Universidade do Minho
Escola de Psicologia

Cláudia Alexandra Castro Dias

Mother's prenatal and postpartum depression and infant's sleep problems during the first six months of infant's life

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Doctoral thesis
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Supervised by
Professora Doutora Bárbara Figueiredo

April, 2020

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I hereby declare having conducted my dissertation with integrity. I confirm that I have not used plagiarism or any form of undue use of information or falsification of results along the process leading to its elaboration.

I further declare that I have fully acknowledged the Code of Ethical Conduct of the University of Minho.

DEPRESSÃO MATERNA PRÉ E PÓS-NATAL E PROBLEMAS DE SONO DO BEBÉ NOS PRIMEIROS SEIS MESES DE VIDA

Resumo

A psicopatologia do desenvolvimento defende que o desenvolvimento normativo do bebé resulta da adequada resolução de tarefas desenvolvimentais. Variáveis dos pais e do bebé podem interferir na resolução das tarefas desenvolvimentais do sono, colocando o bebé em risco de problemas de sono. A sintomatologia depressiva materna foi associada aos problemas de sono do bebé em estudos separados. Diferentes resultados foram reportados na direção desta associação e só recentemente se exploraram as potenciais influências bidirecionais. O sexo e o temperamento do bebé exercem um papel essencial na associação entre a sintomatologia depressiva materna e os problemas de sono do bebé. Esta tese pretendeu explorar os efeitos entre a sintomatologia depressiva materna pré-natal e pós-parto e os problemas de sono do bebé nos primeiros seis meses. Os objetivos específicos incluíram (1) analisar os efeitos da sintomatologia depressiva materna pré-natal e pós-parto nos problemas de sono do bebé aos seis meses; (2) explorar os efeitos unidirecionais e bidirecionais entre a sintomatologia depressiva materna e os problemas de sono do bebé; (3) analisar o papel moderador do sexo do bebé nos efeitos unidirecionais e bidirecionais entre a sintomatologia depressiva materna e os problemas de sono do bebé; e (4) analisar o papel mediador do temperamento às duas semanas no efeito da sintomatologia depressiva materna pré-natal nos problemas de sono dos rapazes. Esta tese foi composta por seis artigos. Os resultados revelaram (1) o efeito negativo da sintomatologia depressiva pré-natal e pós-parto nos problemas de sono do bebé; (2) efeitos unidirecionais e bidirecionais entre a sintomatologia depressiva materna e os problemas de sono do bebé; (3) o papel moderador do sexo do bebé nos efeitos unidirecionais e bidirecionais entre a sintomatologia depressiva materna e os problemas de sono do bebé; e (4) a afetividade negativa às duas semanas medeia os efeitos da sintomatologia depressiva materna pré-natal nos problemas de sono dos rapazes. A sintomatologia depressiva materna pré-natal tem um efeito principal nos problemas de sono do bebé, mas influências mútuas ocorrem no pós-parto. Os rapazes são mais vulneráveis aos efeitos da depressão da mãe e as mães são mais vulneráveis aos efeitos dos problemas de sono dos rapazes. Este efeito diferencial pode ser explicado pelo efeito da sintomatologia depressiva materna pré-natal na afetividade negativa dos rapazes que, por sua vez, causa mais problemas de sono.

Palavras-chaves: sintomatologia depressiva pré-natal; sintomatologia depressiva pós-parto; problemas de sono; sexo; temperamento.

MOTHER'S PRENATAL AND POSTPARTUM DEPRESSION AND INFANT'S SLEEP PROBLEMS DURING THE FIRST SIX MONTHS OF INFANT'S LIFE

Abstract

The developmental psychopathology conceptual model argues that infant's normative development results from the adequate accomplishment of the developmental tasks. Different parental and infant's variables may interfere with the adequate accomplishment of the sleep developmental tasks, putting the infant at risk for sleep problems. Mother's depression symptoms were associated with infant's sleep problems in separate studies. Different findings were reported on the direction of this association and the potential bidirectional influences were only recently explored. Infant's sex and temperament were shown to play a major role on the association between mother's depression symptoms and infant's sleep problems. This thesis aimed to explore the effects between mother's prenatal and postpartum depression symptoms and infant's sleep problems during the first six months of infant's life. The specific objectives comprised: (1) to analyze the effects of mother's prenatal and postpartum depression symptoms on infant's sleep problems during the first six months of life; (2) to explore the unidirectional and bidirectional links between mother's depression symptoms and infant's sleep problems; (3) to analyze the moderator role of infant's sex on the unidirectional and bidirectional links between mother's depression symptoms and infant's sleep problems; and (4) to analyze the mediator effect of infant's temperament at two weeks on the effects of mother's prenatal depression symptoms on infant's sleep problems specifically in boys. This thesis was comprised by six papers. Findings revealed (1) mother's prenatal and early postpartum depression symptoms have a negative effect on infant's sleep problems; (2) both unidirectional and bidirectional effects between mother's depression symptoms and infant's sleep problems; (3) the moderator role of infant's sex on the effects between mother's depression symptoms and infant's sleep problems; and (4) infant's negative affectivity at two weeks mediates the effects of mother's prenatal depression symptoms on infant's sleep problems at six months in boys. Mother's prenatal depression symptoms have a major effect on infant's sleep problems, but mutual influences also occur during postpartum. Boys are more vulnerable to the effects of mother's depression symptoms and mothers are more vulnerable to the effects of their boys' sleep problems. This differential impact may be explained by the effects of mother's prenatal depression symptoms on boys' negative affectivity, which leads to more sleep problems.

Key words: infant's sex; prenatal depression symptoms; postpartum depression symptoms; sleep problems; temperament

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ABBREVIATIONS

A – Actigraphy

BISQ – Brief Infant Sleep Questionnaire

BT – Bedtime

CFI – Comparative Fit Index

CS – Cross-sectional

CSHQ-I – Children's Sleep Habits Questionnaire – Infant Version

CSHQ – Children's Sleep Habits Questionnaire

D – Diary

DV – Dependent Variable

EEG – Electro encephalography

EPDS – Edinburgh Postnatal Depression Scale

I – Interview

IBQ-R – Infant Behavior Questionnaire – Revised

ISC – Item-Subscale Correlation

ISD – If Scale Deleted

ISQ – Infant Sleep Questionnaire

IV – Independent Variable

L - Longitudinal

LSP – Longest sleep period

M – Mean

MANOVA – Multivariate Analyses of Variance

MIC – Mean Item Correlation

MMS – Motility Monitor System

MSC – Mean Scale Correlation

NS – Not Specified

NW – Night wakings

O – Observation

P – Polysmonogrpahy

PRISMA - Preferred Reporting Items for Systematic Reviews and Meta-Analysis

R^2Aj – Adjusted R^2;

R^2Ch – R^2 change

RMSEA – Root Mean Square Error of Approximation

SD – Sleep duration

SDC – Scale-Dimension Correlation

SE – Sleep efficiency

SEM – Structural Equation Modeling

SL – Sleep latency

SP – Sleep periods

Q – Questionnaire

V – Video recording

WASO – Wake After Sleep Onset

WT – Wake Time

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PUBLICATIONS LIST OF THE DISSERTATION

This doctoral thesis was based on the following original publications:

I. Dias, C. C., Figueiredo, B., Rocha, M., & Field, T. (2018). Reference values and changes in infant sleep-wake behavior during the first 12 months of life: a systematic review. *Journal of Sleep Research, 27*, e12654-e12667. doi: 10.1111/jsr.12654

II. Dias, C. C., & Figueiredo, B. (2019). Sleep-wake behavior during the first 12 months of life and associated factors: a systematic review. *Early Child Development and* Care, *online publication before print*. doi: 10.1080/03004430.2019.1582034

III. Dias, C. C., Costa, R., Pinto, T. M., & Figueiredo, B. (under review). The Infant Behavior Questionnaire – Revised from two weeks to 12 months of infant's life. *Early Human Development*

IV. Dias, C. C., & Figueiredo, B. (2020). Mother's prenatal and postpartum depression symptoms and infant's sleep problems at six months. *Infant Mental Health Journal, in press*

V. Dias, C. C., & Figueiredo, B. (under review). Unidirectional and bidirectional links between mother's depression symptoms and infant's sleep problems. *Journal of Affective Disorders*

VI. Dias, C. C., & Figueiredo, B. (under review). Infant's temperament mediates mother's prenatal depression symptoms effects on boys' sleep problems. *Development and Psychopathology*

INTRODUCTION

The introduction section of this doctoral thesis aims to present a closer look on the literature analyzing the links between mother's prenatal and postpartum depression symptoms and infant's sleep problems. This section provides an overview on the infant's sleep-wake behavior and sleep problems during the first year of infant's life, also presenting the parent and infant's variables that are associated with infant's sleep problems during this period.

The first part of the introduction comprises an overview on infant's sleep-wake behavior and infant's sleep problems in the first year of infant's life. The variables most consistently associated with infant's sleep wake-behavior and sleep problems during the first year of life are reviewed. Prevalence rates and the questionnaires available in the literature to assess infant's sleep problems are also presented. The implications of infant's sleep problems for infant's further development and for the family functioning were discussed.

The second part of the introduction section explores the links between mother's prenatal and postpartum depression symptoms and infant's sleep problems. A review of the literature is presented regarding the studies showing (1) an association between mother's prenatal depression symptoms and infant's sleep problems; (2) an association between mother's postpartum depression symptoms and infant's sleep problems; (3) an association between both mother's prenatal and postpartum depression symptoms and infant's sleep problems; and (4) an association between infant's sleep problems and mother's postpartum depression symptoms. The bidirectional links between mother's depression symptoms and infant's sleep problems are also explored. In this part we also reviewed the major role of infant's sex and temperament on the links between mother's prenatal and postpartum depression symptoms and infant's sleep problems. The differential impact of mother's depression symptoms on infant's sleep problems on boys (*versus* girls) and on infants with difficult (*versus* easy) temperament is reviewed.

1.1. Infant's sleep problems

Sleep has been recognized as an essential component of the individual's health and well-being (Matricciani, Olds, Blunden, Rigney, & Williams, 2012; Mukherjee et al., 2015; Watson et al., 2015). Across the life span, sleep-wake behavior change, with the most rapid and significant changes being reported to occur during the first year of life and slighter changes being identified later on (e.g., Bruni et al., 2014; Galland, Taylor, Elder, & Herbison, 2012; Teng, Bartle, Sadeh, & Mindell, 2012). At birth, infants spend most of their time sleeping, presenting short sleep periods over the day and the night (Galland et al., 2012; Meltzer & Mindell, 2006; Sadeh, 2000). Across the first year of life, the sleep hours during the 24-hour period were reported to decrease, with a significant decrease on the sleep hours and sleep periods during the day (e.g., Figueiredo, Dias, Pinto, & Field, 2016; Galland et al., 2012; Iglowstein, Jenni, Molinari, & Largo, 2003). Progressively, the sleep hours during the night increase and night wakings decrease, with the infant being able to sleep more and during longer periods during the night (e.g., Figueiredo et al., 2016; Henderson, France, Owens, & Blampied, 2010; Iglowstein et al., 2003).

These changes result from different and interactive biological, psychosocial, and physiological mechanisms, that help the infants to regulate and consolidate their sleep-wake behavior (Jenni & Carskadom, 2007; Sadeh, 2000; Sadeh & Anders, 1993). Consolidation and regulation of the infant's sleep-wake behavior comprise two major and interactive biopsychosocial processes occurring during the first year of life (Goodlin-Jones, Burnham, Gaylor, & Anders, 2001; Sadeh, 2000; Sadeh & Anders, 1993). While consolidation of sleep-wake behavior refers to the process of sustaining continuous periods of sleep, regulation of sleep-wake behavior refers to the process of easily transitioning from an alert state to a sleep state (Sadeh & Anders, 1993). Circadian and homeostatic processes and social interactions were shown to be involved in the consolidation and regulation of infant's sleep-wake behavior (Jenni & Carskadom, 2007; Sadeh, 2000; Sadeh & Anders, 1993). The regulation and consolidation of sleep-wake behavior have been described as early markers of infant's neurobehavioral maturation, leading to infant's biopsychosocial adaption (Sadeh & Anders, 1993). Difficulties in the regulation and consolidation of sleep-wake behavior may, on its turn, put the infant at risk for the emergence of sleep problems (Sadeh & Anders, 1993).

The emergence of infant's sleep problems may be understood under the framework of the developmental psychopathology conceptual model. The developmental psychopathology conceptual model addresses the adaptive and maladaptive development across the life span (Rutter, 1996; Sroufe, 2009; 2016). In order to identify maladapted patterns of development, it is necessary to firstly understand normal development (Cicchetti, 1993). The identification of the non-normative or problematic patterns of development may be obtained through the comparison with a normative developmental pattern (Sroufe & Rutter, 2000). Normative *versus* non-normative development results from the adequate *versus* non-adequate accomplishment of different tasks across the life span (e.g., Rutter, 1996). Infants are expected to achieve different sleep developmental tasks across the first year of life, including (1) to spend more time awake than asleep, (2) to concentrate sleep time during the night, (3) to self-sooth, and (4) to sleep through the night (Figueiredo et al., 2016; Galland et al., 2012; Goodlin-Jones et al., 2001). The accomplishment of these sleep developmental tasks may result in an adjusted development, while its failure may put the infant at risk for the emergence of sleep problems (Byars et al., 2012; Henderson et al., 2010; Sette, Baumgartner, Ferri, & Bruni, 2017).

The first sleep developmental task – spend more time awake than asleep – is related to the significant reduction on the infant's sleep needs over the first year (Sadeh, 2000). Infants significantly decrease the time they spend sleeping during the 24-hour period, progressively being able to spend more time awaken and engaged in social interactions with their family (e.g., Bruni et al., 2014; Galland et al., 2012; Iglowstein et al., 2003). This reduction on sleep hours during the 24-hour period has been reported to be significant during the first year of life, presenting slighter decreases after the first year (Sadeh, 2000; Sadeh, Mindell, Luedtke, & Wiegand, 2009; Teng et al., 2012). While reducing the time they spend sleeping, infants are also expected to achieve the second sleep developmental task – to concentrate their sleep time during the night period (e.g., Figueiredo et al., 2016; Galland et al., 2012; Goodlin-Jones et al., 2001). During the first year, infants present a significant increase on the sleep hours during the night and a decrease on the sleep hours during the day (e.g., Bruni et al., 2014; Sadeh et al., 2009; Teng et al., 2012). A previous study showed that the night-day ratio of sleep hours increases from about 60% in the first months to nearly 80% at one year of age, showing a clear trend for a concentration of the sleep time during the night (Sadeh et al., 2009). The third sleep developmental task – self-soothing – refers to the ability of the infants to self-regulate during the night period (Anders & Keener, 1985; Burnham, Goodlin-Jones, Gaylor, & Anders, 2002; Goodlin-Jones et al., 2001). The process of self-

soothing involves a control of the internal arousal states, with the infant becoming able of falling asleep and returning to sleep after a night waking without requiring external help (e.g., Anders & Keener, 1985; Burnham et al., 2002; Goodlin-Jones et al., 2001). Although night wakings are reported to still occur during the first year (e.g., Bruni et al., 2014; Sadeh et al., 2009; Teng et al., 2012), infants who achieve the developmental task of self-soothing are progressively able to return to sleep alone, not signaling the night wakings (e.g., Anders & Keener, 1985; Burnham et al., 2002; Goodlin-Jones et al., 2001). Previous studies have been suggesting self-soothing task to be accomplished within the first six months of infant's life (Burnham et al., 2002; Goodlin-Jones et al., 2001). The fourth sleep developmental task – sleep through the night – refers to the ability of the infants to sleep during a longer and uninterrupted period during the night period, coordinating their sleep time with their parents' sleep (e.g., Anders, Halpern, & Hua, 1992; Goodlin-Jones et al., 2022; Henderson et al., 2010). A previous review showed that the majority of the infants is able to sleep through the night within the first four months of life (Henderson, France, & Blampied, 2011).

The accomplishment of these sleep developmental tasks is crucial for infant's development and biopsychosocial adaptation, considering that they are involved in sleep-wake behavior consolidation and regulation, two major processes that have been described in the literature as important early markers of infant's neurobehavioral maturation (Sadeh & Anders, 1993). Infants with difficulties in the accomplishment of these sleep developmental tasks may present increased night wakings and difficulties in sleep initiation (Sadeh & Anders, 1993), two of the most reported sleep problems during the first year (Bayer et al., 2007; Hiscock & Fisher, 2015; Mindell, Kuhn, Lewin, Meltzer, & Sadeh, 2006).

The developmental psychopathology conceptual model argues that development involves continuities and discontinuities between normality and psychopathology (Sroufe & Rutter, 2000). This perspective acknowledges the importance of understanding the mechanisms affecting infant's development and the causal processes of infant's development (Sroufe & Rutter, 2000). Development results from the dynamic interaction between genetic, environmental and psychosocial influences that should be identified and understood (Sroufe & Rutter, 2000). Considering this perspective, it is crucial to fully understand the mechanisms involved in the emergence of infant's sleep problems

1.1.2. Variables associated with infant's sleep problems

A wide broad of variables have been suggested as being associated with infant's sleep-wake behavior and sleep problems (Kaley, Reid, & Flynn, 2012; Martini, Petzoldt, Knappe, Garthus-Niegel, Asselmann, & Wittchen, 2017; Sorondo & Reeb-Sutherland, 2015). The direction between some of these variables and infant's sleep is somewhat controversial among the different studies (Sadeh, 2000).

Different parental variables (e.g., mother's prenatal and postpartum depression symptoms, parental bedtime involvement) were identified in the literature as influencing infant's sleep and putting the infant at increased risk for the emergence of sleep problems (Martini et al., 2017; Philbrook & Teti, 2016; Ystrom Hysing, Torgersen, Ystrom, Reichborn-Kjennerud, & Sivertsen, 2017a). Parental cognitions, expectations, emotions and behaviors regarding their infant's sleep, parent-infant interactions, parental mental health and well-being, bedtime involvement, and parents' socio-cultural context may have an important role in shaping their infant's sleep (Martini et al., 2017; Philbrook & Teti, 2016; Sadeh, Tikotzky, & Scher, 2010). Increased parental involvement at bedtime (e.g., presence of the parents at bedtime, nursing or rocking the infant, putting the infant in the bed asleep, or feeding back the infant to sleep) have been associated with dysregulated sleep-wake behavior and sleep problems (Huang et al., 2016; Philbrook & Teti, 2016; Ramamurthy, Sekartini, Ruangdaraganon, Huynh, Sadeh, & Mindell, 2012). Mother's depression symptoms, both during pregnancy and the postpartum period, are one of the strongest parental variables associated with the emergence of infant's sleep problems in the literature (e.g., Gerardin et al., 2011; Martini et al., 2017; Ystrom et al., 2017a).

Different infant variables (e.g., infant's sex, temperament) were also identified as being associated with infant's sleep problems (Blair et al., 2012; Kaley et al., 2012; Mindell & Lee, 2015). Regarding infant's sex, boys present shorter sleep duration, more night wakings, and shorter sleep periods than girls (Blair et al., 2012; Kaley et al., 2012; Lampl & Johnson, 2011). Infants who are rated with a difficult temperament (e.g., negative mood, high intensity, low distractibility and low rhythmicity) present more night wakings, more time waken after a night waking, more sleep latency, shorter sleep duration, more sleep periods, lower sleep efficiency, later bedtimes and earlier wake times, and more sleep problems than infants who are rated with easy temperament (e.g., Kelmanson, 2004; Mindell & Lee, 2015; Sorondo & Reeb-Sutherland, 2015).

Variables identified as being affected by infant's sleep problems are less studied in previous studies (Sadeh, De Marcas, Guri, Berger, Tikotzky, & Bar-Haim, 2015; Saenz, Yaugher, & Alexander, 2015; Ystrom, Nilsen, Hysing, Sivertsen, & Ystrom, 2017b). Literature has been shown that infant's sleep problems may be associated with the emergence of mother's depression symptoms (Bayer et al., 2007; Hiscock & Wake, 2001; Ystrom et al., 2017b).

Considering the complex and reciprocal links between mother's depression symptoms and infant's sleep problems, two models have been proposed and tested in the literature: the maternal-driven model and the infant-driven model (Teti & Crosby, 2012; Ystrom et al., 2017a, 2017b). The maternal-driven model points that mother's depression symptoms may lead to the emergence of infant's sleep problems (Teti & Crosby, 2012). The infant-driven model points that infant's sleep problems may lead to the emergence of mother's depression symptoms (Ystrom et al., 2017b).

A bidirectional and dynamic interplay between mother's depression symptoms and infant's sleep problems had been also suggested, under the context of a transactional model (Sadeh et al., 2010; Sameroff, 1989, 1993). The transactional model (Sameroff, 1989, 1993) argues that infant's development results from the dynamic interplay between infant, parental and contextual variables. Regarding infant's sleep, the transactional model argues that parental variables (e.g., mother's depression symptoms), not only play a major role in shaping their infant's sleep-wake behavior and influencing infant's sleep problems, but also infant's sleep problems may influence parents' mental health and well-being and parental behaviors (Sadeh et al., 2010). Under the light of the transactional model, the maternal- and infant-driven models have been recently combined in a joint model, where mutual influences between mother's depression symptoms and infant's sleep problems are expected to occur (Ystrom et al., 2017a). Mother's depression symptoms may influence infant's sleep problems and, reciprocally, infant's sleep problems may lead to an increase on mother's depression symptoms.

1.1.3. Infant's problems assessment

Infant's sleep problems comprise one of the major concerns presented by parents of young infants (Byars, Yolton, Rausch, Lanphear, & Beebe 2012). The rates of infant's sleep problems in occidental countries are high, ranging between 15% and 35% (Byars et al., 2012; Mindell, Meltzer, Carskadon, & Chervin, 2009; Mindell, Meltzer, Carskadon, & Chervin, 2010).

No consensual definition of infant's sleep problems has been provided in the literature (Hiscock & Fisher, 2015). The parental reports of what is problematic in their infant's sleep had been shown to be the most useful indicator of an infant's sleep problem (Hiscock & Fisher, 2015). Frequent night wakings and difficulties in sleep initiation are the most reported sleep problems by parents of infants during the first year (Bayer et al., 2007; Hiscock & Fisher, 2015; Mindell et al., 2006). Night wakings are normative during the first months of life (e.g., Dias et al., 2018, for a review), however infants progressively become able to return to sleep alone after an awakening (e.g., Anders & Keener, 1985; Burnham et al., 2002; Goodlin-Jones et al., 2001) Frequent night wakings are usually identified by parents as a sleep problem in infants during the first six months (Bayer et al., 2007). Sleep arrangements characterized by bed-sharing and co-sleeping are also reported by parents as a sleep problem (Bayer et al., 2007), and are often associated with a higher difficulty of the infant to return to sleep after a night waking (Green, Groves, & Tegano, 2004; Morrell & Steele, 2003). This difficulty may result from the higher physical contact with the parents which may interfere with infant's ability to self-sooth (Green et al., 2004; Morrell & Steele, 2003).

A large variety of questionnaires have been proposed to assess sleep problems through the life span, although only a few are available to specifically assess sleep problems in infants during the first year of life. In 2004, Sadeh presented the validation of the Brief Infant Sleep Questionnaire (BISQ), a questionnaire that assesses sleep problems in infants and toddlers aged between zero and three years old (Sadeh, 2004). The BISQ is a questionnaire where parents report their infant's sleep behavior within the previous week (Sadeh, 2004). More recently, the Children's Sleep Habits Questionnaire – Infant Version (CSHQ-I), an adapted version of the Children's Sleep Habits Questionnaire (CSHQ; Owens, Spirito, & McGuinn, 2000), was validated for infants aged between zero and 12 months (Dias, Figueiredo, & Pinto, 2018). The CSHQ-I is a questionnaire to assess sleep problems through the parental reports of their infants' sleep behaviors in a typical week (Dias et al., 2018). Compared with the BISQ, the CSHQ-I presents the advantage of identifying infant's sleep problems based on the International Classification of Sleep Disorders (ICSD-1), allowing the identification of early sleep problems.

When assessing infant's sleep problems, it is crucial to also include an assessment of the social and environmental context of the infant (Meltzer & Mindell, 2006). Considering that different parental and infant's variables may be associated with the emergence of infant's sleep problems, it is important to include an assessment of the impact of infant's sleep problems on the family

functioning, and the assessment of the parental marital status and household arrangements, and sleep practices (Meltzer & Mindell, 2006).

The identification of sleep problems early in infancy is crucial, as sleep problems have been shown to be precursors of further problems in childhood and adolescence and to compromise familiar dynamics. Infants presenting sleep problems during the first months of life were shown to maintain those sleep problems through childhood (Byars et al., 2012; Meltzer, Plaufcan, Thomas, & Mindell, 2014; Williams, Berthelsen, Walker, & Nicholson, 2017). Sleep problems in early infancy are also risk factors for the emergence of further behavioral, emotional and cognitive problems and predictors of later social functioning (Hemmi, Wolke, & Schneider, 2011; Sivertsen, Harvey, Reichborn-Kjennerud, Torgersen, Ystrom, & Hysing, 2015; Vaughn, Elmore-Staton, Shin, & El-Sheikh, 2015). Early sleep problems are commonly comorbid with several pediatric psychiatric disorders and the interaction between sleep problems and children's psychopathology often have a significant adverse effect on the development, severity and prognosis of the psychiatric disorders (Mattai et al., 2006; Ramtekkar, & Ivanenko, 2015; Stores & Wiggs, 2001). The assessment and identification of infant's sleep problems at early age may help to identify infants at risk of presenting further development problems.

Infant's sleep problems have also been reported to seriously compromise the functioning of the infant's family (El-Sheikh & Kelly, 2017). Mothers of infants with sleep problems were usually shown to present less sleep quality and more sleep problems (Kouros & El-Sheikh, 2017; Piteo et al., 2013; Sharkey, Iko, Machan, Thompson-Westra, & Pearlstein, 2016), more fatigue (Dennis & Ross, 2005), and more mental health problems (Bayer et al., 2007; Hiscock & Wake, 2001; Ystrom et al., 2017b). The marital quality of the parents may also be compromised by infant's sleep problems, with an increase on marital conflict being reported among parents who do not agree on infant's sleep routines (Rhoades et al., 2012; Stores, 2009). These results suggest the importance of early identify and intervene on infant's sleep problems and the need that interventions on infant's sleep problems consider these familiar dynamics on their targets.

1.2. Mother's depression symptoms and infant's sleep problems

Mother's depression is a common disorder presented by new mothers and high prevalent rates have been reported during the perinatal period. Mother's depression had been shown as ranging between 10% and 20% during pregnancy (Couto et al., 2016; Figueiredo & Conde, 2011; Underwood, Waldie, D'Souza, Peterson, & Morton, 2016; Verreault, Da Costa, Marchand, Ireland, Dritsa, & Khalifé, 2014), and between 13% and 16% during the postpartum period (Figueiredo & Conde, 2011; Underwood et al., 2016; Verreault, Da Costa, Marchand, Ireland, Dritsa, & Khalifé, 2014). A recent systematic review of the literature identified mother's prenatal depression as one of the strongest risk factors for the emergence of mother's postpartum depression, suggesting that most of the depressed mothers during the postpartum period were already depressed during pregnancy (Underwood et al., 2016).

Mother's depression symptoms, both during pregnancy and the postpartum period have been shown to be associated with several negative outcomes on infant's development (Figueiredo, Pinto, Pacheco, & Field, 2017; Gentile, 2017; Tuovinen et al., 2018). Infants of mothers with more depression symptoms at pregnancy and postpartum have been shown to present poorer neurobehavioral development than infants of mothers with less depression symptoms (Figueiredo et al., 2017; Gentile, 2017; Tuovinen et al., 2018). Mother's prenatal and postpartum depression symptoms were shown to have cumulative adverse impact on infant's development, with infants of depressed mothers both at pregnancy and at postpartum presenting the most pervasive developmental outcomes (Tuovinen et al., 2018).

Literature has been shown that mother's prenatal and postpartum depression symptoms may be associated with the emergence of infant's sleep problems (Gerardin et al., 2011; Martini et al., 2017; Ystrom et al., 2017a). A reverse path, with infant's sleep problems being associated with an increase of mother's depression symptoms, has been also reported (Bayer et al., 2007; Hiscock & Wake, 2001; Ystrom et al., 2017b). This dynamic interplay between mother's depression symptoms and infant's sleep problems may be understood within the context of the transactional model proposed by Sadeh and colleagues (2010). Infant's sleep problems are understood as part of broader transactional familiar dynamics (e.g., Sadeh et al., 2010; Sameroff, 1989, 1993), with reciprocal influences occurring between mother's mental health and well-being and infant's sleep problems (El-Sheikh & Kelly, 2017; Sadeh et al., 2010). These reciprocal influences are also revealed in the intervention studies targeting infant's sleep problems and/or mother's depression

symptoms (Gurung, Jackson, Monahan, Butterworth, & Roberts, 2018; Hiscock, Bayer, Gold, Hampton, Ukoumunne, & Wake, 2007; Kempler, Sharpe, Miller, & Bartlett, 2016). Interventions targeting infant's sleep problems have shown their impact both on reducing infant's sleep problems and decreasing mother's depression symptoms, and interventions targeting mother's depression symptoms have shown their impact both on reducing mother's depression symptoms and on decreasing infant's sleep problems (e.g., Gurung et al., 2018; Hiscock et al., 2007; Kempler et al., 2016).

1.2.1. Mother's prenatal depression symptoms and infant's sleep problems

Literature has been shown that infants of prenatally depressed mothers present more dysregulated sleep patterns than infants of non-depressed mothers (e.g., Gerardin et al., 2011; Martini et al., 2017; Nevarez, Rifas-Shiman, Kleinman, Gillman, & Taveras, 2010). These dysregulated sleep patterns include shorter infant's sleep duration, lower sleep efficiency, more night wakings (Armitage, Flynn, Hoffmann, Vazquez, Lopez, & Marcus, 2009; Nevarez et al., 2010), and more infant's sleep problems (Field, Diego, Hernandez-Reif, Figueiredo, Schanberg, & Kuhn, 2007; Gerardin et al., 2011; Martini et al., 2017). These studies on the association between mother's prenatal depression symptoms and infant's sleep problems did not usually consider the concurrent influences of mother's postpartum depression symptoms.

Mothers with more prenatal depression symptoms were shown to present more sleep problems (Ruiz-Robledillo, Canário, Dias, Moya-Albiol, & Figueiredo, 2015), more unhealthy habits (Miguez, Pereira, & Figueiredo, 2017), less prenatal care (Monk, Georgieff, & Osterholm, 2013), and low cortisol levels (Szpunar & Parry, 2018), which may affect the intrauterine environment and the neurobehavioral development of the fetus (Barker, 2004; Glover, O'Donnel, O'Connor, & Fisher, 2018; Martini et al., 2017). Infants with poorer neurobehavioral development may present increased difficulties in the accomplishment of developmental tasks related with sleep (Dias et al., 2018; Figueiredo et al., 2016; Henderson et al., 2010), which may trigger the emergence of infant's sleep problems during the first year of life (Byars, Yolton, Rausch, Lanphear, & Beebe, 2012; Henderson et al., 2010; Sette et al., 2017).

The fetal programing theory (Barker, 2004) may set a useful framework to understand the influences of mother's prenatal depression symptoms on infant's development. This perspective argues that fetal development is influenced by the biological signs that the mother sents to the

fetus, including signs resulting from the mother's experiences of stress (Glover et al., 2018; Kapoor, Dunn, Kostaki, Andrews, & Matthews, 2006; Weinstock, 2008). These signs may cause changes in fetal and embryotic environment, affecting the fetus' development and causing long term consequences on the individual's development and health (Barker, 2004; Davis, Hankin, Swales, & Hoffman, 2018; Glover, 2011). The fetal programming theory also argues that this programming may comprise an evolutionary advantage as, during gestation, the fetus is being prepared to better adapt to the postnatal environment that is expected to occur (Conradt, Adkins, Crowell, Raby, Diamond, & Ellis, 2018; Davis et al., 2018; Glover, 2011). The exposure to a prenatal adverse environment characterized by increased mother's prenatal depression symptoms, while putting the infant at risk for developmental problems, also prepares the infant to successfully survive in a postpartum adverse environment (Conradt et al., 2018; Davis et al., 2018; Glover, 2011).

The exposure to an adverse intrauterine environment may lead to long-term consequences in infant's health and development, resultant from the changes occurring in the infant's epigenome (Bale, 2015; Cao-Lei et al., 2017). Epigenetics mechanisms have been recently suggested as one of the major processes underlying the association between the exposure to a prenatal adverse environment and infant's developmental outcomes (Bale, 2015; Cao-Lei et al., 2017; Conradt et al., 2018). The exposure to an adverse intrauterine environment leads to chemical changes on fetus' chromatin, that may result on the reprogramation of the fetus genome (Cao-Lei et al., 2017; O'Donnell & Meaney, 2016; Turecki & Meaney, 2016). The reprogramation of the fetus genome leads to consequences on infant's health and development that may help to prepare the infant to successfully adapt to a more challenging postbirth environment, including to interact with a depressed mother during the postpartum (Bale, 2015; Conradt et al., 2018; Serpeloni et al., 2019).

1.2.2. Mother's postpartum depression symptoms and infant's sleep problems

Infants of mothers with more postpartum depression symptoms were shown to present more dysregulated sleep patterns (e.g., Bat-Pitault et al., 2017; Hughes, Gallagher, & Hannigan, 2015; Ystrom et al., 2017a). These dysregulated sleep patterns include more infant's night wakings (Gress-Smith, Luecken, Lemery-Chalfant, Howe, 2012; Karraker & Young, 2006; Warren, Howe, Simmens, & Dahl, 2006) and shorter sleep duration (Hughes et al., 2015; Mao, Zhu, & Su, 2011; Piteo et al., 2013), and more sleep problems (Dennis & Ross, 2005). The studies exploring the

links between mother's postpartum depression symptoms and infant's sleep problems did not usually consider the possible previous influence of mother's prenatal depression symptoms.

Mothers with more postpartum depression symptoms usually present more sleep problems and fatigue (Dennis & Ross, 2005; Okun, Mancuso, Hobel, Schetter, & Coussons-Read, 2018), lower self-efficacy (Dennis & Ross, 2005; Giallo, Rose, & Vittorino, 2011), disadjusted mother-infant interactions (Field, 2010; Field, Hernandez-Reif, & Diego, 2006) and dysfunctional cognitions regarding infant's sleep (Teti & Crosby, 2012). On their turn, mothers presenting increased depression symptoms may have more difficulties in contingently responding to their infants' needs regarding sleep and setting limits (Tikotzky, Sadeh, Volkovich, Manber, Meiri, & Shahar, 2015; Tikotzky & Sadeh, 2010), as they usually present a withdrawn response pattern (Beebe et al., 2008; Leckman-Westin, Cohen, & Stueve, 2009; Santona et al., 2015). These disadjusted interactions may interfere with the accomplishment of the sleep developmental tasks (e.g., concentrate sleep during the night, self-soothing or sleeping through the night) putting the infant at increased risk of presenting a sleep problem (Teti, Kim, Mayer, & Countermine, 2010; Tikotzky et al., 2015; Tikotzky & Sadeh, 2010).

1.2.3. Mother's prenatal and postpartum depression symptoms and infant's sleep problems

Literature has been shown that both mother's prenatal and postpartum depression symptoms are associated with the emergence of infant's sleep problems. Mother's prenatal depression symptoms were shown to be associated with the emergence of infant's sleep problems, in a previous study where the concurrent influences of mother's postpartum depression symptoms were controlled (O'Connor et al., 2007). These studies show evidence on the maternal-driven model, showing that both mother's prenatal and postpartum depression symptoms may lead to the emergence of infant's sleep problems (Teti & Crosby, 2012). To our knowledge, only a recent study considered the concurrent effects of both mother's prenatal and postpartum depression symptoms on infant's sleep problems, showing no effects of mother's prenatal neither postpartum depression symptoms infant's night wakings at six and 12 months (Galbally, Watson, Teti, & Lewis, 2018).

1.2.4. Infant's sleep problems and mother's postpartum depression symptoms

Infant's sleep problems have been shown to increase mother's postpartum depression symptoms (Bayer et al., 2007; Hiscock & Wake, 2001; Ystrom et al., 2017b). Early infant's sleep problems were shown to be associated with the further emergence of mother's depression symptoms (Ystrom et al., 2017b). These studies brought evidence to the infant-driven model, which points that infant's sleep problems may lead to the emergence of mother's depression symptoms (Ystrom et al., 2017b).

Infant's sleep problems represent a large stressor within the family context that may compromise parents' well-being and lead to the emergence of mother's depression symptoms (Sadeh et al., 2010). Mothers whose infants present sleep problems often present fragmented sleep and sleep difficulties (Kouros & El-Sheikh, 2017; Piteo et al., 2013; Sharkey et al., 2016). And mothers with sleep problems were reported to be more tired and with an increased risk of presenting postpartum depression symptoms (Krawczak, Minuzzi, Hidalgo, & Frey, 2013; Lawson, Murphy, Sloan, Uleryk, & Dalfen, 2015; Piteo et al., 2013).

1.2.5. The bidirectional links between mother's depression symptoms and infant's sleep problems

The transactional model (Sameroff, 1989, 1993) understood child development under the context of the dynamic interplay between child and parental variables. Sadeh and colleagues (2010) applied this model to infant's sleep, pointing for the existence of reciprocal and mutual influences between parental variables (e.g., mother's depression symptoms) and infant's variables (e.g., infant's sleep problems). Infants of depressed mothers may be at increased risk of presenting sleep problems and, mothers whose infants have more sleep problems are at increased risk of being more depressed (Sadeh et al., 2010).

Recent research has been acknowledging these mutual influences between mother's depression symptoms and infant's sleep problems (Galbally et al., 2018; Ystrom et al., 2017a, 2017b). The maternal-driven and infant-driven models have been tested in recent research, with some inconsistent findings being presented in the following paragraph (e.g., Teti & Crosby, 2012; Ystrom et al., 2017a, 2017b).

Studies analyzing night wakings in infants aged between one and 18 months found evidence supporting the maternal-driven model. Teti and Crosby (2012) showed that mother's postpartum depression symptoms may affect parental cognitions and behaviors, being associated with more night wakings in infants aged between one and 12 months old (Teti & Crosby, 2012). Ystrom and colleagues tested the two models, and only found evidence on the maternal-driven model (Ystrom et al., 2017a). The authors showed an association between mother's depression symptoms and more infant's night wakings at 18 months, but not between infant's night wakings and the further emergence of mother's depression symptoms (Ystrom et al., 2017a).

On contrary, a study assessing infant's sleep problems in infants aged between 18 months and four years old found stronger evidence on the infant-driven model. Ystrom and colleagues (2017b) tested the two models in a longitudinal study following mother-child dyads from 18 months to four years old and showed that the effects of the infant-driven model were stronger than the effects of the maternal-driven model. In this study, the authors showed that sleep problems during infancy and early childhood may lead to the emergence of mother's depression symptoms (Ystrom et al., 2017b).

More recently, a third model was suggested, with the combination of the maternal- and infant-driven models (Ystrom et al., 2017b). To our knowledge, only one study analyzed the reciprocal links between mother's depression symptoms and infant's sleep problems, while analyzing the concurrent effects of both prenatal and postpartum depression (Galbally et al., 2018). Galbally and colleagues (2018) tested a model to analyze the reciprocal links between mother's depression symptoms and infant's sleep problems, namely infant's night wakings, also testing the effect of antidepressant use, breastfeeding, maternal cognitions and mother's bedtime settling behavior. In this study, the authors did not find evidence on the links between mother's prenatal and postpartum depression symptoms on the emergence of further infant's sleep problems, neither on the links between infant's sleep problems on the emergence of further mother's depression symptoms (Galbally et al., 2018).

Evidence was found both on the maternal-driven and on the infant-driven models, in separate studies that considered different ages across infancy and different infant's sleep problems (Teti & Crosby, 2012; Ystrom et al., 2017a, 2017b), suggesting that mutual influences may occur between mother's depression symptoms and infant's sleep problems. Bidirectional links between mother's depression symptoms and infant's sleep problems were not found in a previous study, that only analyzed infant's night wakings (Galbally et al., 2018). Considering that different infant's

sleep problems have been reported in the literature (e.g., Bayer et al., 2007; Hiscock & Fisher, 2015; Mindell et al., 2006), it is important to consider the unidirectional and bidirectional links between mother's depression symptoms and infant's sleep problems in different infant's sleep problems.

1.2.6. Mother's depression symptoms and infant's sleep problems: the role of infant's sex and temperament

Different infant's variables have been identified as being associated both with mother's prenatal and postpartum depression symptoms (e.g., Beeghly et al., 2017; Gustafsson et al., 2018; Stein, 2014) and with infant's sleep problems (e.g., Kaley et al., 2012; Kelmanson, 2004; Sorondo & Reeb-Sutherland, 2015). Infant's sex, temperament characteristics, social-emotional and cognitive problems have been associated with mother's depression symptoms (e.g., Beeghly et al., 2017; Gustafsson et al., 2018; Stein, 2014) and with infant's sleep problems (e.g., Kaley et al., 2012; Kelmanson, 2004; Sorondo & Reeb-Sutherland, 2015) in separate studies. There is also emerging evidence that, among infant's variables, infant's sex and temperament play a major role on the association between mother's prenatal depression symptoms and infant's sleep problems (Kim, Bird, Peterson, Underwood, Morton, & Grant, 2020; Netsi et al., 2015).

More depression symptoms were found in mothers of boys (*versus* girls) and in mothers of infants with difficult (*versus* easy) temperament (De Tychey et al., 2008; Glyn et al., 2018; Gustafsson et al., 2018). Boys (*versus* girls) and infants with difficult (*versus* easy) temperament were shown to present more sleep problems (Blair et al., 2012; Kaley et al., 2012; Kelmanson, 2004). A previous study also showed that boys with a more difficult temperament, when previously exposed to more mother's prenatal depression symptoms, present more sleep problems (Netsi et al., 2015). Previous findings on the major role of infant's sex and temperament on the links between mother's prenatal and postpartum depression symptoms and infant's sleep problems are reviewed next.

1.2.6.1 Infant's sex

Infant's sex has been shown to be associated with infant's sleep in several studies. Boys were shown to present more dysregulated sleep patterns than girls during the first year of life, that include shorter sleep duration (Blair et al., 2012; So, Adamson, & Horne, 2007; Thomas &

Foreman, 2005), more night wakings (Kaley et al., 2012; Santos, Matijasevich, & Domingues, 2012; Santos, Mota, & Matijasevich, 2008), and shorter sleep periods (Goodlin-Jones et al., 2001; Lampl & Johnson, 2011).

Recent literature has been also shown that the exposure to mother's prenatal depression and stress has a more pervasive effect in boys than in girls' further developmental outcomes (DiPietro & Voegtline, 2017; Sandman, Glynn, & Davis 2013; Sutherland & Brunwasser, 2018). Boys have been shown to present more sleep problems than girls, when exposed to increased mother's prenatal depression symptoms (Netsi et al., 2015). Netsi and collegues found that 18 to 24-month-old boys previously exposed to mother's prenatal depression symptoms presented shorter sleep duration and more night wakings than girls (Netsi et al., 2015).

The fetal programing theory argues that mother's prenatal depression symptoms may influence fetal development, affecting infant's development and health after birth (Barker, 2004; Davis et al., 2018; Glover, 2011). Sex differences have been reported on the consequences of the exposure to a prenatal adverse environment (Rosenfeld, 2015; Sutherland & Brunwasser, 2018). Male fetuses have been shown to present higher vulnerability to a prenatal adverse environment (e.g., mother's prenatal depression symptoms) than female fetuses, being more affected in their further development (DiPietro & Voegtline, 2017; Sandman et al., 2013; Sutherland & Brunwasser, 2018).

Research has been also shown that the infant's exposure to mother's postpartum depression symptoms has a more pervasive effect on further developmental outcomes of boys than girls (Grace, Evindar, & Stewart, 2003; Kurstjens & Wolke, 2001; McGinnis, Bocknek, Beeghly, Rosenblum, & Muzik 2015). Boys exposed to mother's postpartum depression were shown to present more behavioral problems (McGinnis et al., 2015) and impaired cognitive development (Kurstjens & Wolke, 2001) than girls.

Mothers of boys were shown to present more postpartum depression symptoms than mothers of girls, in a previous study (De Tychey et al., 2008). Boys were also shown to present more sleep difficulties than girls (Blair et al., 2012; Kaley et al., 2012; Santos et al., 2012). These results suggest that mothers of boys may present more difficulties in dealing with their infant's sleep routines and difficulties, which may negatively interfere with the infant's ability to achieve the developmental tasks related to sleep, putting boys at higher risk of presenting sleep problems than girls.

1.2.6.2. Infant's temperament

Infant's temperament has been defined as the infants' constitutional differences in reactivity and self-regulation (Bornstein, Putnick, Gartstein, Hahn, Auestad, & O'Connor, 2015; Rothbart, 1981; Rothbart & Derryberry, 1981). Reactivity comprises the infant's emotional, activation and arousal systems responses, and self-regulation includes the processes that modulate the individual's reactivity, namely approximation, avoidance and attention (Carranza, González-Salinas, & Ato, 2013).

Infant's temperament has been conceptualized as biologically based, and temperament characteristics have been reported to present high stability over time (Buss, 1989; Rothbart, 2011; Strelau, 1989). Previous studies have been shown that temperament characteristics may be identified during fetal development or at infant's birth (DiPietro, Ghera, & Costigan, 2008; DiPietro, Hodgson, Costigan, & Johnson, 1996; DiPietro, Voegtline, Pater, & Costigan, 2018). Infant's maturation and contextual experiences after birth have also been reported to influence infant's temperament characteristics (Carranza et al., 2013; Rothbart, 1981; Rothbart & Derryberry, 1981).

Literature has shown that infants of mothers presenting increased prenatal depression symptoms are rated with more difficult temperament (Davis, Glynn, Schetter, Hobel, Chicz-Demet, & Sandman, 2007; Gustafsson et al., 2018; Zhang, Finik, Dana, Glover, Ham, & Nomura, 2018). Mother's prenatal depression symptoms were associated with more infant's negative affectivity (Gustafsson et al., 2018; Zhang et al., 2018) and negative reactivity (Davis et al., 2007). Mother's prenatal depression symptoms were also shown to predict more infant's negative affectivity (Glynn et al., 2018).

The association between mother's postpartum depression symptoms and infant's temperament was also reported (Britton, 2011; Eastwood, Jalaludin, Kemp, Phung, & Barnett, 2012; Shapiro, Jolley, Hildebrandt, & Spieker, 2018). Mother's depression symptoms at early postpartum were associated with infant's difficult temperament in the first month of life (Britton, 2011; Eastwood et al., 2012) and with more infant's negative affectivity, inadaptability and fussiness at six months (Shapiro et al., 2018).

Considering the reported previous studies, evidence has been provided on the links between both mother's prenatal and early postpartum depression symptoms and infant's temperament characteristics (e.g., Gustafsson et al., 2018; Shapiro et al., 2018; Zhang et al., 2018). Most of the reported studies used questionnaires based on maternal reports of

temperament, while controlling for the influences of mother's concurrent depression symptoms (Davis et al., 2007; Gustafsson et al., 2018; Shapiro et al., 2018; Zhang et al., 2018). These results suggest the major impact of mother's prenatal and early depression symptoms on infant's temperament characteristics.

Infant's temperament characteristics have been also linked with infant's further development, including sleep outcomes (e.g., Abulizi, Pryor, Michel, Melchior, Van Der Waerden, & EDEN Mother–Child Cohort Study Group, 2017; Mindell & Lee, 2015; Sorondo & Reeb-Sutherland, 2015). Infant's with difficult temperament, characterized by negative mood, high intensity, low distractibility and low rhythmicity, have been shown to present more night wakings (Bayer et al., 2007; Mindell & Lee, 2015; Palmstierna, Sepa, & Ludvigsson, 2008), more time waken after a night waking (Sorondo & Reeb-Sutherland, 2015), more sleep latency (Gibson, Gander, & Elder, 2012; Sorondo & Reeb-Sutherland, 2015), shorter sleep duration (Gibson et al., 2012; Kaley et al., 2012; Mindell & Lee, 2015), more sleep periods (Mindell & Lee, 2015), lower sleep efficiency (Scher, 2001; Scher, Tirosh, & Lavie, 1998), later bedtimes (Scher et al., 1998) and earlier wake times (Gibson et al., 2012; Mindell & Lee, 2015), and more sleep problems (Kelmanson, 2004). A previous study suggested that infant's temperament characteristics, particularly low reactivity, may negatively interfere with the development of adjusted sleep routines and with infant's sleep-wake behavior consolidation, thus contributing to the emergence of sleep problems (De Marcas, Soffer-Dudek, Dollberg, Bar-Haim, & Sadeh, 2015).

Infant's temperament characteristics have been shown to play a major role on the association between mother's prenatal depression symptoms and infant's sleep problems in previous recent studies (Kim et al., 2020; Netsi et al., 2015). Infants of prenatally depressed mothers, presenting a more reactive temperament at six months were shown to present shorter sleep duration and more night wakings at 18-24 months (Netsi et al., 2015). More recently, a study showed that infant's negative affect at nine months mediated the association between mother's prenatal depression symptoms and infant's night wakings at two years of age (Kim et al., 2020). These results suggest that infant's temperament characteristics may help to explain the association between mother's prenatal depression symptoms and infant's sleep problems. Both studies controlled for the effect of mother's postpartum depression symptoms, although measuring infant's temperament at six and nine months, where infant's maturation or contextual experiences may have influenced infant's temperament characteristics (Carranza et al., 2013; Rothbart, 1981; Rothbart & Derryberry, 1981).

Current thesis

According with the developmental psychopathology conceptual model, infant's normative development results from the adequate accomplishment of the different developmental tasks across the life span (e.g., Rutter, 1996). During the first year of infant's life, several and rapid changes occur on infant's sleep-wake behavior (Bruni et al., 2014; Galland et al., 2012; Teng et al., 2012), with different sleep developmental tasks being expected to occur (Figueiredo et al., 2006; Galland et al., 2012; Goodlin-Jones et al., 2001). The inadequate accomplishment of these developmental tasks related to sleep may put the infant at increased risk of presenting sleep problems (Byars et al., 2012; Henderson et al., 2010; Sette et al., 2017). Different parental and infant's variables have been reported in the literature as being associated with infant's sleep-wake behavior (Kaley et al., 2012; Martini et al., 2017; Sorondo & Reeb-Sutherland, 2015), and putting the infant at increased risk for presenting sleep problems. Mother's depression symptoms were associated with infant's sleep problems in separate studies. Different findings have been reported on the direction of this association (Teti & Crosby, 2012; Ystrom et al., 2017a, 2017b), which suggests that mutual influences may occur between mother's depression symptoms and infant's sleep problems, in accordance with the transactional model (Sadeh et al., 2010; Sameroff, 1989, 1993). The potential bidirectional influences between mother's depression symptoms and infant's sleep problems were only recently explored (Galbally et al., 2018). Evidence has been also provided on the association between infant's characteristics (e.g., sex and temperament) and both mother's depression symptoms and infant's sleep problems (Beeghly et al., 2017; Gustafsson et al., 2018; Stein, 2014). Infant's sex and temperament were also shown to play a major role on the association between mother's depression symptoms and infant's sleep problems (Kim et al., 2020; Netsi et al., 2015).

The present thesis aims to contribute to infant's sleep research and clinical practice, by exploring the effects between mother's prenatal and postpartum depression symptoms and infant's sleep problems in the first six months of infant's life (main objective). The specific objectives comprised: (1) to analyze the effects of mother's prenatal and postpartum depression symptoms on infant's sleep problems during the first six months of life; (2) to explore the unidirectional and bidirectional links between mother's depression symptoms and infant's sleep problems; (3) to analyze the moderator role of infant's sex on the unidirectional and bidirectional links between mother's depression symptoms and infant's sleep problems; and (4) to analyze the mediator effect

of infant's temperament at two weeks on the effects of mother's prenatal depression symptoms on infant's sleep problems specifically in boys.

The present doctoral thesis is comprised of six interrelated papers that were designed to respond to the main aim and specific objectives. The first two publications (systematic reviews of the literature) entailed the empirical background of the present thesis and provided evidence to design the empirical studies. Informed by the developmental psychopathology conceptual model, arguing that infant's normative development results from the adequate accomplishment of the different developmental tasks (e.g., Rutter, 1996), the first two publications aimed to identify (1) the normative reference values for sleep-wake behavior and the periods where developmental tasks related to sleep are expected to occur during the first year of life and (2) the variables that may interfere with the infant's successful achievement of the developmental tasks related to sleep. The first publication (**Paper I**) presented a systematic review of the literature on the reference values and specific times for changes on infant's sleep-wake behavior during the first year of life (Dias, Figueiredo, Rocha, & Field, 2018; see Table 1). The second publication (**Paper II**) comprised a systematic review of the literature on the variables associated with infant's sleep-wake behavior during the first year of life (Dias & Figueiredo, 2019; see Table 1).

The third publication (**Paper III)** comprised a methodological paper that analyzed the reliability of the Infant Behavior Questionnaire – Revised (IBQ-R) to be applied in infants aged less than three months (Dias, Costa, Pinto, & Figueiredo, under review). The IBQ-R is one of the most widely used measures to assess infant's temperament characteristics between three and 12 months of age (e.g., Davis et al., 2007; Gartstein & Robarth, 2003; Gustafsson et al., 2018). The psychometric characteristics of the IBQ-R to assess infant's temperament characteristics in infants aged less than three months were not yet been tested. In **Paper III**, we aimed to analyze (1) the reliability of the IBQ-R at two weeks of age and (2) the IBQ-R factor structure from two weeks to 12 months of infant's life (see Table 1).

The empirical work of this thesis is presented in the three remaining publications. In order to better respond to the studies' objectives, the present thesis presents a longitudinal design with four assessment-points: third pregnancy trimester, two weeks, three months and six months postpartum (see Table 1). The first objective of this thesis was addressed on **Paper IV** and **Paper**

V, the second objective was outlined on **Paper V**, the third objective was underlined on **Paper IV** and **Paper V** and the fourth objective was accomplished on **Paper VII**.

Paper IV was designed to respond to the first and the third objectives of this thesis, by analyzing the concurrent effects of mother's prenatal and postpartum depression symptoms on infant's sleep problems and the moderator role of infant's sex on the effects between mother's depression symptoms and infant's sleep problems. In this publication (Dias & Figueiredo, 2020) we aimed to analyze (1) the effects of mother's prenatal and postpartum depression symptoms, including the effects of prenatal and postpartum anxiety and depression scores of the Edinburgh Postnatal Depression Scale (EPDS), on infant's sleep problems at six months, and (2) the interaction effect between mother's prenatal and postpartum depression symptoms and infant's sex on infant's sleep problems at six months (see Table 1).

Paper V was designed to respond to the first, second and the third objectives of this thesis, by analyzing the unidirectional and bidirectional links between mother's depression symptoms and infant's sleep problems and the moderator role of infant's sex on the unidirectional and bidirectional effects between mother's depression symptoms and infant's sleep problems. In this publication (Dias & Figueiredo, under review) we aimed to explore (1) the unidirectional and bidirectional effects between mother's depression symptoms and infant's sleep problems and (2) the moderator role of infant's sex on these unidirectional and bidirectional effects (see Table 1).

Paper VI was designed to respond to the fourth objective of this thesis, by analyzing the role of infant's temperament on the effects of mother's prenatal depression symptoms on infant's sleep problems. In this publication (Dias & Figueiredo, under review) we aimed to analyze the mediator effect of infant's temperament at two weeks on the effects of mother's prenatal depression symptoms on infant's sleep problems, specifically in boys (see Table 1).

The conclusion section of this thesis offers an integrated discussion of the results found in the included studies, considering the theoretical background previously presented. Contributions for both clinical practice and research are provided, and limitations and strengths of the included studies are acknowledged. New directions for further research are outlined.

METHODS

The methods section aims to present the methodological characteristics of the six interrelated papers that comprise the present thesis. First, the methods of the two systematic reviews (**Paper I** and **Paper II**) are presented. The methods of the empirical papers (**Paper III, Paper IV, Paper V** and **Paper VI**) are next presented. The main characteristics of the included papers are presented in Table 1.

Systematic reviews

Literature search

The two systematic reviews included in the present thesis (**Paper I** and **Paper II**) were based on a standard protocol and conducted according to the PRISMA (Moher, Liberati, Tetzlaff, Altman, & Prisma Group, 2009). The search for relevant papers was independently performed by two researchers. An electronic search was firstly performed in three databases: Medline, ISIs Web of Knwledge and PsycINFO according with a search term.

The titles and abstracts of the manuscripts gathered through the electronic search were analyzed, in a first stage, and the abstracts that did not assess the research question were excluded. Potentially relevant manuscripts were analyzed in a second stage to identify the inclusion and exclusion criteria. Manuscripts that met one or more exclusion criteria were excluded. Seventy-four papers were included in the **Paper I** and 146 papers were included in the **Paper II**.

Table 1.

Main characteristics of the six papers included in the doctoral thesis

	Aims – to analyze	Studied variables	Data analytic strategy
Paper I	(1) the reference values of on infant's sleep-wake behavior during the first year of life; (2) the specific times for changes on infant's sleep-wake behavior during the first year of life.	Infant's sleep-wake behavior	(1) Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) (2) PRISMA
Paper II	(1) the variables associated with infant's sleep-wake behavior during the first year of life.	Infant's sleep-wake behavior Variables associated and affected by infant's sleep-wake behavior	(1) PRISMA
Paper III	(1) the reliability of the IBQ-R at two weeks; (2) the IBQ-R factor structure from two weeks to 12 months.	Infant's temperament	(1) Cronbach's alpha coefficient and Multivariate Analyses of Variance (MANOVA); (2) Pearson correlations and longitudinal confirmatory factor analyses (maximum likelihood estimation).

Paper IV	(1) the effects of mother's prenatal and postpartum depression symptoms on infant's sleep problems at six months; (2) the interaction effect between mother's prenatal and postpartum depression symptoms and infant's sex on infant's sleep problems at six months.	Mother's depression symptoms Infant's sex Infant's sleep problems	(1) Multiple linear regressions (stepwise method); (3) Moderation models through multiple linear regressions (enter method).
Paper V	(1) the unidirectional and bidirectional effects between mother's depression symptoms and infant's sleep problems; (2) the moderator role of infant's sex on these unidirectional and bidirectional effects.	Mother's depression symptoms Infant's sex Infant's sleep problems	(1) Cross-lagged path analyses; (2) Infant's sex included as moderator in the cross-lagged path analyses.
Paper VI	(1) the mediator effect of infant's temperament at two weeks on the effects of mother's prenatal depression symptoms on infant's sleep problems specifically in boys.	Mother's depression symptoms Infant's sex Infant's temperament Infant's sleep problems	(1) Moderated mediation models with Structural Equation Modeling (SEM).

Empirical studies

Participants

The total sample was comprised of 312 mother-infant dyads, followed since the third pregnancy trimester to six months postpartum. Regarding mothers, the majority were Caucasian (91.8%) and married or cohabiting with their partner (80.9%). More than half of the mothers were aged between 25 and 34 years old (68.6%), employed (73.4%), and had more than 12 years of schooling (60.9%).

Table 2.
Socio-demographic characteristics

			N = 312 %
Mother	Age (years)	18-24	10.1
		25-34	68.6
		35-44	21.2
	Ethnicity	Caucasian	91.8
		Other	8.2
	Marital status	Married/cohabiting	80.9
		Single/divorced/widow	19.1
	Occupational status	Employed	73.4
		Unemployed/household/student	26.6
	Socio-economic level	High	58.4
		Medium	32.1
		Low	9.5
	Years of schooling	≤ 12	39.1
		>12	60.9
Gestation	Type of delivery	Vaginal	64.2
		Caesarean	35.8
	Gestational age	< 37 weeks	3.6
		≥ 37 weeks	96.4
Infant	Gender	Female	46.5
		Male	53.5
	Weight	< 2500g	1.7
		≥ 2500 g	98.3
	Length	< 48 cm	21.8
		≥ 48 cm	78.2
	First born	Yes	85.5
		No	14.5
	Bed-sharing	Daily	12.5
		1-6 days/week	27.0
		Solitary sleeping	60.5

Regarding infants, the majority were born at term (≥ 37 weeks of gestation; 96.4%), had normal birth weight (≥ 2500g; 98.3%) and length (≥ 48cm; 78.2%), and were first born (85.5%). More than half of the infants were born by vaginal delivery (64.2%), and about half were males (53.5%; see Table 2).

Procedures

Data from this study took part from a larger longitudinal study "*Breastfeeding and Postpartum Depression*"(PTDC/SAU/SAP/116738/2010). The Ethical Commissions of all the institutions involved approved the study protocol. Pregnant women were contacted at the third pregnancy trimester during their routine prenatal appointments at the Outpatients unit of two public hospitals in the Northern Portugal. Women were informed about the study purposes and procedures and invited to participate. Exclusion criteria included women not able to read or write Portuguese, multiple gestations and gestational complications and psychiatric medication intake (n = 47). Eligible women (n = 536) were invited to participate and those who agreed to participate (n = 485; 95%), signed an informed consent and completed the study measures at the third pregnancy trimester. Socio-demographic information and mother's prenatal and postpartum depression symptoms were collected at the third pregnancy trimester, two weeks, three months and six months postpartum. Infant's sleep problems were assessed at two weeks, three months and six months of infant's life. Infant's temperament characteristics were assessed at two weeks of infant's life.

Three hundred and twelve mothers (64.3%) completed the online measures at least one time between two weeks and six months (Figure 1). Three hundred mothers with term and normal birth weight infant completed measures of infant's temperament at least one time between two weeks and twelve months and were included in **Paper III**. One hundred and sixty-four mothers completed the measures of depression symptoms at the third pregnancy trimester, two weeks, three and six months postpartum and a measure of infant's sleep problems at six months and were included in **Paper IV**. Three hundred and twelve mothers completed the online measures at least one time between two weeks and six months and were included in **Paper V**. From the 312 mothers who completed the online measures at least one time between two weeks and six months, 284 mothers had a term and normal birth weight infant and were included in **Paper VI**.

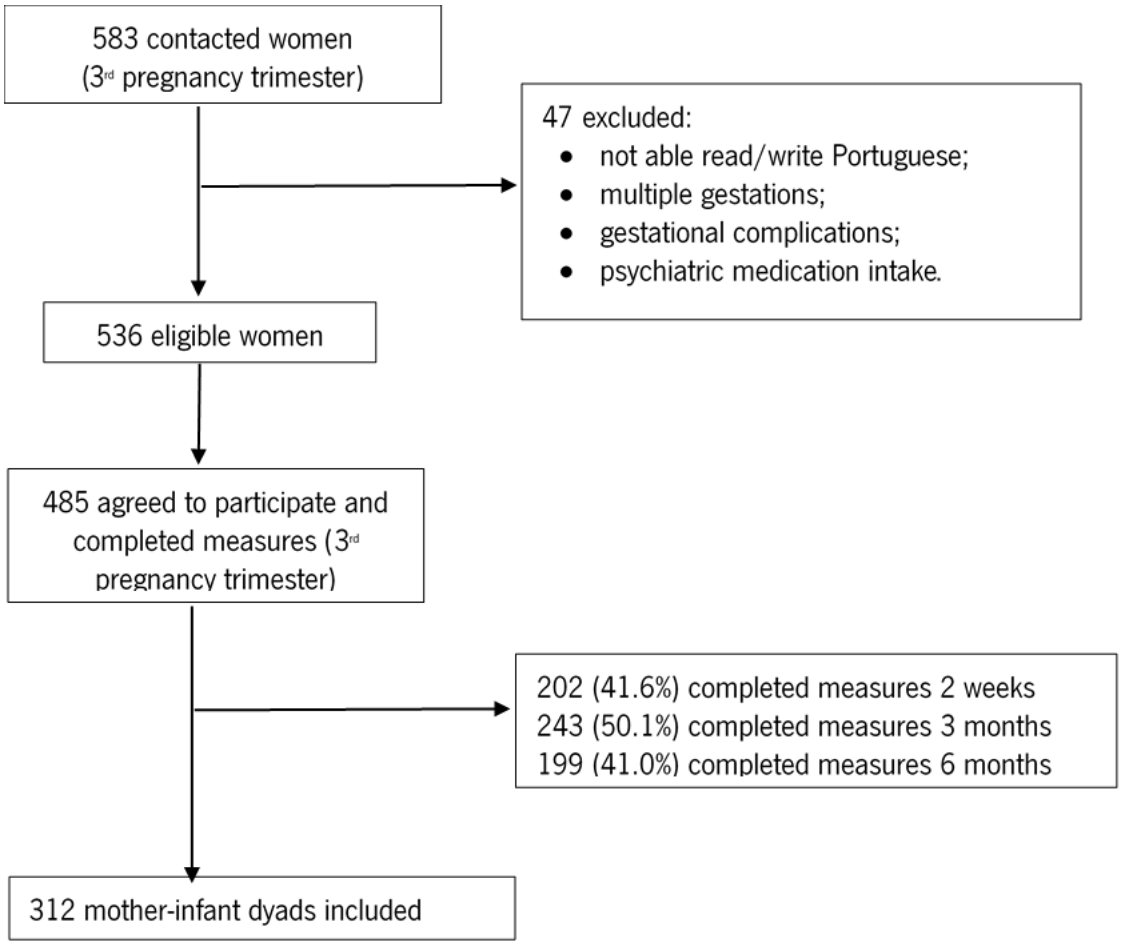


Figure 1. Flowchart of participants' recruitment and assessment waves.

Measures

Socio-demographic information. The Socio-demographic Questionnaire (Figueiredo, Teixeira, Conde, Pinto, & Sarmento, 2009) was used to collect mother's demographic and obstetric data information (e.g., age, marital status, occupational status, socio-economic status, years of schooling, type of delivery, weeks of gestation) and infant's socio-demographic and biometric characteristics (e.g., sex, birth weight, birth length, birth order).

Mother's prenatal and postpartum depression symptoms. The EPDS (Cox, Holden, & Sagovsky, 1987) was used to assess mother's depression symptoms within the previous seven days. This self-report scale encloses 10 items that are scored on a four-point Likert-type scale (total scores ranging from 0 to 30). Higher scores in the EPDS indicate more mother's depression symptoms. The Portuguese version of the EPDS revealed good internal consistency (α= .88;

Tendais, Costa, Conde, & Figueiredo, 2014). The EPDS also revealed a good internal consistency in this study, for pregnancy (α = .85) and for postpartum (α's ranging from .83 to .88).

Infant's sleep problems. The CSHQ-I (Dias et al., 2018) was used to assess infant's sleep problems. The CSHQ-I was adapted from the Children's Sleep Habits Questionnaire – CSHQ (Owens, Spirito, & McGuinn, 2000) to assess sleep problems in infants during the first year of life (Dias et al., 2018).

This parent-report questionnaire encloses 33 items that are scored in a three-point Likert scale, where infant sleep habits and behaviors in a typical week are reported. Higher scores in the CSHQ-I indicate more infant's sleep problems. The CSHQ-I is comprised of four subscales: (1) Bedtime Resistance: infant's resistance to go to bed and frequent night wakings; (2) Sleep Anxiety: infant's anxiety related to sleep, and items of sleep-disordered breathing and parasomnias; (3) Positive Sleep Habits: infant's bedtime and morning waking routines; and (4) Daytime Sleepiness: daytime consequences from sleep problems. Examples of CSHQ-I questions include "*Child falls asleep within 20 min after going to bed*" (Bedtime Resistance sub-scale), "*Child is afraid of sleeping in the dark*" (Sleep anxiety), "*Child goes to bed at the same time at night*" (Positive Sleep Habits), and "*Child takes a long time to become alert in the morning*" (Daytime Sleepiness). The CSHQ-I revealed good internal consistency (α = .77) for the total scale and adequate internal consistency for the sub-scales (α's ranging from .52 to .77) and good construct validity (Dias et al., 2018). The lowest reliability scores were found on the positive sleep habits and daytime sleepiness sub-scales. The CSHQ-I in this study also revealed good internal consistency for the total scale (α's ranging from .71 to .81) and adequate internal consistency for the sub-scales (α's ranging from .39 to .78), similar to reliability scores found in the validation study.

Infant's temperament. The IBQ-R (Gartstein & Rothbart, 2003) was used to assess infant's temperament. The IBQ-R was adapted under the context of this study to be used with infants younger than three months (**Paper III**; Dias et al., under review). This parent-report instrument encloses 191 items that are scored in a seven-point Likert scale to assess infant's temperament in infants aged between three and 12 months old. The IBQ-R assesses 14 scales of temperament (activity level, approach, cuddliness, distress to limitations, duration of orienting, falling and reactivity, fear, high intensity pleasure, low intensity pleasure, perceptual sensitivity, sadness, smiling and laughter, soothability, and vocal reactivity) and is comprised of three dimensions (1)

Surgency/extraversion (activity level, approach, perceptual sensitivity, smiling and laughter and vocal reactivity scales); (2) Negative affectivity (distress to limitations, falling reactivity, fear, and sadness scales); and (3) Orienting Regulation (duration of orienting, low intensity pleasure and soothability scales). The Portuguese version of the IBQ-R revealed good internal consistency (α's ranging between .71 and .93; Costa & Figueiredo, 2018). Also, good internal and construct validity was found when in infants aged two weeks (Dias et al., under review). The three subscales of the IBQ-R showed adequate internal consistency in the present study (α's ranging from .50 to .69).

PAPER I

REFERENCE VALUES AND CHANGES IN INFANT SLEEP-WAKE BEHAVIOR DURING THE FIRST 12 MONTHS OF LIFE: A SYSTEMATIC REVIEW[1]

Dias, C.C., Figueiredo, B., Rocha, M., & Field, T. (2018). Reference values and changes in infant sleep-wake behavior during the first 12 months of life: a systematic review. *Journal of Sleep Research, 27*, e12654-e12667. doi: 10.1111/jsr.12654

[1] This paper is published at the Journal of Sleep Research

Summary

This paper is a systematic review on the reference values and changes in infant sleep-wake behavior during the first 12 months of life. This systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA). Seventy-four papers were included and the reference values and changes in sleep-wake behavior during the first 12 months of life were identified. Sleep duration during the 24-hour period and day and sleep periods during the night decreased over the first 12 months of life. Night wakings and bedtime/sleep onset time decreased, while the longest sleep period increased at night during the first six months. High discrepancy was noted between studies in the reference values of sleep-wake behavior, while more congruence was noted regarding changes, especially those occurring in the first six months of life. Several methodological differences were identified between studies and may partially explain inconsistencies in the results, including the assessment of different sleep-wake behaviors, the focus on specific ages or age ranges, the use of self-report, observational or direct measures, the recruitment of small or large representative samples, and the countries where the research was conducted. These aspects should be considered in future research and caution should be taken when generalizing results from studies with diverse methodological characteristics. Nonetheless, this review identifies normative reference values and the changes occurring in infant sleep-wake behavior and could inform both practitioners and researchers, helping them identify infants with sleep delays or problems.

Keywords: sleep duration; sleep periods; night wakings; sleep latency; bedtime/sleep onset time; longest sleep period

Introduction

Several changes occur in infant sleep-wake behavior (Figueiredo et al., 2016; Galland et al., 2012; Henderson et al., 2011) and four developmental tasks are accomplished during the first 12 months of life (Figueiredo et al., 2016). The infant is progressively able (1) to spend more time awake than asleep, (2) to concentrate the sleep time during the night; (3) to get and return to sleep alone; and (4) to sleep through the night (Figueiredo et al., 2016). Although the accomplishment of these tasks is an important indicator of infant neuro-behavioral development, there is a lack of reference in the literature on sleep-wake behavior normative values during the first 12 months of life (Figueiredo et al., 2016). It is also imperative to identify normative reference values and changes occurring in infant sleep-wake behavior to advise parents of infants with sleep problems (Galland et al., 2012; Jenni and LeBourgeois, 2006).

Sleep-wake behavior has been widely explored. However, studies have used different methodologies assessing (1) different sleep-wake behaviors; (2) in age intervals rather than specific ages; using (3) different sleep-wake measures; and (4) diverse sample sizes. Moreover, studies were conducted in (5) different countries. Considering these divergences, a recent review highlighted the need for the identification of normative reference values in infant sleep-wake behavior (Field, 2017).

A previous systematic review has provided reference values for sleep-wake behavior from zero to 12 years, but analyzed only studies using parent report measures and did not review changes in sleep-wake behavior (Galland et al., 2012). Thus, to our knowledge, no systematic review has provided normative reference values and reported changes in sleep-wake behavior during the first 12 months of life, considering different sleep-wake measures. This paper addresses this gap in the literature and provides a systematic review of the literature on reference values and changes in sleep-wake behavior during the first 12 months of life.

Methods

This systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) (Moher et al., 2009).

Literature search

A literature search was conducted on three databases: MEDLINE, ISIs Web of Knowledge, and PsycINFO for relevant papers published in the last 20 years (between June 1996 and June

2016). This search was conducted to identify publications that referred to infant sleep-wake behavior. The search was limited to English, Portuguese, Spanish, Italian, and French written articles. The following keywords were used for the search: sleep AND infant OR baby. The electronic search was first performed by one author (CCD) and then independently replicated by another author (BF). In a first stage, the titles and the abstracts (n = 8610) were independently analyzed by these two authors to identify potential relevant manuscripts. Abstracts that did not assess infant sleep-wake behavior were excluded (n = 8217). In a second stage, the full texts of the potential relevant articles (n = 393) were independently evaluated by the two authors for inclusion and exclusion criteria examination. In case of disagreement, consensus was reached through discussion. A search for manuscripts that have cited the included records was also performed (backward search) to identify potential relevant records and one more paper was included.

Inclusion and exclusion criteria

Studies were included according to the following criteria: a) original empirical studies; b) studies including infants aged between zero and 12 months; c) studies assessing reference values or changes in at least one sleep-wake behavior. Exclusion criteria included: a) non-original research (e.g., literature reviews, systematic reviews, or meta-analyses); b) studies including infants above 12 months of age or that did not indicate infant age; c) sleep intervention studies or clinical trials; d) case reports or single case studies; and e) non-normative samples.

Quality assessment

For quality assessment purposes, all studies were evaluated according to a checklist based on the system of Downs and Black (1998). This Quality Index evaluates the methodological quality of randomized and non-randomized studies and is comprised of 27 items, aggregated in five sub-scales. In accordance with previous studies, a modified version of the Quality Index was applied (e.g., Galland et al., 2012; Mohan et al., 2015; Salamh et al., 2016). As some items did not apply to this review's studies, the authors selected 14 from the total 27 items of the Quality Index of Downs and Black (1998) to score the selected non-randomized studies. All items were scored between zero and one, with exception of one item that was scored between zero and two, with a maximum possible total score of 15. Following previous studies (e.g., Salamh et al., 2016), scoring for item 27 was modified to be scored between zero and one. Each paper was scored with one in this item if there was sufficient power to detect significant effects. Papers with a total of >10 in the

Quality Index were considered good, between seven and 10 were considered moderate, and <seven were considered poor.

Data extraction

Data from studies that met the inclusion criteria were extracted for five data sheets (Table 3, 4, 5, 6, and 7) and organized according to the year of publication. This information was extracted by one author (CCD) and then reviewed by another author (BF). Studies were organized according to the objective of this review: reference values for exact ages and age ranges, and changes in sleep-wake behaviors during the first 12 months of life.

This review included all the sleep-wake behaviors studied in the literature: sleep duration over three time-periods (length of time infants spend asleep during i) the 24 hour period, ii) the daytime, and iii) the night-time), nocturnal wakefulness (length of time infants spend awake during the night), sleep periods (number of naps/sleep episodes) and night wakings (number of wakings from sleep during the night), sleep latency (length of time infants take to fall asleep), longest sleep period (length of time of the longest sleep episode), bedtime/sleep onset time (start hour of sleep during the night), wake time (morning waking time), and sleep efficiency (percentage of sleep duration from bedtime to wake time).

Results

Databases search

The literature search yielded 8610 relevant papers (after the elimination of duplicates). The examination of the titles and abstracts lead to the exclusion of 8218 non-relevant papers. The full texts of the remaining 392 papers were assessed for inclusion/exclusion criteria. After full-text reading, 319 papers met one or more exclusion criteria and were excluded. A search for manuscripts that have cited the included papers (backward search) was performed and one more manuscript was included. Seventy-four papers were included in the review. Figure 2 presents a flow diagram of the search.

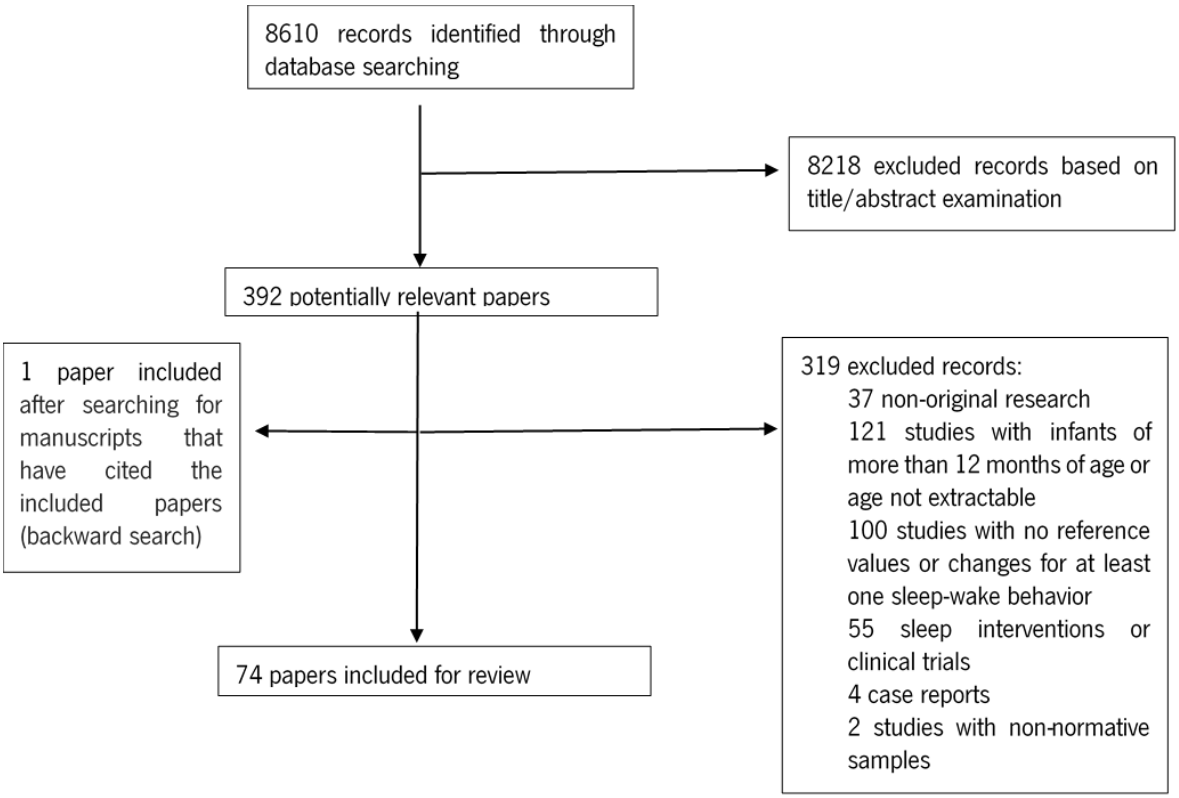


Figure 2. Search strategy flow chart.

Articles reviewed

The studies were performed in the United States (n = 19), Israel (n = 15), United Kingdom (n = 9), Australia (n = 4), and Japan (n = 4). At least one study was considered for 19 other countries (Brazil, Canada, China, Denmark, Ireland, Italy, Korea, Lithuania, Portugal, New Zealand, Spain, Switzerland, Taiwan, and Thailand) and at least one study was considered for one of the four continents (America, Asia, Europe, and Oceania). Studies presented a cross-sectional (n = 37) or a longitudinal (n = 36) design, with only one study presenting both cross-sectional and longitudinal design. Infant sleep-wake behaviors were recorded via questionnaire (n = 22), diary (n = 21), actigraphy (n = 9), interview (n = 7), video recording (n = 4), polysomnography (n = 1), and combined measures (n = 10). Regarding Quality Index, 40 studies were considered good quality and 34 studies moderate quality.

Reference values and changes in infant sleep-wake behavior during the first 12 months of life

Tables 3, 4, 5, and 6 summarize studies of reference values on infant sleep-wake behavior for: sleep duration, nocturnal wakefulness, sleep periods and night wakings, sleep latency, longest sleep period, bedtime/sleep onset time, wake time, and sleep efficiency. Specifically, Tables 3 and 4 summarize studies using infant exact ages, and studies using infant age ranges are presented in tables 5 and 6. Moreover, Tables 3 and 5 summarize studies that used measured based on parent reports and Tables 4 and 6 summarize studies that used direct measures. Mean values for sleep-wake behaviors were presented for studies using exact ages. For studies using age ranges the mean value was averaged for two main age ranges: between zero and six months and between six and 12 months. When studies presented more than one age range between zero and six months or between six and 12 months, the mean value was averaged and variability limits were presented. Table 7 presents changes in infant sleep-wake behavior during the first 12 months of life.

Table 3. Reference values for infant sleep-wake behavior during the first 12 months of life assessed with parent report measures (exact ages)

Author Year of publication	Country	Design	(N)	Sleep measure	Sleep-wake behavior/Age in months												
					Sleep Duration (24h) (hours)												
					<1	1	2	3	4	5	6	7	8	9	10	11	12
Figueiredo et al. (2016)	Portugal	L	94	D	13.3			13.0			12.2						
Bathory et al. (2016)	USA	CS	557	Q										11.3			
Galland et al. (2016)d	New Zealand	CS	160	D							12.8						12.3
Konrad et al. (2016)e	UK	CS	48	A and D							12.6						13.0
Sharkey et al. (2015)	USA	L	31	D	15.3	14.5			13.3								
McGeorge et al. (2015)	Australia	CS	55	D						13.6 a							
Bruni et al. (2014)	Italy	L	704	I				12.8			12.1			12.0			11.8
Johnson et al. (2014)	Australia	L	134	D								10.6					
Cespedes et al. (2014)	USA	L	1864	Q							12.2						12.8
Williams et al. (2013)	USA	L	6776	D													14.0
Klingenberg et al. (2013)	Denmark	L	311	Q										13.8			
Bottino et al. (2012)	USA	CS	1226	Q													12.8
Kaley et al. (2012)	UK	CS	77	D													13.5
Bordeleau et al. (2012)	Canada	L	55	D													13.0

					<1	1	2	3	4	5	6	7	8	9	10	11	12
Santos et al. (2012)	Brazil	CS	885	I													13.4
Blair et al. (2012)	UK	L	11478	Q													13.2
Bernier et al. (2010)	Canada	L	60	D													13.1
Nevarez et al. (2010)	USA	L	1676	Q							12.2						12.8
Tikotzky and Sadeh (2009)	Israel	L	85	Q		14.1					12.9						12.4
Jiang et al. (2007)	China	CS	1129	Q		14		14			13			13			12.0
Jenni et al. (2007)	Switzerland	L	305	I													14.6
O'Connor et al. (2007)	UK	L	11490	Q							12.8						
Montgomery-Downs and Gozal (2006)	USA	CS	944	Q	12.2	12.1	12.0		12.4		12.6			13.0			12.4
Harrison (2004)	UK	L	66	D		13.7	13.6	13.5									
Iglowstein et al. (2003)	Switzerland	L	493	I							14.2			13.9			13.9
St James-Roberts and Plewis (1996)	UK	L	122	D	14.3	13.5		13.6						13.2			
Quillin (1997)	USA	CS	44	D		14.7											

					Sleep Duration (day) (hours)												
					<1	1	2	3	4	5	6	7	8	9	10	11	12
Figueiredo et al. (2016)	Portugal	L	94	D	6.4			5.0			4.0						
Galland et al. (2016)d	New Zealand	CS	160	D							1.2						1.0
Bathory et al. (2016)	USA	CS	557	Q										2.3			
Konrad et al. (2016)e	UK	CS	48	A and D							3.0						1.8
Volkovich et al. (2015)	Israel	L	153	D				3.4			2.7						
Sorondo and Reeb-Sutherland (2015)	USA	L	40	Q						3.5				3.4			3.0
Tikotzky et al. (2015)	Israel	L	57	D				3.4			2.7						
Bruni et al. (2014)	Italy	L	704	I				3.3			2.3			2.1			2.0
Lukowski and Milojevich (2013)	USA	CS	21	Q											2.9		
Williams et al. (2013)	USA	L	6776	D													3.0
Piteo et al. (2013)	Australia	CS	111	Q													2.7
Kaley et al. (2012)	UK	CS	77	D													4.1
Santos et al. (2012)	Brazil	CS	885	I													2.7
Sinai and Tikotzky (2012)	Israel	CS	50	D					2.8a								
Blair et al. (2012)	UK	L	11478	Q													2.4

					<1	1	2	3	4	5	6	7	8	9	10	11	12
Nevarez et al. (2010)	USA	L	1676	Q							2.9						
Tikotzky et al (2010a)	Israel	CS	96	Q							3.1						
Tikotzky and Sadeh (2009)	Israel	L	85	Q		6.4					3.2						2.5
Jiang et al. (2007)	China	CS	1129	Q		5.0		4.0			4.0			3.0			3.0
Montgomery-Downs and Gozal (2006)	USA	CS	944	Q	3.5	3.3	3.1		2.8		2.4			2.5			2.0
Acebo et al. (2005)	USA	CS	169	D													2.8
Iglowstein et al. (2003)	Switzerland	L	493	I							3.4			2.8			2.4

Sleep Duration (night) (hours)

					<1	1	2	3	4	5	6	7	8	9	10	11	12
Figueiredo et al. (2016)	Portugal	L	94	D	6.9			8.0			8.2						
Bathory et al. (2016)	USA	CS	557	Q										9.0			
Galland et al. (2016)d	New Zealand	CS	160	D							10.4						10.6
Sorondo and Reeb-Sutherland (2015)	USA	L	40	Q						9.5				9.9			10.3
Hughes et al. (2015)	Ireland	CS	11134	Q										10.6			
Vijakkhana et al. (2015)	Thailand	L	208	D							9.6/ 9.8b						9.6/ 9.9b

					<1	1	2	3	4	5	6	7	8	9	10	11	12
Bruni et al. (2014)	Italy	L	704	I				9.4			9.8			9.9			9.8
Lukowski and Milojevich (2013)	USA	CS	21	Q											10.3		
Klingenberg et al. (2013)	Denmark	L	311	Q										10.7			
Piteo et al. (2013)	Australia	CS	111	Q													10.6
Kaley et al. (2012)	UK	CS	77	D													9.4
Bordeleau et al. (2012)	Canada	L	55	D													10.4
Santos et al. (2012)	Brazil	CS	885	I													9.4
Blair et al. (2012)	UK	L	11478	Q													10.8
Shinohara and Kodama (2011)	Japan	CS	67	D								9.0a					
Nevarez et al. (2010)	USA	L	1676	Q							9.3						
Tikotzky et al (2010a)	Israel	CS	96	Q							9.5						
Jiang et al. (2007)	China	CS	1129	Q		10.0		10.0			10.0			10.0			10.0
Montgomery-Downs and Gozal (2006)	USA	CS	944	Q	8.7	8.7	8.7		9.6		10.3			10.5			10.3
Iglowstein et al. (2003)	Switzerland	L	493	I							11.0			11.2			11.7
Quillin (1997)	USA	CS	44	D		6.8											

					Nocturnal wakefulness (hours)												
					<1	1	2	3	4	5	6	7	8	9	10	11	12
Figueiredo et al. (2016)	Portugal	L	94	D	4.1			3.1			2.8						
Sorondo and Reeb-Sutherland (2015)	USA	L	40	Q						0.7				0.4			0.3
Sinai and Tikotzky (2012)	Israel	CS	50	D						0.7a							
Tikotzky and Sadeh (2009)	Israel	L	85	Q		2.4					0.7						0.3

					Night wakings (number)												
					<1	1	2	3	4	5	6	7	8	9	10	11	12
Figueiredo et al. (2016)	Portugal	L	94	D	3.0			2.2			2.1						
Galland et al. (2016)d	New Zealand	CS	160	D							1.8						1.0
Volkovich et al. (2015)	Israel	L	153	D				2.2			2.6						
Brown and Harries (2015)	UK	CS	715	Q							2.1	2.1	1.6	1.7	1.5	1.3	1.3
Sorondo and Reeb-Sutherland (2015)	USA	L	40	Q						1.2				1.0			0.9
Tikotzky et al. (2015)d	Israel	L	57	D				2.5			3.2						
Hughes et al. (2015)	Ireland	CS	11134	Q										1.0			
Bruni et al. (2014)	Italy	L	704	I				1.1			1.5			1.8			1.4

					<1	1	2	3	4	5	6	7	8	9	10	11	12
Lukowski and Milojevich (2013)	USA	CS	21	Q											1.1		
McDaniel and Teti (2012)	USA	L	150	D		2.2		1.3									
Zentall et al. (2013)	USA	L	46	Q								1.2					0.7
Piteo et al. (2013)	Australia	CS	111	Q													1.4
Kaley et al. (2012)	UK	CS	77	D													1.7
Sinai and Tikotzky (2012)	Israel	CS	50	D					2.7a								
Shinohara and Kodama (2011)	Japan	CS	67	D								1.5a					
Bernier et al. (2010)	Canada	L	60	D													1.0
Tikotzky et al. (2010b)	Israel	L	56	D							2.9						
Tikotzky et al (2010a)	Israel	CS	96	Q							2.3						
Tikotzky and Sadeh (2009)	Israel	L	85	D							2.7						1.8
Tikotzky and Sadeh (2009)	Israel	L	85	Q		2.6					2.1						1.6
Anuntaseree et al. (2008)	Thailand	CS	3172	I				2.7									
O'Connor et al. (2007)	UK	L	11490	Q							0.7						

					<1	1	2	3	4	5	6	7	8	9	10	11	12
Montgomery-Downs and Gozal (2006)	USA	CS	944	Q	2.2	2.0	1.5		0.9		1.0			0.8			0.8
Quillin (1997)	USA	CS	44	D		1.7											
Scher (2005)	Israel	CS	59	D									1.9				
														Sleep Periods (24h) (number)			
					<1	1	2	3	4	5	6	7	8	9	10	11	12
Figueiredo et al. (2016)	Portugal	L	94	D	6.1			5.5			5.2						
Sharkey et al. (2015)	USA	L	31	D	7.9	6.9			5.9								
Quillin (1997)	USA	CS	44	D		5.9											
														Sleep Periods (day) (number)			
					<1	1	2	3	4	5	6	7	8	9	10	11	12
Figueiredo et al. (2016)	Portugal	L	94	D	3.2			3.3			3.1						
Galland et al. (2016)d	New Zealand	CS	160	D							2.1						1.5
Konrad et al. (2016) e	UK	CS	48	A and D							3.0						2.8
Bruni et al. (2014)	Italy	L	704	I				3.4			2.8			2.3			1.9
Shinohara and Kodama (2011)	Japan	CS	67	D								2.4a					
Montgomery-Downs and Gozal (2006)	USA	CS	944	Q	3.5	3.3	3.0		2.7		2.6			2.1			1.7

					Sleep Latency (24h) (minutes)												
					<1	1	2	3	4	5	6	7	8	9	10	11	12
Figueiredo et al. (2016)	Portugal	L	94	D	21			23			23						

					Sleep Latency (day) (minutes)												
					<1	1	2	3	4	5	6	7	8	9	10	11	12
Figueiredo et al. (2016)	Portugal	L	94	D	22			20			17						

					Sleep Latency (night) (minutes)												
					<1	1	2	3	4	5	6	7	8	9	10	11	12
Figueiredo et al. (2016)	Portugal	L	94	D	23			28			34						
Sorondo and Reeb-Sutherland (2015)	USA	L	40	Q						23.4				20.4			22.7
Bruni et al. (2014)	Italy	L	704	I				15.3			12.8			14.9			14.7
Tikotzky and Sadeh (2009)	Israel	L	85	D							19.2						17
Tikotzky and Sadeh (2009)	Israel	L	85	Q		40.3					21.5						18.2

					Longest Sleep Period (24h) (hours)												
					<1	1	2	3	4	5	6	7	8	9	10	11	12
Figueiredo et al. (2016)	Portugal	L	94	D	3.2			5.2			5.6						
Sharkey et al. (2015)	USA	L	31	D	2.9	3.6			4.7								

					Longest Sleep Period (day) (hours)																			
					<1	1	2	3	4	5	6	7	8	9	10	11	12							
Figueiredo et al. (2016)	Portugal	L	94	D	2.6			2.1			1.8													
					Longest Sleep Period (night) (hours)																			
					<1	1	2	3	4	5	6	7	8	9	10	11	12							
Figueiredo et al. (2016)	Portugal	L	94	D	3.0			5.2			5.6													
Shinohara and Kodama (2011)	Japan	CS	67	D							6.0a													
Henderson (2010)	New Zealand	L	75	D		5.4	7.3	8.0	8.4															
					Bedtime/Sleep Onset Time (hour)																			
					<1	1	2	3	4	5	6	7	8	9	10	11	12							
Mindell et al. (2016)	USA	CS/L	841	D						20:00	20:00	20:00	20:00	20:00		20:00								
Galland et al. (2016)d	New Zealand	CS	160	D							19:39						19:51							
Sharkey et al. (2015)	USA	L	31	D	23:00	22:50			21:58															
Bruni et al. (2014)	Italy	L	704	I				22:00			21:7			21:7			21:7							
Blair et al. (2012)	UK	L	11478	Q													20:08							
Montgomery-Downs and Gozal (2006)	USA	CS	944	Q	19:09	20:07	21:13		20:58		20:54			20:32			20:28							

					Wake Time (hour)												
					<1	1	2	3	4	5	6	7	8	9	10	11	12
Mindell et al. (2016)	USA	CS/L	841	D						7:00	7:00	7:00	7:00	7:00		7:30	
Galland et al. (2016)d	New Zealand	CS	160	D							7:09						6:50
Bruni et al. (2014)	Italy	L	704	I				7:4			7:5			7:6			7:5
Blair et al. (2012)	UK	L	11478	Q													6:56
Montgomery-Downs and Gozal (2006)	USA	CS	944	Q	6:52	6:49	6:36		7:16		8:49			7:33			7:49
					Sleep Efficiency (%)												
					<1	1	2	3	4	5	6	7	8	9	10	11	12
Galland et al. (2016)d	New Zealand	CS	160	D							90.2						96.4

LABEL
Design: CS Cross-sectional; L Longitudinal
Sleep measures: D Diary; I Interview; Q Questionnaire

aMean age of derived from an age range
bWeek day/weekend
cBoys/girls
dThis study used both parent report measures and direct measures to separately assess this sleep-wake behavior (a separate value regarding a different sleep-wake measure is presented elsewhere)
eThis study combined the information retrieved from two sleep-wake measures in the calculation of this sleep-wake behavior

Sleep duration

Sleep duration during the 24-hour period

Values for sleep duration during the 24-hour period in the first six months ranged from lower values (10.4h at six months), reported by studies with large samples (e.g., Galland et al., 2016), to higher values (15.3h at less than one month), presented by studies with small samples (e.g., Sharkey et al., 2015). There was a tendency for studies from European countries (with the exception of one study from Italy; Bruni et al., 2014), and from Canada and Brazil to present longer sleep duration during the 24-hour period (between 13.0h and 14.6h) at 12 months (Jenni et al., 2007; Kaley et al., 2012; Santos et al., 2012), in comparison with studies performed in New Zealand, USA, Israel and China that present lower values (between 11.0h and 12.8h) of sleep duration during the 24-hour period at this age (e.g., Galland et al., 2016; Williams et al., 2013). Values for sleep duration during the 24-hour period did not differ between studies as a function of the use of exact age or age range, the sleep-wake behavior measure or the sample size. A decrease in sleep duration during the 24-hour period from zero to 12 months was reported by studies that used measures based on parent reports (e.g., Bruni et al., 2014; Figueiredo et al., 2016; Teng et al., 2012). Changes in sleep duration during the 24-hour period did not differ between studies as a function of the use of exact age or age range, the sample size or the country where the study was conducted.

Sleep duration during the day

Values for sleep duration during the day in the first months ranged from higher values (6.4h at one month), presented by studies that used small samples (Tikotzky and Sadeh, 2009), to lower values (3.3h at one month), reported by studies with large samples (Montgomery and Gozal, 2006). Studies performed in New Zealand reported the lower values (between 1.0h and 1.6h at 12 months) of sleep duration during the day (Galland et al., 2016; Gibson et al., 2012) in comparison with studies from United Kingdom and United States that presented higher values (between 2.8 and 4.1 at 12 months; e.g., Acebo et al., 2015; Kaley et al., 2012). Values for sleep duration during the day did not differ between studies as a function of the use of exact age or age range, the sleep-wake behavior measure or the sample size. A decrease in sleep duration during the day was noted from zero to 12 months in studies that used measures based on parent reports. Changes in sleep duration during the day did not differ between studies as a function of the use of exact age or age range, the sample size or the country where the study was conducted.

Table 4. Reference values for infant sleep-wake behavior during the first 12 months of life assessed with direct measures (exact ages)

Author Year of publication	Country	Design	(N)	Sleep measure	Sleep-wake behavior/Age in months												
					Sleep Duration (24h) (hours)												
					<1	1	2	3	4	5	6	7	8	9	10	11	12
Galland et al. (2016)d	New Zealand	CS	160	A							10.4						11.0
Konrad et al. (2016)e	UK	CS	48	A and D							12.6						13.0
Gibson et al. (2012)	New Zealand	CS	52	A													12.2
					Sleep Duration (day) (hours)												
					<1	1	2	3	4	5	6	7	8	9	10	11	12
Galland et al. (2016)d	New Zealand	CS	160	A							1.0						0.9
Konrad et al. (2016)e	UK	CS	48	A and D							3.0						1.8
Gibson et al. (2012)	New Zealand	CS	52	A													1.6
					Sleep Duration (night) (hours)												
					<1	1	2	3	4	5	6	7	8	9	10	11	12
Galland et al. (2016)d	New Zealand	CS	160	A							8.8						9.9
Konrad et al. (2016)	UK	CS	48	A							10.4						11.0
Volkovich et al. (2015)	Israel	L	153	A				9.4			9.6						
Sadeh et al. (2015)	Israel	L	43	A													9.9
					<1	1	2	3	4	5	6	7	8	9	10	11	12

St James-Roberts et al. (2015)	UK	L	101	V		6.2		8.2										
Tikotzky et al. (2015)	Israel	L	57	A				9.5			9.7							
Scher and Cohen (2015)	Israel	L	28	A						9.8	10.3	9.8	10.1	10.2	10.0	10.0		
Scher (2012)	Israel	L	34	A									9.6		9.6		9.6	
Gibson et al. (2012)	New Zealand	CS	52	A													10.4	
Tikotzky et al. (2010b)	Israel	L	56	A							9.8							
Tikotzky et al (2010a)	Israel	CS	96	A							9.8							
Tikotzky and Sadeh (2009)	Israel	L	85	A							9.8						9.9	
Scher (2005)	Israel	CS	59	A									9.6					
Acebo et al. (2005)	USA	CS	169	A													8.5	8.4
Scher et al. (2004)	Israel	L	50	A				8.9			8.6			9.3			9.3	
Burnham et al. (2002)	USA	L	80	V		5.7		7.4			8.0			7.8			8.0	
Scher (2001)	Israel	CS	37	A													9.3	

					Nocturnal wakefulness (hours)													
					<1	1	2	3	4	5	6	7	8	9	10	11	12	
Konrad et al. (2016)	UK	CS	48	A							0.6						0.5	
St James-Roberts et al. (2015)	UK	L	101	V		0.8		0.7										
Acebo et al. (2005)	USA	CS	169	A													2	

					Night wakings (number)												
					<1	1	2	3	4	5	6	7	8	9	10	11	12
Konrad et al. (2016)	UK	CS	48	A							1.9						1.8
Galland et al. (2016)d	New Zealand	CS	160	A							2.7						1.7
Atun-Einy and Scher (2016)	Israel	L	20	A								2.2	2.0	2.4	2.0	1.7	
Volkovich et al. (2015)	Israel	L	153	A				2.8			2.2						
Sadeh et al. (2015)	Israel	L	43	A													1.3
St James-Roberts et al. (2015)	UK	L	101	V		3.4		3.1									
Tikotzky et al. (2015)d	Israel	L	57	A				2.5			2.2						
Scher and Cohen (2015)	Israel	L	28	A						2.3	2.4	2.0	2.0	2.1	1.9	1.5	
Gibson et al. (2012)	New Zealand	CS	52	A													1
McDaniel and Teti (2012)	USA	L	150	D		2.2		1.3									
Scher (2012)	Israel	L	34	A									1.8		1.4		1.1
Tikotzky et al. (2010b)	Israel	L	56	A							1.7						
Tikotzky and Sadeh (2009)	Israel	L	85	A							1.7						1.3
Scher et al. (2004)	Israel	L	50	A				2.0			3.3			2.5			2.5
Burnham et al. (2002)	USA	L	80	V		4.1		2.8			3.0			2.8			2.6
Goodlin-Jones et al. (2001)	USA	CS	80	V				2.9			3.5			4.7			2.6

Scher (2001)	Israel	CS	37	A														2.5
					Sleep Periods (24h)													
					<1	1	2	3	4	5	6	7	8	9	10	11	12	
Gibson et al. (2012)	New Zealand	CS	52	A														3
					Sleep Periods (day)													
					<1	1	2	3	4	5	6	7	8	9	10	11	12	
Galland et al. (2016)d	New Zealand	CS	160	A							1.8							1.2
Konrad et al. (2016)e	UK	CS	48	A and D							3.0							2.8
Acebo et al. (2005)	USA	CS	169	A														1.5
Gibson et al. (2012)	New Zealand	CS	52	A														1.5
					Sleep Latency (day) (minutes)													
					<1	1	2	3	4	5	6	7	8	9	10	11	12	
Gibson et al. (2012)	New Zealand	CS	52	A														18
					Sleep Latency (night) (minutes)													
					<1	1	2	3	4	5	6	7	8	9	10	11	12	
Gibson et al. (2012)	New Zealand	CS	52	A														9.3
					Longest Sleep Period (night)													
					<1	1	2	3	4	5	6	7	8	9	10	11	12	
Volkovich et al. (2015)	Israel	L	153	A				4.3			3.9							

					<1	1	2	3	4	5	6	7	8	9	10	11	12
St James-Roberts et al. (2015)	UK	L	101	V		2.1		3.3									
Scher (2012)	Israel	L	34	A									3.8		4.2		4.3
Scher (2005)	Israel	CS	59	A									3.8				
Acebo et al. (2005)	USA	CS	169	A													1.7/ 2.4c
Scher et al. (2004)	Israel	L	50	A				1.8			1.2			1.4			1.6
Burnham et al. (2002)	USA	L	80	V		3.0		4.7			4.8			4.7			4.7
Goodlin-Jones et al. (2001)	USA	CS	80	V				5.1			5.9			4.9			5.9

Bedtime/Sleep Onset Time

					<1	1	2	3	4	5	6	7	8	9	10	11	12
Galland et al. (2016)d	New Zealand	CS	160	A							20:21						19:48
Gibson et al. (2012)	New Zealand	CS	52	A													19:00
Tikotzky et al. (2010b)	Israel	L	56	A							21:19						
Tikotzky and Sadeh (2009)	Israel	L	85	A							21:10						21:10
Scher (2005)	Israel	CS	59	A									20:59				
Scher et al. (2004)	Israel	L	50	A				21:46			21:59			21:36			21:26
Scher (2001)	Israel	CS	37	A													21:43

					Wake Time												
					<1	1	2	3	4	5	6	7	8	9	10	11	12
Galland et al. (2016)d	New Zealand	CS	160	A							6:54						6:38
Gibson et al. (2012)	New Zealand	CS	52	A													6:22
Acebo et al. (2005)	USA	CS	169	A													6:52 7:02
					Sleep Efficiency (%)												
					<1	1	2	3	4	5	6	7	8	9	10	11	12
Galland et al. (2016)d	New Zealand	CS	160	A							82.1						89.7
Konrad et al. (2016)	UK	CS	48	A							93.2						93.1
Atun-Einy and Scher (2016)	Israel	L	20	A								94.2	93.2	92.8	94.1	95.3	
Sadeh et al. (2015)	Israel	L	43	A													96
Tikotzky et al. (2015)	Israel	L	57	A				91.4			93						
Scher and Cohen (2015)	Israel	L	28	A						93	93	94	94	93	95	96	
					<1	1	2	3	4	5	6	7	8	9	10	11	12
Scher (2012)	Israel	L	34	A									94.6		96		97.1
Gibson et al. (2012)	New Zealand	CS	52	A													96
Tikotzky et al (2010a)	Israel	CS	96	A							94.3						
Tikotzky and Sadeh (2009)	Israel	L	85	A							94.3						95.9

					<1	1	2	3	4	5	6	7	8	9	10	11	12
																	79.5
Acebo et al. (2005)	USA	CS	169	A													82.8
																	c
Scher (2005)	Israel	CS	59	A									94.2				
Scher et al. (2004)	Israel	L	50	A				83			82			83.6			87.6
Scher (2001)	Israel	CS	37	A													87.6

LABEL
Design: CS Cross-sectional; L Longitudinal
Sleep measures: A Actigraphy; P Polysmonogrpahy; V Video recording

aMean age of derived from an age range
bWeek day/weekend
cBoys/girls
dThis study used both parent report measures and direct measures to separately assess this sleep-wake behavior (a separate value regarding a different sleep-wake measure is presented elsewhere)
eThis study combined the information retrieved from two sleep-wake measures in the calculation of this sleep-wake behavior

Sleep duration during the night

Values for sleep duration during the night in the first six months ranged from lower values (7.0h at zero-six months), reported by the studies with small samples (Joseph et al., 2015), to higher values (between 10.0h and 11.0h at six months) presented by the studies with large samples and studies from China and Japan (e.g., Iglowstein et al., 2003; Jiang et al., 2007). Sleep duration during the night during the first three months differed across cross-sectional studies (between 6.8h and 10.0h; Jiang et al., 2007; Montgomery-Downs and Gozal, 2006; Quillin, 1997). Values for sleep duration during the night did not differ between studies as a function of the use of exact age or age range, the sleep-wake behavior measure or the sample size. A trend for increased sleep duration during the night from zero to 12 months was also shown in studies using questionnaires or interviews (Bruni et al., 2014; Iglowstein et al., 2003; Miaja et al., 2015; Sadeh, 2004, 2009; Teng et al., 2012). Studies that used actigraphy or diaries and with small samples showed no changes from three to 12 months (Konrad et al., 2016; Scher, 2012; Scher et al., 2004; Tikotzky et al., 2015; Vijakkhana et al., 2015; Volkovich et al., 2015). All studies performed in Israel, using actigraphy and with a longitudinal design showed no changes in sleep duration during the night (Scher, 2012; Scher et al., 2004; Tikotzky et al., 2015; Volkovich et al., 2015), with the exception of one study (Sadeh, 2004). Changes in sleep duration during the night did not differ between studies as a function of the use of exact age or age range.

Nocturnal wakefulness

Studies that used direct measures present lower values (0.6h) for nocturnal wakefulness in the first six months than studies using measures based on parent reports (between 0.7 and 2.8h; Figueiredo et al., 2016; Konrad et al., 2016). A trend for a decrease in infant nocturnal wakefulness from zero to 12 months was shown in studies using questionnaires or diaries (Figueiredo et al., 2016; Sadeh et al., 2009; Teng et al., 2012; Tikotzky and Sadeh, 2009), while no changes were reported in studies performed in the United Kingdom and using actigraphy or video recording (Konrad et al., 2016; St James-Roberts et al., 2015).

Table 5. Reference values for infant sleep-wake behavior during the first 12 months of infancy assessed with parent report measures (age ranges)

Author Year of publication	Country	Design	(N)	Sleep measure	Age range in months	
Sleep Duration (24h) (hours)						
					0-6	6-12
Ahnn et al. (2016)	Korea	CS	1036	Q	13.5 (13.0-14.0)	12.0 (12.0-12.0)
Price et al. (2014)	Australia	CS	10090	D	14.0 (14.0-14.0)	13.5 (13.4-13.6)
Teng et al. (2012)	Australia/ New Zealand	CS	2154	Q	14.4 (13.8-14.9)	13.5 (13.3-13.7)
Kohyama et al. (2011)	Japan	CS	21327	Q	14.7	12.0
Sadeh et al. (2009)	USA/Canada	CS	5006	Q	13.8 (13.3-14.3)	12.9 (12.8-12.9)
Thomas and Burr (2009)	USA	CS	20	D	13.4 (13.3-13.4)	
Chou (2007)	Taiwan	CS	504	D	15.4	13.4
Sadeh (2004)	Israel	CS	1028	Q	12.0	11.5
Sleep Duration (day) (hours)						
					0-6	6-12
Ahnn et al. (2016)	Korea	CS	1036	Q	4.8 (4.0-5.8)	2.8 (2.5-3.0)
Miaja et al. (2015)	Spain	CS	125	Q	4.6	
Price et al. (2014)	Australia	CS	10090	D	3.0 (3.0-3.0)	2.7 (2.6-2.8)
Teng et al. (2012)	Australia/ New Zealand	CS	2154	Q	4.9 (3.8-6.0)	2.9 (2.8-3.1)
Asaka and Takada (2011)d	Japan	CS	52	D		9.7
Kohyama et al. (2011)	Japan	CS	21327	Q	2.0	1.
Sadeh et al. (2009)	USA/Canada	CS	5006	Q	4.8 (3.8-5.8)	2.9 (2.8-3.0)
Sadeh (2004)	Israel	CS	1028	Q	3.6	2.6
Sleep Duration (night) (hours)						
					0-6	6-12
Ahnn et al. (2016)	Korea	CS	1036	Q	8.8 (8.5-9.0)	9.3 (9.0-9.5)

Miaja et al. (2015)	Spain	CS	125	Q	8.3	10.4
Teng et al. (2012)	Australia/ New Zealand	CS	2154	Q	10.0 (8.9-10.0)	10.6 (10.5-10.6)
Komada et al. (2012)	Japan	CS	967	D	9.2/9.6b	9.2/9.6b
Kohyama et al. (2011)	Japan	CS	21327	Q	9.2	9.2
Mindell et al. (2009)	USA	CS	1473	I	9.0	9.0
Sadeh et al. (2009)	USA/Canada	CS	5006	Q	9.0 (8.5-9.5)	9.9 (9.9-9.9)
Sadeh (2004)	Israel	CS	1028	Q	8.4	8.9
Nocturnal Wakefulness (hours)						
					0-6	6-12
Miaja et al. (2015)	Spain	CS	125	Q	0.9	
Teng et al. (2012)	Australia/ New Zealand	CS	2154	Q	0.9 (0.6-1.2)	0.4 (0.3-0.4)
Asaka and Takada (2011)d	Japan	CS	52	D		0.4
Sadeh et al. (2009)	USA/Canada	CS	5006	Q	0.9 (0.5-1.2)	0.4 (0.3-0.4)
Sadeh (2004)	Israel	CS	1028	Q	1.4	1.2
Night Wakings (number)						
					0-6	6-12
Ahnn et al. (2016)	Korea	CS	1036	Q	1.9 (1.8-2.1)	2.2 (2.1-2.4)
Price et al. (2014)	Australia	CS	10090	D	1.1 (1.1-1.1)	0.9 (0.7-1.0)
Teng et al. (2012)	Australia/ New Zealand	CS	2154	Q	1.6 (1.3-1.8)	1.3 (1.2-1.3)
Kohyama et al. (2011)	Japan	CS	21327	Q	1.7	1.9
Asaka and Takada (2011)d	Japan	CS	52	D		1.5
Sadeh et al. (2009)	USA/Canada	CS	5006	Q	1.6 (1.2-1.9)	1.3 (1.2-1.3)
Sadeh (2004)	Israel	CS	1028	Q	2.7	3.3
Sleep Periods (24h) (number)						
					0-6	6-12
Price et al. (2014)	Australia	CS	10090	D	6.1 (6.1-6.1)	5.1 (4.7-5.4)

Thomas and Burr (2009)	USA	CS	20	D	8.8	
Sleep Periods (day) (number)						
					0-6	6-12
Teng et al. (2012)	Australia/ New Zealand	CS	2154	Q	3.3 (3.1-3.5)	2.3 (2.0-2.6)
Kohyama et al. (2011)	Japan	CS	21327	Q	1.1	0.8
Sadeh et al. (2009)	USA/Canada	CS	5006	Q	3.3 (2.9-3.6)	2.2 (2.0-2.4)
Sleep Latency (night) (minutes)						
					0-6	6-12
Miaja et al. (2015)	Spain	CS	125	Q	23.8	
Longest Sleep Period (24h) (hours)						
					0-6	6-12
Thomas and Burr (2009)	USA	CS	20	D	4.8	
Longest Sleep Period (day) (hours)						
					0-6	6-12
Mindell et al. (2016)	USA	CS/L	841	D	0.9	
Komada et al. (2012)	Japan	CS	967	D	1.5/1.4b	1.8/1.5b
Longest Sleep Period (night) (hours)						
					0-6	6-12
Ahnn et al. (2016)	Korea	CS	1036	Q	5.3 (4.0-6.5)	6.8 (6.5-7.0)
Teng et al. (2012)	Australia/ New Zealand	CS	2154	Q	6.4 (5.2-7.6)	8.3 (8.1-8.4)
Kohyama et al. (2011)	Japan	CS	21327	Q	6.5	6.5
Sadeh et al. (2009)	USA/Canada	CS	5006	Q	6.1 (5.0-7.1)	7.9 (7.7-8.0)
Bedtime/Sleep Onset Time (hour)						
					0-6	6-12
Ahnn et al. (2016)	Korea	CS	1036	Q	22:00 (22:00-22:00)	22:00 (22:00-22:00)
Price et al. (2014)	Australia	CS	10090	D	20:00	20:00

Komada et al. (2012)	Japan	CS	967	D	21:38/21:37b	21:26/21:26b
Kohyama et al. (2011)	Japan	CS	21327	Q	21:82	21:40
Asaka and Takada (2011)d	Japan	CS	52	D	21:28	21:36
Chou (2007)	Taiwan	CS	504	D	21:7	21:8
Sadeh (2004)	Israel	CS	1028	Q	21:26	20:64
			Wake Time (hour)			
					0-6	6-12
Komada et al. (2012)	Japan	CS	967	D	7:02/7:34b	7:01/7:28b
Asaka and Takada (2011)d	Japan	CS	52	D	7:17	7:15
Kohyama et al. (2011)	Japan	CS	21327	Q	7:14	7:05

LABEL
Design: CS Cross-sectional; L Longitudinal
Sleep measures: D Diary; I Interview; Q Questionnaire

aMean age of derived from an age range
bWeek day/weekend
cBoys/girls
dThis study used both parent report measures and direct measures to separately assess this sleep-wake behavior (a separate value regarding a different sleep-wake measure is presented elsewhere)

Sleep periods and night wakings

Little attention has been paid to sleep periods in the literature and most of the studies involved a cross-sectional design. Sleep periods were more frequently studied during the day, while awakenings were more often studied at night. Sleep periods during the 24-hour period and during the day were less studied and low variability in the reference values was noted (between 3 and 7.9 during the 24-hour period and between 1.2 and 3.3 during the day). Sleep periods during the day were noted to decrease from zero to 12 months in most of the studies (Bruni et al., 2014; Konrad et al., 2016; Sadeh et al., 2009; Teng et al., 2012), with exception of one study from Portugal that noted no changes in the first six months (Figueiredo et al., 2016).

The number of night wakings ranged from lower values (1.0 at nine months), presented by the studies that used measures based on parent reports (Hughes et al., 2015), to higher values (4.7 at nine months) reported in studies that used direct measures (Goodlin-Jones et al., 2001). Results did not differ between studies as a function of the use of exact age or age range, sample size, or the country where the study was conducted. Night wakings were seen to decrease from zero to three months (Burnham et al., 2002; Jenni et al., 2005; McDaniel and Teti, 2012; Sadeh et al., 2009; Teng et al., 2012). Interestingly, while cross-sectional studies conducted in the United States showed no changes in night wakings from three to 12 months (Goodlin-Jones et al., 2001; Sadeh et al., 2009), almost all longitudinal studies performed in Israel showed decreased night wakings for that time interval (Hughes et al., 2015; Scher et al., 2004; Scher and Cohen, 2015, Tikotzky and Sadeh, 2009). Two studies showed an increase in night wakings from three to six months when measured by diaries, while no changes or a decrease was noted by the same studies when measuring night wakings by actigraphy (Volkovich et al., 2015; Tikotzky et al., 2015).

Sleep latency

Reference values for sleep latency are usually presented in minutes. Sleep latency was more frequently studied during the night and only two studies assessed sleep latency during the day, and one study during the 24-hour period. Values for sleep latency during the night ranged between lower values (9.3 minutes at 12 months) presented by studies that used actigraphy (Gibson et al., 2012), and higher values (34 minutes at six months) reported in studies that used other sleep-wake measures (Figueiredo et al., 2016). Few studies assessed changes in sleep latency during the night and different results were found from one to six months (Bruni et al., 2014; Figueiredo et al., 2016; Tikotzky and Sadeh, 2009). Only one study addressed changes from six to 12 months noting no changes (Bruni et al., 2014).

Table 6. Reference values for infant sleep-wake behavior during the first 12 months of infancy assessed with direct measures (age ranges)

Author Year of publication	Country	Design	(N)	Sleep measure	Age range in months	
Sleep Duration (day) (hours)						
					0-6	6-12
Asaka and Takada (2011)d	Japan	CS	52	A		9.0
Sleep Duration (night) (hours)						
					0-6	6-12
Joseph et al. (2015)	UK	L	35	A	7.0	
Nocturnal Wakefulness (hours)						
					0-6	6-12
Asaka and Takada (2011)d	Japan	CS	52	A		0.6
Night Wakings (number						
					0-6	6-12
Asaka and Takada (2011)d	Japan	CS	52	A		2.5
Ficca et al. (1999)	Italy	CS	48	P	7.4	4.9
Sleep Latency (night) (minutes)						
					0-6	6-12
Joseph et al. (2015)	UK	L	35	A	10.0	
Bedtime/Sleep Onset Time (hour)						
					0-6	6-12
Asaka and Takada (2011)d	Japan	CS	52	A	21:27	21:29

					Wake Time (hour)	
					0-6	6-12
Asaka and Takada (2011)d	Japan	CS	52	A	7:13	7:11

LABEL
Design: CS Cross-sectional; L Longitudinal
Sleep measures: A Actigraphy; P Polysmonogrpahy;
aMean age of derived from an age range
bWeek day/weekend
cBoys/girls
dThis study used both parent report measures and direct measures to separately assess this sleep-wake behavior (a separate value regarding a different sleep-wake measure is presented elsewhere)

Longest Sleep Period

The longest sleep period during the 24-hour period and the day was little studied. The longest sleep period (24-hour period) increased during the first half of the first year (Figueiredo et al., 2016; Mindell et al., 2016), and remained stable from eight to 12 months (Mindell et al., 2016). Only one study assessed changes in the longest sleep period during the day, showing a decrease from zero to six months (Figueiredo et al., 2016).

The longest sleep period during the night ranged from lower values (1.2h at six months) found in studies that used direct measures (Scher, 2004), to higher values (8.4 at five months) reported in studies using measures based on parent reports (Henderson et al., 2010). Results did not differ between studies as a function of the use of exact age or age range, sample size, or the country where the study was conducted. The longest sleep period during the night was noted to increase in the first three-four months in all studies (Burnham et al., 2002; Henderson et al., 2010; Mindell et al., 2016; Sadeh et al., 2009; St James-Roberts et al., 2015; Teng et al., 2012), and between three and 11 months in studies that used age ranges (Sadeh et al., 2009; Teng et al., 2012).

Bedtime/Sleep onset time

Bedtime/sleep onset time ranged from earlier times (19h09 at less than one month), reported by cross-sectional studies and studies performed in New Zealand (Montgomery-Downs and Gozal, 2006), and later times (22h50 at one month), reported in longitudinal studies and studies performed in Israel (Sharkey et al., 2016). Results did not differ between studies as a function of the use of exact age or age range, or sample size. The few studies that assessed changes in bedtime/sleep onset time noted a tendency for a decrease from three to six months (Bruni et al., 2014), with a stabilization from six to 12 months (Tikotzky and Sadeh, 2009).

Wake time

At six months, an early wake time (6h54) was shown in a study that used actigraphy (Galland et al., 2016), and later wake times (between 7h09 and 8h49) were seen in studies that used measures based on parent reports (Bruni et al., 2014; Mindell et al., 2016; Montgomery-Downs and Gozal, 2006). No changes were noted in wake times from zero to 12 months (Bruni et al., 2014).

Table 7. Changes in sleep-wake behavior during the first 12 months of life

Author Year of publication	Country	Design	(N)	Sleep measure	Age (months)	Sleep-wake behavior
			Sleep Duration (24h)			
Figueiredo et al. (2016)	Portugal	L	94	D	>1, 3, 6	>1 > 6
Konrad et al. (2016)b	UK	CS	48	A and D	6, 12	6 = 12
Bruni et al. (2014)	Italy	L	704	I	3, 6, 9, 12	3 >12
Teng et al. (2012)	Australia/ New Zealand	CS	2154	Q	0-2, 3-5, 6-8, 9-11	0-2 > 3-5 > 6-8 > 9-11
Kohyama et al. (2011)	Japan	CS	21327	Q	0-2, 3-11	0-2 > 3-11
Tikotzky and Sadeh (2009)	Israel	L	85	Q	1, 6	1 > 6
Sadeh et al. (2009)	USA/Canada	CS	5006	Q	0-2, 3-5, 6-8, 9-11	0-2 > 3-5 > 6-8 = 9-11
Sadeh (2004)	Israel	CS	1028	Q	0-6, 6-12	0-6 > 6-12
			Sleep Duration (day)			
Figueiredo et al. (2016)	Portugal	L	94	D	>1, 3, 6	>1 > 6
Konrad et al. (2016)b	UK	CS	48	A and D	6, 12	6 = 12
Volkovich et al. (2015)	Israel	L	153	D	3, 6	3 > 6
Tikotzky et al. (2015)	Israel	L	57	D	3, 6	3 > 6
Bruni et al. (2014)	Italy	L	704	I	3, 6, 9, 12	3 > 12
Teng et al. (2012)	Australia/ New Zealand	CS	2154	Q	0-2, 3-5, 6-8, 9-11	0-2 > 3-5 > 6-8 > 9-11
Kohyama et al. (2011)	Japan	CS	21327	Q	0-2, 3-11	0-2 > 3-11
Tikotzky and Sadeh (2009)	Israel	L	85	Q	1, 6, 12	1 > 6 > 12
Sadeh et al. (2009)	USA/Canada	CS	5006	Q	0-2, 3-5, 6-8, 9-11	0-2 > 3-5 > 6-8 > 9-11
Sadeh (2004)	Israel	CS	1028	Q	0-6, 6-12	0-6 > 6-12
			Sleep Duration (night)			
Figueiredo et al. (2016)	Portugal	L	94	D	>1, 3, 6	>1 < 6
Philbrook and Teti (2016)	USA	L	109	V	1, 3, 6	1 < 3 = 6

Konrad et al. (2016)	UK	CS	48	A	6, 12	6 = 12
Volkovich et al. (2015)	Israel	L	153	A	3, 6	3 = 6
Tikotzky et al. (2015)	Israel	L	57	A	3, 6	3 = 6
Vijakkhana et al (2015)	Thailand	L	208	D	6, 12	6 = 12
Miaja et al (2015)	Spain	CS	125	Q	0-6, 6-12	0-6 < 6-12
Bruni et al. (2014)	Italy	L	704	I	3, 6, 9, 12	3 < 6 = 9 = 12
Scher (2012)	Israel	L	34	A	8, 12	8 = 12
Teng et al. (2012)	Australia/ New Zealand	CS	2154	Q	0-2, 3-5, 6-8, 9-11	0-2 < 3-5 < 6-8 = 9-11
Sadeh et al. (2009)	USA/Canada	CS	5006	Q	0-2, 3-5, 6-8, 9-11	0-2 < 3-5 < 6-8 = 9-11
Sadeh (2004)	Israel	CS	1028	Q	0-6, 6-12	0-6 < 6-12
Iglowstein et al. (2003)	Switzerland	L	493	I	3, 12	3 < 12
Scher et al. (2004)	Israel	L	50	A	3, 12	3 = 12
Burnham et al. (2002)	USA	L	80	V	1, 12	1 < 12
			Nocturnal Wakefulness			
Figueiredo et al. (2016)	Portugal	L	94	D	>1, 3, 6	>1 > 6
Konrad et al. (2016)	UK	CS	48	A	6, 12	6 = 12
St James-Roberts et al. (2015)	UK	L	101	V	1, 3	1= 3
Teng et al. (2012)	Australia/ New Zealand	CS	2154	Q	0-2, 3-5, 6-8, 9-11	0-2 > 3-5 > 6-8 = 9-11
Tikotzky and Sadeh (2009)	Israel	L	85	Q	1, 6, 12	1 > 6 > 12
Sadeh et al. (2009)	USA/Canada	CS	5006	Q	0-2, 3-5, 6-8, 9-11	0-2 > 3-5 > 6-8 = 9-11
			Night Wakings			
Figueiredo et al. (2016)	Portugal	L	94	D	>1, 3, 6	>1 > 6
Konrad et al. (2016)	UK	CS	48	A	6, 12	6 = 12

Atun-Einy and Sadeh (2016)	Israel	L	20	A	7, 9, 11	7 = 9 = 11
Volkovich et al. (2015)a	Israel	L	153	A	3, 6	3 > 6
Volkovich et al. (2015)a	Israel	L	153	D	3, 6	3 < 6
Tikotzky et al. (2015)a	Israel	L	57	A	3, 6	3 = 6
Tikotzky et al. (2015)a	Israel	L	57	D	3, 6	3 < 6
Scher and Cohen (2015)	Israel	L	28	A	5, 6, 8, 9,11	5, 6, 8, 9 > 11
Bruni et al. (2014)	Italy	L	704	I	3, 6, 9, 12	3 < 12
McDaniel and Teti (2012)	USA	L	150	D	1, 3	1 > 3
Scher (2012)	Israel	L	34	A	8, 10	8 > 10
Sirvinskiene et al. (2012)	Lithuania	L	189	Q	3, 6	3 > 6
Teng et al. (2012)	Australia/ New Zealand	CS	2154	Q	0-2, 3-5, 6-8, 9-11	0-2 > 3-5 = 6-8 = 9-11
Tikotzky and Sadeh (2009)	Israel	L	85	Q	1, 6, 12	1 > 6 > 12
Sadeh et al. (2009)	USA/Canada	CS	5006	Q	0-2, 3-5, 6-8, 9-11	0-2 > 3-5 = 6-8 = 9-11
Burnham et al. (2002)	USA	L	80	V	1,3	1 > 3
Scher et al. (2004)	Israel	L	50	A	3, 6, 9, 12	3 < 6 > 9, 12
Goodlin-Jones et al. (2001)	USA	CS	80	V	3, 12	3 = 12
Ficca et al. (1999)	Italy	CS	48	P	0-2, 6-12	0-2 > 6-12
Jenni et al. (2005)	Switzerland	L	493	I	1, 3	1 > 3
			Sleep Periods (24h)			
Figueiredo et al. (2016)	Portugal	L	94	D	>1, 3, 6	>1 > 6
			Sleep Periods (day)			
Figueiredo et al. (2016)	Portugal	L	94	D	>1, 3, 6	>1 = 6
Konrad et al. (2016)b	UK	CS	48	A and D	6, 12	6 > 12
Bruni et al. (2014)	Italy	L	704	I	3, 6, 9, 12	3 > 12

Teng et al. (2012)	Australia/ New Zealand	CS	2154	Q	0-2, 3-5, 6-8, 9-11	0-2 > 3-5 > 6-8 > 9-11
Sadeh et al. (2009)	USA/Canada	CS	5006	Q	0-2, 3-5, 6-8, 9-11	0-2 > 3-5 > 6-8 > 9-11
			Sleep Latency (24h)			
Figueiredo et al. (2016)	Portugal	L	94	D	>1, 3, 6	>1 = 6
			Sleep Latency (day)			
Figueiredo et al. (2016)	Portugal	L	94	D	>1, 3, 6	>1 = 6
			Sleep Latency (night)			
Figueiredo et al. (2016)	Portugal	L	94	D	>1, 3, 6	>1 = 6
Bruni et al. (2014)	Italy	L	704	I	3, 6, 9, 12	3 > 6 = 9 = 12
Tikotzky and Sadeh (2009)	Israel	L	85	Q	1, 6	1 > 6
			Longest Sleep Period (24-hour)			
Figueiredo et al. (2016)	Portugal	L	94	D	>1, 3, 6	>1 < 6
Mindell et al. (2016)	USA	CS/ L	841	D	0-2, 5, 8, 12	0-2 < 5, 8 = 12
			Longest Sleep Period (day)			
Figueiredo et al. (2016)	Portugal	L	94	D	>1, 3, 6	>1 > 6
			Longest Sleep Period (night)			
Figueiredo et al. (2016)	Portugal	L	94	D	>1, 3, 6	>1 < 6
Volkovich et al. (2015)	Israel	L	153	A	3, 6	3 > 6
St James-Roberts et al. (2015)	UK	L	101	V	1, 3	1 < 3
Scher (2012)	Israel	L	34	A	8, 12	8 < 12
Teng et al. (2012)	Australia/ New Zealand	CS	2154	Q	0-2, 3-5, 6-8, 9-11	0-2 < 3-5 < 6-8 = 9-11
Henderson et al. (2010)	New Zealand	L	75	D	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12	1 < 4, 5 = 9
Sadeh et al. (2009)	USA/Canada	CS	5006	Q	0-2, 3-5, 6-8, 9-11	0-2 < 3-5 < 6-8 < 9-11

Burnham et al. (2002)	USA	L	80	V	1, 3	1 < 3
Scher et al. (2004)	Israel	L	50	A	3, 6, 9, 12	3 > 6, 9 < 12
Goodlin-Jones et al. (2001)	USA	CS	80	V	3, 12	3 < 12
			Bedtime/Sleep Onset Time			
Bruni et al. (2014)	Italy	L	704	I	3, 6, 9, 12	3 > 6, 9, 12
Tikotzky and Sadeh (2009)	Israel	L	85	A	6, 12	6 = 12
			Wake Time			
Bruni et al. (2014)	Italy	L	704	I	3, 6, 9, 12	3 = 6, 9, 12
			Sleep Efficiency			
Scher (2012)	Israel	L	34	A	8, 10, 12	8 = 10 = 12
Tikotzky and Sadeh (2009)	Israel	L	85	A	6, 12	6 < 12

LABEL
Design: CS Cross-sectional; L Longitudinal
Sleep measures: A Actigraphy; D Diary; I Interview; Q Questionnaire; V Video recording

aThis study used both parent report measures and direct measures to separately assess this sleep-wake behavior (a separate value regarding a different sleep-wake measure is presented elsewhere)
bThis study combined the information retrieved from two sleep-wake measures in the calculation of this sleep-wake behavior

Sleep efficiency

Sleep efficiency was mainly assessed by actigraphy. Reference values and changes for sleep efficiency present large variability (between 82.1% and 94.3% at six months), regardless of the sleep-wake behavior measure, country, study design, or sample size. Although one study showed an increase from six to 12 months in sleep efficiency (Tikotzky and Sadeh, 2009), sleep efficiency did not typically change from eight to 10 months and from 10 to 12 months (Scher, 2012). Despite this result, sleep efficiency has increased by the end of the first 12 months of life (Gibson et al., 2012).

Discussion

This study is a systematic review of the literature on the reference values and changes in infant sleep-wake behavior during the first 12 months of life. Different sleep-wake behaviors were considered, including sleep duration, nocturnal wakefulness, sleep periods and night wakings, sleep latency, longest sleep period, bedtime/sleep onset time, wake time, and sleep efficiency. Seventy-four studies performed over the last 20 years, and with the use of different sleep-wake measures, in 19 countries were included.

Some discrepancy was noted between studies on reference values for sleep duration, consistent with a previous systematic review (Galland et al., 2012). This may reflect large individual differences found in sleep duration in previous research (Figueiredo et al., 2016). And it could also reflect the rapid changes occurring in sleep duration during the first months of life (Galland et al., 2012). Additionally, several methodological differences between the studies were reported.

Values presented for sleep duration during the 24-hour period are consistent with those previously presented in a systematic review (Galland et al., 2012). However, that review was based on studies using parent report measures and did not review changes in sleep-wake behavior. In the present review, no differences in the reference values for sleep duration were found as a function of the sleep-wake measure. However, there were some differences noted in the changes of sleep duration over time between studies that used measures based on parent reports and studies that used direct measures; these were apparent for changes in sleep duration during the night and also, to some extent, for changes in sleep duration during the day and the 24-hour period. A trend for a decrease in sleep duration during the 24-hour period and the day from zero to 12 months was shown in studies that used measures based on parent reports. The only study that combined the information of both actigraphy and diary showed no changes in sleep duration during the 24-hour period and the day. The direction of the changes in sleep duration during the night

was not clear. Studies using questionnaires and interviews showed an increase from zero to 12 months, while no changes were noted from three to 12 months in studies that used actigraphy or diaries and with small samples. Differences in sleep duration during the 24-hour period, the day, and the night were found according to sample size and the country where the study was performed. However, contrary to a previous study that showed lower sleep duration in infants from China and Japan from zero to 36 months (Mindell et al., 2010), this tendency was not always shown in this review. Only two studies presented different reference values for sleep duration during the night for week and week-end days, and longer sleep duration occurred during week-end nights (Komada et al., 2012; Vijakkhana et al., 2015), showing already a tendency for more sleep during week-end nights in the first 12 months of life.

Nocturnal wakefulness was less frequently studied than sleep duration. Few studies addressed this sleep-wake behavior, so cross-comparisons were difficult to perform and no congruence was achieved regarding changes in nocturnal wakefulness.

There were also few studies that addressed sleep periods so again cross-comparisons were not possible. The results are consistent with an earlier study that showed no differences in sleep periods during the day as measured by sleep diaries or actigraphy (Galland et al., 2016). Sleep periods during the day tended to decrease from zero to 12 months (Bruni et al., 2014; Figueredo et al., 2016; Konrad et al., 2016; Sadeh et al., 2009; Teng et al., 2012).

Differences in reference values for night wakings were noted as a function of sleep-wake measure, with a lower number of night wakings being found in the studies that used parent reports. This result seems to indicate that parents may not notice all the infant night wakings, consistent with an earlier study that compared infant sleep-wake behavior based on diary reports and actigraphy (Asaka and Takada, 2011). Night wakings decreased during the first three months (Burnham et al., 2002; Jenni et al., 2005; McDaniel and Teti, 2012; Sadeh et al., 2009; Teng et al., 2012). However, there was no congruence between the different studies regarding changes from three to 12 months.

Sleep latency also received less attention and cross-comparisons were difficult to perform. Differences in reference values for sleep latency during the night were found according to sleep-wake measure. Considering its short duration, it could be more difficult for parents to accurately record sleep latency (Galland et al., 2012). No congruence was found regarding changes in sleep latency during the night from one to six months (Bruni et al., 2014; Figueiredo et al., 2016; Tikotzky and Sadeh, 2009), while no changes were noted from six to 12 months (Bruni et al., 2014).

Few studies explored the longest sleep period during the 24-hour period and the day and cross-comparisons were difficult to perform. The longest sleep period during the 24-hour period increased during the first six months (Figueiredo et al., 2016; Mindell et al., 2016), while during the day a decrease was noted (Figueiredo et al., 2016). Regarding the longest sleep period during the night, higher values were found in studies that used measures based on parent reports. As we previously suggested, parents may not notice all the infant night wakings, recording a longer sleep period duration than actigraphy or video recording measures. All studies showed an increase in the longest sleep period at night from zero-one to three-four months (Burnham et al., 2002; Henderson et al., 2010; Mindell et al., 2016; Sadeh et al., 2009; St James-Roberts et al., 2015; Teng et al., 2012), while no congruence was found from three to 12 months.

Reference values for bedtime/sleep onset time varied across studies. Differences were found in reference values for bedtimes as a function of the study design and the country where the study was performed. At least one study showed cultural differences in bedtimes, with infants from Asian countries showing later bedtimes (Mindell et al., 2010). Studies performed in Asian countries used age ranges, making it difficult to compare with studies from other countries that used exact ages. Although no differences between studies were noted according to the sleep-wake behavior measure, some studies analyzed sleep onset times based on parents' reports, while other studies analyzed sleep onset times derived from actigraphy. The few studies that analyzed changes in bedtime/sleep onset time reported a decrease from three to six months (Bruni et al., 2014), and a stabilization from six to 12 months (Tikotzky and Sadeh, 2009).

Less differences across studies were noted in reference values for wake time, when compared with bedtime/sleep onset time. Although at least one study showed that Asian infants have later wake times (Mindell et al., 2010), no differences were noted between other countries. Again, studies from Asian countries used age ranges, making it difficult to compare with studies that used exact ages. Differences were found in reference values for wake time at six months as a function of sleep-wake measure. Wake times tended to be stable during the first 12 months of life (Bruni et al., 2014).

The studies were discrepant in their reference values on sleep efficiency, regardless of the sleep-wake behavior measure, country, study design, or sample size. The selected studies defined sleep efficiency as the percentage of true/actual sleep or time spent asleep from either the total sleep period or from sleep onset to morning awakening. However, two of the studies did not clarify the definition of sleep efficiency (Galland et al., 2016; Scher and Cohen, 2015). Moreover, although

some studies clearly defined sleep period as from sleep onset to morning awakening, other studies considered the percentage of sleep from the total sleep period, not being clear if sleep latency was also considered as sleep. No congruence was found regarding changes in sleep efficiency from six to 12 months.

Considering the presented results, the literature on infant-sleep wake behavior presents several methodological differences. Regarding the studied variables, different attention has been paid to the different sleep-wake behaviors. Sleep duration during the night and night wakings were extensively studied, while less attention has been paid to nocturnal wakefulness, sleep periods, sleep latency, bedtime, wake time, and sleep efficiency. However, nocturnal wakefulness and sleep efficiency have been associated with infant cognitive development (Gibson et al., 2012; Konrad et al., 2016) and sleep efficiency is an indicator of sleep quality usually defined as the percentage of sleep duration from bedtime to wake time (Konrad et al., 2016). Interestingly, most of the studies that analyzed this sleep-wake behavior used actigraphy and only assessed it after three months. And, even though sleep-wake behaviors were correlated with each other (Acebo et al., 2005), few studies assessed them simultaneously, which could bias the provided results.

Regarding studies that identified specific ages and age ranges, few differences were noted. However, the use of exact ages is more accurate for the identification of normative values, considering the rapid changes that occur in infant sleep-wake behavior during the first 12 months of life.

Differences in the assessment of infant sleep-wake behavior during the night, especially in night wakings, sleep latency and longest sleep period were noted as a function of the different measures used. A previous study showed differences between sleep diaries and actigraphy in the assessment of sleep-wake behavior during the night, but not during the day and the 24-hour period (So et al., 2007). A possible explanation is that parents may not notice all the infant's night wakings providing a less accurate assessment of infant sleep-wake behavior during the night (Asaka and Takada, 2011; So et al., 2007). However, compared with sleep diaries, actigraphy records night wakings that are already episodes of self-soothing (Hall et al., 2015).

Another important limitation of the literature is related to sample differences, namely the use of different sample sizes, and samples from different countries. Differences in normative reference values and changes were identified in studies that used small samples. Large samples are needed when intending normative reference values. Differences according to countries where the study was performed were also identified, suggesting different sleep-wake habits. Cultural

differences in sleep-wake behavior were also identified in previous studies (Field, 2017; Mindell et al., 2010).

Moreover, the possible interaction between these methodological differences could also explain the inconsistent results between studies. The variability of the existing data and the methodological differences between the studies make it difficult to identify the ages where changes in infant sleep-wake behavior occur.

Nonetheless, this review identifies normative reference values and the changes occurring in infant sleep-wake behavior and could inform both practitioners and researchers and help them identify infants with sleep delays or problems. During the 24-hour period, infants showed a decrease in sleep duration over the first 12 months of life, and concentrated their sleep in longer periods, especially in the first six months. This result is consistent with previous literature that showed a decrease in sleep duration and an increase in the longest sleep period during the 24-hour period in the first six months of life (Figueiredo et al., 2016). During the day, infants showed a decrease in sleep duration and in sleep periods over the first 12 months of life. These changes partially corroborated the first and the second developmental tasks presented in the literature: to spend more time awake than asleep and concentrating sleep time during the night (Figueiredo et al., 2016). Less consistency was achieved regarding changes in sleep-wake behavior during the night, especially in the second half of the first 12 months of life. The most consistent changes in sleep-wake behavior during the night occurred during the first six months of life: night wakings and bedtime/sleep onset time decreased during the first month, while the longest sleep period during the night was noted to increase during the first three-four months. These changes are consistent with the two other developmental tasks of sleep-wake behavior described in the literature: getting and returning to sleep alone and sleeping through the night (Figueiredo et al., 2016). While the first and second developmental tasks seem to occur over the first year, these other two developmental tasks seem to occur during the first six months of life. This is congruent with previous literature showing that the ability of the infants to sustain sleep during the night for longer periods occur during the first three-four months of life (Bathory et al., 2016).

Conclusions

Reference values and changes were provided for different sleep-wake behaviors during the first 12 months of life. Some discrepancy between studies was noted as a function of methodological differences. These differences should be considered in future research and caution should be taken when generalizing results from studies using one specific measure, from a specific

country or with small samples. Longitudinal studies should be conducted with representative samples, since the first weeks of life and individual differences in sleep-wake behavior should also be addressed. Considering the differences noted between the different sleep-wake measures, especially in sleep-wake behaviors during the night, the use of both measures based on parent reports and actigraphy or the use of video recording is strongly recommended to assess those behaviors.

References

Acebo, C., Sadeh, A., Seifer, R., Tzischinsky, O., Hafer, A., and Carskadon, M.A. Sleep/wake patterns derived from activity monitoring and maternal report for healthy 1-to 5-year-old children. Sleep, 2005, 28: 1568-1577.

Ahn, Y., Williamson, A.A., Seo, H.J., Sadeh, A., and Mindell, J.A. Sleep patterns among south korean infants and toddlers: global comparison. J Korean Med Sci, 2016, 31: 261-269.

Anuntaseree, W., Mo-Suwan, L., Vasiknanonte, P., Kuasirikul, S., and Choprapawan, C. Night waking in Thai infants at 3 months of age: association between parental practices and infant sleep. Sleep Med, 2008, 9: 564-571.

Asaka, Y., and Takada, S. Comparing sleep measures of infants derived from parental reports in sleep diaries and acceleration sensors. Acta Paediatr, 2011, 100: 1158-1163.

Atun-Einy, O., and Scher, A. Sleep disruption and motor development: does pulling-to-stand impacts sleep–wake regulation? Infant Behav Dev, 2016, 42: 36-44.

Bathory, E., Tomopoulos, S., Rothman, R., et al. Infant sleep and parent health literacy. Acad Pediatr, 2016, 16: 550-557.

Bernier, A., Carlson, S.M., Bordeleau, S., and Carrier, J. Relations between physiological and cognitive regulatory systems: infant sleep regulation and subsequent executive functioning. Child Dev, 2010, 81: 1739-1752.

Blair, P.S., Humphreys, J.S., Gringras. P., et al. Childhood sleep duration and associated demographic characteristics in an English cohort. Sleep, 2012, 35: 353-360.

Bordeleau, S., Bernier, A., Carrier, J. Maternal sensitivity and children's behavior problems: examining the moderating role of infant sleep duration. J Clin Child Adolesc Psychol, 2012, 41: 471-481.

Bottino, C.J., Rifas-Shiman, S.L., Kleinman, K.P., et al. The association of urbanicity with infant sleep duration. Health Place, 2013, 18: 1000-1005.

Brown, A., and Harries, V. Infant sleep and night feeding patterns during later infancy: association with breastfeeding frequency, daytime complementary food intake, and infant weight. Breastfeed Med, 2015, 10: 246-252.

Bruni, O., Baumgartner, E., Sette, S., et al. Longitudinal study of sleep behavior in normal infants during the first year of life. J Clin Sleep Med, 2014, 10: 1119-1127.

Burnham, M.M., Goodlin-Jones, B.L., Gaylor, E.E., and Anders, T.F. Nighttime sleep-wake patterns and self-soothing from birth to one year of age: a longitudinal intervention study. J Child Psychol Psychiatry, 2002, 43: 713-725.

Cespedes, E.M., Gillman, M.W., Kleinman, K., Rifas-Shiman, S.L., Redline, S., and Taveras, E.M. Television viewing, bedroom television, and sleep duration from infancy to mid-childhood. Pediatrics, 2014, 133:e1163-e1171.

Chou, Y.H. Survey of sleep in infants and young children in northern Taiwan. Sleep Biol Rhythms, 2007. 5: 40-49.

Downs, S.H., and Black, N. The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. J Epidemiol Community Health, 1998, 52: 377-384.

Ficca, G., Fagioli, I., Giganti, F., and Salzarulo, P. Spontaneous awakenings from sleep in the first year of life. Early Hum Dev, 1999, 55: 219-228.

Field, T. Infant sleep problems and interventions: a review. Infant Behav Dev, 2017, 47: 40-53.

Figueiredo, F., Dias, C.C., Pinto, T., and Field, T. Infant sleep-wake behaviours at two weeks, three and six months. Infant Behav Dev, 2016, 44: 169-178.

Galland, B., Meredith-Jones, K., Gray, A., et al. Criteria for nap identification in infants and young children using 24-h actigraphy and agreement with parental diary. Sleep Med, 2016, 19: 85-92.

Galland, B.C., Taylor, B.J., Elder, D.E., and Herbison, P. Normal sleep patterns in infants and children: a systematic review of observational studies. Sleep Med Rev, 2012, 16: 213-222.

Gibson, R., Elder, D., and Gander, P. Actigraphic sleep and developmental progress of one-year-old infants. Sleep Biol Rhythms, 2012, 10: 77-83.

Goodlin-Jones, B.L., Burnham, M.M., Gaylor, E.E., and Anders, T.F. Night waking, sleep-wake organization, and self-soothing in the first year of life. J Dev Behav Pediatr, 2001, 22: 226-233.

Hall, W.A., Hutton, E., Brant, R.F., et al. A randomized controlled trial of an intervention for infants' behavioral sleep problems. BMC Pediatr, 2015, 15: 181.

Harrison Y. The relationship between daytime exposure to light and night-time sleep in 6–12-week-old infants. J Sleep Res, 2004, 13: 345-352.

Henderson, J.M., France, K.G., and Blampied, N.M. The consolidation of infants' nocturnal sleep across the first year of life. Sleep Med Rev, 2011, 15: 211-220.

Henderson, J.M., France, K.G., Owens, J.L., and Blampied, N.M. Sleeping through the night: the consolidation of self-regulated sleep across the first year of life. Pediatrics, 2010, 126: e1081-e1087.

Hughes, A., Gallagher, S., and Hannigan, A.A. cluster analysis of reported sleeping patterns of 9-Month old infants and the association with maternal health: results from a population based cohort study. Matern Child Health J, 2015, 19: 1881-1889.

Iglowstein, I., Jenni, O.G., Molinari, L., and Largo, R.H. Sleep duration from infancy to adolescence: reference values and generational trends. Pediatrics, 2003, 111: 302-307.

Jenni, O.G., Fuhrer, H.Z., Iglowstein, I., Molinari, L., and Largo, R.H. A longitudinal study of bed sharing and sleep problems among Swiss children in the first 10 years of life. Pediatrics, 2005, 115: 233-240.

Jenni, O.G., and LeBourgeois, M.K. Understanding sleep–wake behavior and sleep disorders in children: the value of a model. Curr Opin Psychiatry, 2006, 19: 282-287.

Jenni, O.G., Molinari, L., Caflisch, J.A., and Largo, R.H. Sleep duration from ages 1 to 10 years: variability and stability in comparison with growth. Pediatrics, 2007, 120: e769-e776.

Jiang, F., Shen, X., Yan, C., Wu, S., Jin, X., Dyken, M., and Lin-Dyken, D. Epidemiological study of sleep characteristics in Chinese children 1–23 months of age. Pediatrics Int, 2007, 49: 811-816

Johnson, N., McMahon, C., and Gibson, F. Assisted conception, maternal personality and parenting: associations with toddler sleep behaviour. Journal Paediatr Child Health, 2014, 50: 732-738.

Joseph, D., Chong, N.W., Shanks, M.E., et al. Getting rhythm: how do babies do it?. Arch Dis Child Fetal Neonatal Ed, 2015, 100: F50-F44.

Kaley, F., Reid, V., and Flynn, E. Investigating the biographic, social and temperamental correlates of young infants' sleeping, crying and feeding routines. Infant Behav Dev, 2012, 35: 596-605.

Klingenberg, L., Christensen, L.B., Hjorth, M.F., et al. No relation between sleep duration and adiposity indicators in 9–36 months old children: the SKOT cohort. Pediatr Obes, 2013, 8: e14-e18.

Kohyama, J., Mindell, J.A., and Sadeh, A. Sleep characteristics of young children in Japan: internet study and comparison with other Asian countries. Pediatr Int, 2011, 53: 649-655.

Komada, Y., Asaka, S., Abe, T., et al. Relationship between napping pattern and nocturnal sleep among Japanese nursery school children. Sleep Med, 2012, 13: 107-110.

Konrad, C., Herbert, J.S., Schneider, S., and Seehagen, S. The relationship between prior night's sleep and measures of infant imitation. Dev Psychobiol, 2016, 58: 450-461.

Lukowski, A.F., and Milojevich, H.M. Sleeping like a baby: examining relations between habitual infant sleep, recall memory, and generalization across cues at 10 months. Infant Behav Dev, 2013, 36: 369-376.

McDaniel, B.T., and Teti, D.M. Coparenting quality during the first three months after birth: the role of infant sleep quality. J Fam Psychol, 2012, 26: 886-895.

McGeorge, K., Milne, L., Cotton, L., and Whelan, T. Effects of infant and maternal sensory processing on infant fussing, crying, and sleep. Infant Ment Health J, 2015, 36: 275-286.

Miaja, M.F., Fernández, C.R., Pérez, M.F., Zubillaga, D.M., Quiñones, J.M., and Fernández, L.R. Amount of sleep and changes in its patterns in children less than two years old. An Pediatr (Barc), 2015, 82: 89-94.

Mindell, J.A., Leichman, E.S., Composto, J., Lee, C., Bhullar, B., and Walters, R.M. Development of infant and toddler sleep patterns: real-world data from a mobile application. J Sleep Research, 2016, 25: 508-526.

Mindell, J.A., Meltzer, L.J., Carskadon, M.A., and Chervin, R.D. Developmental aspects of sleep hygiene: findings from the 2004 National Sleep Foundation Sleep in America Poll. Sleep Med, 2009, 10: 771-779.

Mindell, J.A., Sadeh, A., Wiegand, B., How, T.H., and Goh, D.Y. Cross-cultural differences in infant and toddler sleep. Sleep Med, 2010, 11: 274-280.

Mohan, H., Nicholson, P., Winter, D. C., et al. Radiofrequency ablation for neuroendocrine liver metastases: a systematic review. J Vasc Interv Radiol, 2015, 26: 935-942.

Moher, D., Liberati, A., Tetzlaff, J., and Altman, D.G. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. Ann Intern Med, 2009, 151: 264-269.

Montgomery-Downs, H.E., and Gozal, D. Sleep habits and risk factors for sleep-disordered breathing in infants and young toddlers in Louisville, Kentucky. Sleep Med, 2006, 7: 211-219.

Nevarez, M.D., Rifas-Shiman, S.L., Kleinman, K.P., Gillman, M.W., and Taveras, E.M. Associations of early life risk factors with infant sleep duration. Acad Pediatr, 2010, 10: 187-193.

O'Connor, T.G., Caprariello, P., Blackmore, E.R., et al. Prenatal mood disturbance predicts sleep problems in infancy and toddlerhood. Early Hum Dev, 2007, 83: 451-458.

Philbrook, L.E., and Teti, D.M. Bidirectional associations between bedtime parenting and infant sleep: parenting quality, parenting practices, and their interaction. J Fam Psychol, 2016, 30: 431-441.

Piteo, A.M., Roberts, R.M., Nettelbeck, T., et al. Postnatal depression mediates the relationship between infant and maternal sleep disruption and family dysfunction. Early Human Dev, 2013, 89: 69-74.

Price, A.M., Brown, J.E., Bittman, M., Wake, M., Quach, J., and Hiscock, H. Children's sleep patterns from 0 to 9 years: Australian population longitudinal study. Arch Dis Child, 2014, 99: 119-125.

Quillin S.I. Infant and mother sleep patterns during 4th postpartum week. Issues Compr Pediatr Nurs, 1997, 20: 115-123.

Sadeh, A. A brief screening questionnaire for infant sleep problems: validation and findings for an Internet sample. Pediatrics, 2004, 113: e570-e577.

Sadeh, A., De Marcas, G., Guri, Y., Berger, A., Tikotzky, L., and Bar-Haim, Y. Infant sleep predicts attention regulation and behavior problems at 3–4 years of age. Dev Neuropsychol, 2015, 40: 122-137.

Sadeh, A., Mindell, J.A., Luedtke, K., and Wiegand, B. Sleep and sleep ecology in the first 3 years: a web-based study. J Sleep Res, 2009, 18: 60-73.

Salamh, P., Cook, C., Reiman, M. P., and Sheets, C. Treatment effectiveness and fidelity of manual therapy to the knee: a systematic review and meta-analysis. Musculoskeletal Care, 2016, 18: 1-11.

Santos, I.S., Matijasevich, A., and Domingues, M.R. Maternal caffeine consumption and infant nighttime waking: prospective cohort study. Pediatrics, 2012, 129: 860-868.

Scher A. Continuity and change in infants' sleep from 8 to 14 months: a longitudinal actigraphy study. Infant Behav Dev, 2012, 35: 870-875.

Scher, A. Crawling in and out of sleep. Infant Child Dev, 2005, 14: 491-500.

Scher, A. Mother–child interaction and sleep regulation in one-year-olds. Infant Men Health J, 2001, 22: 515-28.

Scher, A., and Cohen, D.V. Sleep as a mirror of developmental transitions in infancy: the case of crawling. Monogr Soc Res Child Dev. 2015, 80: 70-88.

Scher, A., Epstein, R., and Tirosh, E. Stability and changes in sleep regulation: a longitudinal study from 3 months to 3 years. Int J Behav Dev, 2004, 28: 268-274.

Sharkey, K.M., Iko, I. N., Machan, J.T., Thompson-Westra, J., and Pearlstein, T.B. Infant sleep and feeding patterns are associated with maternal sleep, stress, and depressed mood in women with a history of major depressive disorder (MDD). Arch Womens Ment Health, 2016, 19: 209-218.

Shinohara, H., and Kodama, H. Relationship between circadian salivary melatonin levels and sleep–wake behavior in infants. Pediatr Int, 2011, 53: 29-35.

Sinai, D., and Tikotzky, L. Infant sleep, parental sleep and parenting stress in families of mothers on maternity leave and in families of working mothers. Infant Behav Dev, 2012, 35: 179-186

Sirvinskiene, G., Zemaitiene, N., Zaborskis, A., Markuniene, E., and Jusiene, R. Infant difficult behaviors in the context of perinatal biomedical conditions and early child environment. BMC Pediatr, 2012, 12: 1-12

So, K., Adamson, T.M., and Horne, R.S. The use of actigraphy for assessment of the development of sleep/wake patterns in infants during the first 12 months of life. J Sleep Res, 2007, 16: 181-187.

Sorondo, B.M., and Reeb-Sutherland, B.C. Associations between infant temperament, maternal stress, and infants' sleep across the first year of life. Infant Behav Dev, 2015, 39: 131-135.

St James-Roberts, I., and Plewis, I. Individual differences, daily fluctuations, and developmental changes in amounts of infant waking, fussing, crying, feeding, and sleeping. Child Dev, 1996, 67: 2527-2540.

St James-Roberts, I., Roberts, M., Hovish, K., and Owen, C. Video evidence that London infants can resettle themselves back to sleep after waking in the night, as well as sleep for long periods, by 3 months of age. J Dev Behav Pediatrics, 2015, 36: 324-329.

Teng, A., Bartle, A., Sadeh, A., and Mindell, J. Infant and toddler sleep in Australia and New Zealand. J Paediatrics Child Health, 2012, 48: 268-273.

Thomas, K.A., and Burr, R.L. Accurate assessment of mother and infant sleep: how many diary days are required?. MCN Am J Matern Child Nurs, 2009, 34: 256-260.

Tikotzky, L., and Sadeh, A. Maternal sleep-related cognitions and infant sleep: a longitudinal study from pregnancy through the 1st year. Child Dev, 2009, 80: 860-874.

Tikotzky, L., De Marcas, G., Har-toov, J., Dollberg, S., Bar-Haim, and Sadeh, A. Sleep and physical growth in infants during the first 6 months. J Sleep Res, 2010a, 19: 103-110.

Tikotzky, L., Sadeh, A., and Glickman-Gavrieli, T. Infant sleep and paternal involvement in infant caregiving during the first 6 months of life. J Pediatr Psychol, 2010b, 36: 36-46.

Tikotzky, L., Sadeh, A., Volkovich, E., Manber, R., Meiri, G., and Shahar, G. VII. Infant sleep development from 3 to 6 months postpartum: Links with maternal sleep and paternal involvement. Monogr Soc Res Child Dev, 2015, 80: 107-124.

Vijakkhana, N., Wilaisakditipakorn, T., Ruedeekhajorn, K., Pruksananonda, C., and Chonchaiya, W. Evening media exposure reduces night-time sleep. Acta Paediatr, 2015, 104: 306-312

Volkovich, E., Ben-Zion, H., Karny, D., Meiri, G., and Tikotzky, L. Sleep patterns of co-sleeping and solitary sleeping infants and mothers: a longitudinal study. Sleep Med, 2015, 16: 1305-1312.

Williams, J.A., Zimmerman, F.J., and Bell, J.F. Norms and trends of sleep time among US children and adolescents. JAMA Pediatr, 2013, 167: 55-60.

Zentall, S.R., Braungart-Rieker, J.M., Ekas, N.V., and Lickenbrock, D.M. Longitudinal assessment of sleep–wake regulation and attachment security with parents. Infant Child Dev, 2013, 21: 443-457.

PAPER II

SLEEP-WAKE BEHAVIOR DURING THE FIRST 12 MONTHS OF LIFE AND ASSOCIATED FACTORS: A SYSTEMATIC REVIEW[2]

Dias, C.C., & Figueiredo, B. (2019). Sleep-wake behavior during the first 12 months of life and associated factors: a systematic review. *Early Child Development and Care, online publication before print*. doi: 10.1080/03004430.2019.1582034

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Abstract

This paper aims to provide a systematic review of the literature on the associated factors with infant sleep-wake behavior during the first 12 months of life, namely 1) the factors positively and negatively associated with sleep-wake behavior and 2) the factors positively and negatively affected by sleep-wake behavior. This systematic review was based on a standard protocol constructed according with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement and included 146 papers. Two typologies of factors were found in the literature: factors positively and negatively associated with infant sleep-wake and effects of sleep-wake behavior. Different factors were identified as being positively and negatively associated with the different sleep-wake behavior and positively and negatively affected by the different sleep-wake behavior during the first 12 months of life. Some inconsistent results could be explained by methodological differences between the studies.

Keywords: sleep-wake behavior; infant; positive factors; negative factors

Introduction

Literature has been shown that infant sleep-wake behavior is associated with several factors: infant factors, namely temperament (Kaley, Reid, & Flynn, 2012; Sorondo & Reeb-Sutherland, 2015) and parental factors, namely parental psychopathology (Sadeh, Tikotzky, & Scher, 2010). Moreover, a recent review has pointed for a bidirectional association, arguing that parental factors influence and are influenced by infant sleep-wake behavior, within the context of a transactional model (Sadeh et al., 2010). The transactional model argues that the bidirectional associations between parental factors and infant sleep-wake behaviors are complex and dynamic (Sadeh et al., 2010).

Several changes and high individual stability have been observed in infant sleep wake-behavior during the first months (Figueiredo, Dias, Pinto, & Field, 2016), being imperative to identify the factors that could be associated with sleep-wake behavior during the first 12 months of life. The identification of these factors could help to the prevention and early intervention in infant sleep problems and to guide future research on infant sleep-wake behavior.

To our knowledge, there is no systematic review in the literature identifying the factors positively and negatively associated with sleep-wake behavior during the first 12 months of life. This paper aims to provide a systematic review of the literature on the associated factors with infant sleep-wake behavior during the first 12 months of life, namely 1) the factors positively and negatively associated with sleep-wake behavior and 2) the factors positively and negatively affected by sleep-wake behavior.

Materials and methods

This systematic review was based on a standard protocol constructed according with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement (Moher, Liberati, Tetzlaff, & Altman, 2009).

Literature search

The authors performed a literature search to identify manuscripts referring infant sleep-wake behavior published between June 1996 and June 2016. The search covered three databases: MEDLINE, ISIs Web of Knowledge, and PsycINFO using the keywords: sleep AND infant OR baby. Considering the spoken languages by the two authors, English, Portuguese, Spanish, Italian, and French written articles were included. The first author performed the electronic search and the second author independently replicated it. To select potentially relevant papers, the two authors independently analyzed the titles and the abstracts (n = 8610) obtained in the electronic search

and excluded the manuscripts that did not study factors associated with infant sleep-wake behavior (n = 8244). The manuscripts whose abstracts assessed factors associated with infant sleep-wake behavior (n = 367) were then independently analyzed for inclusion/exclusion criteria by the two authors, leading to the exclusion of 220 manuscripts. Through all the literature search process, the two authors reached consensus through discussion.

Inclusion and exclusion criteria

This systematic review included only original empirical articles addressing factors associated with sleep-wake behavior during the first 12 months of life. The authors used the following inclusion criteria: a) original studies; b) assessing factors associated with sleep-wake behavior; c) during the first 12 months of life. Studies were excluded based on the following exclusion criteria: a) non-original research (e.g., literature reviews, systematic reviews, or meta-analysis); b) studies assessing infants above 12 months or studies that did not indicate infant age; c) sleep interventions or clinical trials; d) case reports or single case studies.

Quality assessment

All included studies were scored for quality, based on the system of Downs and Black (Downs & Black, 1998), a Quality Index that evaluates the methodological quality of randomized and non-randomized studies. The Quality Index is comprised of 27 items that are aggregated in 5 sub-scales. Fourteen items, from the total 27, were selected to score all the studies that were included in this systematic review, with a maximum possible score of 15. Manuscripts scoring >10 in the Quality Index were considered good, those scored between seven and 10 were considered moderate, and those scoring < seven were considered poor.

Data extraction

One author extracted the data from the studies to two data sheets (Tables 8 and 9) and the other author reviewed the data. The data sheets were organized according with 1) factors typology, namely: factors positively and negatively associated with infant sleep-wake behavior and factors positively and negatively affected by infant sleep-wake behavior and 2) the publication year.

This systematic review included the different sleep-wake behaviors studied in the literature: sleep duration (hours infants spend sleeping), Wake After Sleep Onset (WASO; hours infants spend awake during the night), sleep periods (number of sleep episodes) and night wakings (number of wakings during the night), sleep latency (time infants take to fall asleep), longest sleep period (time of the longest sleep episode), bedtime/sleep onset time (hour of sleep start during the night), wake

time (waking time in the morning), and sleep efficiency (percentage of sleep during the night from bedtime to wake time).

Results

Databases search

After the elimination of duplicates, 8610 relevant papers were identified in the literature search. The examination of titles and abstracts lead to the exclusion of 8244 non-relevant papers and the remaining 366 papers were examined for inclusion/exclusion criteria. Two hundred and twenty papers met one or more exclusion criteria and were excluded. This systematic review included 146 papers. Figure 3 presents a flow diagram of the search.

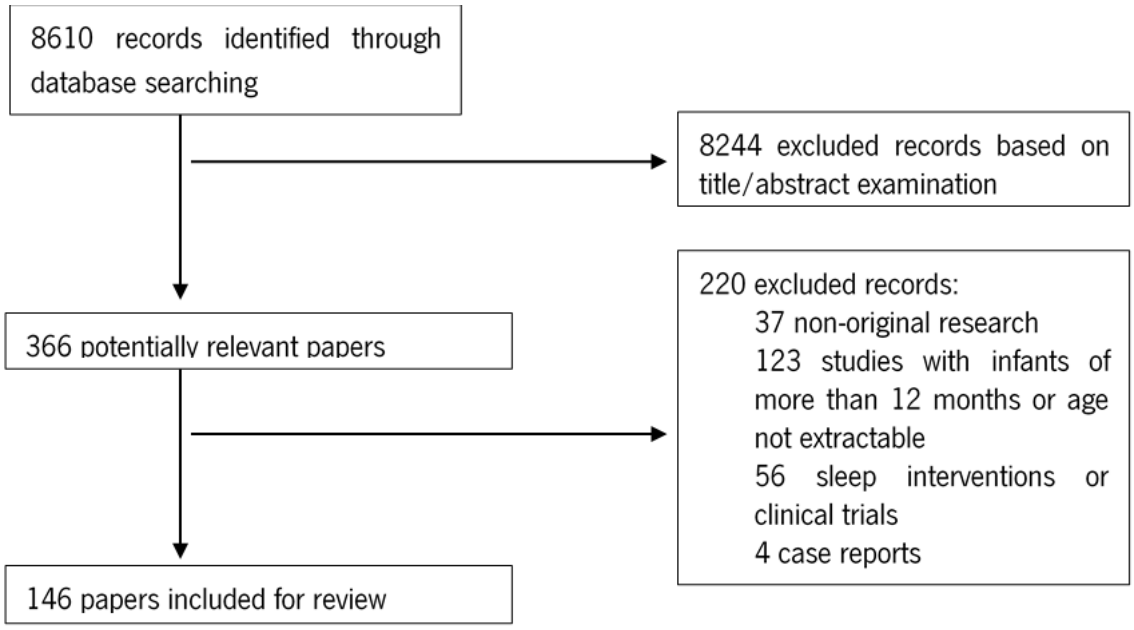


Figure 3. Search strategy flow chart.

Articles reviewed

Studies performed in 25 countries were included. Most of the studies were performed in the United States (n = 42), Israel (n = 22), UK (n = 15), Australia (n = 11), or Canada (n = 10) and about half of the studies presented a longitudinal design (n = 76). Infant sleep-wake behavior measures included questionnaire (n = 53), diary (n = 33), actigraphy (n = 17), interview (n = 10), video recording (n = 7), polysomnography (n = 5), observation by experimented researchers (n =

2), electroencephalography (n = 1), motility monitoring system (n = 1), combined measures (n = 15; 8 studies used actigraphy and sleep diary; 4 studies used actigraphy and questionnaire; 2 studies used actigraphy, sleep diary and questionnaire; and 1 study used sleep diary and polysomnography), and 2 studies did not specify sleep-wake behavior measures. About half of the studies were scored as good (n = 76), and the other half as moderate quality (n = 70) in the Quality Index.

Factors positively and negatively associated with sleep-wake behavior

The following factors emerged as positively associated with sleep-wake behavior during the first 12 months of life: being a first-time infant in 4/6 studies, Caucasian ethnicity in 3/3 studies, higher parental educational/health literacy level in 3/5 studies, lower sensory and environmental stimuli in 1/1 study, better genetic/environmental influences in 1/1 study, outdoor environment in 1/1 study, sleeping in prone position in 1/1 study, wearing Ö4 fabric in 1/1 study, regulated cortisol and melatonin levels in 4/4 studies, infant secure attachment patterns in 2/3 studies, and better mother-infant relationship in 3/3 studies (see Table 8).

Table 8.

Factors positively and negatively associated with infant sleep-wake behavior during the first 12 months of life

First author Year of publication	Country	Design	Associated factor	N / Age (months)	Sleep measure	Sleep-wake behavior	Main result
Factors positively associated with infant sleep-wake behavior during the first 12 months of life							
Blair et al., 2012	UK	L	Birth order	11478 6 months	Q	SD (24h)	SD (24h) at 6 months not associated with number of siblings
Kaley et al., 2012	UK	CS	Birth order	77 1-2 months	D	SD (24h, day, night), NW	↑ SD (24h, day) at 1-2 months in non-first-time infants NW not associated with birth order
Kozyrskyj et al., 2009	Australia	L	Birth order	2398 12 months	Q	NW	↑ NW at 12 months associated with ↑ siblings
Santos et al., 2008	Brazil	L	Birth order	3907 0 and 12 months	I	NW	↑ NW at 12 months in non-first-born infants
So et al., 2007	Australia	L	Birth order	20 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12 months	Combined measures: A and D	SD (24h, day, night), NW	SD (24h, day, night) and NW at 1, 2, 3, 4, 5, 6, 8, 9, 10, 11, and 12 months not associated with birth order ↓ SD (night) at 7 months (measured by D) in non-first-born infants
Quillin, 1997	USA	CS	Birth order	44 1 month	D	SD (24h, night), NW, SP (24h)	SD (24h, night), NW, and SP (24h) at 1 months not associated with birth order
Blair et al., 2012	UK	L	Ethnicity	11478 6 months	Q	SD (24h)	↓ SD (24h) at 6 months in non-white infants
Santos et al., 2012	Brazil	CS	Ethnicity	885 3 months	I	NW	↑ NW at 3 months in non-white infants

Nevarez et al., 2010	USA	L	Ethnicity	1676 6, and 12 months	Q	SD (24h)	↓ SD (24h) at 6 and 12 months in non-white infants
Bathory et al., 2016	USA	CS	Parental education	557 9 months	Q	SD (day, night)	↓ SD (night) associated with ↓ parental health literacy SD (day) not associated with parental health literacy
Blair et al., 2012	UK	L	Parental education	11478 6 months	Q	SD (24h)	SD (24h) at 6 months not associated with maternal education and paternal social class
Kozyrskyj et al., 2009	Australia	L	Parental education	2398 12 months	Q	NW	NW at 12 months not associated with maternal education
Nevarez et al., 2010	USA	L	Parental education	1676 6, and 12 months	Q	SD (24h)	↓ SD (24h) at 6 and 12 months associated with ↓ maternal education
Palmstierna et al., 2008	Sweden	L	Parental education	16467 12 months	Q	NW	↑ NW at 12 months associated with ↑ parental theoretical education
Orsi et al., 2015	Brazil	L	NICU characteristic	13 0 months	P	SD (24h, day, and night)	↑ SD (24h and day) associated with reduced sensory and environmental stimuli SD (night) not associated with sensory and environmental stimuli
Touchette et al., 2013	Canada	L	Genetic/ environment (twins)	995 6 months	Q	SD (day, night)	↑ SD (night) at 6 months associated with genetic influences SD (day) at 6 months associated with environmental influences
Tourula et al., 2010	Finland	CS	Environment	34 3 months	O	SD (day)	↑ SD (day) at 3 months in outdoor environment
Bhat et al., 2006	UK	CS	Sleep position	24 0 months	P	SD (day), SP (day), SE	↑ SD (day), ↓ SP (day), and ↑ SE at 0 months associated with prone position

Utkun et al., 2015	Turkey	CS	Clothes' fabrics	8 6-12 months	NS	SD (night)	↑ SD (night) at 6-12 months associated with wearing Ö4 fabric
Brand et al., 2011	Switzerland	L	Cortisol	16 2 and 3 months	A	SD (day, night), A (day, night)	↑ SD (night) and ↑ NW at 3 months associated with ↑ cortisol secretion in infants with colic
Lucas-Thompson et al., 2009	USA	L	Cortisol	92 6 and 12 months	Q	NW	↑ NW at 6 months and 12 months associated with ↑ cortisol response to stress at 6 and 12 months
Larson et al., 1998	USA	CS	Cortisol	78 2-4 months	D	SD (night)	↑ SD (night) at 2-4 months associated with early morning peak in cortisol levels
Shinohara et al., 2011	Japan	CS	Melatonin	67 3-5 months	D	SD (night), NW, SP (day), LSP (24h)	↑ SD (night) at 3-5 months associated with ↓ morning melatonin levels at 3-5 months
Pennestri et al., 2015	Canada	L	Attachment	138 6, 12 months	Q	SD (night), NW, SL (night), LSP (night), BT	↓ SD (night), ↑ NW and ↑ BT at 6 and 12 months in disorganized children than in secure and ambivalent children ↓ LSP (night) at 12 months in disorganized children than in secure and ambivalent children SL (night) not associated with attachment
Zentall et al., 2012	USA	L	Attachment	46 7, 12 months	Q	NW	↓ NW from 7 to 12 and 14 months in infants with secure attachment NW at 7 months not associated with attachment
Scher, 2001a	Israel	CS	Attachment	94 12 months	A	SD (night), NW, LSP (night), SL (night)	SD (night), NW, LSP (night), and SL (night) at 12 months not associated with attachment style

de Graag et al., 2012	The Netherlands	L	Mother–infant relationship	84 1 and 5 months	D	LSP (24h)	↑ LSP (24h) from 1 to 5 months associated with ↑ flexible mother-infant interactions at 5 months
Schwichtenberg et al., 2011	USA	L	Mother-infant relationship	134 4 and 9 months	D	SD (day), SP (day)	↑ SD (day) at 9 months associated with ↑ maternal negative affect and behavior at 4 and 9 months ↑ SP (day) at 4 and 9 months associated with ↑ optimal maternal interactive behaviors at 24 months
Scher, 2001b	Israel	CS	Mother-infant relationship	37 12 months	A	SD (night), NW, SE, BT	↑ NW at 12 months associated with ↑ mother-infant relationship ↑ SE at 12 months associated with ↑ infant responsiveness, but not with other mother-infant interaction dimensions SD (night) and BT at 12 months not associated with mother-infant interaction
Factors negatively associated with infant sleep-wake behavior during the first 12 months of life							
Saenz et al., 2015	USA	L	Gender	47 3-4 months	A	SD (night), SE	SD (night) and SE at 3-4 months not associated with gender
Blair et al., 2012	UK	L	Gender	11478 6 months	Q	SD (24h)	↓ SD (24h) at 6 months in boys
Kaley et al., 2012	UK	CS	Gender	77 1-2 months	D	SD (24h, day, night), NW	↑ NW at 1-2 months in boys SD (24h, day, night) not associated with gender
Santos et al., 2012	Brazil	CS	Gender	885 3 months	I	NW	↑ NW at 3 months in boys
Lampl et al., 2011	USA	L	Gender	23 0-12 months	D	SD (24h), SP (24h), LSP (24h)	↑ SP (24h) and ↓ LSP (24h) at 0-12 months in boys SD (24h) not associated with gender

Kozyrskyj et al., 2009	Australia	L	Gender	2398 12 months	Q	NW	NW at 12 months not associated with gender
Santos et al., 2008	Brazil	L	Gender	3907 0 and 12 months	I	NW	↑ NW at 12 months more in boys
Anuntaseree et al., 2008	Thailand	CS	Gender	3172 3 months	I	NW	↑ NW at 3 months in boys
So et al., 2007	Australia	L	Gender	20 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12 months	Combined measures: A and D	SD (24h, day, night), WASO, SP (day), LSP (night)	↓ SD (day) at 1 (measured by A and D) and 2 (measured by A) months in boys SD (day) at 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12 months not associated with gender SD (24h, night), WASO, and LSP (night) at 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12 months not associated with gender
Thomas et al., 2005	USA	CS	Gender	37 1-2 months	D	SD (24h), SP (24h), LSP (24h)	↓ SD (24h) at 1-2 months in boys SP (24h), LSP (24h) at 1-2 months not associated with gender
Goodlin-Jones et al., 2001	USA	CS	Gender	80 3, 6, 9, or 12 months	V	NW, LSP (night)	↑ LSP (night) in girls NW not associated with gender
Bach et al., 2000	France	CS	Gender	38 1 month	EEG	SD (24h), LSP (24h)	↓ SD (24h), and ↓ LSP (24h) at 1 month in boys
Blair et al., 2012	UK	L	Parents' socio-demographic factors	11478 6 months	Q	SD (24h)	↓ SD (24h) at 6 months in infants of older mothers
Kozyrskyj et al., 2009	Australia	L	Parents' socio-demographic factors	2398 12 months	Q	NW	↑ NW at 12 months in infants of mothers older than 20 years NW at 12 months not associated with maternal marital status

Nevarez et al., 2010	USA	L	Parents' socio-demographic factors	1676 6, and 12 months	Q	SD (24h)	↓ SD (24h) at 6 and 12 months associated with infants of single/divorced parents
Palmstierna et al., 2008	Sweden	L	Parents' socio-demographic factors	16467 12 months	Q	NW	↑ NW at 12 months associated with non-Swedish parents and marginally associated with single parent at birth
Tomalski et al., 2013	UK	CS	Socio-economic factors	45 6-9 months	Q	SD (24h, day, night), WASO, NW	SD (24h, day, night), WASO, and NW not associated with income
Nevarez et al., 2010	USA	L	Socio-economic factors	1676 6 and 12 months	Q	SD (24h)	↓ SD (24h) at 6 and 12 months associated with ↓ household incomes, and ↑ household members
Kozyrskyj et al., 2009	Australia	L	Socio-economic factors	2398 12 months	Q	NW	NW at 12 months not associated with financial problems and income
Santos et al., 2008	Brazil	L	Socio-economic factors	3907 0 and 12 months	I	NW	↑ NW at 12 months in infants whose mothers were employed during pregnancy
Fouts et al., 2007	USA	CS	Socio-economic factors	62 3-4 months	O	SD (day), SP (day), LSP (day)	↑ SP (day) and ↓ LSP (day) at 3-4 months in infants from ↓ socioeconomic status SD (day) at 3-4 months not associated with socioeconomic status
Cohen et al., 2012	Israel	CS	Environment	34 7 months	A	SD (night), WASO, NW, BT, WT	↑ BT at 7 months in winter months SD (night), WASO, and NW and WT at 7 months not associated with seasonal effects
Bottino et al., 2012	USA	CS	Environment	1226 12 months	Q	SD (24h)	↓ SD (24-hour) at 12 months associated with ↑ urban environments

Harrison, 2004	UK	L	Environment	66 1, 2, 3 months	Combined measures: D and A	SD (night)	↓ SD (night) at 1 month associated with ↓ exposure to light during the afternoon
Kozyrskyj et al., 2009	Australia	L	Environment	2398 12 months	Q	NW	↑ NW at 12 months associated with mothers not smoking at 12 months NW at 12 months not associated with exposure to stressful events
Santos et al., 2012	Brazil	CS	Gestational exposure	885 3 months	I	NW	NW at 3 months not associated with gestational exposure to caffeine ↑ NW at 3 months in infants exposed to smoke and alcohol during pregnancy
Kozyrskyj et al., 2009	Australia	L	Gestational exposure	2398 12 months	Q	NW	↑ NW at 12 months associated with ↑ stressful events during early pregnancy and no exposure to smoke during pregnancy
Lehnkering et al., 2009	Germany	CS	Gestational exposure	22 0 months	Combined measures: A and D	SD (24h)	SD (24h) at 0 months not associated with gestational exposure to smoke
Hanft et al., 2006	USA	L	Gestational exposure	34 1, 3, 6, 9, and 12 months	V	SD (night), WASO, NW, LSP (night)	↓ SD (night) at 3, 6, and 12 months and ↓ LSP (night) at 6 months in infants exposed to substances during pregnancy WASO and NW at 1, 3, 6, 9, and 12 months, SD (night) at 1 and 9 months and LSP (night) at 1, 3, 9, and 12 months not associated with gestational exposure to substances
Korte et al., 2004	Germany	L	Delivery mode	57 0 months	A	SD (24h, day, night), SP (day)	SD (24h, day, night) at 0 months not associated with delivery mode ↑ SP (day) at 0 months in infants born by planed C-section

Huang et al., 2014	China	CS	Gestational age	191 6 months	Q	SD (day, night) NW	↑ SD (day, night) and ↑ NW at 6 months in preterm infants
Guyer et al., 2015	Switzerland	L	Gestational age	48 1, 3, and 6 months	D	SD (24h, day, night), LSP (night)	↑ SD (night) and ↑ LSP (night) at 1, 3, and 6 months in premature infants SD (24h, day) at 1, 3, and 6 months not associated with gestational age
Asaka et al., 2010	Japan	CS	Gestational age	28 12 months	A	SD (24h, day, night), WASO, NW	↓ SD (night) at 12 months in preterm infants SD (24h, day), WASO, and NW at 12 months not associated with gestational age
Kozyrskyj et al., 2009	Australia	L	Gestational age	2398 12 months	Q	NW	↓ NW at 12 months in preterm infants
Volkovich et al., 2015	Israel	L	Feeding method	153 3 and 6 months	Combined measures: A and D	NW	↑ NW at 3 and 6 months associated with breastfeeding at 3 months
Brown et al., 2015	UK	CS	Feeding method	715 6-12 months	Q	NW	NW at 6-12 months not associated with feeding method
Huang et al., 2016	China	L	Feeding method	524 1, 3, 5, and 8 months	D	SD (24h, day, night), NW, SP (day), LSP (night)	↓ SD (24h, day) in the first 8 months in exclusively and partially breastfed infants ↑ NW in the first 8 months in exclusively and partially breastfed infants than in exclusively formula fed SD (night), SP (day) and LSP (night) not associated with feeding method
Tikotzky et al., 2015	Israel	L	Feeding method	57 3 and 6 months	Combined measures: A, D, and Q	NW	↑ NW at 6 months associated with breastfeeding at 3 and 6 months

Hughes et al., 2015	Ireland	CS	Feeding method	11134 9 months	Q	SD (night), NW	↓ SD (night) and ↑ NW at 9 months associated with ↑ breastfeeding rates
Hysing et al., 2014	Norway	L	Feeding method	55831 6 months	Q	NW	↑ NW at 6 months associated with breastfeeding
Gallbally et al., 2013	Australia	CS	Feeding method	4507 3-19 months	Q	NW	↑ NW at 3-19 months associated with breastfeeding at 6 months
Mindell et al., 2012	USA	L	Feeding method	92 3, 6, 12 months	Q	SD (night), NW, SP (day), LSP (24h), SL (night)	↑ NW and ↑ SP (day) at 3-12 months associated with breastfeeding SD (night), LSP (24h), and SL (night) at 3-12 months not associated with feeding method
Ramamurthy et al., 2012	Asia Pacific Region	CS	Feeding method	4602 0-12 months	Q	SD (24h, day, night), NW, SP (day), SL (night), LSP (night), BT, WT	↑ SD (24-hour, day), ↑ NW, ↓ LSP (night), ↑ SP (day), and ↑ BT from 0 to 6 months in breastfed infants ↑ NW, and ↓ LSP (night) from 6 to 12 months in breastfed infants SD (night) and WT not associated with breastfeeding
Demirci et al., 2012	USA	CS	Feeding method	77 6-11 months	Q	SD (24h, day, night), SL (night)	SD (24h, day, night) and SL (night) at 6-11 months not associated with feeding method
Kaley et al., 2012	UK	CS	Feeding method	77 1-2 months	D	SD (24h, day, night), NW	↑ NW at 1-2 months in breastfed infants SD (24h, day, night) at 1-2 months not associated with feeding method
Engler et al., 2012	Israel	CS	Feeding method	94 2-4 months	Q	SD (night), NW, SL (night)	↑ NW and marginally ↑ SD (night) at 2-4 months associated with breastfeeding SL (night) not associated with feeding method

Lampl et al., 2011	USA	L	Feeding method	23 0-12 months	D	SD (24h), SP (24h), LSP (24h)	↑ SP (24h) and ↓ LSP (24h) at 0-12 months associated with breastfeeding SD (24h) not associated with feeding method
Nevarez et al., 2010	USA	L	Feeding method	1676 6, and 12 months	Q	SD (24h)	SD (24h) at 6 and 12 months not associated with feeding method at 6 months
Kozyrskyj et al., 2009	Australia	L	Feeding method	2398 12 months	Q	NW	↑ NW at 12 months associated with ↑ exclusive breastfeeding duration
Anuntaseree et al., 2008	Thailand	CS	Feeding method	3172 3 months	I	NW	↑ NW at 3 months associated with exclusive breastfeeding
Mindell et al., 2009	USA	CS	Feeding method	1473 0-11 months	I	SD (night), NW, SL (night)	↑ NW at 0-11 months associated with breastfeeding SD (night) and SL (night) not associated with feeding method
Schwichtenberg et al., 2009	USA	CS	Feeding method	128 4 months	D	SD (night), NW	↓ SD (night) and ↑ NW at 4 months in breastfed preterm infants
DeLeon et al., 2007	USA	CS	Feeding method	41 9 months	D	SD (24h, day, night), WASO, NW, SP (day)	↓ SD (night), ↑ WASO and ↑ NW at 9 months associated with breastfeeding SD (24h, day), and SP (day) not associated with feeding method
Cubero et al., 2005	Spain	CS	Feeding method	16 3 months	A	SD (night), SL (night), SE	↑ SD (night) and ↑ SE at 3 months associated with breastfeeding SL (night) not associated with feeding method
Morgan et al., 2004	UK	L	Feeding method	1694 6, 9 months	Q	SD (night)	↓ SD (night) at 9 months associated with ↑ breastfed duration in term infants SD (night) at 9 months not associated with breastfeeding duration in term infants

Quillin et al., 2004	USA	CS	Feeding method	33 1 month	D	SD (24h, night), NW, SP (24h)	↓ SD (24h) at 1 month associated with breastfeeding SD (night), NW and SP (24h) not associated with feeding method
Ball, 2003	UK	L	Feeding method	253 1, 3 months	D	NW	↑ NW at 1 and 3 months associated with breastfeeding
Lee, 2000	Korea	CS	Feeding method	188 0-4 months	D	SD (24h), LSP (night)	↑ SD (24h) and ↓ LSP (night) at 0-4 months associated with breastfeeding
Thomas, 2000	USA	CS	Feeding method	37 1 month	D	SD (24h, day, night), WASO	SD (24h, day, night), and WASO not associated with feeding method in preterm infants
Wolke et al., 1998	Finland/ Germany	L	Feeding method	5969 5 months	I	NW	↑ NW at 5 months associated with breastfeeding
Quillin, 1997	USA	CS	Feeding method	44 1 month	D	SD (night), NW, SP (24h)	↓ SD (night) and ↑ NW at 1 month in breastfed infants SP (24h) at 1 month not associated with feeding method
Brown et al., 2015	UK	CS	Diet	715 6-12 months	Q	NW	NW at 6-12 months not associated with milk feeds, age of introduction of solids, number of complementary meals per day, and daytime feeds.
Nevarez et al., 2010	USA	L	Diet	1676 6, and 12 months	Q	SD (24h)	↓ SD (24h) at 12 months associated with introduction of solids < 4 months
Thomas et al., 2005	USA	CS	Diet	37 1-2 months	D	SD (24h), SP (24h), LSP (24h)	↓ SD (24h), ↑ SP (24h), and ↓ SD (24h) associated with ↑ infant feedings

Telliez et al., 2002	France	CS	Diet	17 1 month	P	SD (day)	↑ SD (day) in the medium-chain triacylglycerol diet group
Philbrook et al., 2016	USA	L	Bedtime routines	109 1, 3 and 6 months	V	SD (night)	↓ SD (night) from1 to 6 months associated with ↓ arousing activities
Vijakkhana et al., 2015	Thailand	L	Bedtime routines	208 6 and 12 months	D	SD (night)	↓ SD (night) at 12 months associated with ↑ evening media exposure at 6 and 12 months
Cespedes et al., 2014	USA	L	Bedtime routines	1864 6, 12 months	Q	SD (24h)	↓ SD (24h) at 6 and 12 months associated with ↑ TV viewing
Nevarez et al., 2010	USA	L	Bedtime routines	1676 6, and 12 months	Q	SD (24h)	↓ SD (24h) at 12 months associated with infant TV/video viewing
Mindell et al., 2009	USA	CS	Bedtime routines	1473 0-11 months	I	SD (night), NW, SL (night)	↓ SD (night) at 0-11 months associated with no bedtime routine, late bedtimes, and no reading at bedtime ↑ NW at 0-11 months associated with late bedtimes, and no reading at bedtime but not with no bedtime routine ↑ SL (night) at 0-11 months associated with late bedtimes, but not with no bedtime routine and reading at bedtime
Philbrook et al., 2016	USA	L	Parental bedtime involvement	109 1, 3 and 6 months	V	SD (night)	↓ SD (night) from1 to 6 months associated with close contact with the mother at bedtime, ↓ mother emotional availability, ↓ nursing at bedtime
Ramamurthy et al., 2012	Asia Pacific Region	CS	Parental bedtime involvement	4602 0-12 months	Q	SD (24h, day, night), NW, SP	↑ NW and ↓ LSP in infants fed back to sleep SD (24h, day, night), SP (day), SL (night), BT, and WT not associated with fed back to sleep

						(day), SL (night), LSP (night), BT, WT	
Mindell et al., 2009	USA	CS	Parental bedtime involvement	1473 0-11 months	I	SD (night), NW, SL (night)	↓ SD (night) and ↑ NW at 0-11 months associated with put in crib asleep, parent present at bedtime ↑ SL (night) at 0-11 months associated with put in crib asleep
Tikotzky et al., 2009	Israel	L	Parental bedtime involvement	85 1, 6 and 12 months	Combined measures: A, D, and Q	NW	↑ NW (measured by A, D, Q) at 6 and 12 months associated with maternal cognitions at pregnancy, 6 and 12 months emphasizing the infant's distress and need for help at night, and ↑ parental involvement at bedtime at 6 months
Anuntaseree et al., 2008	Thailand	CS	Parental bedtime involvement	3172 3 months	I	NW	↑ NW at 3 months associated with use of a swinging or rocking cradle, falling asleep while feeding
DeLeon et al., 2007	USA	CS	Parental bedtime involvement	41 9 months	D	SD (24h, day, night), WASO, NW, SP (day)	↓ SD (night) and ↑ WASO at 9 months associated with putting the infant to bed asleep SD (24h, day), NW, SP (day) not associated with putting the infant to bed asleep
Touchette et al., 2005	Canada	L	Parental bedtime involvement	1741 5 months	Q	SD (night)	↓ SD (night) at 5 months associated with feeding after awakenings, rocking to sleep, and bought to parent's bed after awakenings
Goodlin-Jones et al., 2001	USA	CS	Parental bedtime involvement	80 3, 6, 9, or 12 months	V	NW, LSP (night)	↑ NW and ↓ LSP (night) associated with non-self-soothing style
Philbrook et al., 2016	USA	L	Sleep arrangements	109 1, 3 and 6 months	V	SD (night)	↓ SD (night) from1 to 6 months associated with co-sleeping

Volkovich et al., 2015	Israel	L	Sleep arrangements	153 3 and 6 months	Combined measures: A and D	SD (day, night), NW, LSP (night)	↑ NW (measured by D) associated with co-sleeping infants at 3 and 6 months SD (night), NW, LSP (night) (measured by A), and SD (day) (measured by D) not associated with sleep arrangements
Huang et al., 2016	China	L	Sleep arrangements	524 1, 3, 5, and 8 months	D	SD (24h, day, night), NW, SP (day), LSP (night)	↑ SD (24h, day) in the first 8 months associated with room-sharing ↑ SD (night) in the first 8 months associated with independent sleeping NW, SP (day), LSP (night) not associated with sleep arrangements
Bruni et al., 2014	Italy	L	Sleep arrangements	704 1, 3, 6, 9, and 12 months	I	SD (24h, day, night), NW	↑ NW at 3, 6, 9, and 12 months associated with bed-sharing ↑ SD (night) at 3 months, ↑ SD (24h, day) at 3 and 6 months, and ↑ SD (day) at 12 months in infants associated with independent sleeping
Möllborg et al., 2011	Sweden	CS	Sleep arrangements	5605 6 months	Q	NW	↑ NW at 6 months associated with bed sharing
Santos et al., 2008	Brazil	L	Sleep arrangements	3907 0 and 12 months	I	NW	↑ NW at 12 months associated with co-sleeping
DeLeon et al., 2007	USA	CS	Sleep arrangements	41 9 months	D	SD (24h, day, night), WASO, NW, SP (day)	↓ SD (night), ↑ WASO and ↑ NW at 9 months associated with co-sleeping SD (24h, day), and SP (day) not associated with sleep arrangements
Baddock et al., 2006	New Zealand	CS	Sleep arrangements	80 0-6 months	V	SD (night)	SD (night) at 0-6 months not associated with sleep arrangements

Touchette et al., 2005	Canada	L	Sleep arrangements	1741 5 months	Q	SD (night)	↓ SD (night) at 5 months associated with co-sleeping
Jenni et al., 2005	Switzerland	L	Sleep arrangements	493 1, 3, 6, 9, 12 months	I	SD (night), NW	↓ SD (night) and ↑ NW at 6, 9, and 12 months associated with bed sharing
Mao et al., 2004	USA	CS	Sleep arrangements	18 3, 6, 9, 12 months	V	NW	↑ NW at 6, 9, and 12 months associated with co-sleeping
Lukowski et al., 2015	China	CS	Disposable diaper use	82 6 months	D	NW	↑ NW at 6 months in infants associated with cloth diapers use
Thomas et al., 2016	USA	CS	Parental mental health	46 8 months	Q	SD (24h)	SD (24h) at 8 months not associated with maternal fatigue or depression.
Sorondo et al., 2015	USA	L	Parental mental health	40 5, 9, and 12 months	Q	SD (day, night), WASO, NW, SL (night)	↑ SD (day) at 5 months and ↓ SD (day) at 9 and 12 months associated with ↑ maternal stress at 5 months SD (night), WASO, NW, and SL (night) at 5, 9, and 12 months not associated with maternal stress at 5 months
Hughes et al., 2015	Ireland	CS	Parental mental health	11134 9 months	Q	SD (night), NW	↓ SD (night) and ↑ NW at 9 months associated with ↑ maternal stress and depressive symptoms and ↓ self-reported health
Loutzenhiser et al., 2015	Canada	L	Parental mental health	108 1, 3, 6 months	D	SD (night)	↓ SD (night) at 1 month associated with ↑ maternal fatigue
Brand et al., 2014	Switzerland	L	Parental mental health	24 2 and 3 months	Combined measures: A and D	SD (day, night), NW, SP (day)	↑ NW, SP (day) and ↓ SD (day) at 2 months associated with ↑ family strain at 3 months and maternal depression symptoms at 2 and 3 months ↓ SD (night) at 2 months associated with ↑ maternal depression symptoms at 2 months

							↓ SD (night) at 3 months associated with ↑ maternal depression symptoms at 3 months
Piteo et al., 2013	Australia	CS	Parental mental health	111 12 months	Q	SD (day, night), NW	↓ SD (day, night) and ↑ NW at 12 months associated with ↑ family dysfunction ↓ SD (night) and ↑ NW at 12 months associated with ↑ postnatal depression
Goldberg et al., 2012	USA	L	Parental mental health	179 6 and 12 months	Q	NW, WASO	↑ NW and ↑ WASO at 6 and 12 months associated with ↑ maternal depressive symptoms at 6 and 12 months
Gress-Smith et al., 2012	USA	L	Parental mental health	132 5 and 9 months	Q	NW	↑ NW at 9 months associated with ↑ maternal depressive symptoms at 5 months
Sinai et al., 2012	Israel	CS	Parental mental health	50 4-5 months	D	SD (day), WASO (night), NW	↓ SD (day), ↑ WASO associated with ↑ parenting stress in families whose mothers in maternity leave NW not associated with parenting stress in families whose mothers in maternity leave
Mao et al., 2011	China	CS	Parental mental health	420 1-2 months	Q	SD (24h)	↓ SD (24h) at 1-2 months associated with ↑ maternal postpartum depression
Nevarez et al., 2010	USA	L	Parental mental health	1676 6, and 12 months	Q	SD (24h)	↓ SD (24h) at 12 months associated with ↑ maternal antenatal depression
Armitage et al., 2009	USA	L	Parental mental health	18 0 and 6 months	A	SD (24h, day, night), NW, SP (day), SL (night)	↓ SD (night), ↑ SP (day), ↑ NW, ↑ SL (night) at 0 and 6 months in associated with maternal history of depression SD (24h, day) not associated with maternal history of depression
Baird et al., 2009	UK	L	Parental mental health	874	Q	NW	↑ NW at 6 and 12 months associated with maternal pre-conception psychological distress

				6 and 12 months			
Karraker et al., 2007	USA	CS	Parental mental health	1275 6 months	I	NW	↑ NW at 6 months associated with ↑ maternal depression symptoms at 6 months
O'Connor et al., 2007	UK	L	Parental mental health	11490 6 months	Q	SD (24h), NW	SD (24h), and NW at 6 months not associated with prenatal maternal anxiety and depression ↓ SD (24h) associated with maternal depression at 8 weeks and 8 months and anxiety at 8 weeks ↑ NW associated with maternal depression and anxiety at 8 months
Warren et al., 2006	USA	L	Parental mental health	1222 6 months	Q	NW	↑ NW at 6 months associated with ↑ maternal depression symptoms at 1, 6, 15, 24 and 36 months
Dennis et al., 2005	Canada	L	Parental mental health	505 1-2 months	Q	NW, LSP (day)	↑ NW at 1 and 2 months associated with ↑ maternal postpartum depression at 1 and 2 months LSP (day) at 1 and 2 months not associated with maternal postpartum depression at 1 and 2 months
Thomas et al., 2016	USA	CS	Parental sleep	46 8 months	Q	SD (24h)	↓ SD (24h) at 8 months moderately associated with ↓ maternal sleep and ↑ maternal wake disturbance
Sharkey et al., 2015	USA	L	Parental sleep	31 0, 1, and 4 months	D	SD (24h), SP (24h), LSP (24h), BT	↓ LSP (24h) at 0 months associated with ↓ maternal SD and ↓ maternal SE at 0 months ↓ SP (24h) at 0 months associated with ↑ maternal SE at 0 months SD (24h), SP (24h), LSP (24h), BT at 1 and 4 months not associated with maternal sleep
Tikotzky et al., 2015	Israel	L	Parental sleep	57 3 and 6 months	Combined measures:	NW, SE	↑ NW and ↑ SE at 3 and 6 months associated with ↑ maternal NW and ↑ SE at 3 and 6 months

					A, D, and Q		
Brand et al., 2014	Switzerland	L	Parental sleep	24 2 and 3 months	Combined measures: A and D	SD (day, night), NW, SP (day)	↑ NW and SP (day) and ↓ SD (day) at 2 months associated with ↑ maternal insomnia at 2 and 3 months ↓ SD (night) at 2 months associated with ↑ maternal insomnia at 2 months ↑ SP (day) at 3 months associated with ↑ maternal insomnia at 3 months
Demirci et al., 2012	USA	CS	Parental sleep	77 6-11 months	Q	SD (night)	↓ SD (night) at 6-11 months associated with ↓ maternal SD
Sinai et al., 2012	Israel	CS	Parental sleep	50 4-5 months	D	SD (day), WASO, NW	↑ NW and ↑ NA associated with ↑ NW and ↑ WASO of mothers and fathers SD (day) at 4-5 months not associated with parental sleep
Thomas et al., 2005	USA	CS	Parental sleep	37 1-2 months	D	SD (24h) LSP (24h)	↓ LSP (24h) associated with ↓ maternal LSP (24h) and ↓ SP (24h) SD (24h) at 1-2 months not associated with maternal sleep
Tikotzky et al., 2015	Israel	L	Parental involvement	57 3 and 6 months	Combined measures: A, D, and Q	SD (night), NW, SE	↑ NW at 6 months (measured by A and D) associated with ↓ involvement of fathers in infant care at 3 and 6 months ↑ NW at 3 months (measured by D) associated with ↓ involvement of fathers in infant care at 6 months SD (night) and SE at 3 and 6 months not associated with parental involvement

Zaidman-Zait et al., 2015	Canada	L	Parental involvement	1487 5 months	Q	NW	↑ NW at 5 months associated with ↓ maternal parenting impact and self-efficacy scores and ↓ paternal parenting impact and ↑ overprotectiveness scores
Bordeleau et al., 2012	Canada	L	Parental involvement	55 12 months	D	SD (24h, night)	SD (24h, night) at 12 months not associated with maternal sensitivity at 12 months
Tikotzky et al., 2010	Israel	L	Parental involvement	56 1 and 6 months	Combined measures: A and D	SD (night), NW, BT	↓ SD (night) and ↓ NW at 6 months associated with ↑ paternal involvement in overall infant care at 1 and 6 months ↑ BT at 6 months associated with ↑ paternal involvement in overall infant care at 6 months, but not at 1 month
Scher et al., 1999	Israel	L	Parental involvement	81 6 and 12 months	Q	NW	↑ NW at 12 months associated with a facilitator care-giving orientation
Atun-Einy et al., 2016	Israel	L	Motor development	20 7, 8, 9, 10, 11 months	A	NW, SE	NW not associated with the emergence of pulling-to-stand ↑ NW and ↓ SE associated with crawling onset in infants with early crawling
Mindell et al., 2015	Brazil	CS	Motor development	1351 3-13 months	Q	SD (night), SL (night), NW, SP (day), BT, WT	SD (night), SL (night), NW, SP (day), BT, and WT at 3-13 months not associated with fine and gross motor skills scores
Scher et al., 2015	Israel	L	Motor development	28 5, 6, 7, 8, 9, 10, and 11 months	A	NW	↑ NW associated with crawling onset in infants with early crawling

Gibson et al., 2012	New Zealand	CS	Motor development	52 12 months	A	SD (24h, night), SE	SD (24h, night) and SE at 12 months not associated with motor development
Scher, 2005a	Israel	CS	Motor development	59 8 months	Combined measures: A and Q	SD (night), NW, LSP (night), SE, BT	↑ NW at 8 months associated with crawling SD (night), LSP (night), SE, and BT at 8 months not associated with motor development
Scher et al., 2005	Israel	CS	Motor development	107 5-8 months	Q	NW	↑ NW at 5-8 months associated with crawling
Küpers et al., 2015	Netherlan ds	L	Physical growth	2475 1, 6, and 12 months	NS	SD (24h)	↑ SD (24h) at 4 months associated with ↓ weight gain for age
Hiscock et al., 2011	Australia	L	Physical growth	3857 0-12 months	D	SD (24h)	SD (24h) at 0-12 months not associated with body mass index at 0-12 months and later
Lampl et al., 2011	USA	L	Physical growth	23 0-12 months	D	SD (24h), SP (24h), LSP (24h)	↑ SD (24h) and SP (24h) in the first 12 months associated with episodic growth in length LSP (24h) not associated with episodic growth in length
Tikotzky et al., 2010	Israel	CS	Physical growth	96 6 months	Combined measures: A and Q	SD (day, night), NW, SE	↓ SD (night) (measured by Q) and ↓ SE at 6 months associated with ↑ weight-to-length ratio and ↑ weight above weight expected for length ↑ SE at 6 months associated with ↑ length NW (measured by A and Q), SD (night) (measured by A), and SD (day) (measured by Q) at 6 months not associated with physical growth
Kirjavainen et al., 2001	Finland	L	Colic	31 1, 2, 6, 7 months	Combined measures: D and P	SD (24h, night), NW	↓ SD (24h, night) at 1 month in infants with colic ↓ NW at 7 months in infants with colic SD (24h, night) at 2, 6, and 7 months not associated with colic

White et al., 2000	USA	CS	Colic	40 2 months	D	SD (24h, day, night)	↓ SD (24h) at 2 months associated with colic
Anuntaseree et al., 2012	Thailand	CS	Health problems	4085 12 months	I	SD (day, night), NW, SP (day), SL (night)	↓ SL (night) and ↓ SD (night) at 12 months in infants associated with atopic dermatitis SD (day), NW and SP (day) not associated with atopic dermatitis
Pellegrini-Belinchón et al., 2012	Spain	CS	Health problems	750 12 months	Q	NW	↑ NW at 12 months associated with wheezing
Kozyrskyj et al., 2009	Australia	L	Health problems	2398 12 months	Q	NW	NW at 12 months not associated with asthma at 6 years
McKay et al., 2007	USA	L	Health problems	16 3, 4, 5, and 6 months	A	SD (24h)	↓ SD (24h) at 3 months associated with Down Syndrome
Wolke et al., 1998	Finland/ Germany	L	Health problems	5969 5 months	I	NW	↓ NW at 5 months associated with admission to special care units
Ghaem et al., 1998	Australia	CS	Health problems	102 0-3 and 3-12 months	Q	SD (day), NW	↑ NW at 3-12 months associated with gastro-esophageal reflux disease SD (day) at 3-12 months not associated with gastro-esophageal reflux disease
Konrad et al., 2016	UK	CS	Mental development	48 6 and 12 months	Combined measures: A and D (combined)	SD (24h, day, night), WASO, NW, SP (day)	↑ WASO and NW at 6 months infants (but not at 12 months) associated with ↓ imitation score SP (day), SD (24h, day, night) not associated with imitation score
Mindell et al., 2015	Brazil	CS	Mental development	1351 3-13 months	Q	SD (night), SL (night), NW. SP (day), BT, WT	SD (night), SL (night), NW, SP (day), BT, and WT at 3-13 months not associated with problem solving, communication, and personal-social skills scores

Lukowski et al., 2013	USA	CS	Mental development	21 10 months	Q	SD (day, night), NW	↑ SD (day) at 10 months associated with ↑ encoding ↓ NW and ↑ SD (day) at 10 months associated with ↑ generalization SD (day, night) and NW not associated with delayed recall
Gibson et al., 2012	New Zealand	CS	Mental development	52 12 months	A	SE	↑ SE at 12 months associated with ↑ problem solving
Scher, 2005b	Israel	CS	Mental development	50 10 months	Combined measures: A and Q	SD (24h), NW, SE	↓ NW and ↑ SE at 10 months (measured by A) associated with ↑ mental developmental index SD (24h) and NW (measured by Q) not associated with mental development index
Shibagaki et al., 2004	Japan	CS	Mental development	27 4-12 months	P	SD (night), WASO	↓ WASO associated with ↑ developmental quotient in infants with developmental disabilities SD (night) not associated with developmental quotient
Gertner et al., 2002	Israel	L	Mental development	34 0 and 6 months	A	SD (24h, day, night)	↑ SD (24h, night) at 0 months associated with ↓ mental developmental scores at 6 months SD (day) at 0 months not associated with mental developmental scores at 6 months
McGeorge et al., 2015	Australia	CS	Social emotional problems	55 4-7 months	D	SD (24h)	↓ SD (24h) at 4-7 months associated with ↑ sensory sensitivity and sensation avoiding
Humphreys et al., 2014	UK	L	Social emotional problems	14062 6 months	Q	SD (24h), NW	SD (24h) and NW at 6 months not associated with autism
Landau et al., 2010	Israel	CS	Social emotional problems	44 1-2 months	Combined measures: A and D	SD (24h, day, night), NW, SP (day)	SD (24h, day, night), NW, and SP (day) not associated with Attention Deficit Hyperactivity Disorder ↑ stability in SD (day) and SP (day) associated with ↓ risk for Attention Deficit Hyperactivity Disorder

Scher, 2008	Israel	CS	Social emotional problems	52 10 months	Combined measures: A and Q	NW, SE	↑ NW (measured by A, but not measured by Q) and ↓ SE at 10 months associated with ↑ maternal separation anxiety at 10 months
Spruyt et al., 2008	Belgium	L	Social emotional problems	20 3, 6, 11, and 12 months	Combined measures: A and D	SD (day)	↑ SD (day) at 12 months associated with ↓ emotion regulation and ↓ total behavior development score
DeLeon et al., 2007	USA	CS	Social emotional problems	41 9 months	D	SD (24h, day, night), WASO, NW, SP (day)	↓ SD (24h, night), ↑ WASO, ↑ NW, ↑ SP (day) at 9 months associated with ↑ separation distress SD (night) not associated with separation distress
Scher et al., 1999	Israel	L	Social emotional problems	81 6 and 12 months	Q	NW	↑ NW at 12 months associated with ↑ maternal separation anxiety
Mindell et al., 2015	Brazil	CS	Temperament	1351 3-13 months	Q	SD (night), SL (night), NW, SP (day), BT, WT	↑ NW and ↓ SP (day) associated with ↓ bedtime, morning, and daytime mood ↑ BT and ↓ SD (night) associated with ↓ daytime mood ↓ SD (night) and ↑ WT associated with ↓ morning mood SL not associated with mood BT not associated with bedtime and morning mood WT not associated with bedtime and daytime mood SD (night) not associated with bedtime mood
Sorondo et al., 2015	USA	L	Temperament	40 5, 9, and 12 months	Q	SD (day, night), WASO, NW, SL (night)	↑ SL (night) at 5 months and ↑ WASO at 5, 9, and 12 months associated with negative reactivity at 5 months SD (day, night) and NW at 5, 9, and 12 months not associated with negative reactivity

Kaley et al., 2012	UK	CS	Temperament	77 1-2 months	D	SD (24h, day, night), NW	↑ SD (day) at 1-2 months associated with positive temperament ↓ SD (24h, day, night) at 1-2 months correlated with temperament dimensions (activity, approach, intensity, and distractibility) NW at 1-2 months not associated with temperament dimensions
Gibson et al., 2012	New Zealand	CS	Temperament	52 12 months	A	SD (night), SL (night), BT, WT	↓ SL (night) at 12 months in infants more alert during the day ↑ SD (night) and ↑ WT at 12 months in infants in good mood in the morning ↓ WT at 12 months in infants rated as tired at bedtime SD (night), BT, and WT at 12 months not associated with daytime alertness SL (night) and BT at 12 months not associated with morning mood SD (night), SL (night), and BT at 12 months not associated with tired at bedtime SD (night), SL (night), BT and WT at 12 months not associated with bedtime mood and bedtime problems
Spruyt et al., 2008	Belgium	L	Temperament	20 3, 6, 11, and 12 months	Combined measures: A and D	SD (24h, day, night)	↑ SD (24h) at 3 months associated with ↑ approachability ↑ SD (24h) at 6 months associated with ↑ rhythmicity and ↓ distractibility ↑ SD (24h) at 12 months associated with ↑ rhythmicity and ↓ persistence

							↑ SD (day) at 12 months associated with perceived negative mood ↑ SD (night) at 3, 6 and 11 months associated with ↑ approachability
Palmstierna et al., 2008	Sweden	L	Temperament	16467 12 months	Q	NW	↑ NW at 12 months associated with difficult temperament
Bayer et al., 2007	Australia	CS	Temperament	692 3-6 months	Q	NW	↑ NW at 3-6 months associated with difficult temperament
Touchette et al., 2005	Canada	L	Temperament	1741 5 months	Q	SD (night)	↓ SD (night) at 5 months associated with difficult temperament
Scher, 2001a	Israel	CS	Temperament	94 12 months	A	SD (night), NW, LSP (night), SL (night), SE	↑ SE at 12 months associated with ↑ fussiness SD (night), NW, LSP (night), and SL (night) at 12 months not associated with fussiness
Scher et al., 1998	Israel	CS	Temperament	30 12 months	A	SD (night), NW, SE, BT	↑ SD (night), ↑ NW, ↓ SE, and ↓ BT at 12 months associated with ↑ rhythmicity ↓ BT at 12 months associated with positive mood SD, NW, SE, BT at 12 months not associated with other dimensions of temperament
Gibson et al., 2012	New Zealand	CS	Sleep problems	52 12 months	A	SD (24h, day, night), SL (night), SP (24h), SE, BT, WT	↓ SD (24h, night) and ↑ SP (24h) at 12 months in infants rated with sleep problems SD (day), SL (night), SE, BT, and WT at 12 months not associated with sleep problems
Bayer et al., 2007	Australia	CS	Sleep problems	692 3-6 months	Q	NW	↑ NW at 3-6 months associated with maternal report of sleep problem

Hiscock et al., 2001	Australia	CS	Sleep problems	738 7-9 months	Q	NW, SP (day), SL, BT, WT	↑ NW, ↓ SP (day) and ↑ SL at 7-9 months in infants reported by mothers as presenting a sleep problem ↑ BT and ↓ WT marginally associated with maternal reports of sleep problems
St James-Roberts et al., 2011	UK/ Denmark	L	Crying	610 233 1 and 3 months	Q	NW	↑ NW at 3 months associated with prolonged crying at 1 month in one study but not in another
DeLeon et al., 2007	USA	CS	Crying	41 9 months	D	SD (24h, day, night), WASO, NW, SP (day)	↓ SD (night), ↑ WASO, ↑ NW at 9 months associated with ↑ daytime crying SD (24h, day), and SP (day) at 9 months not associated with daytime crying
Harrison, 2004	UK	L	Crying	66 1, 2, 3 months	D	SD (24h, night)	SD (24h, night) not associated with crying ↓ SD (24h, night) at 1 month, but not at 2 and 3 months associated with ↑ evening crying
Lee, 2000	Korea	CS	Crying	188 0-4 months	D	SD (24h)	↓ SD (24h) at 0-4 months associated with ↑ cry duration
St James-Roberts et al., 1997	UK	CS	Crying	132 1 month	D	SD (24h, day, night), WASO	↓ SD (24h, day) at 1 months in persistent than in moderate criers SD (night) and WASO at 1 month not associated with crying
Non-associated factors							
Agarwal et al., 2000	India	CS	Massage and use of oil	125 1 month	D	SD (24h, day, night), NW, SP (24h, day)	SD (24h, day, night), NW and SP (24-h, day) at 1 month not associated with massage and use of oil
Johnson et al., 2014	Australia	L	Conception mode	134 7 months	D	SD (24h)	SD (24h) at 7 months not associated with conception mode

Butler et al., 2015	USA	CS	Sleep aid	104 0-11 months	Q	SD (day, night), NW, SP (day), LSP (night), BT, WT	↑ NW at 0-11 months associated with pacifier use and ↑ LSP (night) at 0-11 months associated with finger suck ↑ SD (day) at 0-11 months associated with non-suck and pacifier use SD (night) and SP (day), BT and WT at 0-11 months not associated with sleep aid
Odoi et al., 2014	Australia	L	Sleep aid	30 0-1, 2-3, 5-6 months	P	SD (day), SP (day)	SD (day) and SP (day) at 0-1, 2-3, and 5-6 months not associated with sleep aid
Burnham et al., 2002	USA	L	Sleep aid	80 1, 3, 6, 9, and 12 months	V	SD (night), NW, LSP (night)	SD (night), NW, and LSP (night) not associated with sleep aid
Ball, 2007	UK	CS	Sleep arrangements (twins)	24 1-3 months	V	SD (night), NW	SD (night) and NW at 1-3 months not associated with sleep arrangements in twin infants

LABEL
Design: CS Cross-sectional; L Longitudinal
Sleep measures: A Actigraphy; D Diary; EEG Electro encephalography I Interview; MMS Motility Monitor System; NS Not Specified; O Observation; P Polysmonogrpahy; Q Questionnaire; V Video recording
Sleep-wake behavior: BT Bedtime; LSP Longest sleep period; SL Sleep latency; NW Night wakings; SD Sleep duration; SE Sleep efficiency; SP Sleep periods; WT Wake Time; WASO Wake After Sleep Onset

On the other hand, the following factors emerged as negatively associated with sleep-wake behavior during the first 12 months of life: male gender in 10/12 studies, older maternal age in 2/2 studies, single/divorced parents in 2/2 studies, non-native parents in 1/1 study, lower socio-economic status in 3/5 studies, winter months in 1/1 study, urban environments in 1/1 study, less exposure to light in 1/1 study, and more exposure to maternal smoking in 1/1 study, gestational exposure to smoke, alcohol, substances, namely alcohol, tobacco, cocaine, marijuana, and methamphetamine, and stressful events in 3/4 studies, planned C-section in 1/1 study, and preterm delivery in 4/4 studies, breastfeeding in 22/27 studies, earlier introduction of solids, higher number of feedings, and diet components in 3/4 studies, later bedtimes, less bedtime activities, and television and media exposure in 5/5 studies, more parental bedtime involvement in 8/8 studies, characterized by parental presence at bedtime, nursing or rocking at bedtime, putting the infant in crib asleep, or feeding back to sleep, bed-sharing or co-sleeping in 10/11 studies, cloth diapers in 1/1 study, maternal depression, stress, or fatigue and family dysfunction and stress in 17/18 studies, worse parental sleep in 7/7 studies, lower parental involvement in 4/5 studies, emergence of crawling in 4/6 studies, weight gain in 3/4 studies, colic in 2/2 studies, health problems in 5/6 studies, lower scores in mental development tasks in 6/7 studies, social and emotional problems in 6/7 studies, difficult temperament in 10/10 studies, sleep problems in 3/3 studies, and crying in 5/5 studies (see Table 8).

Massage and use of oil, conception mode, sleep aid, and sleep arrangements in twins were not associated with infant sleep-wake behavior (see Table 8).

Factors positively and negatively affected by sleep-wake behavior

Sleep-wake behavior during the first 12 months of life was shown to positively affect co-parenting quality in 1/1 study and negatively affect parental bedtime involvement in 2/3 studies, maternal mental health in 2/2 studies, obesity in 1/2 study, performance in mental tasks in 2/2 studies, social emotional problems in 5/6 studies, temperament in 1/1 study, sleep problems in 4/4 studies, and attachment in 2/2 studies (see Table 9).

Table 9.

Factors positively and negatively affected by sleep-wake behavior during the first 12 months of life

First author Year of publication	Country	Design	Associated factor	N / Age (months)	Sleep measure	Sleep-wake behavior	Main result
				Positive factors			
McDaniel et al., 2012	USA	L	Co-parenting	150 1 and 3 months	D	NW	↑ NW at 1 and 3 months indirectly predicted ↓ co-parenting quality
				Negative factors			
Tikotzky et al., 2015	Israel	L	Parental bedtime involvement	57 3 and 6 months	Combined measures: A, D, and Q	SD (night), NW, SE	SD (night), and SE at 3 and 6 months and NW at 3 months not associated with nighttime paternal involvement at 6 months
Johnson et al., 2014	Australia	L	Parental bedtime involvement	134 7 months	D	SD (24h)	↓ SD (24h) at 7 months associated with ↑ maternal bedtime involvement at 18 months
Tikotzky et al., 2012	Israel	L	Parental bedtime involvement	71 12 months	A	NW	↑ NW at 12 months associated with ↑ parental bedtime involvement at 4 years
Sharkey et al., 2015	USA	L	Parental mental health	31 0, 1, and 4 months	D	SD (24h), SP (24h)	↑ SP (24h) at 0 and 1 month associated with ↑ maternal depressive symptoms ↓ SD (24h) at 0 and 1 month associated with ↑ maternal stressors at 4 months
McDaniel et al., 2012	USA	L	Parental mental health	150 1 and 3 months	D	NW	↑ NW at 1 and 3 months indirectly predicted ↑ maternal depression
Klingenberg et al., 2013	Denmark	L	Physical growth	311 9 months	Q	SD (24h, night)	SD (24h, night) at 9 months not associated with adiposity indicators at 36 months
Gillman et al., 2008	USA	L	Physical growth	1100	Q	SD (24h)	↓ SD (24h) at 6 and 12 months associated with ↑ risk of overweight at 3 years

				6 and 12 months			
Dionne et al., 2011	Canada	L	Mental development	1029 6 months	I	LSP (day, night)	↑ LSP (day) at 6 months associated with ↓ language outcome at 18, 30 and 60 months LSP (night) at 6 months not associated with language outcome at 18, 30 and 60 months
Bernier et al., 2010	Canada	L	Mental development	60 12 months	D	SD (24h), NW, SE	↑ SE at 12 months associated with ↑ performance on executive tasks at 26 months (but not at 18 months) SD (24h) and NW at 12 months not associated performance on executive tasks at 18 and 26 months
Bouvette-Turcot et al., 2015	Canada	L	Social emotional problems	209 6 and 12 months	Q	SD (24h)	↓ SD (24h) from 6 to 36 months associated with negative emotionality/behavioral dysregulation at 36 months in infants with 5-HTTLPR allele
Sadeh et al., 2015	Israel	L	Social emotional problems	43 12 months	A	SD (night), NW, SE	↑ NW and ↓ SE at 12 months associated with ↑ attention regulation and behavior problems at 3-4 years SD (night) at 12 months not associated with attention regulation and behavior problems at 3-4 years
Saenz et al., 2015	USA	L	Social emotional problems	47 3-4 months	A	SD (night), SE	↓ SD (night) at 3-4 months associated with ↑ externalizing problems and autism spectrum disorder behaviors at 18-24 months in girls SD (night) at 3-4 months not associated with internalizing and dysregulation problems SE 3-4 months not associated with social emotional problems
Scott et al., 2013	UK	L	Social emotional problems	8195 6 months	Q	SD (night), NW	↓ SD (night) at 6 months associated with attention deficit hyperactivity disorder

							NW at 6 months not associated with attention deficit hyperactivity disorder
Bordeleau et al., 2012	Canada	L	Social emotional problems	55 12 months	D	SD (24h, night)	SD (24h, night) at 12 months not associated with externalizing and internalizing symptoms at 4 years
Jansen et al., 2011	The Netherlands	L	Social emotional problems	4782 2 months	Q	SD (24h), NW	↑ NW at 2 months associated with ↑ anxiety and depression at 3 years SD (24h) at 2 months not associated with anxiety and depression at 3 years
Novosad et al., 1999	USA	CS	Temperament	41 0 and 8 months	MMS	LSP (24h)	↑ LSP (24h) at 0 months associated with ↓ adaptable temperament at 8 months
Hysing et al., 2014	Norway	L	Sleep problems	55831 6 months	Q	SD (night), NW	↓ SD (night) at 6 months associated with ↓ SD (night) at 18 months ↑ NW at 6 months associated with ↑ NW at 18 months
Byars et al., 2012	USA	L	Sleep problems	359 6, 12 months	Q	SD (24h, day), SL (night), SP (day)	↓ SD (24h), ↑ SL (night) at 6 and 12 months associated with ↑ sleep problems SD (day) at 6 and 12 months not associated with sleep problems ↓ SD (24h), ↑ SL (night) at 6 and 12 months associated with ↓ SD (24h), ↑ SL (night) at 24 and 36 months ↑ SP (day) at 6 months associated with ↑ SP (day) at 12 months, but not at 24 and 36 months
Tikotzky et al., 2012	Israel	L	Sleep problems	71 12 months	Combined measures: A, D, and Q	NW, SE	↑ NW at 12 months associated with ↑ NW, ↓ SE, and ↓ SD (night) at 4 years ↑ SE at 12 months associated with ↑ NW (measured by Q) at 4 years

							SE at 12 months not associated with NW (measured by A), SE, and SD (night) at 4 years
Palmstierna et al., 2008	Sweden	L	Sleep problems	16467 12 months	Q	NW	↑ NW at 12 months associated with ↑ NW at 3 and 5 years and with ↓ perceived sleep quality at 12 months, 3 and 5 years
Schwichtenberg et al., 2013	USA	L	Attachment	171 4, 9 months	D	SD (day, night), NW, SP (day)	↑ SD (day) from 4 to 9 months predicted secure attachment at 16 months SD (night) and NW not associated with attachment
Beijers et al., 2011	The Netherlands	L	Attachment	193 0-6 and 12 months	D	NW	↑ NW at 0-6 months associated with insecure-resistant attachment at 12 months ↓ NW at 6 months associated with avoidant attachment at 12 months No associations between NW at 12 months and attachment

LABEL
Design: CS Cross-sectional; L Longitudinal
Sleep measures: A Actigraphy; D Diary; EEG Electro encephalography I Interview; MMS Motility Monitor System; NS Not Specified; O Observation; P Polysmonogrpahy; Q Questionnaire; V Video recording
Sleep-wake behavior: BT Bedtime; LSP Longest sleep period; SL Sleep latency; NW Night wakings; SD Sleep duration; SE Sleep efficiency; SP Sleep periods; WT Wake Time; WASO Wake After Sleep Onset

Discussion

This study aimed to provide a systematic review of the literature on associated factors with sleep-wake behavior during the first 12 months of life. This systematic review considered different sleep-wake behaviors and included studies performed in 25 different countries, over the last 20 years.

Factors positively and negatively associated with sleep-wake behavior

The most consistent factors positively associated with different sleep-wake behaviors during the first 12 months of life found in literature were: being a first-time infant, Caucasian ethnicity, the regulation of the HPA axis, secure attachment pattern and a positive mother-infant relationship. The other factors were either poorly explored or provided inconsistent results across the different studies.

Being a first-time infant was associated with longer sleep duration and less night wakings (Kozyrskyj et al., 2009; Santos et al., 2008; So et al., 2007). Results from studies with the smallest samples either suggested no differences in the different sleep-wake behaviors that were analyzed (Kaley et al., 2012; So et al., 2007, Quillin, 1997) or a tendency for longer sleep duration in non-first-time infants (Kaley et al., 2012). When the number of siblings was assessed, different results were found, namely more night wakings in infants with more siblings in one study (Kozyrskyj et al., 2009) and no differences in another study (Blair et al., 2012). Studies addressing birth order also differed regarding the time of sleep-wake behavior assessment. While during the first months, results were not consistent (Kaley et al., 2012; So et al., 2007, Quillin, 1997), in the second half of the first year, non-first-time infants were shown to present less sleep duration during the night (So et al., 2007), and more night wakings (Kozyrskyj et al., 2009; Santos et al., 2008). As the most important changes in sleep-wake behavior occur during the first 3 months (Burnham, Goodlin-Jones, Gaylor, & Anders, 2002; Henderson, France, & Blampied, 2011), differences in birth order may not be easily seen in the first months.

Caucasian ethnicity was consistently associated with longer sleep duration during the 24-hour period and more night wakings when compared with non-caucasian ethnicity (Blair et al., 2012; Nevarez et al., 2010; Santos et al., 2012). This result is consistent with previous research showing cultural differences in sleep-wake behaviors between Caucasian and Asian infants (Mindell, Sadeh, Wiegand, How, & Goh, 2010).

Although some inconsistent results, a secure attachment was associated with more regulated sleep-wake behavior, characterized by more sleep duration during the night, less night wakings, and a longer longest sleep period in 2 studies (Pennestri et al., 2015; Zentall et al., 2012). This may be explained by the fact that secure infants are more able to deal with the mother separation during the night and rely on mother's availability, presenting a more regulated sleep-wake behavior during the night (Zentall et al., 2012). Regarding mother-infant interaction, different results have been found. A positive mother-infant relationship was associated with a higher increase in the longest sleep periods (de Graag et al., 2012) and with more night wakings, but not with sleep duration during the night and bedtime (Scher, 2001b). Researchers studying preterm infants showed the importance of sleep-wake behaviors during the day in association with the mother-infant relationship (Schwichenberg et al., 2011).

Although few studies addressed infant hormonal factors, results suggested a trend for an association between a regulation of the HPA axis and less night wakings (Lucas-Thompson et al., 2009) and more sleep during the night (Lucas-Thompson et al., 2009). Results from a recent study were controversial, however, this study was conducted with infants with colic (Brand et al., 2011), and colic were shown to be associated with infant sleep-wake behavior in previous research (Kirjavainen et al., 2001; White et al., 2000). Furthermore, lower morning melatonin levels were also associated with increased sleep duration during the night in one study (Shinohara & Kodama, 2011).

The most consistent factors negatively associated with different sleep-wake behaviors during the first 12 months of life were: male gender, breastfeeding, bedtime routines, bed-sharing, parental mental health, parental sleep, and infant social-emotional and sleep problems. Other factors were also negatively associated with sleep-wake behavior, namely lower socio-economic status, preterm birth, crawling onset, difficult temperament, and crying. However, considering the paucity of studies or the inconsistent results, more research is needed.

Male gender was consistently associated with shorter sleep duration, more night wakings, less sleep efficiency, and shorter longest sleep periods during the first 12 months of life. Interestingly, results from studies performed in Australia suggested no gender differences in the different sleep-wake behaviors that were analyzed (Kozyrskyj et al., 2009; So et al., 2007), which can underlie some cultural characteristics. Non-Australian studies, whose results showed no gender differences in the different infant sleep-wake behaviors, were conducted with small samples

and most of them assessed age ranges rather than specific ages (Goodlin-Jones et al., 2001; Kaley et al., 2012; Lampl & Johnson, 2011; Saenz et al., 2015; Thomas & Foreman, 2005). Considering that infant sleep-wake behavior during the first months is marked by both individual and developmental changes (Figueiredo et al., 2016), the use of small sample sizes or age ranges could difficult the assessment of gender differences (Weinraub et al., 2012).

Breastfeeding was consistently associated with more night wakings (Anunstaseree et al., 2008; Ball, 2003; DeLeon & Karraker, 2007; Engler et al., 2012; Galbally et al., 2013; Huang et al., 2016; Hughes et al., 2015; Hysing et al., 2014; Kaley et al., 2012; Kozyrkyj et al., 2009; Mindell et al., 2009; Mindell et al., 2012; Ramamurthy et al., 2012; Shwichtenberg & Poehlmann, 2009; Tikotzky et al., 2015; Wolke et al., 1998). This is congruent with previous literature showing that the quick digestion of breast milk could lead to a more fragmented sleep in breastfed infants (Burness, 1979). However, it is not clear the association between feeding method and other sleep-wake behaviors, namely sleep duration, sleep periods or longest sleep period (Cubero et al., 2005; DeLeon & Karraker, 2007; Demirci et al., 2012; Engler et al., 2012; Huang et al., 2016; Hughes et al., 2014; Kaley et al., 2012; Lampl & Johnson, 2011; Lee, 2000; Mindell et al., 2012; Morgan et al., 2004; Nevarez et al., 2010; Quilin & Glenn, 2004; Ramamurthy et al., 2012; Shwichtenberg & Poehlmann, 2009; Thomas, 2000).

Less arousing activities, no reading, late betimes, no bedtime routine, and television and media exposure before bedtime were associated with shorter sleep duration during the night and more night wakings (Cespedes et al., 2014; Mindell et al., 2009; Nevarez et al., 2010; Philbrook & Teti, 2016; Vijakkhana et al., 2015). This is congruent with findings that show that sleep hygiene is associated with infant sleep-wake behavior (Mindell et al., 2009). Furthermore, higher parental bedtime involvement, characterized by parental presence at bedtime, nursing or rocking at bedtime, putting the infant in crib asleep, or feeding back to sleep were also associated with shorter sleep duration and longest sleep periods, more sleep latency during the night and more night wakings (Anunstaseree et al., 2008; DeLeon & Karraker, 2007; Goodlin-Jones et al., 2001; Huang et al., 2016; Mindell et al., 2009; Philbrook & Teti, 2016; Ramamurthy et al., 2012; Tikotzky & Sadeh, 2009; Touchette et al., 2005). These findings may be explained within the context of the transactional model that argues that parental behaviors are the most immediate and direct factor influencing infant sleep-wake behaviors (Sadeh et al., 2010). The level of parental involvement at bedtime is crucial to the development of the infant's abilities to self-sooth and self-regulate (Sadeh et al., 2010). In the presence of a low parental involvement at bedtime, the infant is taught to self-

sooth and self-regulate its sleep-wake behaviors, while in the presence of high parental involvement at bedtime, the infant is not able to develop these skills (Sadeh et al., 2010).

Sleep arrangements (characterized by bed-sharing or co-sleeping) were consistently associated with shorter sleep duration during the night and more night wakings (Bruni et al., 2014; DeLeon & Karraker, 2007; Guyer et al., 2015; Jenni et al., 2005; Mao et al., 2004; Möllborg et al., 2011; Philbrook & Teti, 2016; Santos et al., 2008; Touchette et al., 2005). Bed-sharing/co-sleeping promotes higher physical contact with the parents and that could interfere with the infant's ability to self-comfort, causing more difficulties in the ability of the infant to return to sleep after night wakings (Green, Groves, & Tegano, 2004; Morrell & steele, 2003). Moreover, previous research also showed an association between co-sleeping/bed-sharing and infant's dysregulation, breastfeeding and putting the infant in bed asleep, arguing that co-sleeping/bed-sharing could be used as a parent's strategy to deal with the infant's characteristics and the feeding method (DeLeon & Karraker, 2007). Only 1 study showed no associations between sleep arrangements and infant sleep-wake behavior (Baddock, Galland, Bolton, Williams, & Taylor, 2006). However, this study analyzed differences between bed-sharing and cot-sleeping, being cot-sleeping defined as sleeping in a cot, that is usually adjacent to the parent's bed (Baddock et al., 2006). Furthermore, this study was performed in New Zealand, where the lowest bed-sharing rates were shown (Mindell et al., 2009). No association between sleep arrangements and sleep-wake behavior, when measured by actigraphy, was found in another study (Volkovich, Ben-Zion, Karny, Meiri, & Tikotzky, 2015). However, the analyses of this study were controlled for feeding method, which has been shown to be associated with sleep arrangements in previous research (DeLeon & Karraker, 2007). Interestingly, although a recent study, performed in China, found more sleep duration during the night in independent sleeping infants, no association was shown between sleep arrangements and night wakings (Huang et al., 2016).

Parental mental health, especially maternal depression and fatigue and family dysfunction and stress have been associated with shorter sleep duration (day, night and 24-hour period) and longest sleep period (night), and more night wakings and WASO (Armitage et al., 2009; Baird et al., 2009; Brand et al., 2014; Dennis & Ross, 2005; Goldberg et al., 2013; Gress-Smith et al., 2012; Hughes et al., 2015; Karraker & Young, 2015; Loutzenhiser et al., 2015; Mao et al., 2011; Nevarez et al., 2010; O'Connor et al., 2007; Piteo et al., 2013; Saenz et al., 2015; Sinai & Tikotzky, 2012; Sorondo & Reeb-Sutherland, 2015; Warren et al., 2006). Depressed mothers may be less able to deal with family activities, namely infant sleep-wake behavior (Piteo et al., 2013). However,

the results of 6 studies indicated no association between parental mental health and the different infant sleep-wake behaviors that were analyzed (Armitage et al., 2009; Dennis & Ross, 2005; O'Connor et al., 2007; Sinai & Tikotzky, 2012; Sorondo & Reeb-Sutherland, 2015; Thomas & Spieker, 2016). Five of these studies used measures based on parental reports (Dennis & Ross, 2005; O'Connor et al., 2007; Sinai & Tikotzky, 2012; Sorondo & Reeb-Sutherland, 2015; Thomas & Spieker, 2016). Curiously, maternal mental health was not associated with infant sleep-wake behavior during the day in the only study that used actigraphy (Armitage et al., 2009).

Parental sleep was also associated with infant sleep-wake behavior, namely sleep duration, sleep periods, longest sleep period, night wakings, sleep efficiency and bedtimes (Brand et al., 2014; Demirci et al., 2012; Sharkey et al., 2016; Sinai & Tikotzky, 2012; Tikotzky et al., 2015; Thomas & Foreman, 2005; Thomas & Spieker, 2016). Parents, especially mothers, presenting poor sleep could be either more stressed during the day or more actively involved in infants' soothing after a night waking which may interfere with infant's ability to self-sooth (Tikotzky et al., 2015; Tikotzky & Sadeh, 2010). Parental sleep was not associated with the different infant sleep-wake behaviors that were analyzed in 3 other studies (Sharkey et al., 2016; Sinai & Tikotzky, 2012; Thomas & Foreman, 2005). These studies were performed with small samples and 1 of them comprised a sample with a history of major depressive disorder (Sharkey et al., 2016). Furthermore, these authors found no association between parental sleep and infant sleep-wake behavior during the day and the 24-hour period, which may suggest that parental sleep is more associated with infant sleep-wake behavior during the night.

The presence of social and emotional problems (DeLeon & Karraker, 2007; Landau et al., 2010; McGeorge et al., 2015; Scher, 2008; Scher & Blumber, 1999; Spruyt et al., 2008), with exception of autism (Humphreys et al., 2013), was also associated with worse sleep-wake behavior.

More night wakings, sleep periods and sleep latency and shorter sleep duration (night and 24-hour period) were associated with sleep problems (Gibson et al., 2012; Hiscock et al., 2001; Scher et al., 1998). In fact, literature has been suggesting that some sleep-wake behaviors, especially night wakings and short sleep duration, are already considered as sleep problems during the first 12 months and remain a concern for parents further in infant development (Bayer et al., 2007).

Lower socio-economic status, larger households, and maternal employment were associated with shorter sleep duration and longest sleep period, and more night wakings and sleep periods (Fouts et al., 2007; Nevarez et al., 2010; Santos et al., 2008). Considering the paucity of

studies and that different parent's socio-demographic and socio-economic factors were assessed, these variables need a more extensive study to a better understanding of their association with sleep-wake behavior during the first 12 months.

Although, during the first 6 months, preterm infants sleep more (day, and night), in longer periods (night), and present more night wakings (Guyer et al., 2015; Huang et al., 2014) at 12 months, results are not consistent across the reviewed studies (Asaka & Takada, 2010; Kozyrskyj et al., 2009). Preterm infants achieve the 24-hour sleep-wake rhythms earlier than term infants (Guyer et al., 2015), and thus the differences between term and preterm infants could be more evident during the first 6 months. However, more research is warranted to better understand the association between gestational age and sleep-wake behavior during the first 12 months of life.

Although no association was found between motor development and infant-sleep wake behavior in 2 studies (Gibson et al., 2012; Mindell & Lee, 2015), more night wakings were reported in the emergence of crawling (Atun-Einy & Scher, 2016; Scher & Cohen, 2005), especially in infants with early crawling (Scher, 2005a; Scher & Cohen, 2015). At crawling onset, mothers may be more involved in infant's bedtime or increase their perception of their involvement in infant sleep-wake behavior during the night, which may increase infant's night wakings (Scher & Cohen, 2005).

Results also suggest a trend for an association between easy temperament and less night wakings (Bayer et al., 2007; Mindell & Lee, 2015; Palmstierna et al., 2008; Scher et al., 1998, less WASO (Sorondo & Reeb-Sutherland, 2015), less sleep latency (Gibson et al., 2012; Sorondo & Reeb-Sutherland, 2015), longer sleep duration (day, night, and 24-hour) (Gibson et al., 2012; Kaley et al., 2012; Mindell & Lee, 2015; Scher et al., 1998; Spruyt et al., 2008; Touchette et al., 2005), less sleep periods (Mindell & Lee, 2015), more sleep efficiency (Scher, 2001a; Scher et al., 1998), earlier bedtime (Scher et al., 1998) and later wake time (Gibson et al., 2012; Mindell & Lee, 2015). Previous authors hypothesized that these associations may be influenced by parents' perceptions (Mindell & Lee, 2015; Spruyt et al., 2008). Moreover, temperament dimensions were not associated with the different infant sleep-wake behaviors that were analyzed (Gibson et al., 2012; Kaley et al., 2012; Mindell & Lee, 2015; Scher, 2001a). However, these results seem to suggest that infants with a more difficult temperament and negative mood present worse sleep-wake behaviors.

Although there is a tendency for an association between crying and less sleep duration and more fragmented sleep (DeLeon & Karraker, 2007; Harrison, 2004; Lee, 2000; St James-Roberts et al., 1997; St James-Roberts & Peachey, 2011), this association is not congruent across the

different studies. Studies addressing this association used parent's reports to assess both crying and infant-sleep wake behavior, which may underlie some biased perceptions. Further studies should address this association using actigraphy.

Factors positively and negatively affected by sleep-wake behavior

Effects of sleep-wake behavior were less studied, but worse sleep-wake behavior were shown to predict later social-emotional (Berneier et al., 2010; Bordeleau et al., 2012; Bouvette-Turcot et al., 2015; Sadeh et al., 2015; Saenz et al., 2015), and sleep problems (Byars et al., 2012; Hysing et al., 2014; Palmstierna et al., 2008; Tikotzky & Shaashua, 2012).

More night wakings, shorter sleep duration (night and 24-hour period) and less sleep efficiency early in infancy were shown in infants with social and emotional problems, namely attention and emotional regulation and attention deficit hyperactivity disorder (Sadeh et al., 2015; Scott et al., 2013), externalizing problems (Saenz et al., 2015), autism disorder (Saenz et al., 2015), and anxiety and depression symptoms (Jansenet al., 2011). This may indicate that early sleep-wake behavior is associated with brain maturation (Saenz et al., 2015). Authors of a recent study stated the importance of differential susceptibility in the association between sleep duration and later emotional development, reporting that this association is only present in infants with 5-HTTLPR allele (Bouvette-Turcot et al., 2015). Sleep-wake behavior was not associated with externalizing problems in 1 study, whose results suggested, however, that sleep duration during the night moderated the association between maternal sensitivity and internalizing/externalizing symptoms (Bordeleau et al., 2012).

Shorter sleep duration, more night wakings, sleep periods and sleep latency were associated with later sleep problems (Byars et al., 2012; Hysing et al., 2014; Palmstierna et al., 2008; Tikotzky & Shaashua, 2012). This is consistent with the results of a previous study, pointing for the individual stability in infant sleep-wake behavior over the first 6 months (Figueiredo et al., 2016).

Conclusions

This systematic review provided information regarding factors associated with the different sleep-wake behavior during the first 12 months of life. Different factors were identified as being positively and negatively associated with different sleep-wake behaviors, namely infant factors, parental and environmental factors. Factors positively and negatively affected by different sleep-

wake behaviors during the first 12 months of life were also presented in this systematic review. Moreover, the bidirectional nature of different factors was shown. For example, infant social-emotional and sleep problems were shown to be negatively associated with some infant sleep-wake behaviors and were also found to be negatively affected by other infant sleep-wake behaviors.

Methodological differences between the studies seemed to underlie some different results between them, namely: 1) the use of different sleep-wake measures; 2) the study of infants with different ages or age-ranges; 3) the study of samples with different characteristics; 4) the use of different definitions of the studied variables; and 5) the study of different sleep-wake behaviors.

Infant sleep-wake behavior presents significant developmental changes and individual differences during the first months (Figueiredo et al., 2016), being imperative the assessment of infants in specific ages and the use of large and representative samples. Infant sleep-wake behavior presents cultural differences (Mindell et al., 2010) and incongruent results were also identified in studies performed in specific countries (e.g., Baddock et al., 2006; Kozyrskyj et al., 2009; So et al., 2007). Considering the homogeneity of some studies' samples, it could be difficult to generalize some results (Field, 2017).

Despite these differences, this systematic review identified several factors associated with the different sleep-wake behaviors during the first 12 months of life.

References

Agarwal, K. N., Gupta, A., Pushkarna, R., & Bhargava, S. K. (2000). Effects of massage & use of oil on growth, blood flow & sleep pattern in infants. *Indian Journal of Medical Research*, *112*, 212-217.

Anuntaseree, W., Mo-Suwan, L., Vasiknanonte, P., Kuasirikul, S., & Choprapawan, C. (2008). Night waking in Thai infants at 3 months of age: association between parental practices and infant sleep. *Sleep Medicine*, *9*, 564-571. doi: 10.1016/j.sleep.2007.07.009

Anuntaseree, W., Sangsupawanich, P., Osmond, C., Mo-Suwan, L., Vasiknanonte, P., & Choprapawon, C. (2012). Sleep quality in infants with atopic dermatitis: a community-based, birth cohort study. *Asian Pacific Journal of Allergy and Immunology*, *30*(1), 26-31.

Armitage, R., Flynn, H., Hoffmann, R., Vazquez, D., Lopez, J., & Marcus, S. (2009). Early developmental changes in sleep in infants: the impact of maternal depression. *Sleep*, *32*, 693-696. doi: 10.1093/sleep/32.5.693

Asaka, Y., & Takada, S. (2010). Activity-based assessment of the sleep behaviors of VLBW preterm infants and full-term infants at around 12 months of age. *Brain and Development*, *32*, 150-155.

Atun-Einy, O., & Scher, A. (2016). Sleep disruption and motor development: Does pulling-to-stand impacts sleep–wake regulation?. *Infant Behavior and Development*, *42*, 36-44. doi: 10.1016/j.infbeh.2015.11.003

Bach, V., Telliez, F., Leke, A., & Libert, J. P. (2000). Gender-related sleep differences in neonates in thermoneutral and cool environments. *Journal of Sleep Research*, *9*, 249-254. doi: 10.1046/j.1365-2869.2000.00206.x

Baddock, S. A., Galland, B. C., Bolton, D. P., Williams, S. M., & Taylor, B. J. (2006). Differences in infant and parent behaviors during routine bed sharing compared with cot sleeping in the home setting. *Pediatrics*, *117*, 1599-1607. doi: 10.1542/peds.2005-1636

Baird, J., Hill, C. M., Kendrick, T., Inskip, H. M., & SWS Study Group. (2009). Infant sleep disturbance is associated with preconceptional psychological distress: findings from the Southampton Women's Survey. *Sleep*, *32*, 566-568. doi: 10.5665/sleep/32.4.566

Ball, H. L. (2003). Breastfeeding, bed-sharing, and infant sleep. *Birth*, *30*, 181-188. doi: 10.1046/j.1523-536X.2003.00243.x

Ball, H. L. (2007). Together or apart? A behavioural and physiological investigation of sleeping arrangements for twin babies. *Midwifery*, *23*, 404-412. doi: 10.1016/j.midw.2006.07.004

Bathory, E., Tomopoulos, S., Rothman, R., Sanders, L., Perrin, E. M., Mendelsohn, A., ... & Yin, H. S. (2016). Infant Sleep and Parent Health Literacy. *Academic Pediatrics*, *16*, 550-557. doi: 10.1016/j.acap.2016.03.004

Bayer, J. K., Hiscock, H., Hampton, A., & Wake, M. (2007). Sleep problems in young infants and maternal mental and physical health. *Journal of Paediatrics and Child Health*, *43*, 66-73. doi: 10.1111/j.1440-1754.2007.01005.x

Beijers, R., Jansen, J., Riksen-Walraven, M., & de Weerth, C. (2011). Attachment and infant night waking: A longitudinal study from birth through the first year of life. *Journal of Developmental & Behavioral Pediatrics*, *32*, 635-643. doi: 10.1097/DBP.0b013e318228888d

Bernier, A., Carlson, S. M., Bordeleau, S., & Carrier, J. (2010). Relations between physiological and cognitive regulatory systems: Infant sleep regulation and subsequent executive functioning. *Child Development*, *81*, 1739-1752. doi: 10.1111/j.1467-8624.2010.01507.x

Bhat, R. Y., Hannam, S., Pressler, R., Rafferty, G. F., Peacock, J. L., & Greenough, A. (2006). Effect of prone and supine position on sleep, apneas, and arousal in preterm infants. *Pediatrics*, *118*, 101-107. doi: 10.1542/peds.2005-1873

Blair, P. S., Humphreys, J. S., Gringras, P., Taheri, S., Scott, N., Emond, A., ... & Fleming, P. J. (2012). Childhood sleep duration and associated demographic characteristics in an English cohort. *Sleep*, *35*, 353-360. doi: 10.5665/sleep.1694

Bordeleau, S., Bernier, A., & Carrier, J. (2012). Maternal sensitivity and children's behavior problems: Examining the moderating role of infant sleep duration. *Journal of Clinical Child & Adolescent Psychology*, *41*, 471-481. doi: 10.1080/15374416.2012.686101

Bottino, C. J., Rifas-Shiman, S. L., Kleinman, K. P., Oken, E., Redline, S., Gold, D., ... & Taveras, E. M. (2012). The association of urbanicity with infant sleep duration. *Health & Place*, *18*, 1000-1005. doi: 10.1016/j.healthplace.2012.06.007

Bouvette-Turcot, A. A., Pluess, M., Bernier, A., Pennestri, M. H., Levitan, R., Sokolowski, M. B., ... & Meaney, M. J. (2015). Effects of genotype and sleep on temperament. *Pediatrics*, *136*, e914-e921. doi: 10.1542/peds.2015-0080

Brand, S., Furlano, R., Sidler, M., Schulz, J., & Holsboer-Trachsler, E. (2011). 'Oh, baby, please don't cry!': in infants suffering from infantile colic hypothalamic-pituitary-adrenocortical axis activity is related to poor sleep and increased crying intensity. *Neuropsychobiology*, *64*, 15-23. doi: 10.1159/000322456

Brand, S., Furlano, R., Sidler, M., Schulz, J., & Holsboer-Trachsler, E. (2014). Associations between infants' crying, sleep and cortisol secretion and mother's sleep and well-being. *Neuropsychobiology*, *69*, 39-51. doi: 10.1159/000356968

Brown, A., & Harries, V. (2015). Infant sleep and night feeding patterns during later infancy: Association with breastfeeding frequency, daytime complementary food intake, and infant weight. *Breastfeeding Medicine*, *10*, 246-252. doi: 10.1089/bfm.2014.0153

Bruni, O., Baumgartner, E., Sette, S., Ancona, M., Caso, G., Di Cosimo, M. E., ... & Ferri, R. (2014). Longitudinal study of sleep behavior in normal infants during the first year of life. *Journal of Clinical Sleep Medicine*, *10*, 1119-1127. doi: 10.5664/jcsm.4114

Burness N. (1979) Infant feeding. In: V.C. Vaughan, R.J. McKay, & R.E. Behrman (Eds.) *Nelson textbook of pediatrics*. Philadelphia, PA: WB Saunders Co.

Burnham, M. M., Goodlin-Jones, B. L., Gaylor, E. E., & Anders, T. F. (2002). Nighttime sleep-wake patterns and self-soothing from birth to one year of age: A longitudinal intervention study. *Journal of Child Psychology and Psychiatry*, *43*, 713-725. doi: 10.1111/1469-7610.00076

Butler, R., Moore, M., & Mindell, J. A. (2016). Pacifier use, finger sucking, and infant sleep. *Behavioral Sleep Medicine*, *14*, 615-623. doi: 10.1080/15402002.2015.1048451

Byars, K. C., Yolton, K., Rausch, J., Lanphear, B., & Beebe, D. W. (2012). Prevalence, patterns, and persistence of sleep problems in the first 3 years of life. *Pediatrics*, *129*, e276-e284. doi: 10.1542/peds.2011-0372

Cespedes, E. M., Gillman, M. W., Kleinman, K., Rifas-Shiman, S. L., Redline, S., & Taveras, E. M. (2014). Television viewing, bedroom television, and sleep duration from infancy to mid-childhood. *Pediatrics*, *133*, e1163-e1171. doi: 10.1542/peds.2013-3998

Cohen, D., Atun-Einy, O., & Scher, A. (2012). Seasonal effect on infants' sleep regulation: a preliminary study in a Mediterranean climate. *Chronobiology International, 29*, 1352-1357. doi: 10.3109/07420528.2012.728654

Cubero, J., Valero, V., Sánchez, J., Rivero, M., Parvez, H., Rodríguez, A. B., & Barriga, C. (2005). The circadian rhythm of tryptophan in breast milk affects the rhythms of 6-sulfatoxymelatonin and sleep in newborn. *Neuroendocrinology Letters*, *26*(6), 657-662.

de Graag, J. A., Cox, R. F., Hasselman, F., Jansen, J., & de Weerth, C. (2012). Functioning within a relationship: Mother–infant synchrony and infant sleep. *Infant Behavior and Development*, *35*, 252-263. doi: 10.1016/j.infbeh.2011.12.006

DeLeon, C. W., & Karraker, K. H. (2007). Intrinsic and extrinsic factors associated with night waking in 9-month-old infants. *Infant Behavior and Development*, *30*, 596-605. doi: 10.1016/j.infbeh.2007.03.009

Demirci, J. R., Braxter, B. J., & Chasens, E. R. (2012). Breastfeeding and short sleep duration in mothers and 6–11-month-old infants. *Infant Behavior and Development*, *35*, 884-886. doi: 10.1016/j.infbeh.2012.06.005

Dennis, C. L., & Ross, L. (2005). Relationships among infant sleep patterns, maternal fatigue, and development of depressive symptomatology. *Birth*, *32*, 187-193. doi: 10.1111/j.0730-7659.2005.00368.x

Dionne, G., Touchette, E., Forget-Dubois, N., Petit, D., Tremblay, R. E., Montplaisir, J. Y., & Boivin, M. (2011). Associations between sleep-wake consolidation and language development in early childhood: a longitudinal twin study. *Sleep*, *34*, 987-995. doi: 10.5665/SLEEP.1148

Downs, S. H., & Black, N. (1998). The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. *Journal of Epidemiology & Community Health*, *52*, 377-384. doi: 10.1136/jech.52.6.377

Engler, A. C., Hadash, A., Shehadeh, N., & Pillar, G. (2012). Breastfeeding may improve nocturnal sleep and reduce infantile colic: potential role of breast milk melatonin. *European Journal of Pediatrics*, *171*, 729-732. doi: 10.1007/s00431-011-1659-3

Field, T. (2017). Infant sleep problems and interventions: A review. *Infant Behavior and Development*, *47*, 40-53. doi: 10.1016/j.infbeh.2017.02.002

Figueiredo, B., Dias, C. C., Pinto, T. M., & Field, T. (2016). Infant sleep-wake behaviors at two weeks, three and six months. *Infant Behavior and Development*, *44*, 169-178. doi: 10.1016/j.infbeh.2016.06.011

Fouts, H. N., Roopnarine, J. L., & Lamb, M. E. (2007). Social experiences and daily routines of African American infants in different socioeconomic contexts. *Journal of Family Psychology*, *21*, 655-664. doi: 10.1037/0893-3200.21.4.655

Galbally, M., Lewis, A. J., McEgan, K., Scalzo, K., & Islam, F. M. (2013). Breastfeeding and infant sleep patterns: an Australian population study. *Journal of Paediatrics and Child Health*, *49*, E147-E152. doi: 10.1111/jpc.12089

Gertner, S., Greenbaum, C. W., Sadeh, A., Dolfin, Z., Sirota, L., & Ben-Nun, Y. (2002). Sleep–wake patterns in preterm infants and 6 month's home environment: implications for early cognitive development. *Early Human Development*, *68*, 93-102. doi: 10.1016/S0378-3782(02)00018-X

Ghaem, M., Armstrong, K. L., Trocki, O., Cleghorn, G. J., Patrick, M. K., & Shepherd, R. W. (1998). The sleep patterns of infants and young children with gastro-oesophageal reflux. *Journal of Paediatrics and Child Health*, *34*, 160-163. doi: 10.1046/j.1440-1754.1998.00191.x

Gibson, R., Elder, D., & Gander, P. (2012). Actigraphic sleep and developmental progress of one-year-old infants. *Sleep and Biological Rhythms*, *10*, 77-83. doi: 10.1111/j.1479-8425.2011.00525.x

Gibson, R., Gander, P., & Elder, D. (2012). Factors differentiating infants identified by parents as problem sleepers, and those that are not. *Sleep and Biological Rhythms*, *10*, 46-52. doi: 10.1111/j.1479-8425.2011.00517.x

Gillman, M. W., Rifas-Shiman, S. L., Kleinman, K., Oken, E., Rich-Edwards, J. W., & Taveras, E. M. (2008). Developmental origins of childhood overweight: potential public health impact. *Obesity*, *16*, 1651-1656. doi: 10.1038/oby.2008.260

Goldberg, W. A., Lucas-Thompson, R. G., Germo, G. R., Keller, M. A., Davis, E. P., & Sandman, C. A. (2013). Eye of the beholder? Maternal mental health and the quality of infant sleep. *Social Science & Medicine*, *79*, 101-108. doi: 10.1016/j.socscimed.2012.07.006

Goodlin-Jones, B. L., Burnham, M. M., Gaylor, E. E., & Anders, T. F. (2001). Night waking, sleep-wake organization, and self-soothing in the first year of life. *Journal of Developmental & Behavioral Pediatrics*, *22*, 226-233. doi: 10.1097/00004703-200108000-00003

Green, K. E., Groves, M. M., & Tegano, D. W. (2004). Parenting practices that limit transitional object use: An illustration. *Early Child Development and Care*, *174*, 427-436. doi: 10.1080/0300443032000153606

Gress-Smith, J. L., Luecken, L. J., Lemery-Chalfant, K., & Howe, R. (2012). Postpartum depression prevalence and impact on infant health, weight, and sleep in low-income and ethnic minority women and infants. *Maternal and Child Health Journal*, *16*, 887-893. doi: 10.1007/s10995-011-0812-y

Guyer, C., Huber, R., Fontijn, J., Bucher, H. U., Nicolai, H., Werner, H., ... & Jenni, O. G. (2015). Very preterm infants show earlier emergence of 24-hour sleep–wake rhythms compared to term infants. *Early Human Development*, *91*, 37-42. doi: 10.1016/j.earlhumdev.2014.11.002

Hanft, A., Burnham, M., Goodlin-Jones, B., & Anders, T. F. (2006). Sleep Architecture in Infants of Substance-Abusing Mothers. *Infant Mental Health Journal*, *27*, 141-151. doi: 10.1002/imhj.20085

Harrison, Y. (2004). The relationship between daytime exposure to light and night-time sleep in 6–12-week-old infants. *Journal of Sleep Research*, *13*, 345-352. doi: 10.1111/j.1365-2869.2004.00435.x

Henderson, J. M., France, K. G., & Blampied, N. M. (2011). The consolidation of infants' nocturnal sleep across the first year of life. *Sleep Medicine Reviews*, *15*, 211-220. doi: 10.1016/j.smrv.2010.08.003

Hiscock, H., & Wake, M. (2001). Infant sleep problems and postnatal depression: a community-based study. *Pediatrics*, *107*, 1317-1322. doi: 10.1542/peds.107.6.1317

Hiscock, H., Scalzo, K., Canterford, L., & Wake, M. (2011). Sleep duration and body mass index in 0–7-year olds. *Archives of Disease in Childhood*, *96*, 735-739. doi: 10.1136/adc.2010.204925

Huang, X. N., Wang, H. S., Chang, J. J., Wang, L. H., Liu, X. C., Jiang, J. X., & An, L. (2016). Feeding methods, sleep arrangement, and infant sleep patterns: a Chinese population-based study. *World Journal of Pediatrics*, *12*, 66-75. doi: 10.1007/s12519-015-0012-8

Huang, Y. S., Paiva, T., Hsu, J. F., Kuo, M. C., & Guilleminault, C. (2014). Sleep and breathing in premature infants at 6 months post-natal age. *BMC Pediatrics*, *14*, 303. doi: 10.1186/s12887-014-0303-6

Hughes, A., Gallagher, S., & Hannigan, A. (2015). A cluster analysis of reported sleeping patterns of 9-Month old infants and the association with maternal health: results from a population based cohort study. *Maternal and Child Health Journal*, *19*, 1881-1889. doi: 10.1007/s10995-015-1701-6

Humphreys, J. S., Gringras, P., Blair, P. S., Scott, N., Henderson, J., Fleming, P. J., & Emond, A. M. (2013). Sleep patterns in children with autistic spectrum disorders: a prospective cohort study. *Archives of Disease in Childhood*, *99*, 114-118. doi: 10.1136/archdischild-2013-304083

Hysing, M., Harvey, A. G., Torgersen, L., Ystrom, E., Reichborn-Kjennerud, T., & Sivertsen, B. (2014). Trajectories and predictors of nocturnal awakenings and sleep duration in infants. *Journal of Developmental & Behavioral Pediatrics*, *35,* 309-316. doi: 10.1097/DBP.0000000000000064

Jansen, P. W., Saridjan, N. S., Hofman, A., Jaddoe, V. W., Verhulst, F. C., & Tiemeier, H. (2011). Does disturbed sleeping precede symptoms of anxiety or depression in toddlers? The generation R study. *Psychosomatic Medicine*, *73*, 242-249. doi: 10.1097/PSY.0b013e31820a4abb

Jenni, O. G., Fuhrer, H. Z., Iglowstein, I., Molinari, L., & Largo, R. H. (2005). A longitudinal study of bed sharing and sleep problems among Swiss children in the first 10 years of life. *Pediatrics*, *115*, 233-240. doi: 10.1542/peds.2004-0815E

Johnson, N., McMahon, C., & Gibson, F. (2014). Assisted conception, maternal personality and parenting: Associations with toddler sleep behaviour. *Journal of Paediatrics and Child Health*, *50*, 732-738. doi: 10.1111/jpc.12654

Kaley, F., Reid, V., & Flynn, E. (2012). Investigating the biographic, social and temperamental correlates of young infants' sleeping, crying and feeding routines. *Infant Behavior and Development*, *35*, 596-605. doi: 10.1016/j.infbeh.2012.03.004

Karraker, K. H., & Young, M. (2007). Night waking in 6-month-old infants and maternal depressive symptoms. *Journal of Applied Developmental Psychology*, *28*, 493-498. doi: 10.1016/j.appdev.2007.06.002

Kirjavainen, J., Kirjavainen, T., Huhtala, V., Lehtonen, L., Korvenranta, H., & Kero, P. (2001). Infants with colic have a normal sleep structure at 2 and 7 months of age. *The Journal of Pediatrics*, *138*, 218-223. doi: 10.1067/mpd.2001.110326

Klingenberg, L., Christensen, L. B., Hjorth, M. F., Zangenberg, S., Chaput, J. P., Sjödin, A., ... & Michaelsen, K. F. (2013). No relation between sleep duration and adiposity indicators in 9–36 months old children: the SKOT cohort. *Pediatric Obesity*, *8*, e14-18. doi: 10.1111/j.2047-6310.2012.00109.x

Konrad, C., Herbert, J. S., Schneider, S., & Seehagen, S. (2016). The relationship between prior night's sleep and measures of infant imitation. *Developmental Psychobiology*, *58*, 450-461. doi: 10.1002/dev.21387

Korte, J., Hoehn, T., & Siegmund, R. (2004). Actigraphic recordings of activity-rest rhythms of neonates born by different delivery modes. *Chronobiology International*, *21*, 95-106. doi: 10.1081/CBI-120027980

Kozyrskyj, A. L., Kendall, G. E., Zubrick, S. R., Newnham, J. P., & Sly, P. D. (2009). Frequent nocturnal awakening in early life is associated with nonatopic asthma in children. *European Respiratory Journal*, *34*, 1288-1295. doi: 10.1183/09031936.00040509

Küpers, L. K., L'Abée, C., Bocca, G., Stolk, R. P., Sauer, P. J., & Corpeleijn, E. (2015). Determinants of weight gain during the first two years of life—the GECKO Drenthe birth cohort. *PloS One*, *10*, e0133326. doi: 10.1371/journal.pone.0133326

Lampl, M., & Johnson, M. L. (2011). Infant growth in length follows prolonged sleep and increased naps. *Sleep*, *34*, 641-650. doi: 10.1093/sleep/34.5.641

Landau, R., Sadeh, A., Vassoly, P., Berger, A., Atzaba-Poria, N., & Auerbach, J. G. (2010). Sleep patterns of 7-week-old infants at familial risk for attention deficit hyperactivity disorder. *Infant Mental Health Journal*, *31*, 630-646. doi: 10.1002/imhj.20275

Larson, M. C., White, B. P., Cochran, A., Donzella, B., & Gunnar, M. (1998). Dampening of the cortisol response to handling at 3 months in human infants and its relation to sleep, circadian cortisol activity, and behavioral distress. *Developmental Psychobiology*, *33*, 327-337. doi: 10.1002/(SICI)1098-2302(199812)33:4<327::AID-DEV4>3.0.CO;2-S

Lee, K. (2000). Crying and behavior pattern in breast-and formula-fed infants. *Early Human Development*, *58*, 133-140. doi: 10.1016/S0378-3782(00)00071-2

Lehnkering, H., Korte, J., & Siegmund, R. (2009). Activity-rest rhythm of term-born neonates exposed to nicotine during pregnancy. *Biological Rhythm Research*, *40*, 145-151. doi: 10.1080/09291010802379204

Loutzenhiser, L., McAuslan, P., & Sharpe, D. P. (2015). The trajectory of maternal and paternal fatigue and factors associated with fatigue across the transition to parenthood. *Clinical Psychologist*, *19*, 15-27. doi: 10.1111/cp.12048

Lucas-Thompson, R., Goldberg, W. A., Germo, G. R., Keller, M. A., Davis, E. P., & Sandman, C. A. (2009). Sleep arrangements and night waking at 6 and 12 months in relation to infants'

stress-induced cortisol responses. *Infant and Child Development*, *18*, 521-544. doi: 10.1002/icd.636

Lukowski, A. F., & Milojevich, H. M. (2013). Sleeping like a baby: Examining relations between habitual infant sleep, recall memory, and generalization across cues at 10 months. *Infant Behavior and Development*, *36*, 369-376. doi: 10.1016/j.infbeh.2013.02.001

Lukowski, A. F., Liu, X., Peirano, P., Odio, M., & Bauer, P. J. (2015). Disposable diaper use promotes consolidated nighttime sleep and positive mother-infant interactions in Chinese 6-month-olds. *Journal of Family Psychology*, *29*, 371-381. doi: 10.1037/fam0000072

Mao, A., Burnham, M. M., Goodlin-Jones, B. L., Gaylor, E. E., & Anders, T. F. (2004). A comparison of the sleep–wake patterns of cosleeping and solitary-sleeping infants. *Child Psychiatry & Human Development*, *35*, 95-105. doi: 10.1007/s10578-004-1879-0

Mao, Q., Zhu, L. X., & Su, X. Y. (2011). A comparison of postnatal depression and related factors between Chinese new mothers and fathers. *Journal of Clinical Nursing*, *20*, 645-652. doi: 10.1111/j.1365-2702.2010.03542.x

McDaniel, B. T., & Teti, D. M. (2012). Coparenting quality during the first three months after birth: the role of infant sleep quality. *Journal of Family Psychology*, *26*, 886-895. doi: 10.1037/a0030707

McGeorge, K., Milne, L., Cotton, L., & Whelan, T. (2015). Effects of infant and maternal sensory processing on infant fussing, crying, and sleep. *Infant Mental Health Journal*, *36*, 275-286. doi: 10.1002/imhj.21510

McKay, S. M., & Angulo-Barroso, R. M. (2006). Longitudinal assessment of leg motor activity and sleep patterns in infants with and without Down syndrome. *Infant Behavior and Development*, *29*, 153-168. doi: 10.1016/j.infbeh.2005.09.004

Mindell, J. A., & Lee, C. (2015). Sleep, mood, and development in infants. *Infant Behavior and Development*, *41*, 102-107. doi: 10.1016/j.infbeh.2015.08.004

Mindell, J. A., Du Mond, C., Tanenbaum, J. B., & Gunn, E. (2012). Long-term relationship between breastfeeding and sleep. *Children's Health Care*, *41*, 190-203. doi: 10.1080/02739615.2012.685038

Mindell, J. A., Meltzer, L. J., Carskadon, M. A., & Chervin, R. D. (2009). Developmental aspects of sleep hygiene: findings from the 2004 National Sleep Foundation Sleep in America Poll. *Sleep Medicine*, *10*, 771-779. doi: 10.1016/j.sleep.2008.07.016

Mindell, J. A., Sadeh, A., Wiegand, B., How, T. H., & Goh, D. Y. (2010). Cross-cultural differences in infant and toddler sleep. *Sleep Medicine*, *11*, 274-280. doi: 10.1016/j.sleep.2009.04.012

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & Prisma Group. (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Medicine*, *6*, e1000097. doi: 10.1371/journal.pmed.1000097

Möllborg, P., Wennergren, G., Norvenius, S. G., & Alm, B. (2011). Bed-sharing among six-month-old infants in western Sweden. *Acta Paediatrica*, *100*, 226-230. doi: 10.1111/j.1651-2227.2010.02008.x

Morgan, J. B., Lucas, A., & Fewtrell, M. S. (2004). Does weaning influence growth and health up to 18 months?. *Archives of Disease in Childhood, 89*, 728-733. doi: 10.1136/adc.2003.036137

Morrell, J., & Steele, H. (2003). The role of attachment *security*, temperament, maternal perception, and care-giving behavior in persistent infant sleeping problems. *Infant Mental Health Journal*, *24*, 447-468. doi: 10.1002/imhj.10072

Nevarez, M. D., Rifas-Shiman, S. L., Kleinman, K. P., Gillman, M. W., & Taveras, E. M. (2010). Associations of early life risk factors with infant sleep duration. *Academic Pediatrics*, *10,* 187-193. doi: 10.1016/j.acap.2010.01.007

Novosad, C., Freudigman, K., & Thoman, E. B. (1999). Sleep patterns in newborns and temperament at eight months: a preliminary study. *Journal of Developmental & Behavioral Pediatrics*, *20*, 99-105. doi: 10.1097/00004703-199904000-00005

O'Connor, T. G., Caprariello, P., Blackmore, E. R., Gregory, A. M., Glover, V., Fleming, P., & ALSPAC Study Team. (2007). Prenatal mood disturbance predicts sleep problems in infancy and toddlerhood. *Early Human Development*, *83*, 451-458. doi: 10.1016/j.earlhumdev.2006.08.006

Odoi, A., Andrew, S., Wong, F. Y., Yiallourou, S. R., & Horne, R. S. (2014). Pacifier use does not alter sleep and spontaneous arousal patterns in healthy term-born infants. *Acta Paediatrica*, *103*, 1244-1250. doi: 10.1111/apa.12790

Orsi, K. C. S. C., Llaguno, N. S., Avelar, A. F. M., Tsunemi, M. H., Pedreira, M. D. L. G., Sato, M. H., & Pinheiro, E. M. (2015). Effect of reducing sensory and environmental stimuli during hospitalized premature infant sleep. *Revista da Escola de Enfermagem da USP*, *49*, 0550-0555. doi: 10.1590/S0080-623420150000400003

Palmstierna, P., Sepa, A., & Ludvigsson, J. (2008). Parent perceptions of child sleep: a study of 10 000 Swedish children. *Acta Paediatrica*, *97*, 1631-1639. doi: 10.1111/j.1651-2227.2008.00967.x

Pellegrini-Belinchón, J., Miguel-Miguel, G., De Dios-Martin, B., Vicente-Galindo, E., Lorente-Toledano, F., & Garcia-Marcos, L. (2012). Study of wheezing and its risk factors in the first year of life in the Province of Salamanca, Spain. The EISL Study. *Allergologia et Immunopathologia*, *40*, 164-171. doi: 10.1016/j.aller.2011.03.014

Pennestri, M. H., Moss, E., O'Donnell, K., Lecompte, V., Bouvette-Turcot, A. A., Atkinson, L., ... & Gaudreau, H. (2015). Establishment and consolidation of the sleep-wake cycle as a function of attachment pattern. *Attachment & Human Development*, *17*, 23-42. doi: 10.1080/14616734.2014.953963

Philbrook, L. E., & Teti, D. M. (2016). Bidirectional associations between bedtime parenting and infant sleep: Parenting quality, parenting practices, and their interaction. *Journal of Family Psychology*, *30*, 431. doi: 10.1037/fam0000198

Piteo, A. M., Roberts, R. M., Nettelbeck, T., Burns, N., Lushington, K., Martin, A. J., & Kennedy, J. D. (2013). Postnatal depression mediates the relationship between infant and maternal sleep disruption and family dysfunction. *Early Human Development*, *89*, 69-74. doi: 10.1016/j.earlhumdev.2012.07.017

Quillin, S. I. (1997). Infant and mother sleep patterns during 4th postpartum week. *Issues in Comprehensive Pediatric Nursing*, *20*, 115-123. doi: 10.3109/01460869709026882

Quillin, S. I., & Glenn, L. L. (2004). Interaction between feeding method and co-sleeping on maternal-newborn sleep. *Journal of Obstetric, Gynecologic, & Neonatal Nursing*, *33*, 580-588. doi: 10.1177/0884217504269013

Ramamurthy, M. B., Sekartini, R., Ruangdaraganon, N., Huynh, D. H. T., Sadeh, A., & Mindell, J. A. (2012). Effect of current breastfeeding on sleep patterns in infants from Asia-Pacific region. *Journal of Paediatrics and Child Health*, *48*, 669-674. doi: 10.1111/j.1440-1754.2012.02453.x

Sadeh, A., De Marcas, G., Guri, Y., Berger, A., Tikotzky, L., & Bar-Haim, Y. (2015). Infant sleep predicts attention regulation and behavior problems at 3–4 years of age. *Developmental Neuropsychology, 40*, 122-137. doi: 10.1080/87565641.2014.973498

Sadeh, A., Tikotzky, L., & Scher, A. (2010). Parenting and infant sleep. *Sleep Medicine Reviews*, *14*, 89-96. doi: 10.1016/j.smrv.2009.05.003

Saenz, J., Yaugher, A., & Alexander, G. M. (2015). Sleep in infancy predicts gender specific social-emotional problems in toddlers. *Frontiers in Pediatrics*, *3*, 1-6. doi: 10.3389/fped.2015.00042

Santos, I. S., Matijasevich, A., & Domingues, M. R. (2012). Maternal caffeine consumption and infant nighttime waking: prospective cohort study. *Pediatrics*, *129*, 860-868. doi: 10.1542/peds.2011-1773

Santos, I. S., Mota, D. M., & Matijasevich, A. (2008). Epidemiology of co-sleeping and nighttime waking at 12 months in a birth cohort. *Jornal de Pediatria, 84*, 114-122. doi: 10.1590/S0021-75572008000200005

Scher, A. (2001a). Attachment and sleep: A study of night waking in 12-month-old infants. *Developmental Psychobiology*, *38*, 274-285. doi: 10.1002/dev.1020

Scher, A. (2001b). Mother–child interaction and sleep regulation in one-year-olds. *Infant Mental Health Journal*, *22*, 515-528. doi: 10.1002/imhj.1015

Scher, A. (2005a). Crawling in and out of sleep. *Infant and Child Development*, *14*, 491-500. doi: 10.1002/icd.427

Scher, A. (2005b). Infant sleep at 10 months of age as a window to cognitive development. *Early Human Development*, *81*, 289-292. doi: 10.1016/j.earlhumdev.2004.07.005

Scher, A. (2008). Maternal separation anxiety as a regulator of infants' sleep. *Journal of Child Psychology and Psychiatry*, *49*, 618-625. doi: 10.1111/j.1469-7610.2007.01872.x

Scher, A., & Blumberg, O. (1999). Night waking among 1-year olds: a study of maternal separation anxiety. *Child: Care, Health and Development*, *25*, 323-334. doi: 10.1046/j.1365-2214.1999.00099.x

Scher, A., & Cohen, D. (2005). Locomotion and nightwaking. *Child: Care, Health and Development*, *31*, 685-691. doi: 10.1111/j.1365-2214.2005.00557.x

Scher, A., & Cohen, D. (2015). V. Sleep as a Mirror of Developmental Transitions in Infancy: The Case of Crawling. *Monographs of the Society for Research in Child Development*, *80*, 70-88. doi: 10.1111/mono.12145

Scher, A., Tirosh, E., & Lavie, P. (1998). The relationship between sleep and temperament revisited: evidence for 12-month-olds: a research note. *The Journal of Child Psychology and Psychiatry and Allied Disciplines*, *39*(5), 785-788.

Schwichtenberg, A. J. M., & Poehlmann, J. (2008). A transactional model of sleep–wake regulation in infants born preterm or low birthweight. *Journal of Pediatric Psychology*, *34*, 837-849. doi: 10.1093/jpepsy/jsn132

Schwichtenberg, A. J., Anders, T. F., Vollbrecht, M., & Poehlmann, J. (2011). Daytime sleep and parenting interactions in infants born preterm. *Journal of Developmental & Behavioral Pediatrics*, *32*, 8-17. doi: 10.1097/DBP.0b013e3181fa57e4

Schwichtenberg, A. J., Shah, P. E., & Poehlmann, J. (2013). Sleep and attachment in preterm infants. *Infant Mental Health Journal*, *34*, 37-46. doi: 10.1002/imhj.21374

Scott, N., Blair, P. S., Emond, A. M., Fleming, P. J., Humphreys, J. S., Henderson, J., & Gringras, P. (2013). Sleep patterns in children with ADHD: a population-based cohort study from birth to 11 years. *Journal of Sleep Research*, *22*, 121-128. doi: 10.1111/j.1365-2869.2012.01054.x

Sharkey, K. M., Iko, I. N., Machan, J. T., Thompson-Westra, J., & Pearlstein, T. B. (2016). Infant sleep and feeding patterns are associated with maternal sleep, stress, and depressed mood in women with a history of major depressive disorder (MDD). *Archives of Women's Mental Health*, *19*, 209-218. doi: 10.1007/s00737-015-0557-5

Shibagaki, M., Sawata, T., & Tachibana, T. (2004). Relation between polysomnographic measures during nocturnal sleep and a quotient of behavioral development in infants with developmental disabilities. *Perceptual and Motor Skills*, *99*, 429-434. doi: 10.2466/pms.99.2.429-434

Shinohara, H., & Kodama, H. (2011). Relationship between circadian salivary melatonin levels and sleep–wake behavior in infants. *Pediatrics International*, *53*, 29-35. doi: 10.1111/j.1442-200X.2010.03186.x

Sinai, D., & Tikotzky, L. (2012). Infant sleep, parental sleep and parenting stress in families of mothers on maternity leave and in families of working mothers. *Infant Behavior and Development*, *35*, 179-186. doi: 10.1016/j.infbeh.2012.01.006

So, K., Adamson, T. M., & Horne, R. S. (2007). The use of actigraphy for assessment of the development of sleep/wake patterns in infants during the first 12 months of life. *Journal of Sleep Research*, *16*, 181-187. doi: 10.1111/j.1365-2869.2007.00582.x

Sorondo, B. M., & Reeb-Sutherland, B. C. (2015). Associations between infant temperament, maternal stress, and infants' sleep across the first year of life. *Infant Behavior and Development*, *39*, 131-135. doi: 10.1016/j.infbeh.2015.02.010

Spruyt, K., Aitken, R. J., So, K., Charlton, M., Adamson, T. M., & Horne, R. S. (2008). Relationship between sleep/wake patterns, temperament and overall development in term infants over the first year of life. *Early Human Development*, *84*, 289-296. doi: 10.1016/j.earlhumdev.2007.07.002

St James-Roberts, I., & Peachey, E. (2011). Distinguishing infant prolonged crying from sleep-waking problems. *Archives of Disease in Childhood, 96,* 340-344. doi: 10.1136/adc.2010.200204

St James-Roberts, I., Conroy, S., & Hurry, J. (1997). Links between infant crying and sleep-waking at six weeks of age. *Early Human Development*, *48*, 143-152. doi: 10.1016/S0378-3782(96)01845-2

Telliez, F., Bach, V., Leke, A., Chardon, K., & Libert, J. P. (2002). Feeding behavior in neonates whose diet contained medium-chain triacylglycerols: short-term effects on thermoregulation and sleep. *The American Journal of Clinical Nutrition*, *76*(5), 1091-1095.

Thomas, K. A. (2000). Differential Effects of Breast-and Formula-Feeding on Preterm Infants' Sleep-Wake Patterns. *Journal of Obstetric, Gynecologic, & Neonatal Nursing*, *29*, 145-152. doi: 10.1111/j.1552-6909.2000.tb02034.x

Thomas, K. A., & Foreman, S. W. (2005). Infant sleep and feeding pattern: Effects on maternal sleep. *Journal of Midwifery & Women's Health*, *50*, 399-404. doi: 10.1016/j.jmwh.2005.04.010

Thomas, K. A., & Spieker, S. (2016). Sleep, depression, and fatigue in late postpartum. *MCN. The American Journal of Maternal Child Nursing*, *41*, 104-109. doi: 10.1097/NMC.0000000000000213

Tikotzky, L., & Sadeh, A. (2009). Maternal sleep-related cognitions and infant sleep: A longitudinal study from pregnancy through the 1st Year. *Child Development*, *80*, 860-874. doi: 10.1111/j.1467-8624.2009.01302.x

Tikotzky, L., & Sadeh, A. (2010). The role of cognitive–behavioral therapy in behavioral childhood insomnia. *Sleep Medicine*, *11*, 686-691. doi: 10.1016/j.sleep.2009.11.017

Tikotzky, L., & Shaashua, L. (2012). Infant sleep and early parental sleep-related cognitions predict sleep in pre-school children. *Sleep Medicine*, *13*, 185-192. doi: 10.1016/j.sleep.2011.07.013

Tikotzky, L., De Marcas, G., Har-Toov, J., Dollberg, S., Bar-Haim, Y., & Sadeh, A. (2010). Sleep and physical growth in infants during the first 6 months. *Journal of Sleep Research*, *19*, 103-110. doi: 10.1111/j.1365-2869.2009.00772.x

Tikotzky, L., Sadeh, A., & Glickman-Gavrieli, T. (2010). Infant sleep and paternal involvement in infant caregiving during the first 6 months of life. *Journal of Pediatric Psychology*, *36*, 36-46. doi: 10.1093/jpepsy/jsq036

Tikotzky, L., Sadeh, A., Volkovich, E., Manber, R., Meiri, G., & Shahar, G. (2015). VII. Infant sleep development from 3 to 6 months postpartum: Links with maternal sleep and paternal involvement. *Monographs of the Society for Research in Child Development*, *80*, 107-124. doi: 10.1111/mono.12147

Tomalski, P., Moore, D. G., Ribeiro, H., Axelsson, E. L., Murphy, E., Karmiloff-Smith, A., ... & Kushnerenko, E. (2013). Socioeconomic status and functional brain development–associations in early infancy. *Developmental Science*, *16*, 676-687. doi: 10.1111/desc.12079

Touchette, E., Dionne, G., Forget-Dubois, N., Petit, D., Pérusse, D., Falissard, B., ... & Montplaisir, J. Y. (2013). Genetic and environmental influences on daytime and nighttime sleep duration in early childhood. *Pediatrics*, *131*, e1874-e1880. doi: 10.1542/peds.2012-2284

Touchette, É., Petit, D., Paquet, J., Boivin, M., Japel, C., Tremblay, R. E., & Montplaisir, J. Y. (2005). Factors associated with fragmented sleep at night across early childhood. *Archives of Pediatrics & Adolescent Medicine*, *159*, 242-249. doi: 10.1001/archpedi.159.3.242

Tourula, M., Isola, A., Hassi, J., Bloigu, R., & Rintamäki, H. (2010). Infants sleeping outdoors in a northern winter climate: skin temperature and duration of sleep. *Acta Paediatrica*, *99*, 1411-1417. doi: 10.1111/j.1651-2227.2010.01814.x

Utkun, E., Öndoğan, Z., Yalaz, M., & Yıldırım Sözmen, E. (2015). The effect of different types of fabric on the clothing comfort, sleep pattern and saliva cortisol & melatonin levels of infants. *Journal of Textile Apparel*, *25*, 119-124.

Vijakkhana, N., Wilaisakditipakorn, T., Ruedeekhajorn, K., Pruksananonda, C., & Chonchaiya, W. (2015). Evening media exposure reduces night-time sleep. *Acta Paediatrica*, *104*, 306-312. doi: 10.1111/apa.12904

Volkovich, E., Ben-Zion, H., Karny, D., Meiri, G., & Tikotzky, L. (2015). Sleep patterns of co-sleeping and solitary sleeping infants and mothers: a longitudinal study. *Sleep Medicine*, *16*, 1305-1312. doi: 10.1016/j.sleep.2015.08.016

Warren, S. L., Howe, G., Simmens, S. J., & Dahl, R. E. (2006). Maternal depressive symptoms and child sleep: Models of mutual influence over time. *Development and Psychopathology*, *18*(1), 1-16. doi: 10.1017/S0954579406060019

Weinraub, M., Bender, R. H., Friedman, S. L., Susman, E. J., Knoke, B., Bradley, R., ... & Williams, J. (2012). Patterns of developmental change in infants' nighttime sleep awakenings from 6 through 36 months of age. *Developmental Psychology*, *48*, 1511-1528. doi: 10.1037/a0027680

White, B. P., Gunnar, M. R., Larson, M. C., Donzella, B., & Barr, R. G. (2000). Behavioral and physiological responsivity, sleep, and patterns of daily cortisol production in infants with and without colic. *Child Development*, *71*, 862-877. doi: 10.1111/1467-8624.00196

Wolke, D., Söhne, B., Riegel, K., Ohrt, B., & Österlund, K. (1998). An epidemiologic longitudinal study of sleeping problems and feeding experience of preterm and term children in southern Finland: comparison with a southern German population sample. *The Journal of Pediatrics*, *133*, 224-231. doi: 10.1016/S0022-3476(98)70224-0

Zaidman-Zait, A., & Hall, W. A. (2015). Children's night waking among toddlers: relationships with mothers' and fathers' parenting approaches and children's behavioural difficulties. *Journal of Advanced Nursing*, *71*, 1639-1649. doi: 10.1111/jan.12636

Zentall, S. R., Braungart-Rieker, J. M., Ekas, N. V., & Lickenbrock, D. M. (2012). Longitudinal assessment of sleep–wake regulation and attachment security with parents. *Infant and Child Development*, *21*, 443-457. doi: 10.1002/icd.175

PAPER III

THE INFANT BEHAVIOR QUESTIONNAIRE – REVISED FROM TWO WEEKS TO 12 MONTHS OF INFANT'S LIFE[3]

Dias, C.C., Costa, R., Pinto, T. M., & Figueiredo, B. (under review). The Infant Behavior Questionnaire – Revised from two weeks to 12 months of infant's life. *Early Human Development*

[3] This manuscript is under review at the Early Human Development

Abstract

Background: Temperament characteristics are a key element for understand infant's developmental trajectory. The Infant Behavior Questionnaire – Revised (IBQ-R) is one of the most widely used measures to assess infants' temperament. However, it was used to assess temperament in infants aged between 3 and 12 months old. The reliability and factor structure of the IBQ-R have not yet been examined in infants younger than 3 months.

Aims: The present study aims to analyze (1) the reliability of the IBQ-R at 2 weeks and (2) the IBQ-R factor structure from 2 weeks to 12 months of the infant's life.

Study design: Longitudinal study.

Subjects: Three hundred mothers completed the IBQ-R when the infants were 2 weeks, and at 3months(m), 6m and 12m.

Outcome measures: Infant temperament.

Results: Adequate reliability was found for the IBQ-R at 2 weeks and the same factor structure was found at 2 weeks, and at 3m, 6m, and 12m.

Conclusions: The findings of this study suggested that the IBQ-R is a reliable measure to be applied since the first weeks of life, and that the IBQ-R factor structure remains stable when applied in different ages throughout infancy.

Keywords: Infant Behavior Questionnaire – Revised; temperament; infancy; reliability; factor structure.

Introduction

Temperament is defined as the behavioral expression of the individual's reactivity to the environment [1]. Although temperament is biologically driven, its behavioral expression is shaped by the exposure to specific environmental experiences [2,3,4,5]. Temperament traits result from the complex and dynamic interplay between genetic, biological and environmental factors across development [6]. However, stability in temperament traits over the life span has been reported in the literature [7,8,9].

It is far known that temperament is already present at birth, and recent evidence shows the emergence of temperament characteristics even during the prenatal period [10,11,12]. These characteristics might be identified at birth by parents and are key elements for infant's developmental trajectory and for the emergence of further problems during childhood [13,14,15]. Still, so far there are no available report measures for infant's temperament in the first weeks of life. Currently, researchers have been relying on psychophysiological indices and observational measures to assess the fetus's and the infant's temperament [11]. Developing user friendly and cost-effective measures of temperament in the first weeks of life is crucial for both practice and research [16]. Parent-report measures to assess infant's temperament comprise advantages due to, among others, their cost-effectiveness and application readiness [17], and, mainly, due to the fact they may be used to increase parents' awareness regarding their infant's individual characteristics.

The Infant Behavior Questionnaire – Revised (IBQ-R)[4] [18] is one of the most widely used parent-report measures of infant's temperament [19]. It relies on the report of the observable behaviors of the infant in response to different daily environmental stimuli across several contexts. It is a revised version of the IBQ that has been firstly developed in 1981 [4]. The IBQ-R assesses 14 scales of the infant's temperament between 3 and 12 months old: activity level, approach, cuddliness, distress to limitations, duration of orienting, falling and reactivity, fear, high intensity pleasure, low intensity pleasure, perceptual sensitivity, sadness, smiling and laughter, soothability, and vocal reactivity. These 14 scales are grouped in 3 dimensions: (1) surgency/extraversion: comprised of the mean scores of approach, vocal reactivity, high intensity pleasure, smiling and laughter, activity level and perceptual sensitivity scales; (2) negative affectivity: comprised of the mean scores of distress to limitations, falling reactivity, fear and sadness scales; and (3) orienting regulation: comprised of the mean scores of low-intensity pleasure, cuddliness, duration of orienting and soothability scales. It is widely used in both boys and girls and few sex differences have been reported [20,21,22].

[4] IBQ-R, Infant Behavior Questionnaire - Revised

The IBQ-R has globally shown validity and reliability in different cultural backgrounds [23,24,25], for example in Portugal [26]. The IBQ-R Portuguese version comprises a 3-factor structure slightly different from the original factor structure, even though similar to a previous structure obtained in a combined US-Russian sample [27]: the (1) high-intensity pleasure scale was excluded from the surgency/extraversion dimension; (2) negative affectivity dimension maintained the same scales of the original structure; and (3) cuddliness scale was excluded from the orienting regulation dimension [26].

Since this questionnaire relies on parental reports of the infant's behavioral manifestations of temperament in daily situations, when applying this questionnaire to younger children concerns arise, mainly due to their overall immaturity, that constraints the ability to provide those behavioral manifestations while across the first year of life those abilities significantly increase [16]. These constraints increase the proportion of "*non-applicable*" responses in parental reports of 3-month-old infants' temperament, compared to 6-month-old infants [16], which are especially high on approach, perceptual sensitivity, duration of orientation and high-intensity pleasure scales, suggesting that behavioral manifestations of temperament assessed in those scales are the most dependent upon infant's development [16].

The IBQ already showed its utility assessing temperament characteristics in infants aged 2 weeks [28], although the psychometric characteristics of the IBQ-R have not yet been tested in infants younger than 3 months. The present study aims to analyze (1) the reliability of the IBQ-R at 2 weeks and (2) the IBQ-R factor structure from 2 weeks to 12 months. To test the reliability and factor structure of the IQB-R to measure temperament in younger infants may be a major advance to temperament research [16].

Methods

Participants

The sample was comprised of 300 infants aged between 2 weeks and 12 months old. The majority of the mothers were white (92.2%), married or cohabiting (83.2%), and employed (78.7%). More than half were aged between 26 and 34 years old (66.1%) and had more than 12 years of schooling (61.3%). The majority of the infants were born with birth length ≥ 48 cm (81.2%), were not resuscitated (91.1%), and were first born (84.6%), and their primary caregiver at 2 weeks was the mother (98.0%). More than a half born by vaginal delivery (64.7%) and a half were males (53.9%; see Table 10). All infants were born with normal birth weight (*M* = 3272.82g, *SD* = 365.66), and at term (*M* = 39.15 gestational weeks, *SD* = 1.10).

Table 10.
Socio-demographic characteristics

			Total
			N = 300
			%
Mother	Age	18-24	11.9
		25-34	66.1
		35-44	22.0
	Ethnicity	White	92.2
		Other	7.8
	Marital status	Married/cohabiting	83.2
		Single/divorced/widow	16.8
	Occupational status	Employed	78.7
		Unemployed/Household/student	21.3
	Years of schooling	≤ 12	38.7
		>12	61.3
Gestation	Resuscitation at birth	No	91.1
		Yes	8.9
	Type of delivery	Vaginal	64.7
		Caesarean	35.3
Infant	Gender	Female	46.1
		Male	53.9
	Length	< 48 cm	18.8
		≥ 48 cm	81.2
	First born	Yes	84.6
		No	15.4
	Primary caregiver at 2 weeks	Mother	98.0
		Other	2.0

Procedures

This study comprised a longitudinal design with 4 assessment waves over the first year of infant's life: 2 weeks, 3, 6, and 12 months. The Ethical Commissions of the institutions involved approved the research protocol. At the third trimester of pregnancy, 536 women who met the inclusion criteria were contacted at two public hospitals in the Northern Portugal, informed about the study purposes and procedures and invited to participate. Women who were not able to read or write Portuguese, who had multiple gestations, and who had gestational complications were excluded. From the eligible women, 485 (90.5%) agreed to participate and signed an informed consent. At childbirth preterm infants (<37 gestational weeks) and infants with low birth weight (<2500g) were excluded (n = 15; 3.0%). 470 women were contacted again by email at 2 weeks (2w), and at 3 (3m), 6 (6m) and 12 months (12m) postpartum

to complete the IBQ-R on-line. 203 completed the IBQ-R at 2w, 233 at 3m, 191 at 6m, and 98 at 12m. The analyses included mothers who completed the IBQ-R at least once (N = 300). These mothers differed from those who were included in the analyses on parity, *Wald* = 7.45, β = -.98, 0R = .36, p = .006, with primiparous mothers being more likely to complete the IBQ-R at least once. No other differences on socio-demographic variables (maternal age, ethnicity, marital status, occupational status, type of delivery, infant's resuscitation at birth, infant's sex, and birth length) were found.

Measures

The Infant Behavior Questionnaire - Revised (IBQ-R). The IBQ-R [18,26] is comprised of 191 items, scored in a 7-point Likert-type scale (1 = never, 2 = very rarely, 3 = less than half the time, 4 = about half the time, 5 = more than half the time, 6 = almost always, 7 = always). The questionnaire also includes the option of "*non-applicable*" response, for the parents to use when they did not observe the infant in the described situation in the previous week/2w. The score of each scale was calculated through the sum of the items with applicable responses divided by the number of items with applicable responses, excluding the items with non-applicable responses. The scores for each scale range from 0 and 7, with high scores indicating higher levels on each temperament trait. The original version of the IBQ-R presented good internal consistency for surgency/extraversion (α = .92), negative affectivity (α = .91), and orienting regulation (α = .91) [18]. The Portuguese version of the IBQ-R has good internal consistency in all the scales (α's = .71-.93), and adequate to good internal consistency for surgency/extraversion (α = .80), negative affectivity (α = .60), and orienting regulation (α = .68) [26].

Data Analysis

To analyze (1) the reliability of the IBQ-R at 2w, the proportion of items with more than 75% of non-applicable responses within each dimension was calculated and analyses of internal consistency were performed. To analyze the internal consistency of the IBQ-R at 2w, 3m, 6m, and 12m analyses of Cronbach's alpha coefficient for the 3 dimensions, scale-dimension correlation, and mean scale correlation were performed. Following previous recommendations [29], Cronbach's alpha > .70, scale-dimension correlation > .30, and mean scale correlation > .15 were considered to indicate good internal consistency. Further Multivariate Analyses of Variance (MANOVA) were performed to analyze the effects of infant's sex on the IBQ-R sub-scales. The models included infant's sex as the independent variable and surgency/extraversion, negative affectivity and orienting regulation sub-scales at 2w, 3m, 6m, and 12m as dependent variables.

To analyze (2) the IBQ-R factor structure from 2w to 12m of infant's life, intercorrelations among the 3 dimensions of the IBQ-R at 2w, 3, 6, and 12 m were calculated using Pearson correlations and 3

longitudinal confirmatory factor analyses (maximum likelihood estimation) were performed – one for each IBQ-R dimension. Following previous recommendations [30,31] indices of different classes were examined to analyze the model goodness of fit, namely the chi square (χ^2) statistics, the ratio of χ^2 to degrees of freedom, the Comparative Fit Index (CFI), and the Root Mean Square Error of Approximation (RMSEA). Recommendations for a good model fit include a non-significant chi-square, a ratio of χ^2 to degrees of freedom of < 2/3, a CFI of .95 or higher and a RMSEA of < .06 to .08 with confidence interval [30,31].

Results

IBQ-R internal consistency

The proportion of items with more than 75% of non-applicable responses was calculated for each IBQ-R scale at 2w. Six of the scales present 0% of the items with more than 75% of non-applicable responses: activity level, cuddliness, falling and reactivity, perceptual sensitivity, fear, and sadness. Six of the scales present between 12.5 and 50% of the items with more than 75% of non-applicable response: distress to limitations (12.5% of the items), soothability (17% of the items), vocal reactivity (17% of the items), low intensity pleasure (23% of the items), smiling and laughter (30% of the items), and approach (50% of the items). Two scales present more than 50% of the items with more than 75% of non-applicable response: duration of orienting (58% of the items) and high intensity pleasure (55% of the items).

The Cronbach's alphas for the IBQ-R scales at 2w, 3m, 6m, and 12m were computed. The highest Cronbach's alphas were found at 6m, where the highest variability was also found (α's ranging between .63 and .74). The lowest Cronbach's alphas were found at 2w (α = .54 in orienting regulation dimension) and at 3m (α = .59 in surgency/extraversion dimension). At 12m, the Cronbach's alphas presented the lowest variability (α's ranging between .61 and .62). More than a half of the scales (64.3% at 2w; 83.3% at 3m, 6m, and 12m) presented a scale-dimension correlation over .30, and a mean scale correlation of within dimensions over .15 (see Table 11).

Table 11.

IBQ-R reliability at 2w, 3m, 6m, and 12m – Internal consistency, scale-dimension correlation and alpha if scale deleted

	2w			3m			6m			12m		
	SDC	MSC	α ISD	SDC	MSC	α ISD	SDC	MSC	α ISD	SDC	MSC	α ISD
Surgency/extraversion		α = 0.64			α = 0.59			α = 0.63			α = 0.61	
		0.394			0.290			0.389			0.387	
Vocal reactivity	0.446		0.56	0.512		0.45	0.584		0.47	0.638		0.43
Perceptual sensitivity	0.386		0.59	0.329		0.55	0.314		0.62	0.383		0.55
Approach	0.394		0.59	0.453		0.47	0.361		0.58	0.464		0.52
Activity level	0.260		0.64	0.048		0.66	0.242		0.64	0.046		0.71
Smiling and laughter	0.484		0.54	0.398		0.50	0.443		0.54	0.403		0.54
Negative affectivity		α = 0.62			α = 0.63			α = 0.74			α = 0.61	
		0.414			0.486			0.532			0.475	
Fear	0.173		0.73	0.242		0.77	0.378		0.76	0.404		0.67
Distress to limitations	0.518		0.47	0.575		0.57	0.642		0.61	0.532		0.59
Falling reactivity	0.427		0.52	0.498		0.61	0.491		0.69	0.393		0.67
Sadness	0.536		0.44	0.630		0.52	0.615		0.62	0.572		0.56
Orienting regulation		α = 0.54			α = 0.61			α = 0.69			α = 0.62	
		0.399			0.458			0.429			0.450	
Duration of orientation	0.411		0.39	0.495		0.47	0.458		0.46	0.455		0.51
Soothability	0.290		0.55	0.324		0.68	0.298		0.66	0.254		0.72
Low intensity pleasure	0.497		0.30	0.554		0.37	0.531		0.34	0.640		0.19

Notes: SDC: Scale Dimension Correlation; MSC: Mean Scale correlation; ISD: If Scale Deleted

Effects of infant's sex on IBQ-R dimensions

Non-significant multivariate effects of infant's sex were found on IBQ-R dimensions at 2w, 3m and 12m. Significant multivariate effects of infant's sex were found on IBQ-R dimensions at 6m, *Wilks' Lambda* = 0.94, $F(1,185) = 3.83$, $p = .011$, $p\eta^2 = 0.06$. Significant univariate effects were found on the orienting regulation dimension at 2w, $F(1,198) = 4.15$, $p = .004$, $p\eta^2 = 0.02$, and at 6m, $F(1,187) = 4.99$, $p = .027$, $p\eta^2 = 0.03$. Higher scores in the orienting regulation dimension were found for boys at 2w and for girls at 6m (see Table 12).

Table 12.

Effects of infant's sex on IBQ-R subscales at 2w, 3m, 6m, and 12m

	2w				3m				6m				12m			
	Total sample	*Boys*	*Girls*		*Total sample*	*Boys*	*Girls*		*Total sample*	*Boys*	*Girls*		*Total sample*	*Boys*	*Girls*	
	M (SD)	*M (SD)*	*M (SD)*	*F*	*M (SD)*	*M (SD)*	*M (SD)*	*F*	*M (SD)*	*M (SD)*	*M (SD)*	*F*	*M (SD)*	*M (SD)*	*M (SD)*	*F*
Surgency extraversion	3.10 (0.83)	3.14 (0.84)	3.06 (0.86)	0.48	3.93 (0.65)	3.96 (0.60)	3.89 (0.71)	0.71	4.65 (0.59)	4.68 (0.54)	4.63 (0.65)	0.34	5.09 (0.51)	5.10 (0.51)	5.07 (0.52)	0.11
Negative affectivity	2.86 (0.77)	2.83 (0.72)	2.89 (0.82)	0.38	2.70 (0.65)	2.69 (0.62)	2.72 (0.68)	0.16	2.75 (0.64)	2.72 (0.63)	2.79 (0.64)	0.65	2.99 (0.63)	2.96 (0.59)	3.02 (0.96)	0.21
Orienting regulation	4.39 (1.02)	4.53 (1.06)	4.24 (0.96)	4.15*[1]	4.68 (0.76)	4.67 (0.73)	4.69 (0.80)	0.01	4.92 (0.62)	4.82 (0.58)	5.02 (0.65)	4.99*[2]	4.79 (0.72)	4.70 (0.72)	4.87 (0.72)	1.25

Notes: *M*: Mean; *SD*: Standard Deviation; $^{*}p < .05$; [1]$p\eta^2 = 0.02$; [2]$p\eta^2 = 0.03$

Factor structure of the IBQ-R from 2w to 12m

Significant intercorrelations were found in more than half of the dimension correlations at 2 weeks, 3m, 6m, and 12m, *r* range = .18 - .62, *p*s < .05 (see Table 13).

Surgency/extraversion dimension. The same 5-factor structure was tested for the surgency/extraversion dimension at 2w, 3m, 6m, and 12m. Longitudinal confirmatory factor analysis for surgency/extraversion dimension revealed that the values for the $\chi 2/df$ and the RMSEA were adequate, although the CFI was below recommended, $\chi 2(152) = 241.27$, $p < .001$, $\chi 2/df = 1.59$, CFI = .89, and RMSEA = .04. The loadings of the surgency/extraversion scales on surgency/extraversion dimension at 2w, 3m, 6m, and 12m are shown in Figure 4. Significant factor loadings were found in almost all the scales at 2w, and 3m, and 12m. Non-significant factor loadings were found in activity level scale at 2w, 3m, and 12m. The model also showed that scores on the surgency/extraversion dimension in one age predicted scores on the following age: 2w-3m, $\beta = .60$, $p < .001$; 3m-6m, $\beta = .66$, $p < .001$; 6m-12m, $\beta = .69$, $p < .001$ (see Figure 4).

Considering that the activity level scale presented a scale-dimension correlation lower than .30 and non-significant factor loadings at 2w, 3m, and 6m, eventual improvements in the model were tested. Then, a 4-factor structure, removing activity level, was tested for the surgency/extraversion dimension. Results revealed that the values for the $\chi 2/df$ and the RMSEA were adequate, still the CFI remained below the recommended, $\chi^2(89) = 135.83$, $p = .001$, $\chi 2/df = 1.52$, CFI = .93, RMSEA = .04.

Table 13.

Correlations between the IBQ-R dimensions from 2w to 12m postpartum

		2w				3m			6m			12m	
		1	2	3	4	5	6	7	8	9	10	11	12
2w	1. surgency extraversion	1											
	2. negative affectivity	.19**	1										
	3. orienting regulation	.42***	-.06	1									
3m	4. surgency extraversion	.41***	-.01	.24***	.1								
	5. negative affectivity	.04	.46***	-.12	.08	1							
	6. orienting regulation	.26**	-.23**	.36***	.55***	-.26**	1						
6m	7. surgency extraversion	.35***	.07	.09	.51***	.07	.39***	1					
	8. negative affectivity	.07	.55***	-.16	-.01	.62***	-.30***	.13	1				
	9. orienting regulation	.18*	-.18*	.28**	.25**	-.12	.55***	.41***	-.24**	1			
12m	10. surgency extraversion	.12	.02	.03	.34**	-.15	.37***	.59***	-.02	.24*	1		
	11. negative affectivity	-.15	.22	-.05	-.11	.33**	-.21	-.10	.55***	-.22*	-.01	1	
	12. orienting regulation	.17	-.06	.18	.25*	-.03	.46***	.42***	-.06	.56***	.44***	-.17	1

Negative affectivity dimension. The same 4-factor structure was tested for the negative affectivity dimension at 2w, 3m, 6m, and 12m. Longitudinal confirmatory factor analysis for negative affectivity dimension revealed that the values for the $\chi 2/df$ and the RMSEA were adequate, although the CFI was below the recommended, $\chi 2(89) = 165.51$, $p < .001$, $\chi 2/df = 1.86$, CFI = .91, and RMSEA = .05. The loadings of the negative affectivity scales on negative affectivity dimension at 2w, 3m, 6m, 12m are shown in Figure 1. Significant factor loadings were found in all scales at 2w, 3m, 6m, 12m. The model also showed that scores on the negative affectivity dimension in one age predicted scores on the following age: 2w-3m, $\beta = .72$, $p < .001$; 3m-6m, $\beta = .82$, $p < .001$; 6m-12m, $\beta = .78$, $p < .001$ (see Figure 4).

Activity level scale presented a scale-dimension correlation lower than .30 and non-significant factor loadings at 2w, 3m, and 6m, in the surgency/extraversion dimension. Considering that activity level scale presented significant factor loadings at 2w, 3m, 6m, and 12m in the negative affectivity dimension (β ranging between .46 and .59, all p's < .001), a 5-factor structure, including activity level was also tested in this dimension. Results revealed that the values for the $\chi 2/df$ and the RMSEA were adequate, still the CFI was below recommended, $\chi^2(152) = 280.45$, $p < .001$, $\chi 2/df = 1.85$, CFI = .88, RMSEA = .05.

Orienting regulation dimension. The same 3-factor structure was tested for the orienting regulation dimension at 2w, 3m, 6m, and 12m. Longitudinal confirmatory factor analysis for orienting regulation dimension revealed that the values for the $\chi 2/df$ and the RMSEA were adequate, although the CFI was below the recommended, $\chi 2(42) = 67.90$, $p = .007$, $\chi 2/df = 1.62$, CFI = .94, RMSEA = .05. The loadings of the orienting regulation scales on orienting regulation dimension at 2w, 3m, 6m, and 12m are shown in Figure 1. Significant factor loadings were found in all the dimensions at 2w, 3m, 6m, and 12m. The model also showed that scores on orienting regulation dimension in one age predicted scores on the following age: 2w-3m, $\beta = .67$, $p < .001$; 3m-6m, $\beta = .80$, $p < .001$; 6m-12m, $\beta = .73$, $p < .001$ (see Figure 4).

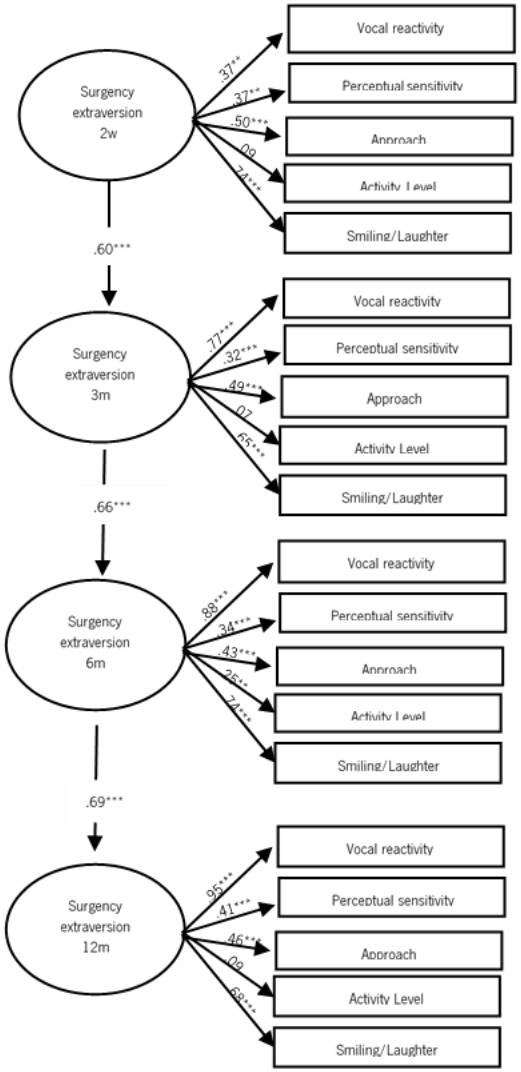


Figure 4a. Longitudinal Confirmatory Factor Analysis for Surgency/extraversion dimension

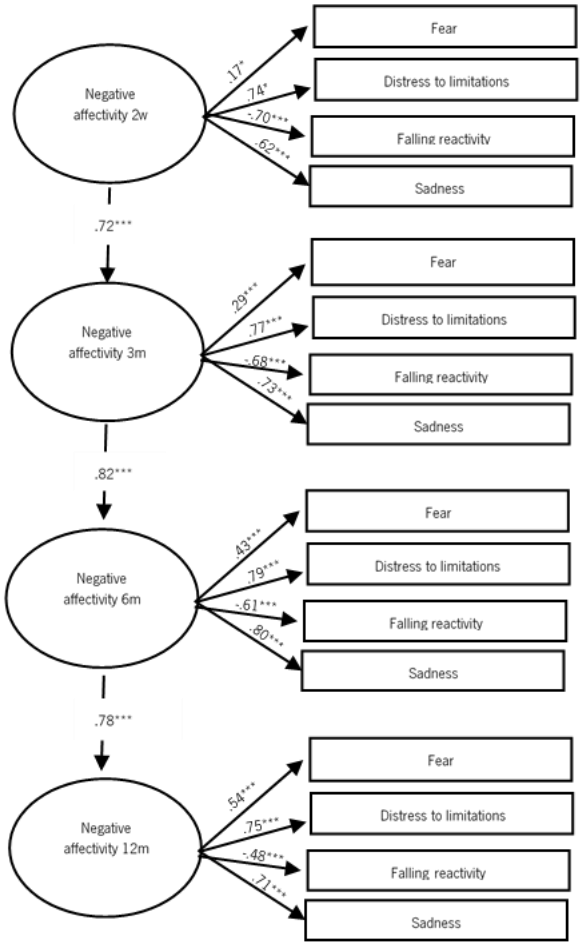


Figure 4b. Longitudinal Confirmatory Factor Analysis for Negative Affectivity dimension

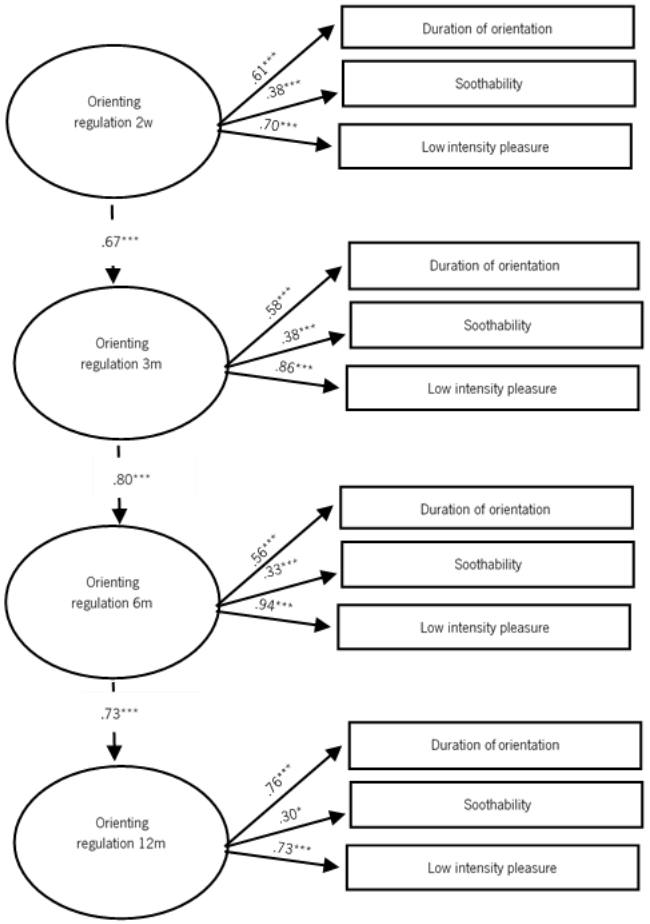


Figure 4c. Longitudinal Confirmatory Factor Analysis for Orienting Regulation dimension

Figure 4. Longitudinal Confirmatory Factor Analysis for the IBQ-R dimensions.

Discussion

The present study aimed to analyze (1) the reliability of the IBQ-R at 2w and (2) the IBQ-R factor structure from 2w to 12m of the infant's life. The findings of this study suggested that (1) the IBQ-R is a reliable measure to apply since the first weeks of the infant's life. At 2w, all the IBQ-R dimensions presented a mean-scale correlation above .15, and more than half of the scales presented a scale-dimension correlation higher than .30. The 3 dimensions presented a Cronbach's alpha at 2w close to the recommended cut-off [29]: surgency extraversion (α = .64), negative affectivity (α = .62), and orienting regulation (α = .63). At 3m, 6m, and 12m, the 3 dimensions also presented an acceptable Cronbach's alpha and similar to the Cronbach's alphas found in the IBQ-R dimensions between 3m and 12m in previous studies [26,32]. These results provide evidence that the IBQ-R is a reliable tool to apply at 2w, considering that the internal consistency of the instrument found at this age is similar to the internal consistency of the IBQ-R in the other ages. Additionally, the results from the present study also revealed few sex differences on IBQ-R dimensions at 2w. This result is in line with previous studies that found few sex differences in IBQ-R dimensions during the first year of the infant's life [20,21,22].

The findings of this study also suggested that (2) the IBQ-R dimensions are differently intercorrelated through the first 12 months of life, although the IBQ-R factor structure remains stable when applied in different ages during infancy. The results of the present study also revealed different intercorrelations between the IBQ-R dimensions over the first year, suggesting that the infant's temperament manifestations may not be always intercorrelated over infancy. This result is line with previous results with the IBQ-R scales in infants aged between 3m and 12m [18,21], and may suggest that the IBQ-R dimensions are not always dependent, and that this independency seems to present differences over the first year. In line with the Portuguese version of the IBQ-R [26], the same factor structure was found for the IBQ-R dimensions from 2w to 12m. Longitudinal confirmatory factor analyses revealed an overall adequate model fit for the IBQ-R dimensions from 2w to 12m, suggesting a replication of the covariance matrix over time. However, non-significant factor loadings were found in activity level scale to surgency/extraversion dimension at 2w, 3m, and 12m. When activity level was removed from the surgency/extraversion dimension and when activity level was included in the negative affectivity dimension, the models did not improve the model fit. These findings seem to suggest that the behavioral manifestations of temperament assessed in the activity level scale rely on infant's developmental achievements within the first year of life. At 2w, infants have motor constrains that compromise their manifestations of temperament

and these motor constrains decrease rapidly in the first year of life [33]. Additionally, the longitudinal confirmatory factor analyses suggested that the scores on the IBQ-R dimensions in one age predicted the scores on the immediately following age. These results are in line with temperament theories that argue that temperament is a stable dimension over the infancy [7,8,9].

The present study results add knowledge to the literature by also showing that the same dimensions of temperament can be observed throughout the first year of the infant's life. The infant's temperament characteristics assessed with the IBQ-R from 3m to 12m of life are already present and may also be assessed with the IBQ-R in 2-week-old infants. Additionally, these results are congruent with previous studies showing that temperament is already present at infant's birth [10,11,12]. Moreover, temperament research has been pointing for the emergence of temperament characteristics during the prenatal period [10,11,12], and that infant's temperament characteristics at childbirth are associated with the emergence of further developmental problems [13,14,15].

For clinicians, the use of the IBQ-R in infants younger than 3 months may be useful for early and accurate identification of specific temperament dimensions and of infants with difficult temperament and, thus at risk of further developmental problems [13,14,15]. For temperament research, the use of the IBQ-R in infants younger than 3 months may be useful to design longitudinal studies on infant development.

Considering the relevance of infant's temperament characteristics at birth, the results from this first study may contribute for the development of further studies on the use of the IBQ-R in infants younger than 3 months. Further research using the IBQ-R at the first weeks post-birth, should consider (1) to analyze the psychometric characteristics of the items of IBQ-R, and (2) to include other variables conceptually associated with the infant's temperament in order to test the IBQ-R criterion validity, (3) including reports of both mothers and fathers while examining the agreement between caregivers.

Conclusion

The findings of this study suggested that the IBQ-R is a reliable measure to apply since the first weeks of the infant's life and that the IBQ-R factor structure remains stable throughout infancy. The study of the IQB-R to measure temperament in younger infants may comprise a major advance to temperament research. The early assessment of infant's temperament is crucial considering that temperament characteristics at birth have been shown as a key element for the infant's developmental trajectory and for the emergence of further problems [13,14,15].

References

[1] M.K. Rothbart, L.K. Ellis, M.I. Posner, Temperament and self-regulation, in R.F. Baumeister, K.D. Vohs (Eds.), Handbook of self-regulation: Research, theory, and applications, Guilford, New York, 2011, pp. 357–370.

[2] M.H. Bornstein, D.L., Putnick, M.A. Gartstein, C.S. Hahn, N. Auestad, D.L. O'Connor, Infant temperament: stability by age, gender, birth order, term status, and socioeconomic status, Child Dev. 86 (2015) 844-863. https://doi.org/10.1111/cdev.12367.

[3] J.A. Carranza, C. González-Salinas, E. Ato, A longitudinal study of temperament continuity through IBQ, TBAQ and CBQ, Infant Behav. Dev. 36 (2013) 749-761. https://doi.org/10.1016/j.infbeh.2013.08.002

[4] M.K Rothbart, Measurement of temperament in infancy, Child Dev. 52 (1981) 569–578. https://doi.org/10.2307/1129176

[5] M.K. Rothbart, D. Derryberry, Development of individual differences in temperament. in M.E. Lamb, A.L. Brown (Series Eds.) Advances in developmental psychology, Vol. 1, Erlbaum, Hillsdale NJ, 1981, pp. 37–86.

[6] R.L. Shiner, K.A. Buss, S.G. McClowry, S.P. Putnam, K.J. Saudino, M. Zentner, What is temperament now? Assessing progress in temperament research on the twenty-fifth anniversary of Goldsmith et al.(1987), Child Dev. Perspect. 6 (2012) 436-444. https://doi.org/10.1111/j.1750-8606.2012.00254.x

[7] A. Buss, Temperaments as personality traits. in G.A. Kohnstamm, J.E. Bates, M.K. Rothbart (Eds.), Temperament in childhood, Wiley, Oxford, UK, 1989, pp. 49–58

[8] M.K. Rothbart, Becoming who we are, Guilford Press, New York, NY, 2011

[9] J. Strelau, The regulative theory of temperament as a result of East-West influences, in G.A. Kohnstamm, J.E. Bates, M.K. Rothbart (Eds.), Temperament in childhood, Wiley, Oxford, UK, 1989, pp. 35–48

[10] J.A. DiPietro, D.M. Hodgson, K.A. Costigan, T.R. Johnson, Fetal antecedents of infant temperament, Child Dev. 67 (1996) 2568-2583. https://doi.org/10.1111/j.1467-8624.1996.tb01875.x

[11] J.A. DiPietro, M.M. Ghera, K.A. Costigan, Prenatal origins of temperamental reactivity in early infancy, Early Hum. Dev. 84 (2008) 569-575. https://doi.org/10.1016/j.earlhumdev.2008.01.004

[12] J.A. DiPietro, K.M. Voegtline, H.A. Pater, K.A. Costigan, Predicting child temperament and behavior from the fetus, Dev. Psychopathol. 30 (2018) 855-870. https://doi.org/10.1017/S0954579418000482

[13] K. Bowers, J. Khoury, H. Sucharew, Y. Xu, A. Chen, B. Lanphear, K. Yolton, Early infant attention as a predictor of social and communicative behavior in childhood, Int. J. Behav. Dev. 43 (2018) 204-211. https://doi.org/10.1177/0165025418797001

[14] J. Canals, C. Hernández-Martínez, G. Esparó, J. Fernández-Ballart, Neonatal behavioral assessment scale as a predictor of cognitive development and IQ in full-term infants: a 6-year longitudinal study, Acta Paediatr. 100 (2011) 1331-1337. https://doi.org/10.1111/j.1651-2227.2011.02306.x

[15] S. Ohgi, T. Takahashi, J.K. Nugent, K. Arisawa, T. Akiyama, Neonatal behavioral characteristics and later behavioral problems, Clin. Pediatr. 42 (2003) 679-686. https://doi.org/10.1177/000992280304200803

[16] G.F. Giesbrecht, D. Dewey, APrON Study Team, The effects of 'does not apply'on measurement of temperament with the Infant Behavior Questionnaire—Revised: A cautionary tale for very young infants, Early Hum. Dev. 90 (2014) 627-634. https://doi.org/10.1016/j.earlhumdev.2014.08.003

[17] M.K. Rothbart, H.H. Goldsmith, Three approaches to the study of infant temperament, Dev. Rev. 5 (1985) 237-260. https://doi.org/10.1016/0273-2297(85)90012-7

[18] M.A. Gartstein, M.K. Rothbart, Studying infant temperament via the revised infant behavior questionnaire, Infant Behav. Dev. 26 (2003) 64-86. https://doi.org/10.1016/S0163-6383(02)00169-8

[19] S.P. Putnam, A.L. Helbig, M.A. Gartstein, M.K. Rothbart, E. Leerkes, Development and assessment of short and very short forms of the Infant Behavior Questionnaire–Revised, J. Pers. Assess. 96 (2014) 445-458. https://doi.org/10.1080/00223891.2013.841171

[20] S. Casalin, P. Luyten, N. Vliegen, P. Meurs, The structure and stability of temperament from infancy to toddlerhood: A one-year prospective study, Infant Behav. Dev. 35 (2012) 94-108. https://doi.org/10.1016/j.infbeh.2011.08.004

[21] M.A. Gartstein, H.R. Slobodskaya, P. Olaf Zylicz, D. Gosztyla, A. Nakagawa, A cross-cultural evaluation of temperament: Japan, USA, Poland and Russia, Int. J. Psychol. Psychologic. Ther. 10 (2010) 55-75.

[22] J. Sung, R. Beijers, M.A. Gartstein, C. de Weerth, S.P Putnam, Exploring temperamental differences in infants from the USA and the Netherlands, Eur. J. Dev. Psychol. 12 (2015) 15-28. https://doi.org/10.1080/17405629.2014.937700

[23] L.M. Gaias, K. Raikkonen, N. Komsi, M.A. Gartstein, P.A. Fisher, S.P. Putnam, Cross-cultural temperamental differences in infants, children, and adults in the United States of America and Finland, Scand. J. Psychol. 53 (2012) 119–128. https://doi.org/10.1111/j.1467-9450.2012.00937.x

[24] R. Montirosso, P. Cozzi, S. Putnam, M.A. Gartstein, R. Borgatti, Studying crosscultural differences in temperament in the first year of life: United States and Italy, Int. J. Behav. Dev. 35 (2011). 27–37. https://doi.org/10.1177/0165025410368944

[25] A. Nakagawa, M. Sukigara, How are cultural differences in the interpretation of infant behavior reflected in the Japonese revised infant behavior questionnaire?, Japanese J. Educ. Psychol. 53(2005) 491–503.

[26] R. Costa, B. Figueiredo, Infant Behavior Questionnaire – Revised Version: a psychometric study in a Portuguese sample, J. Reprod. Infant Psychol. 36 (2018) 207-218. https://doi.org/10.1080/02646838.2018.1436752

[27] M.A. Gartstein, G.G. Knyazev, H.R. Slobodskaya, Cross-cultural differences in the structure of infant temperament: United States of America (US) and Russia, Infant Behav. Dev. 28 (2005) 54-61. https://doi.org/10.1016/j.infbeh.2004.09.003

[28] J. Worobey, V.M. Blajda, Temperament ratings at 2 weeks, 2 months, and 1 year: differential stability of activity and emotionality, Dev. Psychol. 25 (1989) 257-263. https://doi.org/10.1037/0012-1649.25.2.257

[29] A. Field, Discovering statistics using IBM SPSS statistics, fourth ed., Sage, London, England, 2013

[30] P. Kline, The handbook of psychological testing, second ed., Routledge, London, UK, 2005

[31] J.B. Schreiber, A. Nora, F.K. Stage, E.A. Barlow, J. King, Reporting structural equation modeling and confirmatory factor analysis results: a review, J. Educ. Res. 99 (2006) 323-338. https://doi.org/10.3200/JOER.99.6.323-338

[32] B. de Lauzon-Guillain, K. Wijndaele, M. Clark, C.L. Acerini, I.A. Hughes, D.B. Dunger, J.C. Wells, K. Ong, Breastfeeding and infant temperament at age three months, PLoS One 7 (2012) e29326. https://doi.org/10.1371/journal.pone.0029326

[33] WHO Multicentre Growth Reference Study Group, M. de Onis, WHO Motor Development Study: windows of achievement for six gross motor development milestones, Acta Paediatr. 95 (2006) 86-95. https://doi.org/10.1111/j.1651-2227.2006.tb02379.x

PAPER IV

MOTHER'S PRENATAL AND POSTPARTUM DEPRESSION SYMPTOMS AND INFANT'S SLEEP PROBLEMS AT SIX MONTHS[5]

Dias, C.C., & Figueiredo, B. (2020). Mother's prenatal and postpartum depression symptoms and infant's sleep problems at six months. *Infant Mental Health Journal, in press.*

[5] This manuscript is in press at the Infant Mental Health Journal

Abstract

Mother's prenatal and postpartum depression have been associated with infant's sleep problems. This study aimed to analyze (1) the effects of mother's prenatal and postpartum depression symptoms, including the effects of prenatal and postpartum anxiety and depression scores of the Edinburgh Postnatal Depression Scale (EPDS), on infant's sleep problems at six months, and (2) the interaction effect between mother's prenatal and postpartum depression symptoms and infant's sex on infant's sleep problems at six months. The sample was comprised of 164 mother-infant dyads whose mothers completed measures of depression at the third trimester of pregnancy, two weeks, three and six months postpartum and a measure of infant's sleep problems at six months (CSHQ-I). Mother's prenatal depression symptoms, specifically depression scores of the EPDS, predicted more infant's sleep anxiety and daytime sleepiness, while mother's depression symptoms at two weeks postpartum, specifically anxiety scores of the EPDS, predicted more bedtime resistance and CSHQ-I total scores at six months. Boys of mothers with more prenatal depression symptoms presented more sleep anxiety at six months. Both mother's prenatal and early postpartum depression symptoms have a negative effect on the emergence of infant's sleep problems. Additionally, boys seem more vulnerable to mother's prenatal depression symptoms.

Key words: prenatal depression; postpartum depression; sleep problems; sex differences; development

Introduction

The developmental psychopathology conceptual model focuses on the study of the adaptative and maladaptive development (Sroufe, 2009; 2016). According with this conceptual model, infant development is affected by the accomplishment of different tasks across the life span (e.g., Rutter, 1996). Regarding sleep during infancy, literature suggested that four sleep developmental tasks are achieved during the first year of life, namely the ability of (1) spending more time awake than asleep, (2) concentrating sleep during the night, (3) self-soothing, and (4) sleeping through the night (Figueiredo, Dias, Pinto, & Field, 2016; Galland, Taylor, Elder, & Herbison, 2012; Goodlin-Jones, Burnham, Gaylor, & Anders, 2001). The accomplishment of these sleep developmental tasks may lead to infant adjustment and adequate development, while its failure may lead to the emergence of sleep problems (Byars, Yolton, Rausch, Lanphear, & Beebe, 2012; Sette, Baumgartner, Ferri, & Bruni, 2017). The developmental psychopathology conceptual model also highlights the importance of understanding the mechanisms through which development is affected and maladaptive trajectories are established (Sroufe & Rutter, 2000; Sroufe, 2016).

Maternal depression is highly prevalent, with rates ranging 10-20% during pregnancy (Couto et al., 2016; Figueiredo & Conde, 2011a; Underwood, Waldie, D'Souza, Peterson, & Morton, 2016; Verreault, Da Costa, Marchand, Ireland, Dritsa, & Khalifé, 2014), and 13-16.4% during the postpartum period (Figueiredo & Conde, 2011a; Underwood et al., 2016; Verreault, Da Costa, Marchand, Ireland, Dritsa, & Khalifé, 2014). Mother's prenatal (Gerardin et al., 2011; Field, Diego, Hernandez-Reif, Figueiredo, Schanberg, & Kuhn, 2007; Nevarez, Rifas-Shiman, Kleinman, Gillman, & Taveras, 2010) and postpartum depression (Bayer, Hiscock, Hampton, & Wake, 2007; Gress-Smith, Luecken, Lemery-Chalfant, & Howe, 2012; Hughes, Gallagher, & Hannigan, 2015) were both associated with infant's sleep problems. However, studies on the effects of maternal depression on infant's sleep problems did not analyze the concurrent effect of both maternal prenatal and postpartum depression.

Maternal depression effects on infant development may occur through different potential mechanisms: genetic factors, epigenetic change, gene-environment interaction, dysfunctional biological mechanisms, maladaptive cognitions or problematic mother-infant interactions (Field, 2010; Glover, O'Donnel, O'Connor, & Fisher, 2018; Stein et al., 2014). Potential moderators of the effects of maternal depression on infant development were also identified: infant's characteristics, namely sex and temperament, and maternal socio-economic status and parenting style (Beeghly et al., 2017; McGinnis, Bocknek, Beeghly, Rosenblum, & Muzik, 2015; Stein et al., 2014). The differential susceptibility theory argues that infants are not equally affected by the environmental influences, either positively or negatively

(Belsky, Bakermans-Kranenburg, & Van IJzendoorn, 2007). Regarding infant's characteristics, research has shown that boys present more dysregulated sleep patterns than girls in the presence of mother's prenatal depression (Netsi et al., 2015). These differences may be related to the sex differences already present during the fetal development (Rosenfeld, 2015; Sutherland & Brunwasser, 2018). Namely, male infants were shown to present more difficulty to adapt to embryotic adverse environments, for example, having a mother with prenatal depression symptoms (Rosenfeld, 2015; Sutherland & Brunwasser, 2018). Thus, when exposed to prenatal adverse environment, male infants were shown to present more pervasive effects on their further development than females (DiPietro & Voegtline, 2017; Sandman et al., 2013; Sutherland & Brunwasser, 2018).

Both mother's prenatal and postpartum depression symptoms were found to negatively affect infant development (Gerardin et al., 2011; Gress-Smith et al., 2012; Hughes et al., 2015). Additionally, previous literature suggested that infant's sex moderates the effect of maternal depression on infant development (Beeghly et al., 2017; McGinnis et al., 2015; Stein et al., 2014). Considering these previous findings, this longitudinal study aimed to analyze, under the context of developmental psychopathology conceptual model, (1) the effects of mother's prenatal and postpartum depression symptoms, including the effects of prenatal and postpartum anxiety and depression scores of the EPDS, on infant's sleep problems at six months, and (2) the interaction effect between mother's prenatal and postpartum depression symptoms and infant's sex on infant's sleep problems at six months.

Methods

Participants

The sample was comprised of 164 mother-infant dyads whose mothers completed measures of depression at the third trimester of pregnancy, two weeks, three and six months postpartum, and a measure of infant's sleep problems at six months. The majority of the mothers were white (93.7%), married or cohabiting (82.2%), employed (76.8%), and more than half were aged 25-34 years old (73.8%), belonged to a high socio-economic level (53.2%), and had more than 12 years of schooling (66.3%). The majority of infants were born at term (≥ 37 weeks of gestation; 98.2%), were not resuscitated at birth (92.1%), had normal birth weight (≥2500g) (98.8%), and length (≥48cm; 79.3%), and were first born (89.6%). More than half of the infants were born by vaginal delivery (66.5%) and were males (53.7%; Table 14).

Table 14.
Socio-demographic characteristics

			Total
			N = 164
			%
Mother	Age	18-24	9.1
		25-34	73.8
		35-44	17.1
	Ethnicity	White	93.7
		Other	6.3
	Socio-economic level	High	53.2
		Medium	39.7
		Low	7.1
	Marital status	Married/cohabiting	82.2
		Single/divorced/widow	17.8
	Occupational status	Employed	76.8
		Unemployed/Household/student	23.2
	Years of schooling	≤12	33.7
		>12	66.3
Gestation	Gestational age	< 37 weeks	1.8
		≥ 37 weeks	98.2
	Resuscitation at birth	No	92.1
		Yes	7.9
	Type of delivery	Vaginal	66.5
		Caesarean	33.5
Infant	Sex	Female	46.3
		Male	53.7
	Weight	< 2500g	1.2
		≥ 2500 g	98.8
	Length	< 48 cm	20.7
		≥ 48 cm	79.3
	First born	Yes	89.6
		No	10.4

Procedures

This study took part from a larger longitudinal study that received approval of the Ethical Commissions of all the institutions involved. At the third trimester of pregnancy, 536 women who met the inclusion criteria were contacted at two public hospitals in the Northern Portugal, informed about the study's purposes and procedures and invited to participate. Women not reading/writing Portuguese, with gestational complications, psychiatric medication intake, and multiple births were excluded. Four hundred

and eighty-five women (90.5%) agreed to participate, signed an informed consent and completed measures of socio-demographic characteristics and depression symptoms at the third trimester of pregnancy. Women were contacted again and 317 (65.3%) completed online measures of socio-demographic characteristics and depression symptoms at two weeks and 303 (62.5%) at three months postpartum. From these women, 164 (54.1%) completed measures of depression and infant's sleep problems at six months and were included in the study. Significant associations were found between participants who completed all the measures and those who did not completed all the measures, on parity, *Wald* = 6.72, β = -.94, 0R = .39, p = .010. Primiparous women were more likely to complete all the study measures.

Measures

Socio-demographic characteristics. The Socio-demographic Questionnaire is an instrument that assesses maternal demographic and obstetric information, and infants' socio-demographic and biometric information (e.g., age, marital status, occupational status, socio-economic status, years of schooling, type of delivery, weeks of gestation).

Mother's depression symptoms. The EPDS (Cox, Holden, & Sagovsky, 1987) is a self-report measure, comprised of 10 items that are scored on a four-point Likert-type scale to assess pregnancy and postpartum depression symptoms within the previous 7 days (total scores ranging from 0 to 30). Although the Portuguese version validation used the EPDS as an unidimensional measure (Tendais et al., 2014), different studies worldwide have suggested the EPDS to be comprised of two factors: the anxiety subscale and the depression subscale (e.g., Jomeen & Martin, 2005; Matthey, 2008; Phillips, Charles, Sharpe, & Matthey, 2009). Although some variation, several studies have shown the anxiety subscale to be comprised of three items (items 3, 4 and 5: EPDS-3A; Matthey, 2008; Phillips et al., 2009; Smith-Nielsen, Matthey, Lange, & Væver, 2018), and the depression subscale to be comprised of the remaining seven items (Matthey, 2008; Phillips et al., 2009). Good internal consistency was found in the Portuguese version of the EPDS both during pregnancy and postpartum (α = .82 and .88; Tendais, Costa, Conde, & Figueiredo, 2014). In the present sample, the EPDS total score showed good internal consistency at the third trimester of pregnancy (α = .85), and at two weeks, three and six months postpartum (α's ranging from .82 to .89). Additionally, adequate to good internal consistency was found in the two subscales at the third trimester of pregnancy, two weeks, three and six months postpartum, with α's ranging from .68 to .82 in the anxiety subscale and α's ranging from .74 to .84 in the depression subscale.

Infant's sleep problems. The CSHQ-I (Dias, Figueiredo, & Pinto, 2018) was designed to assess sleep problems in infants aged 0 and 12 months old. It is a Portuguese adapted version of the Children's Sleep Habits Questionnaire – CSHQ (Owens, Spirito, & McGuinn, 2000), a measure that has been used worldwide to assess sleep problems in pre-school and school aged children (e.g., Goodlin-Jones, Sitnick, Tang, Liu, & Anders, 2008; Owens et al., 2000; Waumans, Terwee, Van den Berg, Knol, Van Litsenburg, & Gemke, 2010). The CSHQ-I is a retrospective questionnaire, comprised of 33 items scored in a three-point Likert-type scale that identifies infant's sleep problems based on the International Classification of Sleep Disorders (ICSD-1). It is comprised of four subscales: (1) Bedtime Resistance: infant's resistance to go to bed and frequent night waking (e.g., "*Child falls asleep alone in own bed*"); (2) Sleep Anxiety: infant's anxiety related to sleep, and items of sleep-disordered breathing (e.g., "*Child awakens during night screaming, sweating, and inconsolable*"); (3) Positive Sleep Habits: infant's bedtime and morning waking routines (e.g., "*Child goes to bed at the same time at night*"); and (4) Daytime Sleepiness: daytime consequences from sleep problems (e.g., "*Child takes a long time to become alert in the morning*"). The scores of the CSHQ-I total scale and subscales are obtained through the sum of the items divided by the number of items (scores ranging from 0 to 2). Higher scores in the CSHQ-I are indicative of more infant's sleep problems. Adequate to good internal consistency was found for the total scale (α = .77) and the subscales (α's ranging from .52 and .77; Dias et al., 2018). In the present sample, the CSHQ-I total score presented adequate to good internal consistency for the total scale (α = .80) and subscales (α's ranging from .36 and .78).

Statistical Analyses

Statistical analyses were performed with SPSS version 22.0 (SPSS Inc., USA). Multiple linear regressions (stepwise method) were used to determine the stronger predictor (mother's prenatal or postpartum depression symptoms) of infant's sleep problems at six months. Models included mother's prenatal depression symptoms (EPDS total scores at the third trimester of pregnancy) and mother's postpartum depression symptoms (EPDS total scores at two weeks, three months and six months) as independent variables (IVs) and infant's CSHQ-I total score, bedtime resistance, sleep anxiety, positive sleep habits, and daytime sleepiness at six months as dependent variables (DVs).

To analyze the effects of prenatal and postpartum anxiety and depression scores of the EPDS on infant's sleep problems at six months, further multiple linear regressions (stepwise method) were performed to determine the stronger predictor (the prenatal and postpartum anxiety and depression scores of the EPDS) of infant's sleep problems at six months. Models included mother's prenatal

depression and anxiety symptoms (anxiety and depression subscales of EPDS at the third trimester of pregnancy) and mother's postpartum depression and anxiety symptoms (anxiety and depression subscales of EPDS at two weeks, three months and six months) as independent variables (IVs) and infant's CSHQ-I total score, bedtime resistance, sleep anxiety, positive sleep habits, and daytime sleepiness at six months as dependent variables (DVs).

To analyze the interaction effect between mother's prenatal and postpartum depression symptoms and infant's sex on infant's sleep problems at six months, moderation models were tested according to Baron and Kenny guidelines (1986). Models to analyze the interaction effect between mother's prenatal depression symptoms and infant's sex (-1 = male; 1 = female) on infant's sleep anxiety, and daytime sleepiness included: (1) mother's prenatal depression symptoms (EPDS total scores at the third trimester of pregnancy) as IV (path a); (2) infant's sex as IV (path b); and (3) the interaction between mother's prenatal depression symptoms and infant's sex as IV (path c). Infant's sleep anxiety, and daytime sleepiness at six months were included as DVs. Models to analyze the interaction effect between mother's postpartum depression symptoms and infant's sex on infant's CSHQ-I total score and bedtime resistance included: (1) mother's depression symptoms at two weeks (EPDS total scores at two weeks postpartum) as IV (path a); (2) infant's sex as IV (path b); and (3) the interaction between mother's depression symptoms at two weeks postpartum and infant's sex as IV (path c). Infant's CSHQ-I total score and bedtime resistance at six months were included as DVs. Further moderation models were performed to analyze the interaction effect between prenatal and postpartum anxiety and depression scores of the EPDS and infant's sex on infant sleep problems at six months. The same models were tested according to Baron and Kenny guidelines (1986). The first models included: (1) prenatal depression scores of the EPDS as IV (path a); (2) infant's sex as IV (path b); and (3) the interaction between prenatal depression scores of the EPDS and infant's sex as IV (path c). Infant's sleep anxiety, and daytime sleepiness at six months were included as DVs. The second models included: (1) anxiety scores of the EPDS at two weeks as IV (path a); (2) infant's sex as IV (path b); and (3) the interaction between anxiety scores of the EPDS at two weeks postpartum and infant's sex as IV (path c). Infant's CSHQ-I total score and bedtime resistance at six months were included as DVs.

Results

Preliminary analyses

Means and standard deviations for mother's prenatal and postpartum depression symptoms and infant's sleep problems at six months are presented in Table 15. The scores of mother's prenatal and postpartum depression symptoms reported in the present study are similar to the scores found in previous studies with different Portuguese samples (e.g., Figueiredo & Conde, 2011b). A previous study reported mean scores of depression symptoms of 5.97 (*SD* = 4.05) at the third trimester of pregnancy (e.g., Figueiredo & Conde, 2011b), similar to the 6.95 (*SD* = 4.29) found in the present sample. Additionally, mean scores of depression symptoms of 5.88 (*SD* = 4.64) and 4.69 (*SD* = 4.13) were reported at childbirth and at three months postpartum in a previous study (Figueiredo & Conde, 2011b), similar to the 5.35 (*SD* = 4.44) and 4.54 (*SD* = 3.59) found in the present sample at two weeks and three months postpartum.

Correlations between mother's prenatal, postpartum depression symptoms, and infant's sleep problems at six months are also presented in Table 15. Non-significant correlations were found between mother's prenatal and postpartum depression symptoms and socio-demographic variables (maternal age, ethnicity, socio-economic level, marital status, occupational status, gestational age, type of delivery, resuscitation at birth, infant's sex, birth weight, birth length, birth order). A significant correlation was found between mother's postpartum depression symptoms at three months postpartum and maternal years of schooling, $r = .166$, $p = .034$. Considering this result, regression models were adjusted for maternal years of schooling.

Table 15.

Study's variables' means, standard deviations and correlations

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) Pregnancy depression (3rd trimester)									
(2) Postpartum depression (2 weeks)	.574***								
(3) Postpartum depression (3 months)	.544***	.723***							
(4) Postpartum depression (6 months)	.641***	.649***	.695***						
(5) CSHQ-I total score (6 months)	.191*	.180*	.112	.129					
(6) Bedtime resistance (6 months)	.115	.155*	.077	.088	.912***				
(7) Sleep anxiety (6 months)	.308***	.272***	.180*	.256***	.574***	.398***			
(8) Positive sleep habits (6 months)	-.057	-.034	.008	.060	-.592***	-.354***	-.159*		
(9) Daytime sleepiness (6 months)	.183*	.112	.206**	.230**	-.022	-.232**	.146	.030	

		3rd trimester *M* (*SD*)	2 weeks *M* (*SD*)	3 months *M* (*SD*)	6 months *M* (*SD*)
(10)	Depression symptoms	6.85 (4.29)	5.35 (4.44)	4.54 (3.59)	4.82 (3.74)
(11)	CSHQ-I total score				0.40 (0.22)
(12)	Bedtime resistance				0.66 (0.42)
(13)	Sleep anxiety				0.16 (0.21)
(14)	Positive sleep habits				1.48 (0.33)
(15)	Daytime sleepiness				0.09 (0.17)

M = Mean; *SD* = Standard Deviation; **p < .05; **p < .01; ***p < .001*

Mother's prenatal and postpartum depression symptoms (EPDS total score) as predictors of infant's sleep problems at six months postpartum

Mother's prenatal and postpartum depression symptoms (EPDS total score) were tested as predictors of infant's sleep problems at six months (stepwise regression method). Five models were conducted: one for the CSHQ-I total score, and one for each CSHQ-I subscale (bedtime resistance, sleep anxiety, positive sleep habits, and daytime sleepiness) (Table 16).

The regression models explained between 4 and 15% of the variance (adjusted R^2 range = .03 - .14). Mother's prenatal depression symptoms (EPDS total score) were found to be the strongest predictor of infant's sleep anxiety (β = 0.35, p < .001) and daytime sleepiness (β = 0.21, p = .001). Mother's postpartum depression symptoms (EPDS total score) at two weeks were found to be the strongest predictor of infant's CSHQ-I total score (β = 0.25, p = .002) and bedtime resistance (β = 0.20, p = .014) (see Table 16). Mother's prenatal and postpartum depression symptoms (EPDS total score) did not predict infant's positive sleep habits at six months.

Table 16.
Prenatal and postpartum depression symptoms as predictors of infant's sleep problems at 6 months

	R^2 (adj R^2)	*F*	*B*	*t*
Model 1				
CSHQ-I total score				
Postpartum depression symptoms (2 weeks)	0.08 (0.07)	6.68**	0.25	3.20**
Model 2				
Bedtime resistance				
Postpartum depression symptoms (2 weeks)	0.04 (0.03)	3.42*	0.20	2.50*
Model 3				
Sleep Anxiety				
Pregnancy depression symptoms (3rd trimester)	0.15 (0.14)	13.96***	0.35	4.77***
Model 5				
Daytime Sleepiness				
Pregnancy depression symptoms (3rd trimester)	0.05 (0.03)	3.73*	0.21	2.72**

Models were adjusted for mother's years of schooling; ** p < .05; **p < .01; ***p < .001*

Prenatal and postpartum anxiety and depression scores of the EPDS as predictors of infant's sleep problems at six months postpartum

Further analyses were performed with the prenatal and postpartum anxiety and depression scores of the EPDS. The regression models explained between 4 and 12% of the variance (adjusted R^2 range = .06 - .13). The depression scores of the EPDS at the third trimester of pregnancy were found to be the strongest predictor of infant's sleep anxiety (β = 0.32, p < .001), and daytime sleepiness (β = 0.23, p = .003) at six months. The anxiety scores of the EPDS at two weeks postpartum were found to be the strongest predictor of infant's CSHQ-I total score (β = 0.29, p < .000) and bedtime resistance (β = 0.25, p = .002) at six months (see Table 17). Prenatal and postpartum anxiety and depression scores of the EPDS did not predict infant's positive sleep habits at six months.

Table 17.
Prenatal and postpartum depression symptoms (anxiety and depression scores) as predictors of infant's sleep problems at 6 months

	R^2 (adj R^2)	*F*	*B*	*t*
Model 1				
CSHQ-I total score				
Postpartum anxiety scores (2 weeks)	0.10 (0.09)	8.86***	0.29	3.84***
Model 2				
Bedtime resistance				
Postpartum anxiety scores (2 weeks)	0.06 (0.05)	5.43**	0.25	3.22**
Model 3				
Sleep Anxiety				
Pregnancy depression scores (3rd trimester)	0.13 (0.12)	12.09***	0.32	4.38***
Model 5				
Daytime Sleepiness				
Pregnancy depression scores (3rd trimester)	0.06 (0.04)	4.60*	0.23	3.03**

Models were adjusted for mother's years of schooling; ** p < .05; **p < .01; ***p < .001*

The interaction effect between mother's prenatal and postpartum depression symptoms (EPDS total scores) and infant's sex on infant's sleep problems at six months

The interaction effect between mother's prenatal and postpartum depression symptoms (EPDS total scores) and infant's sex on infant's sleep problems at six months was also tested. Considering the results found in the linear regression analyses, it was tested (1) the interaction effect between mother's

prenatal depression symptoms (EPDS total score) and infant's sex on infant's sleep anxiety, and daytime sleepiness at six months; (2) the interaction effect between mother's depression symptoms (EPDS total score) at two weeks and infant's sex on infant's CSHQ-I total score and bedtime resistance at six months; (3) the interaction effect between mother's prenatal depression scores of the EPDS and infant's sex on infant's sleep anxiety, and daytime sleepiness at six months; and (4) the interaction effect between and mother's anxiety scores of the EPDS at two weeks postpartum and infant's sex on infant's CSHQ-I total score and bedtime resistance at six months.

(1) The interaction effect between mother's prenatal depression symptoms (EPDS total score) and infant's sex on infant's sleep anxiety, and daytime sleepiness at six months

First linear regressions (paths a) explained between 4.3 and 12% of variance (adjusted R^2 range = .04 - .12) and revealed that mother's depression symptoms (EPDS total score) at the third trimester of pregnancy predicted infant's sleep anxiety (β = 0.35, p < .001), and daytime sleepiness (β = 0.21, p = .007) at six months postpartum. Second linear regressions (paths b) explained between 4.4 and 12% of variance (adjusted R^2 range = .03 - .12) and revealed that infant's sex did not predict infant's sleep anxiety (β = -0.02, p = .825), and daytime sleepiness (β = -0.08, p = .310). Third linear regressions (paths c) explained between 6.5 and 14% of variance (adjusted R^2 range = .05 - .13) and revealed that the interaction between mother's depression symptoms at the third trimester of pregnancy (EPDS total score) and infant's sex significantly predicted infant's sleep anxiety (β = -0.28, p = .047) at six months, but did not significantly predicted infant's daytime sleepiness (β = -0.23, p = .112) (see Table 18).

Table 18.

The interaction effect between mother's prenatal and postpartum depression symptoms and infant's sex on infant sleep problems at 6 months

	R^2 (R^2Aj)	*F*	β	*p*	R^2Ch
Infant's sleep anxiety					
Path a	.12 (.12)	22.59***			
Mother's prenatal depression symptoms (3rd trimester)			0.35	>.001	
Path b	.12 (.11)	11.25***			.00
Infant's sex			-0.16	.829	
Path c	.14 (.13)	8.97***			.02*
Mother's prenatal depression symptoms (3rd trimester) x infant's sex			-0.28	.047	
Infant's daytime sleepiness					
Path a	.04 (.04)	7.34**			
Mother's prenatal depression symptoms (3rd trimester)			0.21	.007	
Path b	.05 (.04)	4.19*			.01
Infant's sex			-0.08	.310	
Path c	.06 (.05)	3.67*			.02
Mother's prenatal depression symptoms (3rd trimester) x infant's sex			-0.23	.112	
CSHQ-I total score					
Path a	.05 (.04)	8.33*			
Mother's postpartum depression symptoms (2 weeks)			0.22	.004	
Path b	.05 (.04)	4.22*			.00
Infant's sex			-0.03	.697	
Path c	.07 (.05)	4.02**			.02†
Mother's postpartum depression symptoms (2 weeks) x infant's sex			-0.23	.058	
Bedtime resistance					
Path a	.03 (.03)	5.58*			
Mother's postpartum depression symptoms (2 weeks)			0.18	.019	
Path b	.03 (.02)	2.78			.02
Infant's sex			0.01	.895	
Path c	.04 (.02)	2.02			.02
Mother's postpartum depression symptoms (2 weeks) x infant's sex			-0.09	.719	

Notes. R^2Aj = adjusted R^2; R^2Ch = R^2change.

† *p > 0.05 < 0.10;* * *p* < .05; ** *p* < .01; *** *p* < .001

The tested models revealed that the interaction between mother's depression symptoms at the third trimester of pregnancy (EPDS total score) and infant's sex significantly predicted infant's sleep anxiety at six months (see Figure 5). Boys of mothers with more depression symptoms during the third

trimester of pregnancy presented more sleep anxiety at six months. No problems of multicollinearity were found between the variables of the regression analyses (Variance Inflation Factor was < 5 and Tolerance > .2).

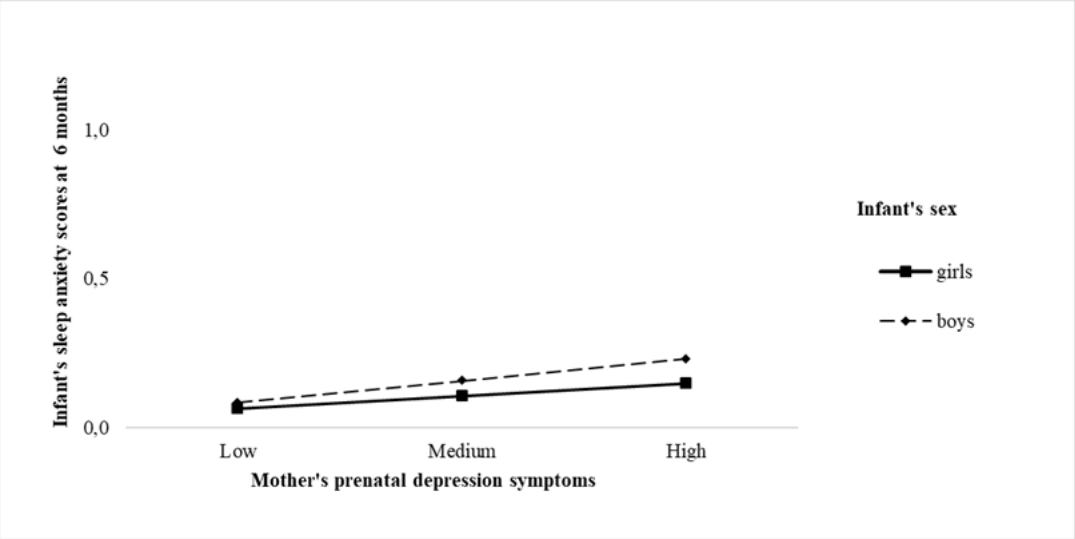


Figure 5. Interaction effect between mother's prenatal depression symptoms and infant's sex on infant's sleep anxiety at 6 months.

(2) The interaction effect between mother's depression symptoms at two weeks (EPDS total score) and infant's sex on infant's CSHQ-I total score and bedtime resistance at six months

First linear regressions (path a) explained 3.3 and 4.9 % of variance (adjusted R^2 range = .03 - .04) and revealed that mother's depression symptoms at two weeks postpartum (EPDS total score) predicted infant's CSHQ-I total score (β = 0.22, p = .004), and bedtime resistance (β = 0.18, p = .019). Second linear regressions (path b) explained between 3.3 and 5.0% of variance (adjusted R^2 range = .02 - .04) and revealed that infant's sex did not predict infant's CSHQ-I total score (β = -0.03, p = .697), and bedtime resistance (β = 0.01, p = .895). Third linear regressions (path c) explained between 3.7 and 7.1% of variance (adjusted R^2 range = .02 - .05) and revealed that the interaction between mother's depression symptoms at two weeks postpartum (EPDS total score) and infant's sex did not significantly predict infant's CSHQ-I total score (β = -0.23, p = .058), and bedtime resistance (β = -0.09, p = .719) (see Table 18). No problems of multicollinearity were found between the variables of the regression analyses (Variance Inflation Factor was < 5 and Tolerance > .2).

(3) The interaction effect between prenatal depression scores of the EPDS and infant's sex on infant's sleep anxiety, and daytime sleepiness at six months

First linear regressions (paths a) explained between 5 and 10% of variance (adjusted R^2 range = .05 - .09) and revealed that depression scores of the EPDS at the third trimester of pregnancy predicted infant's sleep anxiety (β = 0.31, p < .001), and daytime sleepiness (β = 0.23, p = .003) at six months. Second linear regressions (paths b) explained between 6 and 10% of variance (adjusted R^2 range = .05 - .09) and revealed that infant's sex did not predict infant's sleep anxiety (β = -0.03, p = .724), and daytime sleepiness (β = -0.08, p = .286). Third linear regressions (paths c) explained between 8 and 12% of variance (adjusted R^2 range = .06 - .10) and revealed that the interaction between depression scores of the EPDS at the third trimester of pregnancy and infant's sex significantly predicted infant's sleep anxiety (β = -0.22, p = .048) at six months, and did not significantly predict infant's daytime sleepiness (β = -0.21, p = .072) (see Table 19). The tested models revealed that the interaction between depression scores of the EPDS at the third trimester of pregnancy and infant's sex significantly predicted infant's sleep anxiety at six months. Boys of mothers with higher scores on the depression scores of the EPDS during the third trimester of pregnancy presented more sleep anxiety at six months postpartum. No problems of multicollinearity were found between the variables of the regression analyses (Variance Inflation Factor was < 5 and Tolerance > .2).

(4) The interaction effect between anxiety scores of the EPDS at two weeks postpartum and infant's sex on infant's CSHQ-I total score and bedtime resistance at six months

First linear regressions (path a) explained 5.7 and 7.8% of variance (adjusted R^2 range = .05 - .07) and revealed that anxiety scores of the EPDS at two weeks predicted infant's CSHQ-I total score (β = 0.28, p < .001), and bedtime resistance (β = 0.24, p = .002). Second linear regressions (path b) explained between 5.8 and 7.6% of variance (adjusted R^2 range = .05 - .06) and revealed that infant's sex did not predict infant's CSHQ-I total score (β = -0.01, p = .866), and bedtime resistance (β = 0.03, p = .764). Third linear regressions (path c) explained between 6.2 and 9.6% of variance (adjusted R^2 range = .04 - .08) and revealed that the interaction between anxiety scores of the EPDS at two weeks postpartum and infant's sex did not significantly predict infant's CSHQ-I total score (β = -0.24, p = .059), and bedtime resistance (β = -0.10, p = .431) (see Table 19). No problems of multicollinearity were found between the variables of the regression analyses (Variance Inflation Factor was < 5 and Tolerance > .2).

Table 19.

The interaction effect between mother's prenatal and postpartum depression symptoms (anxiety and depression scores) and infant's sex on infant sleep problems at 6 months

	R^2 (R^2Aj)	*F*	β	*p*	R^2Ch
Infant's sleep anxiety					
Path a	.10 (.09)	17.46***			
Pregnancy depression scores (3rd trimester)			0.31	>.001	
Path b	.10 (.09)	8.74***			.00
Infant's sex			-0.03	.724	
Path c	.12 (.10)	7.26***			.02*
Pregnancy depression scores (3rd trimester) x infant's sex			-0.22	.048	
Infant's daytime sleepiness					
Path a	.05 (.05)	8.95**			
Pregnancy depression scores (3rd trimester)			0.23	.003	
Path b	.06 (.05)	5.05**			.01
Infant's sex			-0.08	.286	
Path c	.08 (.06)	4.51**			.02†
Pregnancy depression scores (3rd trimester) x infant's sex			-0.21	.072	
CSHQ-I total score					
Path a	.08 (.07)	13.28***			
Postpartum anxiety scores (2 weeks)			0.88	>.001	
Path b	.08 (.06)	6.62**			.00
Infant's sex			-0.01	.866	
Path c	.10 (.06)	5.68**			.02†
Postpartum anxiety scores (2 weeks) x infant's sex			-0.24	.059	
Bedtime resistance					
Path a	.06 (.05)	9.88**			
Postpartum anxiety scores (2 weeks)			0.24	.002	
Path b	.06 (.05)	4.97**			.00
Infant's sex			0.03	.734	
Path c	.06 (.04)	3.51*			.00
Postpartum anxiety scores (2 weeks) x infant's sex			-0.10	.431	

Notes. R^2Aj = adjusted R^2; R^2Ch = R^2change.

† *p > 0.05 < 0.10;* * *p* < .05; ** *p* < .01; *** *p* < .001

Discussion

The findings of this study showed that mother's depression symptoms at the third trimester of pregnancy predicted more infant's sleep anxiety and daytime sleepiness at six months, while mother's depression symptoms at two weeks postpartum predicted more infant's bedtime resistance and total sleep problems at six months. The depression scores of the EPDS at the third trimester of pregnancy

predicted more infant's sleep anxiety and daytime sleepiness at six months, while the anxiety scores of EPDS at two weeks postpartum predicted more infant's bedtime resistance and total sleep problems at six months. Results also showed that boys of mothers with more depression symptoms at the third trimester of pregnancy presented more sleep anxiety at six months.

Mother's depression symptoms at the third trimester of pregnancy (EPDS total score) were found to predict more infant's sleep problems at six months, specifically more sleep anxiety and daytime sleepiness. These results are in line with previous studies showing mother's prenatal depression is associated with the emergence of infant's sleep problems (Field et al., 2007; Gerardin et al., 2011; Nevarez, et al., 2010). When further analyses were performed with the separated anxiety and depression scores of the EPDS, mother's depression scores at the third trimester of pregnancy significantly predicted more sleep anxiety and daytime sleepiness at six months. This result reinforced the major role of mother's prenatal depression symptoms on the emergence of further infant's sleep problems (Gerardin et al., 2011; Field et al., 2007; Nevarez et al., 2010). Also, this study adds to previous research on the adverse effects of mother's prenatal depression on infant development (e.g., Figueiredo, Pinto, Pacheco, & Field, 2017; Gentile, 2017; Stein et al., 2014), by reporting the adverse effects on infant's sleep problems. In their turn, infant's sleep problems may contribute to the emergence of mother's postpartum anxiety and depression symptoms (Ystrom, Nilsen, Hysing, Sivertsen, & Ystrom 2017), which may help to explain the association between mother's prenatal and postpartum depression.

Mother's postpartum depression symptoms at two weeks (EPDS total score) were found to predict more infant's sleep problems at six months, specifically more bedtime resistance and total sleep problems at six months. This result is in line with previous research associating mother's postpartum depression with infant's sleep problems (Gress-Smith et al., 2012; Hughes et al., 2015), specifically during the early postpartum period (Dennis & Ross, 2005). The present study adds to this previous literature by showing that the effects of mother's postpartum depression symptoms on infant's sleep problems can occur specifically from mother's depression symptoms in the early weeks postpartum, a period where mothers often present poor sleep quality (Hunter, Rychnovsky, & Yount, 2009). Poor maternal sleep quality has been associated with both mother's depression (Lawson, Murphy, Sloan, Uleryk, & Dalfen, 2015; Park, Meltzer-Brody, & Stickgold, 2013) and infant's sleep problems (Dennis & Ross, 2005). When further analyses were performed with separated anxiety and depression scores of the EPDS, mother's anxiety scores at two weeks postpartum significantly predicted more bedtime resistance and total sleep problems at six months. These results suggest that the anxiety scores of the EPDS during the first weeks of the postpartum period have a major role on the emergence of further infant's sleep problems.

This study extended the knowledge of previous studies showing that mother's prenatal (Gerardin et al., 2011; Nevarez, et al., 2010; O'Connor et al., 2007) and postpartum depression (Dennis & Ross, 2005; Gress-Smith et al., 2012; Hughes et al., 2015) predict infant's sleep problems. Mother's prenatal and two weeks postpartum depression symptoms predict different specific sleep problems, suggesting that infant's sleep problems may be affected through different mechanisms. Additionally, while during pregnancy, depression scores of the EPDS predict infant's sleep problems, anxiety scores of the EPDS at two weeks postpartum were found to predict infant's sleep problems. These results are congruent and reinforce the literature that suggests that the effects of mother's depression on infant development may occur through different and interactive mechanisms (Glover et al., 2018; Stein et al., 2014). These results also suggest that these mechanisms may interact differently according with the timing of mother's depression symptoms. The genetic factors, epigenetic change, or dysfunctional biological mechanisms, resultant from mother's depression symptoms during pregnancy may predict the emergence of infant's sleep anxiety and daytime sleepiness. Conversely, infant's CSHQ-I total score and bedtime resistance may be associated with the maladaptive cognitions and interactions presented by the mothers during the early postpartum period, especially associated with mother's anxiety symptoms.

Infant's sex specific effects of mother's prenatal depression symptoms were also found. Boys of mothers with more depression symptoms at the third trimester of pregnancy presented more sleep anxiety at six months. These results are congruent with previous studies showing that boys are more vulnerable to the impact of mother's prenatal depression (Beeghly et al., 2017; McGinnis et al., 2015; Netsi et al., 2015). These results may also be interpreted within the framework of differential susceptibility, suggesting that boys and girls are not equally affected by an early risk factor (Belsky et al., 2007; Netsi et al., 2015). Non-significant interaction effects between mother's prenatal depression symptoms and infant's sex were shown on infant's daytime sleepiness and non-significant interaction effects between mother's depression symptoms at two weeks postpartum and infant's sex were found on infant's CSHQ-I total problems and bedtime resistance. These results suggest that infant's sex specific effects only occur in specific dimensions of infant's sleep problems, namely in sleep anxiety. Previous studies already shown that male fetuses present more difficulty in adapting to a prenatal adverse environment than females (Sutherland & Brunwasser, 2018), and thus are at higher risk of presenting more anxiety related with sleep.

This study presents some strengths, namely by (1) analyzing the concurrent effect of both mother's prenatal and postpartum depression symptoms on infant's sleep problems; (2) considering different specific infant's sleep problems; (3) clarifying the effect of infant's sex; and (4) presenting a longitudinal design, with a community sample followed since the third trimester of pregnancy to six

months postpartum. Some limitations can also be identified. Both dependent and independent variables were assessed through the same informant, which may have led to an increase of the common shared variance. Mother's prenatal depression symptoms were only assessed at the third trimester of pregnancy, which did not account for any depression symptoms experienced during the first or second trimester. The generalization of this study's findings should be performed with caution, considering that primiparous women were more likely to complete all the study measures. However, women who completed all the study measures did not differ from those who did not complete all the study measures in any other socio-demographic variable. The small variance explained by the different tested models also suggests that other variables may affect infant's sleep problems. Additionally, the assessment of other variables that may also be involved in the emergence of infant's sleep problems was not included, namely infant's temperament, parenting quality, maternal anxiety symptoms or sleep quality.

Implications for research and clinical practice

This study highlighted the role of both mother's prenatal and postpartum depression symptoms on the emergence of infant's sleep problems. This finding presents relevant implications for both research and clinical practice, considering that sleep problems during infancy are one common concern for parents and clinicians and are usually predictors of further sleep, behavioral and emotional problems (Byars et al., 2012; Williams, Berthelsen, Walker, & Nicholson, 2017; Sivertsen, Harvey, Reichborn-Kjennerud, Torgersen, Ystrom, & Hysing, 2015). Future research may explore the effect of other variables, namely infant's individual characteristics and maternal sleep quality and anxiety on the emergence of infant's sleep problems.

Regarding the implications for clinical practice, these findings show the importance of screening for mother's prenatal depression and depression in the early postpartum period as part of routine perinatal care to identify infants at risk of presenting developmental problems. Moreover, considering that mother's prenatal and postpartum depression symptoms both affect infant's sleep problems, these results acknowledge the need of intervening on infant's sleep problems when developing mother's depression interventions. This study also identified infant's sex specific effects. By showing that male's and female's sleep problems are differentially affected by maternal prenatal depression symptoms, this study highlights the importance of designing targeted interventions.

Conclusions

This study provides a broader picture of the effects of mother's prenatal and postpartum depression symptoms on infant's sleep problems at six months. Mother's depression during pregnancy and the early postpartum period both predict more infant's sleep problems at six months. Additionally, boys seem more vulnerable to the effects of mother's prenatal depression symptoms. These results extend the knowledge on infant's sleep research, by showing (1) the effects of both mother's prenatal and postpartum depression symptoms on infant's sleep problems at six months, and (2) the sex dependent impact of mother's prenatal depression symptoms on infant's sleep anxiety.

References

Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology, 51*(6), 1173-1182.

Bayer, J. K., Hiscock, H., Hampton, A., & Wake, M. (2007). Sleep problems in young infants and maternal mental and physical health. *Journal of Paediatrics and Child Health*, *43*, 66-73. doi: 10.1111/j.1440-1754.2007.01005.x

Beeghly, M., Partridge, T., Tronick, E., Muzik, M., Mashhadi, M. R., Boeve, J. L., & Irwin, J. L. (2017). Associations between early maternal depressive symptom trajectories and toddlers' felt security at 18 months: are boys and girls at differential risk? *Infant Mental Health Journal, 38*, 53-67. doi: 10.1002/imhj.21617

Belsky, J., Bakermans-Kranenburg, M. J., & Van IJzendoorn, M. H. (2007). For better and for worse: differential susceptibility to environmental influences. *Current Directions in Psychological Science, 16*, 300-304. doi: 10.1111/j.1467-8721.2007.00525.x

Byars, K. C., Yolton, K., Rausch, J., Lanphear, B., & Beebe, D. W. (2012). Prevalence, patterns, and persistence of sleep problems in the first 3 years of life. *Pediatrics*, *129,* e276-e284. doi: 10.1542/peds.2011-0372

Couto, T. C., Cardoso, M. N., Brancaglion, M. M., Faria, G. C., Garcia, F. D., Nicolato, R., ... & Corrêa, H. (2016). Antenatal depression: Prevalence and risk factor patterns across the gestational period. *Journal of Affective Disorders*, *192*, 70-75. doi: 10.1016/j.jad.2015.12.017

Cox, J. L., Holden, J. M., & Sagovsky, R. (1987). Detection of postnatal depression: development of the 10-item Edinburgh Postnatal Depression Scale. *The British Journal of Psychiatry*, *150*, 782-786. doi: 10.1192/bjp.150.6.782

Dennis, C. L., & Ross, L. (2005). Relationships among infant sleep patterns, maternal fatigue, and development of depressive symptomatology. *Birth*, *32*, 187-193. doi: 10.1111/j.0730-7659.2005.00368.x

Dias, C.C., Figueiredo, B., & Pinto, T.M. (2018). Children's Sleep Habits Questionnaire – Infant Version. *Jornal de Pediatria (Rio J), 94*, 146-152. doi: 10.1016/j.jped.2017.05.012.

DiPietro, J. A., & Voegtline, K. M. (2017). The gestational foundation of sex differences in development and vulnerability. *Neuroscience, 342*, 4-20. doi: 10.1016/j.neuroscience.2015.07.068

Field, T. (2010). Postpartum depression effects on early interactions, parenting, and safety practices: a review. *Infant Behavior & Development*, *33*(1), 1-6. doi: 10.1016/j.infbeh.2009.10.005

Field, T., Diego, M., Hernandez-Reif, M., Figueiredo, B., Schanberg, S., & Kuhn, C. (2007). Sleep disturbances in depressed pregnant women and their newborns. *Infant Behavior & Development*, *30*, 127-133. doi:10.1016/j.infbeh.2006.08.002

Figueiredo, B., & Conde, A. (2011a). Anxiety and depression in women and men from early pregnancy to 3-months postpartum. *Archives of Women's Mental Health, 14*, 247-255. doi: 10.1007/s00737-011-0217-3

Figueiredo, B., & Conde, A. (2011b). Anxiety and depression symptoms in women and men from early pregnancy to 3-months postpartum: parity differences and effects. *Journal of Affective Disorders, 132*, 146-157. doi: 10.1016/j.jad.2011.02.007

Figueiredo, F., Dias, C.C., Pinto, T., & Field, T. (2016). Infant sleep-wake behaviors at two weeks, three and six months. *Infant Behavior and Development, 44*, 169-178. doi: 10.1016/j.infbeh.2016.06.011

Figueiredo, B., Pinto, T. M., Pacheco, A., & Field, T. (2017). Fetal heart rate variability mediates prenatal depression effects on neonatal neurobehavioral maturity. *Biological Psychology*, *123*, 294-301. doi: 10.1016/j.biopsycho.2016.10.013

Galland, B.C., Taylor, B.J., Elder, D.E., & Herbison, P. (2012). Normal sleep patterns in infants and children: A systematic review of observational studies. *Sleep Medicine Reviews, 16*, 213-222. doi: 10.1016/j.smrv.2011.06.00

Gentile, S. (2017). Untreated depression during pregnancy: short-and long-term effects in offspring. A systematic review. *Neuroscience, 342*, 154-166. doi: 10.1016/j.neuroscience.2015.09.001

Gerardin, P., Wendland, J., Bodeau, N., Galin, A., Bialobos, S., Tordjman, S., ... & Cohen, D. (2011). Depression during pregnancy: is the developmental impact earlier in boys? A prospective case-control study. *Journal of Clinical Psychiatry*, *72*, 378- 387. doi: 10.4088/JCP.09m05724blu

Glover, V., O'Donnell, K. J., O'Connor, T. G., & Fisher, J. (2018). Prenatal maternal stress, fetal programming, and mechanisms underlying later psychopathology —A global perspective. *Development and Psychopathology, 30*, 843-854. doi: 10.1017/S095457941800038X

Goodlin-Jones, B.L., Burnham, M.M., Gaylor, E.E., & Anders, T.F. (2001). Night waking, sleep-wake organization, and self-soothing in the first year of life. *Journal of Developmental & Behavioral Pediatrics, 22*, 226-233. doi: 10.1097/00004703-200108000-00003

Goodlin-Jones, B. L., Sitnick, S. L., Tang, K., Liu, J., & Anders, T. F. (2008). The Children's Sleep Habits Questionnaire in toddlers and preschool children. *Journal of Developmental & Behavioral Pediatrics, 29*, 82-88. doi: 10.1097/DBP.0b013e318163c39a

Gress-Smith, J. L., Luecken, L. J., Lemery-Chalfant, K., & Howe, R. (2012). Postpartum depression prevalence and impact on infant health, weight, and sleep in low-income and ethnic minority women and infants. *Maternal and Child Health Journal*, *16*(4), 887-893. doi: 10.1007/s10995-011-0812-y

Hughes, A., Gallagher, S., & Hannigan, A. (2015). A cluster analysis of reported sleeping patterns of 9-month old infants and the association with maternal health: results from a population based cohort study. *Maternal and Child Health Journal, 19*, 1881-1889. doi: 10.1007/s10995-015-1701-6

Hunter, L. P., Rychnovsky, J. D., & Yount, S. M. (2009). A selective review of maternal sleep characteristics in the postpartum period. *Journal of Obstetric, Gynecologic & Neonatal Nursing, 38*, 60-68. doi: 10.1111/j.1552-6909.2008.00309.x

Jomeen, J. & Martin, C. R. (2005). Confirmation of an occluded anxiety component within the Edinburgh Postnatal Depression Scale (EPDS) during early pregnancy. *Journal of Reproductive and Infant Psychology, 23*, 143-154, doi: 10.1080/02646830500129297

Lawson, A., Murphy, K. E., Sloan, E., Uleryk, E., & Dalfen, A. (2015). The relationship between sleep and postpartum mental disorders: a systematic review. *Journal of Affective Disorders*, *176*, 65-77. doi: 10.1016/j.jad.2015.01.017

Matthey, S. (2008). Using the Edinburgh Postnatal Depression Scale to screen for anxiety disorders. *Depression and Anxiety*, *25*, 926-931. doi: 10.1002/da.20415

McGinnis, E., Bocknek, E., Beeghly, M., Rosenblum, K. L., & Muzik, M. (2015). Does child sex moderate vulnerability to postpartum risk among infants of mothers at risk for psychopathology?. *Infancy, 20*, 42-69. doi: 10.1111/infa.12065

Netsi, E., van IJzendoorn, M. H., Bakermans-Kranenburg, M. J., Wulff, K., Jansen, P. W., Jaddoe, V. W., ... & Ramchandani, P. G. (2015). Does infant reactivity moderate the association between antenatal maternal depression and infant sleep?. *Journal of Developmental and Behavioral Pediatrics: JDBP*, *36*, 440-449. doi: 10.1097/DBP.0000000000000181.

Nevarez, M. D., Rifas-Shiman, S. L., Kleinman, K. P., Gillman, M. W., & Taveras, E. M. (2010). Associations of early life risk factors with infant sleep duration. *Academic Pediatrics*, *10*, 187-193. doi: 10.1016/j.acap.2010.01.007

O'Connor, T. G., Caprariello, P., Blackmore, E. R., Gregory, A. M., Glover, V., Fleming, P., & ALSPAC Study Team. (2007). Prenatal mood disturbance predicts sleep problems in infancy and toddlerhood. *Early Human Development*, *83*, 451-458. doi: 10.1016/j.earlhumdev.2006.08.006

Owens, J. A., Spirito, A., & McGuinn, M. (2000). The Children's Sleep Habits Questionnaire (CSHQ): psychometric properties of a survey instrument for school-aged children. *Sleep, 23*, 1043-1052. doi:10.1093/sleep/23.8.1d

Park, E. M., Meltzer-Brody, S., & Stickgold, R. (2013). Poor sleep maintenance and subjective sleep quality are associated with postpartum maternal depression symptom severity. *Archives of Women's Mental Health*, *16*, 539-547. doi: 10.1007/s00737-013-0356-9

Phillips, J., Charles, M., Sharpe, L., & Matthey, S. (2009). Validation of the subscales of the Edinburgh Postnatal Depression Scale in a sample of women with unsettled infants. *Journal of Affective Disorders, 118*, 101-112. doi: 10.1016/j.jad.2009.02.004

Rosenfeld, C. S. (2015). Sex-specific placental responses in fetal development. *Endocrinology*, *156*, 3422-3434. doi: 10.1210/en.2015-1227

Rutter, M. (1996). Transitions and turning points in developmental psychopathology: As applied to the age span between childhood and mid-adulthood. *International Journal of Behavioral Development*, *19*(3), 603-626.

Rutter, M., & Sroufe, L. A. (2000). Developmental psychopathology: Concepts and challenges. *Development and Psychopathology, 12*, 265-296. doi: 10.1017/S0954579400003023

Sandman, C., Glynn, L., & Davis E. (2013). Is there a viability–vulnerability tradeoff? Sex differences in fetal programming. *Journal of Psychosomatic Research, 75*, 327–335. doi: 10.1016/j.jpsychores.2013.07.009

Sette, S., Baumgartner, E., Ferri, R., & Bruni, O. (2017). Predictors of sleep disturbances in the first year of life: a longitudinal study. *Sleep Medicine, 36*, 78-85. doi: 10.1016/j.sleep.2017.04.015

Sivertsen, B., Harvey, A. G., Reichborn-Kjennerud, T., Torgersen, L., Ystrom, E., & Hysing, M. (2015). Later emotional and behavioral problems associated with sleep problems in toddlers: a longitudinal study. *JAMA Pediatrics*, *169*, 575-582. doi:10.1001/jamapediatrics.2015.0187

Smith-Nielsen, J., Matthey, S., Lange, T., & Væver, M. S. (2018). Validation of the Edinburgh Postnatal Depression Scale against both DSM-5 and ICD-10 diagnostic criteria for depression. *BMC Psychiatry, 18*, 393-405. doi: 10.1186/s12888-018-1965-7

Sroufe, L. A. (2009). The concept of development in developmental psychopathology. *Child Development Perspectives, 3*, 178-183. doi: 10.1111/j.1750-8606.2009.00103.x

Sroufe, L. A. (2016). Pathways to adaptation and maladaptation: psychopathology as developmental deviation. In D. Cicchetti (Ed.), *The emergence of a discipline: Rochester symposium on developmental psychopathology, volume 1* (pp. 27-54). New York: Taylor & Francis Group

Stein, A., Pearson, R. M., Goodman, S. H., Rapa, E., Rahman, A., McCallum, M., ... & Pariante, C. M. (2014). Effects of perinatal mental disorders on the fetus and child. *The Lancet*, *384*, 1800-1819. doi: 10.1016/S0140-6736(14)61277-0

Sutherland, S., & Brunwasser, S. M. (2018). Sex differences in vulnerability to prenatal stress: a review of the recent literature. *Current Psychiatry Reports, 20*, 102. doi: 10.1007/s11920-018-0961-4

Tendais, I., Costa, R., Conde, A., & Figueiredo, B. (2014). Screening for depression and anxiety disorders from pregnancy to postpartum with the EPDS and STAI. *The Spanish Journal of Psychology*, *17*, 1-9. doi: 10.1017/sjp.2014.7.

Underwood, L., Waldie, K., D'Souza, S., Peterson, E. R., & Morton, S. (2016). A review of longitudinal studies on antenatal and postnatal depression. *Archives of Women's Mental Health*, *19*, 711-720. doi: 10.1007/s00737-016-0629-1

Verreault, N., Da Costa, D., Marchand, A., Ireland, K., Dritsa, M., & Khalifé, S. (2014). Rates and risk factors associated with depressive symptoms during pregnancy and with postpartum onset. *Journal of Psychosomatic Obstetrics & Gynecology*, *35*, 84-91.doi: 10.3109/0167482X.2014.947953

Waumans, R. C., Terwee, C. B., Van den Berg, G., Knol, D. L., Van Litsenburg, R. R., & Gemke, R. J. (2010). Sleep and sleep disturbance in children: reliability and validity of the Dutch version of the Child Sleep Habits Questionnaire. *Sleep, 33*, 841-845. doi: 10.1093/sleep/33.6.841

Williams, K. E., Berthelsen, D., Walker, S., & Nicholson, J. M. (2017). A developmental cascade model of behavioral sleep problems and emotional and attentional self-regulation across early childhood. *Behavioral Sleep Medicine*, *15*(1), 1-21. doi: 10.1080/15402002.2015.1065410

Ystrom, H., Nilsen, W., Hysing, M., Sivertsen, B., & Ystrom, E. (2017). Sleep problems in preschoolers and maternal depressive symptoms: An evaluation of mother-and child-driven effects. *Developmental Psychology, 53*, 2261. doi: 10.1037/dev0000402

PAPER V

UNIDIRECTIONAL AND BIDIRECTIONAL LINKS BETWEEN MOTHER'S DEPRESSION SYMPTOMS AND INFANT'S SLEEP PROBLEMS[6]

Dias, C.C., & Figueiredo, B. (under review). Unidirectional and bidirectional links between mother's depression symptoms and infant's sleep problems. *Journal of Affective Disorders*

[6] This paper is under review at the Journal of Affective Disorders

Abstract

Background: This study explored (1) the unidirectional and bidirectional effects between mother's depression symptoms and infant's sleep problems and (2) the moderator role of infant's sex on these unidirectional and bidirectional effects.

Methods: Mothers (N = 312) completed measures of depression symptoms at the third pregnancy trimester, and measures of depression symptoms and infant's sleep problems at two weeks, and at three and six months postpartum.

Results: Findings revealed (1) a major unidirectional effect of mother's depression symptoms at the third pregnancy trimester on infant's sleep problems, particularly on infant's sleep anxiety and daytime sleepiness at three and six months, (2) bidirectional effects between mother's depression symptoms during the postpartum and infant's sleep anxiety at two weeks, three and six months, and (3) a moderator effect of infant's sex on the unidirectional and bidirectional effects between mother's depression symptoms and infant's sleep problems.

Limitations: Mothers completed both measures of mother's depression symptoms and infant's sleep problems and separate models were performed for each sleep problem.

Conclusions: Mother's prenatal depression symptoms are linked to infant´s sleep problems and infant´s sleep problems are linked to mother's postpartum depression symptoms. Boys are more susceptible to the effects of mother's depression symptoms and mothers are more susceptible to the effects of boys' sleep problems.

Keywords: depression symptoms; infant sleep problems; infant's sex; bidirectional effects.

1. Introduction

The links between mother's depression symptoms and infant sleep problems are complex and dynamic. Two models have been tested in the literature to explore these links: the maternal-driven model (Teti and Crosby, 2012) and the infant-driven model (Ystrom et al., 2017b). The maternal-driven model suggests that mother's depression may predict the emergence of infant's sleep problems (Teti and Crosby, 2012), while the infant-driven model suggests that infant's sleep problems may predict the emergence of mother's depression symptoms (Ystrom et al., 2017b). According to the transactional model (Sadeh et al., 2010; Sameroff, 1993), bidirectional effects may also occur, meaning that mother's depression may influence and concurrently be influenced by infant's sleep problems. Although unidirectional effects between mother's depression symptoms and infant's sleep problems are well established in the literature (Bat-Pitault et al., 2017; Hughes et al., 2015; Martini et al., 2017), the bidirectional effects were only recently investigated (Galbally et al., 2018; Ystrom et al., 2017a).

Research firstly showed that infants of depressed mothers during the postpartum period have more sleep problems (Bat-Pitault et al., 2017; Hughes et al., 2015; Ystrom et al., 2017a). Postpartum depressed mothers often present parenting difficulties, namely regarding feeding practices and sleep routines, more sleep problems, lower self-efficacy, more fatigue, and dysfunctional cognitions (e.g., Field, 2010; Okun et al., 2018; Giallo et al., 2011), that have been shown to be associated with infant's sleep problems (Field, 2017; Kouros and El-Sheikh, 2017; Teti and Crosby, 2012).

Research further showed that infants of depressed mothers during pregnancy have more sleep problems (Gerardin et al., 2011; Martini et al., 2017; Nevarez et al., 2010). Depressed mothers during pregnancy often present sleep difficulties, disruptive hormonal changes, namely reduced morning cortisol levels, tobacco consumption and poorer nutrition (e.g., Miguez et al., 2017; Monk et al., 2013; Szpunar and Parry, 2018), which may affect the environment in uterus and thus the fetus' neurobehavioral development (Barker, 2004; Glover et al., 2018; Martini et al., 2017). Later difficulties in the accomplishment of developmental tasks related with sleep may be expected (Dias et al., 2018; Figueiredo et al., 2016; Paavonen et al., 2020), due to detrimental effects from maternal prenatal depression symptoms on fetal self-regulation maturation (Davis et al., 2011; Figueiredo et al., 2017; Martini et al., 2017). This delay in the accomplishment of the self-regulation developmental task may trigger the emergence of infant's sleep problems during the first year of life (Byars et al., 2012; Paavonen et al., 2020; Sette et al., 2017).

Few studies analyzed the effects of both prenatal and postpartum depression symptoms on infant's sleep problems. To analyze the concurrent effect of both prenatal and postpartum depression on infant's sleep problems is crucial, considering that it is difficult to clearly link infant's sleep problems to postpartum depression symptoms when pregnancy depression symptoms are not taken in account. A large number of depressed mothers in the postpartum are already depressed during pregnancy (Figueiredo et al., 2007; Milgrom et al., 2008; Pampaka et al., 2019) and prenatal depression interfere negatively on infant self-regulation maturation, an important competency to regulate sleep (Davis et al., 2011; Figueiredo et al., 2017; Martini et al., 2017). To our knowledge, only one study analyzed the concurrent effects of mother's prenatal and postpartum depression symptoms on infant's sleep, showing no effect of mother's prenatal neither postpartum depression symptoms on infant's night wakings at six and 12 months (Galbally et al., 2018). In another previous longitudinal study, although the effects of mother's prenatal and postpartum depression were considered, mother postpartum depression was controlled to look at the effects of mother's prenatal depression on infant's sleep problems. This study showed that mother´s prenatal depression has a negative effect on infant's sleep problems, when postpartum depression was controlled (O'Connor et al., 2007).

The effects of mother's prenatal and postpartum depression on infant's development, namely on sleep problems, may be different according to infant's sex (Beeghly et al., 2017; McGinnis et al., 2015; Netsi et al., 2015). A recent study showed that boys of more depressed mothers during pregnancy were shown to present more sleep problems (Netsi et al., 2015).

More recent literature showed that infant's sleep problems may predict the emergence of mother's postpartum depression symptoms (Bayer et al., 2007; Hiscock and Wake, 2001; Ystrom et al., 2017b). Mothers of infants with sleep problems are at increased risk of presenting sleep difficulties (Kouros and El-Sheikh, 2017; Piteo et al., 2013; Sharkey et al., 2016), which in turn may lead to postpartum depression (Krawczak et al., 2016; Lawson et al., 2015; Piteo et al., 2013). And only more recently the reciprocal effects between mother's prenatal and postpartum depression symptoms and infant's sleep problems were considered (Galbally et al., 2018). To our knowledge, only one study included both (a) mother's prenatal and postpartum depression symptoms and (b) the bidirectional effects between mother's depression symptoms and infant's sleep during the first year (Galbally et al., 2018). In this study mother's prenatal and postpartum

depression symptoms were not predictors of infant's sleep problems and infant's sleep problems were not predictors of mother's postpartum depression symptoms (Galbally et al., 2018).

The moderator role of infant's sex was already shown on the bidirectional effects between mother's depression symptoms and different infant developmental outcomes (Antúnez et al., 2018; Choe et al., 2014), although not on infant's sleep problems. Considering previous findings, it can be hypothesized that the effects of mother's depression on infant's sleep problems may be higher in boys than in girls.

This study aimed to explore (1) the unidirectional and bidirectional effects between mother's depression symptoms and infant's sleep problems and (2) the moderator role of infant's sex on these unidirectional and bidirectional effects.

2. Method

2.1. Procedure

This study received approval of the Ethical Commissions of the two public hospitals and the University where the study took place. At the third pregnancy trimester, women were contacted at the Outpatients unit of two public hospitals in the Northern Portugal, during their routine prenatal appointments. Women were informed about the study purposes and procedures and invited to participate. Exclusion criteria included women not reading/writing Portuguese, multiple births, gestational or fetal complications, and psychiatric medication intake. From 536 women who met the inclusion criteria, 485 agreed to participate, signed an informed consent and completed the Socio-demographic Questionnaire and the Edinburgh Postnatal Depression Scale (EPDS) at the third pregnancy trimester. At two weeks, three, and six months postpartum women were contacted again by email and completed the Socio-demographic Questionnaire, the EPDS, and the Children's Sleep Habits Questionnaire – Infant Version (CHSQ-I). From the 485 mothers who completed the EPDS at the third pregnancy trimester, 202 completed the online measures at two weeks (41.6%), 243 at three months (50.1%), and 199 at six months (41.0%). Mothers were included in the analyses if they completed the online measures either two weeks, three or six months (N = 312; 64.3%).

2.2. Measures

2.2.1. Socio-demographic variables

The Socio-demographic Questionnaire assesses mother's demographic and obstetric characteristics, and infant's socio-demographic and biometric characteristics.

2.2.2. Mother's depression symptoms.

The EPDS (Cox et al., 1987) was used to assess prenatal and postpartum depression symptoms. It is a self-report scale that assesses depression symptoms within the previous seven days and includes 10 items scored on a four-point Likert-type scale. Higher scores on the EPDS are indicative of more depression symptoms. The Portuguese version of the EPDS showed good internal consistency (α= .88; Tendais et al., 2014). In the present sample EPDS also showed good internal consistency at the third pregnancy trimester (α= .85), and at two weeks, three and six months postpartum (α's ranging from .83 to .88).

2.2.3. Infant's sleep problems.

The CSHQ-I (Dias et al., 2018) assesses sleep problems in infants aged 0-12 months old, being a Portuguese adapted version of the Children's Sleep Habits Questionnaire – CSHQ (Owens et al., 2000). The CSHQ-I is one of the few existing measures to assess infant's sleep problems in infants during the first year of infant's life (Sadeh, 2004). It is a retrospective questionnaire for parents to report infant sleep habits and behaviors in a typical week. It is comprised of 33 items scored in a three-point Likert scale and encloses four subscales: (1) Bedtime Resistance: infant's resistance to go to bed and frequent night waking (e.g., "*Child falls asleep alone in own bed*"); (2) Sleep Anxiety: infant's anxiety related to sleep, and items of sleep-disordered breathing and parasomnias (e.g., "*Child awakens during night screaming, sweating, and inconsolable*"); (3) Positive Sleep Habits: infant's bedtime and morning waking routines (e.g., "*Child goes to bed at the same time at night*"); and (4) Daytime Sleepiness: daytime consequences from sleep problems (e.g., "*Child takes a long time to become alert in the morning*"). The CSHQ-I total scale and sub-scales scores are computed through the sum of the items divided by the number of items (scores ranging from zero to two). Higher scores in the CSHQ-I are indicative of more sleep problems. The CSHQ-I version showed good internal (α = .77 for the total scale and between .52-.77 for the four sub-scales) and construct validity (Dias et al., 2018). In the present sample, the CSHQ-I presented an internal consistency similar to the validation version (α's .71-.81 for the total scale and .39-.78 for the sub-scales). Similar to what was reported in the validation version, daytime sleepiness sub-scales presented the lowest reliability scores (α's .39-.49).

2.3. Statistical analyses

To explore the (1) unidirectional and bidirectional effects between mother's depression symptoms and infant's sleep problems, cross-lagged path analyses using a structural equation modeling (SEM) were performed in AMOS 22. A path model was tested with the mother's

depression symptoms measured in four time-points (third pregnancy trimester, two weeks, three months, and six months) paired with infant's sleep problems (CSHQ-I total score, bedtime resistance, sleep anxiety, positive sleep habits, and daytimes sleepiness) measured in three time-points (two weeks, three months, and six months), with a focus on the unidirectional associations between mother's prenatal depression symptoms and infant's sleep problems at two weeks, three and six months and in the cross-lagged relationships between mother's depression symptoms and infant's sleep problems. A continuous-time cross-lagged design was adopted to analyze the unidirectional and bidirectional relationships between mother's depression symptoms and infant's sleep problems since the third pregnancy trimester to six months postpartum. The transactional (recursive) paths were tested, controlling for all the potential relationships between the studied variables (Martens and Haase, 2006). The autoregressive paths (e.g., mother's depression symptoms at the third pregnancy trimester on mother's depression symptoms at two weeks) and the within-time correlations (e.g., mother's depression symptoms at two weeks with infant's sleep problems at two weeks) were also tested. The autoregressive paths between mother's depression symptoms at the third pregnancy trimester and mother's depression symptoms at three and six months were also included in the model, considering the association between mother's prenatal and postpartum depression (Figueiredo et al., 2007; Milgrom et al., 2008; Pampaka et al., 2019). As autoregressive paths were included, inferences regarding the temporal relationships between mother's depression symptoms and infant's sleep problems can be performed from the cross-lagged models (Singer and Willett, 2003). All cases were retained using the FIML method for dealing with missing data. The maximum likelihood estimation procedure was used.

To explore (2) the moderator role of infant's sex on the unidirectional and the bidirectional effects between mother's depression symptoms and infant's sleep problems over the first six months of life, infant's sex was included as a multi-group variable in the tested cross-lagged path analyses using a SEM in AMOS 22.

Following previous recommendations (Kline, 2005) indices of different classes were examined to analyze the model goodness of fit, namely the chi square (χ^2) statistics, the ratio of χ^2 to degrees of freedom (χ^2/df), the Comparative Fit Index (CFI), and the Root Mean Square Error of approximation (RMSEA). Recommendations for good model fit suggest a non-significant χ^2, a $\chi^2/df \leq 3$, a CFI $\geq .95$ and a RMSEA $\leq .06$-$.08$ (Kline, 2005; Schreiber et al., 2006).

3. Results

3.1. Participants' characteristics

This study included 312 mother-infant dyads. The majority of the mothers were white (91.8%), married or cohabiting (80.9%), and more than half were aged 25-34 years old (68.6%), employed (73.4%), from a high socio-economic level (58.4%), and had more than 12 years of schooling (60.9%).

Table 20.
Socio-demographic characteristics

			Total
			N = 312
			%
Mother	Age	18-24	10.1
		25-34	68.6
		35-44	21.2
	Ethnicity	White	91.8
		Other	8.2
	Marital status	Married/cohabiting	80.9
		Single/divorced/widow	19.1
	Occupational status	Employed	73.4
		Unemployed/Household/student	26.6
	Socio-economic level	High	58.4
		Medium	32.1
		Low	9.5
	Years of schooling	≤ 12	39.1
		>12	60.9
Gestation	Type of delivery	Vaginal	64.2
		Caesarean	35.8
	Gestational age	< 37 weeks	3.6
		≥ 37 weeks	96.4
Infant	Gender	Female	46.5
		Male	53.5
	Weight	< 2500g	1.7
		≥ 2500 g	98.3
	Length	< 48 cm	21.8
		≥ 48 cm	78.2
	First born	Yes	85.5
		No	14.5
	Sleep arrangements	Daily bed-sharing	12.5
		1-6 days/week bed-sharing	27.0
		Solitary sleeping	60.5

About half of the infants were males (53.5%) and another half were females (46.5%), the majority were born at term (≥ 37 weeks of gestation; 96.4%), had normal birth weight (≥ 2500g; 98.3%) and length (≥ 48cm; 78.2%), were first born (85.5%), were not bedsharing daily with the mother (87.5%) and presented no health problems during the first six months (91.3%). More than half of the infants were born by vaginal delivery (64.2%; see Table 20).

3.2. Preliminary analyses

Means and standard deviations for mother's depression symptoms at the third pregnancy trimester and for mother's depression symptoms and infant's sleep problems at two weeks, three and six months are presented in Table 21.

Table 21.
Study's variables' means and standard deviations

	3rd trimester *M (SD)*	2 weeks *M (SD)*	3 months *M (SD)*	6 months *M (SD)*
Depression symptoms	7.13 (4.40)	5.28 (4.27)	4.82 (3.94)	4.97 (3.82)
CSHQ-I total score		0.52 (0.20)	0.44 (0.23)	0.40 (0.23)
Bedtime resistance		0.74 (0.35)	0.67 (0.41)	0.66 (0.41)
Sleep anxiety		0.13 (0.17)	0.15 (0.20)	0.16 (0.23)
Positive sleep habits		1.05 (0.41)	1.37 (0.37)	1.48 (0.34)
Daytime sleepiness		0.11 (0.27)	0.09 (0.23)	0.10 (0.20)

M = Mean; *SD* = Standard Deviation;

3.3. Unidirectional and bidirectional effects between mother's depression symptoms and infant's sleep problems

The same models were tested for the CSHQ-I total score and each sub-scale (see Table 22). The cross lagged path models (including both unidirectional and bidirectional paths) for CSHQ-I total score, bedtime resistance, positive sleep habits and daytime sleepiness did not reveal a good fit to the data (see Table 22).

Table 22.

Model goodness of fit indices for each tested model

	Cross lagged path models (including both unidirectional and bidirectional paths)				Unidirectional models			
	$\chi 2$	$\chi 2/df$	CFI	RMSEA	$\chi 2$	$\chi 2/df$	CFI	RMSEA
CSHQ-I total score	χ^2 (4) = 10.32, p = .032	2.58	.99	.07	χ^2 (10) = 16.20, p = .070	1.62	.99	.05
Boys					χ^2 (10) = 17.82, p = .058	1.78	.99	.07
Girls					χ^2 (10) = 24.45, p = .006	2.45	.95	.10
Bedtime resistance	χ^2 (4) = 11.83, p = .019	2.96	.99	.08	χ^2 (10) = 16.17, p = .070	1.62	.99	.05
Boys					χ^2 (10) = 16.91, p = .076	1.79	.97	.07
Girls					χ^2 (10) = 24.79, p = .006	2.48	.95	.10
Sleep anxiety	χ^2 (4) = 8.53, p = .074	2.13	.99	.06				
Boys	χ^2 (4) = 5.80, p = .215	1.45	.99	.05				
Girls	χ^2 (5) = 16.04, p = .006	3.21	.95	.15				
Positive sleep habits	χ^2 (4) = 12.28, p = .015	3.01	.98	.08	χ^2 (10) = 15.36, p = .119	1.54	.99	.05
Boys					χ^2 (10) = 16.57, p = .084	1.66	.97	.06
Girls					χ^2 (10) = 18.72, p = .044	1.87	.96	.08
Daytime sleepiness	χ^2 (4) = 10.65, p = .031	2.66	.98	.07	χ^2 (10) = 12.25, p = .162	1.23	.99	.04
Boys					χ^2 (10) = 9.67, p = .470	0.97	1.00	.00
Girls					χ^2 (10) = 19.23, p = .037	1.92	.96	.08

Notes: χ^2: chi square; χ^2/df: ratio of χ^2 to degrees of freedom; CFI: Comparative Fit Index; RMSEA: Root Mean Square Error of approximation

Good fit to the data was found when bidirectional paths were removed (see Figure 6 for an illustrated example of the unidirectional models tested):

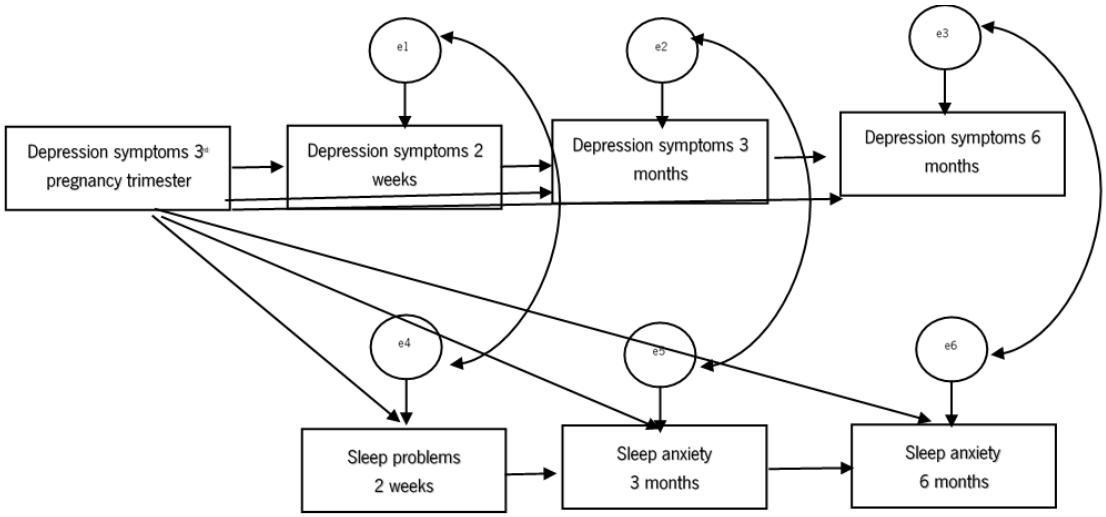


Figure 6. Illustrated example of the unidirectional model for maternal depression symptoms and infant's CSHQ-I total score, bedtime resistance, positive sleep habits and daytime sleepiness.

CSHQ-I total score: more mother's depression symptoms at the third pregnancy trimester marginally predicted more infant's CSHQ-I total score at two weeks, β = .01, p = .053, and significantly predicted more infant's CSHQ-I total score at six months, β = .04, p = .013.

Bedtime resistance: more mother's depression symptoms at the third pregnancy trimester marginally predicted more infant's bedtime resistance at two weeks, β = .01, p = .084.

Positive sleep habits: mother's depression symptoms at the third pregnancy trimester did not predict infant's positive sleep habits at two weeks and at six months.

Daytime sleepiness: more mother's depression symptoms at the third pregnancy trimester significantly predicted more infant's daytime sleepiness at three, β = .01, p = .021, and at six months, β = .01, p = .005.

Sleep anxiety: the cross lagged path model revealed an adequate fit to the data (see Table 22 and Figure 7). The unidirectional paths showed that more mother's depression symptoms at the third pregnancy trimester significantly predicted more infant's sleep anxiety at six months, β = .31, p < .001. The bidirectional (cross-lagged) paths showed that more mother's depression symptoms at the third pregnancy trimester predicted more infant's sleep anxiety at two weeks, β = .21, p = .002, and more infant's sleep anxiety at two weeks predicted more mother's depression symptoms at three months, β = .20, p < .001. Likewise, more infant's sleep anxiety at three

months predicted more mother's depression symptoms at six months, β = .11, p = .041 (see Figure 7). Non-significant cross-lagged effects were found between mother's depression symptoms at three months and infant's sleep anxiety at six months, and between mother's depression symptoms at two weeks and infant's sleep anxiety at three months.

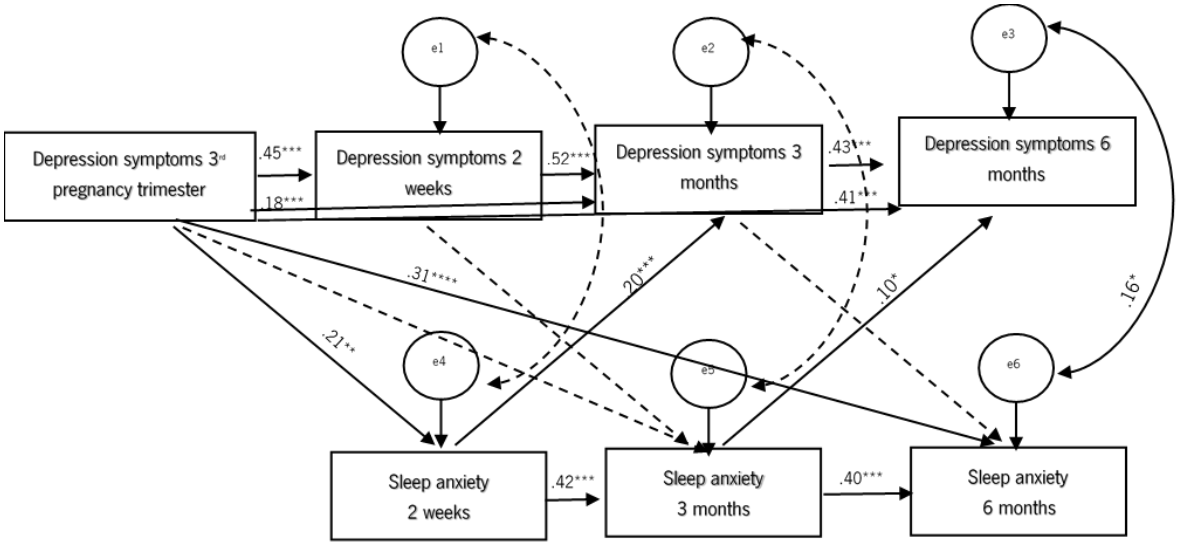


Figure 7. Cross-lagged path model for mother's depression symptoms and infant's sleep anxiety. Significant standardized parameter estimates are shown. Significant paths are shown by solid paths and non-significant paths are shown by dotted paths. * p < .05; **p < .01; ***p < .001.

3.4. The moderator role of infant's sex on the unidirectional and the bidirectional effects between mother's depression symptoms and infant's sleep problems

CSHQ-I total score, bedtime resistance, positive sleep habits and daytime sleepiness: the models revealed good fit for boys, while revealing poor fit for girls (see Table 22). The models for boys revealed that more mother's depression symptoms at the third pregnancy trimester (1) marginally predicted more CSHQ-I total score at two weeks, β = .01, p = .051, and significantly predicted more CSHQ-I total score at six months, β = .02, p = .001; (2) marginally predicted more bedtime resistance at two weeks, β = .01, p = .085, (3) significantly predicted less positive sleep habits at six months, β = -.02, p = .003; and (4) marginally predicted more daytime sleepiness at three months, β = .01, p = .056, and significantly predicted more daytime sleepiness at six months, β = .01, p = .005.

Sleep anxiety: the model revealed good fit for boys, while revealing poor fit for girls (see Table 22). The cross-lagged paths of the model for boys showed that more mother's depression

symptoms at the third pregnancy trimester predicted more sleep anxiety at two weeks in boys, β = .24, p = .013. Likewise, more mother's depression symptoms at two weeks predicted more sleep anxiety at three months in boys, β = .18, p = .038, and more sleep anxiety at three months in boys predicted more mother's depression symptoms at six months, β = .14, p = .050 (see Figure 8).

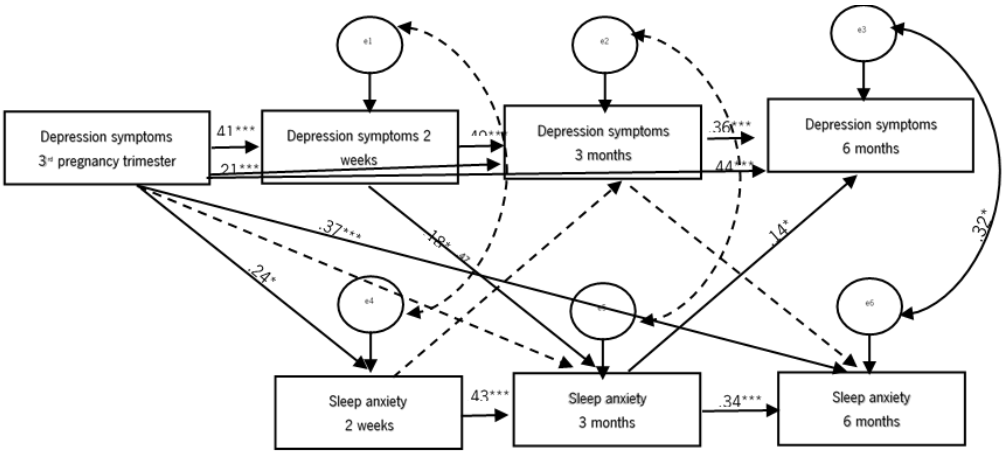


Figure 8. Cross-lagged path model for mother's depression symptoms and infant's sleep anxiety in boys. Significant standardized parameter estimates are shown. Significant paths are shown by solid paths and non-significant paths are shown by dotted paths. * p < .05; **p < .01; ***p < .001.

4. Discussion

Findings revealed (1) a major unidirectional effect of mother's depression symptoms at the third pregnancy trimester on infant's sleep problems, particularly on infant's sleep anxiety and daytime sleepiness at three and six months; (2) bidirectional effects between mother's depression symptoms during the postpartum and infant's sleep anxiety at two weeks, three and six months of life; and (3) a moderator effect of infant's sex on the reported unidirectional and bidirectional effects between mother's depression symptoms and infant's sleep problems.

A major unidirectional effect of mother's depression symptoms at the third pregnancy trimester was found on infant's sleep problems, particularly on infant's sleep anxiety and daytime sleepiness at three and six months. This study highlighted the main role of prenatal depression symptoms on the emergence of infant's sleep problems. Congruent with previous studies (Gerardin et al., 2011; Martini et al., 2017; Nevarez et al., 2010), mother's depression symptoms at the third pregnancy trimester predicted infant's sleep problems at three and six months. Previous

research had already recognized the major impact of mother's prenatal depression on infant's sleep problems, but in a study where mother's postpartum depression was controlled (O'Connor et al., 2007). The present study adds to the literature by showing the significant effect of mother's prenatal depression symptoms on infant's sleep problems at three and six months, even when considering the concurrent effects of mother's postpartum depression symptoms in different time periods.

Pregnancy depression is associated with maternal sleep difficulties, disruptive hormonal changes, and more unhealthy habits, namely tobacco consumption and poorer nutrition (e.g., Miguez et al., 2017; Monk et al., 2013; Szpunar and Parry, 2018). As a consequence, alterations in the embryotic environment may occur, leading to long term consequences on infant development, namely on self-regulation maturation (Davis et al., 2011; Figueiredo et al., 2017; Martini et al., 2017). Due to delayed self-regulation maturation, these infants may present difficulties in accomplishing the developmental tasks related to sleep after birth, which may lead to the emergence of sleep problems (Byars et al., 2012; Paavonen et al., 2020; Sette et al., 2017).

These results may be explained under the light of the fetal programming theory. According with this theory, prenatal maternal depression symptoms may act as a programming signal that infants incorporate into their further development, causing long term consequences on their trajectory (Barker, 2004; Davis et al., 2018; Glover et al., 2018). These prenatal signs may be either an advantage, as they prepare the infant to better adapt and successfully survive in a similar postnatal environment, and also a risk, as they may increase the vulnerability for the emergence of developmental problems (Conradt et al., 2018; Davis et al., 2011; Davis et al., 2018). The signs sent by prenatally depressed mothers may prepare the infants to better deal with a postpartum depressed mother (Conradt et al., 2018; Davis et al., 2011; Davis et al., 2018), who are usually identified in the literature as withdrawn, less sensitive and not contingently responding in the interaction with their infant (e.g., Beebe et al., 2008; Leckman-Westin et al., 2009; Santona et al., 2015). Considering this perspective, a possible explanation for the present study's results is that while presenting more sleep anxiety, for example waking up during the night alarmed by a frightening dream, the infant may promote an increased reactivity and a more vigilant profile on their mothers. However, while presenting a more sleep anxiety, the infant may be also be at increased risk for the emergence of sleep problems (Byars et al., 2012; Paavonen et al., 2020; Sette et al., 2017).

Bidirectional effects between mother's depression symptoms during the postpartum and infant's sleep anxiety at two weeks, three and six months of life were also found. Mother's depression symptoms affect but are also affected by infant's sleep anxiety. The results of this study added that mother's prenatal depression symptoms are specifically linked with more infant's sleep anxiety and that infant's sleep anxiety is specifically linked with more mother's postpartum depression symptoms, which, in turn, is associated with more infant's sleep anxiety. A possible explanation for this result is that infant's sleep anxiety, for example the infant waking up during the night screaming, sweating, and inconsolable, might interfere with mother's sleep, increase mother's fatigue, and decrease mother's perceived self-efficacy, leading to the emergence of depression symptoms (Dennis and Ross, 2005; Giallo et al., 2011; Kouros and El-Sheikh, 2017). Conversely, postpartum depressed mothers may present more sleep problems, lower self-efficacy, fatigue, and dysfunctional cognitions regarding sleep, which may interfere with the mother's ability to implement consistent sleep routines with their infants, and lead to the emergence of more infant's sleep anxiety (e.g., Field, 2017; Kouros and El-Sheikh, 2017; Teti and Crosby, 2012). This result supports the transactional model framework (Sameroff, 1993), suggesting that infant's sleep problems are part of transactional familiar dynamics, with reciprocal effects occurring between infant and parental factors, namely mother's depression symptoms (El-Sheikh and Kelly, 2017; Sadeh et al., 2010).

No bidirectional effects were found between mother's postpartum depression symptoms and infant's bedtime resistance, positive sleep habits, daytime sleepiness and total sleep problems. Considering that bedtime resistance sub-scale assesses infant's frequent night waking, these results are congruent with previous findings that found no bidirectional effects between mother's postpartum depression symptoms and infant's night wakings (Galbally et al., 2018). However, a previous study with older children revealed reciprocal effects between maternal mood and children's sleep problems, although not considering the effects of mother's prenatal depression symptoms (Bell & Belsky, 2008). The absence of bidirectional effects between mother's depression symptoms and most of the sleep problems dimensions during the first six months, may suggest that these effects may only be observable later in childhood.

Unidirectional and bidirectional effects between mother's depression symptoms and infant's sleep problems are moderated by infant's sex. Results revealed that boys are more

susceptible to the effects of mother's depression symptoms and mothers are more susceptible to the effects of their sons' sleep problems.

Regarding unidirectional effects, mother's prenatal depression symptoms were found to affect more boys' than girls' sleep, specifically sleep anxiety, positive sleep habits and daytime sleepiness. This result is congruent with a previous study, that showed that, when the mother is depressed during pregnancy, boys present higher dysregulation of sleep-wake behavior than girls (Netsi et al., 2015). The higher vulnerability of boys to mother's prenatal depression symptoms may result from the embryonic developmental differences between boys and girls, with females presenting a higher ability than males to adapt to sub optimal intrauterine environments (Lorente-Pozo et al., 2018; Sandman et al., 2013; Sutherland and Brunwasser, 2018).

The bidirectional effects between mother's depression symptoms and infant's sleep anxiety also occur only in boys. This result added to the literature by suggesting that mothers are more susceptible to the effects of boys' sleep problems. A previous study already showed an association between infant's sex and mother's depression symptoms, revealing that having a boy is associated with mother's reduced quality of life and more postpartum depression symptoms (De Tychey et al., 2008). The present study shown that sleep anxiety in boys, more than sleep anxiety in girls, is associated with an increase of their mother's depression symptoms. Previous research already showed that boys present more sleep difficulties than girls (Blair et al., 2012; Dias and Figueiredo, 2019; Kaley et al., 2012) and, also, that boys are more affected in their sleep by mother's depression symptoms than girls (Beeghly et al., 2017; McGinnis et al., 2015; Netsi et al., 2015). A possible explanation for this study's results is that mothers of boys may present an increased difficulty in dealing with their infant's sleep routines, leading to lower maternal self-efficacy, which in turn may increase mother's postpartum depression symptoms (Falah-Hassani et al., 2014; Haslam et al., 2006; Giallo et al., 2014).

4.1. Limitations

Limitations of this study should also be pointed out. Mothers completed both measures of mother's depression symptoms and infant's sleep problems. This may be considered a limitation as previous research showed that depressed mothers at postpartum present dysfunctional cognitions related to infant's sleep (e.g., Teti and Crosby, 2012). However, a strong association between direct and parental report measures of infant's sleep has been found in the literature (Werner et al., 2008). Moreover, the within-time correlations between mother's depression

symptoms and infant's sleep problems were controlled in the cross-lagged model. Separate models were performed for each CSHQ-I sub-scale. This may be considered a limitation as the four sub-scales were shown to be significantly correlated (Dias et al., 2018).

4.2. Implications for research and practice

The findings of this study present relevant implications for research and clinical practice. Future research analyzing the effects of mother's depression symptoms on infant's sleep problems should (1) include both mother's prenatal and postpartum depression symptoms and (2) consider both the unidirectional and the bidirectional effects between mother's depression symptoms and infant's sleep problems. Additionally, further studies should deeply explore the moderator effect of infant's sex on the effects between mother's prenatal and postpartum depression symptoms and infant's sleep problems. Namely, future studies should analyze the characteristics of boys that may help to explain their increased vulnerability. Considering previous research showing the effect of father's depression on child developmental outcomes (e.g., Ramchandani et al., 2005; Sweeney and MacBeth, 2016; Volling et al., 2019), future studies should also analyze the effect of father's depression symptoms, specifically during the postpartum, on infant's sleep problems

Regarding the implications for clinical practice, these findings may inform clinicians on the need of screening mother's depression symptoms during prenatal care to better identify infants at risk of sleep problems and mothers at risk of postpartum depression. Moreover, future interventions on infant's sleep problems should clearly include strategies to deal with mother's depression symptoms.

4.3. Conclusion

This study tested a comprehensive mother-infant interactive longitudinal model, (1) including mother's prenatal and postpartum depression symptoms, (2) analyzing the unidirectional and bidirectional effects between mother's depression symptoms and infant's sleep problems, and (3) analyzing the moderator effect of infant's sex on the reported unidirectional and bidirectional effects between mother's depression symptoms and infant's sleep problems. The effects between mother's depression symptoms and infant's sleep problems are mainly unidirectional, and mostly from mother's prenatal depression symptoms to infant sleep problems. During the postpartum period, bidirectional effects may occur, and infant's sleep anxiety increase mother's depression symptoms. This study highlighted that although mother's prenatal depression symptoms are linked

to more infant´s sleep problems, infant's sleep problems are linked to an increase of mother's postpartum depression symptoms. This study also revealed that both unidirectional and bidirectional effects between mother's prenatal and postpartum depression symptoms and infant's sleep problems occur mainly in boys. Boys are more susceptible to the effects of mother's prenatal and postpartum depression symptoms and mothers are more susceptible to the effects of boys' sleep problems.

References

Antúnez, Z., de la Osa, N., Granero, R., Ezpeleta, L., 2018. Reciprocity between parental psychopathology and oppositional symptoms from preschool to middle childhood. J Clin Psych, 74, 489-504. https://doi.org/10.1002/jclp.22504

Barker, D.J.P., 2004. The developmental origins of adult disease. J Am Coll Nut, 23, 588S–595S. https://doi.org/10.1080/07315724.2004.10719428

Bat-Pitault, F., Sesso, G., Deruelle, C., Flori, S., Porcher-Guinet, V., Stagnara, C., ... Patural, H., 2017. Altered sleep architecture during the first months of life in infants born to depressed mothers. Sleep Med, 30, 195-203. https://doi.org/10.1016/j.sleep.2016.11.018

Beebe, B., Jaffe, J., Buck, K., Chen, H., Cohen, P., Feldstein, S., Andrews, H., 2008. Six-week postpartum maternal depressive symptoms and 4-month mother–infant self-and interactive contingency. Infant Men Health J, 29, 442-471. https://doi.org/10.1002/imhj.20191

Beeghly, M., Partridge, T., Tronick, E., Muzik, M., Rahimian Mashhadi, M., Boeve, J. L., Irwin, J.L., 2017. Associations between early maternal depressive symptom trajectories and toddlers' felt security at 18 months: are boys and girls at differential risk? Infant Ment Health J, 38, 53-67. https://doi.org/10.1002/imhj.21617

Blair, P.S., Humphreys, J. S., Gringras, P., Taheri, S., Scott, N., Emond, A., ... Fleming, P.J., 2012. Childhood sleep duration and associated demographic characteristics in an English cohort. Sleep, 35, 353-360. https://doi.org/10.5665/sleep.1694

Byars, K.C., Yolton, K., Rausch, J., Lanphear, B., Beebe, D.W., 2012. Prevalence, patterns, and persistence of sleep problems in the first 3 years of life. Pediatrics, 129, e276-e284. https://doi.org/10.1542/peds.2011-0372

Choe, D.E., Olson, S.L., Sameroff, A.J., 2014. Effortful control moderates bidirectional effects between children's externalizing behavior and their mothers' depressive symptoms. Child Dev, 85, 643-658. https://doi.org/10.1111/cdev.12123

Conradt, E., Adkins, D.E., Crowell, S.E., Raby, K.L., Diamond, L.M., Ellis, B., 2018. Incorporating epigenetic mechanisms to advance fetal programming theories. Dev Psychopathol, 30, 807-824. https://doi.org/10.1017/S0954579418000469

Cox, J.L., Holden, J.M., & Sagovsky, R., 1987. Detection of postnatal depression: development of the 10-item Edinburgh Postnatal Depression Scale. Br J Psychiatry, 150, 782-786. https://doi.org/10.1192/bjp.150.6.782

Davis, E.P., Glynn, L.M., Waffarn, F., Sandman, C.A., 2011. Prenatal maternal stress programs infant stress regulation. J Child Psych Psychiatry, 52, 119-129. https://doi.org/10.1111/j.1469-7610.2010.02314.x

Davis, E. P., Hankin, B.L., Swales, D.A., Hoffman, M.C., 2018. An experimental test of the fetal programming hypothesis: Can we reduce child ontogenetic vulnerability to psychopathology by decreasing maternal depression?. Dev Psychopathol, 30, 787-806. https://doi.org/10.1017/S0954579418000470

De Tychey, C., Briançon, S., Lighezzolo, J., Spitz, E., Kabuth, B., De Luigi, V., ... Vincent, S., 2008. Quality of life, postnatal depression and baby gender. J Clin Nurs, 17, 312-322. https://doi.org/10.1111/j.1365-2702.2006.01911.x

Dias, C.C., Figueiredo, B., 2019. Sleep-wake behavior during the first 12 months of life and associated factors: a systematic review. Early Child Dev Care, online publication before print. https://doi.org/10.1080/03004430.2019.1582034

Dias, C.C., Figueiredo, B., Pinto, T.M., 2018. Children's Sleep Habits Questionnaire – Infant Version. J Ped (Rio J), 94, 146-152. http://dx.doi.org/10.1016/j.jped.2017.05.012

Dias, C.C., Figueiredo, B., Rocha, M., & Field, T., 2018. Reference values and changes in infant sleep-wake behavior during the first 12 months of life: a systematic review. J Sleep Res, 27, e12654. https://doi.org/10.1111/jsr.12654

El-Sheikh, M., Kelly, R.J., 2017. Family functioning and children's sleep. Child Dev Perspect, 11, 264-269. https://doi.org/10.1111/cdep.12243

Falah-Hassani, K., Shiri, R., Dennis, C.L., 2016. Prevalence and risk factors for comorbid postpartum depressive symptomatology and anxiety. J Affect Dis, 198, 142-147. https://doi.org/10.1016/j.jad.2016.03.010

Field, T., 2010. Postpartum depression effects on early interactions, parenting, and safety practices: a review. Infant Behav Dev, 33, 1-6. https://doi.org/10.1016/j.infbeh.2009.10.005

Field, T., 2017. Infant sleep problems and interventions: a review. Infant Behav Dev, 47, 40-53. https://doi.org/10.1016/j.infbeh.2017.02.002

Figueiredo, F., Dias, C.C., Pinto, T., Field, T., 2016. Infant sleep-wake behaviors at two weeks, three and six months. Infant Behav Dev, 44, 169-178. https://doi.org/10.1016/j.infbeh.2016.06.011

Figueiredo, B., Pacheco, A., Costa, R., 2007. Depression during pregnancy and the postpartum period in adolescent and adult Portuguese mothers. Arch Womens Ment Health, 10, 103-109. https://doi.org/10.1007/s00737-007-0178-8

Figueiredo, B., Pinto, T.M., Pacheco, A., Field. T., 2017. Fetal heart rate variability mediates prenatal depression effects on neonatal neurobehavioral maturity. Biol Psychol, 123, 294-301. https://doi.org/10.1016/j.biopsycho.2016.10.013

Galbally, M., Watson, S.J., Teti, D., Lewis, A.J., 2018. Perinatal maternal depression, antidepressant use and infant sleep outcomes: exploring cross-lagged associations in a pregnancy cohort study. J Affect Dis, 238, 218-225. https://doi.org/10.1016/j.jad.2018.05.025

Gerardin, P., Wendland, J., Bodeau, N., Galin, A., Bialobos, S., Tordjman, S., ... Cohen, D., 2011. Depression during pregnancy: is the developmental impact earlier in boys? A prospective case-control study. J Clin Psychiatry, 72, 378- 387. https://doi.org/10.4088/JCP.09m05724blu

Giallo, R., Rose, N., Vittorino, R., 2011. Fatigue, wellbeing and parenting in mothers of infants and toddlers with sleep problems. J Reprod Infant Psychol, 29, 236-249.

Giallo, R., Cooklin, A., Nicholson, J.M., 2014. Risk factors associated with trajectories of mothers' depressive symptoms across the early parenting period: an Australian population-based longitudinal study. Arch Womens Ment Health, 17, 115-125. https://doi.org/10.1080/02646838.2011.593030

Glover, V., O'Donnell, K.J., O'Connor, T.G., Fisher, J., 2018. Prenatal maternal stress, fetal programming, and mechanisms underlying later psychopathology—A global perspective. Dev Psychopathol, 30, 843-854. https://doi.org/10.1017/S095457941800038X

Haslam, D.M., Pakenham, K.I., Smith, A., 2006. Social support and postpartum depressive symptomatology: the mediating role of maternal self-efficacy. Infant Ment Health J, 27, 276-291. https://doi.org/10.1002/imhj.20092

Hiscock, H., Wake, M., 2001. Infant sleep problems and postnatal depression: a community-based study. Pediatrics, 107, 1317-1322. https://doi.org/10.1542/peds.107.6.1317

Hughes, A., Gallagher, S., Hannigan, A., 2015. A cluster analysis of reported sleeping patterns of 9-month old infants and the association with maternal health: results from a population based cohort study. Matern Child Health J, 19, 1881-1889.

https://doi.org/10.1007/s10995-015-1701-6

Kaley, F., Reid, V., Flynn, E., 2012. Investigating the biographic, social and temperamental correlates of young infants' sleeping, crying and feeding routines. Infant Behav Dev, 35, 596-605. https://doi.org/10.1016/j.infbeh.2012.03.004

Kouros, C.D., El-Sheikh, M., 2017. Within-family relations in objective sleep duration, quality, and schedule. Child Dev, 88, 1983-2000. https://doi.org/10.1111/cdev.12667

Krawczak, E.M., Minuzzi, L., Hidalgo, M.P., Frey, B.N., 2016. Do changes in subjective sleep and biological rhythms predict worsening in postpartum depressive symptoms? A prospective study across the perinatal period. Arch Womens Ment Health, 19, 591-598. https://doi.org/10.1007/s00737-016-0612-x

Lawson, A., Murphy, K.E., Sloan, E., Uleryk, E., Dalfen, A., 2015. The relationship between sleep and postpartum mental disorders: a systematic review. J Affect Dis, 176, 65-77. https://doi.org/10.1016/j.jad.2015.01.017

Leckman-Westin, E., Cohen, P.R., Stueve, A., 2009. Maternal depression and mother–child interaction patterns: association with toddler problems and continuity of effects to late childhood. J Child Psychol Psychiatry, 50, 1176-1184. https://doi.org/10.1111/j.1469-7610.2009.02083.x

Lorente-Pozo, S., Parra-Llorca, A., Torres, B., Torres-Cuevas, I., Nuñez-Ramiro, A., Cernada, M., ... Vento, M., 2018. Influence of sex on gestational complications, fetal-to-neonatal transition, and postnatal adaptation. Front Pediatr, 6, 63-89. https://doi.org/10.3389/fped.2018.00063

Martens, M.P., Haase, R.F., 2006. Advanced applications of structural equation modeling in counseling psychology research. Couns Psychol, 34, 878-911. https://doi.org/10.1177/0011000005283395

Martini, J., Petzoldt, J., Knappe, S., Garthus-Niegel, S., Asselmann, E., Wittchen, H.U., 2017. Infant, maternal, and familial predictors and correlates of regulatory problems in early infancy: the differential role of infant temperament and maternal anxiety and depression. Early Hum Dev, 115, 23-31. https://doi.org/10.1016/j.earlhumdev.2017.08.005

McGinnis, E., Bocknek, E., Beeghly, M., Rosenblum, K.L., Muzik, M., 2015. Does child sex moderate vulnerability to postpartum risk among infants of mothers at risk for psychopathology?. Infancy, 20, 42-69. https://doi.org/10.1111/infa.12065

Milgrom, J., Gemmill, A.W., Bilszta, J.L., Hayes, B., Barnett, B., Brooks, J., ... Buist, A., 2008. Antenatal risk factors for postnatal depression: a large prospective study. J Affect Dis, 108, 147-157. https://doi.org/10.1016/j.jad.2007.10.014

Míguez, M.C., Pereira, B., Figueiredo, B., 2017. Tobacco consumption and spontaneous quitting at the first trimester of pregnancy. Addict Behav, 64, 111-117. https://doi.org/10.1016/j.addbeh.2016.08.034

Monk, C., Georgieff, M.K., Osterholm, E.A., 2013. Research review: maternal prenatal distress and poor nutrition—mutually influencing risk factors affecting infant neurocognitive development. J Child Psychol Psychiatry, 54, 115–130. https://doi.org/10.1111/jcpp.12000

Nevarez, M.D., Rifas-Shiman, S.L., Kleinman, K.P., Gillman, M.W., Taveras, E.M., 2010. Associations of early life risk factors with infant sleep duration. Acad Pediatr, 10, 187-193. https://doi.org/10.1016/j.acap.2010.01.007

Netsi, E., van IJzendoorn, M.H., Bakermans-Kranenburg, M.J., Wulff, K., Jansen, P. W., Jaddoe, V.W., ... Ramchandani, P.G., 2015. Does infant reactivity moderate the association between antenatal maternal depression and infant sleep?. J Dev Behav Pediatr, 36, 440-449. https://doi.org/10.1097/DBP.0000000000000181

O'Connor, T.G., Caprariello, P., Blackmore, E.R., Gregory, A.M., Glover, V., Fleming, P., ALSPAC Study Team., 2007. Prenatal mood disturbance predicts sleep problems in infancy and toddlerhood. Early Hum Dev, 83, 451-458. https://doi.org/10.1016/j.earlhumdev.2006.08.006

Okun, M.L., Mancuso, R.A., Hobel, C.J., Schetter, C.D., Coussons-Read, M., 2018. Poor sleep quality increases symptoms of depression and anxiety in postpartum women. J Behav Med, 41, 703-710. https://doi.org/10.1007/s10865-018-9950-7

Owens, J.A., Spirito, A., McGuinn, M., 2000. The Children's Sleep Habits Questionnaire (CSHQ): psychometric properties of a survey instrument for school-aged children. Sleep, 23, 1043-1052. https://doi.org/10.1093/sleep/23.8.1d

Paavonen, E. J., Saarenpää-Heikkilä, O., Morales-Munoz, I., Virta, M., Häkälä, N., Pölkki, P., ... Karlsson, L., 2020. Normal sleep development in infants: findings from two large birth cohorts. Sleep Med, published online before print. https://doi.org/10.1016/j.sleep.2020.01.009

Pampaka, D., Papatheodorou, S.I., AlSeaidan, M., Al Wotayan, R., Wright, R.J., Buring, J.E., ... Christophi, C.A., 2019. Postnatal depressive symptoms in women with and without antenatal depressive symptoms: results from a prospective cohort study. Arch Womens Ment Health, 22, 93-103. https://doi.org/10.1007/s00737-018-0880-8

Piteo, A.M., Roberts, R.M., Nettelbeck, T., Burns, N., Lushington, K., Martin, A.J., Kennedy, J.D., 2013. Postnatal depression mediates the relationship between infant and maternal sleep disruption and family dysfunction. Early Hum Dev, 89, 69-74. https://doi.org/10.1016/j.earlhumdev.2012.07.017

Ramchandani, P., Stein, A., Evans, J., O'Connor, T.G., ALSPAC Study Team., 2005. Paternal depression in the postnatal period and child development: a prospective population study. The Lancet, 365, 2201-2205. https://doi.org/10.1016/S0140-6736(05)66778-5

Sadeh, A., 2004. A brief screening questionnaire for infant sleep problems: validation and findings for an Internet sample. Pediatrics, 113, e570-e577. https://doi.org/10.1542/peds.113.6.e570

Sadeh, A., Tikotzky, L., Scher, A., 2010. Parenting and infant sleep. Sleep Med Rev, 14, 89-96. https://doi.org/10.1016/j.smrv.2009.05.003

Sameroff, A.J., 1993. Models of development and developmental risk. In CH Zeanah (Ed.), Handbook of infant mental health. New York: The Guilford Press

Sandman, C., Glynn, L., Davis E., 2013. Is there a viability–vulnerability tradeoff? Sex differences in fetal programming. J Psychosom Res, 75, 327–335. https://doi.org/10.1016/j.jpsychores.2013.07.009

Santona, A., Tagini, A., Sarracino, D., De Carli, P., Pace, C.S., Parolin, L., Terrone, G., 2015. Maternal depression and attachment: the evaluation of mother–child interactions during feeding practice. Front Psychol, 6, 1235-1246. https://doi.org/10.3389/fpsyg.2015.01235

Sette, S., Baumgartner, E., Ferri, R., Bruni, O., 2017. Predictors of sleep disturbances in the first year of life: a longitudinal study. Sleep Med, 36, 78-85. https://doi.org/10.1016/j.sleep.2017.04.015

Sharkey, K.M., Iko, I.N., Machan, J.T., Thompson-Westra, J., Pearlstein, T.B., 2016. Infant sleep and feeding patterns are associated with maternal sleep, stress, and depressed mood in women with a history of major depressive disorder (MDD). Arch Womens Ment Health, 19, 209-218. https://doi.org/10.1007/s00737-015-0557-5

Singer, J.D., Willett, J.B., 2003. Applied longitudinal data analysis: modeling change and event occurrence. New York: Oxford University Press.

Sweeney, S., MacBeth, A., 2016. The effects of paternal depression on child and adolescent outcomes: a systematic review. J Affect Dis, 205, 44-59. https://doi.org/10.1016/j.jad.2016.05.073

Szpunar, M.J., Parry, B.L., 2018. A systematic review of cortisol, thyroid-stimulating hormone, and prolactin in peripartum women with major depression. Arch Womens Ment Health, 21, 149-161. https://doi.org/10.1007/s00737-017-0787-9

Sutherland, S., Brunwasser, S.M., 2018. Sex differences in vulnerability to prenatal stress: a review of the recent literature. Curr Psychiatry Rep, 20, 102. https://doi.org/10.1007/s11920-018-0961-4

Tendais, I., Costa, R., Conde, A., Figueiredo, B., 2014. Screening for depression and anxiety disorders from pregnancy to postpartum with the EPDS and STAI. Span J Psychol, 17, 1-9. https://doi.org/10.1017/sjp.2014.7

Teti, D.M., Crosby, B., 2012. Maternal depressive symptoms, dysfunctional cognitions, and infant night waking: the role of maternal nighttime behavior. Child Dev, 83, 939-953. https://doi.org/10.1111/j.1467-8624.2012.01760.x

Volling, B.L., Yu, T., Gonzalez, R., Tengelitsch, E., Stevenson, M.M., 2019. Maternal and paternal trajectories of depressive symptoms predict family risk and children's emotional and behavioral problems after the birth of a sibling. Dev Psychopathol, 31, 1307-1324. https://doi.org/10.1017/S0954579418000743

Werner, H., Molinari, L., Guyer, C., & Jenni, O.G., 2008. Agreement rates between actigraphy, diary, and questionnaire for children's sleep patterns. Arch Pediatr Adolesc Med, 162, 350–358. https://doi.org/10.1001/archpedi.162.4.350

Ystrom, E., Hysing, M., Torgersen, L., Ystrom, H., Reichborn-Kjennerud, T., Sivertsen, B., 2017a. Maternal symptoms of anxiety and depression and child nocturnal awakenings at 6 and 18 months. J Pediatr Psychol, 42, 1156-1164. https://doi.org/10.1093/jpepsy/jsx066

Ystrom, H., Nilsen, W., Hysing, M., Sivertsen, B., & Ystrom, E., 2017b. Sleep problems in preschoolers and maternal depressive symptoms: an evaluation of mother-and child-driven effects. Dev Psychol, 53, 2261. https://doi.org/10.1037/dev0000402

PAPER VI

INFANT'S TEMPERAMENT MEDIATES MOTHER'S PRENATAL DEPRESSION SYMPTOMS EFFECTS ON BOYS' SLEEP PROBLEMS [7]

Dias, C.C., & Figueiredo, B. (under review). Infant's temperament mediates mother's prenatal depression symptoms effects on boys' sleep problems. *Development and Psychopathology*

[7] This paper is under review at Development and Psychopathology

Abstract

The present study aimed to analyze the mediator effect of infant's temperament at two weeks in the effects of mother's prenatal depression symptoms on infant's sleep problems specifically in boys. The sample was comprised of 298 mother-infant dyads. Mothers completed measures of depression symptoms, infant's temperament and sleep problems. Results revealed that (1) infant's negative affectivity at two weeks mediated mother's prenatal depression symptoms effects on boys' total sleep problems, and partially mediated mother's prenatal depression symptoms effects on boys' sleep anxiety at six months, and (2) infant's temperament at two weeks did not mediate mother's prenatal depression symptoms effects on girls' sleep problems. This study suggested negative affectivity as an early specific marker of boys' further sleep problems, helping to explain the negative effects of mother's prenatal depression symptoms on boys' sleep problems.

Keywords: prenatal depression; temperament; infant's sleep problems

Introduction

Mother's prenatal depression symptoms have an adverse effect on infant's development (Figueiredo, Pinto, Pacheco, & Field, 2017; Gentile, 2017; Tuovinen et al., 2018) and, specifically, on infant's sleep (Gerardin et al., 2011; Martini, Petzoldt, Knappe, Garthus-Niegel, Asselmann, & Wittchen, 2017; Nevarez, Rifas-Shiman, Kleinman, Gillman, & Taveras, 2010). Infants of mothers with more depression symptoms during pregnancy sleep less hours, show lower sleep efficiency and more night wakings (Armitage, Flynn, Hoffmann, Vazquez, Lopez, & Marcus, 2009; Nevarez et al., 2010). Studies shown that infants of mothers with more depression symptoms during pregnancy also present more sleep problems, namely increased difficulty in initiating or maintaining sleep (Field, Diego, Hernandez-Reif, Figueiredo, Schanberg, & Kuhn, 2007; Gerardin et al., 2011; Martini et al., 2017).

Mother's prenatal depression symptoms also have a negative effect on infant's temperament, namely by impacting infant's negative affectivity and reactivity (Davis, Glynn, Schetter, Hobel, Chicz-Demet, & Sandman, 2007; Gustafsson et al., 2018; Zhang, Finik, Dana, Glover, Ham, & Nomura, 2018). Temperament, on its turn, is associated with infant's sleep problems, namely with increased difficulty in initiating or maintaining sleep (e.g. Kelmanson, 2004). Infants with difficult temperament have dysregulated sleep patterns, namely more night awakenings, shorter sleep duration, and more sleep latency (Kaley, Reid, & Flynn, 2012; Mindell & Lee, 2015; Sorondo & Reeb-Sutherland, 2015).

Fetal programming theory (Barker, 2004; Glover, 2011; Glover, O'Donnell, O'Connor, & Fisher, 2018) has been suggested as a major framework to understand the effects of mother's prenatal depression symptoms on infant's development. Fetal programming theory argues that the changes occurring on embryotic and fetal environment, particularly when occurring in sensitive phases of fetal development, may set the course for infant's development after birth and throughout the lifespan (Barker, 2004; Glover, 2011). During gestation, the fetus is being prepared to optimize the adjustment to the out of uterus context, being programmed according to the signs sent by the mother (Glover, 2011; Glover et al., 2018). This fetal programming prepares the fetus to face a similar environment after birth (Barker, 2004). Epigenetics theory studies the mechanisms through which this fetal programming occurs (Conradt, Adkins, Crowell, Raby, Diamond, & Ellis, 2018). According with epigenetics, the exposure to an adverse prenatal event may lead to the occurrence of a cascade of chemical changes in the fetal chromatin, that may result in the reprogramming of

fetus genome and cause long term consequences on infant's development (Cao-Lei, et al., 2017; O'Donnell & Meaney, 2016; Turecki & Meaney, 2016).

Sex differences in fetal programming and epigenetics have been described, namely the fact that the development of boys and girls is not equally affected by a prenatal adverse environment (DiPietro & Voegtline, 2017; Sandman, Glynn, & Davis, 2013; Sutherland & Brunwasser, 2018). Male fetuses exposed to a prenatal adverse environment have been reported to present more negative effects on their further development than female fetuses (DiPietro & Voegtline, 2017; Sandman et al., 2013; Sutherland & Brunwasser, 2018). This differential impact may be due to early sex differences in the effects of a prenatal adverse environment on embryotic and fetal development (Rosenfeld, 2015; Sutherland & Brunwasser, 2018), namely regarding temperament characteristics (Sutherland & Brunwasser, 2018).

The negative effect of mother's prenatal depression symptoms on infant's development have been shown (Figueiredo et al., 2017; Gentile, 2017; Tuovinen et al., 2018), being these effects more negative for boys than for girls (Gerardin et al., 2011; Netsi et al., 2015; Sutherland & Brunwasser, 2018). Infant's temperament may encompass a possible characteristic that is more negatively affected by mother's prenatal depression symptoms in boys, thus leading to more sleep problems (Netsi et al., 2015).

The present study aimed to analyze the mediator effect of infant's temperament at two weeks in the effects of mother's prenatal depression symptoms on infant's sleep problems specifically in boys. Following previous findings (Gustafsson et al., 2018; Netsi et al., 2015; Sutherland & Brunwasser, 2018), the present study hypothesized that infant's temperament may be an early maker of infant's further sleep problems, particularly in boys, helping to explain the negative effects of mother's prenatal depression symptoms on boys' sleep problems.

Methods

Participants

The sample was comprised of 298 mother-infant dyads. The majority of the mothers were white (92.2%), married or cohabiting (83.1%), and employed (79.3%). More than half of the mothers were aged between 25 and 34 years old (65.4%) and had 12 or more years of schooling (62.1%). All infants were born at term (≥ 37 weeks gestation) and with normal birth weight (≥ 2500g). About half of the infants were boys (53.6%) and another half were girls (46.4%). The majority of the infants were not resuscitated at birth (91.0%), had normal birth length ≥ 48cm (81.0%), and were first

born (85.5%). More than half were born by vaginal delivery (64.6%; see Table 23). Non-significant differences were found between boys and girls in the socio-demographic variables.

Table 23.
Socio-demographic characteristics

			Total
			N = 298
			%
Mother	Age	18-24	11.9
		25-34	66.6
		35-44	21.5
	Ethnicity	White	92.2
		Other	7.8
	Marital status	Married/cohabiting	83.1
		Single/divorced/widow	16.9
	Occupational status	Employed	79.3
		Unemployed/Household/student	20.7
	Socio-economic level	High	59.2
		Medium	31.8
		Low	9.0
	Years of schooling	≤12	37.9
		>12	62.1
Gestation	Resuscitation at birth	No	91.0
		Yes	9.0
	Type of delivery	Vaginal	64.6
		Caesarean	35.4
Infant	Sex	Male	53.6
		Female	46.4
	Length	< 48 cm	19.0
		≥ 48 cm	81.0
	Birth order	First born	85.5
		Non-first born	14.5

Procedures

The Ethical Commissions of the two public hospitals in the Northern Portugal were contacted and, after their approval, 536 women who met the inclusion criteria were contacted at the third pregnancy trimester. Women not reading or writing Portuguese, with multiple gestations and gestational complications were excluded from the study. Pregnant women were informed about the study purposes and procedures and invited to participate. Four hundred and eighty-five

pregnant women agreed to participate in the study and signed an informed consent. At the third pregnancy trimester, mothers completed measures of socio-demographic characteristics and depression symptoms. At two weeks postpartum, mothers were contacted by email and completed a questionnaire concerning socio-demographic characteristics and a measure of infant's temperament. Fourteen infants were excluded from the analyses due to preterm birth or infants with low birth weight. Mothers were contacted again by email at six months postpartum (M = 24.35 weeks, SD = 6.21) and completed measures of depression symptoms and infant's sleep problems. From the infants of the 485 mothers who completed measures at the third pregnancy trimester, 203 completed the online measures at two weeks, and 268 completed the online measures at six months. Mothers were included in the analyses if they completed the online measures at least one time between two weeks and six months (N = 298; 63.3%).

Measures

Socio-demographic characteristics. The Socio-demographic Questionnaire was used to gather mother's demographic and obstetric data, and infant's socio-demographic (e.g., sex, birth order) and biometric data (e.g., birth weight, birth length).

Mother's depression symptoms. The Edinburgh Postnatal Depression Scale (EPDS; Cox, Holden, & Sagovsky, 1987) was used to assess mother's prenatal and postpartum depression symptoms. The EPDS is a self-report instrument used to assess depression symptoms within the previous seven days. It includes 10 items scored on a 4-point Likert-type scale. The Portuguese version of the EPDS exhibited good internal consistency (Figueiredo et al., 2017; Tendais, Costa, Conde, & Figueiredo, 2014). The EPDS also showed good internal consistency in the present sample at pregnancy (α = .85) and at postpartum (α = .83).

Infant's temperament. The IBQ-R (Gartstein & Rothbart, 2003) was used to assess infant's temperament. This instrument is comprised of 191 items scored in a 7-point Likert-type scale, where parents report their infant's temperament. The IBQ-R was designed to assess temperament in infants aged between 3 and 12 months (Gartstein & Rothbart, 2003), and good internal and construct validity was also shown when the IBQ-R was applied in infants aged two weeks (Dias, Costa, Pinto, & Figueiredo, under review). The IBQ-R is comprised of 14 scales of temperament (activity level, approach, cuddliness, distress to limitations, duration of orienting, falling and reactivity, fear, high intensity pleasure, low intensity pleasure, perceptual sensitivity, sadness, smiling and laughter, soothability, and vocal reactivity), that are computed in three dimensions: (1)

surgency/extraversion: comprised of activity level, approach, perceptual sensitivity, smiling and laughter and vocal reactivity dimensions; (2) negative affectivity: comprised of distress to limitations, falling reactivity, fear, and sadness dimensions; and (3) orienting regulation: comprised of duration of orienting, low intensity pleasure and soothability dimensions. Good internal consistency was found in the Portuguese version of the IBQ-R (α's for the dimensions ranging between .71 and .93; Costa & Figueiredo, 2018). In the present study, the IBQ-R dimensions showed adequate internal consistency in the total sample (α's ranging between .54 and .64).

Infant's sleep problems. The Children's Sleep Habits Questionnaire – Infant Version (CSHQ-I; Dias, Figueiredo, & Pinto, 2018) was used to assess infant's sleep problems. This instrument is an adapted version of the Children's Sleep Habits Questionnaire – CSHQ (Owens, Spirito, & McGuinn, 2000), constructed and administered to the parents in Portuguese language. The CSHQ-I is a retrospective questionnaire used for parents to report their infant's sleep habits and behaviors within a typical week across 33 items that are scored in a 3-point Likert-type scale. The CSHQ-I is comprised of 4 subscales: (1) bedtime resistance: assesses the infant's resistance to go to bed and recurrent night waking; (2) sleep anxiety: assesses the infant's anxiety related to sleep, sleep-disordered breathing and parasomnias; (3) positive sleep habits: assesses the infant's bedtime and morning waking routines; and (4) daytime sleepiness: assesses the diurnal consequences from sleep problems. The scores of the CSHQ-I total scale and sub-scales are obtained by computing the mean of the items (scores ranging from 0 to 2). Higher scores in the CSHQ-I are indicative of more infant's sleep problems. Good internal consistency (α = .77) was found for the CSHQ-I total scale and an adequate internal consistency for the sub-scales (α's ranging .52-.77; Dias et al., 2018). In the present study, the CSHQ-I total scale (α = .80) and subscales (α's ranging between .40 and .80) showed adequate to good internal consistency in the total sample.

Statistical analysis

To analyze the mediator effect of infant's temperament at two weeks in the effects of mother's prenatal depression symptoms on infant's sleep problems specifically in boys, two moderated mediation models were tested using structural equation modeling (SEM) in AMOS 22. The moderated mediation models included mother's prenatal depression symptoms as independent (exogenous) variable, infant's temperament dimensions at 2 weeks (surgency/extraversion, negative affectivity and orienting regulation) as mediator variables, and

infant's sleep problems (CSHQ-I total score at model 1 and infant's bedtime resistance, sleep anxiety, positive sleep habits, and daytimes sleepiness at model 2) at six months as dependent (endogenous) variable. Mother's depression symptoms at six months postpartum were also included as an endogenous variable in the models to control the effect of mother's postpartum depression symptoms in the studied variables. Infant's sex was included as a multi-group (moderator) variable in the tested moderated mediation models. Good model fit was considered according with the examination of indices of different classes: a non-significant chi square (χ^2) statistics, Comparative Fit Index (CFI) ≥. 95, and Root Mean Square Error of approximation (RMSEA) > .05 (Kline, 2005).

Results

Means and standard deviations of the study's variables at the third pregnancy trimester, two weeks and six months for boys and girls are presented in Table 24. Non-significant differences between boys and girls were found in the study's variables, with exception for orienting regulation at two weeks, $F(1,198) = 4.31$, $p = .039$, $p\eta^2 = 0.54$. Boys presented more orienting regulation at two weeks than girls.

Table 24.

Study's variables' means and standard deviations

	3rd trimester *M (SD)*			2 weeks *M (SD)*			6 months *M (SD)*		
	Boys	Girls	*F*	Boys	Girls	*F*	Boys	Girls	*F*
Mother's depression symptoms	7.23 (4.38)	7.02 (4.35)	0.20				4.95 (3.75)	4.75 (3.71)	0.06
Surgency/extraversion				3.14 (0.84)	3.08 (0.84)	0.43			
Negative affectivity				2.83 (0.72)	2.91 (0.82)	0.55			
Orienting regulation				4.53 (1.06)	4.23 (0.96)	4.31*			
Bedtime resistance							0.68 (0.43)	0.64 (0.39)	0.00
Sleep anxiety							0.18 (0.27)	0.15 (0.18)	0.75
Positive sleep habits							1.42 (0.36)	1.51 (0.33)	1.29
Daytime sleepiness							0.10 (0.25)	0.08 (0.16)	1.11
CSHQ-I total score							0.43 (0.26)	4.23 (0.96)	1.45

M = Mean; *SD* = Standard Deviation; ** p < .05*

Infant's temperament mediating the effects of mother's prenatal depression symptoms on infant's sleep problems at 6 months

Mother's prenatal depression symptoms significantly predicted more infant's CSHQ-I total score at six months, β = .01, p = .006. After linking mother's depression to the hypothesized mediators and the hypothesized mediators to the CSHQ-I total score, the model indicated that mother's prenatal depression symptoms (1) significantly predicted more infant's negative affectivity at two weeks, β = .04, p < .001, (2) and did not predict infant's surgency/extraversion, β = .01, p = .281, and orienting regulation at two weeks, β = .01, p = .753. Additionally (1) infant's negative affectivity at two weeks significantly predicted more CSHQ-I total score at six months, β = .08, p < .001, (2) and infant's orienting regulation at two weeks significantly predicted predict less CSHQ-I total score at six months, β = -.02, p = .008, and (3) surgency/extraversion at two weeks did not predict CSHQ-I total score at six months, β = -.00, p = .880 (see Figure 9a). These results noted the presence of indirect effects of mother's prenatal depression symptoms on infant's CSHQ-I total score at six months via infant's negative affectivity at two weeks. After linking the indirect effects, mother's prenatal depression symptoms were no longer a predictor of CSHQ-I total score at six months, β = .00, p = .330. These results suggest that infant's negative affectivity at two weeks mediated the effects of mother's prenatal depression symptoms on CSHQ-I total score. The values for the fit model are: χ^2 (18) = 113.74, p < .001; CFI = .73; RMSEA = .13.

Mother's prenatal depression symptoms significantly predicted more infant's sleep anxiety at six months, β = .01, p = .007, marginally predicted more infant's daytime sleepiness at six months, β = .01, p = .056, and did not predict infant's bedtime resistance, β = -.01, p = .205, and positive sleep habits at six months, β = .00, p = .339. After linking mother's depression symptoms to the hypothesized mediators and the hypothesized mediators to the CSHQ-I sub-scales, the model indicated that mother's prenatal depression symptoms (1) significantly predicted more infant's negative affectivity at two weeks, β = .04, p = .001, (2) and did not predict infant's surgency/extraversion, β = .02, p = .232, and orienting regulation at two weeks, β = .00, p = .796. Additionally (1) infant's negative affectivity at two weeks significantly predicted more infant's sleep anxiety at six months, β = .08, p < .001, (2) infant's surgency extraversion predicted at two weeks significantly predicted more infant's sleep anxiety at six months, β = .05, p = .020, and (3) infant's orienting regulation at two weeks significantly predicted predict less infant's sleep anxiety at six months, β = -.05, p = .006 (see Figure 9b).

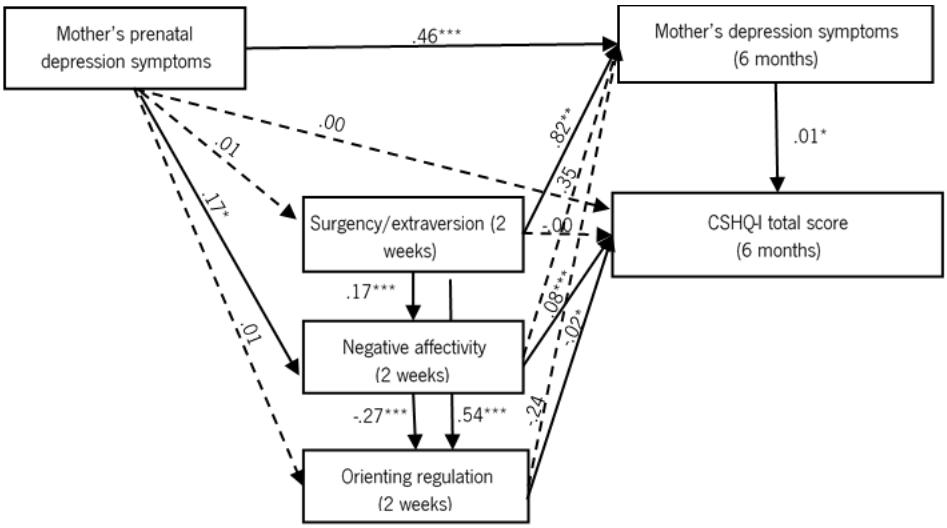


Figure 9a. Longitudinal path analysis model for infant's CSHQ-I total score in the total sample.

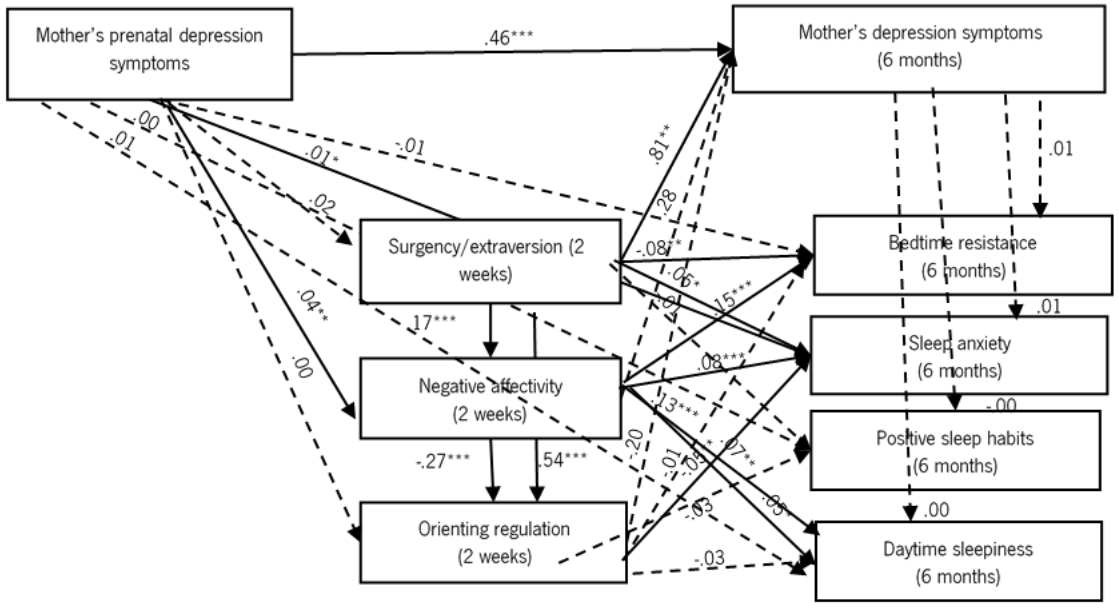


Figure 9b. Longitudinal path analysis model for infant's CSHQ-I sub-scales in the total sample.

Figure 9. Longitudinal path analysis model for infant's CSHQ-I total scale and sub-scales in the total sample. Significant paths are shown by solid paths and non-significant paths are shown by dotted paths. * p < .05; **p < .01; ***p < .001.

These results noted the presence of indirect effects of mother's prenatal depression symptoms on infant's sleep anxiety at six months via infant's negative affectivity at two weeks. After linking the indirect effects, mother's prenatal depression symptoms still predicted more infant's sleep anxiety at six months, $\beta = .01$, $p = .049$. These results suggest that infant's negative affectivity at two weeks partially mediated the effects of mother's prenatal depression symptoms on infant's sleep anxiety at six months. The values for the fit model are: χ^2 (5) = 75.48, $p < .001$; CFI = .80; RMSEA = .21

Temperament mediating the effects of mother's prenatal depression symptoms on infant's sleep problems at six months: boys versus girls

In order to test the moderator role of infant's sex in this model, infant's sex was included as multi-group variable in the tested longitudinal path analysis models.

Mother's prenatal depression symptoms significantly predicted more boys' CSHQ-I total score at six months, $\beta = .01$, $p = .004$. After linking mother's depression to the hypothesized mediators and the hypothesized mediators to the CSHQ-I total score, the model indicated that mother's prenatal depression symptoms (1) significantly predicted more boys' negative affectivity at two weeks, $\beta = .05$, $p = .003$, (2) and did not predict boys' surgency/extraversion, $\beta = -.00$, $p = .977$, and orienting regulation at two weeks, $\beta = .02$, $p = .349$. Additionally (1) boys' negative affectivity at two weeks significantly predicted more CSHQ-I total score at six months, $\beta = .09$, $p < .001$, (2) and boys' orienting regulation at two weeks significantly predicted predict less CSHQ-I total score at six months, $\beta = -.05$, $p < .001$, and (3) surgency/extraversion at two weeks did not predict CSHQ-I total score at six months, $\beta = .01$, $p = .617$ (see Figure 10a). These results noted the presence of indirect effects of mother's prenatal depression symptoms on boys' CSHQ-I total score at six months via boys' negative affectivity at two weeks. After linking the indirect effects, mother's prenatal depression symptoms were no longer a significant predictor of CSHQ-I total score at six months, $\beta = .01$, $p = .068$. These results suggest that infant's negative affectivity at two weeks mediated the effects of mother's prenatal depression symptoms on CSHQ-I total score. The values for the fit model are: χ^2 (18) = 67.58, $p < .001$; CFI = .76; RMSEA = .13.

Mother's prenatal depression symptoms significantly predicted more boys' sleep anxiety, $\beta = .02$, $p = .010$, and daytime sleepiness at six months, $\beta = .01$, $p = .043$, and did not predict boys' bedtime resistance, $\beta = -.01$, $p = .473$, and positive sleep habits at six months, $\beta = .01$, $p = .114$. After linking mother's depression symptoms to the hypothesized mediators and the

hypothesized mediators to the CSHQ-I sub-scales, the model indicated that mother's prenatal depression symptoms (1) significantly predicted more boys' negative affectivity at two weeks, β = .05, p = .005, (2) and did not predict infant's surgency/extraversion, β = .020 p = .992, and orienting regulation at two weeks, β = .02, p = .488. Additionally (1) infant's negative affectivity at two weeks marginally predicted more boys' sleep anxiety at six months, β = .05, p = .088, but did not predict boys' daytime sleepiness, β = .00, p = .892, (2) infant's surgency extraversion predicted at two weeks significantly predicted more boys' sleep anxiety, β = .09, p < .001, and daytime sleepiness at six months, β = .12, p < .001, and (3) infant's orienting regulation at two weeks significantly predicted predict less boys' sleep anxiety at six months, β = -.08, p < .001, and daytime sleepiness at six months, β = -.06, p < .004 (see Figure 10b). These results noted the presence of indirect effects of mother's prenatal depression symptoms on boys' sleep anxiety at six months via boys' negative affectivity at two weeks. After linking the indirect effects, mother's prenatal depression symptoms still predicted more infant's sleep anxiety at six months, β = .01, p = .014. These results suggest that boys' negative affectivity at two weeks partially mediated the effects of mother's prenatal depression symptoms on boys' sleep anxiety at six months. The values for the fit model are: χ^2 (5) = 51.11, p < .001; CFI = .78; RMSEA = .25.

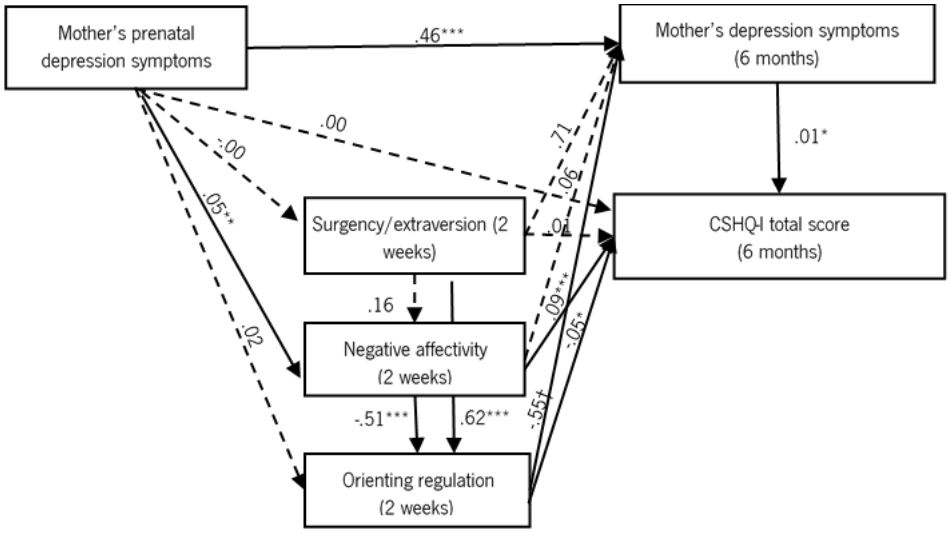


Figure 10a. Longitudinal path analysis model for infant's CSHQ-I total score in boys.

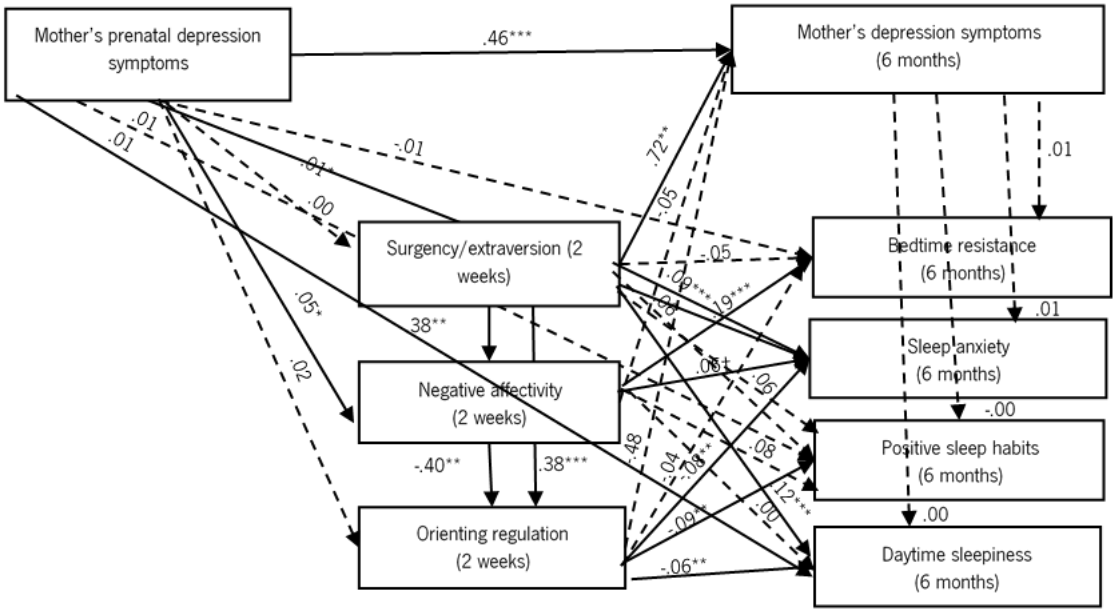


Figure 10b. Longitudinal path analysis model for infant's CSHQ-I sub-scales in boys.

Figure 10. Longitudinal path analysis model for infant's CSHQ-I total scale and sub-scales in boys. Significant paths are shown by solid paths and non-significant paths are shown by dotted paths. * $p < .05$; **$p < .01$; ***$p < .001$.

Contrarily to what was found for boys, mother's prenatal depression symptoms did not significantly predict girls' CSHQ-I total score, $\beta = .00$, $p = .578$, sleep anxiety, and no indirect

effects were found (see Figure 11a). These results suggest that girls' temperament at two weeks did not mediate the effects of mother's prenatal depression symptoms on girls' total sleep problems at six months. The values for the fit model are: χ^2 (5) = 21.03, p = .001; CFI = .86; RMSEA = .16.

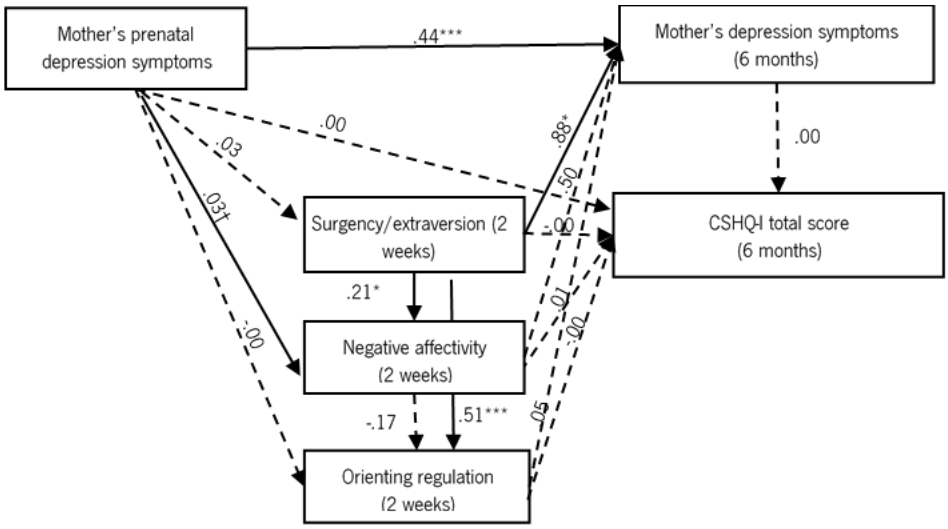


Figure 11a. Longitudinal path analysis model for infant's CSHQ-I total score in girls.

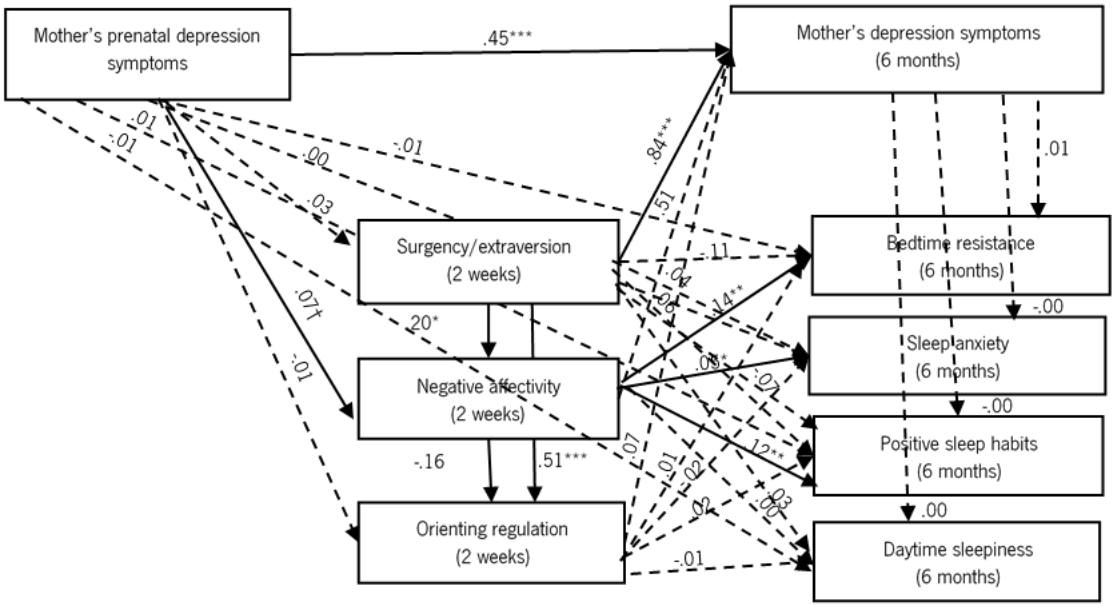


Figure 11b. Longitudinal path analysis model for infant's CSHQ-I sub-scales in girls.

Figure 11. Longitudinal path analysis model for infant's CSHQ-I total scale and sub-scales in girls. Significant paths are shown by solid paths and non-significant paths are shown by dotted paths. * p < .05; **p < .01; ***p < .001.

Mother's prenatal depression symptoms did not significantly predict girls' bedtime resistance, β = -.00, p = .409, sleep anxiety, β = .01, p = .169, positive sleep habits, β = -.01, p = .509, and daytime sleepiness at six months, β = -.00, p = .440, and no indirect effects were found (see Figure 11b). These results suggest that girls' temperament at two weeks did not mediate the effects of mother's prenatal depression symptoms on girls' sleep problems at six months. The values for the fit model are: χ^2 (5) = 48.60, p < .001; CFI = .73; RMSEA = .11.

Discussion

Findings of this study revealed that (1) infant's negative affectivity at two weeks mediated the effects of mother's prenatal depression symptoms on boys' total sleep problems and partially mediated the effects of mother's prenatal depression symptoms on boys' sleep anxiety at six months, and (2) infant's temperament at two weeks did not mediate the effects of mother's prenatal depression symptoms on girls' sleep problems at six months.

The negative impact of mother's prenatal depression symptoms on infant's temperament (Davis et al., 2007; Gustafsson et al., 2018; Zhang et al., 2018) and sleep (Gerardin et al., 2011; Martini et al., 2017; Nevarez et al., 2010) has been previously reported in the literature, particularly in boys (Netsi et al., 2015).. Additionally, literature has shown the negative effects of infant's difficult temperament on infant's sleep as well (Kaley et al., 2012; Mindell & Lee, 2015; Sorondo & Reeb-Sutherland, 2015). The present study's findings revealed that boys of more depressed mothers during pregnancy showed more negative affectivity at two weeks of age, and boys with more negative affectivity at two weeks presented more total sleep problems and sleep anxiety at six months of age. The present study's findings also revealed that temperament at two weeks did not mediate the effects of mother's prenatal depression symptoms on girls' sleep problems. These findings suggested that the impact of mother's prenatal depression symptoms on infant's temperament is greater in boys, thus leading to more sleep problems. A previous study already showed an association between infant's temperament and sex and dysregulated sleep patterns (Netsi et al., 2015). The present study adds to the literature by analyzing these four variables in a joint model, showing that the mediator effect of infant's negative affectivity at two weeks in the effects of mother's prenatal depression on infant's sleep problems at six months only occurs in boys.

The effects of an adverse intrauterine environment were reported to be more negative on male fetuses' and infants' development, namely on their temperament characteristics

(Rosenfeld, 2015; Sutherland & Brunwasser, 2018), which may lead to the emergence of more sleep problems in boys. This result suggests that the increased difficulty to adapt to more adverse prenatal environments presented by male fetuses (DiPietro & Voegtline, 2017; Sandman et al., 2013; Sutherland & Brunwasser, 2018) may result in more negative affectivity early after birth and more sleep problems further in boys' development.

The results of this study may be framed within the context of the fetal programming theory (Barker, 2004) and epigenetics (e.g., Cao-Lei et al., 2017; O'Donnell & Meaney, 2016; Turecki & Meaney, 2016). According to the fetal programming theory, the exposure to mother's prenatal depression symptoms may induce a reprogramming of the fetus, causing consequences on infant's development (Barker, 2004), particularly in boys (DiPietro & Voegtline, 2017; Sandman et al., 2013; Sutherland & Brunwasser, 2018). Epigenetics theory argues that this reprogramming occurs through the chemical changes occurring in the fetal chromatin (Cao-Lei et al., 2017; O'Donnell & Meaney, 2016; Turecki & Meaney, 2016). Namely, infants of depressed mothers during pregnancy were shown to present increased difficulties in neurobehavioral development and regulatory abilities (Davis, Glynn, Waffarn, & Sandman, 2011; Figueiredo et al., 2017; Martini et al., 2017), which may lead to more difficulties in temperament characteristics and sleep. Additionally, fetal programming theory argues that fetuses exposed to mother's prenatal depression symptoms are being prepared to adjust to similar environments after birth (Barker, 2004). Thus, presenting more negative affect may prepare the infants to better interact with their postpartum depressed mothers, namely by increasing the mothers' reactivity to their infants' stimulus.

The present findings showed that negative affectivity predicted further infant's sleep anxiety and total sleep problems only in boys. These results are congruent with an extensive body of research reporting an association between infant's temperament and sleep-wake behavior (Kaley et al., 2012; Mindell & Lee, 2015; Sorondo & Reeb-Sutherland, 2015) and problems (Kelmanson, 2004). Contrarily to negative affectivity, surgency/extraversion and orienting regulation dimensions were not found as mediators of the effects of mother's prenatal depression symptoms on boys' sleep problems. Negative affectivity, which reports to infant's fussing, crying, distress, low mood and infant's rate of recovery to distress (Costa & Figueiredo, 2008; Gartstein & Rothbart, 2003), has been described in the literature as specifically measuring infant's temperament characteristics (Rothbart, Ellis, & Posner, 2011). This study suggested that negative affectivity may be an early marker of boys' sleep problems, mediating the effects of mother's depression symptoms on their further sleep problems. Previous literature already shown an association between maternal

variables, namely lower mother's sensitivity (Jonas et al., 2015) and increased anxiety symptoms (Peltola et al., 2017), and more infant's negative affectivity. Additionally, negative affectivity has been described as a risk factor for infant's developmental problems (Beijers, Riksen-Walraven, Putnam, de Jong, & de Weerth, 2013; Gartstein & Rothbart, 2003; Putnam, & Stifter, 2005). This study showed that this temperament characteristic is specifically associated with sleep problems.

Strengths and limitations

This study presents some key strengths. This study tested a longitudinal model to identify the infant's temperament characteristics that may explain the negative effects of mother's prenatal depression symptoms on infant's sleep problems, specifically in boys. Temperament was assessed early after birth and, thus, assumptions regarding infant's temperament with minimal postbirth environmental influences may be more easily performed.

Some limitations should also be acknowledged. All studied variables were assessed through maternal reports. This may comprise a limitation considering that depressed mothers were reported to present more dysfunctional cognitions regarding infant's sleep (Teti & Crosby, 2012). However, mother's postpartum depression symptoms at six months were controlled in the analyses. Additionally, maternal reports of infant's temperament and sleep problems may be biased by mother's perceptions (Spruyt, Aitken, So, Charlton, Adamson, & Horne, 2008). However, a strong association between mother's reports and behavioral measures was found both regarding infant's temperament and sleep, suggesting that mothers are reliable informants of their infant's behaviors (Rothbart et al., 2011; Werner, Molinari, Guyer, & Jenni, 2008).Moreover, mother's prenatal depression symptoms were assessed only at the third pregnancy trimester. This may comprise a limitation considering that the effects of mother's prenatal depression on infant's temperament may have occurred earlier in pregnancy.

Implications for practice and research

These results have empirical and practical implications. Regarding research, this study provided more clear evidence that infant's temperament characteristics early after birth, particularly infant's negative affectivity, may help to explain the greater impact of mother's prenatal depression symptoms on boys' sleep problems, but not on girls'. This result is congruent with previous research arguing that mother's prenatal depression symptoms may affect children's development through different mechanisms in boys and in girls (Edwards & Hans, 2016; Neuenschwander et al., 2018). Future studies could be performed in order to analyze the characteristics that may impact girls' sleep problems. For example, future studies may consider

performing a more multidisciplinary assessment of infant's temperament, namely by assessing the endophenotypic and genotypic individual characteristics, in order to clarify the gender differential impact. Future research may also analyze the effects of mother's prenatal depression symptoms earlier in pregnancy in order to identify in which pregnancy trimester mother's prenatal depression symptoms may have a major effect on infant's development. Regarding clinical implications, by identifying the mediation role of infant's temperament, particularly in boys, these results highlighted the need of intervening with infants with more negative affectivity in order to early prevent the emergence of potential sleep problems.

Conclusion

The present study's findings revealed that infant's negative affectivity at two weeks mediated the effects of mother's prenatal depression symptom on infant's sleep problems at six months in boys. The present study's findings also revealed that, contrarily to boys, girls' temperament at two weeks did not mediate the effects of mother's prenatal depression symptoms on sleep problems. This study suggested negative affectivity as an early specific marker of boys' further sleep problems, helping to explain the negative effects of mother's prenatal depression symptoms on boys' sleep problems. More research is needed to better identify the characteristics that may impact girls' sleep problems.

References

Armitage, R., Flynn, H., Hoffmann, R., Vazquez, D., Lopez, J., & Marcus, S. (2009). Early developmental changes in sleep in infants: the impact of maternal depression. *Sleep, 32*, 693-696. doi: 10.1093/sleep/32.5.693

Barker, D. J. P. (2004). The developmental origins of adult disease. *Journal of the American College of Nutrition, 23*, 588S–595S. doi: 10.1080/07315724.2004.10719428

Beijers, R., Riksen-Walraven, M., Putnam, S., de Jong, M., & de Weerth, C. (2013). Early non-parental care and toddler behaviour problems: Links with temperamental negative affectivity and inhibitory control. *Early Childhood Research Quarterly, 28*, 714-722. doi: 10.1016/j.ecresq.2013.06.002

Cao-Lei, L., De Rooij, S. R., King, S., Matthews, S. G., Metz, G. A. S., Roseboom, T. J., & Szyf, M. (2017). Prenatal stress and epigenetics. *Neuroscience & Biobehavioral Reviews. Published online before print*. doi: 10.1016/j.neubiorev.2017.05.016.

Conradt, E., Adkins, D. E., Crowell, S. E., Raby, K. L., Diamond, L. M., & Ellis, B. (2018). Incorporating epigenetic mechanisms to advance fetal programming theories. *Development and Psychopathology, 30*, 807-824. doi:10.1017/S0954579418000469

Costa, R., & Figueiredo, B. (2018). Infant Behavior Questionnaire – Revised Version: a psychometric study in a Portuguese sample. *Journal of Reproductive and Infant Psychology, 36,* 207-218. doi: 10.1080/02646838.2018.1436752

Cox, J. L., Holden, J. M., & Sagovsky, R. (1987). Detection of postnatal depression: development of the 10-item Edinburgh Postnatal Depression Scale. *The British Journal of Psychiatry*, *150*, 782-786. doi: 10.1192/bjp.150.6.782

Davis, E. P., Glynn, L. M., Waffarn, F., & Sandman, C. A. (2011). Prenatal maternal stress programs infant stress regulation. *Journal of Child Psychology and Psychiatry*, *52*, 119-129. doi: 10.1111/j.1469-7610.2010.02314.x

Davis, E. P., Glynn, L. M., Schetter, C. D., Hobel, C., Chicz-Demet, A., & Sandman, C. A. (2007). Prenatal exposure to maternal depression and cortisol influences infant temperament. *Journal of the American Academy of Child & Adolescent Psychiatry, 46*, 737-746. doi: 10.1097/chi.0b013e318047b775

Dias, C. C., Costa, R., Pinto, T. M., & Figueiredo, B. (under review). The Infant Behavior Questionnaire – Revised from 2 weeks to 12 months of the infant's life. *Journal of Reproductive and Infant Psychology*.

Dias, C. C., Figueiredo, B., & Pinto, T. M. (2018). Children's Sleep Habits Questionnaire – Infant Version. *Jornal de Pediatria (Rio J), 94*, 146-152. doi: 10.1016/j.jped.2017.05.012.

DiPietro, J. A., & Voegtline, K. M. (2017). The gestational foundation of sex differences in development and vulnerability. *Neuroscience, 342*, 4-20. doi: 10.1016/j.neuroscience.2015.07.068

Edwards, R. C., & Hans, S. L. (2016). Prenatal depressive symptoms and toddler behavior problems: the role of maternal sensitivity and child sex. *Child Psychiatry & Human Development, 47*, 696-707. doi: 10.1007/s10578-015-0603-6

Field, T., Diego, M., Hernandez-Reif, M., Figueiredo, B., Schanberg, S., & Kuhn, C. (2007). Sleep disturbances in depressed pregnant women and their newborns. *Infant Behavior and Development, 30*, 127-133. doi: 10.1016/j.infbeh.2006.08.002

Figueiredo, B., Pinto, T. M., Pacheco, A., & Field, T. (2017). Fetal heart rate variability mediates prenatal depression effects on neonatal neurobehavioral maturity. *Biological Psychology*, *123*, 294-301. doi: 10.1016/j.biopsycho.2016.10.013

Gartstein, M. A., & Rothbart, M. K. (2003). Studying infant temperament via the revised infant behavior questionnaire. *Infant Behavior and Development, 26*, 64-86. doi:10.1016/S0163-6383(02)00169-8

Gentile, S. (2017). Untreated depression during pregnancy: short-and long-term effects in offspring. a systematic review. *Neuroscience*, *342*, 154-166. doi: 10.1016/j.neuroscience.2015.09.001

Gerardin, P., Wendland, J., Bodeau, N., Galin, A., Bialobos, S., Tordjman, S., ... & Cohen, D. (2011). Depression during pregnancy: is the developmental impact earlier in boys? A prospective case-control study. *Journal of Clinical Psychiatry, 72*, 378-387. doi: 10.4088/JCP.09m05724blu

Glover, V. (2011). Annual research review: prenatal stress and the origins of psychopathology: an evolutionary perspective. *Journal of Child Psychology and Psychiatry, 52*, 356-367. doi: 10.1111/j.1469-7610.2011.02371.x

Glover, V., O'Donnell, K. J., O'Connor, T. G., & Fisher, J. (2018). Prenatal maternal stress, fetal programming, and mechanisms underlying later psychopathology — a global perspective. *Development and Psychopathology, 30*, 843-854. doi: 10.1017/S095457941800038X

Gustafsson, H. C., Sullivan, E. L., Nousen, E. K., Sullivan, C. A., Huang, E., Rincon, M., ... & Loftis, J. M. (2018). Maternal prenatal depression predicts infant negative affect via maternal inflammatory cytokine levels. *Brain, Behavior, and Immunity, 73*, 470-481. doi: 10.1016/j.bbi.2018.06.011

Jonas, W., Atkinson, L., Steiner, M., Meaney, M. J., Wazana, A., Fleming, A. S., & MAVAN Research Team. (2015). Breastfeeding and maternal sensitivity predict early infant temperament. *Acta Paediatrica, 104*, 678-686. doi: 10.1111/apa.12987

Kaley, F., Reid, V., & Flynn, E. (2012). Investigating the biographic, social and temperamental correlates of young infants' sleeping, crying and feeding routines. *Infant Behavior and Development*, *35*, 596-605. doi: 10.1016/j.infbeh.2012.03.004

Kelmanson, I. A. (2004). Temperament and sleep characteristics in two-month-old infants. *Sleep and Hypnosis, 6*, 78-84.

Kline, P. (2005). *The handbook of psychological testing* (2nd ed.). London, UK: Routledge.

Martini, J., Petzoldt, J., Knappe, S., Garthus-Niegel, S., Asselmann, E., & Wittchen, H. U. (2017). Infant, maternal, and familial predictors and correlates of regulatory problems in early infancy: the differential role of infant temperament and maternal anxiety and depression. *Early Human Development, 115*, 23-31. doi: 10.1016/j.earlhumdev.2017.08.005

Mindell, J. A., & Lee, C. (2015). Sleep, mood, and development in infants. *Infant Behavior and Development*, *41,* 102-107. doi: 10.1016/j.infbeh.2015.08.004

Netsi, E., van IJzendoorn, M. H., Bakermans-Kranenburg, M. J., Wulff, K., Jansen, P. W., Jaddoe, V. W., ... & Ramchandani, P. G. (2015). Does infant reactivity moderate the association between antenatal maternal depression and infant sleep?. *Journal of Developmental & Behavioral Pediatrics*, *36*, 440-449. doi: 10.1097/DBP.0000000000000181.

Neuenschwander, R., Hookenson, K., Brain, U., Grunau, R. E., Devlin, A. M., Weinberg, J., ... & Oberlander, T. F. (2018). Children's stress regulation mediates the association between prenatal maternal mood and child executive functions for boys, but not girls. *Development and Psychopathology, 30*, 953-969. doi: 10.1017/S095457941800041X

Nevarez, M. D., Rifas-Shiman, S. L., Kleinman, K. P., Gillman, M. W., & Taveras, E. M. (2010). Associations of early life risk factors with infant sleep duration. *Academic Pediatrics*, *10*, 187-193. doi: 10.1016/j.acap.2010.01.007

O'Donnell, K. J., & Meaney, M. J. (2016). Fetal origins of mental health: the developmental origins of health and disease hypothesis. *American Journal of Psychiatry, 174*, 319-328. doi: 10.1176/appi.ajp.2016.16020138

Owens, J.A., Spirito, A., & McGuinn, M. (2000). The Children's Sleep Habits Questionnaire (CSHQ): psychometric properties of a survey instrument for school-aged children. *Sleep, 23*, 1043-1052. doi:10.1093/sleep/23.8.1d

Peltola, M. J., Mäkelä, T., Paavonen, E. J., Vierikko, E., Saarenpää-Heikkilä, O., Paunio, T., ... & Kylliäinen, A. (2017). Respiratory sinus arrhythmia moderates the impact of maternal prenatal anxiety on infant negative affectivity. *Developmental Psychobiology, 59*, 209-216. doi: 10.1002/dev.21483

Putnam, S. P., & Stifter, C. A. (2005). Behavioral approach–inhibition in toddlers: prediction from infancy, positive and negative affective components, and relations with behavior problems. *Child Development*, *76*, 212-226. doi: 10.1111/j.1467-8624.2005.00840.x

Rosenfeld, C. S. (2015). Sex-specific placental responses in fetal development. *Endocrinology*, *156*, 3422-3434. doi: 10.1210/en.2015-1227

Rothbart, M. K., Ellis, L. K., & Posner, M. I. (2011). Temperament and self-regulation. In R. F. Baumeister & K. D. Vohs (Eds.), *Handbook of self-regulation: Research, theory, and applications* (pp. 357–370). New York: Guilford.

Sandman, C. A., Glynn, L. M., & Davis, E. P. (2013). Is there a viability–vulnerability tradeoff? Sex differences in fetal programming. *Journal of Psychosomatic Research, 75*, 327-335. doi:10.1016/j.jpsychores.2013.07.009.

Sorondo, B. M., & Reeb-Sutherland, B. C. (2015). Associations between infant temperament, maternal stress, and infants' sleep across the first year of life. *Infant Behavior and Development*, *39*, 131-135. doi: 10.1016/j.infbeh.2015.02.010

Spruyt, K., Aitken, R. J., So, K., Charlton, M., Adamson, T. M., & Horne, R. S. (2008). Relationship between sleep/wake patterns, temperament and overall development in term infants over the first year of life. *Early Human Development, 84*, 289-296. doi: 10.1016/j.earlhumdev.2007.07.002

Sutherland, S., & Brunwasser, S. M. (2018). Sex differences in vulnerability to prenatal stress: a review of the recent literature. *Current Psychiatry Reports, 20*, 102-114. doi: 10.1007/s11920-018-0961-4

Tendais, I., Costa, R., Conde, A., & Figueiredo, B. (2014). Screening for depression and anxiety disorders from pregnancy to postpartum with the EPDS and STAI. *The Spanish Journal of Psychology*, *17*, 1-9. doi: 10.1017/sjp.2014.7.

Teti, D. M., & Crosby, B. (2012). Maternal depressive symptoms, dysfunctional cognitions, and infant night waking: the role of maternal nighttime behavior. *Child Development, 83*, 939-953. doi: 10.1111/j.1467-8624.2012.01760.x

Tuovinen, S., Lahti-Pulkkinen, M., Girchenko, P., Lipsanen, J., Lahti, J., Heinonen, K., ... & Pesonen, A. K. (2018). Maternal depressive symptoms during and after pregnancy and child developmental milestones. *Depression and Anxiety, 35*, 32-741. doi: 10.1002/da.22756

Turecki, G., & Meaney, M. J. (2016). Effects of the social environment and stress on glucocorticoid receptor gene methylation: a systematic review. *Biological Psychiatry, 79*, 87-96. doi: 10.1016/j.biopsych.2014.11.022

Werner, H., Molinari, L., Guyer, C., & Jenni, O. G. (2008). Agreement rates between actigraphy, diary, and questionnaire for children's sleep patterns. *Archives of Pediatrics & Adolescent Medicine, 162*, 350–358. doi: 10.1001/archpedi.162.4.350.

Zhang, W., Finik, J., Dana, K., Glover, V., Ham, J., & Nomura, Y. (2018). Prenatal depression and infant temperament: the moderating role of placental gene expression. *Infancy, 23*, 211-231. doi: 10.1111/infa.12215

DISCUSSION

Mother's prenatal and postpartum depression symptoms have been associated with infant's sleep problems in separate studies (Gerardin et al., 2011; Martini et al., 2017; Ystrom et al., 2017a). Different findings have been reported on the direction of the association between mother's depression symptoms and infant's sleep problems (Teti & Crosby, 2012; Ystrom et al., 2017a, 2017b), suggesting the existence of mutual influences. The effects of both mother's prenatal and postpartum depression symptoms on infant's sleep problems and the potential bidirectional influences were only recently explored (Galbally et al., 2018). Infant's sex and temperament were identified as being associated with both mother's depression symptoms and infant's sleep problems (e.g., Beeghly et al., 2017; Gustafsson et al., 2018; Stein, 2014). A previous study suggested that infant's sex and temperament play an important role on the association between mother's depression symptoms and infant's sleep problems (Kim et al., 2020; Netsi et al., 2015).

The present thesis explored the effects between mother's prenatal and postpartum depression symptoms and infant's sleep problems during the first six months of infant's life (main objective). The empirical studies comprising this thesis responded to four specific objectives: (1) to analyze the effects of mother's prenatal and postpartum depression symptoms on infant's sleep problems during the first six months of life; (2) to explore the unidirectional and bidirectional links between mother's depression symptoms and infant's sleep problems; (3) to analyze the moderator role of infant's sex on the unidirectional and bidirectional effects between mother's depression symptoms and infant's sleep problems; and (4) to the mediator effect of infant's temperament at two weeks on the effects of mother's prenatal depression symptoms on infant's sleep problems specifically in boys.

In this discussion section, an integrative analysis of the included studies will be performed. Throughout this discussion section, considerations will be made on (1) the key findings drawn from the six studies; (2) the integrative discussion of the six studies; (3) the limitations and strengths of the studies; (4) the implications for infant's sleep research and clinical practice; (5) suggestions for future research; and (6) a final conclusion.

Key findings from the studies

The findings from the studies included in this thesis revealed: 1) the normative reference values and the changes occurring on infant's sleep-wake behavior during the first year of infant's life. During the first six months, night wakings and bedtime were found to decrease, while the longest sleep period during the night was found to increase. During the first 12 months of life, sleep duration during the 24-hour

period and the day and sleep periods during the night were found to decrease (**Paper I**); 2) different variables were found in the reviewed literature as positively and negatively associated with infant's sleep-wake behavior, that include parental mental health, infant's sex, and infant's temperament (**Paper II**); 3) the IBQ-R presented adequate reliability when applied at two weeks of age (**Paper III**); 4) mother's depression symptoms at the third pregnancy trimester and at two weeks postpartum both have a negative effect on infant's sleep problems at six months (Objective I, **Paper IV**). While mother's depression symptoms at the third trimester of pregnancy predicted more infant's sleep anxiety and daytime sleepiness at six months, mother's depression symptoms at two weeks predicted more infant's bedtime resistance and total sleep problems at six months (Dias & Figueiredo, 2020); 5) both unidirectional and bidirectional effects between mother's depression symptoms and infant's sleep problems were found (Objective II, **Paper V**). A major unidirectional effect of mother's prenatal depression symptoms on infant's sleep problems was found, namely on infant's sleep anxiety and daytime sleepiness at three and six months. Bidirectional effects between mother's postpartum depression symptoms and infant's sleep anxiety at two weeks, three and six months of life were also found (Dias & Figueiredo, under review); 6) the moderator role of infant's sex on the unidirectional and bidirectional effects between mother's depression symptoms and infant's sleep problems was found (Objective III, **Paper IV** and **V**). Boys of mothers with more depression symptoms at the third trimester of pregnancy presented more sleep anxiety at six months (Dias & Figueiredo, 2020). Boys were shown to be more vulnerable to the effects of mother's depression symptoms and mothers were shown to be more vulnerable to the effects of their boys' sleep problems, particularly sleep anxiety (Dias & Figueiredo, under review); and 7) infant's negative affectivity at two weeks was found to mediate the effects of mother's prenatal depression symptoms on infant's sleep problems at six months, only in boys (Objective IV, **Paper VI**). Boys of more prenatally depressed mothers showed more negative affectivity at two weeks, and boys with more negative affectivity at two weeks presented more total sleep problems at six months (Dias & Figueiredo, under review).

Integrative discussion of the included studies

The normative reference values for infant's sleep-wake behavior during the first 12 months of life were provided in **Paper I**. Large variability was found on the values reported for the most studied infant's sleep-wake behaviors (e.g., sleep duration, night wakings, longest sleep period during the night), consistent to what was reported on a previous systematic review conducted with studies that used measures based on reports (Galland et al., 2012). Previous literature suggested that rapid changes occur

on sleep-wake behavior across the first year of infant's life (Bruni et al., 2014; Galland et al., 2012; Teng et al., 2012). Previous studies also reported large individual differences on infant's sleep-wake behaviors (Bruni et al., 2014; Figueiredo et al., 2016). We may suggest that the inconsistent findings may reflect both the rapid changes and the individual differences expected to occur on sleep-wake behavior during the first year. Methodological differences between the reviewed studies were also found and may help to explain the inconsistent findings. These methodological differences include the study of different sleep-wake behaviors, the study of specific ages or age ranges, the use of different measures, the use of small or large samples, and the different countries where the study was conducted. We may also suggest that these methodological differences may interact, helping to explain some of the inconsistent findings.

Considering the large variability on the reported values and the methodological differences found in the reviewed studies, it was difficult to clearly identify the specific ages where changes in sleep-wake behavior occur. According with the reviewed studies, we may suggest that, during the first six months, night wakings and bedtime decrease and the longest sleep period during the night increase, consistent with previous studies (Figueiredo et al., 2016; Goodlin-Jones et al., 2001). Across the first year, sleep duration during the 24-hour period and the day and sleep periods during the night decrease, consistent with a previous study (Figueiredo et al., 2016).

These results brought evidence to the developmental psychopathology conceptual model. The developmental psychopathology conceptual model argues that infant's normative (*versus* non-normative) development is resultant from the adjusted (*versus* disadjusted) accomplishment of different tasks across development (e.g., Rutter, 1996). Literature has been identifying different developmental tasks regarding sleep that are expected to be accomplished during the first year of life, including the ability of (1) spending more time awake than asleep, (2) concentrating sleep time during the night, (3) self-soothing, and (4) sleeping through the night (Figueiredo et al., 2006; Galland et al., 2012; Goodlin-Jones et al., 2001). Results from **Paper I** brought additional evidence to the literature by suggesting that, while the infant's ability of spending more time awake than asleep and concentrating sleep time during the night are achieved over the first year of life, the ability of self-soothing and sleeping through the night are achieved earlier, during the first six months of life.

The variables most associated and affected by infant's sleep-wake behavior during the first 12 months of life were systematically reviewed in **Paper II**. Different variables, including parental and infant's variables, were found to be positively and negatively associated with infant's sleep-wake behavior and different variables were also identified as being positively and negatively affected by infant's sleep-wake behavior during the first 12 months. Regarding parental variables, mother's depression symptoms

were one of the most consistently reported variables as being negatively associated with infant's sleep-wake behaviors. Regarding infant's variables, male gender and difficult temperament were also reported in the reviewed studies as being negatively associated with infant's sleep-wake behaviors. Variables positively and negatively affected by infant's sleep-wake behaviors were less studied in the literature. Infant's social-emotional and sleep problems were identified as being negatively affected by infant's sleep-wake behavior (**Paper II**).

These results brought evidence to the developmental psychopathology conceptual model, arguing that infant's development results from the dynamic interplay occurring between genetic, environmental and psychosocial variables (Sroufe & Rutter, 2000). We may suggest that parental variables and infant's individual characteristics, may interact, playing an important role on infant's development. The developmental psychopathology also argues that the adjusted development of the infant results from the successful accomplishment of the developmental tasks (e.g., Rutter, 1996). Regarding parental variables, mothers with more depression symptoms may present more difficulties in dealing with their infant's sleep needs and routines (Piteo et al., 2013). We may suggest that mother's depression symptoms may negatively interfere with the successful accomplishment of the developmental tasks regarding sleep, leading to more infant's sleep-wake behaviors and sleep problems.

Paper I and **Paper II** comprised the empirical background of the present thesis and provided evidence to design the empirical studies. Evidence was provided on the reference values and changes occurring on infant's sleep wake-behavior during the first 12 months of life, suggesting the periods over the first year where the developmental tasks related to sleep are expected to occur. Informed by the developmental psychopathology conceptual model (Rutter, 1996), suggesting that infants who present difficulties in the accomplishment of the developmental tasks related to sleep may be at increased risk for the emergence of sleep problems (Byars et al., 2012; Henderson et al., 2010; Sette et al., 2017), **Paper II** reviewed the variables most consistently associated with infant's sleep-wake behavior. Mother's depression symptoms, infant's sex and temperament were identified as consistently associated with infant's sleep-wake behavior during the first 12 months of life.

Considering the evidence on the association between infant's temperament and sleep-wake behavior (**Paper II**), and the unavailability of parent report measures to assess infant's temperament in the first weeks of life, **Paper III** was designed to assess the reliability of the IBQ-R at two weeks of age. The IBQ-R is one of the most recognized and internationally used measures to assess infant's temperament characteristics between three and 12 months of age (e.g., Davis et al., 2007; Gartstein &

Robarth, 2003; Gustafsson et al., 2018). **Paper III** added to the previous literature by showing the reliability of the IBQ-R to assess infant's temperament characteristics since the first weeks of the infant's life. These results are congruent with previous literature that recognized that infant's temperament characteristics may be identified at birth (DiPietro et al., 1996, 2008, 2018). This result comprises an advantage to the previous literature, considering that temperament characteristics at early age are usually precursors of further developmental problems (Bowers et al., 2018; Canals, Hernández-Martínez, Esparó, & Fernández-Ballart, 2011; Ohgi, Takahashi, Nugent, Arisawa, & Akiyama, 2003). By suggesting the IBQ-R as a reliable instrument to assess infant's temperament characteristics, **Paper III** comprised the methodological basis to draw the empirical studies of this thesis.

The results found on **Paper IV** and **Paper V** allowed us to respond to the first objective of this thesis. Both mother's prenatal and early postpartum depression symptoms negatively affect infant's sleep problems during the first six months of infant's life. The present results are in line with previous research (Gerardin et al., 2011; Martini et al., 2017; Nevarez et al., 2010), that revealed an association between mother's prenatal depression symptoms and infant's sleep problems. These results brought evidence to the maternal-driven model (Teti & Crosby, 2012), by suggesting that mother's prenatal and postpartum depression symptoms may predict the emergence of further infant's sleep problems.

A major effect of mother's prenatal depression symptoms on infant's sleep problems was found (**Paper V**), in line with a previous study (O'Connor et al., 2007). The results of the present empirical studies add to the existing literature by highlighting the major effect of mother's prenatal depression symptoms on infant's sleep problems, when also analyzing the concurrent effects of mother's postpartum depression symptoms. Results from the present thesis also added that, during pregnancy, the depression symptoms of the EPDS (e.g., the mother feeling sad or miserable) are associated with more infant's sleep problems (**Paper IV**), reinforcing the negative effect of mother's prenatal depression symptoms on infant's sleep problems.

These results brought empirical evidence to the developmental psychopathology conceptual model (e.g., Rutter, 1996). According with the developmental psychopathology conceptual model, infants who accomplish the expected developmental tasks present a higher probability of presenting a normative development, while infants who fail to accomplish these developmental tasks are at increased risk of presenting sleep problems (Byars et al., 2012; Henderson et al., 2010; Sette et al., 2017). Mother's prenatal depression symptoms may put the infant at increased risk for the emergence of sleep problems, by negatively interfering with the infant's ability to successfully accomplish the developmental tasks

regarding sleep. Mothers with more prenatal depression symptoms are at increased risk of presenting sleep problems, unhealthy habits, poorer prenatal care, and low cortisol levels (Monk et al., 2013; Ruiz-Robledillho et al., 2015; Szpunar & Parry, 2018), which in turn may affect fetal neurobehavioral maturation (Figueiredo et al., 2017; Glover et al., 2018; Martini et al., 2017). And infants with lower neurobehavioral maturation may present difficulties in the accomplishment of the expected developmental tasks regarding sleep, being at higher risk of presenting more sleep problems at six months (Byars et al., 2012; Henderson et al., 2010; Sette et al., 2017).

The major effect of mother's prenatal depression symptoms on infant's sleep problems brought additional evidence to the fetal programming theory (Barker, 2004). The changes occurring in the embryotic environment, resultant from the fetal exposure to mother's prenatal depression symptoms, may lead to a reprogramation of the fetus, causing long term consequences on infant's developmental outcomes (Barker, 2004; Beydoun & Saftlas, 2008; Glover, 2011). This reprogramation may protect the infants, by preparing them to better adapt and successfully survive in a similar postbirth environment (e.g., the exposure to mother's postpartum depression symptoms), while may also put the infants at risk for the emergence of developmental problems (Conradt et al., 2018; Davis, Glynn, Waffarn, & Sandman 2011; Davis et al., 2018). Depressed mothers during the postpartum period usually present a withdrawn pattern of interaction with their infants (Beebe et al., 2008; Leckman-Westin et al., 2009; Santona et al., 2015). We may argue that a sleep pattern characterized by more sleep anxiety may help to protect the infants in the interaction with their withdrawn mothers, by helping them to assure a more contingent and vigilant reaction from their mothers, while also putting the infants at risk for the emergence of sleep problems (Byars et al., 2012; Henderson et al., 2010; Sette et al., 2017).

Mother's early postpartum depression symptoms were also shown as having a negative impact on infant's sleep problems, in line with previous research that showed an association between mother's postpartum depression symptoms and infant's sleep problems (Bat-Pitault et al., 2017; Hughes et al., 2015; Ystrom et al., 2017a). This result adds to the previous literature by showing the effect of depression symptoms at early postpartum on infant's sleep problems. Results from the present thesis also added to previous literature by showing the specific effect of the anxiety symptoms related with depression, particularly in the early postpartum, on the emergence of infant's sleep problems (**Paper IV**).

These results on the negative effects of mother's postpartum depression symptoms on infant's sleep problems also brought evidence to the developmental psychopathology conceptual model (e.g., Rutter, 1996). According with the developmental psychopathology conceptual model, infants who fail to accomplish the developmental tasks are at increased risk of presenting sleep problems (Byars et al.,

2012; Henderson et al., 2010; Sette et al., 2017). A possible explanation for these results is that mother's postpartum depression symptoms, particularly in the early postpartum period, may have a negative impact on the infant's ability to accomplish the expected sleep developmental tasks during the first year of life, putting the infant at increased risk for the emergence of sleep problems (Byars et al., 2012; Henderson et al., 2010; Sette et al., 2017). Mothers with more postpartum depression symptoms are at increased risk of presenting sleep problems and fatigue, disadjusted mother-infant interactions and dysfunctional cognitions regarding infant's sleep (Dennis & Ross, 2005; Field, 2010; Okun et al., 2018; Teti & Crosby, 2012). Thus, mothers with more depression symptoms may have increased difficulties in establishing adjusted mother-infant interactions, setting limits and contingently responding to their infant's needs regarding sleep (Santona et al., 2015; Tikotzky et al., 2015; Tikotzky & Sadeh, 2010), which may interfere with the infant's accomplishment of the developmental tasks regarding sleep.

Results obtained on **Paper V** allowed us to respond to the second objective of this thesis. Both unidirectional and bidirectional effects were found between mother's postpartum depression symptoms and infant's sleep anxiety during the first six months of life. These results brought evidence on both the maternal- and the infant-driven models (e.g., Teti & Crosby, 2012; Ystrom et al., 2017a; Ystrom et al., 2017b). **Paper V** went further on previous literature that separately tested the maternal- and infant-driven models (e.g., Teti & Crosby, 2012; Ystrom et al., 2017a; Ystrom et al., 2017b), by analyzing the reciprocal influences between mother's depression symptoms and infant's sleep problems in a joint model, under the context of the transactional model (Sameroff, 1989, 1993;). To our knowledge, only one previous study analyzed the bidirectional effects between mother's depression symptoms and infant's night wakings during the first 12 months, concurrently considering the effects of mother's prenatal and postpartum depression symptoms (Galbally et al., 2018). The authors did not find evidence on reciprocal effects between mother's depression symptoms and infant's night wakings (Galbally et al., 2018). Contrary to these previous findings, in the present study, reciprocal effects were found between mother's depression symptoms and infant's sleep anxiety, a sub-scale that assesses infant's anxiety related to sleep, sleep-disordered breathing and parasomnias.

Results from **Paper V** provided evidence on the dynamic interaction between mother's depression symptoms and infant's sleep problems, by showing bidirectional links between mother's depression symptoms and infant's sleep anxiety. These results are congruent with the results from previous studies that showed that infants of more depressed mothers present more sleep problems (Gerardin et al., 2011; Martini et al., 2017; Ystrom et al., 2017a) and with the previous studies that

showed that mothers of infants with sleep problems present more depression symptoms (Bayer et al., 2007; Hiscock & Wake, 2001; Ystrom et al., 2017b). These results are also in line with previous sleep intervention studies that have been shown their effect on both reducing infant's sleep problems and decreasing mother's depression symptoms (Gurung et al., 2018; Hiscock et al., 2007; Kempler et al., 2016). Results from **Paper V** added that infant's sleep anxiety specifically increased mother's postpartum depression symptoms. We may suggest that this negative effect of infant's sleep anxiety on mother's depression symptoms may occur through the interference of infant's sleep anxiety on mother's sleep quality, fatigue and self-efficacy (Dennis & Ross, 2005; Giallo et al., 2011; Kouros & El-Sheikh, 2017).

These results brought evidence to the transactional model (Sameroff, 1989, 1993), by recognizing the dynamic interplay that occurs between mother's depression symptoms and infant's sleep problems (Kouros & El-Sheikh, 2017; Sadeh et al., 2010). The transactional model (Sameroff, 1989, 1993), particularly its application to infant's sleep problems (Sadeh et al., 2010), accounts for a dynamic interaction occurring between parental factors (e.g., mother's depression symptoms) and infant's factors (e.g., infant's sleep problems; Kouros & El-Sheikh, 2017; Sadeh et al., 2010). The transactional model suggests that infant's sleep problems should be understood as part of transactional familiar dynamics, recognizing the existence of mutual influences between mother's depression symptoms and infant's sleep problems (El-Sheikh and Kelly, 2017; Sadeh et al., 2010). Results from **Paper V** brought evidence to the transactional model, by showing that mother's depression symptoms negatively affect infant's sleep anxiety and infant's sleep anxiety negatively affect mother's postpartum depression symptoms.

In line with a previous study that found no bidirectional effects between mother's depression symptoms and infant's night wakings (Galbally et al., 2018), no bidirectional effects were found between mother's depression symptoms and bedtime resistance (a sub-scale that also assesses infant's frequent night wakings), positive sleep habits, daytime sleepiness and total sleep problems. It may be suggested that the bidirectional effects between mother's depression symptoms and infant's sleep problems are only present in specific infant's sleep problems during the first year, namely infant's sleep anxiety. Considering previous research with older children reporting bidirectional effects between mother's mood and sleep problems (Bell & Belsky, 2008), it may also be suggested that the bidirectional effects between mother's depression symptoms and the remaining dimensions of sleep problems only occur further in children's development.

Results from **Paper IV** and **Paper V** allowed us to respond to the third objective of this thesis, by showing the moderator role of infant's sex on the unidirectional and bidirectional effects between mother's depression symptoms and infant's sleep problems. Boys were shown to be more vulnerable to the effects of mother's depression symptoms and mothers were shown to be more vulnerable to the effects of boys' sleep problems (**Paper IV** and **Paper V**).

Results from **Paper IV** and **Paper V** revealed that boys of mothers with more prenatal depression symptoms presented more sleep problems than girls. This result is congruent with previous research showing that the exposure to mother's prenatal depression symptoms has a more pervasive effect on boys' developmental outcomes (Beeghly et al., 2017; McGinnis et al., 2015; Nolvi et al., 2018), including sleep problems (Netsi et al., 2015).

This result also brought evidence to the recent literature that has been pointing for sex differences in fetal programming (DiPietro & Voegtline, 2017; Sandman et al., 2013; Sutherland & Brunwasser, 2018). The fetal programming theory acknowledges that the exposure to mother's prenatal depression symptoms, may lead to long term consequences on infant's developmental outcomes (Barker, 2004; Beydoun & Saftlas, 2008; Glover, 2011). Recent literature has been acknowledging that infants are affected by a prenatal stressor in a sex-dependent way, with male infants being more affected on their development and health than female infants by a prenatal disadvantaged environment (DiPietro & Voegtline, 2017; Sandman et al., 2013; Sutherland & Brunwasser, 2018). The exposure to mother's prenatal depression symptoms may have a different impact on males' and females' developmental outcomes (DiPietro & Voegtline, 2017; Sandman et al., 2013; Sutherland & Brunwasser, 2018). Previous studies showed that male fetuses present more difficulty than female fetuses to adapt to a prenatal adverse environment (Lorente-Pozo et al., 2018; Sandman et al., 2013; Sutherland & Brunwasser, 2018). Considering this increased difficulty, it may be argued that male infants exposed to mother's prenatal depression symptoms may be more affected in their developmental outcomes, including sleep problems, than female infants exposed to mother's prenatal depression symptoms.

Results from **Paper V** add to the previous literature by additionally showing that the bidirectional effects between mother's depression symptoms and infant's sleep anxiety, also occur only in boys. Boys whose mothers reported more depression symptoms at the third pregnancy trimester and at two weeks showed more sleep anxiety at two weeks and three months, and mothers whose boys presented more sleep anxiety at three months reported more depression symptoms at six months postpartum. This result brought a new advance to the literature by showing that mothers of boys are more vulnerable to their infant's sleep problems. Considering previous research showing that boys present more dysregulated

sleep-wake behaviors than girls (e.g., Blair et al., 2012; Kaley et al., 2012; Santos et al., 2012), it may be suggested that mothers of boys may present more difficulties in the management of their sons' sleep, which may affect their self-efficacy and, consequently, lead to the emergence of depression symptoms (Falah-Hassani, Shiri, & Dennis, 2016; Giallo, Cooklin, & Nicholson, 2014; Haslam, Pakenham, & Smith, 2006).

Results from **Paper IV** and **Paper V** and recent evidence on sex differences shed the light to draw **Paper VI**. A previous study (Netsi et al., 2015) and our data brought evidence that mother's prenatal depression symptoms may lead to the emergence of infant's sleep problems, specifically in boys. The characteristics of boys that may contribute to this differential effect were still to explore. Results from **Paper VI** allowed us to respond to the fourth objective of this thesis, by showing that infant's temperament characteristics mediate the effects of mother's prenatal depression symptoms on infant's sleep problems, only in boys.

Boys' negative affectivity at two weeks was shown to mediate the effects of mother's prenatal depression symptoms on infant's total sleep problems at six months (**Paper VI**). Girls' temperament at two weeks did not mediate mother's prenatal depression symptoms effects on girls' sleep problems (**Paper VI**). These results are congruent with previous research showing an association between mother's prenatal depression symptoms and infant's temperament, when mother's concurrent postpartum depression symptoms were controlled (Davis et al., 2007; Gustafsson et al., 2018; Zhang et al., 2018). These results are also congruent with previous studies revealing an association between infant's temperament and dysregulated sleep patterns (Kaley et al., 2012; Mindell & Lee, 2015; Sorondo & Reeb-Sutherland, 2015). These results are also congruent with previous studies showing that infant's temperament play a major role on the association between mother's prenatal depression symptoms and infant's sleep problems (Kim et al., 2020; Netsi et al., 2015), and add to previous literature by showing that the mediator effect of infant's temperament on the association between mother's prenatal depression symptoms and infant's sleep problems only occurs in boys.

These results brought evidence to the fetal programming theory (Barker, 2004), arguing that infant's exposed to a prenatal adverse environment (e.g., mother's prenatal depression symptoms), may present changes on their fetal development, leading to negative consequences on their development and health (Barker, 2004; Beydoun & Saftlas, 2008; Glover, 2011). Previous research already shown that mother's prenatal depression symptoms have a negative effect on infant's neurobehavioral development and self-regulation (Figueiredo et al., 2017; Glover et al., 2018; Martini et al., 2017), which may include

infant's temperament characteristics. These results also brought evidence to the recent literature suggesting that boys are more vulnerable than girls to the exposure to prenatal adverse environments (DiPietro & Voegtline, 2017; Sandman et al., 2013; Sutherland & Brunwasser, 2018). We may suggest that the exposure to mother's prenatal depression has a sex-dependent effect on infant's temperament at two weeks, particularly on infant's negative affectivity. On their turn, infant's negative affectivity has been reported as a precursor of further developmental problems (Beijers, Riksen-Walraven, Putnam, de Jong, & de Weerth, 2013; Gartstein & Rothbart, 2003; Putnam, & Stifter, 2005), and the present results added to previous literature by specifically showing the negative effect of infant's negative affectivity on sleep problems. A previous study suggested that infant's temperament characteristics may be associated with the emergence of sleep problems, by affecting infant's sleep routines and sleep consolidation (De Marcas et al., 2015). A possible explanation for these results is that infant's negative affectivity may interfere with the successful accomplishment of the sleep developmental tasks, contributing to the emergence of sleep problems in boys. We may suggest that infant's negative affectivity at two weeks may be an early marker of boys' sleep problems, explaining the negative effects of mother's prenatal depression symptoms on infant's sleep problems in boys.

Limitations and strengths

The studies that comprise this thesis present some limitations. First, all the studied variables (mother's prenatal and postpartum depression symptoms, infant's sleep problems, and infant's temperament) were assessed with measures based on maternal reports. This should be considered a limitation as parent reports may be subject to reporting biases. Previous research has been found an association between mother's depression symptoms and dysfunctional cognitions regarding infant's sleep (Teti & Crosby, 2012). Depressed mothers were shown to present cognitions reinforcing the need of maternal presence at bedtime, which in turn were associated with increased maternal soothing behaviors (Teti & Crosby, 2012; Tikotzky & Sadeh, 2009) and the association between infant's temperament and sleep problems may also be influenced by parental misperceptions (Mindell & Lee, 2015; Spruyt, Aitken, So, Charlton, Adamson, & Horne, 2008). Literature had, however, acknowledging that parental reports are the most useful indicator of infant's sleep problems (Hiscock & Fisher, 2015) and strong associations have been reported in the literature between measures based on maternal reports and behavioral measures assessing both infant's sleep and temperament (Rothbart, Ellis, & Posner 2011; Werner, Molinari, Guyer, & Jenni, 2008). All the three measures (EPDS, CSHQ-I, and IBQ-R) have been presenting

adequate to good reliability in previous studies (Costa & Figueiredo, 2018; Dias et al., 2018; Figueiredo et al., 2017). The empirical studies also tested the within-time correlations between mother's postpartum depression symptoms and infant's sleep problems.

Second, the differences found between women who did complete all the study measures and women who did not should be acknowledged as a limitation of the present thesis. Considering that primiparous women presented an increased probability of completing all the assessment-points, caution should be taken regarding the generalization of these studies' findings. No other socio-demographic differences were found between women who completed all the assessment points and women who did not complete.

Third, while mother's postpartum depression symptoms were assessed at two weeks, three and six months postpartum, mother's prenatal depression symptomatology was assessed only at the third pregnancy trimester. This may be considered a limitation as we may not assure that the effects of mother's prenatal depression symptoms on the fetus' development occurred at the third pregnancy trimester. Previous literature has been shown the effects of mother's depression symptoms in earlier stages of pregnancy on infant's developmental outcomes (Maina, Saracco, Giolito, Danelon, Bogetto, & Todros, 2008; Suri, Altshuler, Hellemann, Burt, Aquino, & Mintz, 2007; Wisner et al., 2013).

Fourth, the empirical studies of this thesis analyzed the effect of mother's depression symptoms and did not consider the effect of other parental variables that may be associated with the emergence of infant's sleep problems (e.g., mother's anxiety symptoms or sleep quality, and father's variables). This may be considered a limitation of the present thesis, as infant's sleep-wake behaviors were shown to be associated with different parental variables (**Paper II**; Dias & Figueiredo, 2019, for a review), that may had also played an important role explaining the links between mother's depression symptoms and infant's sleep problems.

This thesis also present important strengths that should be highlighted. First, all the studies enclosed a longitudinal design, with mother-infant dyads followed from the third pregnancy trimester to six months postpartum, within four assessment waves.

Second, all the empirical studies used validated measures to assess all the studied variables. Mother's prenatal and postpartum depression symptoms were assessed with a validated and internationally used instrument to screen for prenatal and postpartum depression symptoms (e.g., Eastwood et al., 2012; Mao et al., 2011; Milgrom et al., 2008). This measure also demonstrated its validity in Portuguese samples (Figueiredo & Conde, 2011; Figueiredo et al., 2017; Tendais et al., 2015). Infant's sleep problems were gathered with a validated and worldwide used instrument to assess different

specific sleep problems (e.g., Goodlin-Jones, Sitnick, Tang, Liu, & Anders, 2008; Owens et al., 2000; Waumans, Terwee, Van den Berg, Knol, Van Litsenburg, & Gemke, 2010). This measure was adapted to assess infant's sleep problems during the first year (Dias et al., 2018). A validated and widely used measure was also used to assess infant's temperament characteristics (e.g., Davis et al., 2007; Gartstein & Robarth, 2003; Gustafsson et al., 2018). This measure was adapted to assess infant's temperament characteristics early after birth (**Paper III**, Dias et al., under review).

Third, the present thesis considered the effects of both mother's prenatal and postpartum depression symptoms on infant's sleep problems. This should be considered a strength, as the present results highlighted the major role of mother's prenatal and early postpartum depression symptoms on the emergence of infant's sleep problems, by also testing the within-time correlations between mother's postpartum depression symptoms and infant's sleep problems.

Fourth, **Paper V** tested a joint model that considered the unidirectional and bidirectional effects between mother's depression symptoms and infant's sleep problems. Considering the inconsistent findings reported in previous research that separately tested the maternal- and infant-driven models, the present thesis considered the mutual influences between mother's depression symptoms and infant's sleep problems and studied different infant's sleep problems. This should be acknowledged as a strength as the present results added to previous research, helping to clarify the links between mother's depression symptoms and infant's sleep problems.

Fifth, the empirical studies acknowledged for the emerging evidence reporting sex differences on the developmental effects of the exposure to a prenatal adverse environment (DiPietro & Voegtline, 2017; Sandman et al., 2013; Sutherland & Brunwasser, 2018).

Implications for infant's sleep research and clinical practice

The findings of the studies comprising this thesis enclose important implications for infant's sleep research. The results from these studies provide evidence on the negative effects of both mother's prenatal and early postpartum depression symptoms on the specific infant's sleep problems during the first six months of life. These findings present relevant implications for research considering that sleep problems during infancy are predictors of several developmental problems during childhood (Byars et al., 2012; Sivertsen et al., 2015; Williams et al., 2017).

Evidence was provided on the existence of both unidirectional and bidirectional effects of mother's depression symptoms on infant's sleep problems. This result brought evidence to the

transactional model (Sameroff, 1989, 1993), that pointed for a dynamic interplay between parental factors and infant's sleep problems (Sadeh et al., 2010). This result contributed to the existing literature on infant's sleep problems by showing that the bidirectional effects between mother's depression symptoms and infant's sleep problems specifically occurred on infant's sleep anxiety dimension. These studies added knowledge to the research that have been separately testing the maternal- and infant-driven models, by testing a joint model, that considered the potential mutual influences between mother's depression symptoms and infant's sleep problems.

The empirical studies also contributed to infant's sleep research by identifying sex differences on both the unidirectional and bidirectional effects between mother's depression symptoms and infant's sleep problems. These results added knowledge on the existing literature by showing that boys present increased susceptibility to the effects of mother's depression symptoms and mothers present increased susceptibility to the effects of their sons' sleep problems. Moreover, the present results showed that infant's characteristics, namely infant's temperament, may contribute to the negative effects of mother's prenatal depression on boys' sleep problems.

The present thesis also presents important implications for clinical practice. First, by showing the effects of mother's prenatal and early postpartum depression symptoms on infant's sleep problems, these findings acknowledge the need of screening for mother's depression symptoms during pregnancy and early postpartum routine appointments. The introduction of this early screening on routine perinatal care may help clinicians to identify and early intervene with mothers who present more depression symptoms, helping them to deal with their infant's sleep needs, and preventing the emergence of infant's sleep problems during the first year of life.

Second, by showing the bidirectional effects between mother's depression symptoms and infant's sleep problems, these findings also acknowledge the need of screening for infant's sleep problems to better identify those mothers who are at increased risk of presenting more depression symptoms at postpartum. The bidirectional effects found also provided important guidelines for interventions targeting infant's sleep problems and for interventions targeting mother's depression symptoms. Considering the present results, interventions targeting infant's sleep problems should include on their targets the assessment and intervention on mother's depression symptoms and interventions targeting mother's depression symptoms should include on their targets the assessment and intervention on infant's sleep problems.

By showing the role of infant's sex and infant's temperament on the effects between mother's depression symptoms and infant's sleep problems, these findings may help to inform clinicians on the

need of designing targeted interventions for infant's sleep problems. The present results may help clinicians to identify the infants that may be at increased risk of developing sleep problems, offering to their mothers additional support to deal with their infant's sleep needs.

Suggestions for future research

Further research should be conducted to analyze the effects of mother's prenatal depression symptoms on infant's sleep problems across the three pregnancy trimesters. The assessment of mother's prenatal depression symptoms across the three pregnancy trimesters would enable to compare the effect of mother's depression symptomatology at the first pregnancy trimester on infant's temperament characteristics and sleep problems with the effects of mother's depression symptomatology at the second and third pregnancy trimesters.

Unidirectional and bidirectional effects between mother's depression symptoms and infant's sleep problems were only found in boys in the present thesis. Previous studies already showed that boys exposed to mother's prenatal depression symptoms present more developmental problems than girls (Beeghly et al., 2017; McGinnis et al., 2015; Nolvi et al., 2018). To our knowledge only one previous study analyzed the role of infant's sex on the impact of the exposure to mother's prenatal depression symptoms on infant's sleep problems, showing that boys exposed to more mother's prenatal depression symptoms present more sleep problems than girls (Netsi et al., 2015). Future studies may consider sex differences when studying the effects of mother's prenatal and postpartum depression symptoms on infant's sleep problems.

The present studies showed that infant's negative affectivity at two weeks may be implied in the emergence of sleep problems in boys, but not in girls. Considering this result, further research may be conducted to analyze the infant's characteristics that may contribute to girls' sleep problems.

The present studies revealed the unidirectional and bidirectional effects between mother's prenatal and postpartum depression symptoms and infant's sleep problems. The transactional model (Sameroff, 1989, 1993) argues that infant's development is resultant from a dynamic interplay between infant, parental and contextual variables. Accounting for this perspective, further studies should also include in their models the effects of (1) different mother's variables, namely mother's sleep quality or anxiety symptoms, (2) father's variables, namely father's mental health and involvement, particularly during the postpartum period, and (3) parenting variables, namely parenting quality, on the emergence of infant's sleep problems, considering both the unidirectional and bidirectional effects.

Conclusion

Results from this thesis provided evidence on the reference values and the changes occurring on infant's sleep wake-behavior during the first 12 months of life and identified the variables most consistently associated with infant's sleep-wake behavior during the first year. Results from this thesis also suggested the IBQ-R as a reliable instrument to assess infant's temperament in the first weeks after birth. Results from this thesis also provided consistent evidence on the effects of both mother's prenatal and postpartum depression symptoms on the emergence of infant's sleep problems. Evidence was also provided that both unidirectional and bidirectional effects occur between mother's depression symptoms and infant's sleep problems. The results suggested that these unidirectional and bidirectional effects were moderated by infant's sex and evidence was provided that the negative effect of mother's prenatal depression symptoms on infant's sleep problems was mediated by infant's negative affectivity early after birth, only in boys.

Results from these studies recognized that infant's sleep problems constitute a multidimensional and dynamic process during the first six months of infant's life. Mother's depression symptoms at pregnancy were highlighted as having a major effect on the emergence of infant's sleep problems, and mutual influences between mother's depression symptoms and infant's sleep problems were also identified during the postpartum period. A sex-dependent effect was identified, with boys being shown as more vulnerable to the effects of mother's depression symptoms and mothers being shown as more vulnerable to the effects of their boys' sleep problems. This differential impact was suggested to be explained by the effects of mother's prenatal depression symptoms on boys' negative affectivity at two weeks, which, in turn, leads to more sleep problems.

REFERENCES

Abulizi, X., Pryor, L., Michel, G., Melchior, M., Van Der Waerden, J., & EDEN Mother–Child Cohort Study Group. (2017). Temperament in infancy and behavioral and emotional problems at age 5.5: the EDEN mother-child cohort. *PloS One, 12*, e0171971. doi: 10.1371/journal.pone.0171971

Anders, T. F., Halpern, L. F., & Hua, J. (1992). Sleeping through the night: a developmental perspective. *Pediatrics*, *90*(4), 554-560. Retrieved online from https://pediatrics.aappublications.org/content/90/4/554.long

Anders TF, Keener M. (1985). Developmental course of nighttime sleep-wake patterns in full-term and premature infants during the first year of life. I. *Sleep, 8*, 173-192. doi: 10.1093/sleep/8.3.173

Armitage, R., Flynn, H., Hoffmann, R., Vazquez, D., Lopez, J., & Marcus, S. (2009). Early developmental changes in sleep in infants: the impact of maternal depression. *Sleep, 32*, 693-696. doi: 10.1093/sleep/32.5.693

Bale, T. L. (2015). Epigenetic and transgenerational reprogramming of brain development. *Nature Reviews Neuroscience*, *16*, 332-344. doi: 10.1038/nrn3818

Barker, D. J. P. (2004). The developmental origins of adult disease. *Journal of the American College of Nutrition, 23*, 588S–595S. doi: 10.1080/07315724.2004.10719428

Bat-Pitault, F., Sesso, G., Deruelle, C., Flori, S., Porcher-Guinet, V., Stagnara, C., ... & Patural, H. (2017). Altered sleep architecture during the first months of life in infants born to depressed mothers. *Sleep Medicine, 30*, 195-203. doi: 10.1016/j.sleep.2016.11.018

Bayer, J. K., Hiscock, H., Hampton, A., & Wake, M. (2007). Sleep problems in young infants and maternal mental and physical health. *Journal of Paediatrics and Child Health, 43*, 66-73. doi: 10.1111/j.1440-1754.2007.01005.x

Beebe, B., Jaffe, J., Buck, K., Chen, H., Cohen, P., Feldstein, S., & Andrews, H. (2008). Six-week postpartum maternal depressive symptoms and 4-month mother–infant self-and interactive contingency. *Infant Mental Health Journal, 29*, 442-471. doi: 10.1002/imhj.20191

Beeghly, M., Partridge, T., Tronick, E., Muzik, M., Mashhadi, M. R., Boeve, J. L., & Irwin, J. L. (2017). Associations between early maternal depressive symptom trajectories and toddlers' felt security at 18 months: are boys and girls at differential risk? *Infant Mental Health Journal, 38*, 53-67. doi: 10.1002/imhj.21617

Beijers, R., Riksen-Walraven, M., Putnam, S., de Jong, M., & de Weerth, C. (2013). Early non-parental care and toddler behaviour problems: links with temperamental negative affectivity and

inhibitory control. *Early Childhood Research Quarterly, 28*, 714-722. doi: 10.1016/j.ecresq.2013.06.002

Bell, B. G., & Belsky, J. (2008). Parents, parenting, and children's sleep problems: exploring reciprocal effects. *British Journal of Developmental Psychology*, *26*, 579-593. doi: 10.1348/026151008X285651

Beydoun, H., & Saftlas, A. F. (2008). Physical and mental health outcomes of prenatal maternal stress in human and animal studies: A review of recent evidence. *Paediatric and Perinatal Epidemiology, 22*, 438–466. doi: 10.1111/j.1365-3016.2008.00951.x.

Blair, P. S., Humphreys, J. S., Gringras, P., Taheri, S., Scott, N., Emond, A., ... & Fleming, P. J. (2012). Childhood sleep duration and associated demographic characteristics in an English cohort. *Sleep*, *35*, 353-360. doi: 10.5665/sleep.1694

Bornstein, M. H., Putnick, D. L., Gartstein, M. A., Hahn, C. S., Auestad, N., & O'Connor, D. L. (2015). Infant temperament: stability by age, gender, birth order, term status, and socioeconomic status. *Child Development, 86*, 844-863. doi: 10.1111/cdev.12367

Bowers, K., Khoury, J., Sucharew, H., Xu, Y., Chen, A., Lanphear, B., & Yolton, K. (2018). Early infant attention as a predictor of social and communicative behavior in childhood. *International Journal of Behavioral Development, 43,* 204-211. doi: 10.1177/0165025418797001

Britton, J. R. (2011). Infant temperament and maternal anxiety and depressed mood in the early postpartum period. *Women & Health, 51*, 55-71. doi: 10.1080/03630242.2011.540741

Bruni, O., Baumgartner, E., Sette, S., Ancona, M., Caso, G., Di Cosimo, M. E., . . . & Ferri, R. (2014). Longitudinal study of sleep behavior in normal infants during the first year of life. *Journal of Clinical Sleep Medicine, 10*, 1119–1127. doi: 10.5664/jcsm.4114

Burnham, M. M., Goodlin-Jones, B. L., Gaylor, E. E., & Anders, T. F. (2002). Nighttime sleep-wake patterns and self-soothing from birth to one year of age: a longitudinal intervention study. *Journal of Child Psychology and Psychiatry,* 43, 713-725. doi: 10.1111/1469-7610.00076

Buss, A. (1989). Temperaments as personality traits. In G. A. Kohnstamm, J. E. Bates, & M. K. Rothbart (Eds.), *Temperament in childhood* (pp. 49–58). Oxford, UK: Wiley.

Byars, K. C., Yolton, K., Rausch, J., Lanphear, B., & Beebe, D. W. (2012). Prevalence, patterns, and persistence of sleep problems in the first 3 years of life. *Pediatrics, 129*, e276-e284. doi: 10.1542/peds.2011-0372

Cao-Lei, L., De Rooij, S. R., King, S., Matthews, S. G., Metz, G. A. S., Roseboom, T. J., & Szyf, M. (2017). Prenatal stress and epigenetics. *Neuroscience & Biobehavioral Reviews. Published online before print*. doi: 10.1016/j.neubiorev.2017.05.016.

Canals, J., Hernández-Martínez, C., Esparó, G., & Fernández-Ballart, J. (2011). Neonatal behavioral assessment scale as a predictor of cognitive development and IQ in full-term infants: a 6-year longitudinal study. *Acta Paediatrica, 100*, 1331-1337. doi: 10.1111/j.1651-2227.2011.02306.x

Carranza, J. A., González-Salinas, C., & Ato, E. (2013). A longitudinal study of temperament continuity through IBQ, TBAQ and CBQ. *Infant Behavior and Development*, *36*, 749-761. doi: 10.1016/j.infbeh.2013.08.002

Cicchetti, D. (1993). Developmental psychopathology: reactions, reflections, projections. *Developmental Review, 13*, 471-502. doi: 10.1006/drev.1993.1021

Conradt, E., Adkins, D. E., Crowell, S. E., Raby, K. L., Diamond, L. M., & Ellis, B. (2018). Incorporating epigenetic mechanisms to advance fetal programming theories. *Development and Psychopathology, 30*, 807-824. doi: 10.1017/S0954579418000469

Costa, R., & Figueiredo, B. (2018). Infant Behavior Questionnaire – Revised Version: a psychometric study in a Portuguese sample. *Journal of Reproductive and Infant Psychology, 36,* 207-218. doi: 10.1080/02646838.2018.1436752

Couto, T. C., Cardoso, M. N., Brancaglion, M. M., Faria, G. C., Garcia, F. D., Nicolato, R., ... & Corrêa, H. (2016). Antenatal depression: prevalence and risk factor patterns across the gestational period. *Journal of Affective Disorders*, *192*, 70-75. doi: 10.1016/j.jad.2015.12.017

Cox, J. L., Holden, J. M., & Sagovsky, R. (1987). Detection of postnatal depression: development of the 10-item Edinburgh Postnatal Depression Scale. *The British Journal of Psychiatry*, *150*, 782-786. doi: 10.1192/bjp.150.6.782

Davis, E. P., Glynn, L. M., Schetter, C. D., Hobel, C., Chicz-Demet, A., & Sandman, C. A. (2007). Prenatal exposure to maternal depression and cortisol influences infant temperament. *Journal of the American Academy of Child & Adolescent Psychiatry, 46*, 737-746. doi: 10.1097/chi.0b013e318047b775

Davis, E. P., Glynn, L. M., Waffarn, F., & Sandman, C. A. (2011). Prenatal maternal stress programs infant stress regulation. *Journal of Child Psychology and Psychiatry, 52*, 119-129. doi: 10.1111/j.1469-7610.2010.02314.x

Davis, E. P., Hankin, B. L., Swales, D. A., Hoffman, M. C. (2018). An experimental test of the fetal programming hypothesis: Can we reduce child ontogenetic vulnerability to psychopathology by

decreasing maternal depression? *Development and Psychopathology, 30*, 787-806. doi: 10.1017/S0954579418000470

De Marcas, G. S., Soffer-Dudek, N., Dollberg, S., Bar-Haim, Y., & Sadeh, A. (2015). IV. Reactivity and sleep in infants: a longitudinal objective assessment. *Monographs of the Society for Research in Child Development, 80*, 49-69. doi: 10.1111/mono.12144

Dennis, C. L., & Ross, L. (2005). Relationships among infant sleep patterns, maternal fatigue, and development of depressive symptomatology. *Birth, 32*, 187-193. doi: 10.1111/j.0730-7659.2005.00368.x

DiPietro, J. A., Hodgson, D. M., Costigan, K. A., & Johnson, T. R. (1996). Fetal antecedents of infant temperament. *Child Development, 67*, 2568-2583. doi: 10.1111/j.1467-8624.1996.tb01875.x

DiPietro, J. A., Ghera, M. M., & Costigan, K. A. (2008). Prenatal origins of temperamental reactivity in early infancy. *Early Human Development, 84*, 569-575. doi: 10.1016/j.earlhumdev.2008.01.004

DiPietro, J. A., & Voegtline, K. M. (2017). The gestational foundation of sex differences in development and vulnerability. *Neuroscience, 342*, 4-20. doi: 10.1016/j.neuroscience.2015.07.068

DiPietro, J. A., Voegtline, K. M., Pater, H. A., & Costigan, K. A. (2018). Predicting child temperament and behavior from the fetus. *Development and Psychopathology, 30*, 855-870. doi:10.1017/S0954579418000482

Eastwood, J. G., Jalaludin, B. B., Kemp, L. A., Phung, H. N., & Barnett, B. E. (2012). Relationship of postnatal depressive symptoms to infant temperament, maternal expectations, social support and other potential risk factors: findings from a large Australian cross-sectional study. *BMC Pregnancy and Childbirth, 12*, 148-158. doi: 10.1186/1471-2393-12-148

El-Sheikh, M., & Kelly, R. J. (2017). Family functioning and children's sleep. *Child Development Perspectives, 11*, 264-269. doi: 10.1111/cdep.12243

Falah-Hassani, K., Shiri, R., & Dennis, C. L. (2016). Prevalence and risk factors for comorbid postpartum depressive symptomatology and anxiety. *Journal of Affective Disorders, 198*, 142-147. doi: 10.1016/j.jad.2016.03.010

Field, T. (2010). Postpartum depression effects on early interactions, parenting, and safety practices: a review. *Infant Behavior and Development*, *33*, 1-6. doi: 10.1016/j.infbeh.2009.10.005

Field, T., Diego, M., Hernandez-Reif, M., Figueiredo, B., Schanberg, S., & Kuhn, C. (2007). Sleep disturbances in depressed pregnant women and their newborns. *Infant Behavior and Development, 30*, 127-133. doi: 10.1016/j.infbeh.2006.08.002

Field, T., Hernandez-Reif, M., & Diego, M. (2006). Intrusive and withdrawn depressed mothers and their infants. *Developmental Review*, *26*, 15-30. doi: 10.1016/j.dr.2005.04.001

Figueiredo, B., & Conde, A. (2011). Anxiety and depression in women and men from early pregnancy to 3-months postpartum. *Archives of Women's Mental Health, 14*, 247-255. doi: 10.1007/s00737-011-0217-3

Figueiredo, F., Dias, C. C., Pinto, T., & Field, T. (2016). Infant sleep-wake behaviors at two weeks, three and six months. *Infant Behavior and Development, 44*, 169-178. doi: 10.1016/j.infbeh.2016.06.011

Figueiredo, B., Pinto, T. M., Pacheco, A., & Field, T. (2017). Fetal heart rate variability mediates prenatal depression effects on neonatal neurobehavioral maturity. *Biological Psychology*, *123*, 294-301. doi: 10.1016/j.biopsycho.2016.10.013

Figueiredo, B., Teixeira, C., Conde, A., Pinto, A. R., & Sarmento, P. (2009). Utentes da consulta externa de ginecologia/obstetrícia da Maternidade Júlio Dinis. *Revista Portuguesa de Psicologia, 41,* 45-64. Retrieved from http://repositorio.uportu.pt/xmlui/handle/11328/260

Galland, B.C., Taylor, B. J., Elder, D. E., & Herbison, P. (2012). Normal sleep patterns in infants and children: A systematic review of observational studies. *Sleep Medicine Reviews, 16*, 213-222. doi: 10.1016/j.smrv.2011.06.00

Gartstein, M. A., & Rothbart, M. K. (2003). Studying infant temperament via the revised infant behavior questionnaire. *Infant Behavior and Development, 26*, 64-86. doi:10.1016/S0163-6383(02)00169-8

Gartstein, M.A., Slobodskaya, H.R., Olaf Zylicz, P., Gosztyla, D., & Nakagawa, A. (2010). A cross-cultural evaluation of temperament: Japan, USA, Poland and Russia. *International Journal of Psychology and Psychological Therapy, 10*(1), 55-75

Gentile, S. (2017). Untreated depression during pregnancy: short-and long-term effects in offspring. a systematic review. *Neuroscience*, *342*, 154-166. doi: 10.1016/j.neuroscience.2015.09.001

Gerardin, P., Wendland, J., Bodeau, N., Galin, A., Bialobos, S., Tordjman, S., ... & Cohen, D. (2011). Depression during pregnancy: is the developmental impact earlier in boys? A prospective case-control study. *Journal of Clinical Psychiatry*, *72*, 378- 387. doi: 10.4088/JCP.09m05724blu

Giallo, R., Cooklin, A., & Nicholson, J. M. (2014). Risk factors associated with trajectories of mothers' depressive symptoms across the early parenting period: an Australian population-based longitudinal study. *Archives of Women's Mental Health, 17*, 115-125. doi: 10.1080/02646838.2011.593030

Giallo, R., Rose, N., & Vittorino, R. (2011). Fatigue, wellbeing and parenting in mothers of infants and toddlers with sleep problems. *Journal of Reproductive and Infant Psychology, 29*, 236-249. doi: 10.1080/02646838.2011.593030

Gibson, R., Gander, P., & Elder, D. (2012). Factors differentiating infants identified by parents as problem sleepers, and those that are not. *Sleep and Biological Rhythms*, *10*, 46-52. doi: 10.1111/j.1479-8425.2011.00517.x

Glover, V. (2011). Annual research review: prenatal stress and the origins of psychopathology: an evolutionary perspective. *Journal of Child Psychology and Psychiatry, 52*, 356-367. doi: 10.1111/j.1469-7610.2011.02371.x

Glover, V., O'Donnell, K. J., O'Connor, T. G., & Fisher, J. (2018). Prenatal maternal stress, fetal programming, and mechanisms underlying later psychopathology — a global perspective. *Development and Psychopathology, 30*, 843-854. doi: 10.1017/S095457941800038X

Glynn, L. M., Howland, M. A., Sandman, C. A., Davis, E. P., Phelan, M., Baram, T. Z., & Stern, H. S. (2018). Prenatal maternal mood patterns predict child temperament and adolescent mental health. *Journal of Affective Disorders, 228*, 83-90. doi: 10.1016/j.jad.2017.11.065

Goodlin-Jones, B. L., Burnham, M. M., Gaylor, E. E., & Anders, T. F. (2001). Night waking, sleep-wake organization, and self-soothing in the first year of life. *Journal of Developmental and Behavioral Pediatrics: JDBP*, *22*(4), 226-233.

Goodlin-Jones, B. L., Sitnick, S. L., Tang, K., Liu, J., & Anders, T. F. (2008). The Children's Sleep Habits Questionnaire in toddlers and preschool children. *Journal of Developmental and Behavioral Pediatrics: JDBP, 29*, 82-88. doi: 10.1097/DBP.0b013e318163c39a

Grace, S. L., Evindar, A., & Stewart, D. E. (2003). The effect of postpartum depression on child cognitive development and behavior: a review and critical analysis of the literature. *Archives of Women's Mental Health, 6*, 263-274. doi: 10.1007/s00737-003-0024-6

Gress-Smith, J. L., Luecken, L. J., Lemery-Chalfant, K., & Howe, R. (2012). Postpartum depression prevalence and impact on infant health, weight, and sleep in low-income and ethnic minority women and infants. *Maternal and Child Health Journal*, *16*, 887-893. doi: 10.1007/s10995-011-0812-y

Gurung, B., Jackson, L. J., Monahan, M., Butterworth, R., & Roberts, T. E. (2018). Identifying and assessing the benefits of interventions for postnatal depression: a systematic review of economic evaluations. *BMC Pregnancy and Childbirth, 18*, 179-197. doi: 10.1186/s12884-018-1738-9

Gustafsson, H. C., Sullivan, E. L., Nousen, E. K., Sullivan, C. A., Huang, E., Rincon, M., ... & Loftis, J. M. (2018). Maternal prenatal depression predicts infant negative affect via maternal inflammatory cytokine levels. *Brain, Behavior, and Immunity, 73*, 470-481. doi: 10.1016/j.bbi.2018.06.011

Haslam, D. M., Pakenham, K. I., & Smith, A. (2006). Social support and postpartum depressive symptomatology: the mediating role of maternal self-efficacy. *Infant Mental Health Journal, 27*, 276-291. doi: 10.1002/imhj.20092

Hemmi, M. H., Wolke, D., & Schneider, S. (2011). Associations between problems with crying, sleeping and/or feeding in infancy and long-term behavioural outcomes in childhood: a meta-analysis. *Archives of Disease in Childhood, 96*, 622-629. doi: 10.1136/adc.2010.191312

Henderson, J. M., France, K. G., & Blampied, N. M. (2011). The consolidation of infants' nocturnal sleep across the first year of life. *Sleep Medicine Reviews*, *15*, 211-220. doi: 10.1016/j.smrv.2010.08.003

Henderson, J. M., France, K. G., Owens, J. L., & Blampied, N. M. (2010). Sleeping through the night: the consolidation of self-regulated sleep across the first year of life. *Pediatrics, 126*, e1081–e1087. doi: 10.1542/peds.2010-0976

Hiscock, H., Bayer, J., Gold, L., Hampton, A., Ukoumunne, O., & Wake, M. (2007). Improving infant sleep and maternal mental health: a cluster randomised trial. *Archives of Disease in Childhood, 92*, 952–958. doi: 10.1136/adc.2006.099812

Hiscock, H., & Wake, M. (2001). Infant sleep problems and postnatal depression: a community-based study. *Pediatrics*, *107*, 1317-1322. doi: 10.1542/peds.107.6.1317

Hiscock, H., & Fisher, J. (2015). Sleeping like a baby? Infant sleep: impact on caregivers and current controversies. *Journal of Paediatrics and Child Health, 51*, 361-364. doi: 10.1111/jpc.12752.

Huang, X. N., Wang, H. S., Chang, J. J., Wang, L. H., Liu, X. C., Jiang, J. X., & An, L. (2016). Feeding methods, sleep arrangement, and infant sleep patterns: A Chinese population-based study. World Journal of Pediatrics, 12, 66–75. doi:10.1007/s12519-015-0012-8

Hughes, A., Gallagher, S., & Hannigan, A. (2015). A cluster analysis of reported sleeping patterns of 9-month old infants and the association with maternal health: results from a population-based cohort study. *Maternal and Child Health Journal, 19*, 1881-1889. doi: 10.1007/s10995-015-1701-6

Iglowstein, I., Jenni, O. G., Molinari, L., & Largo, R. H. (2003). Sleep duration from infancy to adolescence: reference values and generational trends. *Pediatrics*, *111*, 302-307. doi: 10.1542/peds.111.2.302

Jenni, O. G., & Carskadon, M. A. (2007). Sleep behavior and sleep regulation from infancy through adolescence: normative aspects. *Sleep Medicine Clinics*, *2*(3), 321-329. doi:10.1016/j.jsmc.2007.05.001

Kaley, F., Reid, V., & Flynn, E. (2012). Investigating the biographic, social and temperamental correlates of young infants' sleeping, crying and feeding routines. *Infant Behavior and Development*, *35*, 596-605. doi: 10.1016/j.infbeh.2012.03.004

Kapoor, A., Dunn, E., Kostaki, A., Andrews, M. H., & Matthews, S. G. (2006). Fetal programming of hypothalamo-pituitary-adrenal function: prenatal stress and glucocorticoids. *The Journal of Physiology, 572*, 31-44. doi: 10.1113/jphysiol.2006.105254

Karraker, K. H., & Young, M. (2007). Night waking in 6-month-old infants and maternal depressive symptoms. *Journal of Applied Developmental Psychology*, *28*, 493-498. doi: 10.1016/j.appdev.2007.06.002

Kelmanson, I. A. (2004). Temperament and sleep characteristics in two-month-old infants. *Sleep and Hypnosis, 6*, 78-84.

Kempler, L., Sharpe, L., Miller, C. B., & Bartlett, D. J. (2016). Do psychosocial sleep interventions improve infant sleep or maternal mood in the postnatal period? A systematic review and meta-analysis of randomised controlled trials. *Sleep Medicine Reviews, 29*, 15-22. doi: 10.1016/j.smrv.2015.08.002

Kim, Y., Bird, A., Peterson, E., Underwood, L., Morton, S. M., & Grant, C. C. (2020). Maternal antenatal depression and early childhood sleep: potential pathways through infant temperament. *Journal of Pediatric Psychology, 45*, 203-217. doi: 10.1093/jpepsy/jsaa001.

Krawczak, E. M., Minuzzi, L., Hidalgo, M. P., & Frey, B. N. (2016). Do changes in subjective sleep and biological rhythms predict worsening in postpartum depressive symptoms? A prospective study across the perinatal period. *Archives of Women's Mental Health*, *19*, 591-598. doi: 10.1007/s00737-016-0612-x

Kurstjens, S., & Wolke, D. (2001). Effects of maternal depression on cognitive development of children over the first 7 years of life. *The Journal of Child Psychology and Psychiatry and Allied Disciplines, 42*, 623-636. doi: 10.1017/S0021963001007296

Lampl, M., & Johnson, M. L. (2011). Infant growth in length follows prolonged sleep and increased naps. *Sleep*, *34*, 641-650. doi: 10.1093/sleep/34.5.641

Lawson, A., Murphy, K. E., Sloan, E., Uleryk, E., & Dalfen, A. (2015). The relationship between sleep and postpartum mental disorders: a systematic review. *Journal of Affective Disorders, 176*, 65-77. doi: 10.1016/j.jad.2015.01.017

Leckman-Westin, E., Cohen, P. R., & Stueve, A. (2009). Maternal depression and mother–child interaction patterns: Association with toddler problems and continuity of effects to late childhood. *Journal of Child Psychology and Psychiatry, 50*, 1176-1184. doi: 10.1002/icd.679

Lorente-Pozo, S., Parra-Llorca, A., Torres, B., Torres-Cuevas, I., Nuñez-Ramiro, A., Cernada, M., ..., & Vento, M. (2018). Influence of sex on gestational complications, fetal-to-neonatal transition, and postnatal adaptation. *Frontiers in Pediatrics, 6*, 63-89. doi: 10.3389/fped.2018.00063

Martini, J., Petzoldt, J., Knappe, S., Garthus-Niegel, S., Asselmann, E., & Wittchen, H. U. (2017). Infant, maternal, and familial predictors and correlates of regulatory problems in early infancy: the differential role of infant temperament and maternal anxiety and depression. *Early Human Development, 115*, 23-31. doi: 10.1016/j.earlhumdev.2017.08.005

Maina, G., Saracco, P., Giolito, M. R., Danelon, D., Bogetto, F., & Todros, T. (2008). Impact of maternal psychological distress on fetal weight, prematurity andintrauterine growth retardation. *Journal of Affective Disorders, 111*, 214–220. doi: 10.1016/j.jad.2008.02.017

Mao, Q., Zhu, L. X., & Su, X. Y. (2011). A comparison of postnatal depression and related factors between Chinese new mothers and fathers. *Journal of Clinical Nursing*, *20*, 645-652. doi: 10.1111/j.1365-2702.2010.03542.x

Matricciani, L. A., Olds, T. S., Blunden, S., Rigney, G., & Williams, M. T. (2012). Never enough sleep: a brief history of sleep recommendations for children. *Pediatrics*, *129*, 548-556. doi: 10.1542/peds.2011-2039

Mattai, A. A., Tossell, J., Greenstein, D. K., Addington, A., Clasen, L. S., Gornick, M. C., ... & Gogtay, N. (2006). Sleep disturbances in childhood-onset schizophrenia. *Schizophrenia Research, 86*, 123-129. doi: 10.1016/j.schres.2006.04.020

McGinnis, E., Bocknek, E., Beeghly, M., Rosenblum, K. L., & Muzik, M. (2015). Does child sex moderate vulnerability to postpartum risk among infants of mothers at risk for psychopathology?. *Infancy, 20*, 42-69. doi: 10.1111/infa.12065

Meltzer, L. J., & Mindell, J. A. (2006). Sleep and sleep disorders in children and adolescents. *Psychiatric Clinics*, *29*, 1059-1076. doi: 10.1016/j.psc.2006.08.004

Meltzer, L. J., Plaufcan, M. R., Thomas, J. H., & Mindell, J. A. (2014). Sleep problems and sleep disorders in pediatric primary care: treatment recommendations, persistence, and health care utilization. *Journal of Clinical Sleep Medicine, 10*, 421-426. doi: 10.5664/jcsm.3620

Mindell, J. A., Kuhn, B., Lewin, D. S., Meltzer, L. J., & Sadeh, A. (2006). Behavioral treatment of bedtime problems and night wakings in infants and young children. *Sleep, 29*, 1263-1276. doi: 10.1093/sleep/29.10.1263

Mindell, J. A., & Lee, C. (2015). Sleep, mood, and development in infants. *Infant Behavior and Development*, *41*, 102-107. doi: 10.1016/j.infbeh.2015.08.004

Mindell, J. A., Meltzer, L. J., Carskadon, M. A., & Chervin, R. D. (2009). Developmental aspects of sleep hygiene: findings from the 2004 National Sleep Foundation Sleep in America Poll. *Sleep Medicine, 10*, 771-779. doi: 10.1016/j.sleep.2008.07.016

Mindell, J. A., Sadeh, A., Wiegand, B., How, T. H., & Goh, D. Y. (2010). Cross-cultural differences in infant and toddler sleep. *Sleep Medicine, 11*, 274-280. doi: 10.1016/j.sleep.2009.04.012

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & Prisma Group. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLoS Medicine, 6*, e1000097. doi: 10.1371/journal.pmed.1000097

Monk, C., Georgieff, M. K., & Osterholm, E. A. (2013) Research review: maternal prenatal distress and poor nutrition—mutually influencing risk factors affecting infant neurocognitive development. *Journal of Child Psychology and Psychiatry, 54*, 115–130. doi: 10.1111/jcpp.12000

Morrell, J., & Steele, H. (2003). The role of attachment security, temperament, maternal perception, and care-giving behavior in persistent infant sleeping problems. *Infant Mental Health Journal, 24*, 447-468. doi: 10.1002/imhj.10072

Mukherjee, S., Patel, S. R., Kales, S. N., Ayas, N. T., Strohl, K. P., Gozal, D., & Malhotra, A. (2015). An official American Thoracic Society statement: the importance of healthy sleep. Recommendations and future priorities. *American Journal of Respiratory and Critical Care Medicine*, *191*, 1450-1458. doi: 10.1164/rccm.201504-0767ST

Netsi, E., van IJzendoorn, M. H., Bakermans-Kranenburg, M. J., Wulff, K., Jansen, P. W., Jaddoe, V. W., ... & Ramchandani, P. G. (2015). Does infant reactivity moderate the association between antenatal maternal depression and infant sleep? *Journal of Developmental and Behavioral Pediatrics: JDBP*, *36*, 440-449. doi: 10.1097/DBP.0000000000000181.

Nevarez, M. D., Rifas-Shiman, S. L., Kleinman, K. P., Gillman, M. W., & Taveras, E. M. (2010). Associations of early life risk factors with infant sleep duration. *Academic Pediatrics*, *10*, 187-193. doi: 10.1016/j.acap.2010.01.007

Nolvi, S., Pesonen, H., Bridgett, D. J., Korja, R., Kataja, E. L., Karlsson, H., & Karlsson, L. (2018). Infant sex moderates the effects of maternal pre-and postnatal stress on executive functioning at 8 months of age. *Infancy, 23*, 194-210. doi: 10.1111/infa.12206

O'Connor, T. G., Caprariello, P., Blackmore, E. R., Gregory, A. M., Glover, V., Fleming, P., & ALSPAC Study Team. (2007). Prenatal mood disturbance predicts sleep problems in infancy and toddlerhood. *Early Human Development*, *83*, 451-458. doi: 10.1016/j.earlhumdev.2006.08.006

O'Donnell, K. J., & Meaney, M. J. (2016). Fetal origins of mental health: the developmental origins of health and disease hypothesis*. American Journal of Psychiatry, 174*, 319-328. doi: 10.1176/appi.ajp.2016.16020138

Ohgi, S., Takahashi, T., Nugent, J. K., Arisawa, K., & Akiyama, T. (2003). Neonatal behavioral characteristics and later behavioral problems. *Clinical Pediatrics, 42*, 679-686. doi: 10.1177/000992280304200803

Okun, M. L., Mancuso, R. A., Hobel, C. J., Schetter, C. D., & Coussons-Read, M. (2018). Poor sleep quality increases symptoms of depression and anxiety in postpartum women. *Journal of Behavioral Medicine, 41*, 703-710. doi: 10.1007/s10865-018-9950-7

Owens, J. A., Spirito, A., & McGuinn, M. (2000). The Children's Sleep Habits Questionnaire (CSHQ): psychometric properties of a survey instrument for school-aged children. *Sleep, 23*, 1043-1052. doi:10.1093/sleep/23.8.1d

Palmstierna, P., Sepa, A., & Ludvigsson, J. (2008). Parent perceptions of child sleep: a study of 10 000 Swedish children. *Acta Paediatrica*, *97*, 1631-1639. doi: 10.1111/j.1651-2227.2008.00967.x

Philbrook, L. E., & Teti, D. M. (2016). Bidirectional associations between bedtime parenting and infant sleep: parenting quality, parenting practices, and their interaction. *Journal of Family Psychology, 30*, 431–441. doi: 10.1037/fam0000198

Piteo, A. M., Roberts, R. M., Nettelbeck, T., Burns, N., Lushington, K., Martin, A. J., & Kennedy, J. D. (2013). Postnatal depression mediates the relationship between infant and maternal sleep disruption and family dysfunction. *Early Human Development*, *89*, 69-74. doi: 10.1016/j.earlhumdev.2012.07.017

Putnam, S. P., & Stifter, C. A. (2005). Behavioral approach–inhibition in toddlers: prediction from infancy, positive and negative affective components, and relations with behavior problems. *Child Development, 76*, 212-226. doi: 10.1111/j.1467-8624.2005.00840.x

Ramamurthy, M. B., Sekartini, R., Ruangdaraganon, N., Huynh, D. H. T., Sadeh, A., & Mindell, J. A. (2012). Effect of current breastfeeding on sleep patterns in infants from Asia-Pacific region. *Journal of Paediatrics and Child Health, 48*, 669–674. doi:10.1111/j.1440-1754.2012.02453.x

Ramtekkar, U., & Ivanenko, A. (2015). Sleep in children with psychiatric disorders. *Seminars in Pediatric Neurology*, 22, 148-155. doi: 10.1016/j.spen.2015.04.004

Rhoades, K. A., Leve, L. D., Harold, G. T., Mannering, A. M., Neiderhiser, J. M., Shaw, D. S., ... & Reiss, D. (2012). Marital hostility and child sleep problems: direct and indirect associations via hostile parenting. *Journal of Family Psychology*, *26*, 488-498. doi: 10.1037/a0029164.

Rosenfeld, C. S. (2015). Sex-specific placental responses in fetal development. *Endocrinology*, *156*, 3422-3434. doi: 10.1210/en.2015-1227

Rothbart, M. K. (1981). Measurement of temperament in infancy. *Child Development, 52*, 569–578. doi: 10.2307/1129176

Rothbart, M. K. (2011). *Becoming who we are*. New York, NY: Guilford Press.

Rothbart, M. K., & Derryberry, D. (1981). Development of individual differences in temperament. In M. E. Lamb and A. L. Brown (Series Eds.) *Advances in developmental psychology*, Vol. 1. (Vol. 1) (pp. 37–86). Hillsdale, NJ: Erlbaum.

Rothbart, M. K., Ellis, L. K., & Posner, M. I. (2011). Temperament and self-regulation. In R. F. Baumeister & K. D. Vohs (Eds.), *Handbook of self-regulation: Research, theory, and applications* (pp. 357–370). New York: Guilford.

Ruiz-Robledillo, N., Canário, C., Dias, C. C., Moya-Albiol, L., & Figueiredo, B. (2015). Sleep during the third trimester of pregnancy: the role of depression and anxiety. *Psychology Health and Medicine, 20*, 927-932. doi: 10.1080/13548506.2015.1017508

Rutter, M. (1996). Transitions and turning points in developmental psychopathology: As applied to the age span between childhood and mid-adulthood. *International Journal of Behavioral Development, 19*, 603-626. doi: 10.1080/016502596385712

Rutter, M., & Sroufe, L. A. (2000). Developmental psychopathology: concepts and challenges. *Development and Psychopathology, 12*, 265-296. doi: 10.1017/S0954579400003023

Sadeh, A. (2004). A brief screening questionnaire for infant sleep problems: validation and findings for an Internet sample. *Pediatrics, 113*, e570-e577. doi: 10.1542/peds.113.6.e570

Sadeh, A. (2000). Maturation of normal sleep patterns from childhood through adolescence. In G. M. Loughlin, J. L. Carrol, & C. L. Marcus (Eds.). *Sleep and breathing in children: a developmental approach*. New York: Marcel Dekker

Sadeh, A., & Anders, T. F. (1993). Infant sleep problems: Origins, assessment, interventions. *Infant Mental Health Journal, 14*, 17-34. doi: 10.1002/1097-0355(199321)14:1<17::AID-IMHJ2280140103>3.0.CO;2-Q

Sadeh, A., De Marcas, G., Guri, Y., Berger, A., Tikotzky, L., & Bar-Haim, Y. (2015). Infant sleep predicts attention regulation and behavior problems at 3–4 years of age. *Developmental Neuropsychology, 40*, 122–137. doi:10.1080/87565641.2014. 973498

Sadeh, A., Mindell, J.A., Luedtke, K., & Wiegand, B. (2009). Sleep and sleep ecology in the first 3 years: a web-based study. *Journal of Sleep Research, 18*, 60-73. doi: 10.1111/j.1365-2869.2008.00699.x

Sadeh, A., Tikotzky, L., & Scher, A. (2010). Parenting and infant sleep. *Sleep Medicine Reviews, 14*, 89-96. doi: 10.1016/j.smrv.2009.05.003

Saenz, J., Yaugher, A., & Alexander, G. M. (2015). Sleep in infancy predicts gender specific social-emotional problems in toddlers. *Frontiers in Pediatrics, 3*, 1–6. doi:10.3389/fped.2015.00042

Sameroff, A. J. (1989). General systems and the regulation of development. In M. Gunnar & E. Thelan (Eds.), *Systems and development* (pp. 219–235). Hillsdale, NJ: Erlbaum.

Sameroff, A. J. (1993). Models of development and developmental risk. In CH Zeanah (Ed.), *Handbook of infant mental health*. New York: The Guilford Press

Sandman, C., Glynn, L., & Davis E. (2013). Is there a viability–vulnerability tradeoff? Sex differences in fetal programming. *Journal of Psychosomatic Research, 75*, 327–335. doi: 10.1016/j.jpsychores.2013.07.009

Santona, A., Tagini, A., Sarracino, D., De Carli, P., Pace, C. S., Parolin, L., & Terrone, G. (2015). Maternal depression and attachment: the evaluation of mother–child interactions during feeding practice. *Frontiers in Psychology, 6*, 1235-1246. doi: 10.3389/fpsyg.2015.01235

Santos, I. S., Matijasevich, A., & Domingues, M. R. (2012). Maternal caffeine consumption and infant nighttime waking: prospective cohort study. *Pediatrics*, *129*, 860-868. doi: 10.1542/peds.2011-1773

Santos, I. S., Mota, D. M., & Matijasevich, A. (2008). Epidemiology of co-sleeping and nighttime waking at 12 months in a birth cohort. *Jornal de Pediatria, 84*, 114-122. doi: 10.1590/S0021-75572008000200005

Scher, A. (2001). Attachment and sleep: a study of night waking in 12-month-old infants. *Developmental Psychobiology*, *38*, 274-285. doi: 10.1002/dev.1020

Scher, A., Tirosh, E., & Lavie, P. (1998). The relationship between sleep and temperament revisited: evidence for 12-month-olds: a research note. *The Journal of Child Psychology and Psychiatry and Allied Disciplines*, *39*, 785-788. doi: 10.1017/S0021963098002546

Serpeloni, F., Radtke, K. M., Hecker, T., Sill, J., Vukojevic, V., Assis, S. G. D., ... & Nätt, D. (2019). Does prenatal stress shape postnatal resilience? An epigenome-wide study on violence and mental health in humans. *Frontiers in Genetics*, *10*, 269-285. doi: 10.3389/fgene.2019.00269

Sette, S., Baumgartner, E., Ferri, R., & Bruni, O. (2017). Predictors of sleep disturbances in the first year of life: a longitudinal study. *Sleep Medicine, 36*, 78-85. doi: 10.1016/j.sleep.2017.04.015

Shapiro, A. F., Jolley, S. N., Hildebrandt, U., & Spieker, S. J. (2018). The effects of early postpartum depression on infant temperament. *Early Child Development and Care*, 1-13. doi: 10.1080/03004430.2018.1552947

Sharkey, K. M., Iko, I. N., Machan, J. T., Thompson-Westra, J., & Pearlstein, T. B. (2016). Infant sleep and feeding patterns are associated with maternal sleep, stress, and depressed mood in women with a history of major depressive disorder (MDD). *Archives of Women's Mental Health, 19*, 209-218. doi: 10.1007/s00737-015-0557-5

Sivertsen, B., Harvey, A. G., Reichborn-Kjennerud, T., Torgersen, L., Ystrom, E., & Hysing, M. (2015). Later emotional and behavioral problems associated with sleep problems in toddlers: a longitudinal study. *JAMA Pediatrics*, *169*, 575-582. doi: 10.1001/jamapediatrics.2015.0187

So, K., Adamson, T. M., & Horne, R. S. (2007). The use of actigraphy for assessment of the development of sleep/wake patterns in infants during the first 12 months of life. *Journal of Sleep Research*, *16*, 181-187. doi: 10.1111/j.1365-2869.2007.00582.x

Sorondo, B. M., & Reeb-Sutherland, B. C. (2015). Associations between infant temperament, maternal stress, and infants' sleep across the first year of life. *Infant Behavior and Development*, *39*, 131-135. doi: 10.1016/j.infbeh.2015.02.010

Spruyt, K., Aitken, R. J., So, K., Charlton, M., Adamson, T. M., & Horne, R. S. (2008). Relationship between sleep/wake patterns, temperament and overall development in term infants over the

first year of life. *Early Human Development*, *84*, 289-296. doi: 10.1016/j.earlhumdev.2007.07.002

Sroufe, L. A. (2009). The concept of development in developmental psychopathology. *Child Development Perspectives*, *3*, 178-183. doi: 10.1111/j.1750-8606.2009.00103.x

Sroufe, L. A. (2016). Pathways to adaptation and maladaptation: psychopathology as developmental deviation. In D. Cicchetti (Ed.), *The emergence of a discipline: Rochester symposium on developmental psychopathology, volume 1* (pp. 27-54). New York: Taylor & Francis Group

Stein, A., Pearson, R. M., Goodman, S. H., Rapa, E., Rahman, A., McCallum, M., ... & Pariante, C. M. (2014). Effects of perinatal mental disorders on the fetus and child. *The Lancet*, *384*, 1800-1819. doi: 10.1016/S0140-6736(14)61277-0Stores, G. (2009). Aspects of sleep disorders in children and adolescents. *Dialogues in Clinical Neuroscience, 11*(1), 81-90.

Stores, G., & Wiggs, L. (Eds.). (2001). Sleep disturbance in children and adolescents with disorders of development: its significance and management. Cambridge University Press.

Strelau, J. (1989). The regulative theory of temperament as a result of East-West influences. In G. A. Kohnstamm, J. E. Bates, & M. K. Rothbart (Eds.), *Temperament in childhood* (pp. 35–48). Oxford, UK: Wiley.

Suri, R., Altshuler, L., Hellemann, G., Burt, V. K., Aquino, A., & Mintz, J. (2007). Effects of antenatal depression and antidepressant treatment on gestationalage at birth and risk of preterm birth. *American Journal of Psychiatry, 164*,1206–1213. doi: 10.1176/appi.ajp.2007.06071172

Sutherland, S., & Brunwasser, S. M. (2018). Sex differences in vulnerability to prenatal stress: a review of the recent literature*. Current Psychiatry Reports, 20*, 102. doi: 10.1007/s11920-018-0961-4

Szpunar, M. J., & Parry, B. L. (2018). A systematic review of cortisol, thyroid-stimulating hormone, and prolactin in peripartum women with major depression. *Archives of Women's Mental Health*, *21*, 149-161. doi: 10.1007/s00737-017-0787-9

Tendais, I., Costa, R., Conde, A., & Figueiredo, B. (2014). Screening for depression and anxiety disorders from pregnancy to postpartum with the EPDS and STAI. *The Spanish Journal of Psychology*, *17(E7)*, 1-9. doi: 10.1017/sjp.2014.7.

Teng, A., Bartle, A., Sadeh, A., & Mindell, J. (2012). Infant and toddler sleep in Australia and New Zealand. *Journal of Paediatrics and Child Health, 48*, 268-273. doi:10.1111/j.1440-1754.2011.02251.x

Teti, D. M., & Crosby, B. (2012). Maternal depressive symptoms, dysfunctional cognitions, and infant night waking: the role of maternal nighttime behavior. *Child Development, 83*, 939-953. doi: 10.1111/j.1467-8624.2012.01760.x

Teti, D. M., Kim, B. R., Mayer, G., & Countermine, M. (2010). Maternal emotional availability at bedtime predicts infant sleep quality. *Journal of Family Psychology, 24*, 307-315. doi: 10.1037/a0019306

Thomas, K. A., & Foreman, S. W. (2005). Infant sleep and feeding pattern: effects on maternal sleep. *Journal of Midwifery & Women's Health*, *50*, 399-404. doi: 10.1016/j.jmwh.2005.04.010

Tikotzky, L., & Sadeh, A. (2009). Maternal sleep-related cognitions and infant sleep: a longitudinal study from pregnancy through the 1st year. *Child Development, 80*, 860-874. doi: 10.1111/j.1467-8624.2009.01302.x

Tikotzky, L., & Sadeh, A. (2010). The role of cognitive–behavioral therapy in behavioral childhood insomnia. *Sleep Medicine*, *11*, 686-691. doi: 10.1016/j.sleep.2009.11.017

Tikotzky, L., Sadeh, A., Volkovich, E., Manber, R., Meiri, G., & Shahar, G. (2015). VII. Infant sleep development from 3 to 6 months postpartum: links with maternal sleep and paternal involvement. *Monographs of the Society for Research in Child Development*, *80*, 107-124. doi: 10.1111/mono.12147

Tuovinen, S., Lahti-Pulkkinen, M., Girchenko, P., Lipsanen, J., Lahti, J., Heinonen, K., ... & Pesonen, A. K. (2018). Maternal depressive symptoms during and after pregnancy and child developmental milestones. *Depression and Anxiety, 35*, 32-741. doi: 10.1002/da.22756

Turecki, G., & Meaney, M. J. (2016). Effects of the social environment and stress on glucocorticoid receptor gene methylation: a systematic review. *Biological Psychiatry, 79*, 87-96. doi: 10.1016/j.biopsych.2014.11.022

Underwood, L., Waldie, K., D'Souza, S., Peterson, E. R., & Morton, S. (2016). A review of longitudinal studies on antenatal and postnatal depression. *Archives of Women's Mental Health*, *19*, 711-720. doi: 10.1007/s00737-016-0629-1

Vaughn, B. E., Elmore-Staton, L., Shin, N., & El-Sheikh, M. (2015). Sleep as a support for social competence, peer relations, and cognitive functioning in preschool children. *Behavioral Sleep Medicine*, *13*, 92-106. doi: 10.1080/15402002.2013.845778

Verreault, N., Da Costa, D., Marchand, A., Ireland, K., Dritsa, M., & Khalifé, S. (2014). Rates and risk factors associated with depressive symptoms during pregnancy and with postpartum

onset. *Journal of Psychosomatic Obstetrics & Gynecology*, *35*, 84-91. doi: 10.3109/0167482X.2014.947953

Watson, N. F., Badr, M. S., Belenky, G., Bliwise, D. L., Buxton, O. M., ... & Kushida, C. (2015). Joint consensus statement of the American Academy of Sleep Medicine and Sleep Research Society on the recommended amount of sleep for a healthy adult: methodology and discussion. *Sleep*, *38*, 1161-1183. doi: 10.5665/sleep.4716

Waumans, R. C., Terwee, C. B., Van den Berg, G., Knol, D. L., Van Litsenburg, R. R., & Gemke, R. J. (2010). Sleep and sleep disturbance in children: reliability and validity of the Dutch version of the Child Sleep Habits Questionnaire. *Sleep, 33*, 841-845. doi: 10.1093/sleep/33.6.841

Warren, S. L., Howe, G., Simmens, S. J., & Dahl, R. E. (2006). Maternal depressive symptoms and child sleep: Models of mutual influence over time. *Development and Psychopathology*, *18*, 1-16. doi:10.1017/S0954579406060019

Weinstock, M. (2008). The long-term behavioural consequences of prenatal stress. *Neuroscience & Biobehavioral Reviews, 32*, 1073-1086. doi: 10.1016/j.neubiorev.2008.03.002

Werner, H., Molinari, L., Guyer, C., & Jenni, O. G. (2008). Agreement rates between actigraphy, diary, and questionnaire for children's sleep patterns. *Archives of Pediatrics & Adolescent Medicine, 162*, 350–358. doi: 10.1001/archpedi.162.4.350.

Williams, K. E., Berthelsen, D., Walker, S., & Nicholson, J. M. (2017). A developmental cascade model of behavioral sleep problems and emotional and attentional self-regulation across early childhood. *Behavioral Sleep Medicine, 15*(1), 1-21. doi: 10.1080/15402002.2015.1065410

Wisner, K. L., Bogen, D. L., Sit, D., McShea, M., Hughes, C., Rizzo, D., . . . & Wisniewski, S. W. (2013). Does fetal exposure to SSRIs or maternal depressionimpact infant growth? *American Journal of Psychiatry, 170*, 485–493. doi: 10.1176/appi.ajp.2012.11121873

Ystrom, E., Hysing, M., Torgersen, L., Ystrom, H., Reichborn-Kjennerud, T., & Sivertsen, B. (2017a). Maternal symptoms of anxiety and depression and child nocturnal awakenings at 6 and 18 months. *Journal of Pediatric Psychology, 42*, 1156-1164. doi: 10.1093/jpepsy/jsx066

Ystrom, H., Nilsen, W., Hysing, M., Sivertsen, B., & Ystrom, E. (2017b). Sleep problems in preschoolers and maternal depressive symptoms: an evaluation of mother-and child-driven effects. *Developmental Psychology, 53*, 2261. doi: 10.1037/dev0000402.

Zhang, W., Finik, J., Dana, K., Glover, V., Ham, J., & Nomura, Y. (2018). Prenatal depression and infant temperament: the moderating role of placental gene expression. *Infancy, 23*, 211-231. doi: 10.1111/infa.12215