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A Data Acquisition and Consolidation System based on openEHR applied to Physical Medicine and Rehabilitation

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Abstract

Shoulder pathologies are prevalent and reduce the quality of life. Due to the shoulder joint's complexity, healthcare professionals face challenges to evaluate, diagnose, and treat these pathologies. On the other hand, the acquisition, presentation, and analysis of patient data in healthcare is complex and hindered by the absence of standardization and interoperability in Database Management Systems. Hence, in this study, we propose a web platform based on openEHR structures that incorporates user interface forms for registering patient physical examinations. The benefits of implementing this approach include structured and standardized data collection, and better communication and information exchange between different systems.

Keywords: OpenEHR; Interoperability; Electronic Health Record; Physical Medicine and Rehabilitation; Shoulder Pathologies.

1. Introduction

Health Information Systems (HISs), specifically Electronic Health Records (EHRs), have become an integral component of modern healthcare practice. EHRs are digital versions of the paper-based medical records that have been used for decades in healthcare organizations. These systems include a wide range of patient data, such as demographics, medical history, medications, lab results, treatment plans, and notes from healthcare providers. By providing a comprehensive view of a patient's health, EHRs can help care providers make more informed decisions, and improve the efficiency and quality of care while reducing costs [1].

However, a major challenge facing the healthcare industry is interoperability. This refers to the ability of different systems and applications to communicate and share data seamlessly. Integrating EHRs with other systems, such as scheduling and lab information systems, allows healthcare providers to gain a more complete picture of the patient's

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condition and treatment history. Furthermore, interoperability also allows for seamless data sharing among different care providers, which improves the continuity of care [2, 3].

In the field of physical medicine and rehabilitation, this is especially important as patients may receive care from a variety of different providers or specialists. Without interoperability, it can be difficult for these providers to access and share the information they need to provide the best possible care, leading to potential clinical errors, increased costs to the institution, and a decline in patient quality of care. One area of focus within this field is shoulder pathologies, one of the most common musculoskeletal complications [4]. These pathologies can greatly impact a patient's quality of life and ability to function, and often require a multidisciplinary approach to diagnosis and management, with input from a wide range of specialists. By utilizing EHRs and working towards interoperability, healthcare providers in physical medicine and rehabilitation can more effectively collaborate and share information, promoting better outcomes for patients.

One of the most problematic barriers to interoperability is the lack of standardization in the healthcare industry when it comes to the format and structure of data, preventing different systems and applications from communicating and sharing data seamlessly. To ensure effective communication, data must be recorded according to globally recognized standards, making it possible to exchange information with consistent meaning and ease of interpretation [5]. In this article, the authors suggest the use of openEHR specifications as a lever for the development of interoperable IT solutions. OpenEHR is a widely accepted standard that encompasses a comprehensive set of open-source specifications, clinical models, and software components. It provides a framework for the development and management of EHRs and is designed to facilitate integration with various HISs. The goal of openEHR is to enable interoperability between different EHR systems and promote the reuse of EHR data for research, quality improvement, and clinical decision support [6].

The openEHR standard utilizes a two-level modelling approach that separates clinical knowledge from the information model, allowing for flexibility and adaptability to different clinical domains while maintaining interoperability [7]. Its Reference Model (RM) and Archetype Object Model (AOM) work together to ensure consistency and computability in clinical information. AOM uses archetypes defined in accordance with the Archetype Definition Language (ADL) and the structures and attributes established by the RM, to define the structure, content, and meaning of various types of clinical data. The archetypes act as a foundation unit, creating connections between data and models, and can be combined and configured to create templates for specific clinical contexts or settings, as illustrated in Figure 1 [8, 9].

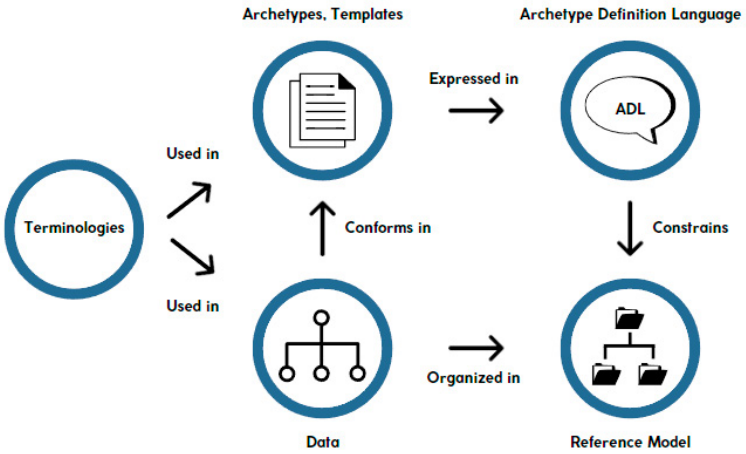

Fig. 1. OpenEHR architecture.

One of the key benefits of openEHR is its ability to reuse archetypes across multiple applications [10, 11]. The openEHR Clinical Knowledge Manager (CKM) acts as an open repository, allowing users to access, manage, and collaborate on archetypes and templates, which can be utilized in the openEHR modelling tool, the Archetype Designer

(AD). The AD tool allows users to create and share custom archetypes, as well as generate Operational Templates (OPTs) and JSON Web Templates for customization, making openEHR suitable for a wide range of healthcare organizations.

The focus of this study is to address the ongoing issues in the field of physical medicine and rehabilitation, particularly for shoulder pathologies. The solution proposed is a web application for data acquisition and consolidation that simplifies the process of collecting, presenting, and analyzing patient information, using openEHR standards to improve interoperability. The ultimate goal of implementing this platform is to standardize and streamline the recording and monitoring of treatment for shoulder pathologies in physical medicine and rehabilitation, support healthcare professionals, and ultimately provide improved care for patients.

The remainder of this paper is organized as follows: after contextualizing the readers in the topic addressed in this study, Section 2 describes the methodological steps taken; Section 3 presents and discusses the main findings of the research; and Section 4 summarizes the paper's conclusions and some ideas for future work.

2. Methodology

In order to develop this study, a series of different methodological steps were planned and followed. The workflow represented in Figure 2 illustrates in a simplified manner the methodology followed for the development of the proposed system. The process began with the study and collection of business and functional requirements. This information was then used to search for relevant archetypes in the CKM. Using the AD tool, the chosen archetypes were customized and combined to create templates for recording physical examination data for patients in Physical Medicine and Rehabilitation. These templates were then used to generate openEHR based forms that were integrated into a web-based application for easy access and usage. The web application was developed according to the requirements collected in the first step. The next subsections describe in detail the different stages of the development process carried out.

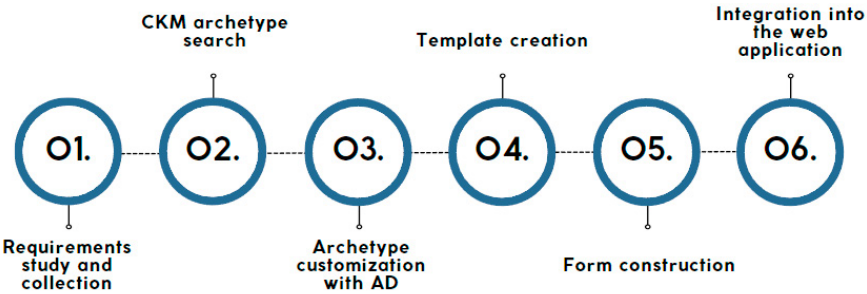

Fig. 2. Pipeline of the research methodology.

2.1. Requirements gathering

To determine the concepts to model and the specifications of the system to be developed, a thorough understanding of the needs of physical medicine and rehabilitation professionals was required. This included identifying the critical areas of focus for effective treatment and care. To gather this information, a survey was conducted among healthcare professionals in the field, which revealed that an initial evaluation and assessment of the patient's complete medical history and overall physical condition, as well as a focus on shoulder pathologies, were identified as priorities. This information was then used to guide the development of the data modelling structures to ensure that the final solution was tailored to the specific needs of the intended users.

2.2. Modelling

Following the collection of requirements, openEHR structures were modelled for the data structuring of clinical records. The process began by utilizing the community and existing structures found on the CKM platform to guide the creation of new openEHR templates. The focus was on selecting existing and relevant archetypes from CKM and modifying them using the AD tool. This tool was used not only to make changes to existing archetypes, but also to strategically combine them in order to build the final template, which later was exported in the OPT format and effectively used with the FormBuilder tool.

The FormBuilder is a tool that allows users to create and design forms by utilizing the openEHR templates defined in the modelling phase. After converting openEHR templates in the OPT format to JSON, the tool uses the JSON structure to automatically generate User Interface (UI) forms [12]. More detailed information about the features and development of FormBuilder will be addressed in a future article.

2.3. Development

The forms created during the modelling phase will be incorporated into the web application that is being developed. To achieve this integration, React was utilized as the main frontend technology, as the FormBuilder Tool is designed to work seamlessly with it. React is an open-source JavaScript library commonly used for building UIs [13].

The web application is using Node.js as the backend technology, which is an open-source, cross-platform tool that enables developers to execute JavaScript outside a browser. Node.js is commonly used for backend development as it allows for using JavaScript on the server-side, making it easier for developers to write both frontend and backend in the same language [14].

The application is using PostgreSQL as its Database Management System (DBMS). PostgreSQL is a robust, open-source, and object-relational DBMS that is known for its reliability. It supports advanced data types such as JSON and other complex structures [15].

Additionally, Axios was included in the application's architecture to handle the communication between the front and backend. This JavaScript library is commonly used to manage network requests and responses, allowing for easy transfer of data between the frontend and backend [16].

The web application is designed with a client-server architecture, where it connects to a database. The data requested by the client is sent through HTTP requests and the server responds by sending the requested data to the client via HTTP responses. Figure 3 illustrates the application's architecture.

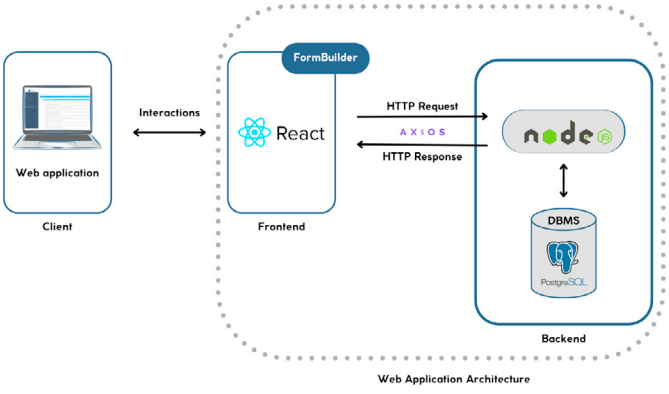

Fig. 3. Web application's architecture.

3. Results and Discussion

During the development of the web application, the specific needs and capabilities required by physical medicine and rehabilitation professionals were prioritized. With the consideration that these professionals need to maintain constant contact with their patients throughout treatment, it was also a priority that the user interface was simple and easy to navigate, allowing for efficient and quick access to patient information and evaluation forms. Therefore, the following four sections were designed and implemented, as shown in Figure 4:

- **Patients** (Utentes): Presents a list of all registered patients;
- **Patient Registry** (Registo Utente): Allows for the registration of new patients;
- **Initial Evaluation** (Avaliação Inicial): Includes a form to register the patient's medical history and to conduct a first assessment of the patient's overall physical condition;
- **Shoulder Evaluation** (Avaliação Ombro): Includes a form with the Oxford Shoulder Score (OSS), a validated scoring system used to evaluate the level of pain and disability caused by shoulder pathology [17].

All forms were generated using openEHR templates, which included the necessary archetypes that then were adjusted accordingly. The forms were translated into the Portuguese language, as the system is being developed in collaboration with Portuguese professionals.

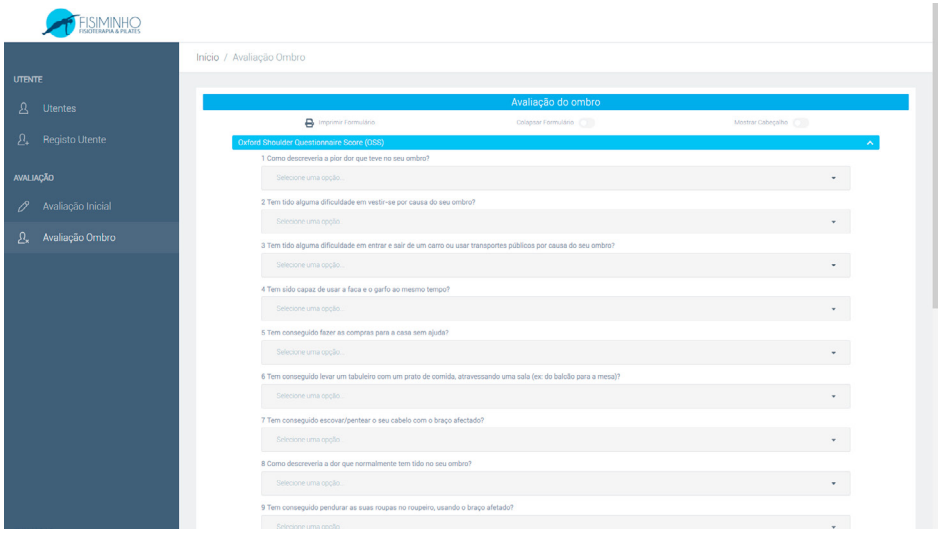

Fig. 4. openEHR form for the OSS, in the developed platform.

The developed platform is a promising start for creating a comprehensive system, as it utilizes international standards and prioritizes user experience. This is demonstrated by its incorporation of openEHR, which enables interoperability with other systems and its focus on usability and simplicity, allowing healthcare providers to effectively and efficiently use the platform. It is important to note that the application is still in development and new features and functionalities will be added to build upon and consolidate it, making the platform more powerful and useful for the healthcare industry.

4. Conclusions and Future Work

This study arose from the need to address the challenges encountered by physical medicine and rehabilitation especially health professionals in determining the optimal treatment plan, in particular for shoulder conditions. The development of a data acquisition and consolidation system utilizing the openEHR standard has been presented as a solution to the challenges of data collection, management, exchange, and analysis in this field. Through the adoption

of interoperability standards, namely openEHR, the proposed system allows for the capture of detailed and structured clinical records, allowing better communication and information exchange between different HISs. The system also enables the integration of data from multiple sources, providing a comprehensive view of the patient's condition and treatment history. In addition, the integration of this system could lead to improved diagnosis, treatment planning, and outcomes evaluation. This can ultimately result in improved healthcare quality, cost savings, shorter wait times, and less time waste. In conclusion, this work has highlighted the importance of accurate and comprehensive data collection in the management of shoulder pathologies in Physical Medicine and Rehabilitation.

In the future, the authors of this study plan to develop an architecture for Machine Learning (ML) and Data Mining (DM) processing. This will enable the export of data in a valid format for health professionals to support the development of more advanced analytics and decision-making tools. These tools may have the potential to identify patterns and trends that may be useful in determining the incidence of certain conditions, as well as making decisions regarding their treatment and prevention.

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References

[1] J. Duarte, M. Salazar, C. Quintas, M. Santos, J. Neves, A. Abelha, J. Machado, Data quality evaluation of electronic health records in the hospital admission process, in: 2010 IEEE/ACIS 9th International Conference on Computer and Information Science, IEEE, 2010, pp. 201–206.

[2] M. Sreenivasan, A. M. Chacko, Interoperability issues in ehr systems: Research directions, Data analytics in biomedical engineering and healthcare (2021) 13–28.

[3] M. J. Dobrow, J. P. Bytautas, S. Tharmalingam, S. Hagens, Interoperable electronic health records and health information exchanges: systematic review, JMIR medical informatics 7 (2) (2019) e12607.

[4] C. Maxwell, K. Robinson, K. McCreesh, Understanding shoulder pain: a qualitative evidence synthesis exploring the patient experience, Physical therapy 101 (3) (2021) pzaa229.

[5] L. Cardoso, F. Marins, F. Portela, M. Santos, A. Abelha, J. Machado, The next generation of interoperability agents in healthcare, International journal of environmental research and public health 11 (5) (2014) 5349–5371.

[6] openEHR - home, [Online; accessed 12-Jan-2023].
URL https://www.openehr.org/

[7] C.-H. Lin, Y.-C. Fann, D.-M. Liou, An exploratory study using an openehr 2-level modeling approach to represent common data elements, Journal of the American Medical Informatics Association 23 (5) (2016) 956–967.

[8] D. Oliveira, A. Santos, D. Braga, I. Silva, R. Sousa, A. Abelha, J. Machado, Openehr modelling applied to complementary diagnostics requests, Procedia Computer Science 210 (2022) 265–270.

[9] openEHR Specifications - home, [Online; accessed 12-Jan-2023].
URL https://specifications.openehr.org/

[10] D. Oliveira, R. Miranda, F. Hak, N. Abreu, P. Leuschner, A. Abelha, J. Machado, Steps towards an healthcare information model based on openehr, Procedia Computer Science 184 (2021) 893–898.

[11] D. Oliveira, D. Ferreira, N. Abreu, P. Leuschner, A. Abelha, J. Machado, Prediction of covid-19 diagnosis based on openehr artefacts, Scientific Reports 12 (1) (2022) 1–13.

[12] A. Afonso, C. Alvaréz, D. Ferreira, D. Oliveira, H. Peixoto, A. Abelha, J. Machado, Openehr based bariatric surgery follow-up, Procedia Computer Science 210 (2022) 271–276.

[13] React - A JavaScript library for building user interfaces, [Online; accessed 12-Jan-2023].
URL https://reactjs.org/

[14] Node.js - JavaScript runtime built on Chrome's V8 JavaScript engine, [Online; accessed 12-Jan-2023].
URL https://nodejs.org/en/

[15] PostgreSQL - The World's Most Advanced Open Source Relational Database, [Online; accessed 12-Jan-2023].
URL https://www.postgresql.org/

[16] Axios - Promise based HTTP client for the browser and node.js, [Online; accessed 12-Jan-2023].
URL https://axios-http.com/

[17] F. Younis, J. Sultan, S. Dix, P. Hughes, The range of the oxford shoulder score in the asymptomatic population: a marker for post-operative improvement, Annals of the Royal College of Surgeons of England 93 (8) (2011) 629—-633.