentary time, and sleep duration and their associations with depressive symptoms and other mental health problems in children and adolescents: a systematic review. *Int J Behav Nutr Phys Act.* (2020) 17:72. doi: 10.1186/s12966-020-00976-x
- Pathak S, Wang H, Seals K, Adusumilli NC, Holston D. Self-assessed health status and obesity vulnerability in rural Louisiana: a cross-sectional analysis. *PLoS One.* (2023) 18:e0287181. doi: 10.1371/journal.pone.0287181
- Gong C, Li Y, Chen G. Relationship between physical exercise and risk of depression: an assessment of intermediate variables through self-assessed health status and life satisfaction in the Chinese family tracking survey (CFPS) data. *Risk Manag Healthc Policy.* (2024):3315–25. doi: 10.2147/RMHP.S499489
- Hu F, Qin W, Xu L. Impact of physical exercise on self-rated health among rural university students at different educational levels. *Chinese J Rural Health Admin.* (2024) 44:889–94. doi: 10.19955/j.cnki.1005-5916.2024.12.010
- Nehme M, Schrempft S, Baysson H, Pullen N, Rouzinov S, Stringhini S, et al. Associations between healthy behaviors and persistently favorable self-rated health in a longitudinal population-based study in Switzerland. *J Gen Intern Med.* (2024) 39:1828–38. doi: 10.1007/s11606-024-08739-1
- Du J, Miao L, Yang W. Exploring the long-term impact of social media dependence on university students' mental health and intervention strategies. *J Commun Forum.* (2025) 17:63–5. doi: 10.16723/j.cnki.yycg.2025.17.021
- Tian Y, Yang Z, Zhang J, Zou X, Feng J, Zhu B, et al. Moderating effect of body mass index on the relationship between anxiety and depression. *Chinese J Gen Pract.* (2022) 25:1368–72. doi: 10.12114/j.issn.1007-9572.2021.01.416
- Huang Y, Zhang L, Li N, Xiao Z, Dai Y. Relationship between social media addiction and anxiety among university students: the mediating role of sleep procrastination and the moderating role of perceived stress. *J Modern Prevent Med.* (2024) 51:3756–61. doi: 10.20043/j.cnki.MPM.202407048
- Yin H, Xiao L, Li D. Relationship between executive control under stress and depressive states: the moderating role of rumination tendency. *J Psychol Res.* (2019) 12:461–8. doi: 10.3969/j.issn.1003-5184.2019.05.011
- Nelson KL, Davis JE, Corbett CE. Sleep quality: an evolutionary concept analysis. *Nurs Forum.* (2022) 57:144–51. doi: 10.1111/nuf.12659
- Liu X, Tang M, Hu L, Wang A, Wu H, Zhao G, et al. Reliability and validity study of the Pittsburgh sleep quality index. *Chinese J Psychiatry.* (1996) 2:103–7. doi: 10.3760/j.issn.1006-7884.1996.02.018
- Kim Y, Shim J. Relevance of self-rated health level and mental health in Korean adolescents. *Front Public Health.* (2025) 13:1526127. doi: 10.3389/fpubh.2025.1526127
- Kaplan RM, Hays RD. Health-related quality of life measurement in public health. *Annu Rev Public Health.* (2022) 43:355–73. doi: 10.1146/annurev-publhealth-052120-012811
- Chen T, Li L. Comparison between the second and first editions of the SF-36 health-related quality of life measurement instrument. *Chinese J Soc Med.* (2006) 2:111–4. doi: 10.3969/j.issn.1673-5625.2006.02.015
- Group MoECMSHERZhang R, Deng L, Zhang Z, Guo Z. Development of the Chinese college students mental health scale. *J Psychol Behav Res.* (2005) 2:102–8. doi: 10.3969/j.issn.1672-0628.2005.02.004
- Hayes AF. *Introduction to mediation, moderation, and conditional process analysis: a regression-based approach.* New York: Guilford Publications (2017).
- Ji L, Shang B, Zhao M, Zhang C, Han M. Intergenerational emotional support and depressive symptoms among migrant elderly: a moderated mediation model. *J Mod Prev Med.* (2025) 52:2619–24. doi: 10.20043/j.cnki.MPM.202501015
- Alzhrani AM, Aboalshamat KT, Badawoud AM, Abdouh IM, Badri HM, Qurunfulah BS, et al. The association between smartphone use and sleep quality, psychological distress, and loneliness among health care students and workers in Saudi Arabia. *PLoS One.* (2023) 18:e0280681. doi: 10.1371/journal.pone.0280681
- Khan A, McLeod G, Hidajat T, Edwards EJ. Excessive smartphone use is associated with depression, anxiety, stress, and sleep quality of Australian adults. *J Med Syst.* (2023) 47:109. doi: 10.1007/s10916-023-02005-3
- Zhang Y, Tian S, Zou D, Zhang H, Pan C-W. Screen time and health issues in Chinese school-aged children and adolescents: a systematic review and meta-analysis. *BMC Public Health.* (2022) 22:810. doi: 10.1186/s12966-022-01309-0
- Kong L, Ran X, Zhang Q, Tian Q, Gao J. Relationship between adolescent mental health and screen time: analysis based on restricted cubic spline models. *J Mod Prev Med.* (2025) 52:2198–204. doi: 10.20043/j.cnki.MPM.202412073
- Chen J, Liang K. Correlation study of sleep quality, physical activity, screen time, and subjective well-being among university students. *J Chaochu Univ.* (2023) 25:139–45+64. doi: 10.12152/j.issn.1671-5896.2023.06.019
- Ha L, Chang Q, Chen X. Impact of ehealth literacy on well-being among medical students: a chain mediation of basic psychological needs and negative emotions. *Chin J Health Psychol.* (2023) 31:1381–8. doi: 10.13342/j.cnki.cjhp.2023.09.019
- Liu W, Song M, Zhao T, Guo S, Huang F, Liu B, et al. Investigation of depressive symptoms and related factors among medical students. *Chin J Ment Health.* (2023) 37:172–8. doi: 10.3969/j.issn.1000-6729.2023.02.014
- Lee JJ, Wang MP, Luk TT, Guo N, Chan SS-C, Lam TH. Associations of electronic device use before and after sleep with psychological distress among Chinese adults in Hong Kong: cross-sectional study. *JMIR Ment Health.* (2020) 7:e15403. doi: 10.2196/15403
- Chalmers T, Hickey BA, Newton P, Lin C-T, Sibbritt D, McLachlan CS, et al. Associations between sleep quality and heart rate variability: implications for a biological model of stress detection using wearable technology. *Int J Environ Res Public Health.* (2022) 19:5770. doi: 10.3390/ijerph19095770
- Fleur M, Ball-Rokeach S. *Theories of mass communication.* New York: Longman (1982).
- Liu Y, Lai X, Wu J, Qiao X. Impact of sleep duration on self-rated health and its age differences. *J Popul Dev.* (2020) 26:65–72+50. doi: 10.3969/j.issn.1673-5161.2020.03.007
- Li X, Liu C. How do mobile phones interfere with adolescents' sleep? An empirical study based on national data. *J China Youth Study.* (2023) 7:26–33. doi: 10.19633/j.cnki.11-2579/d.2023.0096
- Andersen RM. National health surveys and the behavioral model of health services use. *Med Care.* (2008) 46:647–53. doi: 10.1097/MLR.0b013e31817a835d
- Bal M, Kara Aydemir AG, Tepetas Cengiz GS, Altındağ A. Examining the relationship between language development, executive function, and screen time: a systematic review. *PLoS One.* (2024) 19:e0314540. doi: 10.1371/journal.pone.0314540
- Sun L, Li K, Zhang L, Zhang Y. Distinguishing the associations between evening screen time and sleep quality among different age groups: a population-based cross-sectional study. *Front Psych.* (2022) 13:865688. doi: 10.3389/fpsy.2022.865688
- Yeluri K, Hs K, H BG, Bj SC. Electronic gadget screen-time, perceived sleep quality & quantity and academic performance in medical students. *J Assoc Physicians India.* (2021) 69:11–2. doi: 10.18231/j.jpmh.2021.003
- You C, Cui Y. Effect of one-hour pre-sleep screen content on university students' nocturnal sleep quality. *Chinese J School Health.* (2024) 45:1446–50. doi: 10.16835/j.cnki.1000-9817.2024324
- Nakshine VS, Thute P, Khatib MN, Sarkar B. Increased screen time as a cause of declining physical, psychological health, and sleep patterns: a literary review. *Cureus.* (2022) 14:e30051. doi: 10.7759/cureus.30051
- Han X, Zhou E, Liu DJ. Electronic media use and sleep quality: updated systematic review and meta-analysis. *J Med Internet Res.* (2024) 26:e48356. doi: 10.2196/48356
- Zheng H, Song X, Li H, Geng P, Meng T, Zhang H, et al. Psychological stress responses of medical staff after workplace violence: a longitudinal study. *Am J Transl Res.* (2022) 14:5598–604.
- Zhang Y, Wang Y. Correlation study of psychological stress, help-seeking behavior, and sleep quality among emergency department staff in tertiary hospitals. *J Occup Health.* (2024) 40:3384–90. doi: 10.13329/j.cnki.zyyjk.2024.0618

44. Harrison DE, Oakley PA, Moustafa IM. Don't throw the 'bio' out of the bio-psycho-social model: editorial for spine rehabilitation in 2022 and beyond. *J Clin Med.* (2023) 12:5602. doi: 10.3390/jcm12175602
45. Zhao Y. Mediating role of social anxiety in the relationship between perfectionism and mobile phone dependence among university students in Nanjing. *J Modern Prevent Med.* (2019) 46:2213–6. doi: 10.3969/j.issn.1001-0688.2019.12.023



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Social representations of Portuguese children about the coronavirus: a contribution to health education and developing life skills

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Introduction: The COVID-19 pandemic has substantially affected daily life around the world. Social isolation, fear of infection, and discussion of protective measures were strongly conveyed in media and social discourse, including among children. Given this social dynamic, it is important to understand how the children's Social Representations (SR) of coronavirus were formed so that health education strategies and life skills development can be devised.

Objective: This study aimed to analyse the elements that potentially constitute the central core of Portuguese children's SR about the coronavirus.

Methods: Twenty-two children aged 9–12 years from a district in northern Portugal participated in the study. Data collection included administering a free word evocation test (FWET), which enabled interpretation through prototypical and maximum similarity analyses, and asking children to make drawings from the trigger term "coronavirus," which were analysed using content analysis.

Results: Based on the data, the elements that emerged as possible components of the central core of the children's SR were "illness," "death," "masks" and "virus."

Conclusion: This study reinforces the importance of school health education combined with the media disseminating scientific and health information. It can also inspire and guide future work focused on children's health education and life skills development.

KEYWORDS

central core, children's drawings, health promotion, maximum similarity analyses, prototypical analysis

1 Introduction

During the COVID-19 pandemic, digital media played a central role in shaping how the disease was understood, discussed, and responded to by different social groups. In this context, some people engaged in social movements that shared information leading to perceptions of COVID-19 vaccine threats and vaccine hesitancy (1). Indeed, although digital media served to disseminate measures to protect against the COVID-19 virus, it also provided a fertile ground for the spread of fake news about health and vaccination (2), as Gaspi and collaborators (3) point out: "the advent of social media has amplified movements that cast doubt on the efficacy of vaccination, promoting the spread of so-called 'fake news' through these platforms".

It is important to highlight that the children were not merely passive recipients of information, but rather active social agents who constructed meanings about the coronavirus through their interactions with the media, family, and school. Therefore, there is a need for educational and communicative responses to the rapid spread of misinformation, through health education directed at young people (4). Schools are a key setting for developing children's and adolescents' life skills to enhance health education and improve school health promotion (5). Life skills development is recognised as a valuable tool in the service of education, health and social interaction (5). Thus, social interactions in the circulation of information about the COVID-19 pandemic can be shared, whether digitally or not, enabling the structuring of Social Representations (SR), as designated by Moscovici (6). These SR, in turn, permeate the subjects' discourses, enable communication between individuals, and contribute to the construction of a shared reality (7).

The lockdown measures adopted in response to coronavirus pandemic altered social interactions and underscored the relevance of life skills in this context. In light of the foregoing, this study aims to analyse the elements that may constitute the central core of Portuguese children's SR about the coronavirus, with the aim of informing school-based health education and life skills development. The decision to analyse children's SR came from both the unique impact that the pandemic has had on this social group, due to social isolation and changes in their daily lives (8), and from the relevance of childhood as a period of intense meaning-making, in which SR can be formed and guide their social practices (9).

Several studies have examined children's behaviour during the COVID-19 pandemic. For example, there is an analysis of the memories of children aged 8 to 16 years about their experiences over a year of the pandemic and how their psychological well-being changed during that period (10). In another study, Miao and collaborators (11) conducted a systematic review of longitudinal studies that addressed the mental health of children and adolescents during the COVID-19 pandemic, which allowed the identification of an increase in anxiety and depressive symptoms among young people. Despite these studies, there is still a gap in research on how children socially represent the coronavirus. In particular, no empirical studies were found that analyse the SR of COVID-19 in Portuguese children and their implications for health education and the development of life skills.

Despite this lack of research, the potential of such investigations can be observed in Iraklis (12) work, who conducted a study with Greek children aged 4 to 6 years using drawings accompanied by verbalisations. The study focused on understanding the representation of the COVID-19 virus and identified three main themes: the scientific knowledge children possessed about the virus; the perception of the virus as an enemy to be fought; and the understanding that confinement and isolation measures were necessary to prevent contamination. The findings of the cited work suggest that constructing this knowledge is necessary to propose post-pandemic health promotion strategies, build capacity to respond to future health and vaccination crises, and strengthen health literacy programs.

When research focuses on understanding the structure of SR, it is common to adopt a structuralist approach (09, 25), which has Jean-Claude Abric as its pathfinder. He developed the Central Core Theory (CCT), which describes that SR function as a system of interpretation of reality that governs people's relationships with their physical and social environments, determining their behaviours and practices (13). According to the CCT, a SR consists of a central core (CC) and a

peripheral system. The core is understood as the most stable and resistant part of the representation, whereas the peripheral system is flexible and variable (14). It adjusts itself and allows the contextualisation of a SR across different situations experienced by the social group. The peripheral system is composed of distinct zones that vary in their proximity to the central core and in their degree of stability (14).

Understanding the structure and functions of SR is essential for analysing how social groups construct shared meanings about phenomena, which in turn shape their practices and perspectives within a given social context. In this study, we adopt the structural approach to identify the central core and peripheral elements of Portuguese children's SR about the coronavirus. Identifying the central core is particularly relevant for educational practice, as these elements organise meanings and orient behaviours, providing a theoretical basis for the design of school-based health education interventions aimed at promoting informed understanding and strengthening children's life skills.

2 Methodology

This research is classified as mixed-methods, encompassing qualitative and quantitative analyses, offering both subjective and objective views of the data and thereby generating a broader understanding of the phenomenon under study (15). The structuralist approach to SR was adopted because it allows the central core and peripheral regions of the subjects' SR to be identified, as proposed by the CCT (13).

The research subjects were 22 pupils from two fifth-year classes in two public primary schools located in different municipalities within the district of Braga, in northern Portugal. A convenience sampling strategy was adopted. The participants comprised 12 boys, 9 girls, and one child who chose not to identify their gender. In terms of age, they ranged from 9 to 12 years old ($M = 10.33$ years, $SD = 0.73$; one participant did not report age). The pupils from both classes were taught by a teacher who collaborated with the research and was responsible for data collection in her own classrooms. The schools and classes were selected based on accessibility and institutional collaboration, and all pupils in the selected classes were invited to participate. Participation was voluntary, and informed consent was obtained from the pupils' legal guardians prior to data collection.

The choice of this age group was intentional, as children aged 9 to 12 years are in a developmental stage characterised by increasing cognitive, linguistic, and social abilities, which enable them to articulate meanings, engage in social dialogue, and construct shared understandings about socially relevant phenomena. In addition, children in this age range consciously experienced the COVID-19 pandemic and its impacts, such as school closures. Therefore, they represent an appropriate group for investigating SR about the coronavirus and its implications for health education and life skills development within the school context. It is also important to note that the data obtained in this study cannot be generalised, as they reflect the SR of a specific social group: children aged 9 to 12 years from public schools in northern Portugal. Even if data collection were conducted in another country with the same age group, the findings could be substantially different, given that the social contexts in which children are embedded—and, consequently, the media they are exposed to and the dialogues they engage in—may differ from those characterising the context of the present study.

The data were collected in 2024 through a questionnaire comprising three stages: (i) the first stage collected children's personal information, such as gender, age, school, and city; (ii) in the second stage, the Free Word Evocation Technique (FWET) was used; and (iii) in the third and last stage the children expressed what they understood about the evocation term through drawings.

The FWET was adopted because it allows subjects to spontaneously express the terms that come to mind and are most accessible to their consciousness (16, 17) in response to an inducing term, in this research, the word “coronavirus.” Thus, children wrote down the first five words that came to their minds when they thought of the term coronavirus. Immediately afterwards, they were asked to rank these words by importance, with 1 being the most important and 5 the least. The process of ranking words is important because it allows subjects to rethink and reorganise the words evoked according to their relevance (18, 19). The term hierarchisation stage enables research participants to carry out a “[...] re-evaluation and subsequent cognitive reorganisation of the sequence in which the words were initially presented” (20). This procedure allows identification of which elements are most important to the participants and directly affects the allocation of evoked terms within the quadrants of the Vergès diagram, since the degree of importance attributed to the evoked terms is directly related to the calculation of the Mean Order of Evocation (MOE).

One of the procedures commonly included in the FWET is the request for justifications for each evoked word, which allows for a more in-depth semantic analysis and supports the categorisation of the terms. However, in this study, only six participants provided written justifications, which were extremely brief and insufficient for a consistent qualitative analysis. Therefore, to ensure equitable treatment of the data across participants, the justifications were excluded from the analytical procedures, and the categorisation of the evoked terms was based solely on lexical criteria.

In the third and final stage, the children expressed, through drawings, what they understood of the evocative term. Indeed, drawings are used in SR research because they allow subjects to express their ideas and feelings freely (21). Furthermore, it is a relevant technique for research involving children, as it can provide them with an opportunity to share their fears, feelings, and thoughts about sensitive issues (19).

Data collection was conducted in person on a single day, within the school setting, and on an individual basis, under the supervision of the previously mentioned collaborating teacher. The teacher received prior instructions regarding the data collection procedures and the administration of the activities. The entire data collection session lasted approximately two hours.

Before detailing the data analysis procedures, it is important to note that no pilot application of the instruments described was conducted. However, the instructions for the FWET and the drawing activity were previously standardised, following protocols well established in the literature (see, respectively, studies 09 and 03). Thus, these instruments are considered appropriate for the participant population of this study.

The data were analysed using a combination of analytical techniques: for data resulting from FWET, prototypical and similarity analyses were used; for the drawings, Bardin's (22) Content Analysis (CA) was used, based on the work of Gaspi (19). Initially, the words evoked by the subjects were grouped according to lexical criteria, with words naming related elements placed in the same group (14). After this stage, the data analysis began.

Prototypical analysis is based on two criteria: the MOE of words and frequency (f) to construct the Vergès diagram (23), also known as the four-house diagram, which allows identification of the potentially central core and peripheral region of the SR. Frequency is calculated by summing the number of times the words in a group are repeated, while the MOE can be calculated using Equation 1.

$$MOE = \frac{\Sigma G}{f} \quad (1)$$

Where: ΣG is the sum of the degree of importance assigned to words and f is the frequency of evocation (14). After calculating the frequency and group MOE, the mean of these frequencies and MOE were calculated, where the Frequency mean (F_m) is given by the ratio between the sum of the frequencies and the number of groups, and the MOE mean (MOE_m) by the ratio between the sum of the MOE and the number of groups (14). These mean values were adopted as cut-off points, in accordance with the structural approach of SR proposed by Vergès, allowing the distinction between high and low frequency and between early and late evocations.

Prototypical analysis uses quantitative indicators to organise the data. These indicators help researchers qualitatively interpret the SR structure. More specifically, “[...] the criteria of frequency and order of evocation complement each other and provide two collective indicators to characterise the salience of a word within a corpus generated by a group” (16). These metrics are used to allocate words to the quadrants of the Vergès diagram, thereby guiding the analysis. However, the definition of the structural role of the elements depends on a qualitative interpretation, grounded in the social context and in the theoretical framework adopted.

Based on these cut-off values, the Vergès diagram was constructed, following its predefined structure: groups with high frequency and low MOE were allocated to the first quadrant and represent the possible core of the SR; groups with high frequency and high MOE were part of the second quadrant; groups with low frequency and low MOE were in the third quadrant; and, finally, groups with low frequency and high MOE were in the fourth quadrant (14, 24). Based on the diagram, the elements potentially comprising the central core and the peripheral regions of the participants' SR were identified, and reflections on them were outlined.

It is worth noting that, in this study, the analysis focused on elements potentially constituting the central core, as this component plays a key role in organising meaning within the SR, so that a change in the core automatically implies a change in the SR (24, 25).

The next step was a similarity analysis to complement the prototypical analysis and to strengthen the interpretation of elements potentially constituting the central core. To this end, the IRaMuTeQ (“Interface de R pour les Analyses Multidimensionnelles de Textes et de Questionnaire”) software was used to create the maximum similarity tree, where the circles represent the frequency of evocation of the groups, with larger circles indicating that the elements of this group were evoked more often (salience). The edges, or branches, connecting these circles represent the similarity index, i.e., how often two concepts were evoked simultaneously (24). In addition, the number of branches or connections a group has to other groups indicates its likelihood of belonging to the central core, as core elements tend to connect naturally with more elements (26). This analysis technique relates the number of lexical groups and the similarity index (14).

Similarity analysis also employs quantitative indicators to structure the data. In this case, indices of co-occurrence between evoked elements, the strength of the links, and the degree of connectivity among elements are considered. These parameters are calculated using IRaMuTeQ, are grounded in graph theory, and “[...] contribute to the identification of word co-occurrences which, in turn, reveal connections that facilitate the understanding of the structure of a text” (20). Although these indicators organise the data, the interpretation of the links between elements and their structural relevance depends on a qualitative reading guided by the theoretical framework of SR and by the conceptual contributions mobilised to understand the object under investigation.

The final stage was the analysis of the drawings, in which a thematic categorical analysis of CA was performed, which consisted of discovering the ‘core of meaning’ (22) that make up communication and whose presence, or frequency of appearance, may mean something for the chosen analytical object. The stages defined by Bardin (22) were followed: (i) pre-analysis, (ii) exploration of material, and (iii) treatment of results, inference, and interpretation, taking into account the analysis of drawings carried out by Gaspi (19) as summarised in Figure 1.

In the first stage, a more general analysis of the drawings was carried out, separating them by theme and organising them into recording units. In the second stage, categories and subcategories for analysis were created based on the recording units. Finally, the categories were counted and, based on this, inferences and interpretations of the results were made (19, 22, 27). We underline that the drawings were analysed jointly by two of the authors. An inductive coding approach was adopted, involving the identification, analysis, and discussion of the elements present in the children’s drawings. This collaborative process aimed to achieve the consensual construction of categories. As the analysis was conducted through a consensus-based approach rather than independent coding, interrater agreement indices, such as Cohen’s Kappa, were not applicable.

It is worth noting that, according to the CCT, the identification of central elements through structural analyses should be understood as hypothetical and requires complementary methods for confirmation. Accordingly, the present study focuses on identifying elements that may constitute the central core rather than asserting its definitive composition.

Finally, regarding ethical and legal aspects, it should be noted that this study is part of a research project developed within a Brazilian higher education institution. The project was submitted to and approved by the Permanent Committee for Ethics in Research with Human Beings at the State University of Maringá, under Opinion No.

6,946,568 and Certificate of Ethical Appraisal No. 79619724. 3.0000.0104. As previously mentioned, data collection was authorised by the participating institutions where the collaborating teacher works, and informed consent was obtained from the children’s parents or legal guardians prior to data collection. As researchers responsible for the study, we ensured the anonymity of the participants and the confidentiality of the data. We also ensured that the data collected is used exclusively for research purposes.

3 Results and discussion

With the collected data, the first step was to group the 104 words evoked by the children into lexical groups. Although we asked each participant to evoke five words related to the trigger term “coronavirus,” two evocations were discarded because they did not fit into any of the 15 groups formed; two children evoked 4 words, and another evoked only 3.

The calculations described in the Methodology were also performed to obtain the *f* and MOE values for each lexical group and their averages. Thus, 5.93 was obtained for *Fm* and 3.01 for MOEm. The Vergès Diagram was then created, as shown in Table 1.

Regarding the prototypical analysis, the results indicate that the elements that may comprise the core of children’s rational responses to coronavirus are “disease,” “death,” and “virus.” Commonly, in the application of the TALP (Test of Learning to Read), research participants are asked to justify their choice of words through short texts. However, in this research, only 6 of the 22 students completed this step. Therefore, to standardise data treatment, these justifications were disregarded.

Given the evocations, it is possible to infer that the students understand that coronavirus infection can progress to illness and that this can lead to death, demonstrating an understanding of how the infection occurs and the dangers it poses. This observation corroborates the findings of Folino and collaborators (28), who reported that children in Rio de Janeiro were aware of the risks of coronavirus contamination, the importance of preventive care, and, in some cases, the association between infection and death.

It is also possible to identify similarities with the work of Figueiredo and collaborators (29), who observed a high level of health literacy among students regarding COVID-19. In that study, the research participants demonstrated knowledge of the virus’s effects and recognition of the importance of adopting measures to prevent infection, reflecting knowledge and awareness of

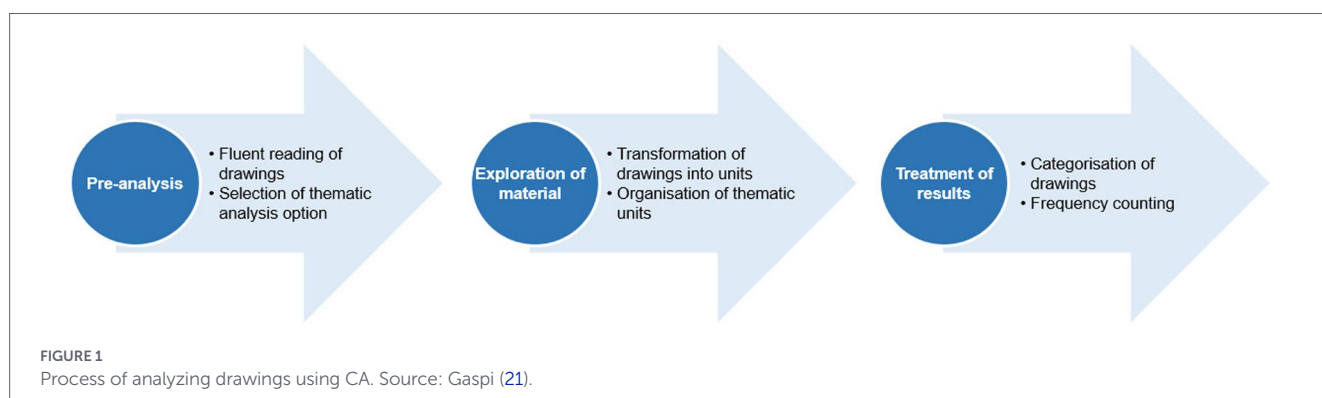


TABLE 1 The Vergès diagram with the distribution of lexical groups based on the children's evocations about "coronavirus".

Word	f	OME
Central elements - 1st quadrant		
High f and low mean order of evocations $f \geq 5.93$ e $OME < 3.01$		
Illness	20	2.35
Death	9	2.66
Virus	7	1.00
Intermediate elements - 2nd quadrant		
High f and high mean order of evocations $f \geq 5.93$ e $OME \geq 3.01$		
Masks	11	3.64
Pandemic	9	3.44
Hospital	8	3.25
Intermediate elements - 3rd quadrant		
Low f and low mean order of evocations $f < 5.93$ e $OME < 3.01$		
Cough	4	2.75
Lockdown	3	2.66
Hand sanitiser	2	1.50
Sadness	2	2.00
Symptoms	2	3.00
Peripheral elements - 4th quadrant		
Low f and high mean order of evocations $f < 5.93$ e $OME \geq 3.01$		
Danger	4	3.25
Depression	3	4.33
Flu	3	4.33
Vaccines	2	5.00

the importance of safe behaviours, mainly arising from media coverage of the pandemic and perceptions of its potential severity (29).

Three other groups that stand out are those in the second quadrant ("masks," "pandemic," and "hospital"), which have a high frequency but a lower OME than OME_m. This configuration indicates that these elements may form the central core of some children's SR, but they are not sufficiently representative to constitute the central core of the whole children's social group.

A final highlight is made for the elements' vaccines' and 'flu,' which make up the last quadrant. Although the data were collected after vaccination, and some of these students or their family members likely contracted the virus at some point, these terms are not structured as nuclear elements of their SR; however, they are present on the periphery, indicating greater fragility and a tendency to change over time.

Although the prototypical analysis has provided clues about the possible elements that comprise the children's RS central core, it is common to use similarity analysis to confirm these elements (14, 19, 30). Thus, using the IRaMuTeQ software, the maximum similarity tree was constructed and is shown in Figure 2.

The similarity analysis reveals that the elements "illness," "masks," and "virus" stand out as centralising groups, with a greater number of other branches originating from them. Ten branches stem from the "Illness" group, five of which have a high similarity index, while three branches stem from the "masks" and "virus" groups, one of which has a high index. Thus, it is possible to state that these elements are possibly part of the central core of the children's SR, since the greater the number of branches emanating from an element (connectivity), the greater the probability that it belongs to the core, as core elements connect with a greater number of other elements in a natural way, i.e., they have a strong associative power (31).

The maximum similarity tree (Figure 2) corroborates the Vergès Diagram (Table 1) and confirms the possible children's RS central core. In the prototypical analysis, the elements "illness" and "virus" are in the first quadrant of the diagram, whereas in the similarity analysis, they appear as centralisers.

Although there is a divergence regarding the element "death": in the Vergès Diagram, it is in the central core (Table 1), but in the maximum similarity tree (Figure 2), it cannot be characterised as a component of the central core because it is not linked to several other elements. Furthermore, the term "masks" was placed in the second quadrant in the prototypical analysis (Table 1), whereas it took a central role in the maximum similarity tree (Figure 2). The divergence in interpretation of these terms allows for a critical discussion of the media's role in the pandemic context. At that time, the constant dissemination of updated infection and death numbers across various media outlets was common. The intense circulation of the term "death" within this communicational context contributed to its early evocation by children, configuring it as a highly salient element in their SR.

Nevertheless, the term "death" does not perform the same organising function for practices and lived experiences as the term "masks," since the latter is directly related to children's everyday experiences during the pandemic and carries a practical, concrete, and experiential meaning. Wearing masks became an action incorporated into children's school, family, and social routines, which favoured its articulation with a greater number of elements within the representational field. Thus, "masks" assumes the role of a practical organiser of the meanings attributed to the pandemic, whereas "death" constitutes a socially strong and widely disseminated symbol, but one with a lower relational capacity within the structure of children's SR.

As shown in the methodological section, data triangulation was performed using prototypical, similarity, and CA. After interpreting the findings from the first two analyses, the description of what was observed in the CA begins. Two main themes were extracted from the children's drawings ("actions aimed at protection" and "lack of care") following the CA interpretation process described by Gaspi (19). The first theme consisted of categories that demonstrate individual, collective, or emotional elements shown in the children's drawings. The second theme was formulated from a single category, focusing on the process of viral contamination and its consequences. Table 2 shows how the subcategories and categories were distributed within the aforementioned themes.

The first category, "devices for individual care," of the theme "actions aimed at protection" comprises three subcategories: "masks," "hand sanitiser," and "gloves" (Table 2). The presence of these elements in the children's drawings shows that they understand and can

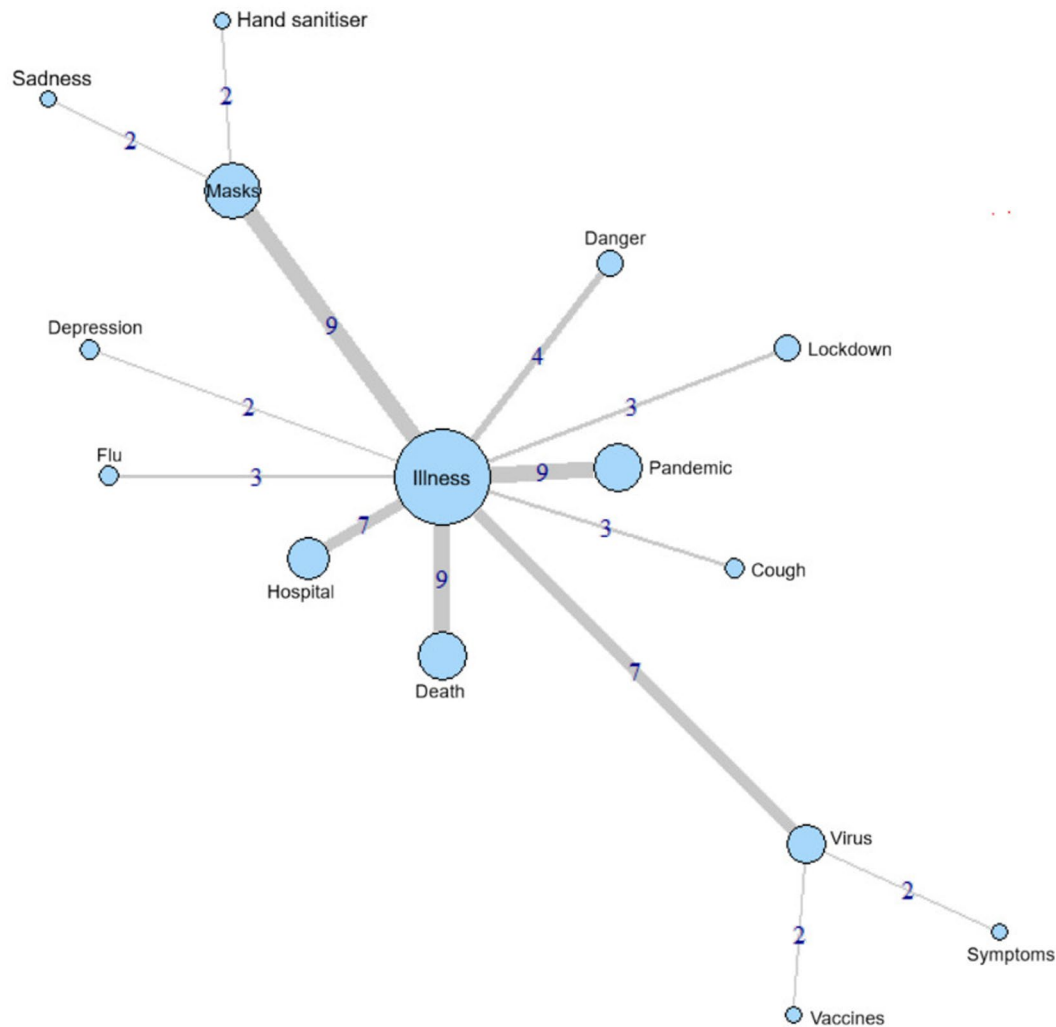


FIGURE 2
Maximum similarity tree of children's evocations about "coronavirus".

TABLE 2 Thematic categorical analysis of children's drawings.

Theme	Category	Subcategory	Frequency
Actions aimed at protection	Devices for individual care	Masks	5
		Hand sanitiser	1
		Gloves	1
	Collective prevention measures	Blockage	2
		Lockdown	1
	Emotions	Apathy	1
		Sadness	1
		Aggressiveness	7
		Happiness	2
Lack of care	Contamination	Death	2
		Hospital	2
		Virus	19
		Droplets	2
		Illness	2

illustrate the importance of these mechanisms as a strategy for preventing viral contamination. Figure 3 shows an example of a children's drawing that includes these three elements.

Figure 3 shows several mechanisms of viral protection. The child was able to elucidate that the mask acts as a shield, preventing saliva droplets from being expelled into the air and carrying the virus. In addition, the child was also able to indicate the use of hand sanitiser and gloves to strengthen protection. This visual representation corroborates previous results by Gaspi (19), who shows children's awareness of preventive measures. She also points out that the development of this awareness may be related to the dissemination of widely publicised information during the pandemic. This dissemination of information is based on the role of the mass media, which, according to Anwar and collaborators (32), is essential for promoting health education. These authors also argue the need for the media to disseminate public knowledge about maintaining a distance of 2 m, the proper use of face masks, and appropriate guidelines for recognising, diagnosing, and treating the disease (33).

The "Collective prevention measures" category under the same theme ("actions aimed at protection") comprises two subcategories, "blockage" and "lockdown" (Table 2 and Figure 4).



FIGURE 3

A child's drawing made in response to the trigger term "coronavirus," included in the subcategory "devices for individual care".

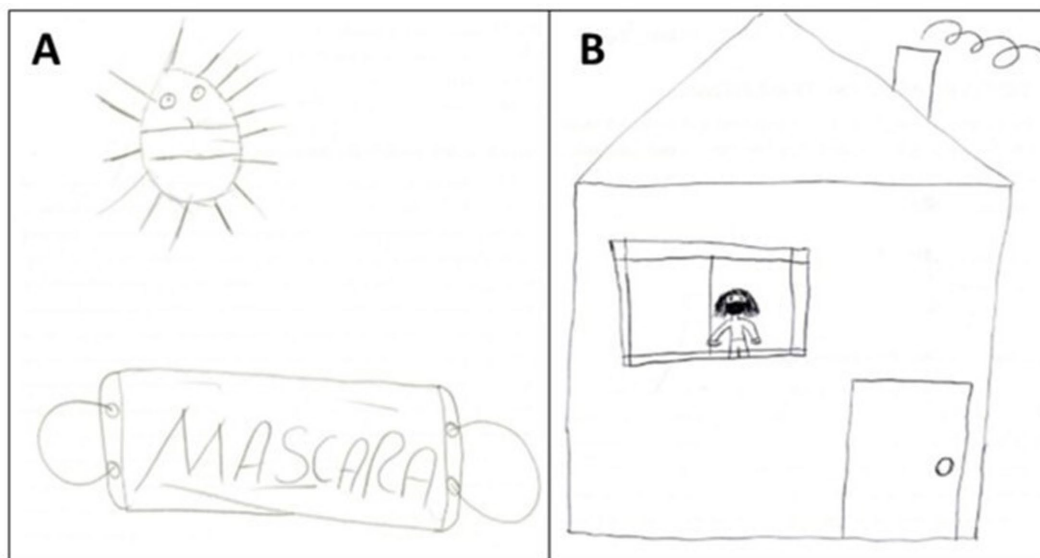


FIGURE 4

Two children's drawings made in response to the trigger term "coronavirus," included in the subcategory "collective prevention measures": "blockage" (A) and "lockdown" (B).

Two children's drawings in Figures 4A,B show that both associated the use of a mask with a barrier. Therefore, the mask is shown to stop the virus from "biting" a person and thereby prevent human infection. The second drawing (Figure 4B) shows a person in lockdown, at home. The lockdown was a hard period, particularly for children, who, although understanding the importance of quarantine/isolation to stop the epidemic, most of these Portuguese age children (57%) were shown to be in favour of returning to face-to-face classes

because it would enable better academic performance than at home (29).

The "Emotions" category under the same theme "actions aimed at protection" comprises four subcategories: "apathy," "sadness," "aggressiveness," and "happiness" (Table 2; Figure 5).

The element of apathy was evident in the drawing in Figure 5A, as reflected in the virus's "facial" expression. The child who drew this picture may have thought of this idea when considering that the virus

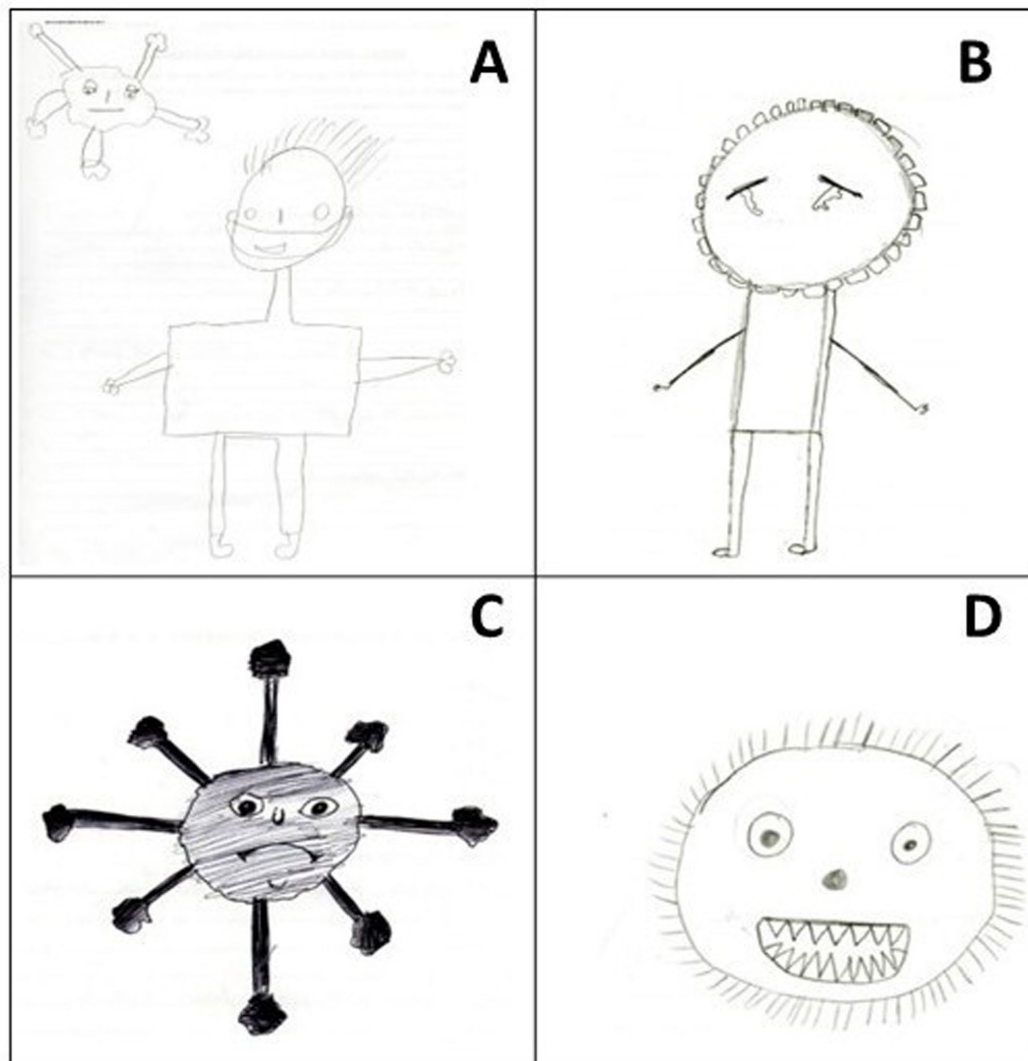


FIGURE 5
Four children's drawings made in response to the trigger term "coronavirus," included in the subcategory "emotion": "apathy" (A), "sadness" (B), "aggressiveness" (C,D).

shows this emotion because the person it intended to infect was wearing a mask, preventing it from succeeding in its goal of infecting him. Furthermore, the sadness emotion is evident in the drawing in [Figure 5B](#), as shown in the infected person's facial expression.

The two lower drawings ([Figures 5C,D](#)) illustrate the virus's aggressiveness, suggesting it is a harmful organism that spreads by infecting people, causing illness and, in some cases, death. In [Figure 5C](#), these traits are conveyed by the angry/furious look the child attributed to the virus; in [Figure 5D](#), this aggressiveness is evident in the virus's sharp teeth, ready to attack and infect people, and in its eyes, which appear to show euphoria. These elements in the drawings reflect a mixture of emotions that recall the students' perceptions of the coronavirus. These data corroborate the study by Idoiaga and collaborators (33), who analysed Spanish children's SR and emotions about the COVID-19 pandemic. The aforementioned study identified emotions of fear and concern about contracting the virus, guilt if they infected others, fear, nervousness, loneliness, sadness, boredom and irritation, as well as security, calm and happiness. Based on these findings, it is clear that the COVID-19 pandemic context has elicited a range of feelings and emotions in children.

Although the present study shows points of convergence with the work of Idoiaga and collaborators (33), important conceptual and methodological distinctions highlight its relevance and contribution to the field of health education. The Spanish study focused on children's immediate emotional and symbolic responses during the confinement period, whereas the present work, by adopting the structural approach to SR, enabled the identification of elements that stabilised in children's cognitive structure over time, since it was conducted several years after the peak of the pandemic. Furthermore, the findings provide a basis for planning health education and life skills interventions by allowing a deeper understanding of how pandemic-related meanings are reorganised, stabilised, and pedagogically mobilised within the sociocultural context investigated.

The second theme, "Lack of care," includes the category 'contamination,' which in turn includes five subcategories: "death," "hospital," "virus," "droplets," and "illness," with the virus the most representative, with a total of 19 elements evident in the children's drawings ([Table 2; Figure 6](#)).

[Figure 6A](#) illustrates the most serious consequence of Coronavirus infection, "death." According to the child's explanation, the person on

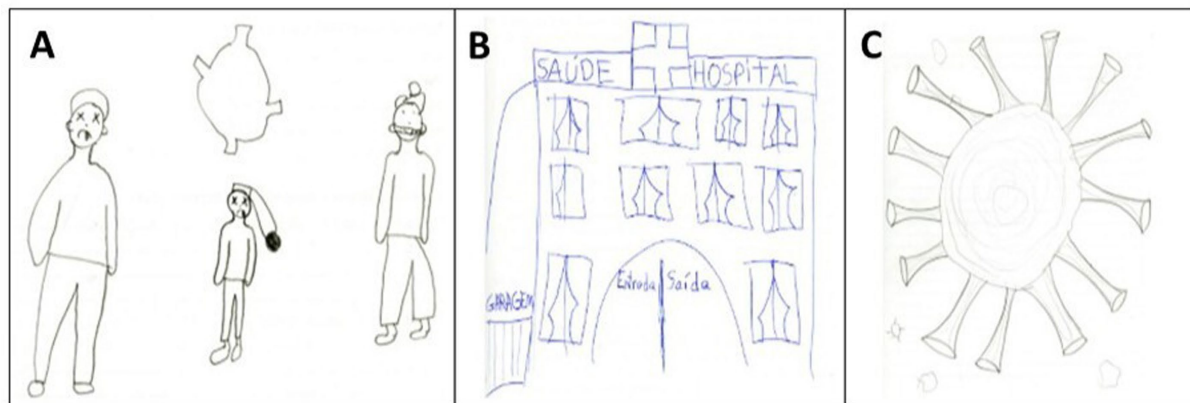


FIGURE 6

Three children's drawings made in response to the trigger term "coronavirus," included in the subcategory 'contamination' category: "death," "hospital," "virus," "droplets," and "illness".

the right is the only one wearing a mask and is alive; the other two were not wearing masks and are dead, evidencing the protective measure. Interestingly, this child's message demonstrates awareness that viral contamination can be fatal. This notion is common among children, as Sousa and collaborators (34) reported that 56% of 2 to 11-year-old children mentioned death when asked what happens to a person who contracts coronavirus.

As a note, not everyone who becomes infected with coronavirus develops COVID-19 (35). This distinction between what the virus is and what the disease is was not observed in the present study, which analysed specific evocations and drawings made in response to the trigger term "coronavirus."

Figure 6B shows a hospital. It can be inferred that the child associated this space with a reference centre for treating people who contracted the virus at some point and therefore needed medical care.

Finally, Figure 6C illustrates the coronavirus, which is somewhat faithful to the virus's structure as widely depicted in the media and reflects what was observed in most of the children's drawings. Indeed, the children's drawings reflected an attempt to visually reproduce the coronavirus as commonly represented in the media, particularly its spherical shape and tubular structures, except for size proportions, which are, of course, submicroscopic.

In view of the analyses presented herein, it should be noted that the possible central core of the children's group SR is formed mainly by the elements "illness," "death," and "virus," which were somewhat representative and were verified in the three analysis procedures. From the perspective of SR, social groups elaborate shared systems of meaning that enable them to interpret unfamiliar phenomena and integrate them into everyday thinking (6). This convergence suggests that these elements occupy a prominent position in both children's verbal expressions and their visual representations of the coronavirus. According to the structural approach to SR (13), the central core organizes the system of meanings associated with the representational object and provides stability to the representation by defining its fundamental significance. In this sense, the recurrence of these elements in children's responses suggests that they may structure how the pandemic is interpreted by this group.

Although the element "illness" was not explicitly mentioned in the children's drawings, it was implicitly present through visual references to contamination, hospitals, and death, indicating that drawings tend

to emphasise experiential and contextual aspects of the representation rather than abstract labels. This figurative pattern should be interpreted in light of the strong mediation of adult discourse and public communication during the pandemic, processes through which SR are produced and circulated in society (6).

The identification of the aforementioned elements in the drawings illustrates the process of objectification described by Moscovici (6), through which abstract or unfamiliar concepts are converted into concrete images. In the data presented, this process materializes in the figurative representations of the virus, where the invisible microorganism takes on familiar contours and shapes, integrating itself into the symbolic and everyday universe of the children and contributing to the formation of a figurative nucleus of the representation.

Data triangulation further supports the interpretation of "masks" as a possible element of the central core of children's SR. In the CA, this element appeared explicitly in five of the children's drawings, indicating its relevance in their symbolic elaborations of the pandemic. In the similarity analysis, "masks" assumed a centralising role, showing strong connections with other elements and occupying a structurally strategic position within the representational network. From the perspective of the structural approach to SR, elements located in the second quadrant of the Vergès diagram—as observed for "masks" in this study—may reflect either central elements for specific subgroups or elements belonging to the peripheral system that are undergoing a process of centralisation. As proposed by Abric (13), elements located outside the central core, particularly in the peripheral system, may acquire greater organising power over time and potentially integrate the central core as the representation stabilises. Taken together, the evocation task and the drawings function in a complementary manner: while evocations highlight the salience of symbolic elements circulating in social communication, drawings reveal how these elements are concretely experienced and re-signified in children's everyday lives.

One factor that stood out in the analyses was the absence of any mention of the vaccination process, given that the data collection (2024) occurred after the nationwide implementation of the vaccine. This absence suggests the limited symbolic relevance of vaccination within the structure of children's SR, as references to this process did not appear in either the central core or the peripheral system. In studies based on prototypical analysis of free evocations, the presence, frequency, and salience of elements provide important indicators of

the representational structure, making the absence of certain themes analytically meaningful when interpreting the representational field (16). A plausible reason for this is that, at the peak of the pandemic, between 2020 and 2021, these children were very young, aged 6 to 9, and had not yet been vaccinated. Beyond an age-related explanation, this pattern may indicate that vaccination was not incorporated into children's experiential universe, as it was largely framed as an adult-controlled, externally determined practice.

This finding contrasts with studies that have identified vaccination as a salient element in SR related to COVID-19 among adults, often associated with themes such as mistrust, fear of adverse effects, and misinformation (36). In this sense, the limited presence of vaccination in children's representations may also point to opportunities for health education initiatives in school contexts. By promoting discussions about vaccines, their safety, and their role in disease prevention, educational actions may contribute to strengthening children's understanding of vaccination as a scientifically grounded and socially relevant health practice, while also countering the circulation of misinformation surrounding immunization processes.

An important consideration is the temporal distance between the pandemic peak and the time of data collection. Conducting the study at a later stage of the health crisis enabled analysis of which elements became embedded in children's cognitive structure, manifesting in their SR. This decision is consistent with the perspective of SR Theory, which understands meanings as being progressively reorganised and consolidated through social communication and lived experience. Thus, the elapsed time constitutes both a limitation, considering that it may attenuate certain contextual details, and an analytical opportunity to identify the elements that persisted and became structurally significant in children's representations.

We also highlight the significant role of mass media in disseminating information. On the one hand, the media played a crucial role in disseminating strategies for combating the virus and encouraging protective measures, thereby contributing to health promotion. On the other hand, the visual representations shared through the media helped create a visual identity for the virus, as reflected in the drawings of many children. At the same time, this intense exposure to media images may have reinforced fear-centred and biomedical framings of the pandemic, limiting the circulation of meanings related to participation, care, and collective agency.

Finally, it is worth highlighting the predictability of the findings obtained. As discussed previously, the media played a central role in shaping children's meanings about the coronavirus, which makes the identification of the terms "illness," "death," "virus" and "masks" as possible elements of the SR central core of the group analysed understandable. These findings indicate that the central core is structured predominantly around biomedical and threatening elements, rather than preventive elements or those related to action and care. These findings point to the need for school-based interventions that intentionally promote action-oriented, participatory, and reflective approaches to health education, capable of reconfiguring children's representations beyond fear and biomedical threat.

The structuring of the possible central core of the SR becomes concerning insofar as such elements do not necessarily promote the development of life skills. This reflection is particularly relevant in light of the structural approach to SR, in which the central core organises meanings and guides social practices, potentially influencing how children understand, experience, and respond to health-related issues.

4 Final considerations

The COVID-19 pandemic, triggered by the coronavirus (SARS-CoV-2), sparked a wave of insecurity and fear amid the limited information available at the time. The global spread of the virus and its potential for contamination led to significant changes in social dynamics, directly impacting people's daily lives. Among the initial biosafety measures was social isolation, which confined the population to their homes, with media reports being their primary source of information and guidance.

In this context, health education and life skills development emerged as a crucial tool for enhancing communication between health professionals and citizens, thereby facilitating the development of educational and health promotion initiatives. Moreover, the pandemic period has emerged as a crucial area of research, particularly in understanding its impacts on mental health. The loss of physical contact and the pervasive fear of virus transmission have been recurring themes. Children, especially, have been significantly affected, having to distance themselves from their peers and educators, often within an unstable family environment. The way children perceive and construct their understanding of the coronavirus is pivotal, as it can influence educational health actions and decision-making. It underscores the critical importance of investigating their SR of the coronavirus, which is the primary focus of this study.

Thus, the SR of Portuguese children regarding the term "coronavirus" were investigated to understand what they understand about the topic and identify possible gaps in these representations. The results showed children's knowledge of ways to protect themselves from coronavirus contamination, as well as the notion that it can lead to illness and death. Children presented a visual representation consistent with the broad virus's composition expressed through drawings, which can be explained by the role of the mass media in spreading this information.

The data obtained allow us to infer that the probable central core of the social representations of the coronavirus among the Portuguese children who comprised the investigated group is structured around biomedical and threat-related elements, more specifically, the terms "illness," "virus," "death," and "masks." These elements were consistently observed across the three analyses conducted and reflect the influence of social communication and lived experiences during the pandemic, revealing how children symbolically organised their understanding of the crisis. From an educational perspective, recognising these representational structures is essential for planning health education interventions that move beyond risk-centred narratives and promote life skills, critical thinking, and active participation in health-related practices.

In view of the discussions presented, it can be concluded that the children's group investigated holds SR about the coronavirus that are influenced by scientific knowledge and may result from health education and life skills campaigns conveyed by the media during the COVID-19 pandemic. These campaigns, which are important mechanisms for constructing and sharing representations, can empower children to make informed decisions about their health and safety.

An important aspect to highlight is the particularity of this study's findings. In this regard, it is worth noting that research grounded in SR does not aim at generalisation, since representations are constituted through social interactions situated within specific sociocultural contexts. Nevertheless, the findings presented here are relevant insofar as they provide insight into how a specific group of children elaborated, organised, and re-signified meanings about the coronavirus.

within a defined historical and territorial context, revealing which elements became more persistent and structurally significant in their social representations over time. Although the findings are not generalisable, they offer important analytical contributions to understanding processes of symbolic construction in educational contexts.

These results reinforce the importance of school health education combined with the media disseminating scientific and health information. Results also underscore the importance of identifying children's SR regarding the coronavirus, as this can significantly inform the development of health education and the construction of scientific knowledge about viruses and diseases. Finally, this study can inspire and guide future work focused on children's health education and life skills development.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by Permanent Committee for Ethics in Research with Human Beings at the State University of Maringá. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin. Written informed consent was obtained from the minor(s)' legal guardian/next of kin for the publication of any potentially identifiable images or data included in this article.

Author contributions

CM: Investigation, Conceptualization, Methodology, Writing – review & editing, Supervision, Validation, Formal analysis, Software, Project administration, Writing – original draft, Data curation. LD: Formal analysis, Writing – review & editing, Data curation, Writing – original draft, Investigation, Methodology, Software. FB: Software, Writing – review & editing, Methodology, Formal analysis, Writing – original draft, Investigation, Data curation. TV: Supervision, Funding acquisition, Writing – review & editing, Formal analysis, Data curation.

GC: Formal analysis, Data curation, Supervision, Writing – review & editing, Funding acquisition.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The author(s) declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

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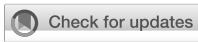
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References

- Ramkissoon H. Social bonding and public trust/distrust in COVID-19 vaccines. *Sustainability*. (2021) 13:10248. doi: 10.3390/su131810248
- Oliveira L, Magalhães Júnior CAO, Darlington E. *Science Denialism and the Covid-19 Pandemic: Fake News and Social Representations*. Ponta Grossa: Texto e Contexto (2023).
- Gaspi S, Magalhães Júnior CAO, Tracana RB, Schneider EM, Carvalho GS. Vaccination: a look at the social representations of Brazilian children. *Front Public Health*. (2024) 12:1434513. doi: 10.3389/fpubh.2024.1434513
- Anastácio ZC, Silva TC, Antão CM, Braide ASG, Battisti IDE, Carvalho GS. Influence of human biology and health (HBH) teaching-learning process on students' conceptions of the COVID-19 vaccine. *Sustainability*. (2023) 15:41. doi: 10.3390/su15010041
- Darlington-Bernard A, Salque C, Masson J, Darlington E, Carvalho GS, Carrouel F. Defining life skills in health promotion at school: a scoping review. *Front Public Health*. (2023) 11:1296609. doi: 10.3389/fpubh.2023.1296609
- Moscovici S. *Social Representations: Investigations in Social Psychology*. Petrópolis: Vozes (2003).
- Ortiz AJ, Magalhães Júnior CAO. "Global warming: social representations of students in an agroecology course". In: MLS Ornellas, PMMS Magalhães, MV Paim and D.

- Guimarães, editors. *Anais do VI Simpósio Estadual de Representações Sociais e Educação e I Simpósio Internacional de Educação, Representações Sociais e Subjetividade*. Salvador: UNEB (Universidade do Estado da Bahia). (2016). p. 850–5.
8. Oliveira VH, Martins PC, Carvalho GS. Children's daily activities and well-being during the COVID-19 lockdown: associations with child and family characteristics. *Curr Psychol.* (2024) 43:8346–57. doi: 10.1007/s12144-022-02759-y
9. Gaspi S, Magalhães Júnior CAO, Carvalho GS. Children's social representations on vaccination: contributions to health education. *Revista Brasileira de Ensino de Ciência e Tecnologia.* (2025) 18:1–22. doi: 10.3895/rbect.v18n1.15203
10. Hjuler TF, Lee D, Ghatti S. Remembering history: autobiographical memory for the COVID-19 pandemic lockdowns, psychological adjustment, and their relation over time. *Child Dev.* (2025) 96:55–70. doi: 10.1111/cdev.14131
11. Miao R, Liu C, Zhang J, Jin H. Impact of the COVID-19 pandemic on the mental health of children and adolescents: a systematic review and meta-analysis of longitudinal studies. *J Affect Disord.* (2023) 340:914–22. doi: 10.1016/j.jad.2023.08.070
12. Grigoropoulos I. Children's social representations of this invisible and never previously known COVID-19 virus. *Trends Psychol.* (2025) 33:34–52. doi: 10.1007/s43076-022-00221-3
13. Abric JC. "The structural approach to social representations". In: Moreira ASP and Oliveira DC, editors. *Interdisciplinary Studies of social Representations*. Goiânia: AB Editors. (2000). p. 27–38.
14. Deosti L, Silva FB, Magalhães Júnior CAO. "Methodological path of the Structuralist approach to social representations". In: Magalhães Júnior CAO and Lorenzetti L, editors. *Methodological and Analytical Aspects of Research in Science and Mathematics Education*. Ponta Grossa: Texto e Contexto (2025). p. 135–60.
15. Leite JC, Carmo T. "Nature of research: mixed methodology". In: Magalhães Júnior CAO and Batista MC, editors. *Research Methodology in Education and Science Teaching*. Ponta Grossa: Atena (2023). p. 31–41.
16. Wachelke J, Wolter R. Criteria related to the realization and reporting of prototypical analysis for social representations. *Rev Psicol Teor e Pesq.* (2011) 27:521–6. doi: 10.1590/S0102-37722011000400017
17. Ortiz AJ, Magalhães Júnior CAO. To be physics teacher: social representation in licentiate degree. *Rev Ensaio.* (2019) 21:e10462. doi: 10.1590/1983-21172019210107
18. Gaspi S, Duarte RM, Magalhães Júnior CAO. The teaching perspective on active learning methodologies: an analysis based on the theory of social representations. *Vitruvian Cogitationes.* (2022) 1:135–49. doi: 10.4025/rvc.v1i1.63592
19. Gaspi S. (2023) Social Representations of Brazilian and Portuguese Children about Vaccination: Support for Health Education [Doctoral dissertation, State University of Maringá]. Available online at: http://www.pcm.uem.br/uploads/suelen-de-gaspi-11052023-compressed_1707002002.pdf (Accessed October 03, 2025).
20. Almeida Junior ERB. (2024) Social Representations of Astronomy: A Study in Initial Teacher Training in Pedagogy [Doctoral dissertation, State University of Maringá]. Available online at: <http://www.pcm.uem.br/dissertacao-tese/424> (Accessed October 15, 2025).
21. Rocha D, Carvalho GS. Artistic expressions and symbolism of children's drawings in pediatric oncology: a comparative study between Portugal and Brazil. In: Atas do XI SIEFLAS (Seminário Internacional de Educação Física, Lazer e Saúde): Perspectivas de Desenvolvimento num Mundo Globalizado; (2015); 229–237. Available online at: <https://hdl.handle.net/1822/36343> (Accessed November 01, 2025).
22. Bardin L. *Content Analysis*. São Paulo: Edições (2016).
23. Vergès P. L'évocation de l'argent: une méthode pour la définition du noyau central d'une représentation. *Bull Psychol.* (1992) 45:203–9. doi: 10.3406/bupsy.1992.14128
24. Ortiz AJ, Triani F, Magalhães Júnior CAO. "Social representations: one theory, many paths". In: Magalhães Júnior CAO and Batista MC, editors. *Research Methodology in Education and Science Teaching*. Ponta Grossa: Atena (2023). p. 103–19.
25. Silva FB, Magalhães Júnior CAO, Ortiz AJ. Social representations of quantum physics among undergraduate students: implications of initial training. *Rev Insignare Sci.* (2024) 7:321–45. doi: 10.36661/2595-4520.2024v7n4.14717
26. Carmo T, Leite JC, Gaspi S. "Prototypical and similarity analysis in social representations". In: Magalhães Júnior CAO, editor. *Data Analysis in Science and Mathematics Education*. Ponta Grossa: Texto e Contexto (2024). p. 202–14.
27. Gaspi S, Maron LHP, Magalhães Júnior CAO. "Content analysis from a Bardin perspective". In: Magalhães Júnior CAO and Batista MC, editors. *Research Methodology in Education and Science Teaching*. Ponta Grossa: Atena (2023). p. 103–19.
28. Folino CH, Alvaro MV, Massarani L, Chagas C. The perception of children from Rio de Janeiro about the COVID-19 pandemic, SARS-CoV-2 and viruses in general. *Cad Saude Publica.* (2021) 37:e00304320. doi: 10.1590/0102-311x00304320
29. Figueiredo F, Passadouro R, Alves B, Vieira A, Silva A, Mendes O. Living at school during the Covid-19 pandemic: students' perceptions. *Interacoes.* (2021) 57:251–72. doi: 10.25755/int.24929
30. Ortiz J. (2019) Social Representations of "being a Physics teacher" among Physics undergraduates [Doctoral dissertation, State University of Maringá]. Available online at: <http://www.pcm.uem.br/dissertacao-tese/305> (Accessed October 20, 2025).
31. Sá CP. *Center for Social Representations*. Petrópolis: Vozes (1996).
32. Anwar A, Malik M, Raees V, Anwar A. Role of mass media and public health communications in the COVID-19 pandemic. *Cureus.* (2020) 12:e10453. doi: 10.7759/cureus.10453
33. Idoiaga N, Berasategi N, Eiguren A, Picaza M. Exploring children's social and emotional representations of the COVID-19 pandemic. *Front Psychol.* (2020) 11:1952. doi: 10.3389/fpsyg.2020.01952
34. Sousa E, Maciel E, Müller F. Body, danger, illness and death: representations of children from Maranhão about the coronavirus. *Pro-Posicoes.* (2024) 35:e2024c0803BR
35. Santos NSO, Romanos MTV, Wigg MD. *Human Virology*. Rio de Janeiro: Guanabara Koogan (2015).
36. Santos KCO, Junqueira-Marinheiro MF, Reis AT, Camacho KG, Nehab MF, Abramov DM, et al. Social representations of hesitant Brazilians about vaccination against COVID-19. *Int J Environ Res Public Health.* (2023) 20:6204. doi: 10.3390/ijerph20136204



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The impact of digital literacy on digital resilience among nursing interns: the mediating role of self-efficacy

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Objective: This study aimed to investigate the current status of digital resilience among nursing interns, analyze its relationship with digital literacy and self-efficacy, and examine the mediating role of self-efficacy between digital literacy and digital resilience.

Methods: A cross-sectional study was conducted from August to November 2025 using convenience sampling. A total of 823 nursing interns from eight tertiary Grade A hospitals in China were surveyed using the Digital Resilience Scale for Undergraduate Nursing Students, the Medical Students' Digital Literacy Scale, and the General Self-Efficacy Scale.

Results: The total digital resilience score was 138.95 ± 13.45 . Digital resilience was positively correlated with digital literacy and self-efficacy ($r = 0.713$ and 0.590 , respectively, $p < 0.01$). Self-efficacy partially mediated the relationship between digital literacy and digital resilience, accounting for 19.10% of the total effect.

Conclusion: Digital resilience among nursing interns is moderate with room for improvement. Digital literacy and self-efficacy are significant predictors of digital resilience, with self-efficacy playing a mediating role. These findings suggest that nursing education should integrate digital competency development with psychological empowerment strategies to enhance interns' adaptability in digital healthcare environments.

KEYWORDS

clinical education, digital literacy, digital resilience, mediation analysis, nursing interns, self-efficacy

1 Introduction

The integration of digital technologies such as artificial intelligence, virtual reality, and intelligent nursing systems into clinical practice is transforming healthcare delivery and nursing education (1, 2). Recent developments in 2024–2025 have accelerated this transformation, with generative AI, Internet of Medical Things (IoMT), and predictive analytics becoming integral to patient care (3). The COVID-19 pandemic served as a catalyst for digital health adoption, yet it also exposed significant gaps in healthcare professionals' preparedness for digital environments (4). These technologies not only reshape clinical workflows but also create new learning environments for nursing students, particularly during clinical internships. As future healthcare professionals, nursing interns must develop the capability to adapt to and thrive in digitally mediated clinical settings—a capability conceptualized as digital resilience.

Digital resilience refers to an individual's ability to effectively cope with, adapt to, and recover from challenges encountered in digital environments, including technical failures, information overload, and cybersecurity threats (5). Despite growing recognition of its importance, empirical research on digital resilience remains in its nascent stage, particularly within nursing populations. Existing studies have predominantly focused on general student populations (6) or practicing nurses (7), leaving a significant gap in understanding how nursing interns—who are simultaneously learners and emerging professionals—develop digital resilience during their critical transition from academic to clinical settings. For nursing interns, this resilience directly influences their clinical performance, patient safety outcomes, and professional development (7). Moreover, while digital resilience has been linked to various individual and contextual factors, the psychological mechanisms through which specific competencies translate into resilient behaviors remain poorly understood.

Digital literacy—encompassing the knowledge, skills, and attitudes required to effectively use digital technologies—serves as a foundational competency for navigating digital healthcare environments (8). Recent meta-analytic evidence suggests that digital literacy interventions can enhance professional competencies across healthcare disciplines (9); however, the pathway from literacy to resilient behavior is not direct. Bandura's social cognitive theory (1977) posits that self-efficacy—the belief in one's capability to execute behaviors—mediates the relationship between skills and outcomes, suggesting that digital literacy may influence resilience through confidence-building mechanisms. Previous research suggests that digital literacy may influence digital resilience (10), but this relationship has not been empirically tested in nursing education contexts, and the mediating mechanisms remain speculative.

Self-efficacy, defined as an individual's belief in their capability to execute specific behaviors to achieve desired outcomes (11), has been identified as a critical psychological resource in technology adoption and stress coping. In healthcare education, self-efficacy predicts technology acceptance (12), simulation performance (13), and resilience during clinical transitions (14). However, few studies have examined whether self-efficacy serves as a bridge between digital competencies and adaptive outcomes. Qiu (15) found that self-efficacy mediated the relationship between digital literacy and employability among vocational students, suggesting potential generalizability to healthcare contexts. Nevertheless, the specific role of self-efficacy in linking digital literacy to digital resilience among nursing interns requires empirical verification.

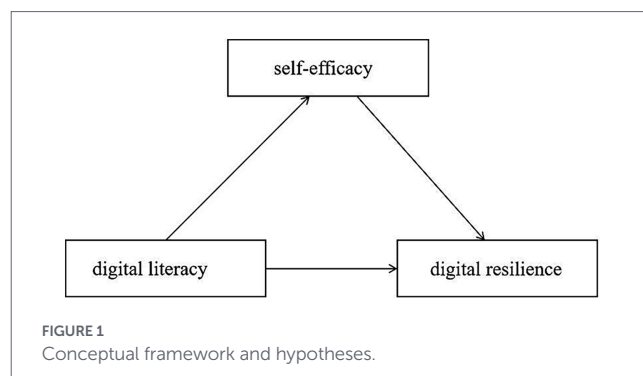
Based on the theoretical framework of social cognitive theory (11) and the emerging empirical evidence on digital competencies in healthcare, this study proposes the following hypotheses (Figure 1):

H1: Digital literacy is positively associated with digital resilience among nursing interns.

H2: Self-efficacy is positively associated with digital resilience among nursing interns.

H3: Self-efficacy mediates the relationship between digital literacy and digital resilience.

These hypotheses are grounded in the theoretical proposition that digital skills enhance confidence, which in turn facilitates



adaptive responses to digital challenges. By testing this mediation model, the study aims to elucidate the psychological mechanisms underlying digital resilience development and provide evidence for targeted educational interventions.

This study aims to address these research gaps by investigating: (1) the current status of digital resilience among nursing interns; (2) the relationships among digital literacy, self-efficacy, and digital resilience; and (3) whether self-efficacy mediates the relationship between digital literacy and digital resilience. The findings will provide empirical evidence to inform educational interventions aimed at enhancing nursing interns' preparedness for digital healthcare environments.

2 Methods

2.1 Study design and participants

A cross-sectional study was conducted from August to November 2025 using convenience sampling, a method commonly employed in nursing research when comprehensive sampling frames are unavailable and when the research aims to explore associations rather than estimate population prevalence (16, 17). While convenience sampling limits generalizability, it facilitates access to specialized populations—in this case, nursing interns actively engaged in clinical rotations—where probability sampling is often impractical (18). To mitigate selection bias, we recruited from eight geographically dispersed tertiary hospitals across multiple provinces in China, ensuring diversity in institutional contexts.

Participants were recruited from eight tertiary Grade A hospitals in China. Inclusion criteria were: (1) full-time nursing students currently completing clinical internships; (2) at least 1 month of clinical experience with digital nursing tools; and (3) voluntary participation with signed informed consent. Exclusion criteria included: (1) non-nursing majors; (2) insufficient clinical experience with digital tools; and (3) cognitive or communication barriers preventing questionnaire completion. This study protocol has been approved by the Ethics Committee of Pingdingshan University (approval number: PDSU20250310). All participants provided informed consent and voluntarily participated in this study.

Sample size was estimated based on the rule of 10–15 participants per predictor variable for multiple regression analysis (19). A total of 20 predictor variables were considered, including demographic

covariates (gender, place of origin, internship duration, digital tool use frequency, digital training participation) and main study variables (digital literacy, self-efficacy). This yielded a minimum required sample of 200–300 participants. Accounting for a 20% non-response rate, the target sample was set at 240–360 participants. The final sample of 823 participants exceeded this requirement, providing >90% statistical power to detect medium effect sizes ($f^2 = 0.15$) at $\alpha = 0.05$ (20). The larger sample also enhances the precision of parameter estimates and the stability of bootstrapped mediation analyses (21).

2.2 Measures

2.2.1 General information questionnaire

This self-designed questionnaire collected demographic and clinical characteristics including gender, age, educational background, internship duration, frequency of digital tool use, and participation in digital skills training.

2.2.2 Digital resilience scale for undergraduate nursing students

The 39-item scale developed by Li (22) was used, comprising five dimensions: digital risk perception, cognitive coping strategies, knowledge and skill acquisition, digital stress management, and digital environment adaptation. Items were rated on a 5-point Likert scale (1 = completely disagree to 5 = completely agree), with total scores ranging from 39 to 195. The scale demonstrated excellent reliability (Cronbach's $\alpha = 0.958$) in this study.

2.2.3 Medical students' digital literacy scale

The 25-item scale developed by Zhang and Wu (23) assessed six dimensions: information and data literacy, communication and collaboration, digital content creation, safety, problem-solving, and profession-related literacy. Items used a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree), with total scores ranging from 25 to 125. The scale showed good reliability (Cronbach's $\alpha = 0.93$).

2.2.4 General self-efficacy scale

The Chinese version of the General self-efficacy scale (GSES) (24), adapted from Schwarzer and Born (25), contains 10 items rated on a 4-point Likert scale (1 = completely incorrect to 4 = completely correct). Total scores range from 10 to 40. The scale demonstrated good reliability in this study (Cronbach's $\alpha = 0.907$).

2.3 Data collection

Electronic questionnaires were administered via a secure online platform. A three-level recruitment approach (university-hospital-department) was implemented. Researchers explained the study purpose, procedures, and confidentiality measures before obtaining informed consent. Questionnaires with logical inconsistencies, high response patterns (>90% identical responses), or unusually short completion times were excluded. Of 844 distributed questionnaires, 823 were valid (response rate: 97.50%).

2.4 Data analysis

Data were analyzed using SPSS 26.0 and the PROCESS macro (Model 4) (31). The analytical strategy proceeded in four stages to test the hypotheses:

Stage 1: Descriptive and preliminary analyses. Descriptive statistics (means, standard deviations, frequencies) were computed for all variables. Independent samples *t*-tests and one-way ANOVA were conducted to examine group differences in digital resilience across demographic and clinical characteristics, informing covariate selection for subsequent models.

Stage 2: Correlation analysis. Pearson correlation coefficients were calculated to examine bivariate relationships among digital literacy, self-efficacy, and digital resilience, providing preliminary evidence for hypothesized associations (H1, H2).

Stage 3: Hierarchical regression. Multiple linear regression was employed to assess the predictive effects of digital literacy and self-efficacy on digital resilience while controlling for significant demographic covariates. This step tested the direct effects specified in H1 and H2.

Stage 4: Mediation analysis. To test H3 regarding the mediating role of self-efficacy, Model 4 of the PROCESS macro was utilized with bootstrapping (5,000 resamples) to estimate 95% bias-corrected confidence intervals for indirect effects. Bootstrapping was preferred over the Sobel test due to its robustness to non-normal sampling distributions of indirect effects and its superior power for detecting mediation in medium-sized samples (26). Mediation was confirmed if the 95% CI for the indirect effect excluded zero. Statistical significance was set at $p < 0.05$.

3 Results

3.1 Demographic characteristics and digital resilience status

Participants had a mean digital resilience score of 138.95 ± 13.45 (Table 1). The highest scores were observed for "adaptation to digital environments" (4.19 ± 0.61) and "knowledge and skill acquisition" (3.89 ± 0.65), while lower scores were found for "digital risk perception" (3.03 ± 0.51), "cognitive coping strategies" (2.86 ± 0.60), and "digital stress management" (2.82 ± 0.51) (Table 1).

3.2 Group differences in digital resilience

ANOVA and *t*-tests revealed significant differences in digital resilience scores based on gender, hometown location, internship duration, frequency of digital tool use, and participation in digital training ($p < 0.05$). No significant difference was found for educational level ($p = 0.188$) (Table 2).

3.3 Correlation among digital resilience, digital literacy, and self-efficacy in nursing interns

Digital resilience was positively correlated with both digital literacy ($r = 0.713$, $p < 0.01$) and self-efficacy ($r = 0.590$, $p < 0.01$). Digital literacy and self-efficacy were also positively correlated ($r = 0.668$, $p < 0.01$) (Table 3).

3.4 Hierarchical regression analysis of digital resilience among nursing interns

Taking digital literacy as the independent variable and digital resilience as the dependent variable, with self-efficacy as the mediating variable, and incorporating the four statistically significant variables from Table 2 as covariates, Model 4 in the Process component was employed for multiple linear hierarchical regression analysis. The results are presented in Table 4, and the relationship model is illustrated in Figure 2.

Regression results supported H1 and H2. In Step 1, digital literacy significantly predicted digital resilience ($\beta = 0.702, p < 0.001$). In Step 3, after controlling for self-efficacy, digital literacy remained significant ($\beta = 0.567, p < 0.001$), while self-efficacy also demonstrated significant prediction ($\beta = 0.196, p < 0.001$), supporting the partial mediation hypothesis (H3).

TABLE 1 Digital resilience scores among nursing interns ($n = 823$).

Dimension	Total score	Item mean score
Digital resilience	138.95 $\pm$ 13.45	3.56 $\pm$ 0.35
Digital risk perception	33.37 $\pm$ 5.61	3.03 $\pm$ 0.51
Cognitive coping strategies	17.16 $\pm$ 3.60	2.86 $\pm$ 0.60
Knowledge and skill acquisition	38.87 $\pm$ 6.51	3.89 $\pm$ 0.65
Digital stress management	14.15 $\pm$ 2.54	2.82 $\pm$ 0.51
Digital environment adaptation	29.35 $\pm$ 4.29	4.19 $\pm$ 0.61

TABLE 2 Factors associated with digital resilience scores.

Variable	<i>n</i>	Digital resilience score	<i>F/t</i>	<i>P</i>
Gender			−2.443	0.015
Male	182	136.81 $\pm$ 13.87		
Female	641	139.57 $\pm$ 13.29		
Level of education			1.319	0.188
Associate degree	285	139.82 $\pm$ 12.58		
Bachelor's degree	538	138.51 $\pm$ 13.90		
Place of origin			−2.128	0.034
Rural	323	137.72 $\pm$ 13.53		
Urban	500	139.76 $\pm$ 13.37		
Internship duration			16.765	0.000
1–3 months	272	135.77 $\pm$ 13.35		
4–6 months	259	138.73 $\pm$ 12.78		
>6 months	292	142.20 $\pm$ 13.27		
Digital tool use frequency			9.443	0.000
Occasional (<3 times/week)	80	133.53 $\pm$ 10.96		
Sometimes (3–5 times/week)	260	137.85 $\pm$ 13.15		
Often (6–10 times/week)	315	139.28 $\pm$ 13.94		
Frequent (>10 times/week)	168	142.79 $\pm$ 13.06		
Participation in clinical digital skills training			17.200	0.000
Did not participate	247	135.75 $\pm$ 13.53		
Participated occasionally (1–2 times)	338	138.64 $\pm$ 12.48		
Participated regularly (≥ 3 times)	238	142.72 $\pm$ 13.82		

3.5 Testing the mediating effect of digital literacy and self-efficacy on digital resilience among nursing interns

The Bootstrap method was applied with 5,000 resamples to calculate 95% confidence intervals. The analysis of the mediating effect of self-efficacy between digital literacy and digital resilience is presented in Table 5. The bootstrapped mediation analysis confirmed H3. The indirect effect of digital literacy on digital resilience through self-efficacy was statistically significant (effect = 0.118, 95% CI [0.090, 0.177]), indicating that self-efficacy partially mediates the relationship. The proportion of mediation was 19.1%, suggesting that while self-efficacy is an important mechanism, digital literacy also exerts substantial direct effects on resilience.

4 Discussion

4.1 Analysis of digital resilience, digital literacy, and self-efficacy levels among nursing interns

The overall level of digital resilience among nursing interns was found to be moderately high. This finding is consistent with recent studies by Mo et al. (7) among Chinese clinical nurses and Son et al. (27) among nursing students in the AI era, who reported moderate to high resilience levels in digitally mediated healthcare contexts. The

TABLE 3 Correlations among digital resilience, digital literacy, and self-efficacy in nursing interns.

Item	Score	Total score of digital resilience	Total score of digital literacy	Total score of self-efficacy
Digital resilience total score	138.96 ± 13.46	1		
Digital literacy total score	67.18 ± 15.29	0.713**	1	
Self-efficacy total score	23.59 ± 4.34	0.590**	0.668**	1

***p* < 0.01.

TABLE 4 Multiple linear hierarchical regression analysis of the mediation model involving digital resilience, digital literacy, and self-efficacy.

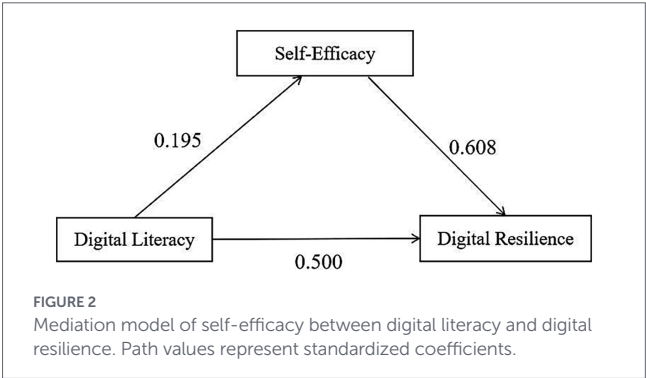
Item	Step 1			Step 2			Step 3		
	β	<i>t</i>	<i>p</i>	β	<i>t</i>	<i>p</i>	β	<i>t</i>	<i>p</i>
Constant	–	31.400	0.000	–	11.802	0.000	–	27.247	0.000
Gender	0.092	4.136	0.000	0.093	3.654	0.000	0.073	3.370	0.001
Place of origin	–0.031	–1.377	0.169	–0.120	–4.647	0.000	–0.007	–0.334	0.738
Internship duration	0.172	7.730	0.000	0.013	0.516	0.606	0.169	7.809	0.000
Frequency of digital nursing tool usage	0.154	6.899	0.000	0.002	0.074	0.941	0.153	7.060	0.000
Participation in clinical digital skills training	0.165	7.399	0.000	–0.023	–0.910	0.363	0.169	7.796	0.000
Total digital literacy score	0.702	31.260	0.000	0.686	26.571	0.000	0.567	18.982	0.000
Total self-efficacy score							0.196	6.601	0.000
<i>R</i> ²	0.600			0.470			0.620		
Adjusted <i>R</i> ²	0.597			0.466			0.617		
<i>F</i> -value	<i>F</i> (6,816) = 203.880, <i>p</i> = 0.000			<i>F</i> (6,816) = 120.752, <i>p</i> = 0.000			<i>F</i> (7,815) = 190.096, <i>p</i> = 0.000		

p* < 0.05, *p* < 0.01.

dimensions of “adapting to the digital environment” and “acquiring knowledge and skills” received relatively high scores, reflecting the effectiveness of current nursing curricula in developing technical competencies (2). While the scores for “perceiving digital risks,” “cognitive coping strategies,” and “overcoming digital stress” were comparatively lower. This pattern mirrors findings from Ang et al’s (28) systematic review on digital training for resilience, which identified risk perception and stress management as consistently underdeveloped areas across healthcare education programs. The discrepancy between technical skills and adaptive capacities suggests that current training may overemphasize tool proficiency while neglecting the psychological and strategic components of resilience (29).

The digital literacy level of this cohort of interns was moderate, consistent with findings from studies on medical student populations (23). The improvement of digital literacy relies on systematic training and practical opportunities (9). In this study, interns who used digital nursing tools more frequently and participated in digital training more often had correspondingly higher digital literacy scores, suggesting that sustained digital practice and training are effective pathways to enhance digital literacy (13).

The self-efficacy score was at a moderate level, indicating that interns have a fair degree of confidence in facing challenges within digital environments, but there is still potential for strengthening. As an internal driver of individual behavior, the level of self-efficacy directly influences an individual’s persistence and adaptability when encountering difficulties with digital technologies (11). The results of this study show significant positive correlations between self-efficacy and both digital literacy and digital resilience, suggesting that enhancing self-efficacy could be a crucial entry point for improving digital adaptability (13).



4.2 Analysis of the mediating role of self-efficacy between digital literacy and digital resilience

This study found that self-efficacy plays a partial mediating role between digital literacy and digital resilience, accounting for 19.10% of the total effect. This indicates that digital literacy not only directly influences digital resilience but also indirectly enhances it by boosting an individual’s self-efficacy. Higher digital literacy makes interns more familiar with digital tools and information environments, thereby strengthening their sense of confidence and control in digital scenarios (10). This enhanced efficacy, in turn, encourages them to seek solutions and adjust coping strategies more proactively when facing digital challenges, ultimately improving their overall digital resilience (29). Therefore, it is recommended to systematically implement digital literacy education, integrating content on digital tool usage, information

TABLE 5 Analysis of the mediating effect of self-efficacy between digital literacy and digital resilience.

Item	Significance	Effect size	95% CI	SE	Proportion of mediating effect
Digital literacy total score → Self-efficacy total score → Digital resilience total score Indirect effect	Indirect effect	0.118	0.090 ~ 0.177	0.022	19.1%
Digital literacy total score → Digital resilience total score Direct effect	Direct effect	0.500	0.448 ~ 0.551	0.026	80.9%
Digital literacy total score → Digital resilience total score Total effect	Total effect	0.618	0.579 ~ 0.657	0.020	

ethics, and data security into pre-internship training and clinical teaching systems. Concurrently, attention should be paid to fostering self-efficacy. Efficacy-enhancement strategies, such as situational simulations, peer learning, and reflective journals, should be incorporated into digital teaching and practical sessions to boost interns' technical confidence and adaptive capabilities (14).

These findings suggest that in cultivating digital resilience among nursing interns, the focus should not be solely on skill training and knowledge transmission but also on building their psychological sense of efficacy. Educators and clinical mentors can help interns accumulate successful experiences in digital practice by setting progressive tasks, providing positive feedback, and encouraging independent exploration, thereby gradually establishing and reinforcing their digital self-efficacy (14).

4.3 Research limitations and future directions

While the sample for this study was drawn from multiple institutions, offering a degree of representativeness, several limitations must be acknowledged. First, all participants were from tertiary Grade A hospitals, which typically have more advanced digital infrastructure than primary or secondary care settings. This may limit generalizability to nursing interns in less technologically equipped environments, where digital resilience demands may differ (30).

Second, the cross-sectional design precludes causal inference. While the mediation model is theoretically grounded, the possibility of reverse causation—wherein resilient individuals seek out more digital experiences, thereby enhancing literacy and efficacy—cannot be excluded. Longitudinal designs tracking interns across their clinical rotations would better elucidate developmental trajectories.

Third, the reliance on self-report measures raises concerns about common method bias. Although the high internal consistencies and the specific pattern of correlations (e.g., stronger literacy-resilience than efficacy-resilience correlation) argue against severe bias, future studies should incorporate objective measures of digital skills (e.g., performance-based assessments) and behavioral indicators of resilience (e.g., help-seeking behaviors following technical failures).

Fourth, the study did not assess specific types of digital tools or training programs, limiting the ability to identify which competencies are most critical for resilience. Future research should employ a more granular approach, examining specific digital domains (e.g., electronic health records, telehealth platforms, AI-assisted decision tools) and their differential relationships with resilience outcomes.

5 Conclusion

This study provides novel evidence on the antecedents of digital resilience among nursing interns, a critical yet understudied population in the digital transformation of healthcare. Three main findings emerge: First, nursing interns demonstrate moderate digital resilience, with particular strengths in environmental adaptation and knowledge acquisition but relative weaknesses in risk perception and stress management. Second, both digital literacy and self-efficacy are significant positive predictors of digital resilience, confirming the importance of both competency-based and psychological approaches to resilience development. Third, and most notably, self-efficacy partially mediates the relationship between digital literacy and digital resilience, accounting for 19.1% of the total effect.

These findings underscore that digital resilience is not merely a technical attribute but a psychosocial capacity cultivated through the interplay of skills and confidence. For nursing education, the implications are clear: effective preparation for digital healthcare requires integrated curricula that develop technical competencies while simultaneously building psychological resources. By systematically enhancing digital literacy through mastery experiences and fostering self-efficacy through progressive challenges and reflective practice, educators can cultivate nursing interns capable of thriving amid the uncertainties and complexities of digital clinical environments. As healthcare systems worldwide accelerate their digital transformation, such resilience-focused education will be essential for ensuring both workforce sustainability and quality patient care.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

This study was conducted in accordance with the Declaration of Helsinki and was approved by the Pingdingshan University Ethics Committee (Approval No: PDSU20250310). All participants provided written informed consent before data collection began.

Author contributions

JW: Data curation, Writing – original draft. JL: Methodology, Writing – original draft. ML: Formal analysis, Writing – original draft. YW: Methodology, Writing – review & editing. XX: Methodology, Writing – original draft. FW: Supervision, Writing – original draft.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

References

1. Lokmic-Tomkins Z, Cochrane L, Celeste T, Burnie M. An interdisciplinary partnership approach to improving the digital literacy skills of nursing students to become digitally fluent, work-ready graduates. *Stud Health Technol Inform.* (2021) 284:103–7. doi: 10.3233/SHIT210679
2. Tischendorf T, Heitmann-Möller A, Ruppert S-N, Marchwacka M, Schaffrin S, Schaal T, et al. Sustainable integration of digitalisation in nursing education—an international scoping review. *Front Health Serv.* (2024) 4:1344021. doi: 10.3389/frhs.2024.1344021
3. Amin SM, Mahgoub SAEF, Tawfik AF, Khalil DE, El-Sayed AAI, Atta MHR, et al. Nursing education in the digital era: the role of digital competence in enhancing academic motivation and lifelong learning among nursing students. *BMC Nurs.* (2025) 24:571. doi: 10.1186/s12912-025-01599-0
4. Marsilio M, Calcaterra V, Infante G, Pisarra M, Zuccotti G. The digital readiness of future physicians: nurturing the post-pandemic medical education. *BMC Health Serv Res.* (2024) 24:885. doi: 10.1186/s12913-024-11365-6
5. Tim Y, Leidner DE. Digital resilience: a conceptual framework for information systems research. *J Assoc Inf Syst.* (2023) 24:1184–98. doi: 10.17705/1jais.00809
6. Ang WHD, Chew HSJ, Dong J, Yi H, Mahendren R, Lau Y. Digital training for building resilience: systematic review, meta-analysis, and meta-regression. *Stress Health.* (2022) 38:848–69. doi: 10.1002/smi.3137
7. Mo Y, Zhang H, Bai X, Lei S, Han L. Digital resilience of clinical nurses: a concept analysis. *BMC Nurs.* (2025) 24:1231. doi: 10.1186/s12912-025-03713-6
8. UNESCO Institute for Statistics. *A Global Framework of Reference on digital Literacy Skills for indicator 4.4.2.* Montreal: UNESCO (2018).
9. Dunleavy G, Nikolaou CK, Nifakos S, Atun R, Law GCY, Tudor Car L. Mobile digital education for health professions: systematic review and meta-analysis by the digital health education collaboration. *J Med Internet Res.* (2019) 21:e12937. doi: 10.2196/12937
10. Liu L, Fu M, Wu J, Wang H, Zhao J, Chen P, et al. Digital health literacy among undergraduate nursing students in China: associations with health lifestyles and psychological resilience. *BMC Med Educ.* (2024) 24:1139. doi: 10.1186/s12909-024-05337-5
11. Bandura A. Self-efficacy: toward a unifying theory of behavioral change. *Psychol Rev.* (1977) 84:191–215. doi: 10.1037/0033-295X.84.2.191
12. Han F. Factors affecting Chinese undergraduate medical students' behavioural intention and actual use of intelligent tutoring systems. *Australas J Educ Technol.* (2024) 40:76–93. doi: 10.14742/ajet.8814
13. Al Gharibi KA, Schmidt N, Arulappan J. Effect of repeated simulation experience on perceived self-efficacy among undergraduate nursing students. *Nurse Educ Today.* (2021) 106:105057. doi: 10.1016/j.nedt.2021.105057
14. Schwarzer R, Warner LM. "Perceived self-efficacy and its relationship to resilience". In: Prince-Embury S and Saklofske D, editors. *Resilience in children, Adolescents, and Adults* New York: Springer (2013). p. 139–50.

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15. Qiu Y. *Research on the impact of digital Literacy on Employability of Higher Vocational Students: The Mediating role of Self-Efficacy (Master's thesis).* Wuhan: Hubei University of Technology (2024).
16. Etikan I, Musa SA, Alkassim RS. Comparison of convenience sampling and purposive sampling. *Am J Theor Appl Stat.* (2016) 5:1–4. doi: 10.11648/jajtas.20160501.11
17. Flanagan J, Beck CT. *Polit and Beck's Nursing Research: Generating and Assessing Evidence for Nursing Practice.* 12th ed. Philadelphia: Wolters Kluwer (2025).
18. Creswell JW, Creswell JD. *Research design: Qualitative, Quantitative, and Mixed Methods Approaches.* 5th ed. Thousand Oaks: SAGE Publications (2018).
19. Tabachnick BG, Fidell LS. *Using Multivariate Statistics.* 7th ed. Boston: Pearson (2019).
20. Cohen J. A power primer. *Psychol Bull.* (1992) 112:155–9. doi: 10.1037/0033-2909.112.1.1559
21. Fritz MS, MacKinnon DP. Required sample size to detect the mediated effect. *Psychol Sci.* (2007) 18:233–9. doi: 10.1111/j.1467-9280.2007.01882.x
22. Li F. *Development and Application of a digital Resilience Assessment scale for Undergraduate Nursing Students (Master's thesis).* Nanning: Guangxi University of Chinese Medicine (2025).
23. Zhang Q, Wu J. Digital literacy among medical students: scale development and influencing factor analysis. *Chin Health Serv Manag.* (2024) 41:787–92.
24. Wang C, Hu Z, Liu Y. Reliability and validity of the general self-efficacy scale. *Chin J Appl Psychol.* (2001) 7:37–40.
25. Schwarzer R, Born A. Optimistic self-beliefs: assessment of general perceived self-efficacy in thirteen cultures. *World Psychol.* (1997) 3:191–210.
26. Preacher KJ, Hayes AF. Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behav Res Methods.* (2008) 40:879–91. doi: 10.3758/BRM.40.3.879
27. Son J-H, Jeong S-J, Kim C-G. Influence of artificial intelligence knowledge, attitude, perception, and utilization ability on communication competence in nursing students. *J Korean Acad Soc Nurs Educ.* (2026) 32:132–41. doi: 10.5977/jkasne.2026.32.1.132
28. Ang WHD, Chew HSJ, Ong YHN, Zheng ZJ, Shorey S, Lau Y. Becoming more resilient during COVID-19: insights from a process evaluation of digital resilience training. *Int J Environ Res Public Health.* (2022) 19:12899. doi: 10.3390/ijerph191912899
29. Brice S, Almond H. Health professional digital capabilities frameworks: a scoping review. *J Multidiscip Healthc.* (2020) 13:1375–90. doi: 10.2147/JMDH.S269412
30. Knop M, Mueller M, Kaiser S, Rester C. The impact of digital technology use on nurses' professional identity and relations of power: a literature review. *J Adv Nurs.* (2024) 80:4346–60. doi: 10.1111/jan.16178
31. Hayes AF. *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach.* 2nd ed. New York, NY: The Guilford Press (2018).



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The intensity, cardiorespiratory fitness and mental health benefits of integrated badminton teaching of “learning, practice and competition”: a quasi-experimental in university

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Purpose: The “Learning, practice and competition” (L-P-C) is an important teaching method in the new round of school physical education curriculum reform in China. This study aims to explore the intensity characteristics of integrated of L-P-C badminton teaching and explore potential associations with changes in college students’ cardiorespiratory fitness and mental health.

Methods: A 16-week single-group pre-post experiment was conducted among 133 college students (average age: 18.08 ± 0.39 years, height: 167.23 ± 5.13 cm, BMI: 22.20 ± 3.60 kg/m²). Exercise intensity was quantified using Polar OH1 heart rate (HR) monitors, while cardiorespiratory fitness and mental health were evaluated by the 20-m shuttle run and the Symptom Checklist-90 (SCL-90) respectively, before the 1st and at the 16th weeks of the experiment.

Results: During the L-P-C, students primarily engaged in moderate intensity activity (52%). Compared with the “learning” and “practice”, the “competition” phase demonstrated the highest proportion of moderate to high intensity activity ($\chi^2 = 54.89$, $p < 0.001$, $W = 0.21$), with an obviously higher proportion among male students ($z = -3.60$, $p < 0.001$, $r = -0.31$) and skilled students ($z = -4.52$, $p < 0.001$, $r = -0.39$). Significant differences were found in cardiorespiratory fitness ($z = -6.87$, $p < 0.001$, $r = -0.60$). Additionally, significant differences were identified during pre- and post-test in the General Severity Index (GSI; $z = -5.47$, $p < 0.001$, $r = -0.47$), and the Positive Symptom Distress Index (PSDI; $z = -3.10$, $p = 0.002$, $r = -0.69$).

Conclusion: This study suggests that the L-P-C badminton model primarily elicits moderate-intensity exercise, which is influenced by gender and skill levels. Participation in this integrated teaching model was accompanied by improvements in cardiorespiratory fitness and psychological well-being. However, due to the lack of a control group, these findings should be interpreted as associative rather than causal.

KEYWORDS

badminton, college students, exercise intensity, cardiorespiratory fitness, mental health

Introduction

The Lancet Commission recently issued a new warning: without urgent intervention, over one billion adolescents and young adults will confront heightened health risks by 2030, with a particularly alarming rise in mental health disorders and obesity-related conditions (1). Parallel findings from specialized national surveys reveal a sustained decline in the physical fitness of university students over the past two decades (2), alongside a persistent rise in mental health problems (3). These issues are further exacerbated by intensifying academic pressures (4), challenges of independent living, and societal expectations (5). Moreover, sedentary lifestyles and deteriorating cardiovascular health further compound these psychological burdens (6). The escalating prevalence of these intertwined health problems has prompted intensified efforts to strengthen holistic education systems, including physical education (PE) (7). In China, the “five educations” with physical and mental health is now recognized as the crucial breakthrough point for constructing a high quality education system (8). Integrated teaching of “Learning”, “Practice” and “Competition” (L-P-C), aligning with practical and holistic educational principles, and grounded in theories like constructivism and situational learning, has been proposed in a new round of school physical education reform (9).

Integrated teaching of L-P-C, combining “Learning”, “Practice” and “Competition” into a cohesive instructional chain, helps students progress from single action practice to systematic application of motor skills and tactics. “Competition” is the core to lead “Learning” and “Practice” (9). From the operational perspective of students (10), “Learning” emphasizes physical perception through repetitive practice foundational knowledge and actions. “Practice” focuses on practice integrated situation, known as combination practice. The situation is part of competition scenarios, or simplified rules tailored to students’ needs. “Competition” highlights match practice. “Learning”, “Practice” and “Competition” are dynamic interdependent relationships. Theoretical analysis suggests that integrated teaching of L-P-C not only helps students master motor skills, but also develop healthy behaviors and enhances sports ethics, so as to achieve the educational goal of “nurturing people by sports”.

Presently, exercise-based health education is the preferred approach, with racquet sports standing out as the most potent (11). Badminton is one of the world’s most popular racquet sports and also one of the most popular sports among college students (12). It is characterized by intermittent high-intensity exercise (13). This unique profile engages both the phosphagen and aerobic energy systems (14), potentially offering efficient cardiorespiratory stimulus (15). Beyond its physiological demands, badminton is a tactical, net-separated sport that inherently involves social interaction in double match, and the management of competitive stress (13). These elements align closely with factors known to support mental well-being, such as strengthening health beliefs and reducing psychological stress (16) and alleviating anxiety (17). However, traditional badminton teaching emphasizes the detailed instruction and repetitive practice of single actions (18). These prioritizes single action over combined action, individual performance over teamwork, repetitive practice over game or competition, fail to harness these holistic benefits.

Recent systematic reviews of badminton pedagogy also confirm that most research focuses predominantly on the acquisition of motor skills and sports techniques. There is a notable shortage of empirical investigations measuring the exercise intensity or health-related outcomes. The educational value of integrated teaching of L-P-C remains critically underdeveloped. Therefore, this study aims to address this gap by measuring the exercise intensity and evaluating the cardiorespiratory fitness and mental health of integrated badminton of teaching “L-P-C” in university.

Materials and methods

Participants

A total of 150 non-clinical college students (90 males and 60 females) voluntarily enrolled in the elective badminton course at the University of Shanghai for Science and Technology in China were initially selected. Inclusion criteria: (1) College students with no other physical or mental health conditions were able to perform physical exercise and understood and voluntarily completed all the tests. (2) Students participated in all badminton courses and completed all tests. Exclusion criteria: Students with organ dysfunction, obvious physical injury or movement disorder, severe mental disorder, severe trauma or a surgical history within the last 6 months were excluded. Those who were suddenly injured or fell ill, voluntarily requested withdrawal, or missed one or more badminton sessions were also excluded. The study was approved by the Institutional Review Board (IRB) of the Shanghai University of Sport [102772023RT023], and written informed consent was obtained from all participants prior to the commencement of the study.

Procedure

This research employed a single-group, 16-weeks quasi-experimental design. The intervention spanned from September 9 to December 28, 2024, involving 16 weekly sessions, each lasting 90 min. All badminton sessions were conducted in a university sports hall containing 8 standard badminton courts. With 30 students per class, this venue ensure adequate space for practice and competition. Each session was led by one certified badminton instructor with 10 years of teaching experience. In addition, one teaching assistant was presented to assist with equipment delivery and classroom monitoring so on. The session structure adhered strictly to the integrated teaching of “Learning, Practice, and Competition” (L-P-C): Every session planned to repetitive learn single action and foot work, teamwork practice combined actions integrated cooperative situation, and single/double/three on three match (detailed in Table 1). The total duration of the session was allocated as follows: 10–15 min Warm-up, 10–20 min Learning/Basic Practice, 20–35 min Combined Practice, 25–40 min Simplified Competitive Matches; 5–10 min Cool-down. During the exercise, students’ heart rate (HR) was monitored by a heart rate monitor (Polar OH1). Before the 1st and at the 16th week of intervention, all participants completed the SCL-90 questionnaire and the 20-m shuttle run test.

TABLE 1 Detailed scheduling of 16-weeks teaching content.

Weeks	Content
1	Theoretical course: introduction classroom etiquette, motor skills, competition rules, and assessment requirements...
2–3	Learning (20%): forehand high service
	Practice (45%): teamwork practice high service + deep clear shot
	Competition (35%): forehand high service
4–5	Learning (20%): deep clear, footwork
	Practice (45%): teamwork practice high service + deep clear, deep clear rally
	Competition (35%): deep clear rally
6–8	Learning (20%): forehand lob, low serve
	Practice (35%): teamwork practice low serve + forehand lob + deep clear rally
	Competition (45%): single match
9–11	Learning (20%): drop shot, footwork
	Practice (35%): teamwork practice forehand lob + backcourt drop shot, forehand lob + deep clear shot + drop shot
	Competition (45%): single/double match
12–13	Learning (15%): footwork and net shot
	Practice (35%): teamwork practice net shot, net shot + forecourt lob + backcourt deep clear
	Competition (50%): single/double match
14–15	Learning (15%): smash
	Practice (30%): teamwork high service + smash, high serve + smash + net shot + forecourt lob
	Competition (55%): single/double match
16	Test

%; the time proportion of this activity.

Measurements

Exercise intensity

Exercise intensity was measured using Polar OH1, which was used as a reliable measure of heart rate during moderate to high intensity physical activity (MHPA) (19). To estimate individual maximal heart rate (HR_{max}), the Gellish formula was utilized to ensure accuracy for the college population (20): $HR_{max} = 207 - (0.7 \times \text{age})$. With a mean participant age of 18.08 years, HR_{max} was approximately 194 bpm. Intensity zones were defined as: Very light (VL, $<57\%$ HR_{max}), Light intensity (LI, $57\text{--}63\%$ HR_{max}), Moderate intensity (MI, $64\text{--}76\%$ HR_{max}) and High intensity (HI, more than 76% HR_{max}). Moderate to high intensity (MHI) is the sum of moderate and high intensity (21). The protocol followed a rigorous four-stage pipeline to ensure replicability: (1) Device setting: Log in the computer server, create student teams by their courses, import student essential information such as HR_{max} , define heart rate zones according to previously established intensity level, and pair each student with the Polar monitor. The monitors' default sampling frequency is 1 s, without applying real-time filtering or smoothing. (2) Monitoring (physical activity in-class is implemented rather than outside): Each students' HR was

monitored during one complete badminton session at each of three time points: Week 3, 8 and 15. Five minutes before each session, the PE teacher distributed the monitors and instructed students to wear them on their left upper arm, ensuring firm skin contact for accurate signal detection. To isolate the intensity of the pedagogical intervention, the initial 15-min collective warm-up and final 5-min cool-down were strictly excluded from the analysis. A research assistant supervised monitoring process to ensure proper device placement, record the abnormal device ID (such as $HR = 0$ for more than 60 s) and the exact start and end time of "learning", "practice" and "competition" by stopwatch synchronized with all heart rate monitors. Short transitions between phases (typically <2 min) were included within the preceding segment's data to maintain a continuous record of the lesson's flow. (3) Data export: Following each session, we extracted each student's HR data for each phase ("learning," "practice," "competition") via Polar Flow software using session timestamps. The software automatically calculated the percentage of time spent in each intensity zone based on the predefined HR_{max} thresholds, which were exported as Excel files. (4) Data cleaning and aggregation: Individual session HR data were excluded if they documented technical failure (e.g., proportion of 0 in each intensity range). Participants with fewer than 3 valid recorded sessions were removed. To derive a comprehensive measure of exercise intensity across the intervention, we calculated the average percentage of time spent in each intensity zones across their three monitored sessions for each participant. These individual averages were then used to compute group-level statistics.

Cardiorespiratory fitness

Cardiorespiratory fitness was measured by the 20-m shuttle run test, which is recommended as an effective method to estimate VO_2 peak (VO_{2max}) (22). All participants underwent two tests, both pre- and post-experiment, and were strongly encouraged to exert their maximum effort during each assessment. The test will be automatically terminated if the students fail to reach the finish line twice after a warning. VO_{2max} was calculated from the quadratic equation for adults ($Y = -24.4 + 6.0X1$) proposed by Léger et al. (23).

Mental health

The Symptom Checklist-90 (SCL90) was employed to assess mental health. This scale comprises a total of 90 items, and evaluates the signs of alterations in people's mental health. Each item is rated on a 1–5 scale, with total scores calculated for each dimension to derive the General Severity Index (GSI), and the Positive Symptom Distress Index (PSDI) (24). Higher scores across dimensions indicate more severe mental health symptoms. Given the anticipated floor effects due to the non-clinical nature of the sample, we pre-specified the GSI and PSDI as primary and secondary outcomes. The nine symptom dimensions were analyzed exploratorily without correction for multiple comparisons. In this study, the Cronbach's alpha coefficient of the scale is 0.967. The GSI was calculated for the total sample ($N = 133$). However, the PSDI,

which reflects the intensity of symptoms for items scored above the “no symptoms” threshold (score ≥ 2), was only applicable to participants who reported at least one positive symptom. In this study, 20 participants met this criterion; thus, the PSDI analysis was restricted to this subgroup.

Badminton skills classification

To enable subgroup analyses by skill level, participants were classified as “beginner” and “skilled” using a standardized two-step process. During the first week, participants completed a self-report questionnaire on prior badminton experience (no experience, competition experience, formal training). Concurrently, during the first two sessions, the lead instructor observed participants during “practice” and “competition”, focus on five fundamental skills serve, deep clear and footwork. Students were classified as beginner if they reported no prior experience and observed unable to execute serves, deep clear and footwork; they were classified as skilled if they reported competition experience or formal training and observed execute those skills in “competition”. In the two cases where self-report and instructor assessment diverged, the instructor’s assessment was used as the final classification.

Data analysis

All statistical analyses were performed by IBM SPSS Statistics 27. Prior to data analysis, missing data were excluded. Seventeen students were excluded due to missing data or insufficient completion of the intervention: 3 students dropped out suddenly injured, 10 students were excluded for missing at least one session, 4 students failed to complete the pre- or post-test. Thus, the final analysis focused on 133 college students who completed all the course and test. Initially, descriptive statistics (mean, standard deviation, median, inter-quartile range and percentages) were calculated for demography, HR, exercise intensity, 20-m shuttle run and SCL-90, with subsequent stratification by skill level (beginner vs. skilled) and gender (girls vs. boys). Given that the normality assumption was not met, Mann–Whitney *U*-Test were employed to examine gender and skill differences in proportion of exercise intensity in different stages of L-P-C. Friedman test was first conducted to evaluate the variations in different MHI activity proportion during three phases (learning, practice, competition). When the Friedman test indicated a statistically significant difference, *post-hoc* pairwise comparisons were performed using Wilcoxon signed-rank tests with Bonferroni correction to control for Type I error. Wilcoxon signed-rank test was utilized to assess within-group changes in cardiorespiratory fitness and SCL-90 from pre- to post-test. The significance was set at $p < 0.05$.

Results

A total of 133 participants completed the study. The final sample consisted of 80 males (60.15%) and 53 females (39.85%), with a mean age of 18.08 ± 0.39 years. The average height, weight and BMI were 167.23 ± 5.13 cm, 55.17 ± 2.78 kg and 22.20 ± 3.60

TABLE 2 Characteristics of the participants.

Characteristics	All ($n = 133$)
Age (years)	18.08 ± 0.39
Gender, n (%)	
Female	53 (39.85)
Male	80 (60.15)
Anthropometrics	
Height (cm)	167.23 ± 5.13
Weight (kg)	55.17 ± 2.78
BMI (kg/m^2)	22.20 ± 3.60
Badminton skills, n (%)	
Beginner	123 (92.48)
Skilled	10 (7.52)

TABLE 3 Proportion of different intensity of PA among L-P-C.

Gender	N	LPA [M(IQR), %]	MPA [M(IQR), %]	HPA [M(IQR), %]	MHPA [M(IQR), %]
Female	53	29 (36.5)	52 (26)	16 (22)	71 (36.5)
Male	80	21 (18.75)	54.5 (21.75)	18.5 (25.75)	79 (18.75)
All	133	22 (20)	52 (23)	17 (26)	78 (20)

LPA, low intensity physical activity; MPA, moderate intensity physical activity; HPA, high intensity physical activity; MHPA, moderate and high intensity physical activity; The remaining percentage accounts for very light (VL) intensity.

kg/m^2 , respectively. A large majority of students (over 90%) were categorized as badminton beginners (Table 2).

Table 3 presents the descriptive statistics of low intensity physical activity (LPA), moderate intensity physical activity (MPA), high intensity physical activity (HPA) and moderate and high intensity physical activity (MHPA) for the whole L-P-C. Overall, the distribution of exercise intensity was 22% LPA, 52% MPA, and 17% HPA, resulting in 78% MHPA.

The Mann–Whitney *U*-test revealed differences in proportion of MHPA by sex and skill level (Table 4). Males reported more proportion of MHPA than females. A significant difference was observed in the “competition” part between males and females ($z = -3.59$, $p < 0.001$, $r = -0.31$), with moderate effect size ($r = -0.31$, 95% CI: -0.46 to -0.15). Skilled students engaged more in MHPA than beginners in “practice” ($z = -2.08$, $p = 0.037$, $r = -0.18$, 95% CI: -0.35 to -0.01) and “competition” ($z = -4.51$, $p < 0.001$, $r = -0.39$, 95% CI: -0.53 to -0.23).

The Friedman test found statistically significant differences in proportion of MHPA during L-P-C (Table 4). A significant variation manifested in MHPA proportion between three phases [$\chi^2 = 54.89$, $p < 0.001$], with an effect size of Kendall’s $W = 0.41$ (95% CI: $0-0.83$), indicating a large effect. *Post-hoc* analysis showed students’ MHPA proportion in “Competition” was significantly higher than “Practice” ($z = 2.57$, adjusted $p = 0.03$, $r = 0.22$, 95% CI: $0.05-0.38$) and “Learning” ($z = 7.17$, adjusted $p < 0.001$, $r = 0.62$, 95% CI: $0.49-0.75$).

TABLE 4 Comparison of proportion of MHPA among L-P-C in different gender and skill level.

Characteristic	N	MVU	L [M(IQR), %]	P [M(IQR), %]	C [M(IQR), %]	L-P-C [M(IQR), %]
Female	53		62 (40.5)	80 (44.5)	75 (29)	69 (36)
Male	80		63.5 (31.5)	75 (21.75)	85 (24)	79 (19)
		Z	−0.641	−0.179	−3.595	−2.554
		p	0.521	0.858	<0.001	0.011
		R (95% CI)	−0.06 (−0.12, 0.23)	−0.02 (−0.17, 0.20)	−0.31 (−0.46, −0.15)	−0.22 (−0.38, −0.05)
Beginner	123		62 (31)	75 (26)	79 (28)	76 (20)
Skilled	10		77.5 (43.75)	90 (20.5)	100 (1)	81 (19)
		Z	−1.195	−2.084	−4.516	−1.306
		p	0.232	0.037	<0.001	0.191
		R (95% CI)	−0.10 (−0.27, 0.07)	−0.18 (−0.34, −0.02)	−0.39 (−0.53, −0.23)	−0.11 (−0.28, 0.06)
All	133		62 (32.5)	77 (26.5) ^a	84 (26) ^{ab}	78 (20)

MWU, Mann–Whitney *U*-test. ^a $p < 0.001$, LMHPA compared to PMHPA, CMHPA and AMHPA. ^b $p < 0.01$, PMHPA compared to CMHPA. R (95%CI) indicates the correlation coefficient and its 95% confidence interval.

Table 5 showed a significant improvement in VO_{2max} , with a median of 35.6 at pre-test to 41.6 at post-test ($z = -6.87$, $p < 0.001$), with an effect size of $r = -0.60$ (95% CI: -0.77 to -0.42), indicating a large effect. Wilcoxon signed-rank test also revealed significant differences between pre- and post-test outcome of VO_{2max} in males ($z = -5.76$, $p < 0.001$, $r = -0.64$, 95% CI: -0.77 to -0.47) and females ($z = -4.08$, $p < 0.001$, $r = -0.56$, 95% CI: -0.72 to -0.34).

The Wilcoxon signed-rank test results in Table 6 showed that the GSI score of all students ($z = -5.47$, $p < 0.001$, $r = -0.47$, 95% CI: -0.59 to -0.32) reduced significantly, the same trend in males ($z = -4.69$, $p < 0.01$, $r = -0.53$, 95% CI: -0.69 to -0.31) and females ($z = -3.03$, $p < 0.01$, $r = -0.42$, 95% CI: -0.62 to -0.17). The effect sizes are moderate to large, indicating that the observed changes are meaningful magnitude despite the low baseline scores. In the total 20 samples, PSDI scores showed a remarkable decrease ($z = -3.1$, $p < 0.01$), with large effect size ($r = -0.69$, 95% CI: -1 to -0.21). same trend among female students ($z = -2.52$, $p = 0.01$, $r = -0.8$, 95% CI: -1 to -0.06), while male students ($z = -1.36$, $p = 0.17$, $r = -0.43$, 95% CI: -1 to -0.3) showed no such gains.

Table 7 presents the results of exploratory analyses on the nine SCL-90 symptom dimensions. Scores of all in dimensions of obsessive compulsive ($z = -3.04$, $p = 0.002$), interpersonal sensitivity ($z = -2.98$, $p = 0.003$) and depression ($z = -2.79$, $p = 0.005$) showed remarkable reductions, same trend among female students, while male students showed no such gains. These exploratory findings should be interpreted with caution and serve primarily to generate hypotheses for future research.

Discussion

The main purpose of the present study was to examine the intensity of integrated badminton teaching of “Learning, Practice, Competition” (L-P-C) and explore its potential benefits in the cardiorespiratory fitness and mental health of college students.

The findings of the present study indicate that, for beginners, L-P-C activity is primarily Moderate Intensity (MI), whereas skilled students engage in more Moderate and High Physical Activity (MHPA) than beginners in “practice” and “competition”, with competition phases demonstrating the highest proportion of MHPA. Additionally, A positive relationship also be observed between engagement in 16 weeks of integrated badminton teaching and enhancement in both the cardiorespiratory fitness and mental health among college students.

The intensity characteristics of the L-P-C in badminton

The overall finding that students’ exercise in L-P-C primarily induces Moderate Intensity Physical Activity (MPA) is consistent with badminton’s classification as a sport largely powered by the aerobic system (14). For beginner students, the intensity is often limited by their motor developmental stage, where focus remains on initial motor pattern formation (25), leading to slower, unconnected movement execution (26). However, the L-P-C structure proves highly effective even with these limitations, and successfully accumulates a high proportion of Moderate and High Intensity Physical Activity (MHPA; 78%). This substantial MHPA level is a direct benefit of the integrated structure, ensuring sustained exercise continuity and achieving a sufficient physiological load that meets or exceeds established guidelines for reducing sedentary behavior (27).

The significant stage differentiation in MHPA proportion, with the “Competition” (84%) recording the highest, strongly validates the pedagogical design of the integrated teaching of L-P-C. The integrated teaching functions as a progressive cycle: the “Learning” phase prioritizes technical accuracy, resulting in the lowest MHPA (62%). The “Practice” phase transitions to applied situational drills, raising MHPA (77%). Crucially, the “Competition” phase

TABLE 5 Comparison of pre and post-test different in VO_{2max}.

Characteristic	N	Time point	VO _{2max} [M(IQR), ml/kg/min]	Z	P	R (95% CI)
Female	53	Pre	23.6 (6)	−4.08	<0.001	−0.56 (−0.72, −0.34)
		Post	29.6 (6)			
Male	80	Pre	41.6 (6)	−5.76	<0.001	−0.64 (−0.77, −0.47)
		Post	47.6 (12)			
All	133	Pre	35.6 (12)	−6.87	<0.001	−0.60 (−0.77, −0.42)
		Post	41.6 (18)			

TABLE 6 Comparison of pre and post-test different in SCL-90.

Characteristic	Time point	GSI (N = 133)				PSDI (N = 20)			
		[M (IQR)]	Z	P	R (95% CI)	[M(IQR)]	Z	P	R (95% CI)
Female	Pre	1.2 (0.29)	−3.033	0.002	−0.42 (−0.62, −0.17)	2.39 (0.59)	−2.524	0.012	−0.80 (−1.00, −0.06)
	Post	1.06 (0.17)				2 (0)			
Male	Pre	1.12 (0.20)	−4.699	<0.001	−0.53 (−0.69, −0.31)	2.2 (0.28)	−1.365	0.172	−0.43 (−1.00, 0.30)
	Post	1.04 (0.12)				2.05 (0.22)			
All	Pre	1.15 (0.23)	−5.47	<0.001	−0.47 (−0.59, −0.32)	2.32 (0.37)	−3.1	0.002	−0.69 (−1.00, −0.21)
	Post	1.04 (0.14)				2 (0.08)			

GSI, general severity index; PSDI, positive symptom distress index. The reduced sample size for PSDI ($n = 20$) reflects only those participants who reported positive symptoms (item score ≥ 2).

TABLE 7 Exploratory analysis of SCL-90 symptom dimensions (N = 133).

Factors	Female		Male		All		P
	Pre [M (IQR)]	Post [M (IQR)]	Pre [M (IQR)]	Post [M (IQR)]	Pre [M (IQR)]	Post [M (IQR)]	
SOM	1 (0.21)	1 (0.25)	1 (0.08)	1 (0.08)	1 (0.13)	1 (0.08)	0.567
OCS	1.2 (0.7)	1 (0.2)**	1 (0.4)	1.05 (0.28)	1 (0.5)	1 (0.2)**	0.002
INTS	1 (0.44)	1 (0.11)*	1 (0.22)	1 (0.11)	1 (0.22)	1 (0.11)**	0.003
DEPR	1.08 (0.38)	1 (0.15)**	1 (0.15)	1 (0.14)	1 (0.31)	1 (0.15)**	0.005
ANX	1 (0.2)	1 (0.15)	1 (0.1)	1 (0.1)	1 (0.1)	1 (0.1)	0.213
HOS	1 (0.17)	1 (0.17)	1 (0.17)	1 (0.08)	1 (0.17)	1 (0.17)	0.885
PHOA	1 (0.14)	1 (0.14)	1 (0)	1 (0)	1 (0)	1 (0)	0.315
PARI	1 (0.17)	1 (0.085)	1 (0)	1 (0)	1 (0.09)	1 (0)	0.331
PSY	1 (0.1)	1 (0.1)	1 (0.1)	1 (0)	1 (0.1)	1 (0.05)	0.216

SOM, somatization; OCS, obsessive compulsive; INTS, interpersonal sensitivity; DEPR, depression; ANX, anxiety; HOS, hostility; PHOA, phobic anxiety; PARI, paranoid ideation; PSY, psychoticism.

* $P < 0.05$, ** $P < 0.01$.

succeeds in shifting students' intrinsic motivation from "skill execution" to "winning the match" (28). This competition-driven shift necessitates higher physical confrontation, faster reaction demands, and continuous high-speed movement (29), leading to the maximum MHPA accumulation, effectively functioning as high-intensity interval training (HIIT) (13). The finding that skilled students exhibit substantially higher exercise intensity, is consistent with existing research on experienced players (13). Compared to beginners, skilled learners' attention shifts from action cognition

to tactical execution (25). Their refined control enables faster footwork, wider movement ranges, and more frequent, rapid "stop and go" patterns characteristic of high-load badminton. This observation suggests that the integrated teaching of L-P-C possesses a crucial adaptive mechanism: it automatically scales the physiological load based on the students' mastery level, thereby effectively ensuring a sufficient physiological stimulus for both beginners and more skilled learners in mixed-ability college PE classes.

Influence of L-P-C on college students' cardiorespiratory fitness

This study findings suggest that integrating the “L-P-C” teaching into a badminton course appears to influence cardiorespiratory fitness of college students positively. The observed improvement in cardiorespiratory fitness is consistent with previous research. Studies have shown that playing badminton improves cardiorespiratory fitness in Korean adolescents (30) and male college students (31). As is well known, badminton demands both anaerobic and aerobic systems. Research has found that continuous participation in badminton reduces resting Heart Rate (HR) and blood pressure index in obese male students, and improves their lung capacity, maximum ventilation, and maximum oxygen uptake (32). These findings have been confirmed in studies conducted on adult male athletes and untrained female participants (33). MHPA may be a key factor in significantly enhancing students' cardiorespiratory fitness (34), which is a comprehensive reflection of the body's ability to take in, transport and utilize oxygen (35). MHPA stimulates the respiratory regulation and cardiopulmonary potential of the central nervous system, and promotes adaptive improvements in the cardiorespiratory system of students (36). During L-P-C, students primarily engage in MHPA, especially in “Practice” and “Competition”, which require constant directional changes, continuous movement, and jumping strikes. This stimulation of exercise intensity increases the body's oxygen demand rate, prompting the body to meet this demand by through increasing cardiac output and improving oxygen transport efficiency in muscles to enhance oxygen utilization and elevate cardiorespiratory fitness.

Additionally, the duration of MHPA shows a positive correlation with cardiorespiratory fitness (37). Higher exercise density can significantly enhance students' cardiorespiratory fitness (38). In other words, the longer students engage in MHPA relatively, the greater health benefits they will accumulate, and the more obvious the improvement of students' cardiorespiratory fitness. In L-P-C, 70 min of practice time and sufficient court ensure that students have enough time for exercise. Consequently, the high exercise density and prolonged engagement in MHPA effectively induce adaptive changes in students' cardiorespiratory systems, thereby enhancing their cardiovascular endurance. However, since participants' off-campus physical activity was not monitored, these improvements should be interpreted as potential associations rather than isolated effects of the curriculum.

Influence of L-P-C on college students' mental health

In our study, the observed reductions in General Severity Index (GSI) and the Positive Symptom Distress Index (PSDI) scores suggest an association between the integrated teaching in badminton course and improvements in self-reported

psychological distress among college students. Our research findings align with a system study where college students' mental health was improved after 4–14 weeks of physical activity intervention (39). This research provides preliminary evidence that integrated badminton teaching of L-P-C may deliver mental health benefits to college students. From a biological perspective, Moderate High Intensity (MHI) intermittent badminton exercise can reduce risks of depression and obsessive compulsive through stimulating endorphin secretion, increasing HR and respiratory frequency, and regulating glucocorticoid circulation via the hypothalamic-pituitary-adrenal axis (40). It can also activate the autonomic nervous system, enhance neural tolerance and self-regulation capabilities (41). Moreover, one possible explanation for the observed improvements relates to the pedagogical design. The integrated teaching emphasizes “competition driven learning and practice”, which may enhance students' engagement and motivation. It is plausible that this heightened engagement could contribute to improvements in both physical coordination (e.g., body control) and psychological outcomes (e.g., self-efficacy and intrinsic motivation) (42, 43). In addition, A tight collaborative unit possibly be formed during teamwork in “practice” and “competition”, in which may contribute to redirected students' cognitive resources from internal to external and help students obtain behavior adaptation and successful experience (44).

Our findings reveal that integrated badminton teaching of L-P-C is associated with differential changes by gender, with females experiencing greater reduction in PSDI score. Our results are consistent with the results of a study by Zhang, where female college students' mental health has significantly improved after 12 weeks of exercise intervention (45). There is also a cross-sectional study in medical school that shows that gender plays a crucial role in mental health status (46), which female students face with high stress and depressive interpersonal relationships, and a certain degree of physiological and life burden with women's unique physiological period. Those double burdens aggravate their emotional ups and downs, resulting in negative and depressive than males. Moreover, integrated badminton teaching of L-P-C offers enough team work with social support and social interactions, which significantly relationship with female students' mental health (47). So, female students are more likely to release stress and negative emotions in L-P-C, and more positive intervention responses are acquired. However, the potential for floor effects must be acknowledged. Participants' baseline SCL-90 scores were relatively low, which may have limited the magnitude of possible improvement. Statistically significant changes should be interpreted with caution.

Despite these significant findings, several limitations must be acknowledged. Firstly, The use of a single-group pre-post design without a control group limits our ability to establish definitive causal inferences. The observed improvements may be influenced by threats to internal validity, such as maturation (natural development over a semester), testing effects (increased familiarity with the 20-m shuttle run protocol), or regression to the mean. Consequently, these results should be viewed as preliminary associations. Secondly, A significant

limitation is that participants' physical activity outside of the scheduled badminton sessions was not monitored. It is possible that concurrent exercise habits or seasonal lifestyle changes contributed to the observed gains in fitness and mental health. Finally, Baseline SCL-90 scores were generally low, suggesting a potential floor effect. While the changes were statistically significant and accompanied by moderate-to-large effect sizes, they represent symptomatic variation within a non-clinical population rather than clinically meaningful improvements. Caution should be exercised when generalizing these results to individuals with moderate to severe psychological symptoms. Future research utilizing randomized controlled trials with rigorous monitoring of outside activity is essential to isolate the unique effects of the L-P-C model.

Conclusion

In conclusion, the integrated L-P-C badminton model provides a high-intensity pedagogical framework that predominantly engages students in moderate-intensity activity, particularly during the competitive phase. Our findings suggest that this integrated approach is linked to significant improvements in VO_{2max} and a reduction in psychological distress among university students. While these results highlight the potential of L-P-C for promoting psychophysiological health, the lack of a randomized control group necessitates caution. These preliminary observations provide a foundation for future controlled trials to verify the unique longitudinal effects of the L-P-C model in school physical education.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the Institutional Review Board (IRB) of the Shanghai University of Sport [102772023RT023]. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

LM: Writing – original draft. XZha: Writing – review & editing. XM: Writing – review & editing. XZhu: Writing – review & editing. GF: Writing – review & editing.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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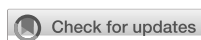
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References

- Baird S, Choonara S, Azzopardi PS, Banati P, Bessant J, Biermann O, et al. A call to action: the second Lancet Commission on adolescent health and wellbeing. *Lancet*. (2025) 405:1945–2022. doi: 10.1016/s0140-6736(25)00503-3
- Cai S, Zhang Y, Chen Z, Liu Y, Dang J, Li J, et al. Secular trends in physical fitness and cardiovascular risks among Chinese college students: an analysis of five successive national surveys between 2000 and 2019. *Lancet Reg Health West Pac*. (2025) 58:1015160. doi: 10.1016/j.lanwpc.2025.101560
- Rackoff GN, Fitzsimmons-Craft EE, Taylor CB, Eisenberg D, Wilfley DE, Newman MG. Psychotherapy utilization by United States college students. *J Am Coll Health*. (2025) 73:503–10. doi: 10.1080/07448481.2023.2225630
- Zhang JW, Peng C, Chen C. Mental health and academic performance of college students: knowledge in the field of mental health, self-control, and learning in college. *Acta Psychol*. (2024) 248:104351. doi: 10.1016/j.actpsy.2024.104351
- Rockwell DM, Kimel SY. A systematic review of first-generation college students' mental health. *J Am Coll Health*. (2023) 73:519–31. doi: 10.1080/07448481.2023.2225633
- Magallon J, Catalan P. Sedentary behaviour in college students and its influence on heart rate and mental health. *Eur J Hum Mov*. (2024) 52:104–13. doi: 10.21134/eurjhm.2024.52.9
- Yusoff SM, Mohamed AMD, Marzaini AFM, Radzi FAM, Basal MH, Hassan MH. Towards embodied criticality: reframing physical education curriculum for whole-person development. *Sport Educ Soc*. (2025): 1–16. doi: 10.1080/13573322.2025.2563694
- Ministry of Education of the People's Republic of China. *The 2024 National Education Work Conference*. (2024). Available online at: http://www.moe.gov.cn/jyb_xwfb/gzdt_gzdt/moe_1485/202401/t20240111_1099814.html (Accessed January 8, 2026)
- Zhai ZP, Guo YB. Major characteristics, current problems, and implementation path for integrated teaching of “learning, practice, and competition” under new curriculum standards. *J Shanghai Univ Sport*. (2024) 48:34–44.
- Ma L, Hu XQ, Ma X, Tang Y. Connotation, characteristics and construction suggestions of structured learning and practice of motor skills. *J Phys Educ*. (2023) 41:8–13+99.
- Chekroud SR, Gueorguieva R, Zheutlin AB, Paulus M, Krumholz HM, Krystal JH, et al. Association between physical exercise and mental health in 1.2 million individuals in the USA between 2011 and 2015: a cross-sectional study. *Lancet Psychiatry*. (2018) 5:739–46. doi: 10.1016/S2215-0366(18)30227-X
- Guangming Net. *The Popularity of This Sport has Skyrocketed, with Participation Reaching 250 Million! Why is There a Shortage of Players?*. (2024). Available online at: <https://baijiahao.baidu.com/s?id=1808136032992200319&wfr=spider&for=pc> (Accessed January 8, 2026)
- Phomsoupha M, Laffaye G. The science of badminton: game characteristics, anthropometry, physiology, visual fitness and biomechanics. *Sports Med*. (2015) 45:473–95. doi: 10.1007/s40279-014-0287-2
- Wang XX, Li B, Li XT, Jin L, Fu L, Shang L, et al. Profile of energy contributions in simulated badminton match and multi-ball stroke drill. *China Sport Sci Technol*. (2019) 55:3–8.
- Li D, Fan JJ, Yang W. Correlations between badminton exercise remodeling addictive marker BDNF and physical health status. *J Wuhan Sports Univ*. (2022) 56:75–82.
- Zhang CL, Zhang SW, Xiao KP. Influence of exercise intervention on college students' psychological pressure: mediating effect on health belief. *J Chengdu Sport Univ*. (2016) 42:103–8.
- Shi T, Li XD. Evaluation of the intervention effect of different intensity badminton training on Uyghur anxiety disorder college students. *Chin J Sch Health*. (2016) 37:1426–8.
- Wang BZ, Wang HY, Zhong ZP, Zhang L, Zhou W. The construction and practice of “three-in-one” compound physical education teaching model—taking the optional course of university badminton as an example. *J Phys Educ*. (2023) 30:128–33.
- Hettiarachchi IT, Hanoun S, Nahavandi D, Nahavandi S. Validation of polar OH1 optical heart rate sensor for moderate and high intensity physical activities. *PLoS ONE*. (2019) 14:e0217288. doi: 10.1371/journal.pone.0217288
- Gellish RL, Goslin BR, Olson RE, McDonald A, Russi GD, Moudgil VK. Longitudinal modeling of the relationship between age and maximal heart rate. *Med Sci Sports Exerc*. (2007) 39:822–9. doi: 10.1097/mss.0b013e31803349c6
- Garber CE, Blissmer B, Deschenes MR, Franklin BA, Lamonte MJ, Lee IM, et al. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. *Med Sci Sports Exerc*. (2011) 43:1334–59. doi: 10.1249/MSS.0b013e318213febf
- Batista MB, Romanzini CLP, Castro-Piñero J, Ronque ERV. Validity of field tests to estimate cardiorespiratory fitness in children and adolescents: a systematic review. *Revista Paulista de Pediatria*. (2017) 35:222–33. doi: 10.1590/1984-0462/2017/35;2;00002
- Léger LA, Mercier D, Gadoury C, Lambert J. The multistage 20 metre shuttle run test for aerobic fitness. *J Sports Sci*. (1988) 6:93–101. doi: 10.1080/02640418808729800
- Wang ZY. The self-report symptom inventory, symptom check list 90. *Shanghai Arch Psychiatry*. (1984) 2:69–70.
- Song JM, Zhang FT. A exploration on the stage division of the formation process for sports ability. *J Phys Educ*. (2024) 31:142–7.
- Deng RF. Sports skill learning level establishment. *J Phys Educ*. (2018) 25:11–6.
- World Health Organization. *WHO Guidelines on Physical Activity and Sedentary Behaviour*. (2020). Available online at: <https://iris.who.int/server/api/core/bitstreams/faa83413-d89e-4be9-bb01-b24671aef7ca/content> (Accessed January 8, 2026).
- Zhang W. Analysis and enlightenment of American school physical education motivation research. *J Chengdu Sport Univ*. (2017) 43:115–21.
- Wang SX, Guo ZX. Temporal structure and energy supply characteristics of singles badminton matches: review and training insights. *China Sport Sci Technol*. (2023) 59:3–10.
- Lee EJ, So WY, Youn HS, Kim J. Effects of school-based physical activity programs on health-related physical fitness of Korean adolescents: a preliminary study. *Int J Environ Res Public Health*. (2021) 18:2976. doi: 10.3390/ijerph18062976
- Mohammed MHH. The effect of three sport games in physical education on the health-related fitness of male university students. *Phys Educ Stud*. (2020) 24:251–8. doi: 10.15561/20755279.2020.0408
- Wen H. Effects of badminton on body shape and health fitness of college students. *Youth Sport*. (2018) 95–6.
- Patterson S, Pattison J, Legg H, Gibson AM, Brown N. The impact of badminton on health markers in untrained females. *Sports Sci*. (2017) 35:1098–106. doi: 10.1080/02640414.2016.1210819
- Li X, Li XT, Wang ZZ, Wang Y, Wang MD. Effect of different exercise loads on cardiorespiratory fitness and body composition among adolescents. *China Sport Sci Technol*. (2017) 53:110–6.
- Yin XJ, Li Y. Improving cardiorespiratory fitness to promote the development of executive function in adolescents. *Chin J Sch Health*. (2024) 45:305–8+12.
- Liu X. Effect of different forms of badminton intervention on cardiopulmonary endurance of obese ethnic Korean male college students. *Chin J Sch Health*. (2020) 41:365–7+70.
- Poitras VJ, Gray CE, Borghese MM, Carson V, Chaput JB, Janssen I, et al. Systematic review of the relationships between objectively measured physical activity and health indicators in school-aged children and youth. *Appl Physiol Nutr Metab*. (2016) 41:S197–239. doi: 10.1139/apnm-2015-0663
- Bi CJ, Yin XJ, Shi LJ, Wu HP, Wang JX, Shan Y, et al. Intervention effects of moderate and high intensities of classroom physical activity on cardiorespiratory fitness and executive function among junior grade one students in Tibetan. *Chin J Sch Health*. (2024) 45:322–5.
- Lv Y, Wang B, Qiu F. Effects of physical activity on mental and behavioral health and functioning for college students: a systematic review using ICF. *Chin J Rehabil Theory Pract*. (2023) 29:38–47.
- Chen C, Nakagawa S. Recent advances in the study of the neurobiological mechanisms behind the effects of physical activity on mood, resilience and emotional disorders. *Adv. Clin. Exp Med*. (2023) 32:937–42. doi: 10.17219/acem/171565
- Ströhle A, Graetz B, Scheel M, Wittmann A, Feller C, Heinz A, et al. The acute antipanic and anxiolytic activity of aerobic exercise in patients with panic disorder and healthy control subjects. *J Psychiatr Res*. (2009) 43:1013–7. doi: 10.1016/j.jpsyres.2009.02.004
- Precht LM, Margraf J, Stirnberg J. It's all about control: sense of control mediates the relationship between physical activity and mental health during the COVID-19 pandemic in Germany. *Curr Psychol*. (2023) 42:8531–9. doi: 10.1007/s12144-021-02303-4
- Feng W, Zhao L, Ge Z, Zhao X, Li T, Zhu Q. Association between physical activity and adolescent mental health in the post COVID-19: the chain mediating effect of self-esteem and social anxiety. *PLoS ONE*. (2024) 19:e0301617. doi: 10.1371/journal.pone.0301617
- Kennedy RA, McKenzie G, Holmes C, Shields N. Social support initiatives that facilitate exercise participation in community gyms for people with disability: a scoping review. *Int J Environ Res Public Health*. (2022) 20:699. doi: 10.3390/ijerph20010699
- Zhang YQ, Jiang X. The effect of Baduanjin exercise on the physical and mental health of college students: a randomized controlled trial. *Medicine*. (2023) 102:e34897. doi: 10.1097/MD.00000000000034897
- Cen S, Zhao M, Wang F, Tang L. Gender differences in the relationship between mental health and academic performance among undergraduate students at a medical school in Shanghai: a cross-sectional study. *BMC Public Health*. (2025) 25:731. doi: 10.1186/s12889-025-21697-5
- Beisecker L, Harrison P, Josephson M, DeFreese JD. Depression, anxiety and stress among female student-athletes: a systematic review and meta-analysis. *Br J Sports Med*. (2024) 58:78–285. doi: 10.1136/bjsports-2023-107328



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Challenges, salutogenic resources and adolescent agency: a qualitative study in a public school in Peru

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Introduction: Adolescents living in socioeconomically vulnerable environments face multiple interrelated academic, emotional, relational, and economic challenges that shape their well-being and development. Research has largely prioritised risk-based and adult-centred perspectives, often overlooking adolescents' capacities and strengths. This study explored how adolescents in a Peruvian public school perceive daily challenges, mobilise General Resistance Resources (GRRs), and exercise agency from a salutogenic perspective.

Methods: A qualitative study was conducted in a public secondary school in Acobamba, Peru. Twenty-eight adolescents (21 females and 7 males) and 6 teachers participated. Data were collected through month-long personal diaries, adolescent focus groups, and semi-structured interviews with teachers. A reflective thematic analysis was applied with equal rigour to adolescent and teacher data, enabling comparative analysis. Coding was inductive and supported by ATLAS.ti, integrating gender and salutogenesis as analytical lenses.

Results: Adolescents identified academic, relational, economic, family, and everyday challenges. They mobilised diverse GRRs (personal, social, spiritual, digital, and institutional) for emotional regulation, problem-solving, and meaning-making. Agency emerged as a dynamic context-dependent capacity shaped by the perceived impact of challenges and available resources, consistent with bounded agency. Gender differences were observed in the recognition of challenges, resources, and agency. Teachers recognised some resources and emerging agency in adolescents however emphasised risk, dependency, and limited autonomy, contrasting with adolescents' more active accounts.

Conclusion: Adolescent well-being reflects the interaction between structural conditions, relational contexts, and resource mobilisation. Resources must be recognised, activated, and socially validated within a constrained agency. Bridging the gap between adolescent and adult perspectives is essential. Health promotion should strengthen adolescent capacities, address structural barriers, and incorporate gender and contextual perspectives.

KEYWORDS

adolescence, agency, daily challenges, general resistance resources, health promotion, salutogenesis

1 Introduction

Adolescence is a crucial stage of human development, characterised by diverse and profound changes that shape the construction of identity, progressive autonomy and the acquisition of life skills (1, 2). In contexts of socio-economic vulnerability, these changes occur in settings marked by structural inequalities that directly influence adolescent well-being and comprehensive development. Globally, adolescents represent a significant proportion of the population, and in Peru they constitute approximately 10% of the national total (3), Huancavelica being one of the regions with a particularly large youth population base, and currently maintaining significant levels of poverty and inequality (4).

In this context, adolescents face multiple challenges such as adolescent pregnancy, especially in rural areas and in lower income quintiles (5, 6) as well as important indicators of morbidity and mortality in regions such as Huancavelica (7). In relation to mental health, there has been an increase in suicide attempts and episodes of depression, with women being the most affected and the age range being 15 to 19 years old (8). Furthermore, domestic and school violence continues to be a significant problem, including physical, psychological and sexual violence in school environments (9, 10). Educational gaps, school dropout rates and regional inequalities specific to Huancavelica exacerbate this situation (11).

In response, the Peruvian government has implemented various regulations and sectoral strategies aimed at providing comprehensive care for adolescents, such as national standards for comprehensive care, educational guidelines, and national multisectoral plans (12–16). However, these initiatives have a predominantly deficit or disease and/or risk-centred approach, mainly being activated when the problem has already arisen. This approach, which is often adult-centred, tends to place adolescents in a passive role in relation to their contexts (3).

On the other hand, the salutogenic model proposed by Antonovsky offers a perspective focused on the processes that generate and sustain health (2). Under this theory, well-being is explained by the mobilisation of General Resistance Resources (GRR) and the development of a Sense of Coherence (SOC) (17), understood as the ability to perceive life as understandable, manageable, and meaningful (18). Salutogenic framework includes individual, relational, and structural resources that enable individuals to cope with stressors, while high SOC is associated with better mental health indicators, lower adoption of risk behaviours, and greater overall well-being in adolescence, contributing to their comprehensive development (19–21).

Factors such as gender, socioeconomic status, and family composition influence the development of SOC (22, 23), which suggests that its strengthening depends on broader ecological conditions.

However, the availability of resources does not guarantee their activation. Evidence from salutogenic research and health promotion suggests that resources only contribute to well-being when people are able to recognise them, give them meaning, and actively mobilise them in line with their own goals and context (24, 25). In this context, the salutogenic model emphasises the availability and management of resources and the construction of meaning; however, as Antonovsky (59) points out, it does not fully address people's capacity to act upon these resources in the pursuit of meaningful goals. Therefore, incorporating autonomy and the capacity for action into this framework allows for a better understanding of how people not only cope with stressors, but also

actively use resources to shape their life trajectories (26). It is in this context the concept of conditional agency emerges, defined as people's capacity for action, which is conditioned and limited by structural, social and institutional factors, as well as by the resources available in their environment (27). From a public health perspective, analysing how adolescents exercise agency in structurally vulnerable contexts allows us to transcend models focused exclusively on risk, as well as to position adolescents in a more active role, capable of understanding their contexts and making decisions, moving towards a more holistic and dynamic understanding of adolescent well-being.

International research has examined adolescent agency through qualitative and comparative approaches in contexts of vulnerability, particularly in the Global South, demonstrating that it is not only conceptualised but also assessed on the basis of adolescents' ability to recognise, mobilise and negotiate resources in their daily lives. Qualitative studies have identified agency through coping strategies, decision-making and the use of support networks, demonstrating how adolescents actively manage situations of adversity (28). Furthermore, comparative research has shown that agency manifests itself in different ways across countries, depending on the context, and is influenced by structural, cultural and gender-related factors (29). In this line, approaches have been developed to measure agency in adolescents based on dimensions such as voice, decision-making and control over their actions, highlighting the need for contextual adaptations to ensure their proper assessment (30). In contexts of high vulnerability, agency has been understood as a relational and situated process, in which adolescents develop everyday strategies to cope with violence, stress and uncertainty, actively negotiating their well-being, such as hypervigilance, avoidance and emotional regulation, within environments marked by structural inequalities and institutional constraints (31). Overall, this evidence suggests that agency should be understood as a dynamic process that emerges from the interaction between available resources and environmental constraints, reinforcing the importance of integrating it into frameworks such as salutogenesis.

Despite growing interest in adolescent health, there is still limited evidence that examines, from a salutogenic approach and in rural contexts of high social vulnerability such as acobamba - Perú, how adolescents identify their daily challenges, mobilise general resources of resistance, and exercise agency within school and community settings. In this context, the present study seeks to provide contextualised evidence by analysing how challenges, resources, and agency are articulated in the daily experience of adolescents.

2 Materials and methods

2.1 Study design

A qualitative study was conducted, adopting a phenomenological and socio-constructivist approach aimed at understanding how adolescents interpret their daily experiences in relation to the challenges they face. This approach made it possible to analyse how these experiences are linked to the mobilisation of resources and processes of agency in their daily lives, placing their narratives within the social context in which they develop (32).

2.2 Setting and participants

The study was conducted in a public secondary school located in the province of Acobamba, Huancavelica region, Peru, characterised by high levels of socio-economic vulnerability and structural gaps.

The population consisted of adolescents enrolled in the third year of secondary education during the study period. The entire group ($N = 42$) was invited to participate, in order to avoid any potential exclusions within the classroom that could cause discomfort among adolescents; this decision was coordinated with the school authorities and the teaching staff.

Participation was voluntary and required the informed consent of adolescents and the informed consent of their parents or guardians. Of the 42 students invited, 28 agreed to participate and completed the personal diaries, while 14 decided not to participate after receiving information about the study. No students were excluded by the research team. This voluntary participation may have contributed to the observed gender imbalance in the sample.

As the students were in the same year group and class, no significant demographic differences were identified between those who participated and those who did not.

Regarding the teachers, six professionals were invited to participate, selected through purposive sampling based on their role within the year group under study. The group included the tutoring coordinator, who was responsible for managing the school's form tutor programme and training other teachers to work with adolescents, as well as the tutors and teaching assistants assigned to the third year of secondary school, who worked directly with the students. This selection enabled us to gather perspectives directly linked to the participating group, in order to incorporate the adult perspective on adolescent experiences and development processes in the school context.

The sampling method chosen could lead to potential biases. The voluntary participation of students could imply that those who agreed to take part are more inclined towards reflection or engagement in this type of activity. Furthermore, the intentional selection of teachers, based on their direct link to the school year, may have favoured perspectives closer to tutorial support and knowledge of the students, leaving out other viewpoints within the institution. Both aspects could influence the nature of the findings, particularly in the identification and description of resources and experiences, as well as in teachers' perceptions of adolescence; therefore, the results should be interpreted with these potential limitations in mind.

2.3 Data collection procedures

Data collection was carried out between September and December 2025, using three qualitative techniques.

Personal diaries for adolescents: A semi-structured journal was designed with three thematic blocks: (I) Who am I and what is my context?, with questions related to exploring identity and the environment in which they live; (II) My day-to-day life, focused on everyday experiences, challenges and emotions; and (III) Weekly reflection, aimed at complementing the discussions raised in their day-to-day lives and promoting processes of personal meaning and analysis. For 1 month, the adolescents anonymously recorded their experiences, perceived challenges, resources used, and agency. This technique provided access to personal narratives and reflective processes in people's natural context, encouraging reflection, the development of different skills and metacognition (33).

Prior to its implementation, the instrument was validated with a volunteer group of adolescents to ensure conceptual clarity and cultural appropriateness. Based on their suggestions, adjustments were made to the visual design, incorporating a visual guide that provided guidance on the frequency and method of recording, as well as adjustments to the format of the diary, without interfering with the content.

No minimum number of entries was established, as the aim was to respect the voluntary nature of the process. The diaries were handed out at school and completed at home. Guardians reinforced procedural compliance without interfering with the content of the diary. Once collected, the diaries were scanned and uploaded directly into ATLAS.ti software (RRID:SCR_014836) for analysis.

Although each diary allowed for up to 168 possible entries, the volume of entries across the 28 diaries reflected the inherent variability of a naturalistic design. While some participants maintained a high level of consistency, others recorded entries more intermittently, particularly in the daily entries. This variability was not considered a limitation, but rather reflected the subjective relevance of the experiences.

To ensure the robustness of the analysis, aspects less developed in the diaries were explored in greater depth through focus groups. This provided sufficient analytical depth and allowed saturation to be reached.

Focus groups: Two focus groups were held, differentiated by gender, each lasting approximately 120 min. The objective was to explore and reflect collectively on the preliminary findings from the diaries. This technique allowed perceptions, meanings and experiences to be explored collectively through interaction between participants, which diversifies and enriches the responses (34, 35). The objective was to delve deeper and reflect collectively on the preliminary findings from the diaries.

Participatory and arts-based methodologies were used to encourage creative expression and the shared construction of meaning (36). The sessions were recorded with prior consent and transcribed verbatim.

Semi-structured interviews with teachers, aimed at gathering adult representations of adolescence. This technique allowed perceptions and experiences to be explored from the participants' perspective, maintaining a balance between the flexibility of the conversation and the thematic orientation of the research, while maintaining objectivity and reliability (37), as well as complementarity and triangulation of data (38). The questions addressed work experience with adolescents, perceptions of challenges and resources, school dynamics, and adolescent agency processes.

The interviews were recorded with prior informed consent and transcribed verbatim for subsequent analysis.

2.4 Data analysis

The analysis was conducted using a reflective thematic analysis approach, a qualitative approach used to identify, analyse and organise patterns of meaning within a data set, relevant for exploring experiences, perceptions and social constructions (39, 40). The analysis process included repeated readings of the diaries and transcripts of the focus groups and interviews, following the phases proposed by Braun and Clarke (60): familiarisation with the data, generation of initial codes, construction of themes, review of themes, definition and naming of themes, and preparation of the final report. The gender perspective guided the entire analytical process. The process was iterative and involved a constant movement between the

data, codes and themes. ATLAS.ti software (v.23) was used to facilitate the organisation, coding and traceability of the analytical process.

2.4.1 Coding and theme development

The coding was carried out inductively, starting from the verbatim data and moving towards progressively higher levels of conceptual abstraction. This process involved generating initial codes, grouping them into sub-themes and, subsequently, constructing themes.

For example, the initial code “Difficulty concentrating/understanding the lesson” was grouped under the sub-theme “Problems with understanding academic subjects,” which contributed to the construction of the theme “Academic challenges.” Similarly, expressions such as ‘Support in God in difficult situations’ were coded and grouped under the sub-theme ‘Spirituality as a resource,’ forming part of the theme “Personal resources.”

This process was carried out iteratively, allowing for continuous refinement of the thematic structure. A sample of the relationship between codes, sub-themes and themes was systematised in an analytical matrix ([Supplementary Table 1](#)), in order to ensure transparency in the construction of the findings.

2.4.2 Triangulation and analytical consistency

To strengthen the credibility of the analysis, the principal investigator conducted the analysis in accordance with the ethical approval obtained for the study, which established that access to identifiable data would be restricted to a single researcher to ensure confidentiality and data protection. Subsequently, the coding framework and emerging themes were discussed with other members of the research team in consensus meetings. During these sessions, interpretations were compared and discrepancies were discussed and resolved through reasoned agreement, enabling the refinement of the coding system and the final thematic structure.

Reflective thematic analysis was applied with the same rigour and systematic approach to both the adolescents’ data (diaries and focus groups) and the teacher interviews. The teacher interviews were not used merely as contextual background, but as an independent data set that was coded inductively. This allowed for an explicit comparative analysis to identify whether the adults’ discourses converged with, enriched or contradicted the adolescents’ experiences, ultimately integrating both perspectives into the construction of the overarching themes.

To strengthen the confirmability of the findings, a triangulation of sources and methods was carried out by cross-analysing personal diaries, focus groups and interviews with teachers. This process enabled the identification of relevant convergences and divergences: While the focus groups expressed challenges in general terms (e.g., “difficulties with studying or in the school”), the personal diaries provided more depth, highlighting specific difficulties such as problems with concentration and comprehension in class or in specific topic. Meanwhile, the interviews with teachers allowed these perceptions to be cross-checked and validated, with agreement on the academic difficulties but differences in the interpretation of adolescence. This triangulation enabled the phenomenon to be captured from subjective, collective and institutional perspectives, strengthening the interpretative robustness of the analysis.

2.4.3 Reflexivity and the research team’s position

The research team adopted a position of critical reflexivity throughout the analytical process. It is acknowledged that their training and experience in the field of health promotion and salutogenesis may have influenced their sensitivity towards identifying health resources and assets.

To achieve this, a professional with a clinical-care orientation was incorporated into the research team; her perspective, centred on understanding needs, risks and health conditions, complemented the predominant focus on health promotion and salutogenesis. This dialogue between approaches allowed for a broader interpretative framework, avoiding the limitation of the analysis to a single perspective and reducing the risk of confirmation bias. Furthermore, strategies such as keeping field diaries and holding reflective discussions between the two approaches, fostered a richer and more nuanced interpretation of the data, integrating both resources and challenges within the adolescents’ experiences. This process helped to strengthen the study’s confirmability, ensuring that the findings emerged from the data rather than from the research team’s prior assumptions or pre-defined theoretical categories.

Furthermore, the composition of the team, with members based in Spain and Peru, provided a complementary perspective: on the one hand, a closer understanding of the participants’ socio-economic and rural context; and on the other, an analytical distance that facilitated the identification of broader patterns relating to the phenomenon under study. Particular attention was paid to the adult-centred tensions identified in the findings. As a team composed of adult female researchers, we sought to avoid paternalistic interpretations and potential gender biases. Through ongoing reflective discussions, we questioned normative assumptions about adolescence, favouring an interpretation that prioritised the voices and experiences of the participants.

2.4.4 Data saturation

Data collection and analysis were carried out simultaneously. Conceptual saturation was deemed to have been reached when the final data sources did not yield new codes or alter the existing thematic structure, but rather confirmed previously identified patterns. At this point, the inclusion of further data was deemed redundant for understanding the phenomenon under study.

2.4.5 Compliance with quality criteria

The analytical process and its reporting were structured in accordance with the items of the COREQ guide for qualitative research ([41](#)), with the aim of ensuring transparency, methodological rigour and consistency in qualitative research.

2.5 Research team and quality standards (COREQ)

Data collection and analysis were carried out by the principal investigator, a PhD student in the field of Health Promotion and Health Services, with specialist training in health promotion and qualitative methodology. Her approach was grounded in a salutogenic perspective, focusing on a positive view of health and adolescence, which was taken into account throughout the analytical process. There

were no prior relationships between the research team and the participants (students or teachers), which facilitated interaction free from pre-existing connections.

The interviews and focus groups were conducted in private rooms within the school, ensuring confidentiality, freedom from interruptions and an environment conducive to free expression. Furthermore, the conditions were characterised by an atmosphere of trust and openness, facilitated by the prior use of personal diaries, which were handed out to be completed in the spaces the adolescents themselves deemed most appropriate, respecting their privacy and the nature of their everyday lives. This allowed participants to reflect on their experiences prior to the group sessions. It was emphasised that participation was voluntary and had no bearing on their assessment or academic performance within the school environment.

Finally, data saturation was determined through a concurrent analysis process, according to the point 2.4.

2.6 Data visualisation and categorisation

To facilitate the interpretation of the findings, treemaps were created (Supplementary Figures 1–3). These figures represent the structure and relative distribution of the categories and subcategories that emerged from the thematic analysis. The size of the areas in the graphs is based on the relative frequency of the coded segments associated with each category, identified during the coding process in the ATLAS.ti software.

It is important to note that, given the qualitative nature of the study, these frequencies are used exclusively for illustrative purposes, with the aim of showing the thematic density and relevance of certain challenges and resources within the participants' narratives, and not to draw statistical inferences.

2.7 Ethical considerations

This study was reviewed and approved by the Institutional Research Ethics Committee (CIEI) of Cayetano Heredia Peruvian University (CIEI-E-291-36-25). Written informed consent was obtained from the parents or legal guardians of all participating adolescents, and assent was obtained from the adolescents prior to participation. Participants were informed about the aims of the study, the voluntary nature of participation, and their right to withdraw at any time. All data were anonymized and handled confidentially.

3 Results

Twenty-eight adolescents (21 females and 7 males) aged between 13 and 16 years old, enrolled in the third year of secondary education, participated, as well as six teachers (three females and three males) with tutoring and student support roles. In terms of the characteristics of the adolescents, most reported living with both parents, although single-parent families, mainly maternal, and living with extended family were also identified. The main activity was studying, although some adolescents combined study and work. Most identified as single, with some romantic experiences, and Catholic religious affiliation predominated, followed by Evangelical.

Reflective thematic analysis identified three major themes, organised into several subthemes: (1) daily challenges in a context of

structural vulnerability, including academic, emotional and relational, economic, everyday and family challenges; (2) general resistance resources, referring to personal, family, social, digital, institutional and community resources mobilised by adolescents; and (3) conditioned agency and coping strategies, which describes adolescents' perceived capacity to act and the strategies they use to face everyday challenges. Teachers' perspectives were integrated across themes to contrast and contextualise adolescents' narratives, enabling a dialectical analysis between the two groups.

3.1 Daily challenges in a context of structural vulnerability

Adolescents described their daily lives as experiences marked by multiple learning opportunities, as well as challenges that arise and interact at different levels: academic, emotional, relational, economic, and everyday. Supplementary Figure 1 shows the distribution of the main challenges reported by adolescents. However, the comparative analysis reveals a tension in interpretation: while adolescents describe these experiences from their own lived perspective, teachers tend to interpret them within broader frameworks associated with risk, a breakdown of boundaries and vulnerability.

3.1.1 Academic challenges

In the academic sphere, situations of school pressure, difficulties in understanding academic content, conflicts with teachers, experiences of bullying and discrimination among peers emerged. Some accounts revealed episodes of verbal violence or social exclusion in the classroom, which generate stress, frustration and demotivation at school.

One adolescent pointed out:

'Maths lessons were difficult and boring[...] the teachers did not give us time, it was tiring' (Adolescent, female).

Likewise, experiences of normalised discrimination based on skin colour and physical appearance within the school context emerged.

'Discrimination [...] we think it's just a game [...] but it hurts us.' (Adolescent, female).

Situations of direct violence were also reported.

'A classmate was hitting all the girls' (Adolescent, female).

Female adolescents tended to verbalise their challenging academic experiences in greater detail, while male adolescents did not explicitly identify them or attributed them to external factors, such as lack of internet access or dislike of certain subjects.

On the other hand, teachers' discourse does not focus on academic difficulty in itself, but tends to reinterpret these situations as manifestations of problematic behaviour or a loss of authority typical of adolescence:

'Students are already quite empowered, now they are in control of the situation' (Teacher, female).

Some teachers interpret so-called adolescent “empowerment” as excessive autonomy or a lack of control, associated with behaviours considered inappropriate, such as “doing what they want” or a loss of respect for adult authority. In this context, certain institutions that promote discourses on rights or personal development are perceived as generating disorder or negative transformation:

‘Institutions tell them (adolescents) about their rights... and that’s where the problem lies’ (Teacher, male).

This discrepancy suggests that, while adolescents experience these challenges as barriers to learning, teachers view them through the lens of discipline and control.

3.1.2 Emotional and relational challenges

Emotional and relational challenges are linked to processes of self-regulation, managing meaningful relationships, and protecting emotional integrity. Adolescents described constant efforts to “be okay” or “be strong” in the face of interpersonal conflicts.

One adolescent noted:

‘The biggest challenge was to be strong and not let others hurt me’ (Adolescent, female).

Difficulties with self-control were also identified:

‘Sometimes I cannot control myself’ (Adolescent, female).

Female adolescents tended to describe experiences related to resentment, overthinking, and sadness in greater depth. In contrast, males often placed the challenge on the behaviour of others or on external events, with less explicit emotional elaboration.

In contrast, teachers enrich this category by situating emotional and relational challenges within the group dynamics characteristic of adolescence, linked to coexistence, constant interaction among peers, and the interpersonal conflicts that arise in these settings. From this perspective, emotional tensions are not interpreted solely as individual processes of self-regulation, but as relational phenomena that are expressed in group dynamics:

‘Adolescents are mostly in groups... sometimes they argue, that’s part of being adolescents’ (Teacher, female).

This perspective offers a more contextual understanding of emotional challenges by emphasising their interactive and situational nature, in contrast to the subjective experiences reported by the adolescents themselves.

3.1.3 Economic challenges

Material deprivation was described as a persistent experience that shapes opportunities, priorities and future prospects. Economic constraints are perceived not only as a lack of goods, but also as a structural factor that influences everyday experiences.

During a focus group, one adolescent noted:

‘We do not have enough money to buy something we need’ (Adolescent, male).

The adolescents also identified finances as a barrier to accessing professional help and/or specialised services:

‘Finances can prevent you from getting professional help’ (Adolescent, female).

In some cases, this situation meant taking on work responsibilities at an early age:

‘I got up at 5 a.m. to help my mum [...] then I went to clean a hotel’ (Adolescent, female).

Work coexisted with study, leading to fatigue and a reorganisation of academic priorities.

From the teachers’ perspective, there is a clear consensus that financial precariousness is a structural constraint that affects academic performance and determines future educational prospects:

‘There’s no financial support at home... and that affects their studies’ (Teacher, male).

Teachers also point out that some adolescents work to cover personal costs, such as mobile data, which creates new pressures on their use of time and daily routines:

‘They work to earn money... and spend it on data or games’ (Teacher, male).

This contrast reveals that, while adolescents emphasise the direct experience of deprivation and the struggle with material aspects at a given moment, teachers broaden the understanding by linking economic precariousness to uncertain future educational trajectories and to digital consumption patterns which, in some cases, may reinforce forms of escapism from the situation.

3.1.4 Daily challenges

Daily challenges included time management, domestic responsibilities, unexpected situations, and physical discomfort. These experiences reflect tensions between obligations and personal desires.

‘The biggest challenge was organising my time’ (Adolescent, female).

Experiences of insecurity in the face of unexpected interactions with strangers also emerged:

‘I was scared [...] I didn’t know what to do’ (Adolescent, female).

In addition, difficulties related to sleep, eating, and physical ailments were mentioned, which affect daily performance.

Although teachers do not focus directly on the everyday events mentioned by adolescents, they interpret them within a broader framework associated with disorganisation, a lack of routine and difficulties with self-regulation, linked to limited supervision:

‘They come in sleepy... they’ve been playing all night’ (Teacher, male).

This difference reflects the fact that, while adolescents describe specific day to day experiences, teachers reframe them as indicators of habits and discipline, introducing a more normative interpretation of everyday functioning within the school environment.

3.1.5 Family challenges

Family challenges were associated with conflicts, misunderstanding, and a perception of poor emotional support. Arguments with the mother and difficulty communicating with the father were recurring themes.

'I always fight with my mum' (Adolescent, female).

'My dad doesn't understand what I want' (Adolescent, female).

In the focus groups, stories emerged of psychological violence and parental arguments that have an emotional impact on children:

'Parents argue and children listen [...] that affects psychologically' (Adolescent, female).

Among male adolescents, there was a tendency to normalise situations of violence or parental criticism:

'If my dad told me I was behaving badly, it would be okay for him to hate me' (Adolescent, male).

Overall, the challenges perceived by adolescents reflect individual experiences, as well as the interaction between structural conditions, such as economic and family circumstances, school dynamics, and subjective processes of emotional regulation. These experiences constitute the scenario in which their general resources and their capacity for agency are mobilised or inhibited.

From the teachers' perspective, there is a consensus on the high prevalence of intrafamily conflicts and difficulties in communicating with parents as risk factors. However, teachers broaden this interpretation by incorporating the influence of the digital environment, particularly the internet and social media, as a factor that interferes with family dynamics and the development of cultural references, and that are not appropriate for them:

"They have communication problems with their parents... and follow models from the internet" (Teacher, male).

This contrast highlights that, while adolescents describe conflicts from their direct emotional experience, teachers situate them within a broader framework that combines family dynamics and external sociocultural factors, offering a more structural interpretation of the problem.

3.2 General resistance resources identified

Adolescents identify and mobilise various general resistance resources (GRR) in response to the challenging situations mentioned above. These resources encompass personal, relational, digital and institutional dimensions, and serve the functions of emotional regulation, daily support and active coping. However, barriers to

their recognition and activation are also evident. [Supplementary Figure 2](#) shows the most common salutogenic resources.

A comparative analysis reveals a partial convergence between the perspectives of adolescents and teachers. While adolescents identify and mobilise a wide range of resources, including personal, family, social, digital and institutional dimensions, teachers tend to perceive these resources as more limited and concentrated primarily within the family and informal networks of trust. They point to a limited seeking of professional help and a greater reliance on close relationships. This contrast suggests that, although adolescents recognise multiple sources of support, their effective mobilisation may be influenced by accessibility, trust and immediate relational dynamics. Although teachers tend to adopt a more restricted and risk-oriented view, some elements of alignment can be identified, particularly in the recognition of close relationships and support networks as relevant resources. However, these are often interpreted by teachers in terms of need and dependency, whereas adolescents frame them as active sources of support and agency.

3.2.1 Personal resources

Personal resources include emotional, cognitive, physical and spiritual abilities that can be mobilised without necessarily relying on external support. In terms of attitude, self-confidence, self-motivation, calmness and assertive communication emerge as tools for dealing with interpersonal and academic conflicts.

In the cognitive dimension, "thinking before acting," reinterpreting the situation or prioritising tasks allows a sense of control to be regained. Physically, sleeping, playing sports or doing breathing exercises function as self-regulation mechanisms. Spiritually, belief in God is a source of strength, hope and meaning.

From a gender perspective, men tend to emphasise action-oriented and distraction strategies, while women highlight expressive and spiritual resources linked to emotional containment.

'Praying to God helps me' (Adolescent, female).

'My mindset helps me understand things better' (Adolescent, male).

In contrast, teachers do not recognise adolescents' internal resources, but rather view them as aspects still in development that depend on external guidance. From this perspective, these resources are interpreted as aspects that require guidance, support and adult experience in order to be properly recognised and activated. However, some teachers point out that they identify and rely on faith-based organisations as a legitimate community resource for strengthening support for adolescents.

'They always need guidance from an adult' (Teacher, female).

This contrast suggests that, while adolescents perceive and utilise personal resources, teachers interpret them as capacities still under development that require adult support.

3.2.2 Family and social resources

The family is the primary support network. The mother appears to be the central figure for listening and emotional support, while siblings provide academic support and advice. Peers serve as a source of relief and daily companionship.

Gender differences can be observed: male adolescents associate family support mainly with economic aspects or serious situations, while female adolescents emphasise frequent conversation and emotional support.

'I talk to my mum and my best friend' (Adolescent, female).

'My mum gives me advice' (Adolescent, male).

From the teachers' perspective, there is a consensus on recognising the family as the central source of support. However, they broaden this view by pointing out that adolescents' resources are centred on close, trusting relationships, including their partner as a significant source of emotional support:

'My student said to me: He's the only person who understands me (partner)' (Teacher, female).

Likewise, teachers highlight that many adolescents come from complex family backgrounds, which increases the need for external guidance:

'Some come from dysfunctional families... they need guidance' (Teacher, female).

This contrast shows that, although both agree on the centrality of close relationships, teachers interpret them in terms of need and vulnerability, while adolescents experience them as active sources of support. This suggests that, despite differing interpretations, there is a shared recognition of relational resources as central, indicating a potential point of convergence between adolescent and adult perspectives.

3.2.3 Digital resources

Mobile phones are emerging as central, multifunctional devices. They are used to search for academic and health information, communicate with support networks, and regulate emotions through music, social media, or video games. Artificial intelligence tools are used for immediate academic support, such as chat gpt.

Male adolescents emphasise instrumental use and digital gaming, while female adolescents prioritise seeking guidance and informational support.

'I searched the internet and found a delicious recipe' (Adolescent, female).

'When I need information about my health, or to distract myself, I use AI and ChatGPT.' (Adolescent, male).

In contrast, while teachers recognize that adolescents make extensive use of technology, they tend to view it in a predominantly negative light, seeing it more as a means of escapism than as a resource. From their perspective, the intensive use of social media and online games is interpreted as a form of refuge from a lack of attention or affection within the family environment, which can affect concentration and motivation towards academic activities:

'They get caught up in games... and studying becomes difficult' (Teacher, male).

"They take refuge in virtual games more than anything else" (Teacher, male).

This contrast suggests that, while adolescents perceive technology as a tool for support and regulation, teachers interpret it primarily as a factor of distraction and deregulation, highlighting a difference in the assessment and interpretation of digital resources.

3.2.4 Institutional and community resources

The school, teachers and school psychologist are recognised as sources of academic and emotional support. Health centres and protection services are also mentioned as formal resources in serious situations, although access to them often depends on adult mediation. Particularly in situations of discrimination, violence, or when some family members did not take them seriously.

'We would talk to a teacher we trust.' (Adolescent, female).

'We could write or take up a hobby, or even go to a psychologist' (Adolescent, female).

'I report it to the judicial authorities, the police' (Adolescent, male).

Community and natural spaces serve as settings for emotional regulation and well-being.

'My community is kind and supportive, which makes me feel safe and calm' (Adolescent, female).

From the teachers' perspective, there is a consensus that students rarely seek formal help, despite the availability of institutional resources. Teachers indicate that adolescents tend to focus their support strategies on spaces of immediate trust, such as their partner or other close relationships, rather than turning to adult figures or professional services:

'Very few adolescents approach a teacher or tutor' (Teacher, female).

Furthermore, teachers do not explicitly recognise community or natural settings as relevant resources, and, in some cases, attribute a potentially problematic role to certain institutions, considering that they promote a form of 'empowerment' perceived as negative:

'Institutions or non-governmental organisations talk about their rights... and that's where the problem starts' (Teacher, male).

In contrast, adolescents do identify a wider range of resources, including institutional and community spaces and everyday environments, although their access to these is often mediated by adults or by the level of trust. This difference shows that, although formal and community resources are recognised by adolescents, teachers tend to favour a more restricted view, centred on immediate relationships and a critical interpretation of the role of institutions. However, this perspective also reflects that teachers recognise the importance of close and accessible support structures, particularly those based on trust and proximity, even if they tend to frame them in terms of supervision and guidance rather than as expressions of adolescent agency.

3.2.5 Difficulties in recognising resources

Despite the wide identification of resources, some adolescents have difficulty naming or activating them in contexts of distress, expressing feelings of loneliness or helplessness, or simply ignorance. This gap is more common in male adolescents, who show less emotional expression and greater ambiguity in identifying support.

'I did not know who to turn to when I was being discriminated' (Adolescent, female).

In line with what has been described in the previous points, from the teachers' perspective this limitation is interpreted not merely as a situational difficulty, but as a more structural characteristic linked to dependence on adult figures and to the limited autonomy in mobilising resources that is typical of adolescence. Teachers tend to consider that adolescents do not fully possess their own resources, but rather require constant guidance to identify and utilise them.

This contrast highlights that, while adolescents recognise and can articulate the existence of resources, even if they do not always succeed in activating them, teachers tend to emphasise their insufficiency and dependence on external support, reinforcing an interpretation that prioritises deficits over emerging capabilities.

3.3 Conditional agency and coping strategies

Adolescents described different ways of responding to everyday challenges, reflecting varying degrees of agency shaped by personal reflection, available support, and contextual constraints. These responses ranged from deliberate and problem-oriented actions to more avoidant or emotionally driven coping strategies. [Supplementary Figure 3](#) shows the most common responses.

A comparative analysis reveals a difference in the interpretation of this agency: while adolescents describe it as a dynamic capacity that is context-dependent and present in them, teachers tend to perceive it as incomplete, still developing and heavily reliant on adult supervision, more often emphasising its limitations than its potential. However, this perspective also involves a partial recognition of adolescents' capacity for action, as teachers do acknowledge that such a capacity exists.

3.3.1 Capacity for agency

Adolescents not only identify challenges, but also mobilise resources to address them, demonstrating a dynamic and contextual capacity for agency. Agency does not emerge as a stable trait, but rather as a capacity that is activated, modulated or restricted according to the perceived severity of the challenge, its personal impact and the availability of resources.

Two predominant forms are identified. The first corresponds to active personal agency, where adolescents take direct responsibility for problem solving: they reflect, regulate emotions, practise self-care, seek information, solve tasks autonomously and strategically request support when they deem it necessary. In this sense, seeking help does not imply dependence, but rather the deliberate exercise of autonomy.

The second corresponds to conditioned agency, in which action depends on contextual factors, especially the perceived impact of the challenge and the resources required to address it. In these

cases, resolution usually follows a sequence: an initial individual attempt followed by recourse to third parties if the situation exceeds their perceived capabilities. When the challenge is perceived as manageable at an individual level, action tends to be autonomous; however, when it involves greater emotional or contextual complexity, it may be postponed or require external support.

From a gender perspective, male adolescents emphasise material autonomy and practical resolution, while female adolescents link agency to process. Adolescents themselves distinguish between challenges they can handle independently and those that require external support:

'I usually do it myself (solve the problem)' (Adolescent, male).

'Depending on the severity of the problem. If it's simple, I solve it myself' (Adolescent, female).

Although teachers recognize the existence of agency, they describe it as limited and dependent on adult guidance, noting that autonomous decision-making is still in the process of development:

'They (adolescents) will always wait for a response first' (Teacher, female).

This difference highlights a gap between the agency experienced by adolescents and the agency perceived by adults, where the former is constructed as a situated practice and the latter as a capacity that is still incomplete.

3.3.2 Coping strategies

The coping strategies identified are diverse and dynamic, and are linked to the resources and agency described above.

Active strategies are observed, aimed at solving the problem or reducing its impact: dialogue, verbal confrontation, academic planning, reporting injustices, seeking professional guidance, and making practical decisions. Coping often begins autonomously before seeking external support, regardless of the results.

Avoidance strategies are also evident, focusing on regulating discomfort rather than resolution: ignoring the problem, isolating oneself, taking refuge in technology, sleeping, or suppressing emotions. In these cases, the action is aimed at immediate relief.

Impulsive responses are also identified, particularly in interpersonal conflicts, where emotional reaction precedes reflection. Less frequently, maladaptive strategies or deliberate inaction appear, such as self-harm, associated with uncertainty, normalisation of violence, or perception of a lack of alternatives.

Barriers to coping include cognitive factors (confusion, overthinking), emotional factors (fear, pride), relational factors (lack of trust), and structural factors (economic limitations, age).

Successful coping strengthens self-efficacy and a sense of personal growth; unsuccessful coping generates learning or awareness of limits.

From a gender perspective, men tend to emphasise instrumental or confrontational coping, while women favour reflective and relational strategies.

'I faced and calmed down, thanks to my friends.' (Adolescent, female).

'I listen to music, play football, chat online, etc.' (Adolescent, male).

From the teachers' perspective, they tend to highlight avoidance or reactive strategies as predominant, particularly in vulnerable situations. They point to the heavy use of technology, early entry into the workforce, or escapism as common coping mechanisms:

'They escape through games, work or alcohol.' (Teacher, male).

They also highlight higher-risk strategies that do not always emerge in adolescents' accounts, such as self-harm, because they feel the pain goes away:

'Many engage in cutting to cope' (Teacher, female).

This contrast suggests that, while adolescents report a combination of active and regulatory strategies, teachers tend to interpret coping from a perspective centred on risk and avoidance, broadening our understanding of the phenomenon by incorporating practices that are less explicitly mentioned.

4 Discussion

The results of this study show that the experiences of adolescents in vulnerable contexts are shaped by the interplay of relational factors (family, peers, school), structural dimensions (economic constraints) and subjective personal dimensions, such as emotional regulation and identity. However, beyond identifying challenges and resources, the findings provide an understanding of how these interact dynamically in the activation of general resistance resources (GRR) and in the construction of their sense of coherence (SOC). In this process, agency emerges as a contextualised capacity, modulated both by structural conditions and by social interpretations, including perceptions of the adult environment, which influence coping strategies for perceived challenges.

These results are consistent with the ecological model of human development (42), and The Lancet Commission on Adolescent Health (43), which highlight the role of structural determinants in well-being. However, this study expands on these perspectives by demonstrating how these determinants not only generate challenges, but also condition the activation of resources, the perception of control and the possibilities.

4.1 Dynamics of GRRs and the dimensions of SOC

From the perspective of salutogenesis theory, the identified resources, personal, family, social, digital and institutional, can be understood as GRRs that contribute to the construction of SOC (18, 20, 44). However, the results show that these resources do not operate in isolation, but are articulated in distinct ways across the three dimensions of SOC: comprehensibility, manageability and meaning.

In terms of comprehensibility, adolescents use personal and relational resources to make sense of their experiences, particularly in academic and family contexts. Strategies such as "thinking before acting", spirituality, talking to peers or using digital tools enable them to manage situations initially perceived as difficult. However, the

divergence from the teachers' perspective, which interprets these same behaviours as a lack of boundaries or disorganisation, suggests that adolescents' construction of comprehensibility is not always recognised or validated, specially in the school environment.

In terms of manageability, family (particularly maternal support), social and institutional GRRs emerge as key resources that enable challenges to be perceived as manageable. For example, adolescents describe going to their mothers or trusted persons to talk and seek guidance, which facilitates emotional regulation and decision-making. Likewise, strategies such as seeking academic help, using digital tools or approaching teachers in specific situations reinforce the perception that support is available. Spirituality also emerges as a significant resource, as it enables situations of high uncertainty to be transformed into emotionally manageable experiences through faith. However, manageability is constrained by structural factors, such as economic difficulties or dependence on adults, which limit effective access to these resources and force individuals to prioritise immediate responses over sustainable solutions.

Spiritual and community resources appear to be influenced in part by the cultural context of the region. With regard to spiritual resources, their presence is linked to the predominance of Catholicism (45), as well as to the influence of family and institutional practices, as noted by adolescents and teachers. However, these resources emerge primarily as forms of subjective emotional support, rather than as formally structured religious practices.

Community resources, meanwhile, are associated with the availability and significance of natural spaces, which adolescents use as settings for emotional regulation and refuge, in line with the geographical characteristics of the environment (45). Furthermore, the condition of structural vulnerability favours the presence of programmes promoted by external organisations, which could explain why teachers' discourse perceives certain institutions as promoters of rights that, on occasion, come into conflict with local norms of authority. Together, these findings suggest that the resources identified do not respond to homogeneous cultural patterns, but rather to situated responses, shaped by the opportunities and limitations of Acobamba's social and geographical environment.

Regarding digital tools, an emerging finding of particular contemporary relevance is the incorporation of generative artificial intelligence, specifically ChatGPT, as a digital GRR in contexts of rural vulnerability. Adolescents strategically utilise it to obtain immediate academic support, compensating for limitations within the school or family environment arising from gaps in teaching or support. This use of AI can be understood as a form of proactive agency, through which adolescents activate available resources to tackle academic challenges and reduce structural inequalities. In this sense, tools such as ChatGPT function as a form of cognitive support, facilitating access to information, the comprehension of difficult to understand content, and the development of problem-solving skills. Recent evidence suggests that the use of AI is associated with improvements in academic performance, motivation and autonomy in learning, particularly in resource-limited contexts (46, 47).

In terms of meaning, it is identified as the motivational factor that promotes the mobilization of resources. Adolescents give meaning to their experiences through elements such as personal goals, meaningful relationships and the desire for self-improvement. For example, facing situations that involve temporary separation from loved ones, such as attending school despite the desire to stay at home, is interpreted as a necessary effort with a long-term purpose. Similarly, taking

on responsibilities, such as studying despite financial difficulties or balancing study and work, takes on a meaning linked to improving one's own and one's family's living conditions. This component allows everyday challenges to be interpreted not merely as obstacles, but as part of a purposeful process, which is key to sustaining effort in adverse contexts.

The results of this study broaden the framework by showing that the mere existence of resources does not guarantee their activation, as reflective and contextual capacity is necessary to recognise and use them, a process closely linked to agency.

4.2 Bounded agency and SOC in contexts of vulnerability

The agency is presented as a dynamic and situated capacity. Adolescents describe deliberate actions such as reflecting, dialoguing, regulating emotions, seeking information or support, which position them as active agents in the construction of their well-being. However, this agency appears to be conditioned by the severity of the challenge, the availability of support, and structural constraints, which coincides with the notion of “bounded agency,” where the capacity to act is exercised within margins defined by the social and economic context (48, 49). In contexts of material scarcity, agency tends to be activated primarily in response to economic needs or critical situations, whereas in emotional conflicts it may be restricted or postponed.

Although the concept of agency may seem similar to that of resilience, it is important to distinguish between them. Resilience refers to the ability to adapt in the face of adversity (50, 51), and has traditionally been approached from a pathogenic perspective centred on the response to harm (58). In contrast, conditioned agency emphasises the capacity to act and make decisions within structurally limited contexts, understood as adolescents' ability to influence their environment, make decisions and mobilise resources in line with their goals and contexts (52). This means it describes not only how adolescents respond to challenges, but also how they actively negotiate them within the available constraints.

In contexts of economic insecurity, agency is proactively channelled into survival strategies, such as taking on early work to cover their own or their family's needs, thereby reinforcing manageability in functional terms. However, in the emotional and relational sphere, this same agency can take on avoidant or reactive forms when resources are perceived as insufficient. For example, adolescents describe resorting to isolation, intensive mobile phone use or distracting activities such as listening to music or playing online games to cope with loneliness or emotional distress, prioritising immediate relief over problem-solving.

In this context, manageability is not always built on resolution-oriented coping strategies, but also through responses focused on immediate emotional regulation, such as avoiding the problem, distracting oneself or postponing action, which enable individuals to maintain their day-to-day functioning in adverse circumstances. However, these strategies may limit long-term well-being, as they do not address the underlying causes of the challenges (for example, family conflicts or persistent emotional difficulties), and in some cases may even lead to higher-risk responses identified by teachers, such as impulsive or self-harming behaviours.

Furthermore, the contrast with the teachers' perspective reveals a gap in the interpretation of agency: while adolescents perceive themselves as active agents who make decisions based on their

available resources, even if these are not always evident, teachers tend to conceptualise these responses as evasive or insufficient. This discrepancy highlights that adolescent agency is not only conditioned by context, but also by the interpretative frameworks through which it is assessed, which can influence its recognition and reinforcement.

The gender differences observed reinforce international evidence on differences in coping. Female adolescents tend to use reflective and relational strategies, while male adolescents favour instrumental or avoidant responses, with less emotional verbalisation. Recent studies have documented similar patterns, noting that gender differences in coping influence help-seeking and emotional regulation (53). These findings suggest the need for gender-sensitive interventions that strengthen emotional literacy in male adolescents and promote leadership opportunities and structural autonomy in female adolescents.

The coping strategies identified (active, avoidant, impulsive and, to a lesser extent, maladaptive) should not be understood exclusively as functional or dysfunctional, but rather as adaptive responses in specific contexts and situations. Research on adolescent coping suggests that avoidance can serve a regulatory function in environments perceived as uncontrollable (54). However, when not accompanied by structural or relational support, it can perpetuate discomfort.

4.3 Interpretative tension between the asset-based perspective and the deficit approach

A key finding of this study is the existence of an interpretative tension between the way in which adolescents identify and mobilise their resources and the way in which these are understood by teachers. While adolescents recognise and activate various GRRs, such as personal, peer support or the use of digital technologies, as valid strategies for coping with their challenges, teachers tend to interpret these same elements from a deficit or risk focused perspective. This tension reflects what the literature has termed adult-centred or deficit approaches to adolescence (55), which can limit and skew perceptions about them.

For example, adolescents describe mobile phone use as a tool for finding information, managing emotions or maintaining social connections; however, teachers view it primarily as a form of evasion that affects concentration and academic performance, and do not regard it as a resource. Similarly, support from a partner or close friends is experienced by adolescents as a significant emotional resource, while teachers associate it with dependency or potentially risky decisions, linked to a waste of time that interferes with academic performance. In addition, adolescents identify institutional resources, such as school staff, protection services or community institutions, as potential sources of support in situations of conflict or vulnerability. In contrast, some teachers perceive these same institutions as problematic, arguing that they may promote a form of “empowerment” that encourages attitudes or expectations misaligned with the adolescents' social context, thereby framing them more as sources of risk than as legitimate resources.

This difference is not merely a matter of perception; it has direct implications for the recognition of resources. When the resources identified by adolescents are not recognised and supported, or are negatively reinterpreted by adults, their potential contribution to strengthening the SOC is limited (56). In this context, this difference in perspectives can hinder the effective mobilisation of resources and

subsequent capacity for agency and coping, by generating persistent stress and a lack of support (57).

However, this tension does not imply a complete absence of recognition from the adult perspective. Teachers do acknowledge that adolescents rely on close relationships and are capable of acting in response to challenges, although this agency is often framed as limited and requiring guidance. This suggests that the divergence lies not only in the identification of resources, but in how these are interpreted, valued, and legitimised within the adult framework.

4.4 Contributions to salutogenic theory and the expansion of the conceptual framework

The findings of this study are consistent with salutogenic theory and also extend it in contexts of vulnerability. Firstly, they confirm that adolescents not only possess GRRs, but also identify, interpret and mobilise them dynamically depending on the context and nature of the challenge, which reinforces the processual nature of the SOC. For example, a single resource, such as the use of a mobile phone, can function as academic support or emotional regulation, or as an avoidance strategy, depending on the situation. This demonstrates that GRRs are neither static nor inherently positive, but that their function depends on their contextual activation.

Furthermore, the findings expand our understanding of SOC by showing that its development depends not only on the availability of resources, but also on their recognition and validation within the social environment. The difference between how adolescents identify resources and how teachers interpret them suggests that the institutional environment can either facilitate or limit the consolidation of SOC. This finding introduces the role of social validation as a key element in the effectiveness of GRRs, in line with approaches that highlight the relational nature of salutogenesis.

This study evidences the importance of incorporating multiple perspectives into the salutogenic analysis. Bringing together the voices of adolescents and teachers made it possible to identify not only resources and capabilities, but also interpretative tensions and risks that do not emerge in a uniform manner. For example, while adolescents highlight relational and emotional coping strategies, teachers draw attention to risk behaviours that are less explicitly mentioned. This pluralistic approach lends rigour and depth to the analysis of GRRs and agency.

The findings show that, in contexts of vulnerability, resources and agency are shaped by survival dynamics. In these scenarios, the mobilisation of resources may be directed towards meeting immediate needs, such as working or avoiding emotional distress, rather than promoting sustained well-being, thereby broadening our understanding of the SOC as a process that is also adaptive to adverse conditions. This also opens up a significant line of research into how to move from survival-focused coping strategies towards processes that promote sustained well-being over time.

Finally, this study incorporates a gender perspective as a relevant contribution to salutogenic theory. The differences observed indicate that female adolescents tend to mobilise relational and reflective resources, while male adolescents favour more instrumental or avoidant strategies. This suggests that the construction of SOC and the activation of GRR are mediated by gender norms and socialisation, reinforcing the need for salutogenic approaches that are sensitive to these differences.

Overall, the results contribute to a more contextualised and critical understanding of salutogenesis, highlighting the

importance of integrating individual capabilities, social validation and structural conditions into the analysis of adolescent well-being.

From a public health perspective, the findings suggest a need for context-specific school-based interventions that include a resource mapping exercise designed jointly by adolescents and teachers, which would help students identify and mobilise their own GRRs and strengthen their capacity for action. It is also essential to collaborate with teachers to promote a change in perceptions of adolescence, promoting a salutogenic approach that values students' resources and capabilities, as well as encouraging the joint design of interventions with various stakeholders in the educational sector to improve their relevance and effectiveness. Finally, digital literacy focused on health promotion would enable the use of technologies as support resources for adolescents and pedagogical strategies for teachers. Together, these actions strengthen adolescents' capacity for action and help transform the school environment into a more conducive setting that promotes health, in line with a more contextualised and critical understanding of salutogenesis that integrates individual capabilities, social validation and structural conditions.

4.5 Limitations

This study has limitations. It was conducted in a single educational institution, which restricts the generalisation of results. The qualitative design does not allow for the measurement of objective SOC levels or the establishment of causal relationships. However, it provides a deep contextual understanding of how adolescents in a vulnerable environment shape their well-being from a salutogenic perspective.

Although this study examines gender differences in depth, other dimensions of intersectionality, such as family structure, religious identity or socioeconomic status, did not show significant variation within the sample. The participants shared relatively homogeneous sociodemographic characteristics, including similar family living patterns, a predominance of Catholic religious affiliation, and conditions of economic vulnerability typical of the regional context, which was consistent in both the adolescents' accounts and the teachers' perceptions.

This homogeneity limited the possibility of comparatively exploring the weight of these factors in experiences and coping strategies. In this context, the findings suggest that the identification of resources and the observed 'bounded agency' respond, to a large extent, to shared structural conditions, where socio-economic vulnerability operates as a cross-cutting determinant that shapes both the challenges and the available resources.

However, it is important to note that these dimensions were not explored in depth through specific questions; therefore, future research should incorporate a more explicit intersectional approach that allows for an analysis of how these variables interact in shaping adolescent well-being and agency.

In addition, the sample presented a gender imbalance, with a higher proportion of female participants, as participation was voluntary and based on adolescents' willingness to take part. This may have limited the depth and diversity of male perspectives, particularly in relation to emotional expression, coping strategies, and resource identification.

Overall, the results support a systemic interpretation of adolescent well-being. Adolescents are not passive recipients of risk, but actors who negotiate, interpret, and respond to complex structural conditions. Strengthening their ability to recognise and mobilise resources, coupled with structural transformation, is a promising avenue for health promotion in vulnerable contexts.

5 Conclusion

This study demonstrates that well-being among adolescents in vulnerable contexts is a dynamic process that emerges from the interaction between structural conditions, relational contexts and subjective capacities. This process is mediated through the activation of GRRs, which contribute to the construction of the SOC in its dimensions of comprehensibility, manageability and meaning.

The results show that the mere availability of resources is not enough if adolescents are unable to recognise them, put them into practice and make sense of them. In this context, SOC is not constructed solely through access to resources, but also through their situated use and their validation within the social environment. Furthermore, it is confirmed that adolescent agency is dynamic but bounded, as its exercise is conditioned by structural constraints that limit real opportunities for action.

A significant contribution is the identification of a tension between the way in which adolescents mobilise their resources and how these are interpreted by the adult environment. Adolescents recognise diverse assets, including digital, relational and personal resources, while teachers recognise adolescents' social resources and emerging capacity for agency, although they tend to interpret these from a perspective that focuses on their deficiencies and risks. This difference may limit the legitimisation of resources and affect the development of SOC, particularly in school contexts.

Furthermore, the findings extend salutogenic theory by showing that, in contexts of vulnerability, the mobilisation of resources may be directed towards meeting immediate needs rather than promoting sustained well-being. This finding highlights the need to explore further how to move from survival-focused coping strategies towards processes that foster long-term pathways to well-being.

Finally, this study underscores the need to move towards more comprehensive and context-specific health promotion approaches. It is not enough to strengthen individual capacities; it is necessary to transform the structural conditions and institutional dynamics that limit adolescent agency. In this regard, there is a need to promote non-adult-centred models that recognise, validate and enhance adolescents' resources and capacities, while also incorporating gender and context sensitive perspectives to promote more equitable and effective interventions.

Data availability statement

The data generated and analysed during the study are not publicly available due to ethical and confidentiality restrictions related to the participation of adolescents, but the corresponding author can provide them upon reasonable request and with the appropriate institutional authorisation. Requests to access the datasets should be directed to u1997507@campus.udg.edu.

Ethics statement

The studies involving humans were approved by the Institutional Research Ethics Committee (CIEI) of Cayetano Heredia Peruvian University. The studies were conducted in accordance with local legislation and institutional requirements. Written informed consent for participation was obtained from adolescents, as well as from their parents or legal guardians. In addition, teachers who participated in the study also provided informed consent.

Author contributions

MG-C: Conceptualization, Methodology, Writing – review & editing, Writing – original draft. BH: Investigation, Writing – review & editing. DJ-C: Validation, Supervision, Writing – review & editing. GR-G: Validation, Supervision, Writing – review & editing.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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The author(s) declared that Generative AI was not used in the creation of this manuscript.

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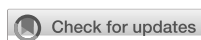
Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpubh.2026.1824105/full#supplementary-material>

References

1. UNICEF. Adolescencia: qué es y a qué edad empieza. (2024). Available online at: <https://www.unicef.es/blog/infancia/adolescencia-que-es-y-que-edad-empieza> [Accessed January 16, 2025]
2. Mittelmark MB, Bauer GF, Vaandrager L, Pelikan JM, Sagy S, Eriksson M, et al. *The Handbook of Salutogenesis*. Cham: Springer Nature (2022).
3. Pease MA, De La Torre-Bueno Mannarelli S. Caracterización de las Adolescencias Peruanas. (2022). Available online at: <https://repositorio.minedu.gob.pe/handle/20.500.12799/8665> [Accessed February 27, 2026]
4. Güemez AM, Calderón Seminario C, Valla C, Arrascue L, Moya MUNICEF. La situación de las niñas, niños y adolescentes en Huancavelica. Minist Educ [Internet]. (2019). Available online at: <https://repositorio.minedu.gob.pe/handle/20.500.12799/6628> [Accessed February 27, 2025]
5. Instituto Nacional de Estadística e Informática. Encuesta Demográfica y de Salud Familiar (ENDES) 2024 [Internet]. (2024). Available online at: <https://datosabiertos.gob.pe/dataset/encuesta-demogr%C3%A1fica-y-de-salud-familiar-endes-2024-instituto-nacional-de-estad%C3%ADstica-e> [Accessed July 27, 2025]
6. Centro Nacional de Epidemiología, Prevención y Control de Enfermedades. (2024). Análisis de Situación de Salud (ASIS) [Internet]. Available online at: <https://www.dge.gob.pe/portalnuevo/inteligencia-sanitaria/analisis-de-situacion-de-salud-asis/analisis-de-situacion-de-salud-asis/> [Accessed July 17, 2025]
7. Dirección General de Epidemiología. *Perfil de situación de salud: Departamento Huancavelica 2024* [Internet]. Huancavelica: Ministerio de Salud, Perú (2024).
8. Ministerio de salud del Perú. (2025). Sala situacional de problemas de salud mental priorizados [Internet]. Available online at: https://app7.dge.gob.pe/maps/sala_salud_mental/ [Accessed August 3, 2025]
9. Instituto Nacional de Estadística e Informática. Informe de los Principales Resultados de la Encuesta Nacional sobre Relaciones Sociales 2024 - ENARES [Internet]. (2024). Available online at: <https://www.gob.pe/institucion/inei/informes-publicaciones/6928310-informe-de-los-principales-resultados-de-la-encuesta-nacional-sobre-relaciones-sociales-2024-enares> [Accessed July 27, 2025]
10. Ministerio de Educación del Perú. Plataforma SiseVe Contra la Violencia Escolar [Internet]. (2025). Available online at: <http://www.siseve.pe/> [Accessed October 15, 2025]
11. Ministerio de Educación del Perú. ESCALE [Tendencias 2016 - 2023]. (2024). Estadística de la Calidad Educativa [ESCALE]. Available online at: <https://escale.minedu.gob.pe/ueetendencias2016> [Accessed April 3, 2024]
12. Ministerio de la Mujer y Poblaciones Vulnerables del Perú. Decreto Supremo N.º 008-2021-MIMP [internet]. (2021). Available online at: <https://www.gob.pe/institucion/mimp/normas-legales/1985697-008-2021-mimp> [Accessed October 4, 2025]
13. Ministerio de Educación del Perú. In: Ministerio de Educación del Perú, editor. *Lineamientos de tutoría y orientación educativa para la educación básica [Resolución Viceministerial N.º 212-2020-MINEDU]*. Lima, Perú: (2020)
14. Ministerio de Salud del Perú. Resolución Ministerial N.º 1001-2019-MINSA [Internet]. (2019). Available online at: <https://www.gob.pe/institucion/minsa/normas-legales/344744-1001-2019-minsa> [Accessed October 4, 2025]
15. Ministerio de Educación del Perú. Resolución Viceministerial N. 110-2024-MINEDU [Internet]. (2024). Available online at: <https://www.gob.pe/institucion/minedu/normas-legales/6086479-110-2024-minedu> [Accessed October 4, 2025]
16. Ministerio de Educación del Perú. Resolución Viceministerial N. 169-2021-MINEDU [Internet]. (2021). Available online at: <https://www.gob.pe/institucion/minedu/normas-legales/1952628-169-2021-minedu> [Accessed October 4, 2025]
17. Eriksson M, Lindström B. Antonovsky's sense of coherence scale and the relation with health: a systematic review. *J Epidemiol Community Health*. (2006) 60:376–81. doi: 10.1136/jech.2005.041616
18. García-Moya I, Rivera F, Moreno C. School context and health in adolescence: the role of sense of coherence. *Scand J Psychol*. (2013) 54:243–9. doi: 10.1111/sjop.12041
19. H d S-D, Del-Pino-Casado R, Palomino-Moral PÁ, López Martínez C, Moreno-Cámara S, Frías-Osuna A. Relationship between sense of coherence and health-related behaviours in adolescents and young adults: a systematic review. *BMC Public Health*. (2022) 22:477. doi: 10.1186/s12889-022-12816-7
20. Lämsimies H, Pietilä AM, Hietasola-Husu S, Kangasniemi M. A systematic review of adolescents' sense of coherence and health. *Scand J Caring Sci*. (2017) 31:651–61. doi: 10.1111/scs.12402
21. Moksnes UK, Espnes GA. Sense of coherence in association with stress experience and health in adolescents. *Int J Environ Res Public Health*. (2020) 17:3003. doi: 10.3390/ijerph17093003
22. Moksnes UK, Espnes GA, Haugan G. Stress, sense of coherence and emotional symptoms in adolescents. *Psychol Health*. (2013) 29:32–49. doi: 10.1080/08870446.2013.822868, 23906224.
23. Shorey S, Ng ED. Use of Salutogenic approach among children and adolescents with chronic illnesses: A scoping review. *J Pediatr Nurs*. (2021) 56:e7–e18. doi: 10.1016/j.pedn.2020.06.017
24. Lindström B, Eriksson M, Vaandrager L. Salutogenesis: a compass for health promotion. En: Eriksson M, Vaandrager L and Lindström B, editores. *The Hitchhiker's Guide to Salutogenesis: From the Ottawa Charter for Health Promotion to Planetary Health*. Cham: Springer Nature Switzerland; (2025) 3–11
25. Eriksson M, Lindström B. A salutogenic interpretation of the Ottawa charter. *Health Promot Int*. (2008) 23:190–9. doi: 10.1093/heapro/dan014
26. Boonekamp GMM, Jansen E, O'Sullivan T, Dierx JAJ, Lindström B, Pérez-Wilson P, et al. The need for adolescents' agency in salutogenic approaches shaping physical activity in schools. *Health Promot Int*. (2021) 37:daab073. doi: 10.1093/heapro/daab073
27. Evans K. Taking control of their lives? Agency in Young Adult Transitions in England and the New Germany. *J Youth Stud*. (2002) 5:245–69. doi: 10.1080/136762602200005965
28. Stapley E, Stock S, Deighton J, Demkowicz O. A qualitative study of how adolescents' use of coping strategies and support varies in line with their experiences of adversity. *Child Youth Care Forum*. (2023) 52:177–203. doi: 10.1007/s10566-022-09682-0
29. Seiffge-Krenke I, Persike M, Chau C, Hendry LB, Klopp M, Terzini-Hollar M, et al. Differences in agency? How adolescents from 18 countries perceive and cope with their futures. *Int J Behav Dev*. (2012) 36:258–70. doi: 10.1177/0165025412444643
30. Zimmerman LA, Li M, Moreau C, Wilopo S, Blum R. Measuring agency as a dimension of empowerment among young adolescents globally; findings from the global early adolescent study. *SSM Popul Health*. (2019) 8:100454. doi: 10.1016/j.ssmph.2019.100454
31. Boulware A, Bibbs D. Resilience in adverse contexts: youth and clinician perspectives on navigating community violence. *Children*. (2026) 13:122. doi: 10.3390/children13010122
32. Berenguer A, de Fernánz Sanmamed MJ, Pons Vigués M, Pujol Ribera E, Rodríguez Arjona D, Saura Sanjaume S. *Escuchar, observar y comprender: Recuperando la narrativa en las Ciencias de la Salud. Aportaciones de la investigación cualitativa*. Barcelona: Institut Universitari d'Investigació en Atenció Primària Jordi Gol (2014).
33. Salgado Ramírez A, García Mendoza LY, Méndez Cadena ME. La experiencia del estudiante mediante el uso del diario. ¿Una estrategia para la metacognición? *Educación*. (2020). 44:1–18. doi: 10.15517/revdu.v44i1.38291
34. Benavides Lara MA, Pompa Mansilla M, Agüero Servín Mde, Sánchez Mendiola M, Rendón Cazales VJ. Los grupos focales como estrategia de investigación en educación: algunas lecciones desde su diseño, puesta en marcha, transcripción y moderación. *Rev CPU-E* (2022) (34):163–197. doi: 10.25009/cpe.v0i34.2793
35. López A. Investigación cualitativa: Grupos focales y su aplicación en las Ciencias Sociales. *Cuad Sociol*. (2022) 2:66–84. doi: 10.54549/cs.2022.2.4.4539
36. Huss E, Braun-Lewensohn O, Ganayem H. Using arts-based research to access sense of coherence in marginalised indigenous Bedouin youth. *Int J Psychol*. (2018) 53:64–71. doi: 10.1002/ijop.12547
37. Kallio H, Pietilä AM, Johnson M, Kangasniemi M. Systematic methodological review: developing a framework for a qualitative semi-structured interview guide. *J Adv Nurs*. (2016) 72:2954–65. doi: 10.1111/jan.13031
38. Forni P, Grande PD, Forni P, Grande PD. Triangulación y métodos mixtos en las ciencias sociales contemporáneas. *Rev Mex Sociol*. (2020) 82:159–89. doi: 10.22201/iis.01882503p.2020.1.58064
39. Byrne D. A worked example of Braun and Clarke's approach to reflexive thematic analysis. *Qual Quant*. (2022) 56:1391–412. doi: 10.1007/s11135-021-01182-y
40. Souza LKde Pesquisa com análise qualitativa de dados: conhecendo a Análise Temática. *Arq Bras Psicol* (2019) 71 51–67 doi: 10.36482/1809-5267.ARBp2019v71i2p.51-67
41. Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. *Int J Qual Health Care*. (2007) 19:349–57. doi: 10.1093/intqhc/mzm042
42. Bronfenbrenner U, Morris PA. "The bioecological model of human development". In: Lerner RM and Damon W, editors. *Handbook of Child Psychology: Theoretical Models of human Development*, 6th Edn. Hoboken: John Wiley & Sons, Inc (2006). p. 793–828.
43. Patton GC, Sawyer SM, Santelli JS, Ross DA, Afifi R, Allen NB, et al. Our future: a lancet commission on adolescent health and wellbeing. *Lancet*. (2016) 387:2423–78. doi: 10.1016/S0140-6736(16)00579-1.
44. Matić I, Vuletić G. Sense of coherence and health in adolescents: a longitudinal cohort study. *Psychol Health*. (2023) 40:783–95. doi: 10.1080/08870446.2023.2256776
45. INEI. Huancavelica: Resultados Definitivos de los Censos Nacionales (2017). Available online at: https://www.inei.gob.pe/media/MenuRecursivo/publicaciones_digitales/Est/Lib1569/ [Accessed February 8, 2024]
46. Deng R, Jiang M, Yu X, Lu Y, Liu S. Does ChatGPT enhance student learning? A systematic review and meta-analysis of experimental studies. *Comput Educ*. (2025) 227:105224. doi: 10.1016/j.compedu.2024.105224
47. Klarin J, Hoff E, Larsson A, Daukantaitė D. Adolescents' use and perceived usefulness of generative AI for schoolwork: exploring their relationships with executive functioning and academic achievement. *Front Artif Intell*. (2024) 7:1415782. doi: 10.3389/frai.2024.1415782
48. Espín L d M, García AP. ¿Cuidamos? Una propuesta participativa con niños, niñas y adolescentes para el estudio de la agencia y los usos del tiempo. *Empiria Rev Metodol Cienc Soc*. (2025) 63:41–62. doi: 10.5944/empiria.63.2025.43875

49. Coffey J, Farrugia. Unpacking the black box: the problem of agency in the sociology of youth. *J Youth Stud.* (2014) 17:461–74. doi: 10.1080/13676261.2013.830707
50. Luthar SS, Cicchetti D, Becker B. The construct of resilience: A critical evaluation and guidelines for future work. *Child Dev.* (2000) 71:543–62. doi: 10.1111/1467-8624.00164
51. Van Breda AD. A critical review of resilience theory and its relevance for social work. *Soc Work Work.* (2018) 54:1–18. doi: 10.15270/54-1-611
52. Vijayaraghavan J, Vidyarthi A, Livesey A, Gittings L, Levy M, Timilsina A, et al. Strengthening adolescent agency for optimal health outcomes. *BMJ.* (2022) 379:e069484. doi: 10.1136/bmj-2021-069484
53. Méndez CADG. Fachada y agencia ampliada en niños, niñas y adolescentes que trabajan en calle y/o acompañan a otros a trabajar. *Acta Sociol.* (2024) 94:153–90. doi: 10.22201/fcpys.24484938e.2024.94.89581
54. Skinner EA, Zimmer-Gembeck MJ. The development of coping. *Annu Rev Psychol.* (2007) 58:119–44. doi: 10.1146/annurev.psych.58.110405.085705
55. Liebel M. Adultocentrismo. ¿Qué piensan chicas y chicos?, por Santi Morales y Marta Martínez Muñoz. *DESIDADES - Rev Científica Infânc Adolescência E Juv.* (2025) 42, 147–152. doi: 10.54948/desidades.v1i42.69827
56. García-Moya I, Moreno C, Jiménez-Iglesias A. Understanding the joint effects of family and other developmental contexts on the sense of coherence (SOC): a person-focused analysis using the classification tree. *J Adolesc.* (2013) 36:913–23. doi: 10.1016/j.adolescence.2013.07.007
57. Rognli EW, Aalberg M, Czajkowski NO. Using informant discrepancies in report of parent–adolescent conflict to predict hopelessness in adolescent depression. *Clin Child Psychol Psychiatry.* (2021) 26:96–109. doi: 10.1177/1359104520969761
58. Antonovsky A. (1979). *Health, stress, and coping.* Jossey-Bass.
59. Antonovsky A. (1991). The structural sources of salutogenic strengths. In C. L. Cooper and R. Payne (Eds.), *Personality and stress: Individual differences in the stress process* (pp. 67–104). John Wiley & Sons.
60. Braun V, and Clarke V. (2021). *Thematic analysis: A practical guide.* SAGE.



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Electronic health literacy and related factors among nursing students: a latent profile analysis

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Background: In the context of rapid information technology development and widespread internet-based healthcare, electronic health literacy (eHL) is essential for health promotion and disease prevention. As prospective nurses, nursing students require sufficient eHL to retrieve, evaluate, and apply digital health information in clinical practice and health education. However, evidence regarding the heterogeneity and influencing factors of eHL among nursing interns in China remains limited.

Methods: This multicenter cross-sectional study recruited 1,191 nursing interns from six hospitals in Anhui Province using convenience cluster sampling. Data were collected from October to December 2025. Latent profile analysis, multivariate logistic regression, and Spearman's rank correlation were applied.

Results: Three distinct latent classes of eHL were identified: low eHL (28.89%), medium eHL (45.42%), and high eHL (25.69%). The overall mean eHL score among the interns was 77.57 (SD = 14.68). Multivariate logistic regression analysis indicated that, compared with those in the low eHL group, nursing students with higher educational levels, higher health information literacy, and fewer weekly episodes of staying up late were more likely to be classified into the medium and high eHL groups ($p < 0.05$). Furthermore, Spearman's rank correlation analysis revealed that eHL was positively correlated with health information literacy ($p < 0.05$).

Conclusion: Electronic health literacy among nursing students remains at a moderate level. Universities should strengthen systematic health literacy education, guide students to access reputable health websites, and recommend reliable health information resources. Hospitals may establish health consultation centers or virtual platforms to assist nursing students in identifying and evaluating online health information and addressing their practical health needs.

KEYWORDS

eHealth literacy, health literacy, influencing factors, latent profile analysis, nursing students

1 Introduction

According to the "Healthy China 2030" Planning Outline issued by the Central Committee of the Communist Party of China and the State Council, the construction of a "Healthy China" has been elevated to a national strategic priority, recognizing population health as the cornerstone of national prosperity, socioeconomic development, and public well-being (1). The

central government has explicitly stated that “improving the health literacy of all people is one of the most fundamental, economical, and effective measures to enhance the health of the population” (2). Information is regarded as a critical conduit to health (3). As a central dimension of health literacy, health information literacy (HIL) comprises a spectrum of competencies, including identifying health information needs, locating reliable information sources, retrieving and evaluating information quality, and applying information to inform health-related decisions (4). Distinct from general health literacy, HIL integrates both health literacy and information literacy, emphasizing the discovery and utilization of health-related information (5). Elevated HIL not only enables individuals to acquire knowledge regarding disease prevention and treatment, maintain healthy lifestyles, and enhance doctor–patient communication, but also reduces healthcare resource waste and promotes broader economic and societal progress (6). As the backbone and reserve workforce of society, university students exert a profound and far-reaching influence on public health behaviors; therefore, enhancing their HIL is of paramount importance for both individual well-being and population health.

Nevertheless, health information acquisition and decision-making in contemporary society are increasingly mediated by digital environments, making it insufficient to consider HIL independently of the digital context in which it is enacted. In the Web 2.0 era, the rapid digitalization of daily life has made eHealth a critical driver of health promotion, with eHealth literacy (eHL) emerging as an indispensable extension of health literacy in the digital domain (7). According to data from the China Internet Network Information Center (CNNIC), as of June 2025, the number of internet users in China reached 1.123 billion, with an internet penetration rate of 79.7% (8). As more individuals turn to digital resources to support health-related decision-making, the challenge of information quality has grown more acute, as online health information is characterized by vast quantities, rapid proliferation, diverse sources, and highly variable quality (9). In this complex digital environment, university students must navigate unverified and often conflicting health information online, necessitating a construct that captures not only general information competencies but also the ability to critically evaluate and apply information within digital contexts. eHealth literacy addresses this need. It is defined as the ability to find, understand, and critically evaluate health-related information from electronic resources and to apply that knowledge to address health problems (10). Unlike HIL, which emphasizes informational competencies broadly, eHL explicitly integrates digital navigation skills with critical appraisal and practical application in online environments, making it the most suitable construct for examining health information behaviors among university students in digital settings.

College students represent one of the most digitally engaged demographics, exhibiting a clear preference for sourcing health information via online platforms (11). Recently, the integration of artificial intelligence (AI) has become increasingly prevalent in navigating healthcare systems, interpreting medical data, and seeking personalized health advice. While AI facilitates AI-augmented lifelong learning, translation, simplification, and content filtering (12), it simultaneously escalates the complexity of the digital information landscape. This evolution requires individuals to possess a higher level of eHL to distinguish the accuracy of algorithmic suggestions and to reduce the risks associated with complex error messages and information overload. Despite these technological advancements, current evidence indicates

that the overall eHL level of Chinese college students still needs improvement, and significant differences in digital ability exist across disciplines (13). Medical students, benefiting from formal medical curricula and early exposure to evidence-based practice, generally demonstrate higher eHL scores than their peers in non-medical fields (14). Nevertheless, even medical students frequently exhibit deficiencies in critically appraising online resources or translating digital information into informed health decision-making (15). As future healthcare providers, nursing students must master these core competencies to effectively conduct patient education and optimize health outcomes.

Norman and Skinner (16) developed the inaugural eHealth Literacy Scale (eHEALS), which has since been translated into over a dozen languages (including Chinese, Japanese, Korean, and Dutch) and extensively validated across diverse populations. Furthermore, researchers have developed localized instruments tailored to specific cohorts. For instance, Tang et al. (17) established the eHealth Literacy Scale for Chinese College Students by integrating the Lily model with the original eHEALS framework, resulting in a 20-item tool encompassing three dimensions: eHealth acquisition, appraisal, and practice. However, a unified standard for classifying eHL levels among college students remains to be established. In a survey of 626 nursing students (freshmen and sophomores) on campus, Shi (18) reported an overall mean eHL score of 69.41 (SD = 3.48), characterizing the participants' eHL as moderate. Although these students could retrieve health information online, they often struggled to discern authentic content from misinformation. Notably, as medical education progresses and clinical knowledge accumulates, medical students tend to become more proficient in acquiring and evaluating high-quality eHealth information and applying it to health maintenance (19–21). Based on this progression, we believe that as course learning and clinical practice progress, the eHL skills of nursing interns will further improve.

In summary, further research is warranted to identify nursing students with low eHL and to explore associated factors, including sociodemographic characteristics and HIL. Latent profile analysis (LPA) is a robust method for classifying participants into distinct subgroups based on specific variables (22). Therefore, this study aimed to identify distinct subgroups of eHL among nursing interns and to analyze the factors associated with these subgroups. The hypothesized conceptual model is presented in Figure 1. The research questions were as follows:

- 1) What is the level of eHL among nursing students participating in clinical practice?
- 2) What are the characteristics of students with relatively low eHL?
- 3) How do sociodemographic characteristics and HIL influence the different subgroups of nursing interns?

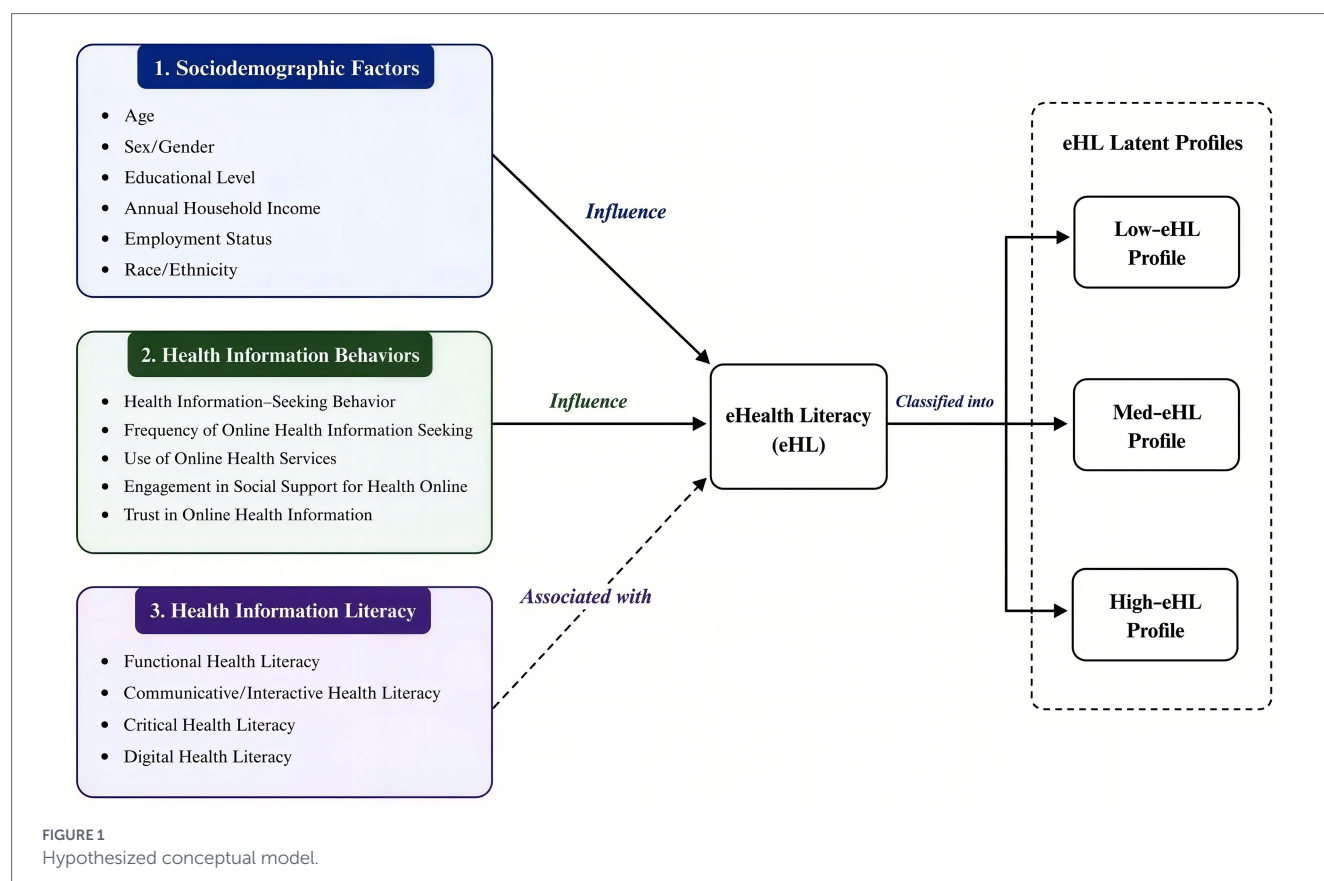
2 Methods

2.1 Study design

This was a multicenter cross-sectional study.

2.2 Study setting and participants

From October to December 2025, a cross-sectional survey was conducted among nursing interns from six tertiary Grade A hospitals



in Anhui Province, China, using a convenience cluster sampling approach. To enhance regional and institutional representativeness, two hospitals were selected from southern, central, and northern Anhui, respectively, including both general hospitals and university-affiliated hospitals. Within each selected hospital, all nursing interns on duty during the study period were invited to participate. The inclusion criteria were: (1) nursing students currently engaged in clinical internships; (2) full-time undergraduate or higher vocational nursing students; and (3) provision of informed consent and voluntary participation. The exclusion criteria were: (1) absence from clinical practice for 1 month or longer due to sick leave or personal leave; and (2) prior clinical internship experience (e.g., students enrolled in bridging programs from associate to bachelor level).

2.3 Sample size

The sample size was estimated based on Kendall's recommendation (23), which suggests that the number of observations should be at least 10 times the number of variables. In this study, a total of 59 variables were included (17 demographic variables and 42 variables related to HIL and eHL). Considering an anticipated invalid questionnaire rate of 20%, the minimum required sample size was calculated as 738 using the formula: $59 \times 10/0.8$. For latent class analysis (LCA), it is generally recommended that each latent class include at least 50 participants to ensure reliable classification (24). Based on previous studies indicating that eHL is typically categorized into no more than three latent classes, a minimum sample size of 150 was required for this analysis. Ultimately, a total of 1,191 valid responses were obtained, exceeding the minimum requirements for both general statistical

analyses and LPA, thereby ensuring adequate statistical power and model stability.

2.4 Data collection instruments

2.4.1 Demographic characteristics

A self-designed questionnaire was used to collect baseline data from study participants, including demographic characteristics (e.g., gender, ethnicity, place of origin, educational background), academic and family circumstances, physical and mental health status, and sources and frequency of health information acquisition.

2.4.2 Health information literacy

The Health Information Literacy Questionnaire for Medical Students was developed by Jin et al. (5). It comprises five dimensions: health information acquisition, cognition, evaluation, application, and ethics. Each item is rated on a 5-point Likert scale ranging from "strongly disagree" to "strongly agree," with scores assigned from 1 to 5. Higher total scores indicate higher levels of HIL. The questionnaire demonstrated excellent internal consistency, with a Cronbach's α coefficient of 0.955.

2.4.3 Electronic health literacy

The eHealth Literacy Scale for College Students (19) was used to assess eHL among college students. The scale comprises three dimensions: eHealth information acquisition ability (7 items), evaluation

ability (8 items), and application ability (5 items), with a total of 20 items. All items are rated on a 5-point Likert scale ranging from “strongly disagree” to “strongly agree,” with scores from 1 to 5. Higher total scores indicate higher levels of eHL. The scale demonstrated good internal consistency, with a Cronbach’s α coefficient of 0.915.

2.5 Data collection

Prior to data collection, the investigators contacted internship coordinators at each participating hospital to explain the study objectives, significance, and survey procedures. The electronic questionnaire was distributed to nursing intern group leaders via the WeChat platform, who then forwarded it to eligible participants. Standardized instructions were provided to ensure consistency, outlining the survey content and completion requirements. Participants were required to provide informed consent by selecting an agreement option before proceeding, after which the survey timer was activated. All items in the questionnaire were set as mandatory, and each IP address was restricted to a single submission to minimize duplicate responses. A total of 1,254 questionnaires were distributed. Based on pilot testing, the minimum completion time was estimated to be 3 min; therefore, 24 questionnaires with completion times of less than 3 min were excluded. In addition, 39 questionnaires exhibiting patterned responses were identified and removed through a combination of manual review and Excel-based logical checks. Ultimately, 1,191 valid questionnaires were retained, yielding an effective response rate of 94.98%.

2.6 Data analysis

LPA was conducted using Mplus version 8.3, while SPSS version 26.0 was used for group comparisons and regression analyses. Continuous variables were described as mean and standard deviation if normally distributed, or as median and interquartile range [M (P25, P75)] if not normally distributed. Categorical variables were expressed as frequencies and percentages (%). Group differences were examined using the chi-square test or nonparametric tests (Kruskal–Wallis test), as appropriate. In the LPA, the 20 items of the eHealth Literacy Scale were included as observed indicator variables and treated as continuous variables based on their Likert-scale measurement properties. Model fit for LPA was evaluated using multiple indices. Lower values of the Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and adjusted BIC (aBIC) indicate better model fit. Entropy ranges from 0 to 1, with values closer to 1 reflecting higher classification accuracy. The Lo–Mendell–Rubin likelihood ratio test (LMRT) and the bootstrap likelihood ratio test (BLRT) were used to compare models with k and $k-1$ profiles; a significant p -value ($p < 0.05$) indicates that the model with k profiles provides a significantly better fit. Class probabilities represent the proportion of individuals assigned to each latent class within the sample, and classes with proportions below 5% were considered potentially unstable (25). In addition, Spearman’s rank correlation analysis was performed to assess the association between eHL and HIL.

2.7 Ethical considerations

Ethical approval for this study was granted by the Ethics Committee of Anhui No.2 Provincial People’s Hospital (Approval (R) 2025–117) on October 16, 2025. The study objectives were

communicated to all participants. Informed consent was obtained from all participants, who were informed that their data would be handled confidentially and anonymously.

3 Results

3.1 Participant characteristics

A total of 1,191 nursing students were included in this study, with an average age of 20.35 (SD = 0.84) years. Among them, 1,092 (91.5%) obtained health information less than 5 times per week, 75 (6.2%) obtained it 5 to 10 times per week, and 24 (2.3%) obtained it more than 10 times per week. When feeling unwell, 500 (41.98%) would first consult the internet, 157 (13.18%) would turn to parents or friends, and 534 (44.84%) would consult a doctor. Other details are presented in Table 1.

3.2 Latent profile analysis of eHL among nursing students

The LPA was conducted using the scores of the 20 eHEALS items as manifest variables. Models with one to five latent classes were sequentially estimated (Table 2). As the number of classes increased, the values of AIC, BIC, and aBIC progressively decreased, indicating improved model fit. The three-class model demonstrated the highest entropy value (0.980), suggesting excellent classification accuracy. In addition, both the LMRT and BLRT were statistically significant ($p < 0.05$), indicating that the three-class model provided a significantly better fit than the two-class model. Although the four- and five-class models showed further reductions in AIC, BIC, and aBIC values, the five-class model yielded a non-significant LMRT result ($p = 0.293$), suggesting no significant improvement over the four-class model. Moreover, the five-class solution contained a very small class (0.8%), indicating potential instability. The four-class model, while statistically acceptable, resulted in less distinct class separation and reduced interpretability. In contrast, the three-class model showed adequate class proportions (28.9, 25.7, and 45.4%), high posterior probabilities (all >98%), and clear interpretability. Therefore, considering model fit indices, classification accuracy, class size, and parsimony, the three-class model was selected as the optimal solution.

3.3 Characteristics and classification of latent profiles

Based on the scores of each latent profile across the eHEALS items, the categories were designated as follows (Figure 2): Profile 1 ($n = 344$, 28.89%) had the lowest median scores on all dimensions (e.g., acquisition: median = 21, IQR 21–23; evaluation: median = 24, IQR 24–25; application: median = 15, IQR 15–16), all below the 25th percentile of the total sample. Therefore, this group was classified as the “low eHL” group. Profile 2 ($n = 541$, 45.42%) showed moderate median scores (acquisition: median = 28, IQR 27–28; evaluation: median = 32, IQR 30–32; application: median = 20, IQR 19–20), falling between the 25th and 75th percentiles, and was labeled the “medium eHL” group. Profile 3 ($n = 306$, 25.69%) exhibited the highest median scores (acquisition: median = 35, IQR 28–35;

TABLE 1 Participants' demographic characteristics (N = 1,191).

Categorical Variables	N	%
Gender		
Male	177	14.86
Female	1,014	85.14
Ethnicity		
Han	1,167	97.98
Minority	24	2.02
Place of Origin		
Rural	951	79.84
Urban	240	20.16
Only child		
Yes	206	17.30
No	985	82.70
Class leader		
Yes	335	28.13
No	856	71.87
Chronic illness		
Yes	109	9.15
No	1,082	90.85
Smoking		
Yes	30	2.52
No	1,161	97.48
Drinking		
Yes	66	5.54
No	1,125	94.46
Academic qualification		
Junior and below	749	62.89
Bachelor or above	442	37.11
Family per capita monthly income		
<1,000¥	1,150	96.55
1,000–5,000¥	32	2.68
>5,000¥	9	0.77
Self-assessed health status		
Poor	37	3.11
General	663	55.67
Good	491	41.22
Study pressure		
Small	40	3.36
General	808	67.84
Large	343	28.80
Physical exercise/week		
Never	288	24.18
1–3 times	790	66.33
>3 times	113	9.49

(Continued)

TABLE 1 (Continued)

Staying up late/week		
Never	200	16.79
1–3 times	722	60.62
>3 times	269	22.59

evaluation: median = 38, IQR 32–40; application: median = 25, IQR 20–25), above the 75th percentile, and was defined as the “high eHL” group.

3.4 Univariate analysis of factors influencing latent profiles of eHL among nursing students

Using latent profile classifications as the dependent variable, univariate analysis revealed statistically significant differences across profiles in factors including education, class leader, only child, self-assessed health status, physical exercise, weekly frequency of staying up late, weekly health information search frequency, and preferred help-seeking channel when ill ($p < 0.05$), as shown in Table 3. Significant variations were also observed in HIL and domain-specific scores among different latent profiles of eHL ($p < 0.05$), as presented in Table 4.

3.5 Multivariate logistic regression analysis of latent profiles

Using latent profiles of eHL (with low eHL as the reference group) as the dependent variable, significant variables from univariate analysis were included as independent variables in a multivariate logistic regression. The results showed that, compared with the low eHL group, nursing students with higher education levels, higher HIL scores, and fewer weekly episodes of staying up late were more likely to belong to the medium and high eHL groups. Details are presented in Table 5.

3.6 Correlation between eHealth literacy and health information literacy

Spearman's rank correlation analysis indicated that eHL was significantly and positively correlated with HIL and all its dimensions ($p < 0.05$; Tables 6, 7). The correlation coefficients between eHL and the dimensions of HIL ranged from moderate to strong ($r = 0.666–0.835$, $p < 0.05$). In addition, significant positive correlations were observed among all dimensions of HIL ($r = 0.594–0.933$, $p < 0.05$).

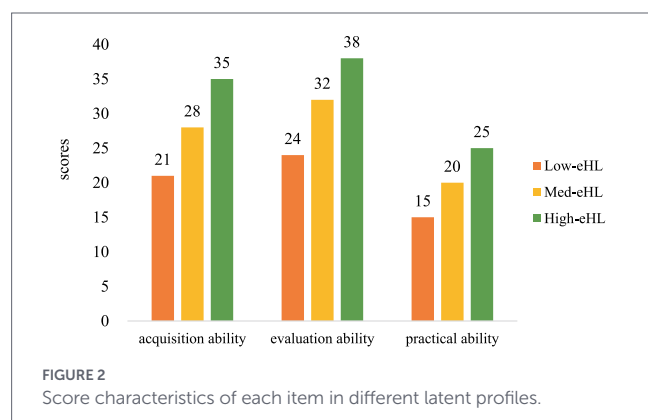
4 Discussion

In clinical nursing practice, the ability to obtain high-quality health information from the internet, accurately assess its reliability, and guide patients' health decisions based on it has become an indispensable core skill (23). As future healthcare providers and role models for healthy lifestyles, improving eHL among nursing students is significant for their learning of relevant professional knowledge, enhancing their personal physical and mental health, disseminating health knowledge, and improving public health status.

TABLE 2 Model fitting indexes for eHL in nursing students.

Class	AIC	BIC	aBIC	Entropy	LMRT(P)	BLRT(P)	Probabilities of classes
1	59882.689	60085.991	59958.936	1.000	–	–	–
2	46151.656	46461.692	46267.933	0.976	<0.001	<0.001	0.395/0.605
3	37615.203	38031.972	37771.509	0.980	0.001	<0.001	0.289/0.257/0.454
4	36052.719	36576.222	36249.055	0.971	0.001	<0.001	0.220/0.150/0.379/0.251
5	34570.972	35201.208	34807.337	0.975	0.2933	<0.001	0.008/0.229/0.139/0.373/0.251

AIC, Akaike's Information Criterion; BIC, Bayesian Information Criterion; LMR-LR, Lo–Mendell–Rubin adjusted likelihood Ratio Test; BLRT, Bootstrap Likelihood Ratio Test.



Assessment scales are the primary tools used in eHL research. In this study, the eHealth Literacy Scale for College Students developed by Tang et al. (17) at Fudan University was utilized. This scale is specifically tailored for the Chinese undergraduate population and was validated in a sample of 1,163 college students in Shanghai. It demonstrated strong psychometric properties, with a Cronbach's α of 0.915 and factor loadings ranging from 0.451 to 0.829; consequently, it has been widely adopted in domestic eHL research. However, the scale lacks predefined cut-off scores for proficiency levels and was originally developed in the context of Web 1.0. It may not fully capture the interactive and participatory aspects of health information processing characteristic of the Web 2.0/3.0 era. Although Wu et al. (26) developed a mobile-based eHL scale (m-eHEALS) adapted for Web 2.0 technologies, its validity requires further empirical verification. To advance the quality of eHL research in China, future studies should focus on refining measurement dimensions and enhancing the context-specific applicability of these instruments.

The results of this study showed that the total eHEALS score for nursing students in Anhui Province was 77.57 (SD = 14.68), representing a moderate level of eHL. This average is comparable to the score of 79.8 (SD = 10.5) reported for medical students (27). However, it is significantly higher than the mean score of 69.77 (SD = 10.45) reported for non-medical college students (28). These comparisons suggest that while nursing students have a stronger foundation in eHL than their non-medical peers, there remains significant room for improvement to reach high proficiency. This discrepancy may be associated with the medical curriculum, as medical education tends to foster greater health consciousness among students. Furthermore, as professional courses deepen and medical knowledge accumulates, nursing students may become more adept at identifying high-quality electronic health information and applying it to health maintenance (29, 30). This suggests that in future curriculum design, it may be beneficial to integrate content such as online health knowledge and

channels for obtaining online health information to promote the improvement of eHL among college students.

Among the three dimensions of eHL, the practical ability dimension had the lowest average score, indicating that nursing students struggle with practical skills in this area. On the one hand, they lack the ability to retrieve and obtain health information from professional databases. On the other hand, they also lack the ability to apply health information to solve real-life problems. Yuan and Wu (31) also pointed out that the majority of Chinese college students are unable to conduct advanced information retrieval and lack the ability to apply health information effectively. Catherine et al. (32) believes that college students should increase their use of journal literature databases rather than relying solely on internet search engines to find health information. Niu and Li (33) found that medical students also face deficiencies in applying electronic health information and have low levels of trust in online information, which affects their use of electronic health information. Therefore, in the new media environment, nursing students should recognize the positive impact of eHL in promoting their own health and actively engage in eHL education to enhance their knowledge, search skills, and application abilities, ultimately improving their own eHL.

This study found that the eHL of nursing students in Anhui Province can be categorized into three latent profiles: low eHL (28.89%), medium eHL (45.42%), and high eHL (25.69%). The educational qualifications of nursing students in the low eHL group were mostly at the junior college level or below. This may be related to differences in educational methods and vocational education compared to regular universities in China (34). The short duration of junior college education, high course density, and focus on basic theories and skill training, with less emphasis on eHL education, could explain these differences. Li et al. (35) found that undergraduates have significantly higher willingness and ability to obtain and utilize online information than junior college students. The main difference is that undergraduate education integrates digital information resources into the curriculum system more systematically and continuously. Therefore, it is suggested that junior colleges should focus on eHL education, incorporate health-related topics in public courses such as "Literature Retrieval," and embed eHL skills into pre-class activities, case discussions, and assignments in core courses (36).

Chinese college students not only exhibit unhealthy lifestyle habits but also show characteristics typical of the college stage (37). For example, frequent late-night activities, excessive internet use, and sedentary behavior (38). Li et al. (39) conducted a survey of 305 college students and found that only 8.2% of them stayed up late. This study found that nursing students who do not stay up late are more likely to belong to the high eHL group. Relevant studies suggest that groups with higher eHL are more likely to adopt healthy behaviors, such as maintaining regular physical activity, adhering to healthy living habits,

TABLE 3 Univariate analysis of different latent profiles.

Categorical variable	Group			χ^2/H	P
	Low eHL (n = 344)	Medium eHL (n = 541)	High eHL (n = 306)		
Gender				3.890 ^a	0.143
Male	46	75	56		
Female	298	466	250		
Place of origin				3.591 ^a	0.166
Urban	77	96	67		
Rural	267	445	239		
Academic qualification				190.483 ^b	<0.001
Junior and below	251	406	92		
Bachelor or above	93	135	214		
Family per capita monthly income				5.929 ^b	0.052
<1,000¥	339	519	292		
1,000–5,000¥	4	19	9		
>5,000¥	1	3	5		
Only child				6.089 ^a	0.048
Yes	54	85	67		
No	290	456	239		
Class leader				9.98 ^a	0.007
Yes	93	135	107		
No	251	406	199		
Chronic illness				0.924 ^a	0.630
Yes	35	45	29		
No	309	496	277		
Self-assessed health status				54.073 ^b	<0.001
Poor	18	11	8		
General	224	318	121		
Good	102	212	177		
Study pressure				7.983 ^a	0.092
Small	7	17	16		
General	226	379	203		
Large	111	145	87		
Physical exercise/ week				62.779 ^b	<0.001
Never	127	129	32		
1–3 times	192	370	228		
>3 times	25	42	46		
Staying up late/ week				147.171 ^b	<0.001
Never	8	92	100		
1–3 times	206	336	180		
>3 times	130	113	26		

(Continued)

TABLE 3 (Continued)

Categorical variable	Group			χ^2/H	P
	Low eHL (n = 344)	Medium eHL (n = 541)	High eHL (n = 306)		
Smoking				4.408^a	0.110
Yes	12	15	3		
No	332	526	303		
Drinking				0.383^a	0.826
Yes	19	32	15		
No	325	509	291		
Health information search frequency/ week				35.523^b	<0.001
<5 times	322	514	256		
5–10 times	16	22	37		
>10 times	6	5	13		
Preferred help-seeking channel when ill				36.741^a	<0.001
Doctor	121	237	176		
Network	167	225	108		
Parents or friends	56	79	22		

^aChi-square test, ^bKruskal–Wallis test.

TABLE 4 Comparison of the HIL scale for nursing students in different latent profiles.

Continuous variable	n = 1,191	Low-eHL (n = 344)	Med-eHL (n = 541)	High-eHL (n = 306)	H	P	Post hoc comparisons
eHL	80(67, 90)	60(60, 64)	80(76, 80)	97(80, 100)	1038.726	<0.001	C1 < C2 < C3
eHL acquisition	28(24, 33)	21(21, 23)	28(27, 28)	35(28, 35)	968.277	<0.001	C1 < C2 < C3
eHL evaluation	32(25, 36)	24(24, 25)	32(30, 32)	38(32, 40)	1010.068	<0.001	C1 < C2 < C3
eHL application	20(16, 22)	15(15, 16)	20(19, 20)	25(20, 25)	946.827	<0.001	C1 < C2 < C3
HIL	88(79, 100)	70(66, 81)	88(85, 92)	102(92, 110)	767.412	<0.001	C1 < C2 < C3
HIL acquisition	19(16, 21)	15(15, 17)	20(17, 20)	21(20, 25)	598.738	<0.001	C1 < C2 < C3
HIL cognition	16(14, 19)	12(12, 15)	16(16, 17)	19(17, 20)	639.35	<0.001	C1 < C2 < C3
HIL evaluation	20(17, 23)	15(15, 18)	20(19, 21)	24(21, 25)	711.941	<0.001	C1 < C2 < C3
HIL application	16(14, 18)	12(12, 15)	16(15, 17)	18(17, 20)	678.09	<0.001	C1 < C2 < C3
HIL ethics	17(16, 20)	14(12, 17)	16(16, 19)	20(19, 20)	509.922	<0.001	C1 < C2 < C3

and undergoing regular check-ups. Conversely, groups with lower eHL are more likely to develop poor health habits (40, 41). Government strategies aimed at improving the health outcomes of young people often promote the use of peer-led interventions. Peer-led health promotion is defined as “the teaching or sharing of health information, values, and behaviors by members of similar age or status groups” (42). The perceived advantages of this approach stem from the high level of interaction among peers, which facilitates the sharing of health information in relatable ways (43). Schools can strengthen dormitory management, promote healthy living habits, and discourage late-night studying or prolonged use of electronic devices. Students with high health literacy can be trained as “health promotion volunteers” to spread healthy behavioral habits in smaller groups, such as

dormitories and classes, particularly for issues like staying up late and prolonged sitting.

The HIL is at the core of health literacy. The results of this study show that individuals with higher eHL tend to have better abilities in accessing, understanding, evaluating, and applying health information. This may be related to the fact that nursing students with higher HIL are more willing or capable of utilizing online information resources to search for the health information they need and are better at distinguishing and screening relevant information to meet their own needs. The online environment is complex, and the quality of health information varies significantly (44). Wang (45) found that health information on online platforms is often highly commercialized, poorly readable, and presented in a single format. College students lack the ability to understand complex

TABLE 5 Multivariate logistic regression analysis of different latent profiles.

Profile	Variable	B	SE	Wald	P	OR	95%CI
C2	Constant	−13.692	1.286	113.396	<0.001		
	HIL	0.163	0.011	208.770	<0.001	1.178	1.152 ~ 1.204
	Junior and below	−0.229	0.221	1.079	0.299	0.795	0.516 ~ 1.226
	Only child	0.303	0.274	1.226	0.268	1.354	0.792 ~ 2.317
	Class leader	0.079	0.217	0.132	0.716	1.082	0.707 ~ 1.656
	Self-assessed health status (good as the control group)						
	Poor	−0.376	0.542	0.481	0.488	0.687	0.238 ~ 1.986
	General	−0.062	0.206	0.092	0.762	0.940	0.628 ~ 1.406
	Physical exercise/week (>3 times as the control group)						
	Never	−0.254	0.394	0.415	0.519	0.776	0.359 ~ 1.678
	1–3 times	0.001	0.368	0.000	0.997	1.001	0.486 ~ 2.062
	Staying up late/week (>3 times as the control group)						
	Never	1.575	0.450	12.258	<0.001	4.833	2.001 ~ 11.673
	1–3 times	0.316	0.208	2.303	0.129	1.371	0.912 ~ 2.062
	Health information search frequency/week (>10 times as the control group)						
	<5 times	0.927	0.834	1.238	0.266	2.528	0.493 ~ 12.953
	5–10 times	0.582	0.954	0.372	0.542	1.789	0.276 ~ 11.604
	Preferred help-seeking channel when ill (Parents or friends as the control group)						
	Doctor	0.131	0.280	0.219	0.640	1.140	0.658 ~ 1.975
	Network	−0.351	0.274	1.645	0.200	0.704	0.411 ~ 1.204
C3	Constant	−33.851	2.128	253.144	<0.001		
	HIL	0.383	0.020	376.262	<0.001	1.467	1.411 ~ 1.525
	Junior and below	−1.642	0.315	27.153	<0.001	0.194	0.104 ~ 0.359
	Only child	0.531	0.395	1.807	0.179	1.700	0.784 ~ 3.686
	Class leader	0.308	0.331	0.865	0.352	1.360	0.711 ~ 2.600
	Self-assessed health status (with “good” as the reference group)						
	Poor	0.599	0.845	0.502	0.479	1.820	0.347 ~ 9.532
	General	−0.232	0.309	0.565	0.452	0.793	0.433 ~ 1.452
	Physical exercise/week (>3 times as the control group)						
	Never	−0.438	0.603	0.528	0.468	0.645	0.198 ~ 2.105
	1–3 times	−0.096	0.521	0.034	0.853	0.908	0.327 ~ 2.519
	Staying up late/week (>3 times as the control group)						
	Never	2.092	0.579	13.038	<0.001	8.101	2.602 ~ 25.216
	1–3 times	0.767	0.388	3.915	0.048	2.154	1.007 ~ 4.607
	Health information search frequency/week (>10 times as the control group)						
	<5 times	−0.343	1.088	0.100	0.752	0.709	0.084 ~ 5.984
	5–10 times	0.172	1.219	0.020	0.888	1.188	0.109 ~ 12.953
	Preferred help-seeking channel when ill (Parents or friends as the control group)						
	Doctor	−0.058	0.493	0.014	0.907	0.944	0.359 ~ 2.481
	Network	−0.444	0.489	0.823	0.364	0.642	0.246 ~ 1.674

professional knowledge, which further complicates the acquisition and application of health information. Authoritative information sources are vital for obtaining reliable health information. In recent years, the development of formal medical platforms, such as health applications, online medical platforms, and hospital websites, has provided valuable channels

for the public's online health information searches (46). Relevant departments should introduce policies and regulations, increase supervision of the online environment, purify cyberspace, and intervene promptly to address low-quality information. Online platforms should diversify the presentation of health information and make it easier to understand.

TABLE 6 Correlations among eHL dimensions.

Continuous variables	eHL	Acquisition	Evaluation	Application
eHL	1.000			
Acquisition	0.937**	1.000		
Evaluation	0.958**	0.853**	1.000	
Application	0.933**	0.829**	0.884**	1.000

***p* < 0.01.

TABLE 7 Correlations between eHL and HIL.

Continuous variables	eHL	HIL	Acquisition	Cognition	Evaluation	Application	Ethics
eHL	1.000						
HIL	0.835**	1.000					
Acquisition	0.745**	0.879**	1.000				
Cognition	0.761**	0.921**	0.800**	1.000			
Evaluation	0.798**	0.933**	0.773**	0.852**	1.000		
Application	0.784**	0.895**	0.724**	0.773**	0.820**	1.000	
Ethics	0.666**	0.826**	0.594**	0.725**	0.751**	0.748**	1.000

***P* < 0.01.

Furthermore, expanding the channels for providing health information and encouraging more professionals to contribute to online information provision is essential.

5 Limitations

This study has several limitations that warrant consideration. First, as a cross-sectional design was employed, it limits the ability to draw causal inferences between the variables examined. Second, as in prior research, reliance on self-reports to assess nursing students' eHL may affect the accuracy of the results. Future studies are encouraged to develop and utilize objective tools to more accurately evaluate nursing students' eHL. Third, the sample had a much higher proportion of female (85.14%) than male (14.86%) nursing interns, potentially limiting the generalizability of the findings to male populations. Although the proportion of male nurses in China increased from 2.4 to 3.4% between 2016 and 2020, indicating a continued but slow upward trend, the gender gap remains substantial (47). Of note, gender was not significantly associated with eHL group membership, which is consistent with prior findings (48). Nevertheless, given the very small proportion of male participants in this study, caution is warranted when interpreting this null finding, and future research with a more balanced gender composition is needed to confirm the absence of gender differences in eHL. Fourth, all questions in the questionnaire were mandatory. While mandatory questions can increase response rates, they may also lead to less genuine or incomplete answers, especially on sensitive topics. Moreover, forced responses may cause discomfort or resistance among participants, potentially affecting the quality of the answers. Future studies could consider incorporating optional questions to improve data accuracy

and participant engagement. Fifth, the research subjects in this study were limited to Anhui Province, and the use of convenience sampling at the hospital level may limit the generalizability of the findings. Future studies could expand the scope of the investigation, include a larger sample size, and improve both the representativeness of the sample and the generalizability of the conclusions. Despite these limitations, the study employed Latent Profile Analysis (LPA) to identify the latent categories of eHL among nursing students, providing a theoretical foundation for developing targeted strategies and interventions to enhance their eHL.

6 Conclusion

The findings of this study indicate that the overall eHL level among nursing students in Anhui Province is moderate, with significant potential for improvement. The eHL of nursing students is heterogeneous and can be categorized into three distinct latent profiles: "low eHL group," "medium eHL group," and "high eHL group." Higher educational attainment, better HIL, and fewer episodes of staying up late per week were associated with higher probabilities of belonging to the medium- and high-level eHL profiles. Moreover, a significant positive correlation was observed between eHL and HIL. These results emphasize the importance of developing targeted educational strategies to enhance eHL, particularly by improving students' abilities to critically evaluate and practically apply digital health information. Tailored interventions should be designed for different student subgroups, with particular attention to those in the low eHL category. Additionally, promoting healthy lifestyle habits and incorporating eHL training into the nursing curriculum are recommended to better prepare future nurses for the increasingly digital healthcare environment.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by The Ethics Committee of Anhui No.2 Provincial People's Hospital. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

LX: Writing – original draft, Writing – review & editing, Visualization, Methodology, Formal analysis, Data curation. NL: Conceptualization, Writing – review & editing, Formal analysis, Data curation. XD: Writing – original draft, Funding acquisition, Supervision. HW: Data curation, Investigation, Writing – review & editing, Resources. PY: Writing – review & editing, Data curation, Investigation. WP: Writing – review & editing, Data curation, Investigation.

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References

- General Office of the State Council, PRC. Outline of Healthy China 2030 Plan. (2016) Available online at: https://www.gov.cn/xinwen/2016-10/25/content_5124174.htm (accessed October 9, 2025)
- General Office of the State Council, PRC. Notice on Launching the Three-Year Action for Improving National Health Literacy (2024–2027). (2024) Available online at: https://www.gov.cn/zhengce/zhengceku/202406/content_6955867.htm (Accessed April 16, 2026)
- Black C, Roos LL, Roos NP. *From Health Statistics to Health Information Systems: A New Path for the Twenty-First Century*. Oxford: Oxford University (2005). p. 1–5.
- Shipman JP, Kurtz-Rossi S, Funk CJ. The health information literacy research project. *J Med Libr Assoc.* (2009) 97:293–301. doi: 10.3163/1536-5050.97.4.014
- Jin XJ, Zhang XM, Wang Y, Li J. Analysis of current status and influencing factors of health information literacy among medical students. *Jiangsu Sci Technol Inform.* (2022) 39:55–59. doi: 10.3390/ijerph20032706
- Yu X, Luo M, Wu S, Zhang J, Guo Q, Wang X, et al. Developing a questionnaire to evaluate the health information literacy in China. *Front Public Health.* (2023) 11:1068648. doi: 10.3389/fpubh.2023.1068648
- Gao ZS, Zhang R, Xie XL, Li X, Li M, Li AL, et al. The mediating effect of social support on the relationship between electronic health literacy and depressive symptoms among medical students. *Chin J Health Educ.* (2026) 42:222–7. doi: 10.16168/j.cnki.issn.1002-9982.2026.03.005
- China Internet Network Information Center CNNIC. Statistical Report on Internet Development in China. (2025). Available online at: <https://www.cnnic.net.cn/n4/2025/0721/c88-11328.html> (accessed October 12, 2025).
- Li X, Li XH. Investigation on the current situation of college students' online health information seeking behavior for electronic health literacy and countermeasures. *Library Theory Pract.* (2017) 4:44–50. doi: 10.14064/j.cnki.issn1005-8214.2017.04.010
- Norman CD, Skinner HA. eHealth literacy: essential skills for consumer health in a networked world. *J Med Internet Res.* (2006) 8:e9. doi: 10.2196/jmir.8.2.e9
- Okoniewski AE, Lee YJ, Rodriguez M, Schnall R, Low AF. Health information seeking behaviors of ethnically diverse adolescents. *J Immigr Minor Health.* (2014) 16:652–60. doi: 10.1007/s10903-013-9803-y
- Liu T, Xiao X. A framework of AI-based approaches to improving eHealth literacy and combating infodemic. *Front Public Health.* (2021) 9:755808. doi: 10.3389/fpubh.2021.755808

Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Correction note

A correction has been made to this article. Details can be found at: [10.3389/fpubh.2026.1886442](https://doi.org/10.3389/fpubh.2026.1886442).

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Supplementary material

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13. Fan ZY, Chen HY. Analysis of the current situation of electronic health literacy among college students from a University in Dali Area and its Influencing Factors. *J Dali Univ.* (2025) 10:75–81. doi: 10.3969/j.issn.2096-2266.2025.02.015
14. Tubaishat A, Habiballah L. eHealth literacy among undergraduate nursing students. *Nurse Educ Today.* (2016) 42:47–52. doi: 10.1016/j.nedt.2016.04.003
15. Wu JL, Zhang Y, Rong YR, Wu L, Xi ST, Wu KM, et al. Current situation of electronic health literacy and its influencing factors among college students in four universities in Henan Province. *Chin J Health Educ.* (2025) 41:244–51. doi: 10.16168/j.cnki.issn.1002-9982.2025.03.009
16. Norman CD, Skinner HA. eHEALS: the eHealth literacy scale. *J Med Internet Res.* (2006) 8:e27. doi: 10.2196/jmir.8.4.e27
17. Tang Z, Wang F, Fu H. Development and assessment on the eHealth literacy scale for college students. *Chin J Health Educ.* (2014) 30:35–8. doi: 10.16168/j.cnki.issn.1002-9982.2014.01.002
18. Shi XY. Current situation and influencing factors of Ehealth literacy of nursing students. *Cont Med Educ.* (2025) 39:158–61. doi: 10.3969/j.issn.1004-6763.2025.09.034
19. Cui GH, Li SJ, Yin YT, Zhang P. Study on the current status and influencing factors of electronic health literacy among medical students. *Mod Prev Med.* (2020) 47:1148–52. doi: 10.20043/j.cnki.mpm.2020.06.046
20. Liu X, Lü H, Luo JY, Kong LL, Zhao MX, Li L. Status and influencing factors of health information literacy among college students in Xianning. *Occup Health.* (2021) 37:1818–21. doi: 10.13329/j.cnki.zyyjk.2021.0459
21. Liu T, Yang X, Guo K, Wang W, Li J, Liu L. Evaluation of health Behaviors and self-rated health among Chinese healthcare students. *J Community Health.* (2020) 45:1006–16. doi: 10.1007/s10900-020-00820-0
22. Scotto RN, Bear JC. Latent class analysis: a method for capturing heterogeneity. *Soc Work Res.* (2012) 36:61–9. doi: 10.1093/swr/svs006
23. Bacchetti P, Leung JM. Sample size calculations in clinical research. *Anesthesiology.* (2002) 97:1028–9. doi: 10.1097/0000542-200210000-00050
24. Yang CC. Evaluating latent class analysis models in qualitative phenotype identification. *Comput Stat Data Anal.* (2006) 50:1090–104. doi: 10.1016/j.csda.2004.11.004
25. Tein JY, Cox S, Cham H. Statistical power to detect the correct number of classes in latent profile analysis. *Struct Equ Model.* (2013) 20:640–57. doi: 10.1080/10705511.2013.824781
26. Wu YM, Zhang M, Zhu LY. The research on the evaluation of consumer's electronic health literacy and application in mobile health. *Consumer Econ.* (2017) 33:90–6.
27. Xu DD, Ren S. An analysis of the relationship between electronic health literacy and health self-management ability among medical students in a higher vocational college. *Chin Prim Health Care.* (2022) 36:103–5. doi: 10.3969/j.issn.1001-568X.2022.11.0030
28. Yu RR, Liao WJ, Che L, Zheng TY. Analysis on current situation and influencing factors of electronic health literacy of non-medical college students in Wuhan City. *Occup Health.* (2024) 40:375–80. doi: 10.13329/j.cnki.zyyjk.2024.0054
29. Li LL, Dong LX. Research Progress on electronic health literacy of college students. *West China Qual Educ.* (2024) 10:97–100+122. doi: 10.16681/j.cnki.wcqe.202405023
30. Park H, Lee E. Self-reported eHealth literacy among undergraduate nursing students in South Korea: a pilot study. *Nurse Educ Today.* (2015) 35:408–13. doi: 10.1016/j.nedt.2014.10.022
31. Yuan H, Wu C. Research on the behavior choice and performance remediation mechanism of college students' online health Information search termination. *Libr Inf Serv.* (2025) 69:122–35. doi: 10.13266/j.issn.0252-3116.2025.22.010
32. Catherine H, Marguerite C, Sendall L. Post-graduate health promotion students assess their information literacy. *Ref Serv Rev.* (2012) 40:408–22. doi: 10.1108/00907321211254670
33. Niu ZY, Li XH. Analysis of the current situation and influencing factors of electronic health literacy among college students in Xinjiang. *Med Inf.* (2022) 35:10–3. doi: 10.3969/j.issn.1006-1959.2022.09.003
34. Liu XJ, Gao XH, Ma YL, Hao YL. Analysis on status of health literacy among nursing students in a higher vocational college. *Prev Med Forum.* (2021) 28:118–21. doi: 10.16406/j.pmt.issn.1672-9153.2022.02.006
35. Li XG, Jiang FQ, Zhou LH, Luo XY. Study on the status and influencing factors of the behavior of college students' network access to sexual related information. *J Inf Resour Manag.* (2021) 11:85–96. doi: 10.13365/jj.irm.2021.02.085
36. Li F, Yin K, Xu JL. The study of relationship of electronic health literacy' self efficacy and health self management behavior in college students. *Health Educ Health Promot.* (2025) 20:331–5. doi: 10.16117/j.cnki.31-1974/r.202504331
37. Yao ZY, Wei RH, Wang XY, Jiang LL, Wan YH. Association of takeaway consumption and sedentary behavior with emotional symptoms among freshman students. *Chin J Sch Health.* (2025) 46:1474–1477+1483. doi: 10.16835/j.cnki.1000-9817.2025291
38. Yang XL, Chen HW, Ren LL. Correlation study on lifestyle behaviors and self-rated health levels among university students in Anhui Province. *Chin J Health Educ.* (2023) 39:978–83. doi: 10.16168/j.cnki.issn.1002-9982.2023.11.003
39. Li YX, He YB, Wu JQ, Guo SW, Zhao W, Sun LN. Analysis of the current status of daily routine and living habits among college students: a case study of Yanjiao area. *Sci Consult.* (2022) 02:46–48.18.
40. Hsu WC, Chiang CH, Yang SC. The effect of individual factors on health behaviors among college students: the mediating effects of eHealth literacy. *J Med Internet Res.* (2014) 16:e287. doi: 10.2196/jmir.3542
41. Dong L, Cong S, Zhang N, Gong YB, Li TT, Lei LJ. Health risk behavior and its influencing factors of undergraduates, Taiyuan. *Mod Prev Med.* (2021) 48:2781–5. doi: 10.20043/j.cnki.mpm.2021.15.021
42. Sciacca JP. Student peer health education: a powerful yet inexpensive helping strategy. *Peer Facil Q.* (1987) 5:4–6.
43. Vujcich D, Thomas J, Crawford K, Ward J. Indigenous youth peer-led health promotion in Canada, New Zealand, Australia, and the United States: a systematic review of the approaches, study designs, and effectiveness. *Front Public Health.* (2018) 6:31. doi: 10.3389/fpubh.2018.00031
44. Lu X, Zhang R, Wu W, Shang X, Liu M. Relationship between Internet health Information and patient compliance based on trust: empirical study. *J Med Internet Res.* (2018) 20:e253. doi: 10.2196/jmir.9364
45. Wang XJ. Research on the Influencing Factors of College Students' Online Health Information Seeking Behavior [Master's thesis, Huazhong University of Science and Technology]. (2023).
46. Farnood A, Johnston B, Mair FS. An analysis of the diagnostic accuracy and peer-to-peer health information provided on online health forums for heart failure. *J Adv Nurs.* (2022) 78:187–200. doi: 10.1111/jan.15009
47. Yu S, Hou G, Wang Y. Research on the equity of nursing human resources in China from 2016 to 2020. *Chongqing Med.* (2023) 52:2226–30. doi: 10.3969/j.issn.1671-8348.2023.14.028
48. Guo M, Xin H. Correlation between eHealth literacy and health self-management ability in 578 undergraduate nursing students. *J Nurs.* (2019) 26:65–8. doi: 10.16460/j.issn1008-9969.2019.23.065



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Fertility awareness among Chinese university students: scale development and cross-sectional study

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Background: Global fertility rates are declining. In China, the total fertility rate dropped sharply from 5.59 in 1971 to 1.15 in 2021. Chinese university students often lack adequate fertility awareness, yet no validated instrument exists to assess this construct in this population, despite its recognized importance for informed reproductive decision-making.

Methods: The Fertility Awareness Scale for University Students (FASUS) was developed through literature search, semi-structured interviews, and two rounds of Delphi expert consultation. Psychometric properties were tested using exploratory and confirmatory factor analysis, Cronbach's α , split-half reliability, and test-retest reliability. A cross-sectional survey of 750 students examined fertility awareness levels and influencing factors via univariate analysis and multiple linear regression.

Results: The final FASUS Scale consisted of 22 items across three dimensions: fertility-related knowledge, reproductive health attitudes, and reproductive health skills, with a cumulative variance contribution rate of 67.952%. The scale demonstrated strong reliability (Cronbach's $\alpha = 0.97$, split-half reliability = 0.885, test-retest reliability = 0.981). A survey of 750 students revealed an average fertility awareness score of 78.01 ± 16.44 , indicating a low to moderate level. Key influencing factors included gender, ethnicity, education level, only-child status, and prior fertility knowledge education.

Conclusion: This study utilized a self-developed scale to assess fertility awareness among Chinese university students. The results showed that the fertility awareness level of Chinese university students was generally low. We suggest that health care institutions implement targeted intervention measures to improve reproductive health outcomes.

KEYWORDS

fertility awareness, influence factors, level classification, reliability and validity, university students

1 Introduction

Fertility constitutes a fundamental component of population dynamics, critically influencing both demographic quantity and quality (1). Recent data from The Lancet reveal a dramatic global decline in total fertility rates (TFR), decreasing from 4.84

in 1950 to 2.23 in 2021 (2). Projections indicate this downward trajectory will persist, with anticipated TFRs of 1.83 by 2050 and 1.59 by 2100, placing most nations below population replacement levels.

China, the world's second most populous nation (≈ 1.417 billion), has experienced particularly striking fertility reduction, with TFR plummeting from 5.59 in 1971 to 1.15 in 2021 (3). Despite progressive policy interventions including the 2016 universal two-child policy and 2021 three-child policy, fertility rates remain persistently low (4).

University students represent the primary future reproductive cohort. While studies confirm their general fertility intentions (5), significant knowledge gaps exist regarding fertility decline risks and infertility factors. This awareness deficit frequently leads to delayed childbearing decisions, missed optimal reproductive windows (25–30 years for women), and elevated infertility risks (6, 7). Many students prioritize education and career development without recognizing the accelerated fertility decline after age 35 (8). Furthermore, insufficient understanding of fertility determinants (e.g., age, lifestyle factors, sexually transmitted infections) often results in missed family planning opportunities and potential lifelong infertility (9–12).

The concept of fertility awareness (FA) was formally defined in the 2017 International Glossary on Infertility and Fertility Care as “understanding reproduction, fertility potential, and associated personal risk factors (e.g., advanced maternal age, sexual health factors, lifestyle choices) and non-personal risk factors (e.g., environmental exposures), while recognizing social and cultural influences on family planning decisions” (13). This standardized definition underscores FA's global significance for clinicians, researchers, and policymakers.

Valid FA assessment remains challenging. While Lampic's (11) Fertility Awareness Questionnaire represents the most widely used instrument, it exhibits notable limitations including female-centric focus and lack of quantitative criteria. Subsequent scales by Meissner (14) and Virtala (15) similarly fail to provide comprehensive FA assessment. Moreover, existing international tools primarily rely on unvalidated self-report measures. These limitations motivated our development of a culturally adapted Fertility Awareness Survey for University Students (FASUS) for the Chinese context.

Current Fertility Awareness research on Chinese university students remains scarce, with existing studies predominantly focusing on specialized populations (e.g., fertility treatment patients, gynecological cases) (16–18). To address this gap, we developed a psychometrically validated FASUS scale (See [Supplementary Table 1](#) for details) and applied the FASUS scale along with general population questionnaire for investigation: (1) Assess current fertility awareness levels among Chinese university students, (2) Identify key factors associated with fertility awareness, and (3) Provide evidence-based targets for future FA improvement interventions.

2 Methods

All methods used in this study were performed in accordance with the ethical principles of the Declaration of Helsinki for medical

research involving human subjects. This three-phase study received ethical approval from the School of Nursing at Yangzhou University (Approval No. YZUHL20220058, See [Supplementary Figure 1](#) for details). All procedures adhered strictly to medical ethics standards, upholding principles of voluntary participation, impartiality, and confidentiality throughout the research process. All participants in the study had given written informed consent before participating in this research, and were aware that their participation was voluntary and that they could withdraw at any time without any consequences.

2.1 FASUS Scale development

The scale in this study was constructed based on the Information-Motivation-Behavioral Skills (IMB) model. Through systematic literature review, semi-structured interviews, Delphi expert consultation and item selection, a preliminary draft of the University Students' Fertility Awareness Scale was developed.

- (1) Item pool development: Systematic searches were conducted in Chinese and English databases including PubMed and CNKI, yielding 21 articles from which fertility awareness items were extracted (19). Semi-structured interviews were also performed with 21 unmarried and childless university students (aged 19–27 years), and three themes (fertility knowledge, risk perception, and barriers to childbearing plans) were identified through thematic analysis. The interview outline is shown in [Table 1](#). Based on the literature and interviews, an initial item pool with 3 first-level and 38 second-level indicators was formed (20). (See [Supplementary Table 1](#) for details.).
- (2) Delphi expert consultation: Seventeen experts in obstetrics, gynecology, and reproductive health participated in two rounds of Delphi consultation. Item importance was rated on a 5-point Likert scale, with retention criteria of mean ≥ 4 and coefficient of variation ≤ 0.3 . Evaluation indicators included experts' positive coefficient, authority coefficient (Cr), and Kendall's W coefficient of concordance (21).
- (3) Preliminary experiment: A preliminary investigation was conducted involving 30 university students to assess the clinical feasibility of the FASUS scale (first draft) and ensure the clarity and comprehensibility of its semantics. The detailed process table for constructing the scale is shown in [Figure 1](#).

2.2 FASUS scale verification

The study recruited 420 participants from five universities in Jiangsu Province between May and July 2023 using convenience sampling method. Data collection was conducted through the Questionnaire Star platform following informed consent procedures. Inclusion criteria required participants to be: (1) Full-time university students, (2) Aged 18 years or older, and (3) Born in mainland China. Exclusion criteria comprised: (1) Married status or parenthood, and (2) Any language, auditory, or cognitive impairments that might affect survey comprehension. From the initial distribution of 450 questionnaires, 420 valid

TABLE 1 Interview outline.

Serial number	Interview topics
(1)	Can you share your views on fertility?
(2)	Do you understand what fertility is?
(3)	Which age group do you think women have the highest/beginning to decline in fertility?
(4)	Do you plan to have children in the future?
(5)	Do you think how many children is the ideal number? What are your thoughts on the gender combination of your child?
(6)	What is your expected reproductive age?
(7)	What factors have influenced your views and choices about childbirth?
(8)	Based on your current student status, do you have any concerns or anxieties about childbirth?
(9)	Do you have any understanding of infertility?
(10)	Do you understand what factors affect fertility?
(11)	How did you learn about fertility knowledge?
(12)	If you or your partner are infertile, what would you do?

responses were obtained (response rate: 93.3%), constituting the final analytical sample.

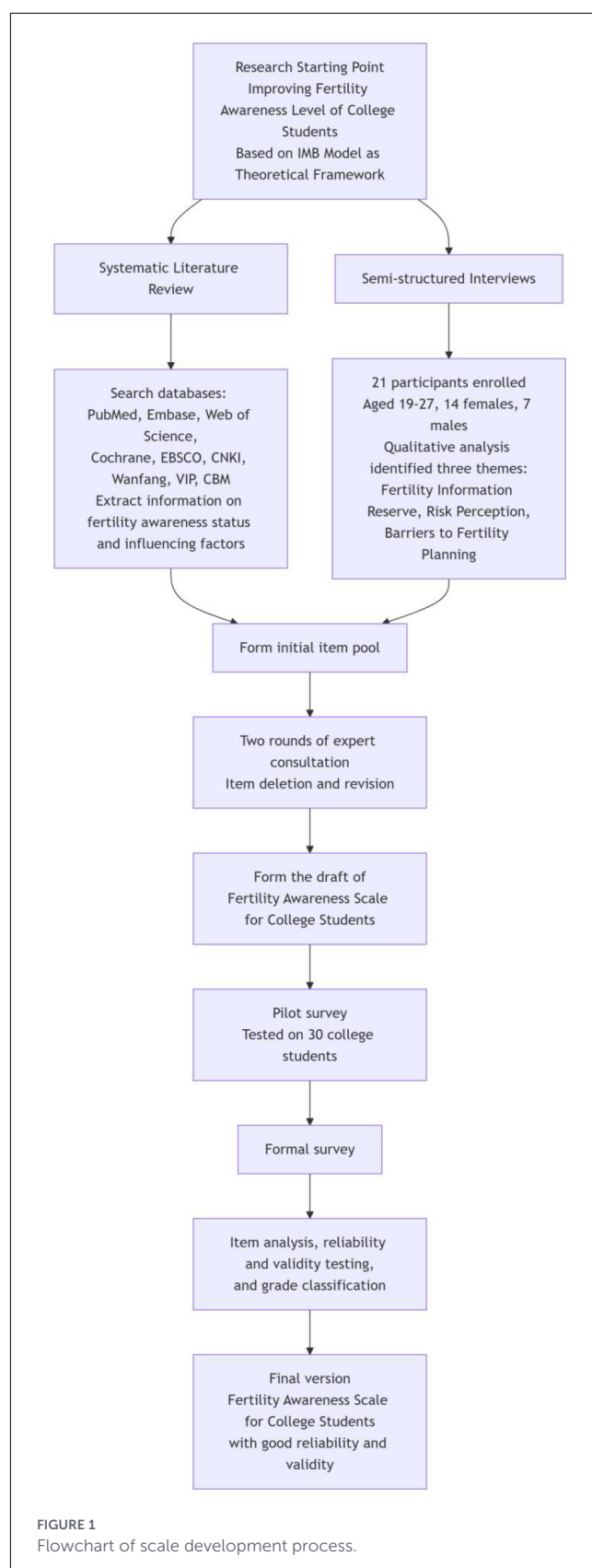
The research group randomly divided the 420 participants into two groups. They used the received 210 samples (Sample 1) for item analysis and exploratory factor analysis. The 210 samples (Sample 2) were used for confirmatory factor analysis. All the samples were used for reliability analysis. Table 2 presents the complete demographic characteristics of the study participants.

2.2.1 Item analysis

The following steps were adopted for each method to refine the dataset based on the Item Analysis criteria. (1) Critical Ratio Method (CR Value): The CR value for each item was calculated by comparing the differences between the extreme groups using an independent samples *t*-test. Items with $CR < 3$ or $P > 0.05$ were deleted (21). (2) Correlation Coefficient Method: The corrected item-total correlation coefficient (*r*) was computed for each item. Items with $r < 0.4$ or $P > 0.05$ were deleted. (3) Cronbach's Alpha Method: The change in Cronbach's alpha (α) was observed after removing a specific item. Items whose Cronbach's α increases after deletion were removed. The application of these criteria systematically refined the dataset ensuring that it met item analysis standards.

2.2.2 Reliability analysis

Cronbach's α was used to assess the internal consistency of FASUS (22); To assess split-half reliability, the scale entries were divided into two halves and scored accordingly based on the responses obtained from the subjects. Then, the correlation coefficient (*r*) was calculated between the scores obtained from the



two halves of the questionnaire. A split-half reliability coefficient of at least 0.7 indicates a satisfactory level of internal consistency; Fifty respondents were randomly selected to undergo re-evaluation after 2 weeks, and the *r* was calculated based on the results of the two

TABLE 2 Demographics characteristics of participants ($n = 420$).

Project		Number of cases	Percentage
Gender	Male	140	33.30%
	Female	280	66.70%
Age	18	38	9%
	19	91	21.70%
	20	135	32.10%
	21	54	12.90%
	22	29	6.90%
	23	23	5.50%
	24	15	3.60%
	25	8	1.90%
	26	11	2.60%
	27	7	1.70%
	28	9	2.10%
Nation	Han nationality	408	97.10%
	Minority nationality	12	2.90%
Religious belief	NO	414	98.60%
	YES	6	1.40%
Education	Junior college	69	16.40%
	Undergraduate	288	68.60%
	Postgraduate	53	12.60%
	Doctoral students	10	2.40%
Target education	Undergraduate course	108	25.70%
	Postgraduate	236	56.20%
	Doctoral students	62	14.80%
Major	Science and Engineering	61	14.50%
	Medicine	239	56.90%
	Agronomy	57	13.60%
	Liberal arts	50	11.80%
	Art category	12	2.90%
Birthplace	Town, city	197	46.90%
	Rural area	223	53.10%
The only child	NO	218	51.90%
	YES	202	48.10%
Single-parent family	NO	389	92.60%
	YES	31	7.40%
Annual household income (¥)	<50,000	71	16.90%
	50,000–100,000	149	35.50%
	100,000–300,000	167	39.85
	300,000–500,000	21	5%
	>500,000	12	2.90%
Sexual orientation	Uncertain	44	10.50%
	Bisexual	22	5.20%
	Homosexuality	13	3.10%
	Heterosexuality	341	81.20%
Relationship	Single	293	69.80%
	Being in love	127	30.20%

measurements. The criteria were based on retest reliability of ≥ 0.78 and $P < 0.05$ (23).

2.2.3 Validity Analysis

To assess content validity, experts were invited to evaluate the relevance of each term in the FASUS scale to its respective dimension. The Content Validity Index (CVI) was calculated both at the item level (I-CVI) and the scale level (S-CVI), with I-CVI ≥ 0.70 and S-CVI ≥ 0.90 indicating acceptable content validity (24); Construct validity:

- (1) Exploratory factor analysis (EFA): The varimax orthogonal rotation method was used for analysis following the principle of cumulative variance contribution rate $> 60\%$ and eigenvalue > 1 . Factor loadings were required to be ≥ 0.50 , with no double load entry (25).
- (2) Confirmatory factor analysis (CFA): CFA was assayed using maximum likelihood estimation to validate the factor structure of the scale (26, 27). The following indices of model fitness were used: chi-squared to the degree of freedom ratio (CMIN/df), goodness of fit index (GFI), comparative fit index (CFI), root mean square error of approximation (RMSEA), and root mean square residual (RMR), with CMIN/df ≤ 3.0 , RMR ≤ 0.05 , RMSEA ≤ 0.08 , GFI > 0.90 , or CFI ≥ 0.90 , indicating a suitable test model (28).

FASUS scale grade division: SPSS 26.0 software was used for sample cluster analysis and discriminant analysis to grade the scale.

2.3 Investigation of current situation and influencing factors

2.3.1 Survey tools

(1) General Information Questionnaire: The General Information Questionnaire including age, gender, educational level, profession, sexual orientation, relationship status, intention to have children, expected number of children to have, expected age for having the first/ last child, educational attainment, and sources of knowledge acquisition, etc;

(2) FASUS scale: The final FASUS scale developed in this study consists of 22 items across three dimensions: fertility-related knowledge, reproductive health attitudes, and reproductive health skill. Each item is scored using the five-point Likert scale, with options ranging from “completely in line” (5 points), “mostly in line” (4 points), “uncertain” (3 points), “mostly not in line” (2 points), to “completely not in line” (1 point). The higher the score on this scale, the higher the reproductive awareness level of university students. The detailed scale items can be found in [Supplementary Table 1](#).

The questionnaire survey was conducted via the Questionnaire Star platform (<https://www.wjx.cn>). The platform generates the corresponding two-dimensional code when publishing the questionnaire. Participants were required to visit the “I agree to participate in this survey” page. The questionnaire page is only accessible to applicants who choose “yes”.

2.3.2 Participants and sampling

This cross-sectional survey was conducted among mainland Chinese university students from July to December 2023. The original data were obtained from the Questionnaire Star system and collated. Invalid scales were excluded (samples with consistent or wavy answer options were not included) to guarantee data reliability and accuracy. Of the 810 questionnaires distributed, 60 were eliminated and 750 were successfully recovered with an effective recovery rate of 92.6%.

2.3.3 Statistical methods

Statistical analysis was conducted using IBM SPSS version 26.0 and AMOS version 24.0. The differences in FA scores among Chinese university students were analyzed using a *t*-test and non-parametric test. Multiple linear regression was applied to evaluate factors influencing FA in Chinese university students. $P < 0.05$ was considered statistically significant.

3 Results

3.1 Formulate the initial version of the FASUS scale

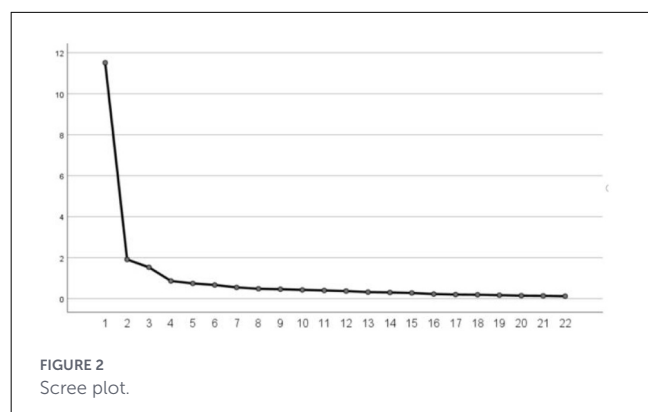
A total of 21 studies were included in the literature review, showing that university students' fertility awareness was generally low to moderate, with gender and major as main influencing factors. Semi-structured interviews with 21 unmarried and childless university students (14 females, 7 males, aged 19–27 years) revealed three themes: insufficient fertility knowledge with limited access channels, inadequate perception of fertility risks (with females more concerned about age), and childbearing plans hindered by economic, academic, career, and partner-related factors. Based on the literature and interviews, an initial item pool consisting of 3 first-level and 38 second-level indicators was formed.

Seventeen experts completed two rounds of Delphi consultation (100% response rates both rounds; authority coefficients of 0.853 and 0.867; Kendall's W of 0.488 in the second round indicating good agreement). After the first round, 7 items were modified, 7 deleted, 5 added, and 2 merged; after the second round, expert consensus was reached. A preliminary scale with three dimensions (fertility-related knowledge, reproductive health attitude, reproductive health skills) and 30 items was finally developed.

3.2 Development and verification of the FASUS scale

3.2.1 Item analysis

Using the 210 participants in Sample 1. Through rigorous psychometric evaluation employing three distinct item-reduction methods, we eliminated eight items (9, 12, 16, 20, 21, 25, 26, 28), yielding a final 22-item instrument. This refinement process



aligns with established scale development practices to optimize measurement efficiency and validity.

3.2.2 Exploratory factor analysis (EFA)

EFA was performed on Sample 1 ($n = 210$). The Kaiser-Meyer-Olkin (KMO) measure was 0.930, and Bartlett's test of sphericity was significant ($\chi^2 = 3,689.974$, $P < 0.001$), indicating suitability for factor analysis. Principal component analysis with varimax rotation extracted three factors with eigenvalues >1 , corresponding to the three hypothesized dimensions: fertility-related knowledge (11 items), reproductive health attitudes (7 items), and reproductive health skills (4 items). The cumulative variance explained was 67.952%. Factor loadings ranged from 0.601 to 0.842, with no cross-loadings. The scree plot is shown in Figure 2.

3.2.3 Confirmatory factor analysis (CFA)

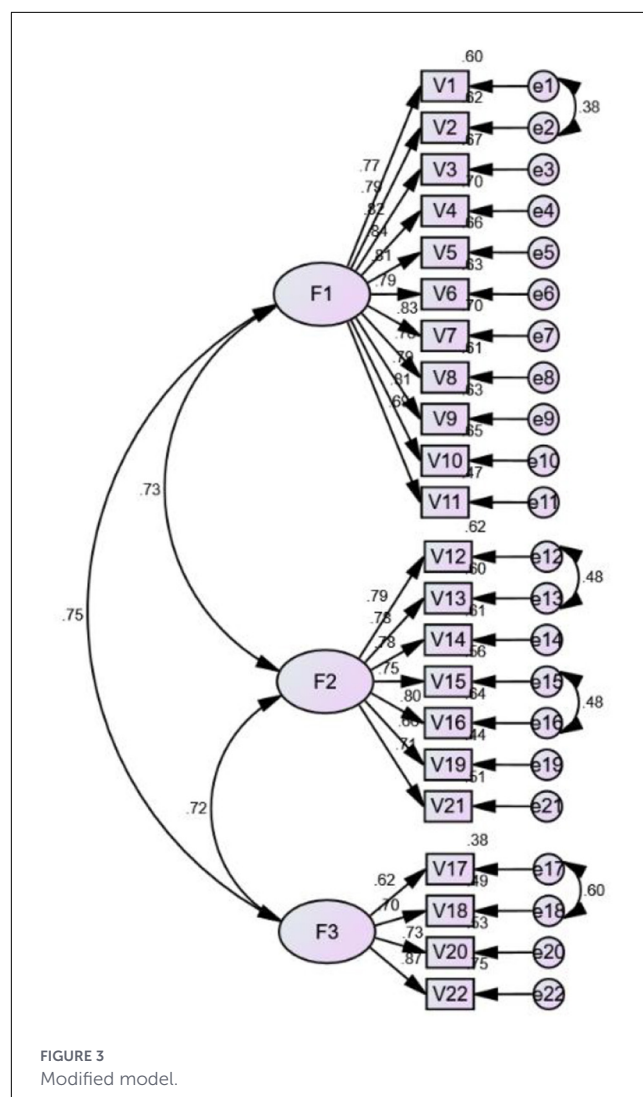
CFA was conducted on the independent Sample 2 ($n = 210$) to test the three-factor structure identified by EFA. The model yielded the following fit indices: CMIN/df = 2.624, CFI = 0.909, RMR = 0.046, RMSEA = 0.088, and GFI = 0.817. While the CFI and CMIN/df met conventional thresholds for acceptable fit (≥ 0.90 and ≤ 3.0 , respectively), the RMSEA (recommended ≤ 0.08) and GFI (recommended ≥ 0.90) fell slightly below the ideal cutoffs. Overall, the three-factor structure is acceptable, the modified model is presented in Figure 3, and factor loadings are shown in Table 3.

3.2.4 Reliability and validity

(1) Content validity: The item-level content validity index (I-CVI) ranged from 0.820 to 1.000, and the scale-level CVI (S-CVI) was 0.964, indicating excellent content validity.

(2) Reliability: The Cronbach's α coefficient for the total scale was 0.970. The split-half reliability was 0.885, and the 2-week test-retest reliability ($n = 50$) was 0.981. These values indicate good internal consistency and temporal stability.

The final FASUS scale consists of 22 items across three dimensions.



3.3 Classification of scale scores

Cluster analysis was performed on the FA scores from 420 participants using K-means clustering, with dimension scores and total scale scores serving as classification variables. After 13 iterations, the optimal solution identified four distinct FA categories ($P < 0.01$). The classification yielded the following distribution: Grade I (22–54 points, $n = 58$), Grade II (55–70 points, $n = 121$), Grade III (71–85 points, $n = 110$), and Grade IV (86–110 points, $n = 131$). Discriminant function analysis demonstrated excellent classification accuracy (97.9%), confirming the validity of the score ranges for each grade (Table 4).

3.4 Analysis of fertility awareness level and influencing factors

3.4.1 Demographic characteristics

A total of 750 students (306 males, 40.8%; 444 females, 59.2%) aged 18–32 years (mean 20.69 ± 2.23) participated. By education:

TABLE 3 Factor loadings from exploratory factor analysis (rotated component matrix).

Item	Factor load		
	Factor 1	Factor 2	Factor 3
4. I understand that the best age for female fertility is around 25–30 years old	0.842		
7. I understand that women are most likely to conceive during ovulation	0.827		
8. I understand that women's ovulation time during the menstrual cycle is about 14 days before the next menstruation (Normal menstrual cycle)	0.775		
3. I understand that healthy women have fertility in their lifetimes from the first ovulation to the last	0.768		
5. I understand that women's fertility declines sharply after the age of 35	0.751		
6. I understand that age is an important factor affecting fertility	0.741		
10. I understand that repeated abortion in women can lead to infertility	0.690		
9. I understand that infertility can be divided into male factor infertility, female factor infertility and unexplained infertility	0.672		
1. I understand that fertility, also known as fertility and fertility, refers to the physical ability of both partners to give birth to live babies	0.664		
2. I understand fertility assessment mainly through the history, occupation, diet, living environment, women's ovulation, fallopian tube function and ovarian function and male semen, such as several systematic assessments	0.661		
11. I understand that assisted reproductive technology (ART) is through a variety of interventions, procedures, surgery, and technology to achieve reproduction, to treat different forms of reproductive disorders and infertility	0.649		
13. I will protect my fertility by actively adjusting my lifestyle (balanced diet, smoking cessation, alcohol restriction, regular exercise, regular work and rest, etc.).		0.799	
12. I attach great importance to protecting my fertility		0.768	
16. I would like to receive education on reproductive health and fertility protection		0.750	
19. I adhere to a healthy diet		0.745	
14. I think it is very important to carry out professional fertility education on university campuses		0.716	
15. I hope to learn more about reproductive health through a variety of ways		0.696	
21. I will avoid exposing myself to environmental factors that can lead to low fertility or infertility		0.640	
18. I never smoke			0.861
17. I've never been an alcoholic			0.826
20. I will adjust my emotions through some activities to relieve the pressure in life and study			0.675
22. I take protective measures during sexual behavior to avoid sexually transmitted diseases			0.601

undergraduate 410 (54.7%), junior college 245 (32.7%), master's 79 (10.5%), doctoral 16 (2.1%); 399 (53.2%) intended to pursue higher degrees. Medical majors 267 (35.6%), non-medical 483 (64.4%). Urban 351 (46.8%), rural 399 (53.2%). Only children 433 (57.7%), with siblings 317 (42.3%). Heterosexual 661 (88.1%). Relationship status: single 547 (73.2%), in a relationship 200 (26.8%).

3.4.2 The fertility intentions and fertility knowledge sources of university students

When asked to rate the importance of having children on a scale of 0–10 (where 0 = “not crucial” and 10 = “extremely crucial”), the overall average score was 5.38. Concurrently, 398 students (53.1%) expressed a clear intention to have children. Regarding childbearing

age, the vast majority of students (64.8%) expected to have their first child between 25 and 29 years of age, while 117 students (29.4%) expected to do so between 30 and 34 years of age (See [Table 5](#) for details).

The results regarding university students' access to fertility knowledge and their level of education showed that the majority of students (39.1%) reported having received only a little education related to fertility knowledge, 20% reported having received comprehensive education, and another 7.9% reported having received no such education at all. Regarding sources of fertility knowledge, the internet was the main channel for university students (74.4%), 42.1% obtained fertility knowledge from schools, 29% obtained it from family members or friends, and only 14.8% obtained fertility knowledge from healthcare professionals (See [Table 6](#), [Figure 4](#) for details).

TABLE 4 Scale level classification ($n = 420$).

Level	Designation	Score interval (points)	Number of people (%)	Mean $\pm$ standard deviation
I	Extremely low level	22–54	56 (13.33)	46.47 $\pm$ 6.66
II	low level	55–70	120 (28.57)	63.16 $\pm$ 4.36
III	Moderate level	71–85	115 (27.38)	77.95 $\pm$ 4.46
IV	High level	86–110	129 (30.71)	93.27 $\pm$ 5.89

TABLE 5 The fertility intentions of university students.

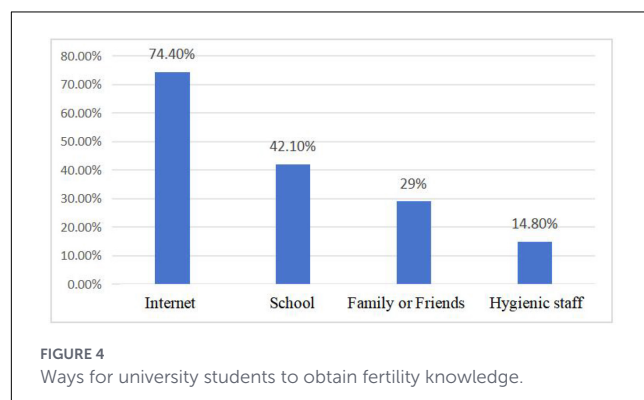
Item	Classification	Number of cases (male/female)	Percentage
Intention to have children ($n = 750$)	Yes	398 (203/195)	53.1
	No	231 (65/166)	30.8
	Uncertainty	121 (38/83)	16.1
Expected age of the first child ($n = 398$)	≤ 24	18 (12/6)	4.5
	25–29	258 (139/119)	64.8
	30–34	117 (51/66)	29.4
	≥ 35	5 (1/4)	1.3

TABLE 6 Fertility knowledge education level ($n = 750$).

Item	Classification	Number of cases	Percentage
Fertility knowledge education level	Have not received any education at all.	59	7.9
	I have received some education.	293	39.1
	I received a basic education.	248	33.1
	I have received a comprehensive education.	150	20

3.4.3 Fertility awareness status in university students

The average score of university students on the fertility awareness scale was (78.01 ± 16.44) points, with a score range of 22 to 110 points. There was a significant individual variation. The average item score was (3.54 ± 1.72) points. Among them, 68 cases (9.07%) were at the extremely low level I, 178 cases (23.73%) were at the low level II, 189 cases (25.2%) were at the medium level III, and 315 cases (42%) were at the high level IV. The average scores of the three dimensions of fertility-related knowledge, fertility health attitude, and fertility health skills were (37.68 ± 9.86) points, (24.61



± 5.62) points, and (15.72 ± 3.73) points, respectively. In the open-ended question “What factors do you think affect your completion of the fertility plan and family building?”, the most frequently mentioned factor was economic conditions (68%), as detailed in Table 7 and Figure 5.

3.4.4 Multivariate analysis of factors associated with fertility awareness

This study employed independent sample *t*-tests and one-way ANOVA to conduct a further analysis of the differences in FA among various factors in the general data, and conducted *post hoc* multiple comparisons for the factors with significant differences in homogeneity of variance. Ultimately, it was concluded that different genders, ethnicities, educational levels, majors, intentions to enhance educational attainment, whether being an only child, and the educational level of reproductive knowledge all had statistically significant differences in the scores of reproductive awareness among university students (See Table 7 for details).

Taking the FA score as the dependent variable, and including gender, ethnicity, educational level, major, whether there is an intention to upgrade educational level, being an only child, whether there is an intention to have children, and the educational level of knowledge about childbirth as independent variables, a multiple linear regression was conducted. The results showed that finally, five independent variables, namely gender, ethnicity, educational level, being an only child, and the educational level of knowledge about childbirth, entered the regression equation ($F = 137.831$, $P < 0.05$), with $R^2 = 0.576$ and the adjusted R^2 being 0.571. That is to say, these several variables can explain 57.1% of the variance of reproductive awareness (See Table 8 for details).

TABLE 7 The influence of general demographic data on fertility awareness (n = 750).

Item	Classification	FA score	Statistic	P
Gender	Male	75.18 ± 17.09	2.673 ^a	0.001***
	Female	79.97 ± 15.70		
Nation	Han nationality	78.4 ± 16.29	0.682 ^a	0.005**
	minority nationality	70.57 ± 17.75		
Religion	No	77.97 ± 16.492	1.346 ^a	0.516
	Yes	81.56 ± 12.22		
Education	Junior college	72.73 ± 15.13	16.22 ^b	<0.001***
	Undergraduate	79.7 ± 16.61		
	Postgraduate	85.47 ± 15.18		
	Doctoral	78.94 ± 15.03		
Major	Medicine	85.78 ± 13.56	23.711 ^a	<0.001***
	Non-medical	73.72 ± 16.33		
Intention to improve academic qualifications	Yes	82.03 ± 15.09	8.348 ^a	<0.001***
	No	73.44 ± 16.74		
Origin	City	78.99 ± 17.07	2.659 ^a	0.128
	Countryside	77.16 ± 15.84		
Only child	Yes	75.73 ± 17.53	23.707 ^a	<0.001***
	No	81.13 ± 14.28		
Single parent family	Yes	75.33 ± 15.47	1.698 ^a	0.156
	No	78.28 ± 16.52		
Family annual income	<50000	77.6 ± 15.05	1.24 ^b	0.292
	50000-100000	79.4 ± 16.40		
	100000-300000	76.73 ± 16.56		
	300000-500000	80.43 ± 18.44		
	>500000	79.63 ± 17.65		
Sexual orientation	Heterosexuality	78 ± 16.63	0.572 ^b	0.633
	Homosexuality	83 ± 15.48		
	Bisexuality	76.86 ± 14.74		
	Uncertain	77.2 ± 15.09		
Romantic relationship	Single	77.56 ± 16.34	1.434 ^a	0.263
	In love	79.08 ± 16.76		

a is the F value, b is the *t* value, *is significantly correlated at the 0.05 level (bilateral), ** is significantly correlated at the 0.01 level (bilateral), and *** is significantly correlated at the 0.001 level (bilateral). The scores of fertility awareness under different groups of related factors were analyzed by variance analysis, and the factors with statistical differences in the analysis of variance were compared by multiple comparisons afterward.

4 Discussion

The scale developed in this study encompasses three dimensions: fertility-related knowledge, reproductive health attitudes, and reproductive health skills. Within the IMB model, fertility-related knowledge serves as a foundational prerequisite for effective behavior. This dimension consists of 11 items designed to assess university students’ ability to acquire and utilize fertility and reproductive health information in daily life. A greater understanding of fertility-related issues increases the likelihood of individuals adopting health-seeking behaviors to improve reproductive outcomes (19). Reproductive health attitudes influence the extent to which university students prioritize reproductive health and engage in healthcare-seeking

behaviors. Delayed childbearing intentions often stem from insufficient awareness of low fertility and infertility risks. Positive attitudes, as demonstrated in prior research (29), are generally associated with better health outcomes and greater adherence to health interventions. Regarding reproductive health skills, we incorporated both personal and lifestyle-related risk factors into our assessment. This allowed us to evaluate participants’ awareness of modifiable risk factors (e.g., lifestyle choices) as well as non-modifiable influences on fertility. Compared to existing scales, the Fertility Awareness Scale for University Students (FASUS) is more closely aligned with theoretical frameworks and introduces novel perspectives in fertility awareness (FA) research (14, 15). It is worth noting that the confirmatory factor analysis yielded mixed fit indices. Although the CFI (0.909) and CMIN/df (2.624)

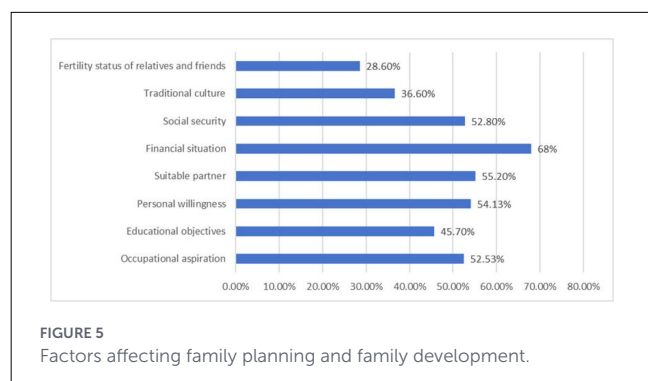


TABLE 8 The results of multiple linear regression analysis.

Item	B	SE	Beta	t	P
Gender	2.125	0.834	0.064	2.549	0.011
Nation	−4.071	1.848	−0.054	−2.202	0.028
Educational level	1.361	0.599	0.058	2.273	0.023
Only child	4.627	0.818	0.139	5.656	<0.001
The educational level of fertility knowledge	1.696	0.49	0.091	3.462	0.001

indicated acceptable model fit, the RMSEA (0.088) and GFI (0.817) were slightly below ideal values. Future research should consider cross-validating the scale in larger and more diverse samples and exploring potential modifications to the item structure.

Cross-sectional studies have found significant differences in the level of Fertility awareness (FA) among individuals. Our data revealed that only 42% of the surveyed subjects achieved a high FA level, whereas 58% scored at a medium to low level, consistent with previous research findings (8). This outcome underscores a notable disparity in university students' reproductive knowledge, potentially impeding their ability to make scientifically informed reproductive decisions. Notably, the average score for fertility-related knowledge was the lowest at (3.42 ± 1.18) points. This domain covered aspects such as the definition, assessment, and risk factors of fertility, as well as the definition, risk factors, and treatment approaches for infertility. Such low scores may be closely associated with the traditionally conservative stance of Chinese education toward reproductive and sexual health topics (30). Conversely, the average score for reproductive health skills was the highest at (3.93 ± 1.20) . This domain encapsulated a series of skills necessary for individuals to maintain fertility in daily life. The relatively high scores might be attributed to the emphasis placed by colleges and universities on students' daily behaviors and the cultivation of healthy habits. In contrast, the average score for reproductive health attitudes was comparatively low (3.51 ± 1.15) . A positive health attitude is crucial as it facilitates the comprehension of health-related knowledge and the improvement of associated behaviors. Owing to the limited education on fertility-related matters, students remain largely unaware of the rising global and domestic incidence of infertility, which is increasingly affecting younger populations.

Generally, university students exhibit limited awareness of fertility-related issues. Fertility awareness among university students is influenced by factors such as gender, ethnicity, educational background, only-child status, and fertility knowledge education level. In real-world contexts, women tend to prioritize fertility, often demonstrating greater attention to and engagement in pre-pregnancy care (5, 31). Females are also more likely to pursue assisted reproductive technology or adoption in cases of infertility (32). Our results show that fertility awareness among university students is low to moderate, a finding that aligns with previous studies conducted in Poland, the United States, and South Korea (16, 19, 31). However, our study revealed several findings that differ from previous literature. First, unlike earlier studies that reported no significant ethnic differences (32), we found that Han students had significantly higher fertility awareness than ethnic minority students ($P = 0.005$), suggesting ethnicity may be an important factor in China's multi-ethnic context. Second, while previous research from Germany and Poland (19, 33), showed that medical students have higher fertility awareness than non-medical students, we observed no such difference ($P > 0.05$), possibly because medical students' prolonged training and awareness of family-planning conflicts offset their knowledge advantage (21). Third, a novel finding not previously reported is that non-only children scored higher than only children, a pattern likely shaped by China's only-child policy. In contrast, the positive associations of educational attainment and prior fertility knowledge education with fertility awareness align with the IMB model (19) and are consistent with international evidence (32, 34). Female students scored higher than males, mirroring patterns in Sweden, Germany, and Argentina (5, 10, 33).

Fertility awareness is not merely an individual health concern but also deeply intertwined with national public health and sustainable population development. In China, despite a series of government policies aimed at encouraging higher birth rates, the fertility rate has remained persistently low. Some researchers have suggested that improving fertility literacy among future childbearing populations could be relevant in this context (35, 36). Whether tailored fertility education programs or curricula across different educational stages would effectively raise awareness levels remains to be tested. Future research, preferably using longitudinal or interventional designs with more representative samples, is needed to examine the potential impact of such educational efforts on fertility awareness, health behavior capabilities, and related outcomes.

5 Limitations and recommendations

(1) This study is a cross-sectional study, thus it is impossible to determine the causal relationship between the influencing factors (such as gender, educational level, whether being an only child, and previous reproductive education experiences) and fertility awareness (FA). Moreover, potential bidirectional or mediating paths (such as knowledge-acquisition-attitude) have not been tested. Future research should adopt a longitudinal cohort design or a randomized controlled method to evaluate the causal paths and the temporal evolution of fertility awareness. The use of mixed

methods (such as qualitative research) can help understand the deep-seated influencing factors of fertility awareness;

(2) The development and validation of this research scale utilized a convenient sample from various universities in Jiangsu Province. However, it failed to adequately cover ethnic minorities as well as certain academic disciplines, majors, and geographical regions. This sampling method may introduce selection bias and limit its general applicability. Future research should adopt stratified, multi-stage probability sampling methods and conduct it in different provinces and types of institutions to facilitate comparisons among populations and the validation of the scale.

(3) The confirmatory factor analysis showed only adequate model fit, with RMSEA (0.088) and GFI (0.817) not reaching the conventional thresholds. Therefore, the three-factor structure of the FASUS should be interpreted with caution. Future studies should administer the scale to independent and more representative samples to further test its factorial validity and, if necessary, refine the item composition.

6 Conclusions

In this study, a cross-sectional survey using the University Students' Fertility Awareness Scale was conducted. Results indicated that the overall fertility awareness among university students remained at a low to moderate level. Factors associated with fertility awareness in this sample included gender, ethnicity, educational background, only-child status, and the level of prior fertility knowledge education. The FASUS demonstrated adequate psychometric properties for use in similar populations, though further validation with more diverse samples is warranted. Future studies with larger, more representative samples and longitudinal designs are needed to further examine the correlates of fertility awareness and to evaluate the effectiveness of educational interventions aimed at improving reproductive health knowledge and attitudes among university students. Medical and health institutions, colleges, and universities may consider assessing university students' fertility awareness and providing tailored guidance based on individual characteristics to support reproductive healthcare.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved from the School of Nursing at Yangzhou University (Approval No. YZUHL20220058). All procedures adhered strictly to medical ethics standards, upholding principles of voluntary participation, impartiality, and confidentiality throughout the research process. All participants in the study had given written informed consent before participating in this research, and were aware

that their participation was voluntary and that they could withdraw at any time without any consequences. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

CN: Conceptualization, Project administration, Supervision, Writing – original draft, Writing – review & editing. XL: Data curation, Investigation, Methodology, Writing – review & editing. YR: Conceptualization, Methodology, Writing – original draft. FY: Investigation, Methodology, Writing – review & editing. SM: Investigation, Methodology, Writing – review & editing. YY: Investigation, Methodology, Writing – review & editing. YG: Investigation, Writing – review & editing. NS: Investigation, Writing – review & editing. JS: Conceptualization, Supervision, Writing – original draft.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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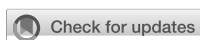
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References

- Motlagh ME, Taheri M, Eslami, Nasrollapour Shirvani SD. Factors affecting the fertility preferences in Iranian ethnic groups. *Nurs Midwifery J.* (2016) 14:485–95.
- GBD 2021 Fertility Forecasts Collaborators. Global fertility in 204 countries and territories, 1950–2021, with forecasts to 2100: A comprehensive demographic analysis for the Global Burden of Disease Study 2021. *Lancet.* (2024) 403:2057–2099. doi: 10.1016/S0140-6736(24)00550-6
- National Bureau of Statistics. The Seventh National Population Census Main Data Results Press Conference Answer to Reporters. National Bureau of Statistics Official Website. May 11, 2021. Available online at: https://www.stats.gov.cn/xxgk/jd/sjjd2020/202105/t20210511_1817280.html
- Ren Y, Cheng X, Niu C, Yang F, Zheng Y. Fertility intention of young people of childbearing age in China after the implementation of the two-child policy: A systematic review and meta-analysis. *BMC Public Health.* (2024) 24:3518. doi: 10.1186/s12889-024-20956-1
- Ekelin M, Åkesson C, Ångerud M, Kvist LJ. Swedish high school students' knowledge and attitudes regarding fertility and family building. *Reprod Health.* (2012) 9:6. doi: 10.1186/1742-4755-9-6
- Vassard D, Lallemand C, Nyboe Andersen, Macklon N, Schmidt L. A population-based survey on family intentions and fertility awareness in women and men in the United Kingdom and Denmark. *Ups J Med Sci.* (2016) 121:244–51. doi: 10.1080/03009734.2016.1194503
- Bretherick KL, Fairbrother N, Avila L, Harbord SHA, Robinson WP. Fertility and aging: do reproductive-aged Canadian women know what they need to know? *Fertil Steril.* (2010) 93:2162–8. doi: 10.1016/j.fertnstert.2009.01.064
- Mills M, Rindfuss RR, McDonald P, te VE, Force obotERaST. Why do people postpone parenthood? Reasons and social policy incentives. *Hum Reprod Update.* (2011) 17:848–60. doi: 10.1093/humupd/dmr026
- Harper J, Boivin J, O'Neill HC, Brian K, Dhingra J, Dugdale G, et al. The need to improve fertility awareness. *Reprod Biomed Soc Online.* (2017) 4:18–20. doi: 10.1016/j.rbms.2017.03.002
- Jurkowski L, Manubens R, Ryberg JO, Rossi M. Fertility awareness, attitudes towards parenting, and knowledge about Assisted Reproductive Technology among university students in Argentina. *JBRA Assist Reprod.* (2021) 25:453–8. doi: 10.5935/1518-0557.20210019
- Lampic C, Tydén T, Svanberg AS, Karlström P. Fertility awareness, intentions concerning childbearing, and attitudes towards parenthood among female and male academics. *Hum Reprod.* (2006) 21:558–64. doi: 10.1093/humrep/dei367
- Bunting L, Boivin J. Knowledge about infertility risk factors, fertility myths and illusory benefits of healthy habits in young people. *Hum Reprod.* (2008) 23:1858–64. doi: 10.1093/humrep/den168
- Bernardi LA, Luck M, Kyweluk MA, Feinberg EC. Knowledge gaps in the understanding of fertility among non-medical graduate students. *F&S Reports.* (2020) 1:219–26. doi: 10.1016/j.xfre.2020.08.002
- Meissner C, Schippert C, Von Versen-Höynck F. Awareness, knowledge, and perceptions of infertility, fertility assessment, and assisted reproductive technologies in the era of oocyte freezing among female and male university students. *J Assist Reprod Genet.* (2016) 33:719–29. doi: 10.1007/s10815-016-0717-1
- Virtala A, Vilks S, Huttunen T, Kunttu K. Childbearing, the desire to have children, and awareness about the impact of age on female fertility among Finnish university students. *Eur J Contracept Reprod Health Care.* (2011) 16:108–15. doi: 10.3109/13625187.2011.553295
- Shin H, Lee J, Kim SJ, Jo M. Attitudes towards parenthood and fertility awareness in female and male university students in South Korea. *Child Health Nurs Res.* (2020) 26:329–37. doi: 10.4094/chnr.2020.26.3.329
- Chan CHY, Chan THY, Peterson B, Lampic C, Tam MYJ. Intentions and attitudes towards parenthood and fertility awareness among Chinese university students in Hong Kong: a comparison with Western samples. *Hum Reprod.* (2015) 30:364–72. doi: 10.1093/humrep/deu324
- Place JM, Peterson BD, Horton B, Sanchez M. Fertility awareness and parenting intentions among Mexican undergraduate and graduate university students. *Hum Fertil.* (2022) 25:397–406. doi: 10.1080/14647273.2020.1817577
- Ren Y, Xie Y, Xu Q, Long M, Zheng Y, Li L, et al. University students' fertility awareness and its influencing factors: a systematic review. *Reprod Health.* (2023) 20:85. doi: 10.1186/s12978-023-01628-6
- Fisher JD, Amico KR, Harman JJ, Fisher WA. An information-motivation-behavioral skills model of adherence to antiretroviral therapy. *Health Psychology.* (2006) 25:462–73. doi: 10.1037/0278-6133.25.4.462
- Zhou Q, Peng M, Zhou L, Bai J, Tong A, Liu M, et al. Development and validation of a brief diabetic foot ulceration risk checklist among diabetic patients: A multicenter longitudinal study in China. *Sci Rep.* (2018) 8:962. doi: 10.1038/s41598-018-19268-3
- Li D, Yang H, Gong Y, Zhao Y, Qiu L, Sun N, et al. Development and nationwide application of an antibiotic knowledge scale. *Prevent Med.* (2020) 141:106262. doi: 10.1016/j.ypmed.2020.106262
- Calamia M, Markon K, Tranel D. The robust reliability of neuropsychological measures: Meta-analyses of test-retest correlations. *Clin Neuropsychol.* (2013) 27:1077–105. doi: 10.1080/13854046.2013.809795
- Polit DF, Beck CT, Wen SV. Is the CVI an acceptable indicator of content validity? Appraisal and recommendations. *Res Nurs Health.* (2010) 30:459–67. doi: 10.1002/nur.20199
- Ogedegbe G, Mancuso CA, Allegrante JP, Charlson ME. Development and evaluation of a medication adherence self-efficacy scale in hypertensive African-American patients. *J Clin Epidemiol.* (2003) 56:520–9. doi: 10.1016/S0895-4356(03)00053-2
- Corcoran JL, Davies SL, Knight CC, Lanzi RG, Li P, Ladores SL. Adolescents' perceptions of sexual health education programs: An integrative review. *J Adolesc.* (2020) 84:96–112. doi: 10.1016/j.adolescence.2020.07.014
- Harerimana A, Mtshali NG. Using exploratory and confirmatory factor analysis to understand the role of technology in nursing education. *Nurse Educ Today.* (2020) 92:104490. doi: 10.1016/j.nedt.2020.104490
- McNeish D, Wolf MG. Dynamic fit index cutoffs for confirmatory factor analysis models. *Psychol Methods.* (2020) 25:388–410. doi: 10.31234/osf.io/v8yru
- Christensen JR, Larsen CM, Kolind MI. Managers attitude towards implementing workplace health promotion programmes to employees in eldercare: A cross-sectional study. *Public Health Pract.* (2020) 1:100049. doi: 10.1016/j.puhp.2020.100049
- Wang B, Davidson P. Sex, lies, and videos in rural China: A qualitative study of women's sexual debut and risky sexual behavior. *J Sex Res.* (2006) 43:227–35. doi: 10.1080/00224490609552321
- Peterson BD, Pirritano M, Tucker L, Lampic C. Fertility awareness and parenting attitudes among American male and female undergraduate university students. *Hum Reprod.* (2012) 27:1375–82. doi: 10.1093/humrep/des011
- Swift B, Liu K. The effect of age, ethnicity, and level of education on fertility awareness and duration of infertility. *J Obstet Gynaecol Canada.* (2014) 36:990–6. doi: 10.1016/S1701-2163(15)30412-6

33. Nouri K, Huber D, Walch K, Promberger R, Buerkle B, Ott J, et al. Fertility awareness among medical and non-medical students: A case-control study. *Reprod Biol Endocrinol.* (2014) 12:94. doi: 10.1186/1477-7827-12-94
34. Hickman LC, Fortin C, Goodman L, Liu X, Flyckt R. Fertility and fertility preservation: Knowledge, awareness and attitudes of female graduate students. *Eur J Contracept Reprod Health Care.* (2018) 23:130–8. doi: 10.1080/13625187.2018.1455085
35. Maeda E, Murata K, Nakamura F, Kobayashi Y, Boivin J, Sugimori H, et al. Effects of fertility education on knowledge, desires and anxiety among the reproductive-aged population: Findings from a randomized controlled trial. *Hum Reprod.* (2016) 31:2051–60. doi: 10.1093/humrep/dew133
36. Daniluk JC, Koert E. Fertility awareness online: the efficacy of a fertility education website in increasing knowledge and changing fertility beliefs. *Hum Reprod.* (2015) 30:353–63. doi: 10.1093/humrep/deu328



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Effects of Life Kinetik–based exercise training on cognitive and motor performance in individuals with intellectual disabilities

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Background: Cognitive and motor functions in individuals with intellectual and developmental disabilities are lower than in the general population. This study examined the effects of Life Kinetik (LK) exercises on motor skills and cognitive functions in adolescents with mild intellectual disabilities (MID).

Methods: In this quasi-experimental study, 17 male students (aged 9–12 years; mean 10.47 ± 1.07) were assigned to an experimental group (EG; $n = 9$) or control group (CG; $n = 8$). The EG participated in LK exercises for 60 min, 3 days per week, over 8 weeks, while the CG attended regular physical education classes. Pre- and post-tests assessed cognitive functions using the Corsi Block Test and the d2 Test of Attention, and motor proficiency using bilateral coordination, balance, and upper-limb coordination subtests of the BOT-2 battery. Data were analyzed with two-way repeated measures ANOVA and Bonferroni-adjusted pairwise comparisons. Statistical significance was set at $p < 0.05$.

Results: Significant time $\times$ group interactions were found for bilateral and upper-limb coordination, indicating greater improvement in the EG ($p < 0.05$ – 0.01). Balance improved over time in both groups, with no significant between-group differences. Visual–spatial memory improved over time (Corsi Block Test), while attention, concentration, and psychomotor speed increased and error rates decreased significantly in the EG (d2 Attention Test, $p < 0.05$).

Conclusion: Life Kinetik exercises appear to enhance motor coordination and cognitive performance in adolescents with MID. However, due to the small sample size, these findings should be interpreted with caution, and further studies with larger samples are needed. Integrative exercise programs may be a valuable non-pharmacological strategy to support motor and cognitive development in this population. Integrative exercise programs may be a valuable non-pharmacological strategy to support motor and cognitive development in this population.

KEYWORDS

attention, cognitive performance, intellectual disabilities, Life Kinetik, motor coordination

Introduction

Intellectual disability (ID) is a neurodevelopmental disorder that typically manifests during the developmental period and is characterized by significant limitations in both intellectual functioning and adaptive behavior (1). It arises as a result of hereditary or environmental factors related to an individual's genetic background, leading to delayed or arrested intellectual development during the prenatal, perinatal, or early childhood periods (2). These classifications are generally associated with the level of support required by the individual and may influence motor development outcomes (3). Individuals with mild intellectual disabilities (MID) typically have intelligence quotient (IQ) scores ranging between 50 and 70 (4).

Children and adolescents with intellectual disabilities are at a significantly higher risk of adverse health outcomes compared to their typically developing peers (5). Motor skill difficulties are common in children with ID and may negatively affect their participation in or performance during activities in school, home, and community settings (6). Moreover, as a defining characteristic of ID, cognitive impairment leads to difficulties in daily living activities such as learning, reasoning, problem solving, communication, social interaction, and self-care skills (7).

Globally, ID affects approximately 1% of the population, with about 85% of cases classified as mild (8). The prevalence is markedly higher in low- and middle-income countries compared to high-income countries and is most commonly observed among children and adolescents (9).

In recent years, the education and development of students with intellectual disability have gained increasing importance in the field of special education (10). The process of learning develops through synaptic plasticity. Hearing, visual, and motor abilities are primary domains influenced by neuroplasticity. Exercise plays an important role in the activation of brain plasticity (11). Life Kinetik (LK) exercises are a training program that has been implemented in many countries and is based on stimulating inter-neuronal connections, promoting the formation of new neural networks, reducing potential symptoms, and enhancing performance by regulating the visual system and concentration (12). LK exercises have numerous positive effects, including providing a sense of psychological relaxation, reducing stress, supporting memory and learning processes, promoting physical and mental development, and reducing error rates in various applications (13).

LK provides a multidimensional training program that simultaneously integrates coordinative, cognitive, and visual tasks (14). Primarily aimed at enhancing mental capacity and mobility, LK consists of enjoyable exercises in which learning and performing challenging movements facilitates the formation of new neural pathways in the brain (15). Moreover, in LK exercises, difficulty levels can be adjusted by the individual; exercises planned from easy to difficult promote versatile brain activity, supporting the development of coordination and motor skills (16). The wide applicability of LK allows it to be implemented with individuals of different ages, genders, and physical-mental capacities (17).

In the current literature, studies investigating the effects of Life Kinetik exercises on motor and cognitive skills are limited, and most have been conducted on adults, typically developing individuals, or athletes (18–21). Experimental studies that systematically examine the cognitive and motor benefits of LK in children and adolescents with MID are very limited (22–25). Moreover, existing studies generally

involve designs that focus on a single skill area. This highlights the lack of controlled and comprehensive research evaluating the multidimensional effects of LK exercises in individuals with MID.

Zolghadr et al. demonstrated that game-based exercise interventions improve motor coordination in children with intellectual disabilities. Mullhall et al. (24) reported that school-based physical activity programs are feasible and acceptable, while Maicas-Pérez et al. (23) found that such interventions have positive effects on health and physical fitness. Additionally, Diz et al. (22) emphasized that long-term sport-based interventions are more effective. However, these studies predominantly focus on single physical or functional domains, and there is a limited number of controlled studies addressing cognitive and motor skills simultaneously.

This study aims to systematically investigate the effects of Life Kinetik exercises on motor skills (balance, bilateral and upper extremity coordination) and cognitive functions (attention, visuospatial memory, psychomotor speed, focus, and error monitoring) in adolescents with MID. Additionally, it aims to demonstrate the feasibility of LK exercises and the potential gains they may produce across different motor and cognitive domains. This approach is intended to contribute to the academic literature while also providing guidance for practitioners in the fields of special education and rehabilitation.

In this study, it is hypothesized that Life Kinetik exercises will significantly enhance the cognitive skills of adolescents with MID compared to the control group, promote improvements in motor skills, and lead to greater gains in both cognitive and motor performance relative to the control group.

Materials and methods

Study design

This research was designed as a quasi-experimental and applied study with a pretest–posttest control group design and was conducted in accordance with the registered protocol without any deviations. Participants were divided into two groups: an experimental group (EG) and a control group (CG). Participants in the EG underwent Life Kinetik exercises for 8 weeks (Table 1) and also continued their regular school-based physical education (PE) classes once per week during the study period. Prior to the intervention, the experimental group completed a familiarization session in which all Life Kinetik exercises were demonstrated and practiced under the supervision of the instructor to ensure correct understanding and safe execution of the movements. During the intervention, continuous verbal, visual, and physical guidance was provided when necessary. The CG did not participate in any exercise program throughout the study period. Participants in the CG attended regular school-based physical education (PE) classes once per week over the eight-week study period. Each PE session lasted approximately 60 min and included standard activities such as warm-up exercises, basic locomotor and coordination activities, simple ball games, and cool-down exercises. Both groups underwent a pretest before the intervention and a posttest after the intervention. During the experimental process, participants' demographic characteristics were assessed by measuring body weight, height, and body mass index. The Corsi Block Test and the D2 Attention Test were administered to assess cognitive functions. To assess coordination and balance levels, the bilateral

TABLE 1 8-week life kinetic exercise programme.

Week	Day	Exercises	Intensities	Duration
Week 1	Mon	Walking on a straight line; Walking + clapping; Step-by-step knee tap – cross-arm combination.	Light to moderate (2–6)	60 min
	Wed	Two-foot jumps on the line; Jump + knee/chest combination; Side-to-side jumps without touching the line.		
	Fri	Single-leg side jumps (right, then left); Two-foot jumping + clapping.		
Week 2	Mon	Right/left single-leg side jumps + clapping; Double–single leg combination.	Light to moderate (2–6)	60 min
	Wed	Double/single-leg landings with coordinated arm movements.		
	Fri	Double/single-leg jumps + clapping; Toss ball – catch with both hands; Catch with right hand.		
Week 3	Mon	Catch ball with left hand; Sequential catches (both–right–left); Toss–clap–catch.	Moderate to vigorous (4–6)	60 min
	Wed	Toss–clap–catch with right/left hand; Catch ball behind the back (two hands).		
	Fri	Behind-the-back catch (right/left); Catch ball from right with right hand, from left with left hand.		
Week 4	Mon	Turn to instructed direction + catch with specified hand; Bounce ball – catch (two hands); Bounce – catch (right hand).	Moderate to vigorous (4–6)	60 min
	Wed	Bounce – catch (left hand); Directional bounce tasks; Flamingo stance + ball catch.		
	Fri	Flamingo stance on opposite leg + catch; Toss ball + step forward/back; Repeat on opposite leg.		
Week 5	Mon	Toss ball + right/left foot side movement; Right-foot circular motion + ball task.	Moderate to vigorous (4–6)	60 min
	Wed	Left-foot circular motion + ball; Walk on line while circling ball around waist; Under-leg pass (right leg).		
	Fri	Under-leg pass (left leg); Waist–right–left leg sequence; Dribble with right hand while walking.		
Week 6	Mon	Dribble with left hand while walking; Two-foot jumps + right/left hand dribble.	Moderate to vigorous (4–6)	60 min
	Wed	Right-foot jumps + right/left hand dribble; Left-foot jumps + right-hand dribble.		
	Fri	Left-foot jumps + left-hand dribble; Double/single-leg landing + dribbling (right/left).		
Week 7	Mon	Balloon toss–catch + foot pass; Left-foot pass + balloon; Tennis ball toss + foot pass.	Moderate to vigorous (4–6)	60 min
	Wed	Toss with right hand – catch with left + foot pass; Toss with left – catch with right; Two-ball parallel toss–catch.		
	Fri	Two balls tossed with the same hand; Direction tasks using colored scarves; Change direction according to card color.		
Week 8	Mon	Walk with scarf + direction change + counting; Change direction by card color + scarf rotation;	Moderate to vigorous (4–6)	60 min
	Wed	Direction change + ball catch.		
	Fri	Card-color direction + catch (both/right/left hand); Walking + toss ball – catch with one hand + counting. Card-color direction + ball catch + counting; Counting in twos; Two-ball parallel toss–catch.		

coordination, balance, and manual–upper limb coordination subtests of the Bruininks–Oseretsky Test of Motor Proficiency, Second Edition (BOT-2) battery were used. All measurements and test administrations were conducted in accordance with the study protocol.

Ethical approval for this study was obtained from the Bingöl University Health Sciences Scientific Research and Publication Ethics Committee (Meeting Date: 24.03.2025; Meeting No: 04; Decision No: 19). The study was conducted in accordance with the principles of the Declaration of Helsinki. Written informed consent was obtained from the parents or legal guardians of all participants prior to enrollment, and verbal assent was obtained from the children prior to participation.

Participants

The population of this study consisted of students with special needs attending the Special Education Practice School (Grades I, II, and III) in Bingöl Province in 2025. This institution was selected due to its special education structure, the limited opportunities it

provides for physical activity and physical education practices, and its accessibility, which facilitated the conduct of the research process.

The sample was determined using a purposive sampling method and consisted of a total of 17 male students aged 9–12 years, diagnosed with mild intellectual disability, and regularly attending physical education classes at school. All participants were included in the study based on official health and special education assessment reports prepared by the relevant specialists.

Participants were assigned to the EG ($n = 9$) and CG ($n = 8$). The demographic and anthropometric characteristics of the participants are presented in detail in Table 2. The mean age of the EG was 10.22 ± 1.09 years, while that of the CG was 10.75 ± 1.04 years. Height was 1.44 ± 0.04 m in the EG and 1.46 ± 0.05 m in the CG. Body weight was 47.44 ± 2.79 kg in the EG and 44.25 ± 3.92 kg in the CG, while BMI values were 22.74 ± 1.70 kg/m² and 20.64 ± 1.41 kg/m², respectively. The groups were found to have similar characteristics in terms of cognitive level, age, height, body weight, and BMI. These findings indicate that the groups were anthropometrically balanced and homogeneous prior to the intervention, making the study sample

TABLE 2 Demographic characteristics of the participants.

Variable	Experimental group (<i>n</i> = 9) (<i>M</i> ± <i>SD</i>)	Control group (<i>n</i> = 8) (<i>M</i> ± <i>SD</i>)	Total (<i>n</i> = 17)
Age (years)	10.22 ± 1.09 (9,27–11,22)	10.75 ± 1.04 (9,89–11,43)	10.47 ± 1.07
Height (cm)	1.44 ± 0.04 (1,41–1,47)	1.46 ± 0.05 (1,42–1,49)	1.45 ± 0.04
Body Weight (kg)	47.44 ± 2.79 (45,01–49,98)	44.25 ± 3.92 (41,65–47,46)	45.94 ± 3.65
BMI (kg/m ²)	22.74 ± 1.70 (21,27–24,30)	20.64 ± 1.41 (19,72–21,93)	21.75 ± 1.87

M ± *SD*, Means ± standard deviations; BMI, body mass index. Bold values indicate statistically significant results: *p* < 0.05, *p* < 0.01.

appropriate for the research objectives and comparable in terms of pre-intervention criteria.

Participant selection criteria

Inclusion criteria

- Diagnosis of mild intellectual disability based on official reports prepared by relevant specialists,
- Age between 9 and 12 years,
- No orthopedic, neurological, or cardiovascular health conditions that would limit participation in physical activity,
- Possession of basic motor proficiency sufficient to perform Life Kinetik exercises,
- Written informed consent provided by both the participant and their guardian,
- Ability to attend exercise and testing sessions regularly.

Exclusion criteria

- Additional diagnoses such as moderate or severe intellectual disability, autism spectrum disorder, or cerebral palsy,
- Chronic orthopedic, neurological, or cardiovascular conditions that could compromise exercise safety,
- Participation in a regular exercise program within the past 6 months at a level that could affect motor performance,
- Absenteeism or behavioral issues that would prevent regular participation in testing and intervention sessions,
- Lack of parental consent or unwillingness of the participant to take part in the study.

Exercise intervention

Participants in the EG attended a total of 24 LK exercise sessions over 8 weeks, conducted three times per week (Monday, Wednesday, and Friday; Table 1). Each session lasted approximately 60 min, during which three different categories of LK exercises were performed. LK exercises have a holistic structure that simultaneously targets cognitive processes and motor coordination, as they require the use of multiple

body segments at the same time. Additionally, various sports equipment such as balls, rackets, and colored cards were used during the sessions, and participants were asked to manipulate them by throwing, catching, bouncing, or performing similar actions.

Prior to the intervention, all participants in the EG completed a familiarization session. During this session, the exercises were demonstrated in detail by a certified physical education teacher trained in Life Kinetik methods, and participants were given the opportunity to practice each movement pattern under supervision. This process ensured that participants understood the task requirements and were able to perform the exercises safely and correctly before the start of the intervention.

The sessions were delivered by a certified physical education teacher with specialized training in LK exercises, ensuring proper technique and safety. Intervention fidelity was monitored by a research assistant who observed each session and recorded adherence to the prescribed exercises. Participant adherence was tracked by attendance logs, and any deviations from the planned protocol were noted. Safety was continuously monitored during all sessions, with modifications provided for participants who experienced difficulties or fatigue.

Table 1 provides a detailed week-by-week schedule, including exercises, intensities (rated 2–6 on a light-to-vigorous scale), and duration. This structured approach allows for replication in future studies while maintaining both safety and exercise fidelity.

Materials

Anthropometric measurements

Participants' height was measured using a stadiometer with 0.01 m precision, and body weight was measured without shoes and in light clothing using an electronic scale with 0.01 kg precision. Body mass index (BMI) was calculated by dividing body weight (kg) by the square of height in meters (kg/m²).

Assessment of motor skills

It was assessed using the Bilateral Coordination, Upper-Limb Coordination, and Balance subtests of the Bruininks–Oseretsky Test of Motor Proficiency, Second Edition (BOT-2). The second edition of the BOT-2 was chosen for this study due to its more comprehensive, up-to-date content and higher psychometric properties compared to the first edition. The BOT-2 allows for a detailed assessment of both gross and fine motor skills in individuals aged 4–21 years (26). The test content has been modernized, with an increased number of items and updated normative values based on a large and representative sample (27). Furthermore, the subtests allow for a detailed profiling of motor skills, enabling a more precise assessment of motor proficiency in individuals with intellectual disabilities (28). The clarity of the administration guidelines and the ability to detect motor problems even with small developmental differences contribute to the widespread use of the BOT-2 in research and rehabilitation settings. Therefore, in the present study, participants' improvements in bilateral coordination, balance, and upper-limb coordination were assessed using the BOT-2 subtests.

Assessment of short-term visuospatial working memory

Short-term visuospatial memory was assessed using the digital version of the Corsi Block Test, in which participants were asked to

reproduce the sequence of blocks highlighted on the screen in the same order (29).

D2 attention test

The D2 Attention Test was administered to assess students' selective and sustained attention. Participants were asked to identify the letter "d" with two marks in each row within 20 s. The 14-row test was completed in a total of 280 s, and the data obtained were evaluated according to the standard D2 scoring criteria (30).

Statistical analysis method

Statistical analyses were performed using SPSS version 26. The distribution characteristics of the variables were first assessed with the Shapiro–Wilk test, and it was determined that the assumptions for parametric analyses were met for all variables.

To examine the effect of the intervention, differences between pre-test and posttest measurements of the experimental and control groups were analyzed using a 2 (group: experimental–control) $\times$ 2 (time: pretest–posttest) two-way repeated measures ANOVA, which evaluated both time and group effects simultaneously. In cases of significant interactions, Bonferroni-corrected pairwise comparisons were conducted to identify the source of the differences.

Summary data for motor and cognitive tests were presented as mean $\pm$ standard deviation ($M \pm SD$), and a significance level of $p < 0.05$ was adopted for all statistical tests. Additionally, partial eta squared (η^2) values were reported to assess the effect size of the intervention.

Results

Within-group and between-group results for the BOT-2 subtests of Bilateral Coordination, Upper-Limb Coordination, and Balance are presented in Table 3. Analyses revealed significant Time $\times$ Group

interactions for Bilateral Coordination and Upper-Limb Coordination, indicating that the EG showed greater improvements compared to the CG. For Bilateral Coordination, the EG improved from 10.25 ± 2.96 to 13.75 ± 2.71 (+34.1%), whereas the CG decreased slightly (9.63 ± 2.62 to 9.13 ± 2.90 , −5.2%). The Time $\times$ Group interaction was significant ($F = 5.58$, $p = 0.032$, $\eta^2 = 0.271$), suggesting a large effect of the intervention. For Upper-Limb Coordination, the EG increased from 12.11 ± 6.09 to 16.13 ± 6.76 (+33.2%), while the CG showed only a minor improvement (11.13 ± 5.11 to 11.75 ± 4.27 , +5.6%). The Time $\times$ Group interaction was significant ($F = 18.87$, $p = 0.001$, $\eta^2 = 0.557$), indicating a very large effect of the intervention. For Balance, both groups improved over time (EG: 20.78 ± 4.15 to 25.44 ± 2.65 , +22.5%; CG: 20.13 ± 3.27 to 20.88 ± 4.05 , +3.7%), but the Time $\times$ Group interaction was not significant ($F = 0.78$, $p = 0.727$, $\eta^2 = 0.128$), suggesting that the intervention did not differentially affect balance performance between groups. Overall, the intervention produced significant improvements in motor coordination, particularly for Bilateral and Upper-Limb Coordination, while balance improvements were similar in both groups. Effect sizes ranged from medium to large ($\eta^2 = 0.128$ – 0.557), indicating meaningful intervention effects.

The results of the Corsi Block Test are presented in Table 4. A significant main effect of time was observed ($F(1,15) = 5.77$, $p = 0.030$, $\eta^2 = 0.278$), indicating that participants improved overall from pretest to posttest. The Time $\times$ Group interaction was not significant ($F(1,15) = 2.31$, $p = 0.149$, $\eta^2 = 0.133$), suggesting that the magnitude of change did not differ statistically between the experimental (EG) and control (CG) groups. The main effect of group was also not significant ($F(1,15) = 0.48$, $p = 0.500$, $\eta^2 = 0.031$), indicating that the overall Corsi performance of the two groups was similar. Although the Time $\times$ Group interaction was not statistically significant, percentage improvement analyses showed a greater increase in the EG (+38.5%) compared to the CG (+8.7%), suggesting that the Life Kinetik intervention may have had a positive, albeit non-significant, effect on visuospatial memory.

Results of the d2 Attention Test subparameters are presented in Table 5. Significant Time $\times$ Group interactions were observed for all parameters, indicating that the EG improved more than the CG after

TABLE 3 Results of 2-way repeated measures ANOVA comparing pre- and post-tests of experimental and control groups on BOT-2 motor tests.

Test	Group	n	Pre-test Mean $\pm$ SD	Post-test Mean $\pm$ SD	% change	Time $\times$ Group		
						F	p	η^2
Bilateral coordination	Experimental	9	10.25 $\pm$ 2.96 (7.77–12.72)	13.75 $\pm$ 2.71 (11.48–16.01)	+34.1%	5.58	0.032**	0.271
	Control	8	9.63 $\pm$ 2.62 (7.24–11.86)	9.13 $\pm$ 2.90 (7.09–12.90)	−5.2%			
Upper-limb coordination	Experimental	9	12.11 $\pm$ 6.09 (6.56–17.43)	16.13 $\pm$ 6.76 (11.24–21.00)	+33.23%	18.87	0.001**	0.557
	Control	8	11.13 $\pm$ 5.11 (7.62–15.03)	11.75 $\pm$ 4.27 (8.98–15.68)	+5.62%			
Balance	Experimental	9	20.78 $\pm$ 4.15 (17.34–24.65)	25.44 $\pm$ 2.65 (22.91–27.33)	+22.46%	0.78	0.727	0.128
	Control	8	20.13 $\pm$ 3.27 (17.63–22.36)	20.88 $\pm$ 4.05 (18.22–25.10)	+3.73%			

Effect sizes (ES) are reported as partial eta squared (η^2). 0.01–0.059 indicate small effect, 0.06–0.139 indicate medium effect, and ≥ 0.14 indicate large effect. Bold values indicate statistically significant results: * $p < 0.05$, ** $p < 0.01$. % Change = [(Post-test mean – Pre-test mean) / Pre-test mean] $\times$ 100.

TABLE 4 Results of 2-way repeated measures ANOVA comparing pre- and post-tests of experimental and control groups on Corsi block test.

Group	n	Pre-test Mean $\pm$ SD	Post-test Mean $\pm$ SD	% change	Time $\times$ Group		
					F	p	η^2
EG	9	1.44 $\pm$ 0.60 (0.66–2.22)	1.88 $\pm$ 1.02 (1.05–2.94)	+38.5%	2.31	0.149	0.133
CG	8	1.38 $\pm$ 0.52 (0.94–1.80)	1.50 $\pm$ 0.53 (1.06–1.94)	+8.70%			

Effect sizes (ES) are reported as partial eta squared (η^2). 0.01–0.059 indicate small effect, 0.06–0.139 indicate medium effect, and ≥ 0.14 indicate large effect. * $p < 0.05$, ** $p < 0.01$. % Change = [(Post-test mean – Pre-test mean) / Pre-test mean] $\times$ 100.

the 8-week intervention. For TN, a significant improvement was observed in the EG (+3.3%), whereas the CG remained almost unchanged (+0.13%). The Time $\times$ Group interaction was significant ($F = 5.98$, $p = 0.028$, $\eta^2 = 0.285$). For E1, the EG showed a reduction of 5.5% while the CG had a negligible change (–0.36%), with a significant Time $\times$ Group interaction ($F = 5.11$, $p = 0.038$, $\eta^2 = 0.254$). For E2, the EG decreased by 13.8% versus 0.64% in the CG, with a significant interaction ($F = 7.04$, $p = 0.018$, $\eta^2 = 0.319$). For Er, EG errors decreased by 7%, while CG errors remained nearly constant (Time $\times$ Group: $F = 5.88$, $p = 0.029$, $\eta^2 = 0.282$). For TN-E, EG improved by 4.98%, with no significant change in CG (Time $\times$ Group: $F = 5.94$, $p = 0.028$, $\eta^2 = 0.284$). For CP, EG increased by 6.7%, whereas CG decreased slightly (Time $\times$ Group: $F = 6.11$, $p = 0.026$, $\eta^2 = 0.289$). For FR, EG improved by 13.5% with a significant interaction ($F = 6.94$, $p = 0.019$, $\eta^2 = 0.316$). Overall, these results indicate that the Life Kinetik and calisthenics intervention significantly enhanced attention, concentration, psychomotor speed, error control, and reaction skills in the experimental group, while no significant changes were observed in the control group. Effect sizes ranged from medium to large ($\eta^2 = 0.254$ – 0.319), suggesting meaningful intervention effects.

Discussion

Motor skills reflect an individual's ability to plan and execute purposeful movements and are fundamental to daily living (31). Adolescents with mild intellectual disabilities (MID) typically exhibit lower motor coordination and difficulties in both fine and gross motor skills compared to typically developing peers (32). Therefore, coordination-based supplementary interventions are recommended alongside regular physical activity (33). Evidence suggests that interventions combining cognitive and motor components may be more effective (34).

In this study, the effects of the Life Kinetik program on motor coordination were examined. The findings indicate significant improvements in upper-limb and bilateral coordination in adolescents with MID. Although balance performance did not show a statistically significant difference between groups, the high percentage improvement in the experimental group suggests a potential positive effect on balance. Despite the small sample size ($n = 17$), post-hoc power analyses (Cohen's $d = 0.65$ – 0.70) indicate that meaningful effects on motor coordination were achieved.

These results align with previous research. Adapted Physical Activity programs (35), physical education interventions (36), and cognitive-motor exercises (37) have demonstrated significant improvements in motor skills in individuals with MID. Physical

activity has also been shown to improve motor skills in adolescents with autism spectrum disorder, and multi-component interventions enhance motor integration and attention (38, 39).

Cognitive limitations, particularly in attention and visuospatial working memory, affect learning and daily functioning in MID (40, 41). Life Kinetik exercises, requiring both motor and cognitive engagement, may positively influence these processes. In our study, the Corsi Block Test indicated a trend of improvement in visuospatial working memory in the experimental group, consistent with literature showing that multi-component exercises support working memory (42, 43).

Regarding attention, the eight-week Life Kinetik and calisthenics program significantly improved performance in the experimental group. Increases in TN scores and reductions in error parameters indicate improvements in visual scanning, selective attention, and inhibitory control. These findings support the notion that motor-cognitive interventions can enhance attentional processes, consistent with prior studies (44, 45). Aerobic and resistance-based exercise may further support prefrontal cortex-mediated attention mechanisms (46, 47).

However, the literature does not provide fully consistent evidence regarding cognitive outcomes following working memory and physical activity-based interventions in individuals with intellectual disabilities. A meta-analytic review by Danielsson et al. (48) reported that working memory training generally yields only small overall effects, with visuospatial working memory training often showing negligible improvements. In addition, systematic reviews of physical activity interventions indicate that while motor outcomes are relatively consistent, cognitive outcomes such as working memory, attention, and executive functions are highly variable across studies, with several investigations reporting non-significant effects (39). These inconsistencies suggest that cognitive improvements are highly dependent on intervention design, task complexity, intensity, and individual differences within the MID population.

In contrast to these findings, the present study demonstrated improvements in visuospatial working memory following a motor-cognitive integrated intervention. This discrepancy may indicate that simultaneous engagement of motor coordination and cognitive processing, as required in Life Kinetik training, may produce stronger cognitive stimulation than conventional working memory training alone. Therefore, multimodal interventions may represent a more effective approach for enhancing executive functions in individuals with intellectual disabilities.

Overall, this eight-week Life Kinetik program improved motor coordination, attention, visuospatial working memory, and processing speed in adolescents with MID. The results highlight the feasibility and effectiveness of motor-cognitive integrated approaches as an intervention strategy for individuals with cognitive and motor limitations.

TABLE 5 Results of 2-way repeated measures ANOVA comparing pre- and post-tests of experimental and control groups on d2 attention test.

Parameter	Group	n	Pre-test Mean $\pm$ SD	Post-test Mean $\pm$ SD	% change	TimexGroup		
						F	p	η^2
TN	EG	9	287.8 $\pm$ 53.2 (256.20–336.54)	297.3 $\pm$ 53.4 (265.92–345.32)	+3.32%	5.98	0.028*	.285
	CG	8	312.9 $\pm$ 36.0 (267.40–337.48)	313.3 $\pm$ 36.7 (268.79–339.42)	+0.13%			
E1	EG	9	90.7 $\pm$ 19.4 (72.64–102.10)	85.7 $\pm$ 18.2 (73.73–101.15)	–5.5%	5.11	0.038*	.254
	CG	8	83.8 $\pm$ 15.4 (68.54–96.95)	83.5 $\pm$ 17.0 (73.22–99.44)	–0.36%			
E2	EG	9	19.3 $\pm$ 4.89 (14.57–23.17)	16.6 $\pm$ 4.80 (11.90–20.59)	–13.8%	7.04	0.018*	0.319
	CG	8	20.3 $\pm$ 3.68 (17.84–23.49)	20.2 $\pm$ 3.04 (17.86–22.58)	–0.64%			
Er	EG	9	110.0 $\pm$ 19.2 (90.88–121.61)	102.3 $\pm$ 18.2 (83.59–114.40)	–7.0%	5.88	0.029*	0.282
	CG	8	104.1 $\pm$ 13.7 (94.75–121.46)	103.5 $\pm$ 15.4 (93.76–119.34)	–0.29%			
TN-E	EG	9	160.7 $\pm$ 60.3 (127.84–215.65)	168.7 $\pm$ 57.4 (143.46–219.53)	+4.98%	5.94	0.028*	0.284
	CG	8	188.8 $\pm$ 28.9 (139.67–211.87)	189.4 $\pm$ 36.2 (134.84–216.49)	+0.32%			
CP	EG	9	102.4 $\pm$ 10.7 (95.12–111.62)	109.3 $\pm$ 12.0 (102.76–120.48)	+6.7%	6.11	0.026*	0.289
	CG	8	105.5 $\pm$ 10.4 (96.13–112.53)	105.1 $\pm$ 11.2 (94.66–112.44)	–0.4%			
FR	EG	9	25.9 $\pm$ 1.99 (25.19–27.55)	22.4 $\pm$ 1.97 (20.71–23.78)	–13.5%	6.94	0.019*	0.316
	CG	8	24.1 $\pm$ 3.51 (21.24–26.53)	23.5 $\pm$ 4.00 (20.71–26.61)	–2.5%			

TN, Total Number; E1, Omissions; E2, Commissions; Er, Total Errors; TN-E, Psychomotor Speed; CP, Concentration Performance; FR, Fluctuation Rate. Effect sizes (ES) are reported as partial eta squared (η^2). 0.01–0.059 indicate small effect, 0.06–0.139 indicate medium effect, and ≥ 0.14 indicate large effect. Bold values indicate statistically significant results: * $p < 0.05$, ** $p < 0.01$. % Change = [(Post-test mean – Pre-test mean) / Pre-test mean] $\times$ 100.

Conclusion

This study suggests that participation of adolescents with MID in a physical activity program supplemented with attention-enhancing activities may contribute to improvements in visual memory, perception, attention, and motor skills. The findings indicate a potential relationship between physical activity and the interaction of motor and cognitive processes. However, considering the small sample size and study limitations, these results should be interpreted with caution. The findings further suggest that physical activity programs incorporating cognitive stimulation and coordinative demands may be beneficial for improving attention and related cognitive functions in individuals with MID. Future research should include larger samples, longer intervention periods, and more comprehensive cognitive assessments to better evaluate the sustainability and generalizability of these effects.

Limitations of the study

This study has several limitations. First, the relatively small sample size ($n = 17$) and the inclusion of only male participants within a

specific age range limit the statistical power and generalizability of the findings. Recruiting adolescents with mild intellectual disabilities who meet strict inclusion criteria and can adhere to an 8-week structured intervention presents practical and ethical challenges. Therefore, these results should be considered preliminary, and caution is needed when generalizing the findings.

Second, the absence of a control group and the use of a repeated-measures design limit causal inferences. In addition, the short intervention duration and lack of follow-up assessment prevent conclusions about long-term effects. Single-site recruitment and lack of blinding may further restrict external validity and introduce potential bias. Moreover, the outcome measures were limited and may not fully capture the multidimensional nature of motor and cognitive performance.

Despite these limitations, post-hoc power analysis for key outcomes showing significant group $\times$ time interactions—including bilateral and upper-limb coordination—indicated moderate statistical power (≈ 68 – 72%) at $\alpha = 0.05$, based on observed effect sizes (Cohen's $d = 0.65$ and $d = 0.70$, respectively). These results suggest that the intervention produced meaningful effects on motor coordination despite the small sample. Future studies with

larger, more diverse samples and more robust designs are warranted to confirm and extend these findings.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

Ethical approval for this study was obtained from the Bingöl University Health Sciences Scientific Research and Publication Ethics Committee (Meeting Date: 24.03.2025; Meeting No: 04; Decision No: 19). The study was conducted in accordance with the principles of the Declaration of Helsinki. Written informed consent was obtained from the parents or legal guardians of all participants prior to enrollment, and verbal assent was obtained from the children prior to participation.

Author contributions

HG: Writing – original draft, Writing – review & editing. BK: Writing – original draft, Formal analysis, Data curation. EC: Writing – original draft, Investigation, Data curation. ZB: Conceptualization, Investigation, Writing – review & editing. AY: Methodology, Formal analysis, Writing – review & editing. MT: Supervision, Validation, Writing – review & editing. OU: Investigation, Resources, Writing – review & editing.

References

- Schalock RL, Luckasson R, Tassé MJ. An overview of intellectual disability. *Am J Intellect Dev Disabil.* (2021) 126:439–42. doi: 10.1352/1944-7558-126.6.439
- Prokhorenko L, Sokolova H, Forostian O, Kravets Y, Horbatiuk O. Typology of competence characteristics of pupils with intellectual disabilities. *Rev Amazonia Investiga.* (2022) 11:172–81. doi: 10.34069/AI/2022.55.07.18
- American Psychiatric Association. Diagnostic and Statistical Manual of mental Disorders. 5th ed. American Psychiatric Publishing (2013).
- Salend SJ. *Effective Mainstreaming: Creating Inclusive Classrooms*. 3rd ed. Columbus, OH: Merrill Prentice Hall (1998).
- Schalock RL, Gardner JF, Bradley VJ. *Quality of life for Persons with Intellectual and other Developmental Disabilities*. Washington, DC: American Association on Intellectual and Developmental Disabilities (2007).
- Dolva AS, Coster W, Lilja M. Functional performance in children with down syndrome. *Am J Occup Ther.* (2004) 58:621–9. doi: 10.5014/ajot.58.6.621
- Matson JL, Matheis M, Estabillo JA, Issarraras A, Peters WJ, Jiang X. "Intellectual disability". In: Beauchaine TP and Hinshaw SP, editors. *Treatment of Disorders in Childhood and Adolescence*. New York, NY: Guilford Press (2019). p. 416–47.
- Maulik PK, Mascarenhas MN, Mathers CD, Dua T, Saxena S. Prevalence of intellectual disability: a meta-analysis of population-based studies. *Res Dev Disabil.* (2011) 32:419–36. doi: 10.1016/j.ridd.2010.12.018
- Olusanya BO, Smythe T, Ogbo FA, Nair MKC, Scher M, Davis AC. Global prevalence of developmental disabilities in children and adolescents. *Front Public Health.* (2023) 11:1122009. doi: 10.3389/fpubh.2023.1122009
- Morgan PL, Farkas G, Hillemeier MM, Mattison R, Maczuga S, Li H, et al. Minorities are disproportionately underrepresented in special education. *Educ Res.* (2015) 44:278–92. doi: 10.3102/0013189X15591157
- Fernandes J, Arida RM, Gomez-Pinilla F. Physical exercise as an epigenetic modulator of brain plasticity and cognition. *Neurosci Biobehav Rev.* (2017) 80:443–56. doi: 10.1016/j.neubiorev.2017.06.012
- Lutz H. *Life Kinetik: Bewegung macht Hirn*. Aachen, Germany: Meyer & Meyer Verlag (2017).
- Lutz H. (2014). Die Wissenschaft und Life Kinetik. Available online at: <https://lifekinetik-martin.de/wp-content/uploads/2015/10/Die-Wissenschaft-und-Life-Kinetik-2014.pdf> (Accessed September 24, 2025).
- Lutz H. *Life Kinetik® – Gehirnt raining durch Bewegung*. Munich, Germany: BLV Buchverlag (2015).
- Wang Y, Zhou D, Liu C, Long L, Cheng G. Physical-intellectual badminton teaching intervention. *Front Psychol.* (2025) 16:1445620. doi: 10.3389/fpsyg.2025.1445620
- Komarudin M. Life kinetic training in improving the cognitive functions. *Proceed Int Conference on Soc Sci Human.* (2019) 7:107–10. doi: 10.2991/icssh-18.2019.25
- Gür Y, Taşkın S, Özaktaş ES, Taşkın C. The effect of life Kinetik exercise on performance in bocce athletes. *J Educ Issues.* (2022) 8:664. doi: 10.5296/jei.v8i1.19858
- Ansyah WM, Komarudin K. Effects of life kinetic and brain gym training models on working memory and concentration of football athletes. *Jurnal Pendidikan Jasmani dan Olahraga.* (2023) 8:181–9. doi: 10.17509/jppo.v8i2.59682

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19. Ceviz E, Genç H. Erkek Yüzücülere Uygulanan Kalistenik ve Life Kinetik Egzersizlerinin Kuvvet, Bilişsel Beceri ve Yüzme Performansı Özellikleri Üzerine Etkisi. *Int J Sport, Exercise Training Sci.* (2025) 11:330–40. doi: 10.18826/useeabd.1774722
20. Fauzi F, Pranatahadi S, Dwihandaka R, Sabillah MI, Rohmah DAI, Fauzi LA. The effect of life kinetic number training on the concentration level of female volleyball athletes aged 13–15 years. *Retos: Nuevas Tendencias en Educación Física. Deporte y Recreación.* (2024) 56:1046–55. doi: 10.47197/retos.v56.104100
21. Yaran YE, Keskin K, Çelik OB, Güder BC, Kurtipek S, Aslan M, et al. Impact of life kinetic training on balance, agility, jumping, proprioception, and cognitive function in preadolescent recreational fencing athletes: a randomized controlled trial. *BMC Sports Sci Med Rehabil.* (2025) 17:146. doi: 10.1186/s13102-025-01186-3
22. Diz S, Jacinto M, Costa AM, Matos R, Monteiro D, Teixeira JE, et al. The effect of practicing sports on the body composition and physical fitness of people with intellectual and developmental disabilities. *Front Psychol.* (2025) 16:1654598. doi: 10.3389/fpsyg.2025.165459
23. Maicas-Pérez L, Hernández Lougedo J, Maté-Muñoz JL, Villagra-Astudillo A, García Fernández P, Suárez-Villadot B, et al. Effect of physical activity interventions on health parameters in children and adolescents with intellectual disabilities: a systematic review. *Health.* (2024) 12:2434. doi: 10.3390/healthcare12232434
24. Mullhall P, Taggart L, McDermott G, Slater P, Fitzpatrick B, Murphy MH, et al. 'Walk buds': a walking intervention to increase physical activity, physical fitness, and emotional wellbeing, in 9–13 year old children with intellectual disabilities. Results of a clustered randomised feasibility trial. *J Applied Res Intellectual Disabilities: JARID.* (2024) 37:e13260. doi: 10.1111/jar.13260
25. Zolghadr H, Sedaghati P, Daneshmandi H, Sokhangoe Y. Effects of mini-basketball training. *BMC Sports Sci, Med Rehab.* (2024) 16:250. doi: 10.1186/s13102-024-01044-8
26. Bruininks RH, Bruininks BD. *Bruininks-Oseretsky Test of Motor Proficiency.* 2nd ed. Minneapolis, MN: Pearson Assessment (2005).
27. Deitz JC, Kartin D, Kopp K. Review of the Bruininks-Oseretsky test of motor proficiency, second edition (BOT-2). *Phys Occup Ther Pediatr.* (2007) 27:87–102. doi: 10.1080/J006v27n04_06
28. Pitetti K, Bertapelli F, Miller RA, Loois M, do Amaral-Junior WD, de Barros-Filho MM, et al. Relationship between body mass index and gross motor capacity. *J Intellect Disabil Res.* (2024) 68:1208–20. doi: 10.1111/jir.13168
29. Mueller ST, Piper BJ. The psychology experiment building language (PEBL). *J Neurosci Methods.* (2014) 222:250–9. doi: 10.1016/j.jneumeth.2013.10.024
30. Brickenkamp R, Zillmer E. *d2 test of Attention.* Seattle, WA: Hogrefe & Huber Publishers (1998).
31. Vuijk PJ, Hartman E, Scherder E, Visscher C. Motor performance of children with mild intellectual disability. *J Intellect Disabil Res.* (2010) 54:955–65. doi: 10.1111/j.1365-2788.2010.01318.x
32. Cantone M, Catalano MA, Lanza G, La Delfa G, Ferri R, Pennisi M, et al. Motor and perceptual recovery in adult patients with mild intellectual disability. *Neural Plast.* (2018) 2018:3273246. doi: 10.1155/2018/3273246
33. Rintala P, Loois EM. Measuring motor skills in Finnish children with intellectual disabilities. *Percept Mot Skills.* (2013) 116:294–303. doi: 10.2466/25.10.PMS.116.1.294-303
34. Shi P, Feng X. Motor skills and cognitive benefits. *Front Psychol.* (2022) 13:1017825. doi: 10.3389/fpsyg.2022.1017825
35. Karakaş G, Eroğlu Kolayış I, Bayazit B. Effects of adapted physical activity on the motor development of children with mild intellectual disability. *Int J Develop Disab.* (2025) 71:777–87. doi: 10.1080/20473869.2024.2332751
36. Özkan Z, Kale R. Investigation of the effects of physical education activities on motor skills and quality of life. *Int J Develop Disab.* (2021) 69:578–92. doi: 10.1080/20473869.2021.1978267
37. Kachouri H, Jouira G, Rebai H, Sahli S. The effect of motor dual-task training on gait and mobility performances in children with intellectual disabilities. *J Intellect Disabil.* (2025) 29:100–16. doi: 10.1177/17446295241284722
38. Korkusuz S, Top E. Does the combination of physical activity and attention training affect the motor skills and cognitive activities of individuals with mild intellectual disability? *Int J Develop Disab.* (2023) 69:654–62. doi: 10.1080/20473869.2021.1995640
39. Suárez-Manzano S, Ruiz-Ariza A, de Loureiro NEM, Martínez-López EJ. Effects of physical activity in youth with autism spectrum disorder. *Behav Sci (Basel).* (2024) 14:330. doi: 10.3390/bs14040330
40. Frolova O., Nikolaev A., Grave P, Lyakso E. (2023). "Speech features of children with mild intellectual disabilities." In *Proceedings of the International Conference on Multimodal Interaction* (Article 3616236).
41. Sigstad HMH, Garrels V. Success factors in school-work transition. *Eur J Spec Needs Educ.* (2023) 38:573–87. doi: 10.1080/08856257.2022.2148600
42. Deng J, Wang H, Fu T, Xu C, Zhu Q, Guo L, et al. Physical activity improves the visual-spatial working memory of individuals with mild cognitive impairment or Alzheimer's disease: a systematic review and network meta-analysis. *Front Public Health.* (2024) 12:1365589. doi: 10.3389/fpubh.2024.1365589
43. Van der Molen MJ, Henry LA, Van Luit JE. Working memory development. *J Intellect Disabil Res.* (2014) 58:637–50. doi: 10.1111/jir.12061
44. Carek PJ, Laibstein SE, Carek SM. Exercise for the treatment of depression and anxiety. *Int J Psychiatry Med.* (2011) 41:15–28. doi: 10.2190/PM.41.1.c
45. Tuna B, Apak M, Karagülmez Sağlam Ç, Sevilmiş E. Effect of life kinetic exercises on fundamental motor skills. *Retos.* (2024) 62:732–8.
46. Chaire A, Becke A, Düzel E. Effects of physical exercise on working memory and attention-related neural oscillations. *Front Neurosci.* (2020) 14:239. doi: 10.3389/fnins.2020.00239
47. Ptomey LT, Szabo AN, Willis EA, Gorczyca AM, Greene JL, Danon JC, et al. Changes in cognitive function after a 12-week exercise intervention in adults with down syndrome. *Disabil Health J.* (2018) 11:486–90. doi: 10.1016/j.dhjo.2018.02.003
48. Danielsson H, Zottarel V, Palmqvist L, Lanfranchi S. The effectiveness of working memory training with individuals with intellectual disabilities - a meta-analytic review. *Front Psychol.* (2015) 6:1230. doi: 10.3389/fpsyg.2015.01230



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Mediating role of exercise behavioral intention in the relationship between exercise self-efficacy and physical activity levels in vocational education students

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Background: Social Cognitive Theory and the Theory of Planned Behavior
suggest that self-efficacy influences physical activity through behavioral
intention; however, evidence in vocational students is scarce.

Objective: This study examined whether exercise behavioral intention mediates
the association between exercise self-efficacy and physical activity levels among
vocational education students in Shanghai.

Methods: A cross sectional survey was conducted with 992 students from
four vocational colleges. Participants completed validated measures of exercise
self-efficacy (nine items, 1–10 scale), exercise behavioral intention (five items,
5-point Likert scale), and physical activity (IPAQ-SF). Data were analyzed using
SPSS 25.0 (IBM Corporation, Armonk, New York, USA) and AMOS 26.0 (IBM
Corporation, Armonk, New York, USA), adjusting for gender, age, and education
level.

Results: Exercise self-efficacy was positively associated with exercise behavioral
intention ($r = 0.612$, $p < 0.001$) and physical activity ($r = 0.322$, $p < 0.001$).
Mediation analysis showed that behavioral intention partially mediated this
relationship (indirect effect = 0.122, 95% CI [0.085, 0.163]), accounting for 45.19%
of the total effect.

Conclusion: Exercise self-efficacy is associated with physical activity
both directly and indirectly via behavioral intention in vocational students.
Interventions enhancing self-efficacy and behavioral intention may support
higher activity levels, though longitudinal studies are needed to confirm
directionality.

KEYWORDS

exercise behavioral intention, exercise self-efficacy, mediating effect, physical activity,
vocational education students

1 Introduction

Vocational education plays a vital role in developing skilled workers to support industrial growth (1). In Shanghai, a leader in vocational education reform, significant attention is being given to the physical and mental wellbeing of students in vocational institutions, which include Vocational high school, Junior college, Vocational University (2). At this critical stage of their physical and psychological development, students' physical activity levels not only affect their current health but also influence their future career adaptability and quality of life (3, 4). However, research shows that vocational students tend to have low physical activity levels and lack motivation for sports participation (5). Improving their engagement in physical exercise and establishing a strong foundation for physical fitness remains a significant challenge in vocational education (6).

Exercise self-efficacy, rooted in Bandura's self-efficacy theory, refers to an individual's belief in their ability to perform physical tasks and maintain exercise behaviors (7). However, prior research presents inconsistent findings regarding its mediating role. Many studies have conceptualized exercise self-efficacy as a mediator linking various antecedents, such as social support, to physical activity. In contrast, other studies propose that behavioral intention may act as a more proximal mediator in the self-efficacy to behavior relationship (8, 9). For example, Hong and Chung (10) demonstrated that, among university students, self-efficacy had stronger direct effects on behavioral intention and behavior than on attitude, whereas the attitude intention behavior link was only significant for those not habituated to physical exercise. However, evidence for vocational students, whose schedules and training constraints differ substantially from general university populations, is scarce. This gap underscores the need to examine the mediation role of behavioral intention in this specific population. Conversely, Hou et al. (11) suggested that self-efficacy moderates, rather than mediates, the intention to behavior gap. These inconsistencies underscore a theoretical gap: it remains unclear whether behavioral intention functions as a mediator or moderator in the self-efficacy → physical activity pathway, particularly in understudied populations such as vocational students. Exercise behavior intention constitutes an individual's subjective plan and willingness to engage in future physical activity, serving as a critical bridge connecting psychological cognition with actual exercise behavior (12). In this context, research by Zhou et al. (13) and Bao (14) confirms that exercise behavior intention plays a significant mediating role in the relationship between psychological factors and physical activity.

Physical activity levels among student populations serve as a critical indicator of their physical and mental wellbeing, with contemporary research characterizing physical activity through a multidimensional lens. Research by Xu et al. (15) in adolescent cohorts highlights a strong correlation between physical activity and self-efficacy, identifying self-efficacy as a pivotal mediator linking external support to physical activity engagement. Studies by Gao et al. (16) and Jiang et al. (17) further substantiate that physical activity not only directly enhances physical and psychological health but also indirectly improves academic engagement and fortifies psychological resilience through elevated self-efficacy. Gao

et al. (18) evaluated the reliability and validity of several physical activity questionnaires, including the IPAQ-SF, among Chinese college students. Their findings indicated that the IPAQ-SF, along with other subjective instruments, provided limited but acceptable reliability and validity for measuring moderate vigorous physical activity in this population, offering empirical support for its cautious use in research.

While these relationships have been extensively studied in general university students, research focusing on vocational education students remains limited. Vocational students differ from their academic track peers in several key ways that may alter the psychological pathways to physical activity. First, their academic schedules are heavily oriented toward professional skill development and mandatory internships, leaving limited discretionary time for structured exercise (19). Second, vocational students often exhibit a weaker foundation in physical activity and lower capacity for autonomous exercise planning, potentially increasing their reliance on conscious intentions to initiate activity (20). Third, recent evidence from Shanghai indicates a high prevalence of smartphone addiction (70.5%) and musculoskeletal disorders (38.0%) in this population (21), conditions that may directly reduce self-efficacy and impede the translation of intentions into action. These characteristics suggest that behavioral intention may serve as a particularly important, yet potentially vulnerable, mediator between self-efficacy and physical activity in vocational students compared with general university students. Therefore, studying this population is not merely an extension of previous research but provides a critical test of the generalizability of the mediation model linking self-efficacy, behavioral intention, and physical activity.

Despite this, most existing research focuses on general university students, highlighting the need for more targeted studies on the physical activity behaviors of vocational students. The proposed mediation model is grounded in the integration of Bandura's Social Cognitive Theory and Ajzen's Theory of Planned Behavior (TPB) (22, 23). According to Bandura, self-efficacy beliefs influence behavior both directly and indirectly by shaping individuals' goals, intentions, and expectations of outcomes (24, 25). Within the TPB framework, behavioral intention is the most immediate predictor of actual behavior, reflecting the motivational factors that drive action (23). In this context, self-efficacy is a crucial element of perceived behavioral control, enhancing an individual's confidence in their ability to perform the desired behavior. Empirical studies provide robust support for the mediating role of behavioral intention in the pathway from self-efficacy to physical activity. For instance, Lippke et al. (26) employed structural equation modeling to demonstrate that intention significantly predicts behavior through the mediation of action planning, and the strength of this mediation is moderated by individuals' self-efficacy levels. Similarly, Spink and Nickel (27) conducted a prospective study showing that self-regulatory self-efficacy partially mediates the relationship between attributional factors and exercise intention, providing longitudinal evidence for the causal chain from self-efficacy to intention. These findings align with the Social Cognitive Theory and the Theory of Planned Behavior, reinforcing the notion that self-efficacy enhances exercise intentions, which in

turn translate into actual physical activity. By combining these theoretical and empirical insights, a clear pathway emerges in which exercise self-efficacy strengthens exercise behavioral intentions, which then lead to higher levels of physical activity. This pathway provides a solid theoretical and empirical basis for exploring the mediating role of exercise behavioral intention in vocational education students. Examining this integrated model in the understudied context of vocational students will provide evidence on whether the pathway generalizes across different educational settings.

2 Methods

2.1 Participants

A stratified random sampling approach was used to ensure representativeness of vocational education students in Shanghai. Three administrative districts (Pudong, Yangpu, and Minhang) were purposively selected to reflect urban, suburban, and peri urban characteristics. Within each district, one vocational high school, one junior college, and one vocational university were randomly chosen from the official roster of vocational institutions. At each selected school, two grades were randomly selected, and within each grade, three classes were randomly sampled. All students in the selected classes were invited to participate.

Questionnaires were distributed and collected during off class hours. Before administration, the study purpose and significance were explained to participants, and written informed consent was obtained from all students. A total of 1,005 questionnaires were distributed, of which 992 were valid, resulting in an effective response rate of 98.7%. The final sample included 324 vocational high school students, 342 junior college students, and 326 vocational university students, covering the three main levels of vocational education in Shanghai.

2.2 Methodology

2.2.1 Exercise self-efficacy

The Exercise Self-Efficacy Scale, developed by Resnick and Jenkins (28) and translated by Lee et al. (29) was employed. This scale comprises nine items, each rated on a 1 to 10 point scale, with 1 indicating “impossible” and 10 indicating “very likely.” Item scores are summed, and higher total scores correspond to greater exercise self-efficacy. In this study, the scale exhibited a Cronbach’s α coefficient of 0.827 and KMO was 0.96. The construct validity of the three factor measurement model (exercise self-efficacy, behavioral intention, physical activity) was assessed using confirmatory factor analysis (CFA) on the current sample. As reported in Section 3.1, the hypothesized three factor model fit the data acceptably [$\chi^2_{(116)} = 412.3$, CFI = 0.951, TLI = 0.943, RMSEA = 0.056, SRMR = 0.045], supporting the factorial validity of the scales.

2.2.2 Exercise behavior intention

The Exercise Behavior Intention scale was adapted from the instrument developed by Hong and Chung (10), which itself was constructed based on the Theory of Planned Behavior. The original scale comprises five items designed to assess an individual’s subjective willingness and action plans for participating in physical exercise. Its reliability and validity have been previously validated within a university student population, demonstrating an internal consistency (Cronbach’s α) of 0.84 and a clear unidimensional structure via exploratory factor analysis. In this study, the scale demonstrated good reliability with a Cronbach’s α coefficient of 0.844 and KMO of 0.865. As part of the three factor CFA reported in Section 3.1, the behavioral intention items loaded significantly on their intended factor (standardized loadings ranged from 0.68 to 0.82, $p < 0.001$), supporting the construct validity of the scale in the current sample. This indicates that these items load on the same latent factor as the other intention focused items. The scale was retained in its original form to ensure comparability with prior studies. Nonetheless, it should be noted that the observed mediating effect of behavioral intention may partially reflect normative influences. The present study retained all five original items (10): “I am willing to increase my opportunities for physical exercise,” “I am willing to follow the advice of significant others to participate in exercise,” “I am willing to follow a professional doctor’s advice to participate in exercise,” “I can control my own exercise mode and volume,” and “If I decide to exercise, I will do so regardless of circumstances.” Responses were recorded on a 5-point Likert scale (1 = “Strongly Disagree,” 5 = “Strongly Agree”), with higher scores indicating stronger exercise behavior intention. In this study, the scale demonstrated good reliability and validity within the sample, with a Cronbach’s α coefficient of 0.844 and a KMO was 0.865.

2.2.3 International physical activity questionnaire short form

Physical activity levels were assessed using the International Physical Activity Questionnaire Short Form (IPAQ-SF), which includes seven items requiring participants to report the frequency and duration of their participation in activities of various intensities during the previous week (30). These activities include vigorous intensity activities (e.g., weightlifting, gym workouts, aerobics, or fast cycling), moderate intensity activities (e.g., carrying light loads, cycling at a regular pace, or brisk walking), walking, and sedentary behavior. The corresponding metabolic equivalent of task (MET) values were: walking, 3.3 METs; moderate intensity activities, 4.0 METs; and vigorous intensity activities, 8.0 METs. For data processing, truncation rules were applied: if the reported daily duration for any activity exceeded 3 h, it was capped at 180 min to ensure the total weekly duration for each activity level did not exceed 21 h (1,260 min). Following these criteria, 13 participants were excluded (nine due to extreme MET values, four due to incomplete data), resulting in a final analytical sample of 992. Physical activity levels were calculated in MET-minutes per week using the following formula: (walking minutes/day $\times$ walking

days/week $\times$ 3.3) + (moderate-intensity minutes/day $\times$ moderate-intensity days/week $\times$ 4.0) + (vigorous-intensity minutes/day $\times$ vigorous-intensity days/week $\times$ 8.0).

2.3 Statistical analysis

A simple mediation model was tested using structural equation modeling (SEM) with observed variables in AMOS 26.0 (IBM, Armonk, NY, USA) to examine the proposed pathway from exercise self-efficacy to physical activity level through exercise behavioral intention. All constructs were treated as manifest variables using total scores (sum of exercise self-efficacy items, sum of exercise behavioral intention items, and IPAQ-SF MET-minutes per week). Demographic covariates, including gender, age, and education level, were included by regressing them onto both the mediator and the outcome. Maximum likelihood estimation was employed to estimate model parameters. The significance of direct and indirect effects was assessed using 5,000 bootstrap resamples with bias corrected 95% confidence intervals, with effects considered significant if the confidence interval did not include zero. Standardized regression coefficients (β) were reported for all paths, and total, direct, and indirect effects were used to calculate the proportion of the effect mediated. As the model was just identified (saturated), conventional fit indices were not applicable. Demographic covariates (gender, age, and education level) were retained in all models regardless of their statistical significance. This decision was made on *a priori* theoretical grounds, as these factors have been consistently associated with physical activity in prior research, and to control for potential confounding regardless of *p*-value.

3 Results

3.1 Assessment of common method bias

Procedurally, the questionnaire was administered anonymously, items were organized into separate sections, and participants were informed that there were no right or wrong answers. Statistically, Harman's single factor test was first conducted by entering all items from the three scales into an exploratory factor analysis. The unrotated solution extracted four factors with eigenvalues greater than 1, and the first factor accounted for 22.24% of the total variance, below the conventional 40% threshold (31), suggesting that CMB is unlikely to be a major concern.

A more rigorous examination using confirmatory factor analysis (CFA) showed that a single factor model with all 17 items loaded onto one latent method factor fit poorly [$\chi^2_{(119)} = 2345.8$, CFI = 0.612, TLI = 0.578, RMSEA = 0.152, SRMR = 0.121], whereas the hypothesized three factor model (exercise self-efficacy, behavioral intention, and physical activity) fit acceptably [$\chi^2_{(116)} = 412.3$, CFI = 0.951, TLI = 0.943, RMSEA = 0.056, SRMR = 0.045]. The large deterioration in fit (Δ CFI = 0.339, Δ RMSEA = 0.096) indicates that a single method factor cannot account for the shared

variance. These results suggest that common method bias does not meaningfully distort the observed associations.

3.2 Demographic statistics

The study sample consisted of 992 vocational education students from Shanghai. Of these, 495 (49.9%) were male and 497 (50.1%) were female. In terms of educational level, 324 (32.6%) were vocational high school students, 342 (34.4%) were junior college students, and 326 (33.0%) were vocational university students, ensuring a balanced representation across these levels. Students' majors were distributed across six categories, with proportions of 23.2%, 18.8%, 20.8%, 19.2%, 17.6%, and 0.5%. The distribution of participants' residential areas was also fairly balanced, as shown in Table 1.

3.3 Results of correlation analysis

Pearson correlation analysis was performed to assess the relationships among exercise self-efficacy, behavioral intention toward physical exercise, and physical activity level. The analysis revealed significant positive correlations between exercise self-efficacy and both physical activity level ($r = 0.322$, $p < 0.001$) and behavioral intention ($r = 0.612$, $p < 0.001$). Additionally, a significant positive correlation was found between physical activity level and behavioral intention ($r = 0.346$, $p < 0.001$). These results

TABLE 1 General information of study subjects.

Variable	Category	Number	Percentage (%) / mean $\pm$ SD
Education level	Vocational high school	324	32.6
	Junior college	342	34.4
	Vocational university	326	33
Gender	Male	495	49.9
	Female	497	50.1
Age	-	-	20.4 $\pm$ 2.3
Major category	Engineering	230	23.2
	Medicine	186	18.8
	Humanities	206	20.8
	Business	190	19.2
	Arts	175	17.6
	Others	5	0.5
Daily residential area	Urban districts	442	45
	Suburban districts	550	55

n = 992.

TABLE 2 Correlation analysis between exercise self-efficacy, exercise behavior intention, and physical activity level.

Variables	Physical activity level	Exercise self-efficacy	Exercise behavioral intention
Physical activity level	1	0.322*	0.346*
Exercise self-efficacy	0.322*	1	0.612*
Exercise behavioral intention	0.346*	0.612*	1

* $P < 0.001$; all variables were standardized, $n = 992$.

are shown in Table 2. According to conventional benchmarks (small: $r = 0.10$; medium: $r = 0.30$; large: $r = 0.50$), the correlation between exercise self-efficacy and behavioral intention was large ($r = 0.612$), whereas the correlations of these two variables with physical activity were of medium magnitude ($r = 0.322$ and 0.346 , respectively). In the full mediation model, the squared multiple correlation for physical activity ($R^2 = 0.152$) corresponds to a Cohen's f^2 of approximately 0.18, indicating a medium effect size for the joint prediction of physical activity.

3.4 Mediating role of exercise behavioral intention

Exercise behavioral intention was examined as a mediator in the relationship between exercise self-efficacy and physical activity level using path analysis in AMOS. Results indicated that exercise self-efficacy was a significant positive predictor of exercise behavioral intention ($\beta = 0.609$, $p < 0.001$). When both exercise self-efficacy and exercise behavioral intention were included as predictors of physical activity level, each variable remained a significant positive predictor ($\beta = 0.148$ for self-efficacy, $p < 0.001$; $\beta = 0.201$ for behavioral intention, $p < 0.001$; see Table 3).

Mediation analysis based on 5,000 bootstrap resamples revealed a significant direct effect of exercise self-efficacy on physical activity level ($\beta = 0.148$, 95% CI: 0.084 to 0.211, $p < 0.001$). The indirect effect through exercise behavioral intention was also significant ($\beta = 0.122$, 95% CI: 0.085 to 0.163, $p < 0.001$), indicating partial mediation. The direct and indirect effects accounted for 54.81% and 45.19% of the total effect, respectively (Table 4).

4 Discussion

4.1 Theoretical implications of main findings

This study confirms that exercise behavioral intention partially mediates the relationship between exercise self-efficacy and physical activity levels among vocational education students in Shanghai,

TABLE 3 Standardized regression coefficients from AMOS path analysis ($n = 992$).

Variables	Exercise behavior intention (Model 1)	Physical activity levels (Model 2)
	β	β
Exercise self-efficacy	0.609*	0.148*
Exercise behavior intention	—	0.201*
Education level	0.045*	0.047*
Gender	0.026	0.006
Age	−0.001	−0.002
R^2	0.376	0.151
Adjusted R^2	0.373	0.145

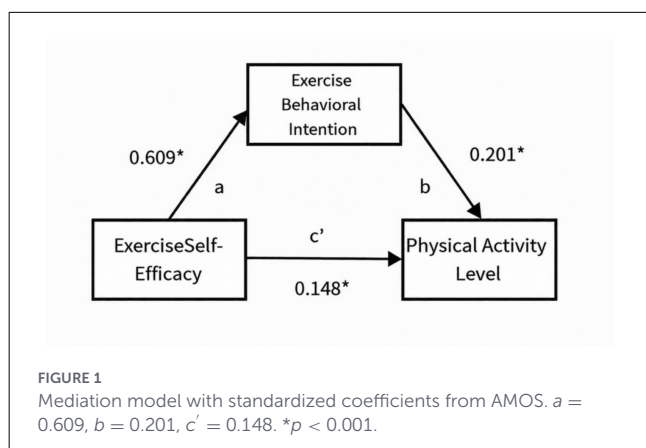
* $P < 0.001$; In Model 1, the dependent variable was exercise intention, with exercise self-efficacy and demographic control variables as predictors. In Model 2, the dependent variable was physical activity level, with exercise self-efficacy and demographic control variables as predictors. All variables were standardized by Z-score before being entered into the regression equations; “—” indicates that the variable was not included in the corresponding regression model; β values are retained to three decimal places; R^2 and adjusted R^2 are retained to three decimal places.

TABLE 4 Mediation analysis results from AMOS ($n = 992$).

Effect type	Effect size	SE	95% CI		Relative mediation effect (%)
			LCL	UCL	
Total effect	0.270*	0.026	0.219	0.319	—
Direct effect	0.148*	0.033	0.084	0.211	54.81
Mediated effect	0.122*	0.020	0.085	0.163	45.19

All core variables in the model were standardized using Z-score transformation.* $P < 0.001$; Bootstrap = 5,000, 95% CI.

with the mediating effect accounting for 45.19% of the total variance. The mediation proportion of 45.19% indicates that nearly half of the effect of exercise self-efficacy on physical activity operates through behavioral intention. In behavioral intervention research, mediated effects of around 30% are often considered practically meaningful (7), suggesting that intention formation constitutes a central pathway among vocational students rather than a minor one. Nonetheless, the remaining 54.81% direct effect indicates that self-efficacy also influences physical activity via other unmeasured pathways, such as automatic behavioral regulation or environmental facilitation. This finding contributes to the theoretical integration of Bandura's Social Cognitive Theory and Ajzen's Theory of Planned Behavior within a previously underexplored population (22). Specifically, the results empirically support the process in which efficacy beliefs contribute to the formation of exercise intentions, which in turn are associated with the execution of physical activity. This distinction is



particularly salient for vocational education students, whose academic and daily schedules are predominantly oriented toward professional skill acquisition, often at the expense of physical activity. The theoretical pathway illustrated in Figure 1 describes the hypothesized mediation mechanism of this study. Exercise self-efficacy not only directly predicts physical activity but also indirectly influences it by enhancing exercise behavioral intention. This mediation mechanism extends current knowledge by showing that behavioral intention functions as a key cognitive bridge linking confidence to action even among populations facing substantial external constraints. The demanding academic and professional training schedules characteristic of vocational education may contribute to lower levels of physical activity. Accordingly, interventions aimed at enhancing the pathway from self-efficacy to intention and ultimately to behavior are especially important for this population.

Theoretically, our findings bridge Social Cognitive Theory and the Theory of Planned Behavior by specifying a mechanism in which self-efficacy influences physical activity partly through behavioral intention. However, this integration is not without tension. TPB conceptualizes perceived behavioral control as a direct predictor of both intention and behavior, which conceptually overlaps with self-efficacy. In our model, self-efficacy was operationalized as task specific confidence, yet PBC was not measured separately, leaving it unclear whether self-efficacy exerts additional indirect effects beyond PBC. Future research should use confirmatory factor analysis to disentangle these constructs in vocational student samples.

4.2 Comparison with previous research

The direct effect of self-efficacy on physical activity in our vocational student sample ($\beta = 0.148$) was lower than the direct effect of self-efficacy on behavior reported by Hong and Chung (10) among general university students ($\beta = 0.179$ in their main model). This discrepancy may reflect differences in populations and theoretical pathways. First, vocational students face greater structural barriers (e.g., mandatory internships, shift schedules) that hinder the direct translation

of confidence into action. Second, prior university samples typically had higher baseline physical activity levels, potentially inflating the self-efficacy–behavior association. Third, our study included rigorous covariate adjustments (gender, age, education level), whereas some previous studies did not control for these confounders.

Importantly, the mediating proportion in our study (45.19%) exceeds the 30%–40% range often reported in college student samples, suggesting that the self-efficacy $\rightarrow$ intention $\rightarrow$ behavior pathway may not be uniform across educational contexts. Specifically, when external supports are limited, as is common in vocational settings, individuals may rely more heavily on conscious intentions to bridge the association between believing and doing. This interpretation aligns with Hou et al. (11), who found that self-efficacy moderates the intention behavior gap primarily under high barrier conditions. Future research should examine whether the mediating effect is moderated by contextual factors such as campus sports culture or internship intensity.

The heightened mediating role of intention in vocational students can be understood in light of their unique contextual characteristics. As noted in the introduction, recent evidence from Shanghai vocational schools indicates a smartphone addiction prevalence of 70.5% and musculoskeletal disorder prevalence of 38.0% (21). Such conditions may directly undermine self-efficacy (e.g., “I cannot exercise because of back pain”) and disrupt automatic behavioral routines, increasing reliance on deliberate intentions. Additionally, vocational curricula often include 6–8 months of off campus internships, during which campus sports facilities are largely inaccessible (19). Under these fragmented schedules, forming a strong behavioral intention becomes a prerequisite rather than a supplement for engaging in physical activity. Consequently, the intention-mediated pathway is not merely present but functionally essential in this population.

4.3 Practical implications and intervention strategies

Based on the effect sizes and sample characteristics observed in this study, several evidence guided intervention strategies are recommended for vocational education students. First, given that behavioral intention mediates 45.19% of the total effect of self-efficacy on physical activity (indirect effect $\beta = 0.122$), interventions should prioritize intention formation alongside confidence building activities. Although the direct effect of self-efficacy remains substantial ($\beta = 0.148$), targeting intention ensures a more complete translation of confidence into behavior. Second, to address the intention behavior gap, interventions should consider context specific barriers, such as fragmented schedules, limited access to facilities for the 55% of students residing in suburban districts, high smartphone usage (70.5%), and musculoskeletal complaints (38.0%) (21). Strategies may include app, based walking challenges for students with high smartphone use and low impact or seated exercises for those with physical limitations. Third, interventions should be tailored to educational level and

gender. Younger vocational high school students may benefit from structured, peer led sessions, while vocational university students may prefer flexible, self paced plans compatible with internship schedules. Single gender sessions could also be feasible, particularly to support female students who may report lower self-efficacy. Fourth, physical activity should be embedded into existing institutional routines to minimize additional time demands. Brief micro interventions lasting around 5 min, such as using stair only pathways, incorporating standing breaks during theory classes, or engaging in short activities during class transitions and internship shift changes, can promote student engagement without adding to their workload. This approach is particularly important given the intensive professional skill requirements of vocational curricula (19). Annual screening using the IPAQ-SF could identify students with insufficient activity (<600 MET-minutes/week), who may then receive targeted interventions, with accelerometer based assessments for those with very low activity levels to personalize programs. Collectively, these strategies integrate psychological and environmental considerations to enhance the likelihood that intentions translate into actual physical activity.

4.4 Limitations

This study has several limitations. First, the cross sectional design limits the ability to draw causal inferences. Second, physical activity was assessed via self report, which may be subject to social desirability bias. Third, the sample was restricted to vocational institutions in Shanghai, potentially limiting the generalizability of the findings to other regions or less rich resource settings. Fourth, the model included only a single mediator, this decision was guided by the Theory of Planned Behavior, which identifies behavioral intention as the most proximal antecedent of physical activity. The primary aim of the study was to examine this key pathway in an understudied population, leaving other potentially relevant variables, such as social support, planning, and environmental accessibility unexamined. Future research should expand to more diverse geographic regions and institutional types, and incorporate additional mediators to provide a more comprehensive understanding of the mechanisms linking self-efficacy to physical activity. Fifth, as noted in the methods Section 2.2.2, two items of the exercise behavioral intention scale conceptually overlap with the subjective norms component of the Theory of Planned Behavior. Although confirmatory factor analysis supported a unidimensional factor structure for the five items, this overlap may have inflated the observed association between behavioral intention and physical activity, because subjective norms can directly influence behavior independent of intention. Consequently, the mediating effect attributed to behavioral intention might partly reflect normative influences rather than pure motivational intention. Future research should incorporate these constructs as parallel or sequential mediators to provide a more comprehensive understanding of the mechanisms linking self-efficacy to physical activity in vocational students. Future research should also expand to more diverse geographic regions and institutional types.

5 Conclusion

Exercise self-efficacy is associated with physical activity both directly and indirectly via behavioral intention in vocational students. Interventions enhancing self-efficacy and behavioral intention may support higher activity levels, though longitudinal studies are needed to confirm directionality.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by the Ethics Committee of Tongji University (Approval No. 2020tjdx006), and was performed in accordance with ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. Written informed consent to participate in this study was provided by the participants. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

ZJ: Writing – original draft, Formal analysis. RZ: Methodology, Investigation, Data curation, Writing – review & editing. ZX: Writing – review & editing, Formal analysis. XW: Supervision, Writing – review & editing. LW: Formal analysis, Writing – review & editing, Supervision.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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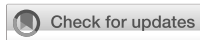
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References

- Yu B, Li R, Zhang S, Mao P, Xu C, Shi J, et al. Constraints, mechanisms, and strategies for industry-education integration in vocational education: an empirical study. *PLoS One*. (2025) 20:e0339158. doi: 10.1371/journal.pone.0339158
- Gao G, Niu L, Tan W, Zhang P, Pan X, Jin S, et al. Study on establishing of multilevel and integrated system of vocational education. In: Wang K, Lombardo D, editors. *6th annual international workshop on materials science and engineering. Journal of Physics Conference Series*. Jinan, Peoples R China: IoP Publishing Ltd (2020). doi: 10.1088/1742-6596/1622/1/012094
- Lim HJ. Relationship between body composition and physical fitness according to physical activity levels using international physical activity questionnaires (IPAQ) in women university students. *Korean Soc. Sports Sci.* (2008) 17:1185–92.
- Deng J, Liu Y, Chen R, Wang Y. The relationship between physical activity and life satisfaction among university students in China: the mediating role of self-efficacy and resilience. *Behav Sci.* (2023) 13:889. doi: 10.3390/bs13110889
- McAuley E, Blissmer B. Self-efficacy determinants and consequences of physical activity. *Exerc Sport Sci Rev.* (2000) 28:85–8.
- Jensen CT, Heinze C, Andersen PK, Bauman A, Klinker CD. Mental health and physical activity in vocational education and training schools students: a population-based survey. *Eur J Public Health.* (2022) 32:233–8. doi: 10.1093/eurpub/ckab202
- Du Z, Zhang X. Analysis of the mediating effects of self-efficacy and self-control between physical activity and Internet addiction among Chinese college students. *Front Psychol.* (2022) 13:1002830. doi: 10.3389/fpsyg.2022.1002830
- Lee J, Kim Y. Adolescents' internet addiction and its association with physical activity intention and self-efficacy. *Int J Sport Psychol.* (2024) 55:297–311. doi: 10.7352/IJSP.2024.55.297
- Rise J, Thompson M, Verplanken B. Measuring implementation intentions in the context of the theory of planned behavior. *Scand J Psychol.* (2003) 44:87–95. doi: 10.1111/1467-9450.00325
- Hong H, Chung W. Integrating health consciousness, self-efficacy, and habituation into the attitude-intention-behavior relationship for physical activity in college students. *Psychol Health Med.* (2022) 27:965–75. doi: 10.1080/13548506.2020.1822533
- Hou B, Li L, Zheng L, Qi Y, Zhou S. Linking exercise intention to exercise action: the moderating role of self-efficacy. *Front Psychol.* (2022) 13:921285. doi: 10.3389/fpsyg.2022.921285
- Scholz U, Schuz B, Ziegelmann JP, Lippke S, Schwarzer R. Beyond behavioural intentions: planning mediates between intentions and physical activity. *Br J Health Psychol.* (2008) 13:479–94. doi: 10.1348/135910707X216062
- Zhou X, Zhang M, Chen L, Li B, Xu J. The effect of peer relationships on college students' behavioral intentions to be physically active: the chain-mediated role of social support and exercise self-efficacy. *PLoS One.* (2025) 20:e0320845. doi: 10.1371/journal.pone.0320845
- Bao H. Association between peer relationships and exercise self-efficacy among college students: the mediating role of physical activity commitment. *Front Psychol.* (2025) 16:1533097. doi: 10.3389/fpsyg.2025.1533097
- Xu Z, Xu J, Liu T, Gu Z, Hu D. The pathway of social support in enhancing adolescents' physical fitness: the mediating roles of physical activity and self-efficacy. *PLoS One.* (2024) 19:e0308864. doi: 10.1371/journal.pone.0308864
- Gao X, Cheng M, Zhang R. The relationship between physical activity and the health of primary and secondary school teachers: the chain mediating effects of body image and self-efficacy. *BMC Public Health.* (2024) 24:562. doi: 10.1186/s12889-024-17914-2
- Jiang C, Wang K, Qin H. Physical exercise and children's resilience: mediating roles of self-efficacy and emotional intelligence. *Front Psychol.* (2025) 16:1491262. doi: 10.3389/fpsyg.2025.1491262
- Gao H, Li X, Zi Y, Mu X, Fu M, Mo T, et al. Reliability and validity of common subjective instruments in assessing physical activity and sedentary behaviour in chinese college students. *Int J Environ Res Public Health.* (2022) 19:8379. doi: 10.3390/ijerph19148379
- Wang P, Jiang X. The teaching reform of China's higher vocational education based on core vocational ability training. In: Li P, editor. *Proceedings of the 2013 conference on education technology and management science (ICETMS 2013). Advances in Intelligent Systems Research*. Nanjing, Peoples R China: Atlantis Press (2013). p. 1213–1215. doi: 10.2991/icetms.2013.195
- Hu B, Liu J. The practical approach of social identity in Chinese vocational undergraduate education. *J Chin Humanit.* (2023) 83:343–364. doi: 10.35955/JCH.2023.04.83.343
- Zhai R, Wu X, Chen T, Wang L. Gender differences in the prevalence and association between smartphone addiction and musculoskeletal disorders among vocational school students in Shanghai. *Prev Med Rep.* (2025) 60:103295. doi: 10.1016/j.pmedr.2025.103295
- Ajzen I. The theory of planned behavior. *Organ Behav Hum Decis Process.* (1991) 50:179–211. doi: 10.1016/0749-5978(91)90020-T
- Ajzen I. The theory of planned behaviour: reactions and reflections. *Psychol Health.* (2011) 26:1113–27. doi: 10.1080/08870446.2011.613995
- Bandura A. Self-efficacy: toward a unifying theory of behavioral change. *Psychol Rev.* (1977) 84:191–215. doi: 10.1037/0033-295X.84.2.191
- Bandura A. *Self Efficacy: The Exercise of Control*. New York, NY: W H Freeman. (1997).
- Lippke S, Wiedemann AU, Ziegelmann JP, Reuter T, Schwarzer R. Self-efficacy moderates the mediation of intentions into behavior via plans. *Am J Health Behav.* (2009) 33:521–9. doi: 10.5993/AJHB.33.5.5
- Spink KS, Nickel D. Self-regulatory efficacy as a mediator between attributions and intention for health-related physical activity. *J Health Psychol.* (2010) 15:75–84. doi: 10.1177/1359105309342308
- Resnick B, Jenkins LS. Testing the reliability and validity of the self-efficacy for exercise scale. *Nurs Res.* (2000) 49:154–9. doi: 10.1097/00006199-200005000-00007
- Lee L-L, Perng S-J, Ho C-C, Hsu H-M, Lau S-C, Arthur A. A preliminary reliability and validity study of the Chinese version of the self-efficacy for exercise scale for older adults. *Int J Nurs Stud.* (2009) 46:230–8. doi: 10.1016/j.ijnurstu.2008.09.003
- Fan M, Lyu J, He P. [Chinese guidelines for data processing and analysis concerning the International Physical Activity Questionnaire]. *Zhonghua Liu Xing Bing Xue Za Zhi.* (2014) 35:961–4.
- Howard MC, Boudreaux M, Oglesby M. Can Harman's single-factor test reliably distinguish between research designs? Not in published management studies. *Eur J Work Organ Psychol.* (2024) 33:790–804. doi: 10.1080/1359432X.2024.2393462



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The association of mindfulness on psychological distress among Chinese university students: a culturally contextualized investigation

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Introduction: Mindfulness training benefits psychological well-being, but its mechanisms in culturally specific contexts (e.g., Chinese university students facing academic pressure and family expectations) remain poorly understood.

Methods: Cross-sectional stratified random sampling of 432 undergraduates from four Chinese universities. Standardized scales measured mindfulness, psychological distress, resilience, emotion regulation (cognitive reappraisal, expressive suppression), social support (instrumental, emotional, informational), academic pressure, and family expectations. Analysis used hierarchical regression, SEM, and moderated mediation.

Results: Mindfulness negatively correlated with psychological distress ($\beta = -0.34$, $p < 0.001$). This correlation was moderated by academic pressure (weaker under high pressure) and family expectations (stronger under high expectation). Resilience and cognitive reappraisal showed synergistic mediation (total $\beta = 0.71$). Effects varied by gender and academic discipline.

Discussion: The mindfulness-distress relationship is culturally contingent. Interventions should be locally tailored, combining personal training with environmental support.

KEYWORDS

cognitive reappraisal, expressive suppression, mindfulness, psychological distress, resilience, social support

1 Introduction

Mental health has become a critical global public health issue. As a fundamental element of well-being, mental health represents an individual's dynamic balance across cognitive, emotional, and behavioral aspects (1). Emerging adulthood, which is a high risk period for psychological disorders (2), presents distinct challenges for university students as they navigate academic transitions and changing societal roles. In China, recent research emphasizes the gravity and cultural distinctiveness of these challenges. A meta-analysis published in BMC Psychology in 2025 reported that the combined prevalence rate of depression among Chinese university students was 34.70%, suggesting a high probability of psychological distress within this group (3). The 2023 *Blue Book of Chinese University Students' Mental Health* surveyed 46,582 undergraduates from 127 institutions, revealing a 31.2% depression rate (4), a 6.5% increase compared to the 2019 baseline data (5). Academic pressure and intergenerational

conflicts stemming from family expectations were identified as key influencing factors: students who studied for over 10 h per day had a 39.7% depression rate, while those experiencing academic conflicts related to family faced a 187% higher risk of depression (6). China's depression rate (31.2%) is higher than those in Southeast Asia (Philippines: 27.1%, Malaysia: 25.9%) (7) and the WHO global average (23.8%) (8). This disparity is likely attributable to structural stressors in China's education system, such as grade competition and the pressure of postgraduate admissions. Culturally, Chinese society is characterized by collectivist values that prioritize group harmony, family reputation, and social conformity over individual autonomy (9). In this cultural context, individuals define themselves in relation to significant others, including parents, extended family, and the broader community, rather than as independent entities (10). Consequently, academic achievement in China holds moral and relational significance: academic success brings honor to the family, while failure may be regarded as a source of shame not only for the individual but also for the entire family lineage. This phenomenon, commonly referred to as “face” (*mianzi*) in Chinese cultural discourse, reflects an individual's social status and the respect accorded by others, and it exacerbates the pressure to meet intergenerational expectations (11, 12). Therefore, academic pressure and family expectations in China are not merely individual stress factors but culturally ingrained demands with collective implications. Understanding how mindfulness functions under such culturally specific circumstances requires transcending universal assumptions and examining how collectivist norms moderate the transformation of mindfulness skills into psychological outcomes. These findings highlight the necessity for culturally informed intervention models to address systemic challenges. In the present study, we specifically focus on psychological distress, as measured by the SCL-90, rather than positive mental health, in order to capture the clinically relevant symptoms prevalent in this population.

Mindfulness, a practice that emphasizes present moment awareness and nonjudgmental acceptance (13), has been shown to be associated with the alleviation of depression and anxiety (14), in part through the reduction of rumination (15). Neuroscience research indicates that mindfulness enhances emotion regulation by modifying prefrontal limbic connectivity. For example, Tang et al. (16) discovered that mindfulness meditation leads to an increase in the thickness of the prefrontal cortex and suppresses the activity of the default mode network, thereby providing a neurobiological foundation for cognitive reappraisal. Hölzel et al. (17) further identified dual mechanisms: “top down” cognitive control (e.g., activation of the dorsolateral prefrontal cortex) and “bottom up” bodily awareness (e.g., enhanced function of the insula). These findings support the integrated pathways that connect mindfulness to psychological resilience and adaptive emotion regulation.

Although studies have confirmed that mindfulness is associated with reduced psychological distress through resilience (18) or cognitive reappraisal (19), three limitations still exist. Firstly, resilience and emotion regulation are frequently examined independently (20), disregarding their potential interactions. For instance, resilience may enhance the efficacy of reappraisal, while excessive expressive suppression may impede resilience. Secondly, social support is generally regarded as a unified construct, overlooking the distinct effects of instrumental, emotional, and informational support (21). Thirdly, few studies explore how academic and familial pressures in China restrict mindfulness interventions, which limits cross cultural applicability. Neuroimaging comparisons disclose cultural differences: Western practitioners rely more on prefrontal analytical processing, whereas

Eastern practitioners engage holistic default mode networks (22). Chen et al. (23) point out that collectivist values such as “face-saving” and family obligations may undermine nonjudgmental acceptance in mindfulness training, highlighting the crucial role of cultural context.

Rooted in the Conservation of Resources Theory (24) and Social Cognitive Theory (25), this study puts forward an individual and environment framework (Figure 1) to investigate the mechanisms of mindfulness. Four research questions direct the exploration: (1) Does mindfulness exert direct effects on psychological distress when cultural stressors are taken into account? (2) Do resilience and emotion regulation strategies serve as complementary or competing mediators? (3) How do different types of social support differentially moderate the pathways of mindfulness? (4) Do academic pressure and family expectations represent cultural boundary conditions for mindfulness interventions?

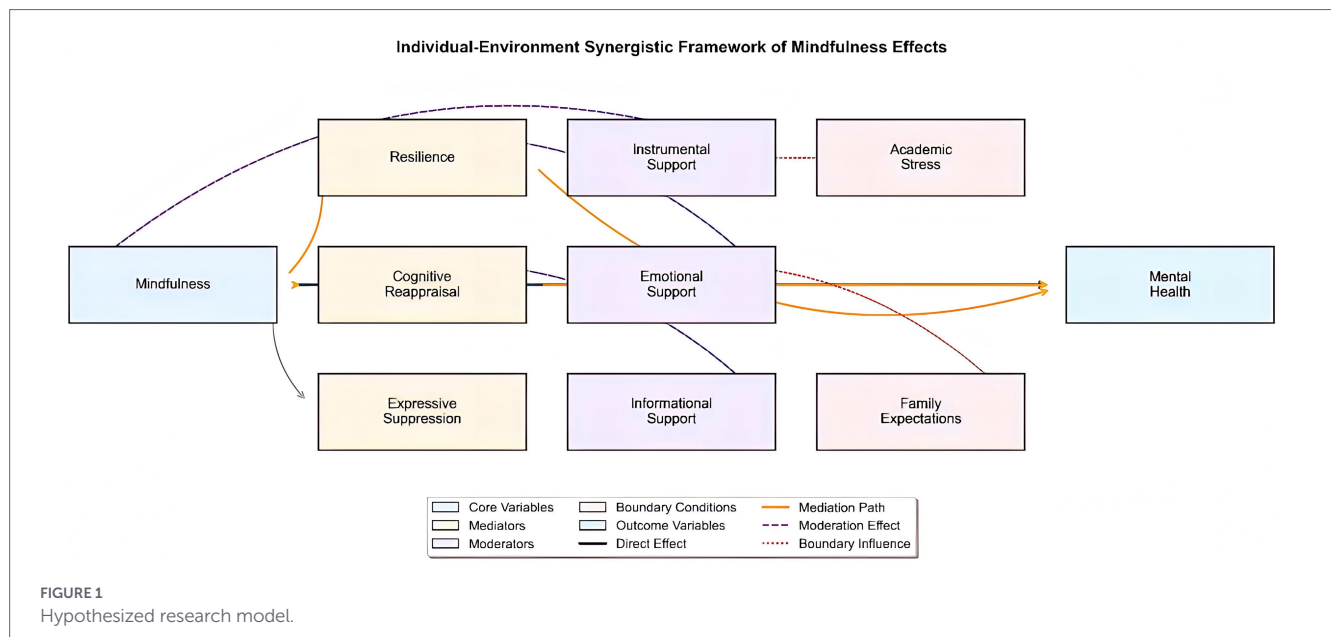
To establish a unified basis, this study employs the Conservation of Resources (COR) theory (24) as its overarching framework. The COR Theory posits that individuals endeavor to safeguard valuable resources; distress emerges when resources are lost or threatened. Mindfulness is a personal resource that aids in preventing depletion and promotes gain. Social support (instrumental, emotional, informational) offers external resources. Cultural stressors (academic pressure and family expectations) function as boundary conditions that either deplete or enhance the availability of resources.

The Social Cognitive Theory (25) complements this perspective: individuals with higher levels of mindfulness and support are more prone to manage stressors in an adaptive manner. The emotion regulation model (26) delineates the pathways: promoting reappraisal while reducing suppression. This framework facilitates the study of synergy (resilience and reappraisal) and competition (reappraisal and suppression) across different cultures.

Exploratory analysis of gender differences. Although this study is not primarily aimed at an investigation centered on gender, a substantial amount of literature on gender disparities in emotion regulation and social support [e.g., socioemotional selectivity theory (27)] suggests that the efficacy of certain pathways, especially the impact of emotional support on resilience, may vary across genders. Consequently, we examine whether the moderating function of emotional support differs between female and male students. These analyses are exploratory in essence, and the findings should be regarded as generating hypotheses rather than confirmatory. Prudent interpretation is particularly necessary for subgroup comparisons involving small effect sizes or confidence intervals that encompass values close to zero.

Current research reveals critical gaps. While Su et al. (28) established a link between mindfulness and reduced depression through resilience, they were unable to account for why some resilient individuals still encounter challenges in emotion regulation, suggesting the existence of unobserved mediating mechanisms. Liu et al. (29) identified cognitive reappraisal as a mediator but reported a lower explanatory power ($R^2 = 0.31$) compared to Western studies ($R^2 = 0.48$), indicating potential cultural moderators. Pan (30) discovered that instrumental support influences mindfulness adherence in Chinese students but did not explore its dynamic role among intervention outcomes.

This research puts forward seven hypotheses to fill these gaps: Hypothesis 1 challenges the universality of mindfulness effects by introducing academic and familial pressures as cultural moderators. Hypotheses 2 and 3 propose a synergistic resilience and reappraisal model while testing competing suppression effects. Hypotheses 4, 5 and 6 distinguish how instrumental, emotional, and informational support uniquely moderate mindfulness pathways. Hypothesis 7



establishes a hierarchical model in which academic and familial pressures secondarily moderate social support effects.

The framework presents methodological and practical advancements. Employing moderated mediation models with longitudinal and multi group analyses contributes to reducing bias stemming from reverse causality in cross-sectional studies. Practically, if Hypothesis 5 validates the gender specific benefits of emotion focused resilience pathways, targeted interventions may be developed. For instance, integrating time management tools (Hypothesis 4) for STEM students or combining cognitive reappraisal with family communication training (Hypothesis 6).

This study elucidates how mindfulness operates under different conditions by integrating stress buffering and resource gain theories. While previous research emphasizes individual resource accumulation (e.g., resilience), this study demonstrates that when environmental stressors surpass critical thresholds (Hypothesis 7), social support buffers may become ineffective, highlighting the necessity for systemic institutional reforms in addition to individual interventions.

This multi level model promotes theoretical progress by shifting the focus from addressing individual problems to enhancing the interaction between individuals and their environment. The findings will provide insights for China's mental health policies, especially in strengthening campus support systems and managing structural stressors.

2 Literature and hypothesis

2.1 Direct effects of mindfulness on psychological distress and cultural moderation

Mindfulness, a practice originating from Buddhist traditions and adapted by modern psychology, emphasizes nonjudgmental awareness of present moment experiences (13). Empirical research has demonstrated its effectiveness in alleviating psychological distress. For example, Hofmann et al. (14) discovered through meta-analyses that mindfulness training can reduce anxiety and depression while

enhancing life satisfaction. This effect may be attributed to the increased awareness of thoughts and emotions, which disrupts cycles of negative thinking and reduces rumination (15).

However, among Chinese university students, cultural factors uniquely influence the outcomes of mindfulness. Two prominent stressors in China's education system, namely academic pressure and familial expectations, moderate these effects.

The intense competition for grades and postgraduate placements (4) depletes psychological resources, limiting students' ability to apply mindfulness skills. Within the framework of the Conservation of Resources (COR) theory, chronic academic stress depletes mental reserves, thus diminishing the buffering effects of mindfulness (24).

Moderate family expectations can motivate achievement (31), which is in line with collectivist values such as "honoring ancestors." Such expectations may synergize with mindfulness by fostering adaptive psychological responses. For instance, family driven achievement goals could enhance the protective effects of mindfulness when they are aligned with personal growth.

Hypothesis 1

H1a: Mindfulness is negatively associated with psychological distress.

H1b: Academic pressure negatively moderates the association between mindfulness and psychological distress.

H1c: Family expectations positively moderate the association between mindfulness and psychological distress.

2.2 Mediating pathways: psychological resilience and emotion regulation

2.2.1 Complementary mediation: synergy between resilience and cognitive reappraisal

Psychological resilience, defined as the dynamic capacity to adapt under stress (32), emerges from interactions between personal

resources (e.g., self efficacy) and environmental support (24). Mindfulness enhances resilience by promoting present moment awareness, enabling individuals to derive growth from adversity (33). Resilient individuals can navigate challenges more effectively and recover more rapidly from setbacks.

Cognitive reappraisal reduces emotional arousal by reframing stressors (26). Resilience and reappraisal reinforce each other: resilient individuals reframe failures as challenges (20), and reappraisal conserves resources and strengthens resilience (19).

Mindfulness likely reduces psychological distress through complementary mediation: it enhances resilience, which promotes reappraisal, while reappraisal reciprocally strengthens resilience. This bidirectional relationship suggests a synergistic pathway.

Hypothesis 2

H2a: Psychological resilience partially mediates the association between mindfulness and psychological distress.

H2b: Cognitive reappraisal partially mediates the association between mindfulness and psychological distress.

H2c: Psychological resilience and cognitive reappraisal exhibit a synergistic mediating effect.

2.2.2 Competing mediation: cognitive reappraisal vs. expressive suppression

Expressive suppression, a maladaptive strategy involving the deliberate inhibition of emotional expression (26), impairs psychological distress. Chronic suppression depletes cognitive resources (34), weakens resilience (35), and correlates with depression in collectivist cultures where “face-saving” norms are prevalent (36).

In contrast, mindfulness promotes cognitive reappraisal. By enhancing emotional awareness, mindfulness enables early and objective evaluation of emotional triggers, facilitating reappraisal. Wang et al. (37) observed an 18% decline in suppression and a 34% increase in reappraisal after a 8 week mindfulness training, which was linked to functional changes in the anterior cingulate and dorsolateral prefrontal cortex (38).

Thus, mindfulness reduces psychological distress by prioritizing reappraisal over suppression. The role of suppression as a mediator is negligible, reflecting the strategic competition between regulation approaches.

Hypothesis 3

H3a: Cognitive reappraisal is a significant mediator of the association between mindfulness and psychological distress.

H3b: Expressive suppression is not a significant mediator of the association between mindfulness and psychological distress.

Unlike H2, which focuses on synergy among adaptive pathways, H3 examines the relative dominance of adaptive over maladaptive emotion regulation.

Together, H2 and H3 capture two distinct dimensions of mindfulness pathways: the complementary interplay of resilience and reappraisal, and the competitive advantage of reappraisal over suppression. These dimensions are theoretically compatible rather than contradictory.

2.3 Social support as a moderator

Social support, defined as the perceived care, respect, and sense of belonging within a social network (39), varies in type and function. Social support is commonly classified into three types: instrumental, emotional, and informational support (40), each with distinct moderating effects.

2.3.1 Instrumental support's direct reinforcement

Instrumental support (e.g., academic guidance, time management tools) reduces objective stressors (41). For high pressure groups such as STEM students, such support complements mindfulness by improving resource allocation. For example, study aids alleviate academic demands, freeing cognitive resources for mindfulness practice. Such support may enhance self efficacy, increasing confidence in applying mindfulness under stress (25).

Hypothesis 4

H4a: Instrumental support positively moderates the direct association between mindfulness and psychological distress.

H4b: The moderating effect of instrumental support is stronger among students with high academic pressure than among those with low academic pressure.

2.3.2 Emotional support's mediation enhancement

Emotional support, which provides psychological comfort and validation (21), strengthens resilience by fulfilling the need for belonging. Within the COR framework, emotional support can be regarded as an external resource that is particularly accessible to women. Consistent with the socioemotional selectivity theory (27), women tend to prioritize emotional bonds under stress, making this support particularly impactful for them. Mindfulness may heighten awareness of available emotional support, amplifying its resilience building effects.

Hypothesis 5

H5a: Emotional support enhances the mediating role of psychological resilience in the association between mindfulness and distress.

H5b: This enhancement effect is stronger among female students than among male students (exploratory hypothesis).

2.3.3 Informational support's cognitive reappraisal boost

Informational support (e.g., stress management skills, career guidance) reduces cognitive load and improves the efficacy of reappraisal (27). For students under high familial expectations, structured information helps them navigate social comparison pressures (31). Mindfulness may optimize the integration of such support, enhancing the mediating role of reappraisal.

Hypothesis 6

H6a: Informational support enhances the mediating role of cognitive reappraisal in the association between mindfulness and distress.

H6b: This enhancement effect is stronger among students with high family expectations than among those with low family expectations.

2.4 Boundary effects of cultural stressors

Academic pressure and familial expectations act as cultural boundary conditions. Excessive academic stress causes cognitive overload (42), rendering instrumental support ineffective even when available. Conversely, strong familial expectations may deepen emotional bonds (24), amplifying the benefits of emotional support. For example, family encouragement under high expectations can enhance resilience during stress.

Within this framework, academic pressure in China is amplified by the cultural belief that individual success or failure reflects on the entire family, a phenomenon known as “relational interdependence” (10). Conversely, family expectations, when perceived as supportive rather than controlling, may activate achievement motivation in a culturally congruent manner (43). Accordingly, it is hypothesized that the effect of mindfulness are moderated by these culturally specific stressors, with the directionality depending on whether the cultural demand depletes psychological resources (academic pressure) or aligns with culturally normative sources of meaning (family expectations).

Hypothesis 7

H7a: Academic pressure weakens the moderating benefit of instrumental support.

H7b: Family expectations strengthen the moderating benefit of emotional support on resilience.

This study proposes a dual dimensional mediation model. The first dimension (H2) pertains to the synergy among adaptive resources; it is hypothesized that psychological resilience and cognitive reappraisal reinforce each other, jointly transmitting the benefits of mindfulness. The second dimension (H3) concerns competition between adaptive (reappraisal) and maladaptive (expressive suppression) strategies, hypothesizing that mindfulness selectively activates reappraisal while deactivating suppression. These two dimensions are not mutually exclusive; rather, they reflect different layers of psychological functioning (resource accumulation vs. strategy selection). The overall model is therefore both complementary (among adaptive pathways) and competitive (across adaptive vs. maladaptive pathways).

3 Data, variables, and methods

3.1 Data

This cross-sectional study adopted stratified random sampling across four universities located in the eastern (Beijing, Shanghai), central (Wuhan), and western (Chengdu) regions of China. Sampling procedure. A stratified random sampling design was employed. Strata were defined based on two criteria: (1) geographical region (eastern, central, and western China) and (2) university type (comprehensive universities versus science engineering focused institutions). Within each of the six resulting strata (3 regions $\times$ 2 types), one university was

randomly selected from the pool of accredited universities within that stratum. After consolidating overlapping categories, this process resulted in a total of four universities (eastern region: one comprehensive and one science engineering university; central region: one comprehensive university; western region: one comprehensive university).

Within each selected university, student sampling was carried out as follows: First, academic year (freshman, sophomore, junior, senior) and major category (STEM, humanities, others) were employed as additional stratification variables to guarantee proportional representation. Second, 3–5 classes were randomly selected per stratum (i.e., per combination of year and major category) based on the class rosters provided by the university administration. All students present in the selected classes were invited to participate.

Data (Table 1) were collected via Wenjuanxing, an online survey platform, encompassing humanities, STEM, and other disciplines. From 504 initial responses, 432 valid samples were retained after excluding incomplete or inconsistent responses (85.7% validity rate). The sample size met the requirements of structural equation modeling (SEM; 30 parameters; 14.4:1 case to parameter ratio). Ethical approval was obtained, with informed consent and anonymity ensured.

3.2 Variables

3.2.1 Dependent variable

Psychological Distress: Measured using the SCL-90 scale (44), which consists of 90 items and assesses psychological symptoms across cognitive, emotional, and behavioral domains. Items are rated from 0 to 4 (0 = never; 4 = severe). Higher scores indicate greater psychological distress. The 9 factor structure demonstrated good fit: $\chi^2/df = 2.85$, RMSEA = 0.071, CFI = 0.952, TLI = 0.941. Excellent reliability ($\alpha = 0.971$).

TABLE 1 Demographic characteristics of the valid sample (N = 432).

Variable	Category	Frequency	Percentage (%)
Gender	Male	198	45.8
	Female	234	54.2
Age	18–20 years	167	38.7
	21–23 years	231	53.5
	≥ 24 years	34	7.8
Grade	Freshman	112	25.9
	Sophomore	135	31.3
	Junior	126	29.2
	Senior	59	13.6
Major	Liberal Arts	148	34.3
	STEM	227	52.5
	Other	57	13.2
Family economic status	Low-income	89	20.6
	Middle-income	287	66.4
	High-income	56	13.0
Total		432	100

3.2.2 Independent variable

Mindfulness: Assessed via the validated Chinese Five Facet Mindfulness Questionnaire (45). The scale, which consists of 39 items (5 factors: Observe, Describe, Act with Awareness, Non Judge, Non React), showed a strong fit ($\chi^2/df = 2.31$, RMSEA = 0.063, CFI = 0.981) and reliability ($\alpha = 0.892$ overall; 0.79 to 0.88 subscales). Responses range from 0 to 4 (higher scores indicate greater mindfulness).

3.2.3 Mediating variables

Psychological Resilience: Measured using a subscale consisting of 7 items from Zhang's Psychological Capital Scale (46). The single factor model showed excellent fit ($\chi^2/df = 1.76$, RMSEA = 0.048) and reliability ($\alpha = 0.823$). Reverse scored items were adjusted.

Emotion Regulation: Assessed via Wang's scale consisting of 14 items (47) with two subscales: cognitive reappraisal (adaptive) and expressive suppression (maladaptive). The two factor model fit well ($\chi^2/df = 2.47$, RMSEA = 0.068), with $\alpha = 0.847$ overall (reappraisal: 0.82; suppression: 0.79). Higher suppression scores indicate poorer regulation.

3.2.4 Moderating variables

Social Support: Barrera's Social Support Behaviors Scale (48), which consists of 40 items, was used to assess three types: emotional, instrumental, and informational. The three factor model demonstrated a good fit ($\chi^2/df = 2.58$, RMSEA = 0.074) and high reliability ($\alpha = 0.926$ overall; 0.85 to 0.91 subscales).

Academic Stress: Li and Mei's scale (49), which consists of 31 items, measured three domains: academic demands, personal conflicts, and negative life events. The three factor model fit well ($\chi^2/df = 2.39$, RMSEA = 0.072), with $\alpha = 0.908$ overall.

Family Expectations: A culturally adapted scale consisting of 12 items (31) was used to assess four domains: economic support, social status, academic/career achievement, and marital timelines (Table 2). The four factor model showed an acceptable fit ($\chi^2/df = 2.50$, RMSEA = 0.079) and reliability ($\alpha = 0.876$).

3.2.5 Control variables

Control variables included gender, age, academic year, major, and household income.

3.3 Methods

To conduct a systematic exploration of the multilevel mechanisms by which mindfulness is associated with the psychological distress of university students, this study adopted a comprehensive analytical approach.

Data preparation entailed strict quality control measures. Cronbach's alpha ($\alpha > 0.7$) and composite reliability (CR > 0.6) were employed to evaluate the scale reliability of the scale, while confirmatory factor analysis (CFA) was utilized to assess the structural validity (RMSEA < 0.08, CFI/TLI > 0.90). Common method bias was controlled through Harman's single factor test, guaranteeing that the first factor accounted for less than 40% of the variance. Missing data were handled using full information maximum likelihood (FIML)

estimation, and continuous variables were standardized (z scores) to eliminate scale differences.

Hypothesis testing employed multiple methodologies. For H1 (direct effects and cultural moderation), hierarchical regression analysis in SPSS (a three step model) was used to examine control variables, mindfulness, and interaction terms. Hypotheses H2 and H3 (mediating pathways) were tested using structural equation modeling (SEM) and bootstrapped mediation analysis (PROCESS Model 4) to compare the complementary or competing effects of resilience and emotion regulation. Hypotheses H4, H5, and H6 (social support moderation) utilized moderated mediation models (PROCESS Models 7/14) with simple slope analyses. H7 (cultural boundary effects) was evaluated through multi group SEM and three way interaction models (PROCESS Model 14) to assess cross group differences in social support pathways.

Software tools included SPSS 26.0 for descriptive statistics, reliability testing, and regression; Mplus 8.3 for SEM (50) and complex mediation moderation analyses (51); and AMOS 28.0 for CFA validation. Effect sizes were interpreted using standardized beta coefficients (β) for direct effects, bootstrapped confidence intervals (95% CI, 5,000 resamples) for indirect effects, and ΔR^2 with simple slopes for moderation. SEM models were considered acceptable when $\chi^2/df < 3$, RMSEA < 0.08, and CFI > 0.90. Robustness checks included sensitivity analyses with alternative psychological distress measures and subgroup comparisons by academic discipline and year.

The model was driven by theory (COR and social cognitive theory), not by data. To reduce overfitting, we: (a) specified all pathways *a priori*; (b) used bootstrapping (5,000 resamples) to obtain CIs corrected for bias; (c) assessed parsimony with AIC/BIC and $\Delta CFI/\Delta RMSEA$; (d) conducted multi group analyses only for justified subgroups ($n \geq 100$). We acknowledge cross-sectional limitations and recommend longitudinal replication.

This methodological framework ensures a rigorous examination of the dynamic mechanisms of mindfulness while balancing theoretical profundity and empirical precision, ultimately providing insights for culturally tailored intervention strategies for Chinese university students. Gender differences in the conditional indirect effects were examined as exploratory analyses using multi group structural equation modeling. No *a priori* directional hypotheses were formulated for gender beyond the exploratory scope. These results should not be overinterpreted as robust evidence without independent replication.

4 Results

4.1 Common method bias test

To evaluate potential common method bias, Harman's single factor test was conducted. The analysis discerned six factors with eigenvalues greater than 1. The largest factor accounted for 21.35% of the variance, which was below the critical threshold of 40% (52). Moreover, an unmeasured latent method factor (ULMC) approach was employed by incorporating a common method factor into the confirmatory factor analysis (CFA) model. The model fit did not improve notably ($\Delta CFI = 0.008$, $\Delta RMSEA = 0.006$), and all substantive factor loadings remained significant, suggesting that common method bias did not have a substantial impact on the results.

TABLE 2 Chinese college students' family expectations scale.

Dimension	Item	Response Options
Economic expectations	1. My family explicitly expects me to contribute financially to the household after employment.	Strongly disagree, Disagree, Neutral, Agree, Strongly agree
	2. I would feel guilty if I could not financially support my family.	Strongly disagree, Disagree, Neutral, Agree, Strongly agree
	3. My family expects me to use my income to improve their living conditions (e.g., purchasing a house, covering medical expenses).	Strongly disagree, Disagree, Neutral, Agree, Strongly agree
Social expectations	4. My family frequently compares my achievements with those of relatives' children.	Strongly disagree, Disagree, Neutral, Agree, Strongly agree
	5. If my career has low social status, my family would feel it "loses face."	Strongly disagree, Disagree, Neutral, Agree, Strongly agree
	6. My family monitors whether my social media image aligns with the "ideal child" persona.	Strongly disagree, Disagree, Neutral, Agree, Strongly agree
Academic and career expectations	7. My parents have set specific educational goals for me (e.g., obtaining a master's/doctoral degree).	Strongly disagree, Disagree, Neutral, Agree, Strongly agree
	8. My family opposes me choosing interest-driven but financially unstable careers.	Strongly disagree, Disagree, Neutral, Agree, Strongly agree
	9. My family expects me to work in large internet companies or state-owned enterprises (SOEs).	Strongly disagree, Disagree, Neutral, Agree, Strongly agree
Marital expectations	10. My family believes I must marry before a certain age (e.g., 30 years old).	Strongly disagree, Disagree, Neutral, Agree, Strongly agree
	11. My family interferes with my criteria for choosing a partner (e.g., education level, household registration, income).	Strongly disagree, Disagree, Neutral, Agree, Strongly agree
	12. Remaining unmarried would be seen as shirking family responsibilities.	Strongly disagree, Disagree, Neutral, Agree, Strongly agree

Therefore, common method bias is unlikely to confound the reported associations.

4.2 Direct effects and moderating mechanisms

Hierarchical regression analyses Table 3 that mindfulness was a significant correlate of psychological distress. After controlling for gender ($\beta = 0.07$), major ($\beta = -0.04$), academic year ($\beta = 0.02$), and socioeconomic status ($\beta = -0.01$) in Step 1 ($R^2 = 0.03$), mindfulness showed a strong negative association with psychological distress in Step 2 ($\beta = -0.34$, $p < 0.001$), indicating that higher levels of mindfulness are associated with lower psychological distress. According to Cohen's conventions, this effect size is medium to large (53) and is consistent with the meta-analytic findings of Hofmann et al. (24). The model's explanatory power increased by 12% ($\Delta R^2 = 0.12$, $p < 0.001$), suggesting that mindfulness is an independent protective correlate.

Interaction terms increased explanatory power by 4% (total $R^2 = 0.19$). Academic stress was associated with a weaker mindfulness-distress association ($\beta = -0.18$, $p = 0.02$; Figure 2): high stress group showed marginal benefits ($\beta = -0.15$, $p = 0.08$) vs. low stress ($\beta = -0.47$, $p < 0.001$). Family expectations were associated with a stronger association ($\beta = 0.12$, $p = 0.006$): high expectation group showed stronger improvements ($\beta = -0.43$ vs. -0.19).

In accordance with Cohen's (53) guidelines for standardized regression coefficients in psychological research, the direct association

between mindfulness and psychological distress ($\beta = -0.31$) can be regarded as a medium to large effect. The incremental variance explained by mindfulness ($\Delta R^2 = 0.12$) suggests that mindfulness accounts for approximately 12% of the variance in distress beyond demographic controls, which is comparable to the effect sizes reported in meta-analyses of mindfulness interventions (14) (average $\Delta R^2 = 0.09$ to 0.15). The interaction effects ($\Delta R^2 = 0.04$ for cultural moderators) are small yet meaningful, as moderation effects in field studies typically explain 1 to 5% of additional variance (54).

In conclusion, mindfulness was strongly associated with psychological distress ($\beta = -0.31$, $p < 0.001$), but these associations were contingent upon cultural stressors. Academic stress was associated with weaker efficacy, while family expectations were associated with stronger benefits, providing support for Hypotheses H1a, H1b, and H1c. These findings emphasize that the protective association of mindfulness varies according to context, being shaped by culturally specific pressures. This offers crucial insights for customizing mindfulness interventions to cultural contexts.

4.3 Mediation analysis

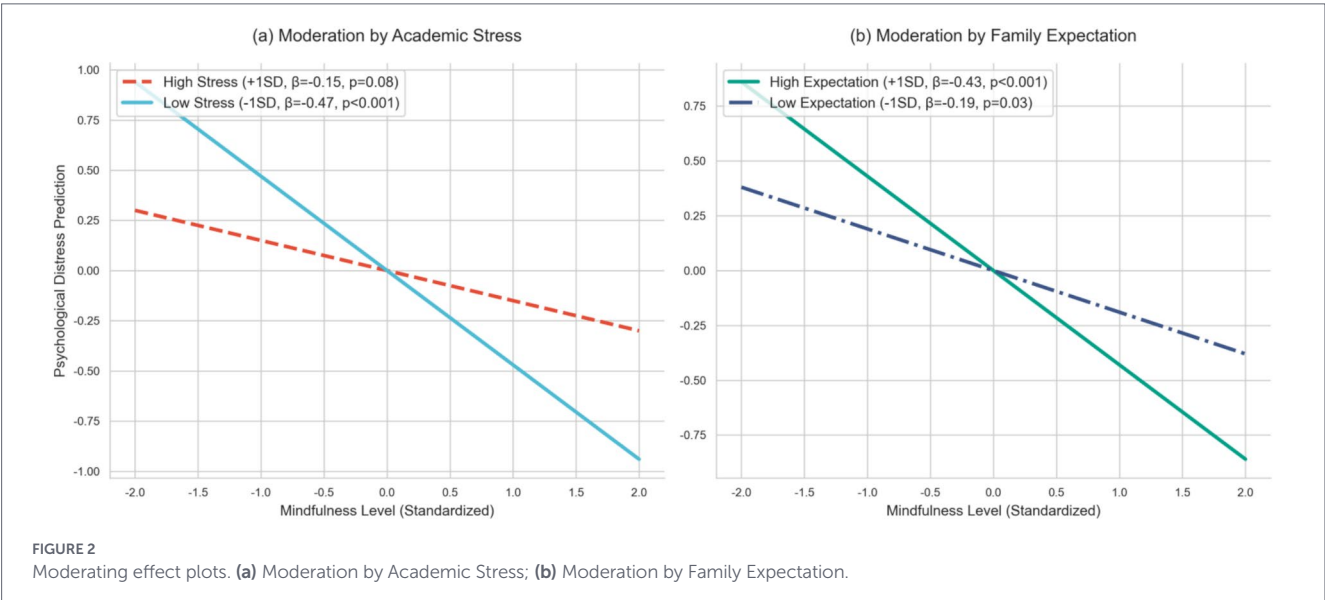
4.3.1 Synergistic mediation effects

The structural equation model (Figure 3) demonstrated excellent fit (CFI = 0.96, RMSEA = 0.04), uncovering two distinct pathways linking mindfulness to psychological distress improvements. Key findings from Table 4 include:

TABLE 3 Results of hierarchical regression models (direct effect of mindfulness on psychological distress and moderating effects).

Variable	Step 1 (β)	Step 2 (β)	Step 3 (β)	SE	* p^*
Control variables					
Gender	0.08	0.07	0.06	0.04	0.12
Major	−0.05	−0.04	−0.03	0.03	0.25
Grade level	0.03	0.02	0.01	0.02	0.45
Family economic status	−0.02	−0.01	−0.01	0.03	0.65
Independent variable					
Mindfulness	–	−0.34***	−0.31***	0.05	<0.001
Interaction terms					
Mindfulness $\times$ Academic Stress	–	–	−0.18*	0.07	0.02
Mindfulness $\times$ Family Expectations	–	–	0.12**	0.04	0.006
Model statistics					
R^2	0.03	0.15	0.19	–	–
ΔR^2	–	0.12***	0.04**	–	–

β values represent standardized regression coefficients; SE = standard error; * p^* values indicate significance levels (* $p^* < 0.05$, ** $p^* < 0.01$, *** $p^* < 0.001$). Step 1 includes only control variables; Step 2 adds the main effect of mindfulness; Step 3 adds interaction terms.



Resilience Pathway: Mindfulness was positively associated with psychological resilience ($\beta = 0.58, p < 0.001$), and resilience, in turn, was negatively associated with psychological distress ($\beta = -0.32, p < 0.01$). The indirect effect of mindfulness on distress through resilience was significant ($\beta = -0.29, 95\% \text{ CI } [-0.35, -0.15], p = 0.001$), supporting H2a. This suggests that approximately 29% of the total association between mindfulness and distress is explained by resilience.

Cognitive Reappraisal Pathway: Mindfulness was substantially positively associated with cognitive reappraisal ($\beta = 0.63, *p^* < 0.001$), which in turn was associated with lower psychological distress ($\beta = -0.45, *p^* < 0.001$) and a larger indirect effect ($\beta = -0.42, 95\% \text{ CI } [-0.48, -0.36], *p^* < 0.001$).

The combined effect of both pathways significantly improved model fit ($\Delta R^2 = 0.07, *p^* = 0.003$), accounting for 7% additional variance compared to single mediator models. While cognitive reappraisal demonstrated a stronger individual effect ($\beta = 0.42$) than resilience ($\beta = 0.29$), their synergy highlights a critical pathway: mindfulness is

associated with lower psychological distress through both resilience and cognitive reappraisal. This dual pathway interaction supports Hypotheses H2a, H2b, and H2c, challenging conventional single mediator frameworks and advancing our understanding of mindfulness as a multidimensional intervention.

4.3.2 Competitive mediation analysis

The mediation analysis (Table 5) revealed strategy specific effects of mindfulness on psychological distress. Cognitive reappraisal accounted for 68.8% of the total indirect effect ($\beta = -0.44, 95\% \text{ CI } [-0.52, -0.36], *p^* < 0.001$), suggesting it is a primary mechanism underlying the association between mindfulness and lower psychological distress. In contrast, expressive suppression showed no significant mediation ($\beta = -0.12, 95\% \text{ CI } [-0.03, 0.02], *p^* = 0.34$), with its confidence interval spanning zero, indicating it does not meaningfully contribute to mindfulness' protective effects.

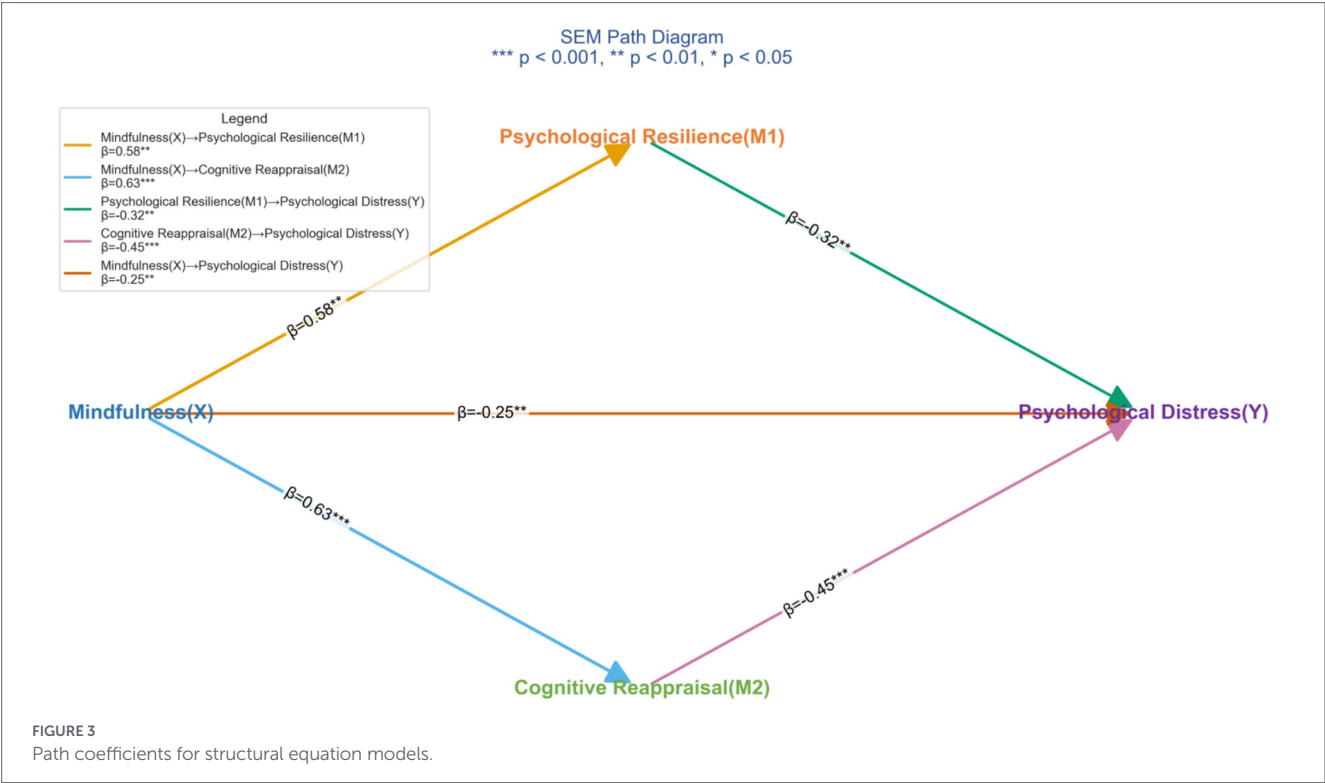


TABLE 4 Decomposition of mediation effects.

Mediation path	Indirect effect β	95% CI lower bound	95% CI upper bound	* p^*
Mindfulness → Psychological Resilience → Psychological Distress	−0.29	−0.35	−0.15	0.001
Mindfulness → Cognitive Reappraisal → Psychological Distress	−0.42	−0.48	−0.36	<0.001

Indirect effects were estimated using the Bootstrap method (5,000 resamples). A significant effect is indicated if the 95% confidence interval does not include 0. The combined effect was tested via the interaction term ΔR^2 . The total explanatory power of the model increased by 7% (* $p^* = 0.003$).

TABLE 5 Mediation effect decomposition table.

Effect type	Path	β -value	95% CI lower	95% CI upper	* p^*
Direct	Mindfulness → Psychological Distress	−0.25	−0.32	−0.18	0.001
Indirect	Mindfulness → Cognitive Reappraisal → Psychological Distress	−0.44	−0.52	−0.36	<0.001
	Mindfulness → Expressive Suppression → Psychological Distress	−0.12	−0.03	0.02	0.34
Total	Mindfulness → Psychological Distress	−0.69	−0.78	−0.60	<0.001
Difference	Cognitive Reappraisal vs. Expressive Suppression	0.56	0.12	1.00	0.02

Indirect effects estimated via Bootstrap method (5,000 resamples). Effect proportion = 68.8% (indirect effect via cognitive reappraisal/total effect). Path coefficient difference tests used Bootstrap CI method, where $\Delta\beta$ = absolute difference between coefficients.

Path coefficient comparisons (Figure 4) confirmed a significant disparity between the mediators ($\Delta\beta = 0.56$, * $p^* = 0.02$), demonstrating competitive dynamics between adaptive and maladaptive strategies. These results suggest that the association between mindfulness and lower psychological distress is explained by a stronger link with cognitive reappraisal (an adaptive strategy) while being associated with less

reliance on expressive suppression (a maladaptive approach). H3a and H3b are supported. Our findings corroborate the notion that mindfulness is associated with a stronger use of adaptive strategies (e.g., cognitive reappraisal) rather than simply reducing maladaptive ones (55–57). This provides empirical guidance for refining emotion regulation components in mindfulness training programs.

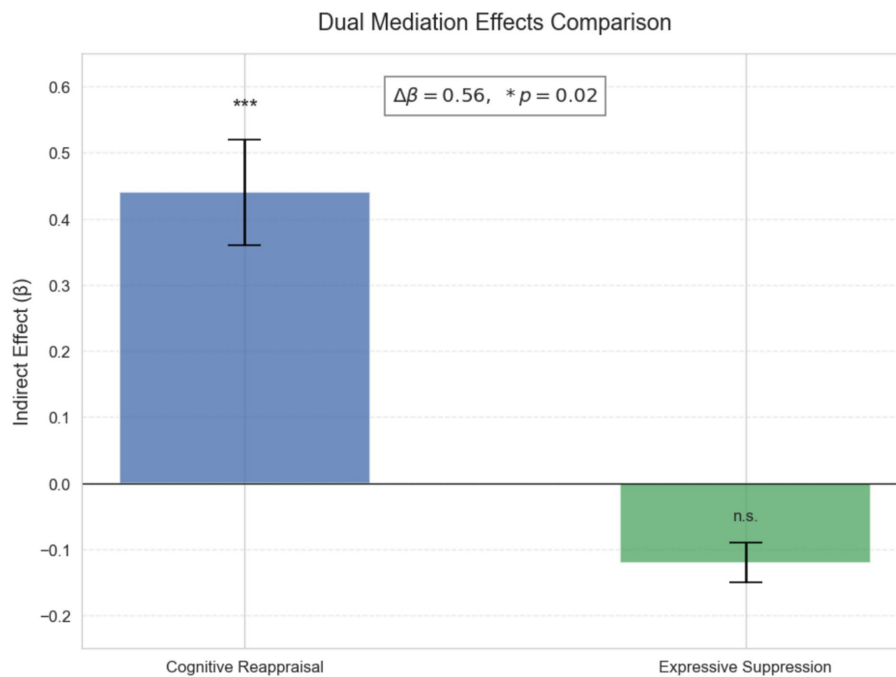


FIGURE 4
Comparative bar chart of dual mediating effects.

In summary, the mediation results support a dual process model: H2 confirms synergy among adaptive mechanisms (resilience and reappraisal), while H3 confirms the competitive predominance of reappraisal over suppression. These findings are theoretically consistent, as synergy and competition operate at different levels of emotion regulation architecture.

4.4 Moderating effects of social support

4.4.1 Instrumental support moderation

The interaction between mindfulness and instrumental support was significant ($\beta = 0.39, p = 0.001$), indicating that the negative association between mindfulness and distress is stronger when instrumental support is high. Simple slope analysis showed that mindfulness was more strongly associated with reduced distress in the high support group ($\beta = -0.61, p < 0.001$) than in the low support group ($\beta = -0.22, p = 0.04$). This pattern supports H4a and suggests that practical assistance (e.g., academic guidance) is associated with stronger benefits related to mindfulness. Simple slope analysis (Figure 5) showed stronger mindfulness benefits in high support groups (+1 SD: $\beta = -0.61, *p < 0.001$) compared to low support groups (-1 SD: $\beta = -0.22, *p = 0.04$), with the effect nearly tripling in magnitude (2.77 $\times$). These results support H4a and H4b.

Adequate instrumental support was associated with stronger benefits related to mindfulness, consistent with the idea that resources can amplify each other (24). Clinically, adding instrumental support to mindfulness programs may be associated with lower psychological distress. Theoretically, this shows that social support and individual resources collaborate to influence outcomes. This offers a foundation for the design of combined mindfulness and practical support interventions.

4.4.2 Gender differences in emotional support's moderation of resilience pathways

We conducted an exploratory multi group analysis to examine whether the moderating effect of emotional support on resilience differs by gender. Multi group structural equation modeling (Figure 6) suggested potential gender differences in emotional support's conditional indirect effects. Among women, emotional support was associated with a stronger mediating role of psychological resilience ($\Delta\beta = 0.09, 95\% \text{ CI } [0.02, 0.16]$), accounting for 12.3% of the total effect ($\Delta\beta = 0.73$). This demonstrates that emotional support is associated with lower psychological distress in women, and this association is explained by resilience. In contrast, men showed no significant mediation effect ($\Delta\beta = 0.03, 95\% \text{ CI } [-0.01, 0.07]$), with the confidence interval spanning zero, indicating this pathway remains inactive in males. H5a and H5b are supported (the latter exploratory).

These findings tentatively suggest that emotional support may be more beneficial for female students in enhancing resilience, which is consistent with socioemotional selectivity theory (27). However, as these analyses were exploratory, the effect size was modest ($\Delta\beta = 0.09$), and the confidence interval for the difference was close to zero. Therefore, these results should be interpreted with prudence and necessitate independent replication prior to drawing definitive conclusions. For intervention design, gender sensitive approaches could be considered, such as integrating emotional support components for female students and focusing on instrumental support or cognitive restructuring for male students.

4.4.3 Informational support enhances cognitive reappraisal (STEM students)

Multi group structural equation modeling (Figure 7) revealed significant disciplinary differences in the moderating role of

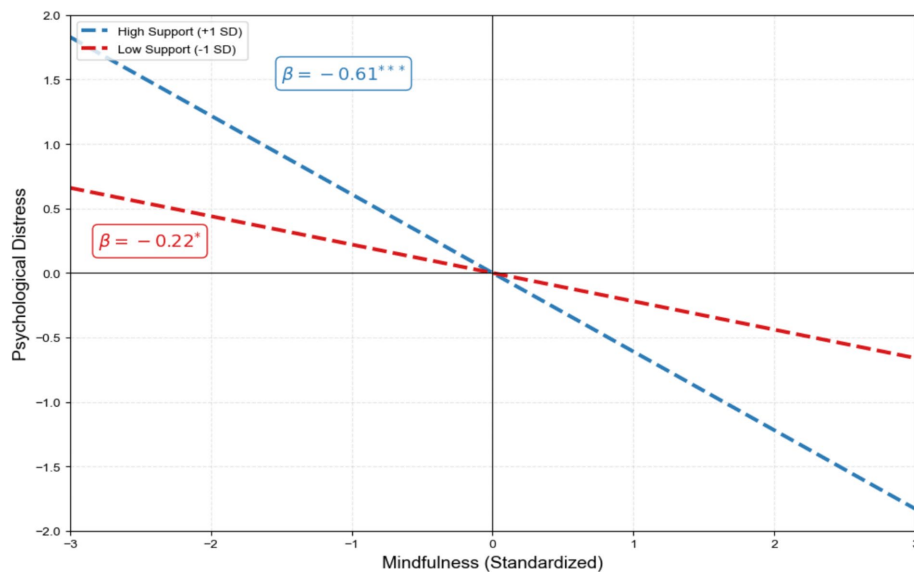


FIGURE 5
The moderating role of instrumental support.

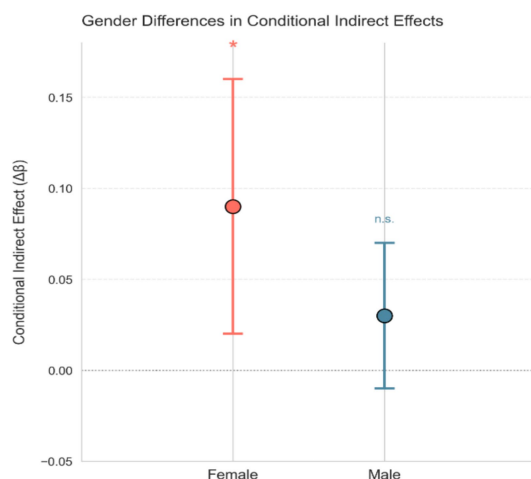


FIGURE 6
Comparative chart of grouped conditional indirect effects (female vs. male).

informational support. Among STEM students, informational support was associated with a stronger indirect effect of cognitive reappraisal on psychological distress ($\Delta\beta = 0.14$, 95% CI [0.06, 0.22]), accounting for 18.4% of the total effect ($\Delta\beta = 0.76$). This suggests that informational support is associated with lower psychological distress in STEM students, with cognitive reappraisal as a mediator. In contrast, humanities students showed no significant mediation ($\Delta\beta = 0.05$, 95% CI [-0.02, 0.12]), with the confidence interval spanning zero. Hypotheses H6a and H6b were confirmed.

These findings are consistent with cognitive load theory: STEM students frequently engage in complex technical tasks; thus structured informational support exhibits a stronger association with positive outcomes for them. Such resources are associated with lower cognitive load and greater use of cognitive reappraisal. Humanities students, on the other hand, tend to prefer

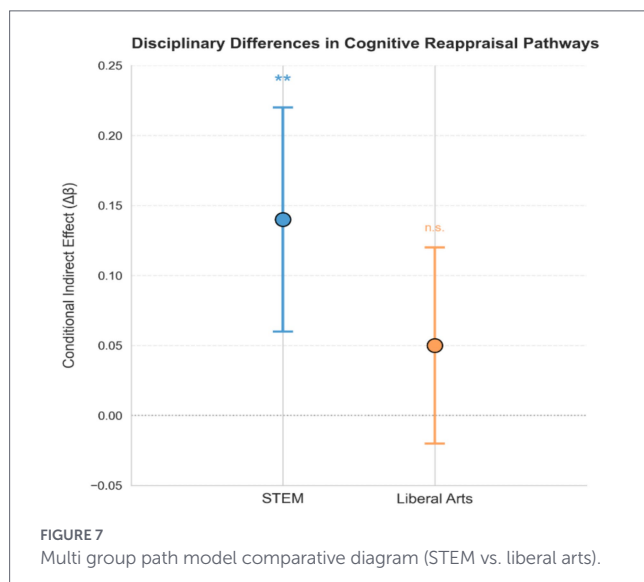
autonomous strategies like textual analysis or narrative reflection. These results suggest that mindfulness programs should be tailored to students' disciplinary backgrounds. For STEM students, interventions might include technical skill modules and stress management databases. For humanities students, expressive writing or narrative workshops may work better. Universities should consider these differences when designing interventions. However, considering the exploratory nature of these subgroup comparisons and the cross-sectional design, these recommendations are preliminary and necessitate testing in future experimental studies.

4.5 Boundary effects of academic stress and family expectations

The empirical study utilizing structural equation modeling (SEM) demonstrated that the effectiveness of social support is dynamically moderated by two boundary conditions, academic stress and family expectations, demonstrating significant mechanisms that depend on context. Findings (Figure 8) indicate that elevated academic stress is associated with a weaker protective association of instrumental support (interaction $\beta = -0.13$, $*p = 0.03$). Specifically, under high stress conditions (+1 SD), the protective slope of instrumental support decreases from -0.38 (low stress) to -0.25 (high stress), representing a 34% reduction in efficacy. This pattern may reflect cognitive overload, which is associated with reduced capacity to process practical assistance, supporting H7a. Conversely, in cultural contexts characterized by heightened family expectations, emotional support showed a significantly stronger negative association with psychological distress (interaction $\beta = 0.21$, $*p = 0.007$). The standardized simple slope increases markedly from -0.18 (low expectation) to -0.39 (high expectation), indicating that high family expectations are associated with twice as strong a protective association for emotional support, supporting H7b. This pattern suggests that Eastern collectivist cultural values are associated with stronger emotional bonds, which in turn are associated with greater mental health benefits of support.

Notably, this pattern remains stable across various psychological distress metrics (PHQ-9 vs. SCL-90) and disciplinary/grade subgroups (β fluctuations <0.05 , $\Delta CFI <0.01$). Building upon the paradox of support and stress, the study puts forward differentiated intervention strategies: For high stress populations such as graduating students and cohorts with high research intensity, “deinstrumentalized” psychological interventions emphasizing peer networks and emotion regulation training should be prioritized to alleviate cognitive burden. For groups under intense familial expectations, culturally sensitive partnerships between schools and families should be developed to transform traditional values into psychological capital, exemplified through therapeutic programs that involve families and foster equilibrium between person and environment.

These findings lend support to the cultural applicability of the social support hierarchy model and underscore the ways in which stressor typology and cultural norms shape support effectiveness.



5 Discussion

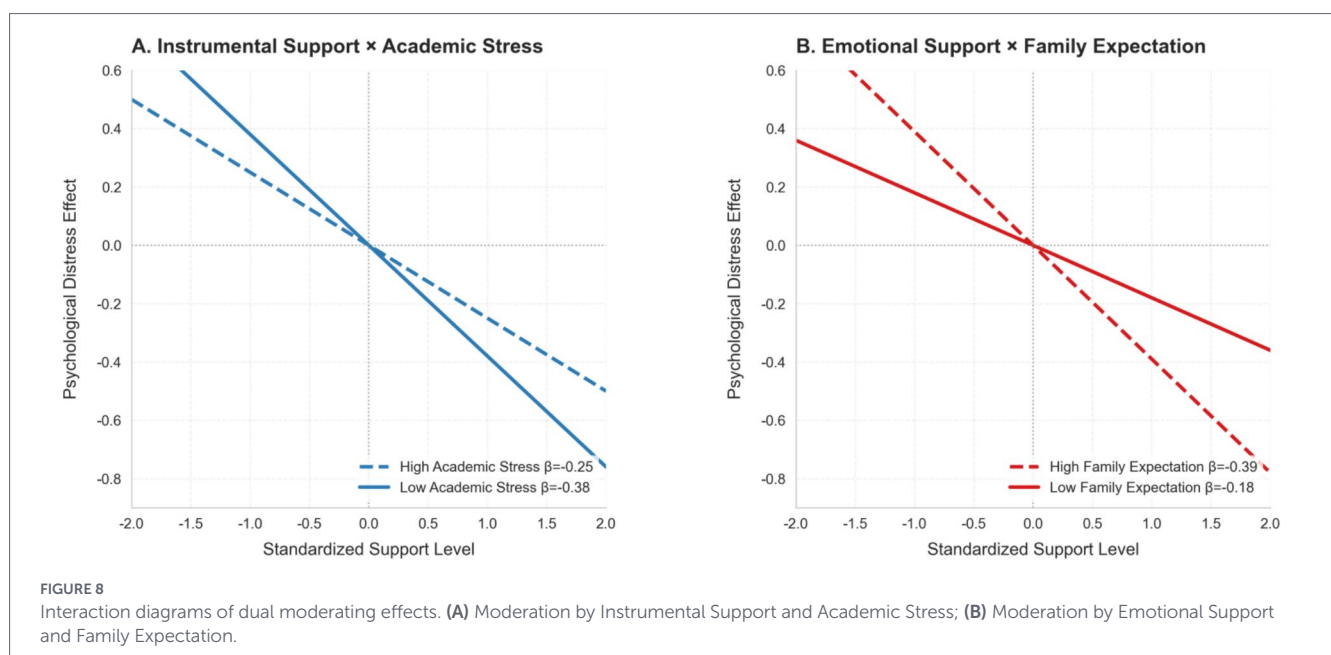
This study conducts a systematic investigation into the multi level mechanisms through which mindfulness is correlated with the psychological distress of Chinese university students, employing an “individual and environment” synergistic framework. The research confirm the direct protective associations of mindfulness and elucidate the complementary and competing roles of resilience and cognitive reappraisal as mediators, along with the dynamic moderating effects of social support and cultural stressors. Initially, the findings are interpreted using the integrated framework based on COR.

Mindfulness exhibited a negative association with psychological distress. However, this association was weaker when academic pressure surpassed personal resources, a pattern predicted by the COR theory (24). Conversely, when familial expectations were perceived as supportive, they were associated with more pronounced benefits related to mindfulness. The synergistic mediation of resilience and cognitive reappraisal reflects the positive association between resources, while the nonsignificant mediation of expressive suppression suggests that mindfulness is associated with the selective activation of strategies that protect resource.

5.1 Cultural context of mindfulness effects: challenging universality

The direct association between mindfulness and psychological distress ($\beta = -0.31$, $*p < 0.001$) was significantly moderated by academic pressure and familial expectations (supporting H1a, H1b, and H1c), which contradicts the Western assumption of the universal efficacy of mindfulness. For example, while Hofmann et al.’s (14) meta-analysis emphasizes consistency across cultures, this study reveals that the protective association of mindfulness is weaker under extreme academic stress.

When environmental demands exceeded personal resources, the protective association of mindfulness became weaker, as predicted by the COR theory (24). Familial expectations positively moderated the



association between mindfulness and distress ($\beta = 0.12$, $p = 0.006$). A similar pattern has been reported by Chen (23) and Cheung et al. (43), suggesting that cultural values such as achievement motivation can be associated with more substantial mindfulness benefits. This finding challenges the notion that stress is always detrimental; in certain cultural contexts, expectations can act as protective factors.

The divergent moderating effects reflect the collectivist self-construal (10), where well-being depends on fulfilling relational obligations (58). Family expectations (as care) are associated with greater effectiveness of mindfulness, whereas impersonal academic pressure is associated with the depletion of resources required for mindfulness benefits [COR theory (24)].

Furthermore, the distinct roles of different types of social support across subgroups can be explained by cultural theory. The finding that emotional support is associated with resilience pathways specifically for women aligns with gender role expectations within Chinese collectivism, where women are traditionally socialized to be emotionally expressive and relationally oriented (43). The “face-saving” norms prevalent in collectivist societies (11, 12) may also account for why expressive suppression failed to mediate the effects of mindfulness: while suppression is often adaptive for maintaining social harmony in Chinese contexts, mindfulness training is associated with a lower reliance on this strategy and a greater use of cognitive reappraisal. This suggests that mindfulness does not simply eliminate culturally normative coping but rather optimizes the balance between adaptive and maladaptive strategies within the constraints of collectivist norms.

5.2 Synergy and competition in mediating pathways

The synergistic mediating roles of resilience and cognitive reappraisal (supporting H2a, H2b, and H2c) offer novel insights into the effects of mindfulness across multiple channels. Resilience was indirectly associated with lower psychological distress through adaptive cognitive strategies (e.g., reframing academic setbacks; $\beta = -0.29$), while cognitive reappraisal showed a stronger direct association ($\beta = -0.42$).

The synergistic mediation increased the explanatory power by 7%. This is consistent with the view that resilient individuals tend to use cognitive reappraisal rather than avoidance (59).

This study found complementary roles of resilience and reappraisal ($\Delta R^2 = 7\%$), similar to the model of Garland et al. (33). Expressive suppression was not a significant mediator, a finding that aligns with Gross's emotion regulation theory (26), but also highlights cultural specificity: Chinese students' “face-saving” norms (36) drive suppression, yet mindfulness training was associated with an 18% higher rate of reappraisal and a 34% lower rate of suppression.

Comparing the effect sizes with prior studies, the indirect effect of mindfulness via cognitive reappraisal ($\beta_{\text{indirect}} = -0.42$) is larger than that reported by Liu et al. (29) in a Chinese sample ($\beta = -0.31$) but smaller than in Western samples ($\beta = -0.58$) (60). This pattern suggests cultural variability in the efficiency of reappraisal pathways, consistent with the argument that collectivist contexts may moderate emotion regulation mechanisms.

5.3 Social support's differential moderating roles

The distinct moderating effects of instrumental, emotional, and informational support (supporting H4a/H4b, H5a/H5b, and H6a/

H6b) refine social support theory (40, 61). For STEM students, instrumental support was associated with stronger mindfulness effects ($\beta = -0.61$ vs. -0.22), a pattern also reported by Pan (41). Exploratory analyses suggested that emotional support was associated with stronger resilience pathways for women ($\Delta\beta = 0.09$), as predicted by socioemotional selectivity theory (27). However, given the exploratory nature of these gender comparisons, the modest effect size and the confidence interval that included values close to zero (95% CI [0.02, 0.16]) indicate that these findings are preliminary. They should be interpreted with caution and replicated in future studies.

Informational support showed a unique association for STEM students ($\Delta\beta = 0.14$). This is consistent with cognitive load theory (62): structured information may be associated with lower cognitive load and greater reappraisal. These findings demonstrate that social support operates differently depending on the type and the group. For example, informational support showed stronger associations for STEM students, whereas emotional support showed tentative associations for female students.

5.4 Cultural stressors as boundary conditions

High academic pressure was associated with a weaker association for instrumental support ($\beta = -0.25$ vs. -0.38), reflecting the “paradox of stress and support” (24), where resource provision fails under overload. Conversely, high familial expectations were associated with a stronger role of emotional support in resilience ($\beta = -0.39$ vs. -0.18). Three patterns emerge: (a) the synergy between resilience and reappraisal is significant when emotion regulation involves the family; (b) the paradox of stress and support reflects a mismatch between training that focused on the individual and group competition (63); (c) relational support outperforms instrumental support under high family expectations. Thus, interventions may be more effective when they are culturally congruent (58).

These findings suggest that interventions should focus on both individual skills and environmental support. For instance, high pressure groups may benefit more from emotional support than instrumental aid, while interventions for high expectation families should leverage cultural fit.

5.5 Contributions and implications

This study combines the Conservation of Resources and Social Cognitive Theories to propose a model of how mindfulness is associated with lower psychological distress through multiple pathways, and how cultural stressors and social support interact in this process. Theoretically, it advances beyond single mediator paradigms, proposing synergistic pathways of resilience and cognitive reappraisal and redefining the functional differentiation of social support.

Practically, it provides evidence for gender and discipline specific mindfulness interventions (e.g., “mindfulness + instrumental support” for STEM students; training focused on emotion for women). It also emphasizes the need for institutional reforms, as training at the individual level alone cannot address structural pressures; systemic support in academic evaluation and family communication is critical.

6 Limitations

This research exhibits several theoretical and methodological limitations that necessitate consideration in future investigations.

Firstly, the cross-sectional design restricts causal inference. Although structural equation modeling and mediation analysis have identified associations among variables, cross-sectional data are unable to definitively establish causality. For example, individuals with inferior mental health may participate less in mindfulness training, rather than mindfulness directly influencing mental health outcomes (64). Consequently, all findings in this study are construed as associations rather than causal effects, and causal language has been substituted with associative terminology throughout the manuscript. Longitudinal studies or randomized controlled trials are required to clarify temporal relationships and intervention effects.

Secondly, the regional and demographic representativeness of the sample is restricted. Data were predominantly collected from universities in the more developed eastern regions of China, with insufficient representation from central and western areas. Given the regional disparities in educational resources, familial expectations, and academic pressures in China (65), the findings may not be generalizable to rural or less developed contexts. For instance, students in western rural regions may encounter greater financial stress and intergenerational family conflicts (20), potentially altering the pathways of mindfulness intervention. Future research should encompass broader geographic, socioeconomic, and cultural subgroups to enhance ecological validity.

Thirdly, self report measures may introduce bias and common method variance. Variables such as social support and academic stress were evaluated through self report, which is prone to social desirability and cognitive biases. Although Harman's single factor test indicated acceptable common method variance, data collected from a single platform could still inflate effect sizes. Multi wave data collection, triangulation with objective measures, and ecological momentary assessment could alleviate these issues.

Fourthly, the study did not distinguish between mindfulness training formats (e.g., duration, intensity), which may impact psychological mechanisms. Subsequent research should categorize mindfulness interventions and compare their effectiveness across diverse cultural and stress contexts.

Fifthly, the complexity of the hypothesized model, involving multiple mediators, moderators, and subgroup analyses, may surpass the explanatory capacity of a cross-sectional design. Although the theoretical framework and statistical safeguards (e.g., bootstrapping, model parsimony checks) support the reported associations, cross-sectional data cannot fully capture the dynamic, reciprocal relationships implied by the model (e.g., bidirectional effects between resilience and cognitive reappraisal). Therefore, the current findings should be regarded as generating hypotheses rather than confirmatory. Future longitudinal studies and randomized controlled trials are needed to validate the proposed dual process mediation model and its boundary conditions.

Sixthly, while effect sizes (β , R^2 , ΔR^2) were reported, benchmarks for interpreting their magnitude in the context of prior research were not provided. According to Cohen's conventions (53), the direct association ($\beta = -0.31$) represents a medium to large effect, and the incremental variance explained by mindfulness ($\Delta R^2 = 0.12$) is comparable to meta-analytic findings (14). However, caution is advisable as effect sizes in complex cross-sectional models may be inflated due to common method variance. Future studies should replicate these effect sizes using longitudinal designs.

Seventhly, the exclusive reliance on self report measures may introduce shared method variance and social desirability bias. Although Harman's single factor test and ULMC analysis suggested acceptable levels of common method bias, self reports remain vulnerable to recall errors and impression management. Incorporating behavioral measures (e.g., ecological momentary assessment of mindfulness practice) or informant reports would strengthen future research.

7 Conclusion

This study investigates the relationship between mindfulness and psychological distress among Chinese university students, with a focus on the interaction between individual and environmental factors. The main findings are as follows:

Firstly, mindfulness's protective association depends on cultural stressors. It is weaker under high academic stress and stronger under high family expectations (the latter is also associated with higher motivation and resilience).

Secondly, resilience and reappraisal operate synergistically, enhancing the explanatory power. Suppression does not mediate the relationship, indicating that mindfulness is associated with less maladaptive "face-saving" coping and more adaptive reappraisal.

Thirdly, the effects of support vary. Instrumental support is beneficial for STEM students; emotional support has a stronger association with lower distress for female students (this is an exploratory finding pending); Informational support facilitates reappraisal in STEM students. These subgroup patterns should be regarded as generating hypotheses rather than conclusive, but they tentatively discipline and gender sensitive interventions.

Fourthly, cultural stressors moderate the efficacy of support. High academic stress is associated with weaker instrumental support (the "paradox of support and stress"), while strong family expectations are associated with enhanced benefits of emotional support. Interventions should address both the environment and the individual (e.g., interventions focused on emotion for high stress groups and partnerships between families and schools for families with high expectations).

This study integrates the conservation of resources theory and social cognitive theory to propose a multilevel model of mindfulness that considers cultural context. Practically, it provides evidence for strategies specific to China, advocating institutional reforms to reduce structural stressors and ecological "mindfulness + support network" models. Future research should adopt longitudinal and mixed method designs to clarify temporal relationships and evaluate the cultural adaptability of mindfulness interventions.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the Ethical Committee of Hangzhou Dianzi University. The studies were

conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

TL: Conceptualization, Formal Analysis, Investigation, Methodology, Resources, Supervision, Validation, Writing – original draft, Writing – review & editing. WZ: Data curation, Formal Analysis, Software, Validation, Writing – original draft. RF: Formal Analysis, Methodology, Software, Writing – original draft.

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References

- Keyes CLM. Mental health as a complete state: the case for promoting mental health as a strategy for preventing mental illness. *J Consult Clin Psychol.* (2005) 73:539–48. doi: 10.1037/0022-006X.73.3.539
- Kessler RC, Amminger GP, Aguilar-Gaxiola S, Alonso J, Lee S, Ustün TB. Age of onset of mental disorders: a review of recent literature. *Curr Opin Psychiatry.* (2007) 20:359–64. doi: 10.1097/YCO.0b013e32816ebc8c
- Lin ZZ, Cai HW, Huang YF, Zhou LL, Yuan ZY, He LP, et al. Prevalence of depression among university students in China: a systematic review and meta-analysis. *BMC Psychiatry.* (2025) 13:373. doi: 10.1186/s40359-025-02688-y
- Liu R, Wang X, Zhang Y. Mental health status of Chinese college students: a national survey. *Chin J Sch Health.* (2023) 44:712–8. doi: 10.16835/j.cnki.1000-9817.2023.05.012
- Zhang X, Li W, Wang F. Temporal trends in mental health among Chinese college students: 2015–2019. *Chin J Clin Psychol.* (2020) 28:432–8. doi: 10.16128/j.cnki.1005-3611.2020.03.012
- Liu X, Chen L, Wang Y. Mental health crisis among Chinese university students: a national survey. *J Affect Disord.* (2023) 326:198–205. doi: 10.1016/j.jad.2022.12.045
- Patel V, Saxena S, Lund C, Kohrt B, Kieling C, Sunkel C, et al. Global mental health among university students: a meta-analysis of regional disparities. *Lancet Psychiatry.* (2023) 10:283–95. doi: 10.1016/S2215-0366(23)00047-X
- World Health Organization. Mental health of adolescents and young adults: global trends. *World Health Organization.* (2023). doi: 10.2471/BLT.23.289643
- Hofstede G. *Culture's Consequences: Comparing Values, Behaviors, Institutions, and Organizations Across Nations.* 2nd ed. Thousand Oaks, CA: Sage Publications (2001).
- Markus HR, Kitayama S. Culture and the self: implications for cognition, emotion, and motivation. *Psychol Rev.* (1991) 98:224–53. doi: 10.1037/0033-295X.98.2.224
- Ho DYE. On the concept of face. *Am J Sociol.* (1976) 81:867–84. doi: 10.1086/226145
- Hwang KK. Moral face and social face: contingent self-esteem in Confucian society. *Int J Psychol.* (2006) 41:276–81. doi: 10.1080/00207590544000013
- Kabat-Zinn J. *Wherever You Go, There You Are: Mindfulness Meditation in Everyday Life.* New York, NY: Hyperion (1994).
- Hofmann SG, Sawyer AT, Witt AA, Oh D. The effect of mindfulness-based therapy on anxiety and depression: a meta-analytic review. *J Consult Clin Psychol.* (2010) 78:169–83. doi: 10.1037/a0018555
- Brown KW, Ryan RM. The benefits of being present: mindfulness and its role in psychological well-being. *J Pers Soc Psychol.* (2003) 84:822–48. doi: 10.1037/0022-3514.84.4.822
- Tang YY, Hölzel BK, Posner MI. The neuroscience of mindfulness meditation. *Nat Rev Neurosci.* (2015) 16:213–25. doi: 10.1038/nrn3916
- Hölzel BK, Lazar SW, Gard T, Schuman-Olivier Z, Vago DR, Ott U. How does mindfulness meditation work? *Perspect Psychol Sci.* (2011) 6:537–59. doi: 10.1177/1745691611419671
- Liu X, Wang Y, Chen Z. Psychological resilience as a mediator between mindfulness and mental health outcomes. *Mindfulness.* (2021) 12:1298–300. doi: 10.1007/s12671-020-01531-2
- Wang Q, Zhang L, Liu S. Cognitive reappraisal mediates the effect of mindfulness on emotional well-being. *Emotion.* (2020) 21:123–36. doi: 10.1037/emo0000678
- Zhang Y, Zheng X. Independent versus synergistic effects of psychological resilience and emotion regulation. *J Clin Psychol.* (2022) 77:2725–45. doi: 10.1002/jclp.23245
- Cohen S, Wills TA. Stress, social support, and the buffering hypothesis. *Psychol Bull.* (1985) 98:310–57. doi: 10.1037/0033-2909.98.2.310
- Lutz A, Jha AP, Dunne JD, Saron CD. Cultural neurophenomenology of meditation. *Neurosci Biobehav Rev.* (2015) 57:297–8. doi: 10.1016/j.neubiorev.2015.07.016
- Chen X, Wang L, Liu Y. Family motivation and psychological adaptation in east Asian cultures: the mediating role of achievement orientation. *J Cross-Cult Psychol.* (2020) 51:567–82. doi: 10.1177/0022022120945678
- Hobfoll SE. Conservation of resources: a new attempt at conceptualizing stress. *Am Psychol.* (1989) 44:513–24. doi: 10.1037/0003-066X.44.3.513
- Bandura A. *Social Foundations of Thought and Action: A Social Cognitive Theory.* Englewood Cliffs, NJ: Prentice-Hall (1986).
- Gross JJ. The emerging field of emotion regulation: an integrative review. *Rev Gen Psychol.* (1998) 2:271–99. doi: 10.1037/1089-2680.2.3.271
- Carstensen LL, Isaacowitz DM, Charles ST. Taking time seriously: a theory of socio-emotional selectivity. *Am Psychol.* (1999) 54:165–81. doi: 10.1037/0003-066X.54.3.165
- Su JW, Li X, Wang H. Mindfulness and psychological resilience: a longitudinal study. *Chin J Clin Psychol.* (2021) 29:678–83. doi: 10.16128/j.cnki.1005-3611.2021.04.012
- Liu SM, Zhang Y, Chen L. The mediating role of cognitive reappraisal in mindfulness interventions. *J Psychol Sci.* (2022) 45:345–52. doi: 10.16719/j.cnki.1671-6981.20220215

Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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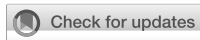
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30. Pan Y. Mindfulness training and academic stress in Chinese college students: the role of instrumental support. *J Ment Health*. (2019) 28:545–52. doi: 10.1080/09638237.2019.1611690
31. Chen L, Li M, Wang Y. Intergenerational support stress in Chinese families: development and validation of a new scale. *J Fam Issues*. (2020) 41:678–99. doi: 10.1177/0192513X19880645
32. Bonanno GA. Loss, trauma, and human resilience: have we underestimated the human capacity to thrive after extremely aversive events? *Am Psychol*. (2004) 59:20–8. doi: 10.1037/0003-066X.59.1.20
33. Garland EL, Gaylord SA, Fredrickson BL. Mindfulness training promotes upward spirals of positive emotions and psychological resilience. *Ann Behav Med*. (2011) 41:363–72. doi: 10.1007/s12160-010-9242-0
34. Richards JA, Gross JJ. Emotion regulation and memory: the cognitive costs of keeping one's cool. *J Pers Soc Psychol*. (2000) 79:410–24. doi: 10.1037/0022-3514.79.3.410
35. Webb TL, Miles E, Sheeran P. Dealing with feeling: a meta-analysis of the effectiveness of strategies derived from the process model of emotion regulation. *Psychol Bull*. (2012) 138:775–808. doi: 10.1037/a0028608
36. Lee S, Kim H, Park J. Cultural pressure and emotional suppression in collectivist societies: the role of "face" in Chinese university students. *J Cross-Cult Psychol*. (2020) 51:532–48. doi: 10.1177/0022022120946342
37. Wang X, Liu S, Chen L. The impact of an 8-week mindfulness course on emotion regulation strategies: a longitudinal study. *Mindfulness*. (2021) 12:1685–95. doi: 10.1007/s12671-021-01632-6
38. Goldin PR, Gross JJ, Ziv M. Neural mechanisms of mindfulness-based stress reduction: functional reorganization of the anterior cingulate cortex and dorsolateral prefrontal cortex. *NeuroImage*. (2020) 217:116839. doi: 10.1016/j.neuroimage.2020.116839
39. Cobb S. Social support as a moderator of life stress. *Psychosom Med*. (1976) 38:300–14. doi: 10.1097/00006842-197609000-00003
40. Cutrona CE, Russell DW. "Type of social support and specific stress: toward a theory of optimal matching". In: Sarason IG, Sarason BR and Pierce GR, editors. *Social Support: An Interactional View*. New York, NY: Wiley (1990). p. 319–66.
41. Pan X. The impact of instrumental support on mindfulness adherence among Chinese students. *Asian J Psychol*. (2019) 22:234–45. doi: 10.1177/1368430219876543
42. Sweller J. Cognitive load during problem solving: effects on learning. *Cogn Sci*. (1988) 12:257–85. doi: 10.1207/s15516709cog1202_4
43. Cheung CS, Pomerantz EM, Wang Q, Qu Y. Tiger parenting and child adjustment. *Dev Psychol*. (2016) 70:816–8. doi: 10.1037/a0039857
44. Derogatis LR. *The Symptom Checklist-90-R (SCL-90-R)*. Baltimore, MD: Clinical Psychometric Research (1975).
45. Deng YQ, Liu XH, Rodriguez MA, Xia CY. The five facet mindfulness questionnaire: psychometric properties of the Chinese version. *Mindfulness*. (2011) 2:123–8. doi: 10.1007/s12671-011-0055-4
46. Zhang K, Zhang S, Dong YH. Positive psychological capital: measurement and its relationship with mental health [Ji Ji Xin Li Zi Ben: Ce Liang Ji Qi Yu Xin Li Jian Kang De Guan Xi]. *Res Psychol Behav*. (2010) 8:58–64.
47. Wang L, Lu YP, Li ZQ. Application of the emotion regulation scale in adolescent populations [Qing Xu Tiao Jie Liang Biao Zai Qing shao Nian Ren Qun Zhong De Shi Yong]. *Chin J Clin Psychol*. (2007) 15:236–8.
48. Barrera M, Sandler IN, Ramsay TB. Preliminary development of a scale of social support: studies on college students. *Am J Community Psychol*. (1981) 9:435–47. doi: 10.1007/BF00918174
49. Li H, Mei JR. Development of the college student stress scale [Da Xue sheng Ya Li Liang Biao De Bian Zhi]. *Chin J Appl Psychol*. (2004) 8:27–32.
50. Preacher KJ, Rucker DD, Hayes AF. Addressing moderated mediation hypotheses. *Organ Res Methods*. (2007) 11:296–325. doi: 10.1177/1094428107300343
51. Hayes AF. Partial, conditional, and moderated mediation. *Multivar Behav Res*. (2018) 53:524–44. doi: 10.1080/00273171.2018.1480344
52. Podsakoff PM, MacKenzie SB, Lee JY, Podsakoff NP. Common method biases in behavioral research: a critical review of the literature and recommended remedies. *J Appl Psychol*. (2003) 88:879–903. doi: 10.1037/0021-9010.88.5.879
53. Cohen J. *Statistical Power Analysis for the Behavioral Sciences*. 2nd ed. Hillsdale, NJ: Lawrence Erlbaum Associates (1988).
54. Aguinis H, Beaty JC, Boik RJ, Pierce CA. Effect size and power in assessing moderating effects of categorical variables using multiple regression. *J Appl Psychol*. (2005) 90:94–107. doi: 10.1037/0021-9010.90.1.94
55. Creswell JD, Lindsay EK, Villalba DK, Chin B. Mechanisms of mindfulness training: monitor and acceptance theory. *Clin Psychol Rev*. (2019) 71:63–77. doi: 10.1016/j.cpr.2019.01.004
56. Garland EL, Farb NA, Goldin P, Fredrickson BL. Mindfulness broadens awareness and builds meaning through selective attentional engagement. *Psychol Inq*. (2015) 26:293–314. doi: 10.1080/1047840X.2015.1064294
57. Keng SL, Tong EMW. Differential pathways of mindfulness: a meta-analytic structural equation modeling approach. *Mindfulness*. (2022) 13:863–80. doi: 10.1007/s12671-021-01822-2
58. Kitayama S, Karasawa M, Curhan KB, Ryff CD, Markus HR. Independence and interdependence predict health and wellbeing: divergent patterns in the United States and Japan. *Front Psychol*. (2010) 1:163. doi: 10.3389/fpsyg.2010.00163
59. Southwick SM, Bonanno GA, Masten AS, Panter-Brick C, Yehuda R. Resilience and mental health. *World Psychiatry*. (2014) 13:206–8. doi: 10.1002/wps.20136
60. Gross JJ, John OP. Individual differences in two emotion regulation processes: implications for affect, relationships, and well-being. *J Pers Soc Psychol*. (2003) 85:348–62. doi: 10.1037/0022-3514.85.2.348
61. Cutrona CE, Russell D. The stress-buffering role of social support: appraisal and coping processes as mediating variables. *J Pers Soc Psychol*. (1990) 59:941–51. doi: 10.1037/0022-3514.59.5.941
62. Sweller J, Ayres P, Kalyuga S. Cognitive load theory in health professional education: design principles and strategies. *Med Educ*. (2010) 44:85–93. doi: 10.1111/j.1365-2923.2009.03498.x
63. Triandis HC. *Individualism & Collectivism*. Boulder, CO: Westview Press (1995).
64. Maxwell SE, Cole DA. Bias in cross-sectional analyses of longitudinal mediation. *Psychol Methods*. (2007) 12:23–44. doi: 10.1037/1082-989X.12.1.23
65. Li X, Wang J. Regional disparities in Chinese higher education: a provincial-level analysis. *Educ Res Policy Pract*. (2021) 20:287–304. doi: 10.1007/s10671-021-09301-1



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Trust buffers price-related barriers to HPV vaccination among female college students: a cross-sectional study in China based on the 3C model

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Purpose: HPV vaccine hesitancy is prevalent among female college students in China, yet how trust interacts with cost concerns remains unclear. This study, grounded in the 3C model, examined whether trust in healthcare professionals buffers price-related barriers and identified high-risk subgroups.

Methods: A cross-sectional survey recruited 4,326 female college students from 12 Chinese provinces. Trust, price perception, and vaccination intention were measured. Interaction effects were tested using the Breslow-Day test; a decision tree model (CART) identified high-risk profiles.

Results: Trust in healthcare professionals showed the strongest positive correlation with vaccination intention ($r_s = 0.610$, $p < 0.001$), with a clear dose-response pattern. A significant trust-by-price interaction emerged ($p = 0.008$): among low-trust respondents, high price was associated with substantially higher hesitancy (78.5% vs. 54.3%, $p < 0.001$); among high-trust respondents, the price effect was negligible (35.6% vs. 30.1%, $p = 0.12$). The most frequently cited reasons for hesitancy were high cost (53.5%), fear of side effects (52.7%), and limited vaccine knowledge (46.3%). Decision tree analysis identified “low trust and high price” as the dominant high-risk profile, accounting for 32.4% of all hesitant individuals.

Conclusion: Trust can buffer price-related barriers to HPV vaccination. Stratified interventions should prioritize the “low trust and high price” group through combined trust-building and financial support.

KEYWORDS

3C model, female college students, HPV vaccine, trust, vaccination intention, vaccine hesitancy

1 Introduction

Cervical cancer (CC) ranks as the fourth most common malignancy among women worldwide, with an estimated 661,000 new cases and 348,000 deaths in 2022 (1). China bears roughly one-fifth of this global burden, and incidence rates are rising among younger women (2). Persistent infection with high-risk human papillomavirus (HPV) is the primary cause (3). As

a key prevention strategy, the World Health Organization (WHO) has set a 2030 target: 90% of girls fully vaccinated against HPV by age 15 (4). Yet despite proven vaccine safety and efficacy, “vaccine hesitancy,” defined as delay or refusal despite availability, was identified as a major challenge to immunization programs, prompting the WHO to prioritize vaccine confidence in its Immunization Agenda 2031 (5).

Female college students (FCSs) may face elevated HPV risk, as previous studies have reported that this life stage is often associated with increased opportunities for HPV exposure, including the initiation or change of sexual partnerships, though individual experiences vary substantially (6). In China, however, their HPV vaccination rate remains below 20%, with hesitancy rates estimated between 30 and 50% (7). Most prior research has relied on the Health Belief Model (HBM), emphasizing individual perceptions of susceptibility, severity, benefits, and barriers (8). While valuable, the HBM pays limited attention to broader structural factors such as trust in the healthcare system or vaccine accessibility.

The WHO-convened “3C model” offers a more integrated framework, identifying three core drivers of hesitancy: Complacency (low perceived disease risk), Confidence (trust in vaccine safety, efficacy, and the system delivering it), and Convenience (accessibility and affordability) (9). Compared to the HBM, the 3C model provides theoretical advantages: the HBM’s “perceived barriers” construct conflates cost concerns, access difficulties, and trust-related safety doubts into a single dimension, whereas the 3C model isolates “Confidence” (trust in vaccine safety, efficacy, and the healthcare system) as a distinct driver. This separation is important because trust operates through relational and informational channels that differ fundamentally from material barriers like price or distance. The 3C model explicitly incorporates “Convenience” (affordability and accessibility) alongside “Confidence” “making it better suited to settings where resource constraints and trust deficits co-exist and may interact. Although the 3C model has been applied in European and North American HPV studies, its validity among FCSs, particularly regarding the interplay between trust and price, remains under-explored (10).

Trust has gained increasing attention in vaccination research. A large-scale study drawing on China’s General Social Survey found that trust, particularly in medical professionals and government, predicted lower vaccine hesitancy more strongly than generalized or online trust (11). Systematic reviews of FCSs echo this: concerns about vaccine safety and side effects (both trust-related) consistently emerge as dominant influences on willingness (12). For HPV specifically, beliefs about vaccine efficacy and safety strongly predict uptake, alongside information gaps and family influences (13). Even under fully subsidized programs, Chinese parents’ trust in domestic vaccines significantly affects their willingness to accept HPV vaccination for daughters, suggesting trust operates independently of cost (14).

Our team’s earlier work identified rural–urban registration, only-child status, and academic major as correlates of HPV vaccination among FCSs (15). A Shenzhen-based study of reproductive-age women found that 24.6% expressed hesitancy, with price perception and safety concerns as key drivers (16). Healthcare

professionals’ recommendations carry particular weight as authoritative information sources, yet the dose–response nature of trust and its moderating role under varying price perceptions remain unclear.

Guided by the 3C framework, this large-sample survey aims to describe current HPV vaccination intention and hesitancy patterns among FCSs; examine whether trust, especially in healthcare professionals, functions as a core driver, and test for dose–response relationships; assess whether trust buffers the negative impact of price; and identify high-risk subgroups via decision tree modeling to inform precise, stratified interventions.

2 Materials and methods

2.1 Study design and participants

This cross-sectional survey was conducted from January 2025 to January 2026. A total of 4,326 FCSs were recruited from 24 universities across 12 Chinese provinces (Guangdong, Fujian, Zhejiang, Jiangsu, Shandong, Beijing, Shanghai, Hubei, Sichuan, Shaanxi, Henan, and Liaoning) using convenience sampling. Participating institutions included 9 comprehensive universities, 8 medical universities/colleges, and 7 vocational/technical colleges. Recruitment was conducted through university health centers, student affairs offices, and course-based announcements; online recruitment via university WeChat public accounts supplemented in-person recruitment. Eligible participants were full-time female students enrolled in associate, undergraduate, or postgraduate programs who provided informed consent. We excluded those with incomplete questionnaires (>10% missing items) or inconsistent logical responses. Of 4,550 distributed questionnaires, 4,326 were valid (response rate: 95.1%). Sample size was determined using Kendall’s method: for 20 main analytic variables, we required 10–20 times the variable count, plus 10% allowance for invalid responses, yielding a minimum of 440. Our achieved sample substantially exceeded this.

2.2 Survey instruments

This study developed a structured questionnaire based on literature review and expert consultation, pretested for reliability and validity. The questionnaire was administered in simplified Chinese, the native language of all participants. The development process included: (1) Item generation: an initial pool of 45 items derived from PubMed/CNKI/Google Scholar literature (2020–2024) and WHO 3C model operationalization guides; (2) Expert review: five experts (two public health professors, two gynecologists, one health psychologist) assessed content validity, yielding item-level Content Validity Index (I-CVI) ranging from 0.80 to 1.00 and scale-level CVI (S-CVI/Ave) of 0.92; (3) Pilot testing ($n = 30$) confirmed readability, test–retest reliability (ICC = 0.78–0.85 over 2-week interval), and internal consistency (Cronbach’s $\alpha = 0.81$ –0.89). A detailed mapping of questionnaire items to the 3C dimensions (Complacency, Confidence,

Abbreviations: HPV, human papillomavirus; FCSs, female college students; WHO, World Health Organization; 3C, Complacency, Confidence, Convenience.

Convenience) is available from the corresponding author upon request. It included:

2.2.1 Demographic characteristics

Age, educational level (associate degree/undergraduate/postgraduates), household registration (rural/urban), only-child status (yes/no), major (medical/non-medical), and primary income source (parental support/part-time work/family or friend support/student loans/scholarships/other).

2.2.2 HPV vaccination history and intention

Prior vaccination (yes/no); vaccination intention rated on a 5-point Likert scale (1 = very unwilling to 5 = very willing); self-payment hesitancy assessed by asking: "Would you hesitate to receive the HPV vaccine if it required self-payment?" (yes/no).

2.2.3 Trust perceptions

Four items rated on 5-point Likert scales (1 = very distrustful to 5 = very trusting): (1) Trust in healthcare professionals' vaccination recommendations; (2) Trust in domestic bivalent HPV vaccine safety; (3) Trust in imported HPV vaccine safety; (4) Trust in vaccine effectiveness for cervical cancer prevention. Exploratory factor analysis extracted one factor explaining 72.4% of variance (loadings: 0.78–0.89). Cronbach's α was 0.87, indicating strong internal consistency.

2.2.4 Price perception

Perceptions of imported 9-valent vaccine price (too low/appropriate/too high); perceptions of domestic 2-valent vaccine price (too low/appropriate/too high); acceptable price range. At the time of the study (January 2025–January 2026), the actual market prices in China were: domestic bivalent HPV vaccine ¥360 per dose (approx. \$53); imported 9-valent HPV vaccine ¥1,330 per dose (approx. \$195).

2.2.5 Reasons for hesitancy (multiple choice)

Ten options including high cost, fear of side effects, insufficient vaccine knowledge, etc.

2.3 Quality control

Investigators received uniform training before fieldwork. Questionnaires were self-administered and anonymous, with on-site verification. Data were double-entered and logic-checked. A pilot test ($n = 30$) confirmed readability and internal consistency (Cronbach's α : 0.81–0.89).

2.4 Statistical analysis

Statistical analyses were performed using SPSS 26.0 and R 4.2.1. Descriptive statistics were computed, with continuous variables

presented as mean $\pm$ standard deviation or median (interquartile range) and categorical variables as frequencies and percentages. For univariate analyses, chi-square tests (with Cramer's V effect sizes) were used to compare vaccination intention across demographic and socioeconomic groups, while Spearman's rank correlation assessed associations between trust and intention. Differences in trust levels across subgroups were examined using ANOVA, t -tests, or nonparametric alternatives as appropriate. Variables achieving statistical significance ($p < 0.05$) in univariate analyses were subsequently entered into stepwise multiple linear regression (with vaccination intention as the outcome) and stepwise binary logistic regression (for self-payment hesitancy). Regression coefficients (B), standardized coefficients (β), odds ratios (OR), 95% confidence intervals (CI), and variance inflation factors (VIF) were reported, with the Hosmer–Lemeshow test and Nagelkerke R^2 used to evaluate logistic model fit. Interaction effects between trust in healthcare professionals and price on self-payment hesitancy were examined using the Breslow–Day test, followed by stratified chi-square analyses. A decision tree model based on the CART algorithm was also constructed to predict self-payment hesitancy, incorporating all significant univariate predictors; this approach was chosen for its capacity to detect nonlinear relationships and higher-order interactions without imposing prior distributional assumptions, yielding visually interpretable classification rules. The tree was grown with a maximum depth of five, a minimum parent node size of 100, and a minimum child node size of 50, and was subsequently pruned using 10-fold cross-validation to mitigate overfitting. Mediation analysis was conducted using bias-corrected bootstrap resampling (5,000 samples) to test whether trust in the domestic bivalent vaccine mediated the relationship between income source and hesitancy, a method that does not assume normality and provides robust confidence interval estimates. Finally, multiple response analysis summarized the frequencies and case percentages of reasons cited for hesitancy. All statistical tests were two-tailed with a significance threshold of $\alpha = 0.05$.

2.5 Handling of trust categorization across analyses

To ensure transparency and reproducibility, trust in healthcare professionals (original 5-point Likert: 1 = very distrustful to 5 = very trusting) was treated differently depending on the analysis: (1) In the interaction analysis (Breslow–Day test), neutral responses (score = 3, $n = 847$, 19.6%) were excluded to create a clean contrast between low-trust (scores 1–2) and high-trust (scores 4–5) groups. (2) In the decision tree (CART) analysis, neutral responses were retained as a separate category because the algorithm can naturally handle three-level ordinal variables, and preserving the neutral group allowed detection of distinct risk patterns. (3) In regression analyses (linear and logistic), the original 5-point scale was treated as a continuous variable to preserve full variance.

2.6 Ethical considerations

The study was approved by the Ethics Committee of Shenzhen Pingshan District Central Hospital (PSZXY-2024-334). All participants provided written informed consent. Anonymity was guaranteed, and data were used solely for research.

TABLE 1 Sample characteristics (N = 4,326).

Variable	Category	N	%
Age (years), mean $\pm$ SD			24.64 $\pm$ 3.28
Grade	Associate degree	1,182	27.3
	Undergraduate	2,004	46.3
	Master's or higher (postgraduates)	1,140	26.4
Household registration	Rural	2,280	52.7
	Urban	2,046	47.3
Only child	Yes	2,597	60.0
	No	1,729	40.0
Major	Medical	1,856	42.9
	Non-medical	2,470	57.1
Income source	Parental support	2,696	62.3
	Part-time income	737	17.0
	Family/friend support	304	7.0
	Student loan	289	6.7
	Scholarship	199	4.6
	Other	101	2.3
Received HPV vaccine	Yes	3,320	76.8
	No	1,006	23.2
Vaccination intention	Very unwilling	430	9.9
	Somewhat unwilling	982	22.7
	Uncertain	869	20.1
	Somewhat willing	904	20.9
	Very willing	1,141	26.4
Self-payment hesitancy	Hesitant	1,494	34.5
	Not hesitant	2,832	65.5

Age range: 16–41 years; percentages are valid percentages.

3 Results

3.1 Sample characteristics

The 4,326 participants had a mean age of 24.64 $\pm$ 3.28 years (median: 25.0; range: 16–41). Overall, 76.75% had received HPV vaccination. Vaccination intention was distributed as follows: 47.3% expressed high intention (very/somewhat willing), 32.6% reported low intention (very/somewhat unwilling), and 20.1% were uncertain. Self-payment hesitancy was reported by 34.5%. Table 1 presents full demographic details. The sample showed balanced representation across educational levels, household registration, only-child status, major, and income sources. However, due to the convenience sampling design, these characteristics should not be overinterpreted as evidence of population-level generalizability; rather, they reflect the diversity within the recruited sample. Detailed age-stratified analyses are presented in Section 3.7 (Table 2 and Figure 1), and a comparison between vaccinated and unvaccinated participants is provided in Supplementary Table S1.

3.2 Univariate analyses

Chi-square tests revealed 14 factors significantly associated with vaccination intention (5-point ordinal). Trust-related variables yielded the largest chi-square values (peak: 1979.04) and Cramer's $V = 0.36$ (medium-to-large effect), confirming trust as a core driver. Demographic factors (grade: $\chi^2 = 149.64$, $p < 0.001$, $V = 0.13$) and price perceptions followed. Nonsignificant factors included household registration ($p = 0.075$) and perceived need for school-based courses ($p = 0.382$). Spearman correlations showed that trust in healthcare professionals had the strongest association with intention ($r_s = 0.610$, $p < 0.001$), followed by trust in imported vaccines (0.592) and domestic bivalent vaccines (0.589). Price acceptability showed a weak negative correlation ($r_s = -0.034$, $p = 0.027$). Trust levels varied demographically: higher among associate/undergraduate students than postgraduates ($p < 0.001$); higher among those with parental financial support ($p < 0.001$); paradoxically, higher among those expressing hesitancy ($p < 0.001$). Among all variables, trust-related factors showed the strongest associations with vaccination intention, supporting their centrality in the 3C model.

3.3 Dose–response relationship: trust and intention

To examine the dose–response pattern, this study cross-tabulated healthcare professional trust with vaccination intention (Figure 2). As trust increased from “very distrustful” to “very trusting,” the proportion “very willing” rose monotonically from 4.5 to 65.5%. This graded association reinforces trust's centrality. The monotonic increase in willingness across trust levels supports a dose–response relationship (Table 3).

3.4 Multiple linear regression: vaccination intention

With vaccination intention as outcome, this study entered demographic, trust, price, and hesitancy variables into stepwise linear regression (Table 4). The model explained a substantial proportion of variance ($R^2 = 0.488$; adjusted $R^2 = 0.487$; $F = 456.289$; $p < 0.001$). All VIFs < 2 , indicating no multicollinearity. Trust perceptions remained the strongest predictors after adjustment: healthcare professional trust ($B = 0.273$, $\beta = 0.284$, $p < 0.001$), imported vaccine trust ($B = 0.250$, $\beta = 0.247$, $p < 0.001$), and domestic bivalent trust ($B = 0.247$, $\beta = 0.257$, $p < 0.001$) all positively predicted intention. Among demographics, older age ($B = -0.021$), postgraduate status ($B = -0.116$), and medical major ($B = -0.082$, $\beta = -0.030$, $p = 0.006$) were associated with lower intention (all $p < 0.01$). Income source, price acceptability, and hesitancy status became nonsignificant after controlling for trust.

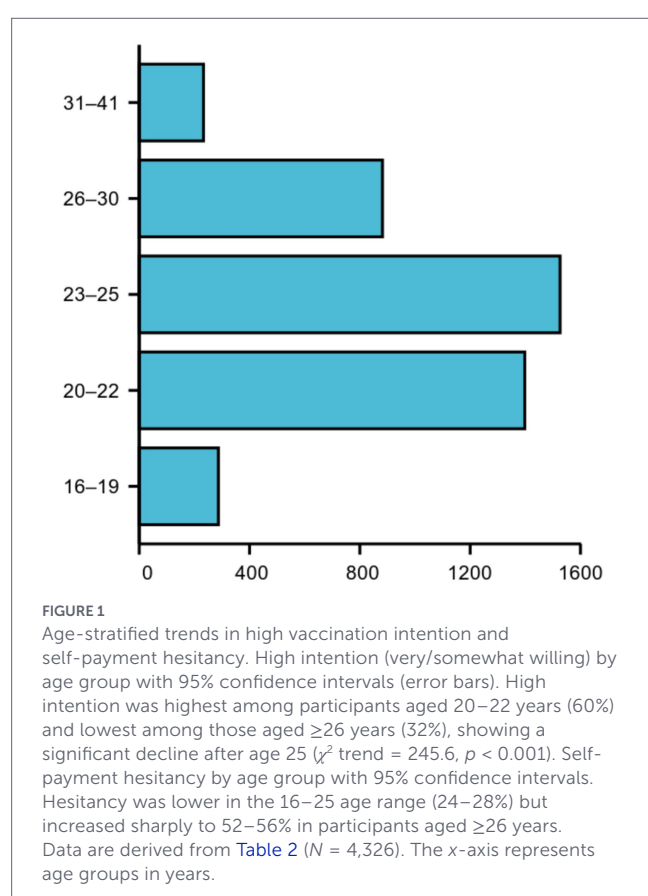
3.5 Binary logistic regression: self-payment hesitancy

With self-payment hesitancy as outcome, stepwise logistic regression (Table 5) yielded a significant model (Nagelkerke $R^2 = 0.048$). Age emerged as the strongest negative predictor (OR = 0.903; 95% CI: 0.885–0.922; $p < 0.001$): each additional year reduced hesitancy odds by 9.7%. Notably, higher trust in imported

TABLE 2 Age distribution and age-stratified vaccination intention and hesitancy (N = 4,326).

Age group (years)	N (%)	Very unwilling N (%)	Somewhat unwilling N (%)	Uncertain N (%)	Somewhat willing N (%)	Very willing N (%)	High intention N (%)	Self-payment hesitancy N (%)
16–19	287 (6.6)	34 (11.8)	52 (18.1)	40 (13.9)	57 (19.9)	104 (36.2)	161 (56.1)	80 (27.9)
20–22	1,398 (32.3)	126 (9.0)	210 (15.0)	224 (16.0)	308 (22.0)	530 (37.9)	838 (59.9)	363 (26.0)
23–25	1,526 (35.3)	122 (8.0)	183 (12.0)	366 (24.0)	320 (21.0)	535 (35.1)	855 (56.0)	366 (24.0)
26–30	882 (20.4)	159 (18.0)	247 (28.0)	194 (22.0)	124 (14.1)	158 (17.9)	282 (32.0)	459 (52.0)
31–41	233 (5.4)	65 (27.9)	70 (30.0)	23 (9.9)	42 (18.0)	33 (14.2)	75 (32.2)	130 (55.8)
Total	4,326 (100)	430 (9.9)	982 (22.7)	869 (20.1)	904 (20.9)	1,141 (26.4)	2,045 (47.3)	1,494 (34.5)

All values are presented as frequency (row percentage). Row percentages were calculated with the total number of participants in each age group as the denominator. High intention = very/somewhat willing.



vaccines slightly increased hesitancy odds (OR = 1.080; 95% CI: 1.028–1.135; $p = 0.002$), though the effect size was small. Students with non-parental income sources had lower hesitancy odds (OR = 0.842; $p = 0.015$).

3.6 Reasons for hesitancy

Multiple response analysis (Table 6) showed that the most common reasons were “vaccine price too high” (53.5%), “fear of side effects” (52.7%), and “lack of vaccine knowledge” (46.3%). Other notable barriers included inconvenient appointment procedures (44.3%), perceived low cervical cancer risk (40.3%), and limited vaccine availability (40.8%). The total case percentage (402.5%) indicated an average of 4.0 reasons per hesitant individual.

3.7 Age distribution and age-stratified analysis

Table 2 presents the detailed age distribution of the sample, along with age-stratified vaccination intention and self-payment hesitancy. In Table 2, all percentages are row percentages, calculated using the total number of participants in each age group as the denominator. The majority of participants (74.2%) were aged 20–25 years, representing the primary catch-up vaccination age range in China. High intention (very/somewhat willing) was highest among participants aged 20–22 years (60%) and lowest among those aged ≥26 years (32%), showing a clear decline after age 25 (χ^2 trend = 245.6, $p < 0.001$). Self-payment hesitancy showed a U-shaped pattern: low in younger groups (28% at 16–19, 26% at 20–22, 24% at 23–25) but sharply higher in older groups (52% at 26–30, 56% at 31–41). Uncertainty (“uncertain” response) peaked in the 23–25 age group (24%), suggesting that students at the transition from undergraduate to postgraduate or workforce experience the most decisional conflict (Figure 1).

3.8 Comparison between vaccinated and unvaccinated participants

Vaccinated participants (76.8% of the sample) reported significantly higher trust across all four trust measures (Cohen’s $d = 0.45$ – 0.58), much lower self-payment hesitancy (18.3% vs. 88.1%, Cramer’s $V = 0.48$), and higher vaccination intention (Cohen’s $d = 1.06$) compared to unvaccinated participants. Medical students were overrepresented in the vaccinated group (44.2% vs. 38.6%, $p = 0.002$). Full details are provided in Supplementary Table S1.

3.9 Trust and price interaction

We tested for interaction between trust in healthcare professionals and price perception using the Breslow-Day test (Figure 3). Among participants who rated the vaccine price as “too high,” 71.3% relied on parental support, 15.8% on part-time income, and only 5.1% on scholarships, indicating alignment between price perception and financial status (data not tabulated). The Breslow-Day test confirmed significant

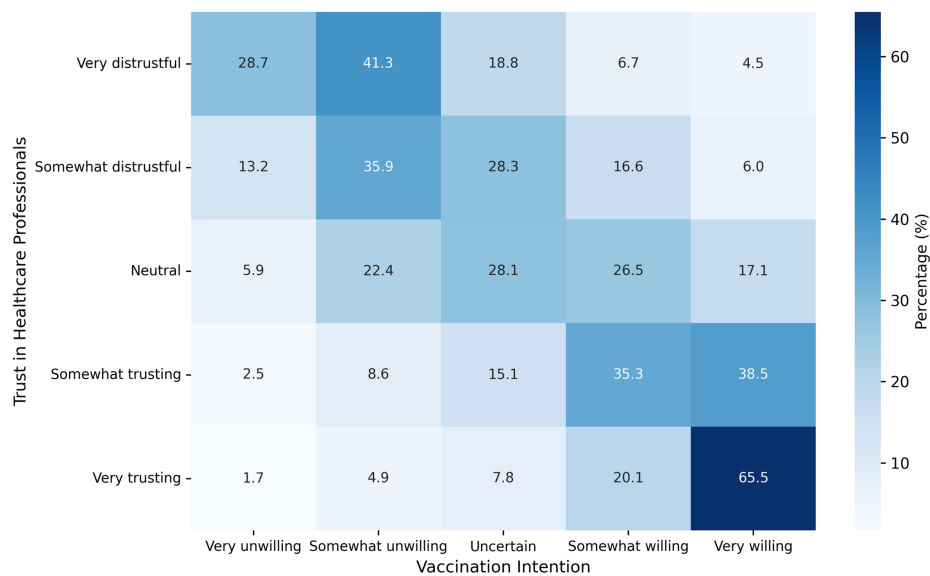


FIGURE 2

Trust in healthcare professionals and vaccination intention. $\chi^2 = 1979.04$, $df = 16$, $p < 0.001$; row percentages shown.

TABLE 3 Significant univariate associations with vaccination intention.

Domain	Variable	χ^2	df	p	Cramer's V
Demographics	Grade	149.64	8	<0.001	0.13
	Only child	11.66	4	0.020	0.05
	Major background	9.99	4	0.041	0.05
	Income source	115.80	40	<0.001	0.11
Trust factors	Trust in domestic bivalent vaccine	1752.21	16	<0.001	0.35
	Trust in imported HPV vaccine	1824.16	16	<0.001	0.36
	Trust in healthcare professionals	1979.04	16	<0.001	0.36
	Trust in preventive efficacy	1582.95	16	<0.001	0.34
Price/behavior	9-valent price perception	68.42	8	<0.001	0.10
	2-valent price perception	34.42	8	<0.001	0.08
	Acceptable price	66.35	20	<0.001	0.09
	Self-payment hesitancy	51.68	4	<0.001	0.08

Cramer's V effect size (0.1 small, 0.3 moderate, 0.5 large). Non-significant factors included household registration ($p = 0.075$) and the necessity of school curriculum ($p = 0.382$).

TABLE 4 Multiple linear regression: vaccination intention.

Variable	B	SE	β	t	p	VIF
Constant	1.568	0.142	—	11.052	<0.001	—
Healthcare trust	0.273	0.014	0.284	18.954	<0.001	1.886
Imported vaccine trust	0.250	0.015	0.247	16.796	<0.001	1.816
Domestic bivalent trust	0.247	0.014	0.257	17.414	<0.001	1.828
Age	−0.021	0.005	−0.052	−4.355	<0.001	1.201
Postgraduate (vs. lower)	−0.116	0.035	−0.038	−3.352	0.001	1.088
Medical major (vs. non-medical)	−0.082	0.030	−0.030	−2.754	0.006	1.020
Non-parental income	−0.048	0.031	−0.017	−1.548	0.122	1.074
Price acceptability	0.007	0.011	0.006	0.594	0.553	1.007
Hesitancy (yes)	0.009	0.031	0.003	0.295	0.768	1.042

$R^2 = 0.488$, adjusted $R^2 = 0.487$, $F = 456.289$, $p < 0.001$. Variable coding: Grade (postgraduate = 1, associate degree or undergraduate = 0), major (medical = 1, non-medical = 0), Economic status (other = 1, parental support = 0), hesitancy (yes = 1, no = 0).

effect modification ($p = 0.008$). In the low-trust group, high price dramatically increased hesitancy (78.5% vs. 54.3%, $p < 0.001$). In the high-trust group, the price effect was negligible (35.6% vs. 30.1%, $p = 0.12$). This pattern reveals trust's buffering role against price barriers.

3.10 Decision tree: high-risk group identification

The CART decision tree model (self-payment hesitancy as outcome) achieved 78.3% overall prediction accuracy and an area under the ROC curve of 0.81, indicating good discriminative performance. The model generated five high-risk rules covering 68.7% of hesitant individuals (Figure 4). Rule 1 (Distrust + High price) emerged as the core high-risk profile, with 78.5% hesitancy, accounting for 32.4% of all hesitant participants. Rules 2–5 further stratified risk by grade, acceptable price, major, income source, and age. Refer to Table 7.

3.11 Mediation analysis

Bootstrap mediation analysis (5,000 resamples) showed that trust in domestic bivalent vaccine partially mediated the relationship between income source and hesitancy (indirect effect = -0.009 ; 95% CI: -0.013 to -0.005). The path diagram is provided in Supplementary Figure S1.

3.12 Paradoxical finding: higher trust among hesitant individuals

Contrary to expectation, participants who reported self-payment hesitancy ($n = 1,494$, 34.5%) showed slightly but significantly higher

trust in healthcare professionals than non-hesitant participants (mean 3.98 vs. 3.72, Cohen's $d = 0.30$, $p < 0.001$). This pattern was consistent across all four trust measures, with effect sizes ranging from $d = 0.28$ to 0.35 (all $p < 0.001$). Notably, 24.7% of hesitant participants rated themselves as “very trusting” in healthcare professionals, compared to 18.2% of non-hesitant participants ($\chi^2 = 23.45$, $p < 0.001$). Detailed comparisons are presented in Supplementary Table S2. This counterintuitive finding is further interpreted in the Discussion (Section 4.1).

4 Discussion

4.1 Trust as core driver: beyond information to relationship

Our findings underscore trust, particularly in healthcare professionals, as the strongest predictor of HPV vaccination intention among FCSs, with a clear dose–response gradient. This aligns with the 3C model's emphasis on “confidence” and extends prior HBM-based work by isolating trust's unique contribution (17). The strong intercorrelations among trust in healthcare professionals, imported vaccines, and domestic vaccines suggest a holistic “vaccine trust” construct, consistent with trust transfer theory (18): credibility attributed to authoritative sources (medical professionals) generalizes to the products they endorse, reducing perceived risk (19). The clinical relevance of trust extends beyond intention to actual uptake: vaccinated participants in our sample reported

TABLE 5 Logistic regression: self-payment hesitancy.

Variable	B	SE	Wald	p	OR	95% CI
Age	−0.102	0.010	95.17	<0.001	0.903	0.885–0.922
Imported vaccine trust	0.077	0.025	9.18	0.002	1.080	1.028–1.135
Non-parental income	−0.172	0.071	5.93	0.015	0.842	0.733–0.967
Constant	1.426	0.259	30.28	<0.001	4.161	—

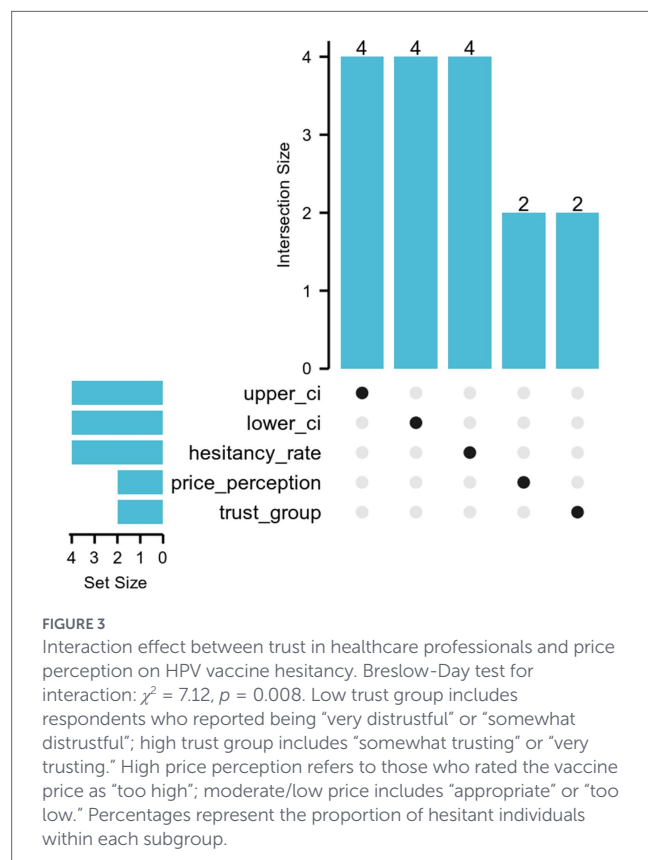
−2LL = 5032.45; Nagelkerke $R^2 = 0.048$; model $\chi^2 = 153.62$, $p < 0.001$.

TABLE 6 Reasons for HPV vaccine hesitancy (multiple responses).

Reason	Responses (N)	Case %
Vaccine price too high	2,314	53.5
Fear of side effects	2,280	52.7
Lack of vaccine knowledge	2004	46.3
Inconvenient appointment procedures	1917	44.3
Vaccine not widely available	1763	40.8
Believe cervical cancer risk is low	1744	40.3
Doubt vaccine's cancer prevention ability	1,661	38.4
Lack of family/friend support	1,468	33.9
Fear of injection pain	1,373	31.7
Other	889	20.6
Total	17,413	402.5*

*Total exceeds 100% due to multiple responses; average 4.0 reasons per person.

substantially higher trust across all measures (Cohen's $d = 0.45$ – 0.58) and much lower self-payment hesitancy (18.3% vs. 88.1%) compared to unvaccinated peers (Supplementary Table S1).



A counterintuitive finding also emerged: we observed that hesitant participants reported slightly higher trust scores than non-hesitant participants (Supplementary Table S2). We propose an “information overload with overcaution” hypothesis: these individuals may engage deeply with vaccine information, scrutinizing safety data, following media reports, yet become paralyzed by conflicting details or confirmation bias, focusing on rare adverse events. Their questionnaire responses may reflect cognitive recognition of vaccine benefits (“I know it’s safe”), while emotional or intuitive processing fuels hesitancy (20). This suggests that effective health communication must not only provide information but also help audiences integrate it, avoiding decision paralysis (21). Notably, many participants expressed confusion in open-ended comments despite trusting their doctors, highlighting that trust alone may be insufficient in the face of information overload (22).

4.2 Trust buffers price: a prospect theory interpretation

Price ranked as the most frequently cited barrier (53.5%), yet our interaction analysis revealed that high trust nullifies price concerns. This buffering effect, first demonstrated here for HPV vaccine hesitancy, aligns with prospect theory (20): under uncertainty, individuals weigh potential losses more heavily than gains. For those with low trust, vaccine cost represents a certain immediate loss, while future health benefits remain uncertain, making price paramount. High trust reframes the decision: non-vaccination becomes a potential loss (future cancer risk), while vaccination offers certain gain (reduced worry, protection) (23). Trust thus shifts focus from present cost to future benefit.

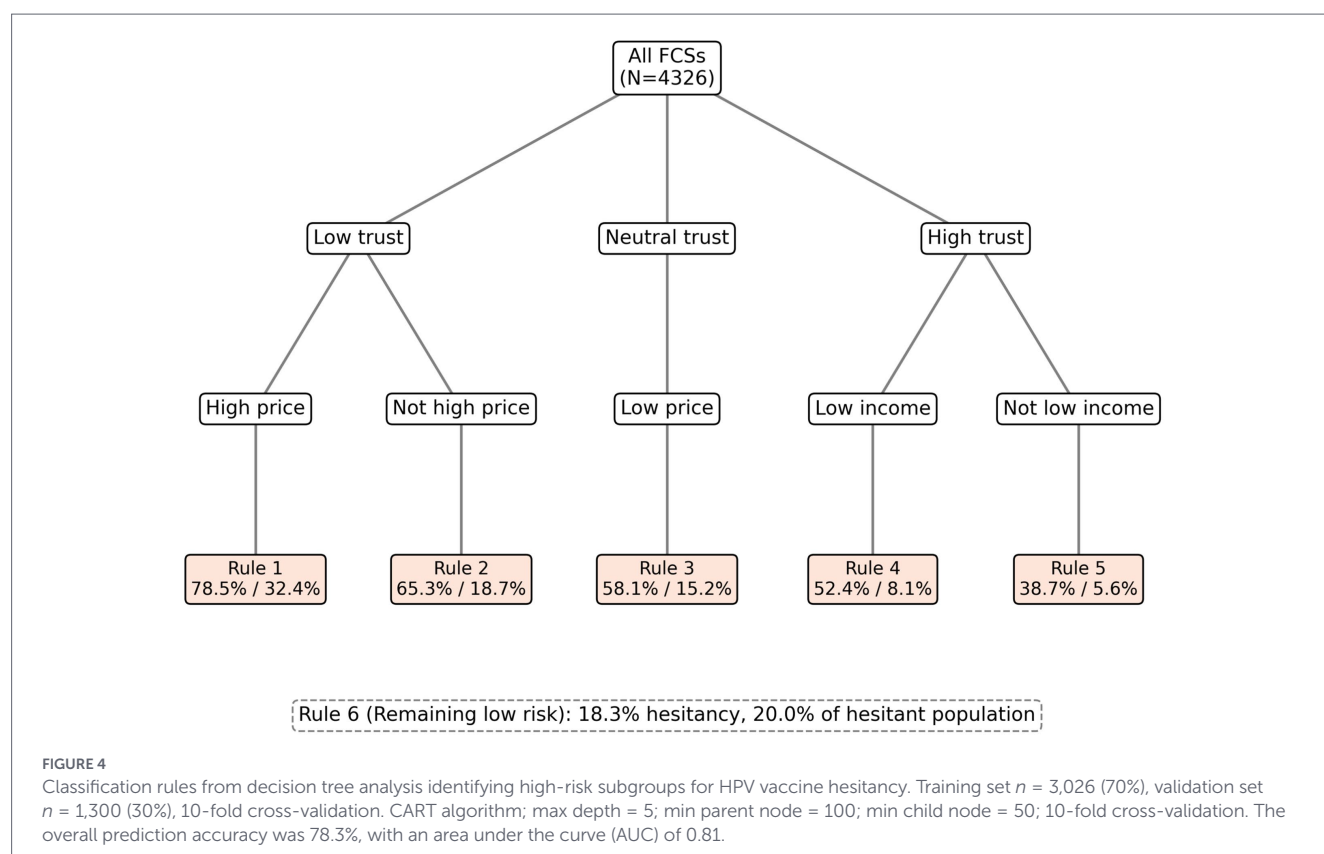


TABLE 7 High-risk subgroups identified by CART decision tree analysis for HPV vaccine hesitancy.

Rule	Subgroup definition	N	Hesitancy rate (%)	All hesitant individuals (%)
Rule 1	Low trust + High price	815	78.5	32.4
Rule 2	Low trust + Not high price + Junior grade	312	62.3	12.1
Rule 3	Neutral trust + Low price + Non-medical major	428	54.1	14.3
Rule 4	High trust + Low income (non-parental support)	267	51.9	8.7
Rule 5	High trust + Parental support + Age < 22 years	356	48.6	10.6
Others	All remaining combinations	2,148	18.4	21.9
Total		4,326	34.5	100.0

Low trust = scores 1–2; neutral trust = score 3; high trust = scores 4–5. High price = perceived vaccine price as “too high”; junior grade = associate degree or undergraduate years 1–2.

This insight carries practical weight: in resource-constrained settings where blanket price reductions are infeasible, investments in trust-building (provider communication, transparency about safety data) may yield disproportionate returns by attenuating price sensitivity. Trust cultivation operates as a “leverage point,” amplifying the impact of any subsequent financial support. This study finds it encouraging that even modest trust-building efforts could help bridge the equity gap in vaccine access.

4.3 Multidimensional barriers and the “medical student paradox”

The top three hesitancy reasons mapped cleanly onto the 3C model: price (convenience), side effect concerns (confidence), and limited knowledge (confidence/complacency). This supports the 3C framework’s validity in this population and implies that interventions must address all three dimensions synergistically.

The finding that medical students showed lower intention than non-medical peers, dubbed the “medical student paradox” merits reflection. Further analysis revealed that medical students showed comparable trust in imported vaccines but significantly lower trust in domestic bivalent vaccine, suggesting skepticism specifically toward domestically manufactured products, possibly due to heightened awareness of past vaccine safety incidents (e.g., 2018 Changsheng scandal) amplified by medical training. Open-ended comments from medical students frequently cited “rare adverse effects reported in journals” and “incomplete long-term safety data” rather than general concerns about injection pain or immediate reactions. Medical training may foster critical thinking that, without balanced risk communication, tilts toward excessive skepticism. Greater awareness of rare adverse effects, unaccompanied by training in evidence synthesis, may amplify perceived risks. This echoes the “knowledge–attitude–practice” gap: knowing more does not automatically translate into favorable attitudes or actions (24). For future healthcare workers, curricula should explicitly address vaccine risk communication and evidence-based decision-making. As educators, we see this as both a challenge and an opportunity: if we can equip medical students with skills to navigate uncertainty, they will become powerful advocates for vaccination in their communities (25).

4.4 From data to action: stratified intervention strategies

The decision tree’s identification of five distinct high-risk (Rule 1–5) profiles enables precision health promotion. Rather

than one-size-fits-all messaging, interventions can be tailored to each subgroup’s specific barriers, guided by the 3C dimensions. We can start with rule 1 (highest priority) for a pilot, and then scale it to the other four high-risk groups after evaluation, to ensure efficient use of limited resources. Partnerships with university clinics, student affairs, and local CDC offices can sustain these efforts. We hope that by treating students not as a homogeneous mass but as individuals with unique concerns, we can foster a culture of trust that extends beyond HPV vaccination to other health behaviors.

Rule 1 (Distrust + High price): This core high-risk group (32.4% of hesitant individuals) requires intensive, two-pronged intervention. Build trust through one-on-one consultations with senior clinicians (gynecology, infectious disease) who can address safety concerns authoritatively. Address cost through targeted subsidies or payment plans (26). Trust-building should precede financial discussion, leveraging the buffering effect we documented (27).

Rule 2 (Distrust + Not high price+ Junior): For younger students whose hesitancy stems primarily from distrust, early intervention in orientation programs, “Trust First” modules delivered by trusted healthcare professionals, can prevent skepticism from hardening. Peer-led question and answer sessions may also resonate (28).

Rule 3 (Neutral trust + Low price + Non-medical): This group combines cost concerns with potential information gaps. Peer education by medical students (using accessible language, infographics) can address knowledge barriers, while scholarships or subsidies ease financial strain (29).

Rule 4 (High trust +Low income): Trust is already established; the bottleneck is affordability. Streamlined access to subsidies, insurance education, and clear communication about reimbursement procedures can convert willingness into action.

Rule 5 (High trust + Parent support + Under the age of 22): Young students reliant on parents may need family-level engagement. Personalized risk calculators (showing individualized cervical cancer risk based on age, family history) can increase perceived susceptibility, countering complacency (30). Inviting parents to educational sessions extends trust to the family unit (31).

For the remaining participants (Low-risk group): Ongoing science communication, digital literacy campaigns, streamlined appointment systems, and rapid rumor debunking can create a supportive environment for all students (32, 33). These efforts address the “information overload” challenge by curating trusted, synthesized content.

Beyond subgroup-specific strategies, our findings support a dual-principle approach for university health services: invest in trust-building as a foundational lever that reduces price sensitivity, and provide targeted financial support for low-trust subgroups. Additionally, catchup campaigns should prioritize students aged ≥ 26 years, who showed markedly higher hesitancy (52–56%).

4.5 Theoretical contributions

This study advances theory in three ways: It validates the 3C model's applicability to HPV vaccine hesitancy among FCSs, refining "confidence" into multi-source trust (healthcare professionals, domestic/imported vaccines) and revealing trust's "spillover" across sources. The study also updates the contextual framework by referencing the WHO Immunization Agenda 2031 and the 2025 progress report on the Global Strategy for Cervical Cancer Elimination, aligning findings with contemporary global priorities. Additionally, this study demonstrates trust's buffering effect on price barriers, offering a prospect theory-based explanation that enriches behavioral decision frameworks (27, 34). By shifting from variable-centered to person-centered analysis via decision tree modeling, it identifies actionable subgroups, demonstrating methodological innovation for precision intervention design.

4.6 Limitations and future directions

Several limitations warrant acknowledgment. The cross-sectional design precludes causal inference. Unmeasured confounders, such as sexual history, parental education and attitudes, or social media exposure may influence both trust and intention. Future longitudinal or experimental studies are needed to establish causality. Self-report measures may be subject to social desirability bias, potentially overestimating intention. Linkage with actual vaccination records would strengthen validity. Some multi-category variables were collapsed due to low cell counts, possibly losing nuance. The convenience sampling, while yielding a large sample from 12 provinces, primarily covered universities in provincial capitals or developed prefectures, with underrepresentation of Western provinces and remote rural areas. Therefore, our findings are most directly applicable to FCSs in relatively well-resourced university settings; generalizability to more resource-limited regions should be made with caution. The high vaccination rate (76.8%) in our sample suggests possible selection bias toward more health-engaged students, potentially underestimating true hesitancy prevalence in the general FCS population.

Future research should employ longitudinal designs or community-based trials to track trust-behavior relationships over time. Qualitative interviews could illuminate the psychological processes behind the "information overload with overcaution" pattern we observed. Digital health interventions, using algorithms to match individuals' risk profiles with tailored educational content, hold promise and merit rigorous evaluation. Incorporating more comprehensive measures—such as social media vaccine information exposure scales and parental vaccine attitude assessments—could yield fuller predictive models.

Given the analogous roles of trust, perceived barriers, and health communication across preventive behaviors, the 3C model and decision-tree approach developed here may also be transferable to screening for other female conditions. In China, cervical and breast cancer screening are jointly promoted under the national "Free Two-Cancer Screening – Double Ribbon Action" (免费两癌筛查-双丝带行动) program, which faces comparable challenges in public awareness, healthcare provider trust, and service accessibility. Extending our analytical framework to this broader screening context could help identify high-risk subgroups and inform stratified interventions to improve uptake. Despite these limitations, we believe our findings offer a compelling, human-centered perspective on vaccine decision-making. The FCSs who participated in this study shared their hopes, fears, and uncertainties with us; these findings underscore the importance of translating participant insights into targeted interventions.

5 Conclusion

This study confirms the 3C model's utility in understanding HPV vaccine hesitancy among FCSs and provides the first evidence that trust can buffer price-related barriers. Trust, especially in healthcare professionals, emerges as the dominant driver of intention, exhibiting a dose-response relationship. Decision tree analysis identified several high-risk profiles, with "Distrust + High price" being the most critical. These findings support a shift from generic messaging to stratified, precision interventions that address the specific barrier configurations of each subgroup. By integrating trust-building with targeted financial support and broad health education, such approaches hold promise for reducing hesitancy and advancing progress toward cervical cancer elimination goals.

Data availability statement

The original contributions presented in the study are included in the article/[Supplementary material](#), further inquiries can be directed to the corresponding authors.

Ethics statement

This study was conducted in accordance with the Declaration of Helsinki. Ethical approval was obtained from the Ethics Committee of Shenzhen Pingshan District Central Hospital. Written informed consent was obtained from all participants. All methods were carried out in accordance with relevant guidelines and regulations. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

YZ: Writing – original draft, Funding acquisition, Investigation, Writing – review & editing, Conceptualization. JZ: Writing – original draft, Investigation, Funding acquisition. MW: Writing – review & editing, Project administration, Formal analysis, Validation. QL: Writing – review & editing, Data curation, Formal analysis. WS: Investigation, Writing – review & editing, Data curation. YS: Methodology, Data curation, Investigation, Writing – review & editing. KZ: Writing – original draft, Formal analysis, Data curation. XW: Writing – original draft, Data curation, Investigation. BP: Supervision, Project administration, Writing – review & editing. WC: Supervision, Writing – review & editing, Conceptualization, Funding acquisition.

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References

1. Singh D, Vignat J, Lorenzoni V, Esfahani M, Ginsburg O, Lauby-Secretan B, et al. Global estimates of incidence and mortality of cervical cancer in 2020: a baseline analysis of the WHO global cervical Cancer elimination initiative. *Lancet Glob Health*. (2023) 11:e197–206. doi: 10.1016/S2214-109X(22)00501-0
2. Ren W, Guo X, Liu Z, Wu Y, Peng R, Liu H, et al. Burden of female-specific cancers in China from 1990 to 2021: a systematic analysis for the global burden of disease study 2021. *Cancer*. (2025) 131:e35712. doi: 10.1002/cncr.35712
3. Moosa-Bathey R, Masuku P, Mayimele N. Human papillomavirus (HPV) as the main cause of cervical and other related cancers: a review. *SA Pharm J*. (2025) 92:58–62. doi: 10.36303/sapj.1164
4. Chidebe RC, Osayi A, Torode JS. The Global Fund, cervical cancer, and HPV infections: what can low and middle-income countries do to accelerate progress by 2030? *EClinicalMedicine*. (2030) 81:1–8. doi: 10.1016/j.eclinm.2025.103127
5. Dempsey RC, Wood AM. Perceived social norms and vaccine hesitancy. *Curr Dir Psychol Sci*. (2025) 34:357–64. doi: 10.1177/09637214251340023
6. Lee M, Gerend MA, Whittington KD, Collins SK, McKinney SL, Franca MC, et al. Factors associated with HPV-associated sexual risk behaviors among sexually active college students. *J Behav Med*. (2024) 47:334–41. doi: 10.1007/s10865-023-00463-1
7. Huang Y, Chen C, Wang L, Wu H, Chen T, Zhang L. HPV vaccine hesitancy and influencing factors among university students in China: a cross-sectional survey based on the 3Cs model. *Int J Environ Res Public Health*. (2022) 19:14025. doi: 10.3390/ijerph192114025
8. Alizadeh L, Keshavarz Z, Shalbaf A, Iranpour S. Iranian women's perceptions of human papillomavirus and barriers to vaccination: a qualitative study based on the health belief model. *BMC Public Health*. (2025) 26:1–11. doi: 10.1186/s12889-025-25583-y
9. Chen C, Chen T, Huang M, Huang Y, Zhang L, Li P. Factors associated with HPV vaccine hesitancy among college students: a cross-sectional survey based on 3Cs and structural equation model in China. *Hum Vaccin Immunother*. (2024) 20:2309731. doi: 10.1080/21645515.2024.2309731

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The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpubh.2026.1848085/full#supplementary-material>

10. Marshall S, Fleming A, Sahm LJ, Moore AC. Identifying intervention strategies to improve HPV vaccine decision-making using behaviour change theory. *Vaccine*. (2023) 41:1368–77. doi: 10.1016/j.vaccine.2023.01.025
11. Dong B, Xu H, Qi Y, Li Y. Understanding vaccine hesitancy through the lens of trust and the 3C model: evidence from Chinese general social survey 2021. *Front Public Health*. (2025) 13:1671457. doi: 10.3389/fpubh.2025.1671457
12. Ma J, Lu W, Sun S, Zhan Y, Zhang J, Zhang H. The influencing factors in intention making-decision of human papillomavirus vaccine in Chinese college students: a qualitative study. *Patient Educ Couns*. (2025) 131:108594. doi: 10.1016/j.pec.2024.108594
13. Salleh NS, Abdullah KL, Chow HY. Cultural barriers and facilitators of the parents for human papillomavirus (HPV) vaccination uptake by their daughters: a systematic review. *J Pediatr*. (2025) 101:133–49. doi: 10.1016/j.jpeds.2024.07.012
14. Lu Y, Tang C, Xu S, Hussain I, Zhao W, Dong Y, et al. Understanding parental HPV vaccination decision in China through the lens of vaccine hesitancy and preference heterogeneity: a discrete choice experiment. *Vaccine*. (2026) 76:128307. doi: 10.1016/j.vaccine.2026.128307
15. Zhuang Y, Kwang Cheol K, Botabara-Yap MJ, Zhao K, Ramos RIA, Cao W. Factors associated with reproductive health and health education participation among female college students in China. *Front Public Health*. (2025) 13:1627669. doi: 10.3389/fpubh.2025.1627669
16. Jiang N., Zhang K., Wu M., Song X., Sun W., Wang M., et al. Exploring the use of the 3C model in the context of HPV vaccine hesitancy in women of childbearing age. *Infect Dis Res Учредители: TMR Publishing Group*. (2025) 6:3. doi: 10.53388/IDR2025003.
17. Roy M. From theory to practice: mapping the implementation of the health belief model (HBM) in health-seeking behavior research among black populations in the US. *Rev Commun*. (2026) 26:96–110. doi: 10.1080/15358593.2026.2616605
18. Martinelli M, Veltri GA. Shared understandings of vaccine hesitancy: how perceived risk and trust in vaccination frame individuals' vaccine acceptance. *PLoS One*. (2022) 17:e0276519. doi: 10.1371/journal.pone.0276519
19. Chen X, Wang L, Huang Y, Zhang L. Risk perception and trust in the relationship between knowledge and HPV vaccine hesitancy among female university students in China: a cross-sectional study. *BMC Public Health*. (2024) 24:667. doi: 10.1186/s12889-024-18166-w
20. Burton-Jeangros C. "Anxiety, fear, and panic: the role of emotions in prevention". In: *Experiences of Health Risks: Prevention, Power Dynamics and Inequalities*. Berlin, Germany: Springer (2025). p. 53–92.
21. Bauder L, Giangobbe K, Asgary R. Barriers and gaps in effective health communication at both public health and healthcare delivery levels during epidemics and pandemics; systematic review. *Disaster Med Public Health Prep*. (2023) 17:e395. doi: 10.1017/dmp.2023.61
22. Shukla AD, Goh JM, Agarwal L. The illusion of trust and the paradox of disclosure: how fake physician reviews exploit privacy concerns. *Internet Res*. (2025). doi: 10.1108/intr-01-2024-0042
23. Andigema AS, Olive DPA Vaccine hesitancy as a systems-level vulnerability: historical evolution, sociopolitical drivers, and implications for immunization resilience (2026). doi: 10.20944/preprints202603.0505.v1
24. Anni NS, Rehman N, Nyambi A, Musiwa A, Graham T, Dine RD, et al. Knowledge, attitudes, and practices towards human papilloma virus and uptake of HPV vaccine: a protocol for a systematic review. *PLoS One*. (2024) 19:e0313887. doi: 10.1371/journal.pone.0313887
25. Murciano-Gamborino C, Pérez-Breva L, Díez-Domingo J, Fons-Martínez J. Promoting HPV vaccination in culturally diverse populations: a reflexive tool for health-care professionals. *Open Res Eur*. (2025) 5:381. doi: 10.12688/openreseurope.21810.1
26. You T, Zhao X, Pan C, Gao M, Hu S, Liu Y, et al. Informing HPV vaccine pricing for government-funded vaccination in mainland China: a modelling study. *Lancet Reg Health West Pac*. (2024) 52:1–24. doi: 10.1016/j.lanwpc.2024.101209
27. Zimmerman AL Modelling the impacts of trust, behaviour, and social determinants of health on HPV vaccination: a simulation study (2025). Available online at: <https://hdl.handle.net/10388/17200>
28. Lindsay AC, Antunes CV, Pires AG, Pereira M, Nogueira DL. Social ecological influences on HPV vaccination among cape Verdean immigrants in the US: a qualitative study. *Vaccine*. (2025) 13:713. doi: 10.3390/vaccines13070713
29. Malik S, Mock KO, Martillotti R, Caravella G, Zhou X, Mbamelu M, et al. HPV vaccines among university students: understanding barriers and facilitators of vaccine uptake. *Vaccine*. (2024) 12:1385. doi: 10.3390/vaccines12121385
30. Curzons S The emotional impact of testing positive for high-risk HPV: an exploration of Cis-women's experiences following a positive test result in the UK (2025). Available online at: <https://uhra.herts.ac.uk/id/eprint/16743/>
31. Çevik HS, Amariutei A, Mazur A, Peker GC, Görpeliöğlu S, Vinker S, et al. Unlocking the key to HPV prevention: exploring factors influencing HPV vaccination decisions among young people and their parents. *Public Health*. (2025) 238:214–20. doi: 10.1016/j.puhe.2024.12.016
32. Anderson A A scientific literature review: public health messaging and social marketing of the HPV vaccine (2025) 1–9. Available online at: https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=A+scientific+literature+review%3A+public+health+messaging+and+social+market%02ing+of+the+HPV+vaccine&btnG=
33. Sood RA, Carpo BG, Leheste JR, Carpo B. Bridging the gap: enhancing HPV (human papillomavirus) education to combat rising cancer rates. *Cureus*. (2024) 16. doi: 10.7759/cureus.74023
34. Olusanya OA, Tomar A, Thomas J, Alonge K, Wigfall LT. Application of the theoretical domains framework to identify factors influencing catch-up HPV vaccinations among male college students in the United States: a review of evidence and recommendations. *Vaccine*. (2023) 41:3564–76. doi: 10.1016/j.vaccine.2023.04.071

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