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Management of a Pandemic Based on an openEHR approach

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Abstract

The COVID-19 pandemic has collapsed several national health systems, due to the lack of healthcare professionals and exhaustion of those employed, as well as the lack of interoperability and capacity to restructure their informatic systems. Therefore, the restructuring of institutions at all levels is essential, mainly at the level of their Information Systems. When the COVID-19 pandemic had spread to Portugal in March 2020, with a breakout on the northern region, the Centro Hospitalar Universitário do Porto (CHUP) healthcare institution had felt the need to develop and integrate a new approach based on the openEHR standard to interoperate with the institution’s existing information systems, with the aim of responding quickly to the pandemic’s evolution.

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1. Introduction

Clinical data can have a complex structure and meaning, making the different Healthcare Information Systems (HIS) incompatible for their own reasons. Progressively, information exchange and sharing will become very difficult, compromising the entire Information System (IS) ecosystem.

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When this happens, additional problems can appear, increasing the probability of clinical errors to occur, rising costs for the institution and decreasing the quality of healthcare [1–3]. In this area, the role of Medical Informatics (MI) is important for the development of ubiquitous, interoperable, secure, and hybrid EHR systems that communicates with multiple institutions and healthcare providers.

These new systems will help facilitate the subsequent data collection, aggregation, data analysis, and continuous sharing. Furthermore, future Clinical Decision Support (CDS) systems will be based on these new approaches, making them more realist and trustworthy.

After the World Health Organization (WHO) had declared a Public Health Emergency of International Concern on 23 January 2020, the COVID-19 epidemic had overburdened many healthcare systems of practically all countries, with some collapsing where they were not prepared. This was due to a lack of human and material resources, causing further stress upon the health professionals. On top of that, the difficulties experienced in sharing and transferring data on normal day-to-day work are mostly felt when health professionals are under pressure [4].

In unexpected pandemic situations, the main objective is to save lives in the face of an unknown strain of a virus. But for that to happen, it is necessary to constantly extract new knowledge from all generated clinical data in real time. During the COVID-19 pandemic, several risk factors have been discovered at various levels, such as at the level of the virus by itself, as well as the host, the community, and the environment itself, as seen in Fig. 1. [5][6].

![COVID-19 Risk Factors](image)

**Fig. 1. COVID-19 Risk Factors.**

In order to optimize the workflow for the reception and treatment of patients with COVID-19 in Portugal, the Centro Hospitalar Universitário do Porto (CHUP) institution has developed a new system based on the openEHR specification. Thus, a hybrid solution that interoperated with existing systems was developed, ensuring quick and effective communication protocols between users with minimum effort. The next chapters will offer a main overview of the developed platform.

1.1. **Interoperability in Healthcare and Global Standards**

Clinical data interoperability represents the capability of two or more systems to exchange, share, and interpret data in the same way. Each interoperability level has its specific syntactic, semantic, and cross-domain requirements. Additionally, international e-health communities has been advising and working on the use of several clinical models based on standards [1][7–9].

The European Committee for Standardization (CEN) focus on the development and publishing of European standards that are applied every day by millions of businesses and organizations. For CEN, the use of standards can make people’s lives simpler and more efficient when properly used. Products become more reliable and connected with other appliances and components, resulting in a more efficient working environment. Thus, healthcare interoperability can be ensured using IT standards, with the aim to harmonize and enable interoperability with external applications as much as possible [10].

The semantic interoperability level of EHR systems is critical for the continuous improvement of the patient’s quality of care, global health research, and the management of healthcare institutions. This level of interoperability ensures the meaning and semantic understanding of the information is exchanged between different systems [11]. The dual architecture approach has been gaining strength to promote and secure the meaning of knowledge and
information. Many studies compare the ISO 13606 standard with the openEHR standard. Both have their similarities as they use the two-level domain modelling, based on Archetype Object Model (AOM) for characterize their clinical content. However, the archetypes developed by each of them are very different and are not compatible. Moreover, their Reference Models (RMs) are very different as well as their conceptual structures. Besides, while ISO 13606 is more focused in data communication, openEHR is prioritizes data persistence and query [12,13]. Henceforth, according to the main objective of the proposed case study, namely the implementation of an interoperable system in a pandemic situation, the persistence and consultation of data proves to be important in monitoring the evolution of the pandemic and the discovery of new knowledge, revealed from the data produced. Thus, openEHR was the adopted standard to use and will be briefly described in the following section.

1.2. openEHR

OpenEHR is a non-profit organization that has the collaboration of a vast international community, with the goal of creating clinically comprehensive and interoperable EHRs. Its main objective is to guarantee the semantic interoperability of clinical information between EHRs. It is based on a dual architecture in terms of information and knowledge, aligning technical knowledge with clinical knowledge. Clinical information is modeled through RM, while knowledge is streamlined through AOM. This standard is based on its clinical knowledge artifacts, called Archetypes, that clinically speaking, represent the basis for defining, discussing, and presenting clinical content [14–16]. The AOM presents the clinical concepts in a combined, structured, and restricted way to the entities contained in the RM. Therefore, the archetypes are presented using the Archetype Definition Language (ADL) format, giving them an abstract syntax that can be used in any RM [17–19].

In terms of safety of data, the openEHR approach ensures data resilience, maintaining them in the system in a historic and revision approach. Each change in the patient’s EHR is saved through the audit system, which offers a high reliability to the structure [20].

2. Methodology

As previously mentioned, this unexpected pandemic situation has caused the collapse of National Healthcare Systems. Thus, the restructuring of institutions at all levels is necessary, mainly at the level of their Information Systems. Officially, the COVID-19 pandemic had spread to Portugal in March 2020, with a breakout on the north of the country. Hence, the CHUP healthcare institution has decided to develop a new system based on the openEHR specifications that would interoperate with all other HISs, in order to quickly respond to the growth of suspected and confirmed cases of COVID-19. For this, a multidisciplinary team of researchers and healthcare professionals was created to outline the clinical process of a patient and proceed to the subsequent openEHR modeling.

The new architecture developed and represented in Fig. 2 involves different domains and their respective performers. On the knowledge domain, the healthcare professionals specialized in clinical modeling have developed the openEHR base structures. On the other hand, in the development domain, the IT specialists are responsible for the software coding with the RM and its integration with the AOM. At the repository level, the patients’ clinical data is separated from their administrative data, ensuring the patient’s confidentiality.

![Fig. 2. New system architecture developed based on openEHR.](image-url)
2.1 Modulation

With the help of the community and structures published in the Clinical Knowledge Manager (CKM) platform, a modeling method for new openEHR templates was adopted and used. The next figure (Fig.3) represents the implemented modulation process.

![Modulation method used to development of openEHR structures.](image)

As the previous schema represents, to collect the domain concepts to model, it was necessary to understand the needs of the moment at the administrative and clinical level at the CHUP healthcare institution. To do so, the COVID-19 patient treatment process was developed, from their referral for suspected infection to their cure. This process is proven as the workflow of different healthcare professionals since the epidemic.

Both references to a suspected case or to a positive case go through the COVID-19 contingency area in order to be validated and tested. Depending on the result and their symptoms, the patient can stay at home or in hospital. In both scenarios, patients are monitored daily, and in the case of home care the patients can self-monitor themselves. This whole process involves several openEHR structures and software developed for this purpose.

3. Results

The developed platform was able to support the health professionals during the COVID-19 epidemic, supporting the present and future needs of the CHUP. The openEHR standard has allowed for a full representation of the adopted patient workflow, while enabling interoperability between different EHRs. To analyze the impact of the implemented solution, Business Intelligence tools were adopted, namely Tableau Desktop, to create statistics and insights.

As a result, 8 templates were modulated and developed to integrate into the COVID-19 patient treatment process, using 34 reused and modified archetypes (see Fig. 4).

![Representation of reused archetypes and created templates.](image)
With the distributed architecture implemented, it was possible to quickly obtain information regarding the developed openEHR structures and their rate of reuse. In addition to reusing archetypes in different templates throughout the COVID-19 patient treatment workflow, the templates were reused in different contexts, which validates a careful and extensive modeling.

4. Conclusion and Future Work

The CHUP project in partnership with the University of Minho comes from extensive research in the area of HISs and in the elicitation of the institution's requirements and needs. After analyzing this research venture, a new clinical methodology was adopted in an open format, with a vast community and constantly evolving. All the work that was carried out during the the COVID-19 pandemic was accordingly used to assist the institution in times of high crisis and pressure. Therefore, the adoption of the developed system based on the openEHR standard proved to be fast and rewarding, resulting in a practical case study. Its modeling capacity gave the system a dynamic flexibility associated with the experienced pandemic, managing to easily interoperate with all other HISs. In addition to this versatility, its structured and standardized method of recording the data allowed the institution to obtain its own indicators, and to reorganize itself accordingly in its day-to-day activities.

The next step in this investigation will be to organize the workflow of a COVID-19 patient treatment process based on the task planning engine designed by the openEHR community.

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