Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 210 (2022) 271–276

Procedia Computer Science

www.elsevier.com/locate/procedia

The 3rd International Workshop on Healthcare Open Data, Intelligence and Interoperability (HODII)
October 26-28, 2022, Leuven, Belgium

OpenEHR based bariatric surgery follow-up

Ana Afonso[a], César Alvaréz[b], Diana Ferreira[a], Daniela Oliveira[a], Hugo Peixoto[a], António Abelha[a], José Machado[a,*]

[a]*ALGORITMI/LASI, University of Minho, Braga 4710, Portugal*
[b]*Centro Hospitalar do Tâmega e Sousa E.P.E., Penafiel 4564, Portugal*

Abstract

According to the World Health Organization (WHO), more than one billion people in the world are obese, and this number is still increasing. When this disease becomes a high risk to the individual's health and the non-invasive approach does not result in weight loss, it is usual to resort to an invasive intervention, bariatric surgery. Due to all the specifications, as well as the multidisciplinary treatment inherent to this procedure, the need for a specialized environment emerges. In this context, the main objective of this topic focuses on the development of a platform for registration and monitoring of bariatric surgery. For this purpose, a web platform was created, which integrates openEHR forms for the registration of appointments regarding this intervention, and uses openEHR modeling to build the interoperable template. The development of this project aims to provide greater ease and speed in patient care, assisting health professionals in their daily lives.

Keywords: Bariatric surgery; Obesity; Health Information Systems; Electronic Health Records; Interoperability; OpenEHR

1. Introduction

Since the first contact of technology with the healthcare universe, this pleasant and harmonious relationship has become more and more powerful and majestic. The use of information systems in healthcare has served several purposes, whether in the management of health professionals, in the discovery of new cures, in the diagnosis of patients, or even in the storage of all the information concerning this environment. Health Information Systems (HIS), particularly the Electronic Health Record (EHR), arise from the importance of promoting efficiency, effectiveness, speed, and quality in health care delivery. These benefits and the guarantee of interoperability common to all health institutions, which provides permanence and persistence of information according to the same standards, allowing open

* Corresponding author. Tel.: +351253604430
E-mail address: jmac@di.uminho.pt

1877-0509
10.1016/j.procs.2022.10.149

and continuous communication, bring the best arguments that point to the numerous advantages inherent in the symbiosis mentioned above. The clinical information constantly produced may present itself with distinct and complex structures and meanings. Without this data standardization, the exchange and sharing of information will become progressively more complicated due to incompatibility between HIS, thus compromising this entire ecosystem. By ensuring interoperability through the development of interoperable and secure EHRs systems that can be interpreted and, consequently, enable communication to be established between healthcare institutions and providers, facilitating the ongoing collection, analysis, and sharing of data. Otherwise, there is a strong likelihood of the emergence of problems and clinical errors, which will lead to additional costs for the institution as well as a decrease in the quality of patient care [10, 9]. In order to ensure the ability to communicate according to a list of semantic rules, keeping the data recorded according to the same standard, so that it is possible to exchange information with reliable meaning, remaining consistent and facilitating the interpretation of the same, it is intended to design and incorporate the standards of openEHR in forms where the records of appointments will be made. The use and creation of structured clinical records, as well as the use of globally recognized standards is of extreme importance, since this is the necessary fuel for communication between health institutions, allowing the exchange of information between them (for example, a patient can go to a health unit for the first time and this already contains all the information about him).

Bariatric surgery emerges as a more invasive solution for the treatment of obesity, being ”an intervention that alters the digestive system, in order to enable the reduction of body weight enough to no longer represent a health risk and, at the same time, contribute to an overall improvement of health” [6]. In order to perform the aforementioned surgery, it is necessary to comply with a specific set of requirements, among which is the monitoring of the patient by a specialized multidisciplinary team through several appointments. These appointments result from many data about the patient, which needs to be accessible among the intervening health professionals and organized within the same standards, so that they can be easily and quickly interpreted.

What is the advantage of developing a multidisciplinary platform for recording and monitoring bariatric surgery based on openEHR? To answer this question, firstly it is crucial to understand how a chronic disease such as obesity can negatively influence an individual’s quality of life. In a second aspect, it is fundamental to resort, once again, to the concept of semantic interoperability and its importance for health. Given the above-mentioned aspects, this paper proposes a platform, entitled BaSuP (Bariatric Surgery Platform), capable of dealing with and satisfying the complexities underlying the aforementioned surgical intervention, implementing functionalities for the registration and monitoring of health information by specialists, allowing them to be able to perform and access appointments, as well as electronically register and observe data in a form format designed and built according to openEHR standards, promoting the much desired semantic interoperability in EHRs. The global vision of implementing a multidisciplinary platform that allows registration and monitoring directed to bariatric surgery and based on openEHR forms, in order to standardize, according to the same standard, the transmission of information, demonstrates the urgency associated with the existence of an EHR suitable for this form of treatment of a pathology so well known, that makes its mathematics worldwide in the billions, thus providing constant support to the health professionals involved, simplifying the complexities in terms of recording and monitoring everything that encompasses this surgical intervention, and offering quality service to the patient.

2. Related Work

The research conducted reveals the existence of very few studies that simultaneously address an environment for manipulating information related to bariatric surgery and interoperability in the EHRs generated from this intervention in the treatment of obesity. However, there are multiple works related to the importance of interoperability in HIS, more specifically in the field of records, and the increasingly active implementation of this in health. On the other hand, there are also many other articles directed to bariatric surgery, but their content is more focused on the theory of the procedure, highlighting the benefits, complications, restrictions and possible obstacles of the surgery. The work referenced in [2] is based on the development of a tool for EHRs optimization in the multidisciplinary approach to obesity treatment, presenting as the only and main concern the optimization of the records made by three specialties involved in the treatment, with no focus on the entire process monitoring, as well as on the interoperability of the information generated.

SeamLessMD [14] is an application to monitor patients undergoing bariatric surgery (among other types of procedures) that, among the various features, allows personalized education, where the patient can access the information about the surgery and communicate with health professionals, in other words, offers virtual care by remotely tracking and monitoring patient progress. Additionally, it uses the HL7 FHIR protocol to ensure interoperability. Despite being a handy and interesting application, it is not a platform that helps health professionals and patients with the varied information generated through appointments on a daily basis and in different formats.

In addition to works related to bariatric surgery, many others are directed to different areas of health, examples of which are the references [7] and [10]. The first paper presents a solution for integrating eating disorder tools into the EHRs via openEHR archetypes and understanding the challenges surrounding this process. To do this they perform ”an exploratory study focused on finding the main scales applied to screening so that these can be organized and structured into openEHR archetypes”, thus improving clinical practice for this type of problem. The second portrays ”the development and integration of a new approach based on the openEHR standard to interoperate with existing information systems” in the healthcare institution Centro Hospitalar Universitário do Porto (CHUP) in Portugal, with the primary goal of responding quickly to the evolution of the pandemic period.

The largest percentage of articles associated with this study is on interoperability in healthcare in general [15] and [8], more specifically in the promotion of interoperability in EHRs, presenting semantic interoperability as the most challenging, not discounting the obstacles of implementation of any type of interoperability. Given the importance of this topic, a lot of research has been done on how to architect the best strategies to improve interoperability in healthcare information systems, relying on existing knowledge about biomedical terminologies and clinical information models and their ability to provide semantic patterns that can be transformed into ”formal ontologies to assist in the recognition and automatic processing of such heterogeneous but isosemantic expressions” in order to create interoperability in EHRs for each health area, such as [13], [4], [12] and [5].

This paper is intended to explore and solve in the best and smartest way the unsolved problems within this field, while being based on the answers to similar problems, combined with the motivation behind improving healthcare systems. To this end, it is intended to present the best strategy to deal with the aforementioned surgical procedure, making the elaborated system useful and functional in any healthcare institution.

3. BaSuP Architecture

Like some areas of healthcare, bariatric surgery does not have a platform for a more focused and specialized service to the patient. Furthermore, being a procedure that has several specialties and is accompanied by many appointments and care before and after the procedure, it is essential to develop a system that facilitates and optimizes this whole process. Hence, it is intended to elaborate a new system based on the openEHR specifications that would interoperate with all other HISs, in order to quickly respond to the needs of this type of surgery. The implemented architecture mainly features the logical separation of backend and frontend. The interactive process of the application begins with the placement of a request, by the client, to the frontend. In turn, to answer the requests, the frontend receives information coming from the backend, communicating with it in the established EHR format.

As can also be seen in figure 1, the backend is composed of the controllers, which establish the communication between the models and the frontend and the models, which contain all the relevant information for each entity in the system) are responsible for the interaction with the database. Given the nature of communication according to the specified format, the platform allows communication with external entities using the same protocol. This ensures semantic interoperability between the developed platform and other healthcare institutions platforms. The architecture selected was the Model - View - Controller, which presents the modularization of each component, with an abstraction of the different segments in the program’s internal workflow.

In general, for health systems, interoperability can be defined as two or more independent systems with the ability to communicate, exchange and interpret important information with one another, aiming to work together to achieve a common goal [1]. In this topic, there are two major types of interoperability, syntactic and semantic. While syntactic interoperability is concerned with data formats and communication protocols in order to ensure communication and sharing of data [3]. Semantic interoperability fundamentally focuses on the interpretation of the exchanged information ”in a meaningful and accurate way, in order to produce useful results through deference to a common reference model of information exchange” [3]. This last level of interoperability is the most desired and difficult to achieve by

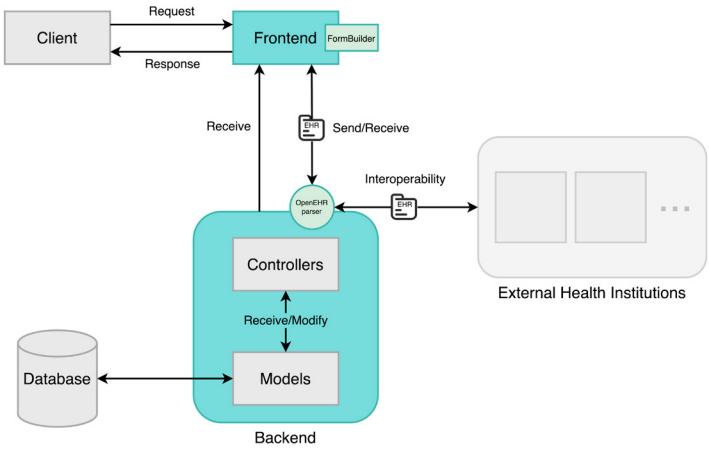

Fig. 1. Schematization of the developed architecture.

EHRs systems, as it ensures the semantic meaning and understanding of the information that is exchanged between the different healthcare systems [1].

The OpenEHR is ”a non-profit organization that publishes technical standards for an EHRs platform along with domain-developed clinical models to define the content” [11]. This community’s main goal is to ”change the quality of information technology serving medicine to essentially improve outcomes in clinical healthcare” [11]. This technology creates standards and builds interoperable solutions for healthcare, in other words, it ensures semantic interoperability of clinical information between EHRs. This standard is patient-centered and based on a dual architecture, combining technical and clinical knowledge, and presents an organized and hierarchical structure that starts with the basic units, the clinical knowledge artifacts called archetypes, which are a standardized record structure. The methodology used, in figure 2, begins with a detailed study about the archetypes essential to the case under study, for this it is used the Clinical Knowledge Manager (CKM). After the research, the Archetype Designer (AD) was used to import the encounter and the archetypes selected in existing repositories such as ckm-mirror and surgery protocols. Once the selection was done, the constructed template was exported in OPT format, to then go through a conversion algorithm that allows the transformation from OPT to JSON format, so that this structure is able to be consumed by the FormBuilder tool, which in the near future will be exposed in an article dedicated exclusively to the features and development of this package. FormBuilder is a tool created specifically for building forms automatically from the openEHR structures defined in the modeling phase, which were then integrated into the interface of BaSuP to be filled out by the health professionals involved in the process.

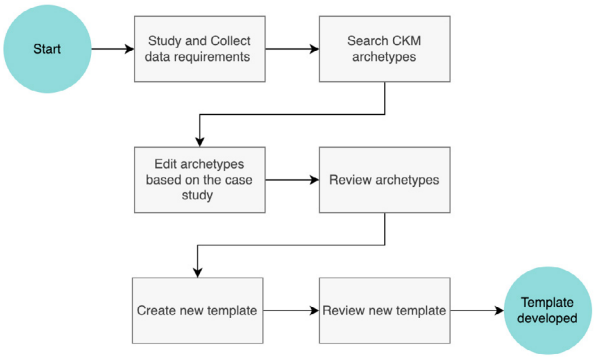

Fig. 2. Schematic representation of the modulation method used to development of openEHR structures.

4. BaSuP Implementation

Throughout development, it was taken into consideration the needs and functionalities that are essential to the treatment of obesity via bariatric surgery, particularly with regard to the registration, monitoring and storage of all patient information from the various existing appointments. In order to offer not only an effective, but also a comfortable and user-friendly graphic interface, four distinct spaces were created (as shown in the figure 3), the ”Today’s Appointments” (”Consultas de Hoje” in portuguese) where the appointments of the day itself appear, and after selecting a day, the ”My Appointments” (”Minhas Consultas” in portuguese) where the health professional has access only to his/her appointments, the ”Specialty Appointments” (”Consultas da Especialidade” in portuguese) where the care provider can view all appointments in his/her specialty and, finally, the ”Clinical Records” (”Processos Clínicos” in portuguese) which presents all the data of each patient that the health professional monitors and the history of all his appointments from all specialties that includes his patients. This ensures that the professional has quick access to all information about the patient, which can also be relevant for decision support. Regarding the records of each appointment, as described in subsection 3, a form was generated based on a template into which the necessary archetypes were inserted and then manipulated, with proper translation into portuguese language. This implementation of openEHR standards allowed interoperability between EHRs. Additionally, it should be noted that BaSuP is ready to be integrated into any health institution, not only because of its characteristics and the fact that it is a specialized place focused and designed for monitoring the peculiarities of bariatric surgery, but also because of the creation of interoperable records, which means that the information generated follows the same structure and format and has the same meaning capable of being interpreted by other health units.

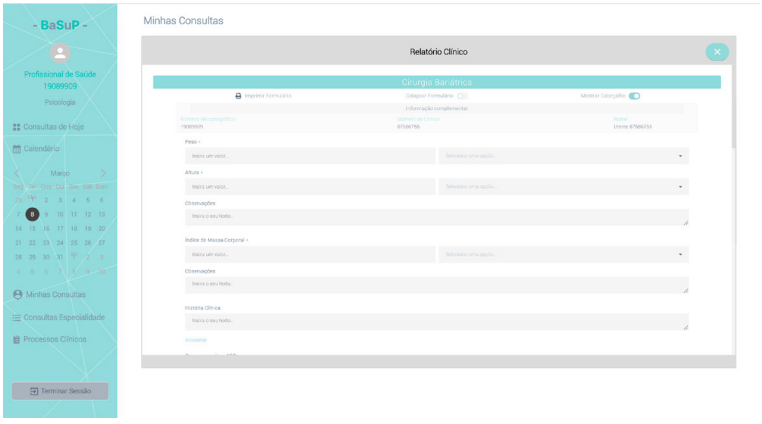

Fig. 3. Demonstration of the openEHR form for the registration of appointments in the developed platform.

After being developed and thoroughly tested, the BaSuP platform was submitted to a evaluation process. During this evaluation, it was found that BaSuP meets the requirements, satisfies the needs, and ensures the desired functionalities, which were commented on, verified, and evaluated by health professionals of the intervening specialties to ensure compliance with all necessary requirements and the practicability of the system, as well as the format and content of the forms designed for the registration of information related to the pathology mentioned. Furthermore, being a system ready to be integrated and merged in any health institution, with the security of creating portable data and with required authentication, is emphasized. Based on what has been stated, it is believed that all of the research conducted, as well as the final project developed, are in line with what was envisioned at the beginning of the project, revealing a pioneering, useful, and interesting result.

5. Conclusion and Future Work

This work arose from the need to fill a gap regarding the EHR module specific to obesity treatment in HISs. In this sense, the developed tool has demonstrated its ability to meet the proposed goal, which is to assist clinicians in recording and monitoring appropriate appointments, thereby increasing the efficiency and speed of the process and,

consequently, offering better quality care and follow-up to these patients. The adoption of openEHR standards revealed to be an astute strategy as incorporating them into clinical record forms ensured interoperability with other HISs. Aside from its adaptability, its structured and standardized data recording method enables information sharing between institutions. Furthermore, future Clinical Decision Support (CDS) systems may be based on these new approaches, making them more realistic and trustworthy as well as leading to better health outcomes. As future work, BaSuP platform itself could be improved by including Artificial Intelligence (AI) algorithms to suggest dates for future appointments, estimations of surgical recovery time, among others. Finally, it would be interesting to include a Business Intelligence (BI) module with the data being collected to provide health professionals with a more visual representation of data, allowing them to make more informed health decisions.

Acknowledgements

This work has been supported by "FCT–Fundação para a Ciência e Tecnologia" within the R&D Units Project Scope: UIDB/00319/2020. D.F. thanks FCT Portugal for the grant 2021.06308.BD.

References

[1] Cardoso, L., Marins, F., Portela, F., Santos, M., Abelha, A., Machado, J., 2014. The next generation of interoperability agents in healthcare. International Journal of Environmental Research and Public Health 11, 5349–5371. URL: https://www.mdpi.com/1660-4601/11/5/5349, doi:10.3390/ijerph110505349.

[2] Gouveia Pedro, L., 2020. Desenvolvimento de uma ferramenta para a otimização do registo de saúde eletrónico na abordagem multidisciplinar no tratamento da obesidade. https://recipp.ipp.pt/bitstream/10400.22/16939/1/DM_LilianaPedro_2020_MCIM.pdf. Acessed: 2022-06-28.

[3] Ide, N., Pustejovsky, J., 2010. What does interoperability mean, anyway? toward an operational definition of interoperability for language technology. URL: https://www.cs.vassar.edu/~ide/papers/ICGL10.pdf. Accessed: 2022-06-18.

[4] Liyanage, H., Krause, P., Lusignan, S., 2015. Using ontologies to improve semantic interoperability in health data. J Innov Health Inform 22, 309–315. doi:10.14236/jhi.v22i2.159.

[5] Loreto, P., Fonseca, F., Morais, A., Peixoto, H., Abelha, A., Machado, J., 2017. Improving maternity care with business intelligence, in: 5th International Conference on Future Internet of Things and Cloud Workshops, FiCloud Workshops 2017, Prague, Czech Republic, August 21-23, 2017, IEEE. pp. 170–177. doi:10.1109/FiCloudW.2017.89.

[6] Manso, P., Maria, C., 2018. Impacto da cirurgia bariátrica na qualidade de vida dos doentes. https://web.esenfc.pt/pav02/include/download.php?id_ficheiro=62765. Acessed: 2022-07-03.

[7] Maranhão, P.A., Bacelar-Silva, G.M., Gonçalves-Ferreira, D.N., Calhau, C., Vieira Marques, P., Alvarenga, M., Cruz-Correia, R.J., 2018. Openehr modeling applied to eating disorders in clinical practice: Openehr-archetypes in eating disorders, in: 2018 IEEE 31st International Symposium On Computer-Based Medical Systems (CBMS), pp. 36–41. doi:10.1109/CBMS.2018.00014.

[8] Helena de Mello, B., José Rigo, S., André da Costa, C., Rosa Righi, R., Donida, B., Rosecler Bez, M., Carina Schunke, L., 2022. Semantic interoperability in health records standards: a systematic literature review. Health Technology (Berl) 12, 255–272. doi:10.1007/s12553-022-00639-w.

[9] Oliveira, D., Ferreira, D., Abreu, N., Leuschner, P., Abelha, A., Machado, J., 2022. Prediction of covid-19 diagnosis based on openehr artefacts. Scientific Reports 12. doi:10.1038/s41598-022-15968-z.

[10] Oliveira, D., Miranda, R., Abreu, N., Leuschner, P., Abelha, A., Santos, M., Machado, J., 2020. Management of a pandemic based on an openehr approach. Procedia Computer Science 577, 522–527. doi:10.1016/j.procs.2020.10.072.

[11] OpenEHR, . Official website of openEHR. URL: https://www.openehr.org/. Accessed: 2022-07-18.

[12] Pereira Detro, S., Morozov, D., Lezoche, M., Panetto, H., Alves Portela Santos, E., Zdravković, M., 2016. Enhancing semantic interoperability in healthcare using semantic process mining, in: 6th International Conference On Information Society And Techology, ICIST 2016, pp. 80–85. URL: https://hal.archives-ouvertes.fr/hal-01298125.

[13] Schulz, S., Martínez-Costa, C., 2013. How ontologies can improve semantic interoperability in health care, in: Riaño, D., Lenz, R., Miksch, S., Peleg, M., Reichert, M., ten Teije, A. (Eds.), Process Support and Knowledge Representation in Health Care, Springer Cham. pp. 1–10. doi:10.1007/978-3-319-03916-9_1.

[14] SeamlessMD, . Official website of the SeamLessMD application. URL: https://seamless.md/. Accessed: 2022-07-20.

[15] Ángel Sicilia, M., Balazote, P., 2013. Interoperability in Healthcare Information Systems: Standards, Management, and Technology. Medical Information Science Reference - IGI Global.