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An OpenEHR Adoption in a Portuguese Healthcare Facility

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Abstract

The quality and safety of clinical decisions depend to a large extent on the knowledge acquired by the records of health professionals. However, a traditional Electronic Health Record (EHR) has become insufficient in terms of knowledge acquisition and clinical decision support. The development of these aspects may bring marked improvements in the quality and safety of health care. The usage of open models promotes interoperability between systems, minimizing the impact of information systems on the efficient production of knowledge useful for clinical decisions. In this sense, this article describes an implementation project of a system that support the production and use of knowledge in clinical environments, based on OpenEHR two levels modelling open data approach, in a healthcare facility on the north of Portugal.

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1. Introduction

Upon a patient encounter with a health professional in a healthcare facility, a data set about his health is stored in an Electronic Health Record (EHR) system. Such practice has been increasing on a large scale currently, eliminating the use of paper and simplifying the clinical process.

Commonly, a health facility integrates several heterogeneous systems that, somehow, speak different languages [1]. These systems must be interoperable, i.e., be able to communicate in a noticeable and effective manner. This focus is based on building communication without data loss and preserving the meaning intend by the author of the record, referred to as semantic interoperability.

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Thereby, the OpenEHR approach aims to achieve interoperability between EHR systems, by constraining the information model through structuring archetypes that represent clinical concepts [2]. Besides, clinical terminologies are also used, allowing clinical terms to be recorded in a comprehensive way. Thus, data exchange between systems does not compromise the quality of receptive information.

Nevertheless, a simple health information system became incapable to support decision making on a daily basis, because its primary role was merely to store and reuse clinical records in the point of care [3]. Hence, this inefficiency propelled the need to explore new techniques for reusing clinical knowledge stored in database and semantic interoperability in order to improve the decision process in healthcare.

A healthcare facility in the north of Portugal, the Centro Hospitalar Universitário do Porto (CHUP), took the initiative to explore the OpenEHR standard to restructure the institution's current system. The main motivation was to improve interoperability levels between systems, establish a standardization process and formalize clinical decision support practices, providing open clinical knowledge. In this sense, this article aims to describe the study process adopted in the implementation of the OpenEHR open data approach at CHUP.

This paper is divided in five sections. The first one introduces the groundwork of the present case study. The second describes key concepts in the applied field such as interoperability, open knowledge and OpenEHR. The third section presents the proposed methodology applied to this case study. Following the process validation, the results of the project development are exposed in the fourth section. At last, in section five, conclusions are drawn from the work done and description of the future work.

2. Background

2.1. Interoperability

Considering the constant production of data in healthcare, a well-established communication between information systems of this domain is necessary. For that, it is essential that such systems communicate correctly and effectively, transmitting information from one system to another [1]. In this sense, the concept of interoperability emerges reflecting this continuous exchange of information between systems.

IDABC [4], defines interoperability as “the ability of information technology systems and the business processes that support them, communicate to exchange data and make information and knowledge sharing available”. Therefore, the main objective of health interoperability is the possibility of distributing and exchanging patient data among healthcare professionals, when and where it is needed [5]. Interoperability is not seen as an option for an Electronic Health Record (HER) but as a fundamental requirement to ensure the continuity of care, and there for promote quality health care [6].

2.2. Open Knowledge in Health Information Systems

The Open Knowledge International's Foundation [7], the most important international pattern of open data, granted the first definition of open data as “data that can be used in a freeway, shared and built for anyone, anywhere and to everything”. Consequently, open knowledge is defined as “any content, information or data that society is free to use, reuse and redistribute, without any legal, social or technological restriction”.

To summarize, the open data term has gained popularity in the transparency and open government movement around the world, as it manages the access to public information as a rule and can be freely used, modified and shared by anyone and without any financial or other restrictions and it is also applied to the health domain [8].

2.3. OpenEHR

The OpenEHR approach follows the open data and free access standard for health information specifications and is used in management, storage and querying of Electronic Health Record (HER). The use of this model provides an interoperable framework that organizes clinical content with patient information, enabling integration with different health information systems [9].

The OpenEHR Foundation states that OpenEHR has “multilevel single-source modelling within a service-oriented software architecture where models built by domain experts are in their layer”. In this sense, the OpenEHR architecture is based on two levels, separating information from knowledge, as it is demonstrated in Fig. 1.

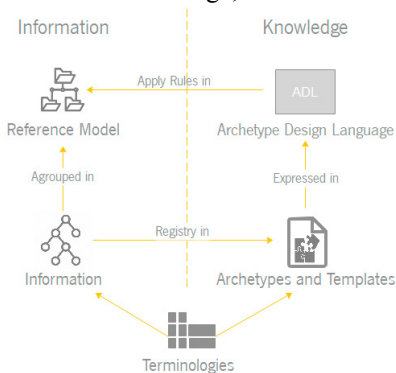


Fig. 1. OpenEHR architecture

The first level contains the Reference Model (RM) that groups and defines the information processed in the system for each patient, followed by data items such as quantity, text or date. The second model holds the clinical knowledge applied in a structured and archetype-oriented manner, according to the Archetype Definition Language (ADL), promoting semantic interoperability [10].

One of the main objectives of OpenEHR is the universal use of the same data structure based on archetypes by heterogeneous systems. In this sense, the standard provides OpenEHR Clinical Knowledge Management (CKM), an open knowledge repository that provides free access, management and interaction of archetypes and templates, where are selected and modeled according to a clinical purpose.

3. Process Overview

A new challenge based on the adoption of open knowledge models was proposed for Centro Hospitalar Universitário do Porto (CHUP). The OpenEHR was the chosen standard for this process, providing a particular architecture based on two levels. This project was developed by a technical team made up of engineers with the support of a clinical team composed by doctors and nurses.

3.1. Problem Description

Health information system “primary purpose is the support of life-long, effective, high quality and safe integrated healthcare” [11]. However, the amount of data produced daily in different formats and data structures from different systems, is an important barrier to quality health care, by producing different clinical artefacts with same semantic.

These data could be extracted and used to generate information and clinical knowledge, however most of these records are not commonly available or even structured, which generates dispersion, failure to understand and sometimes data loss. Consequently, this lack of data standardization in data extraction leads to inefficiency of data analysis techniques and clinical decision support in healthcare.

Another subject to be improved at Centro Hospitalar Universitário do Porto (CHUP) is the interoperability and standardization between systems. That is, seamless and lossless communication between systems with mutual understanding is the most important requirement in a healthcare facility.

Hereupon, this project was motivated to establish a semantic standard for clinical concepts and vocabularies in order to satisfy the remaining levels of interoperability, providing a structured model of clinical knowledge and information.

3.2. Research Questions

Based on problem description, some requirements were identified. A set of five questions were selected to evaluate the project success, presented as:

- What is the importance of structured information at the level of health information systems?
- What are the reasons for using globally recognized standards?
- What is the initial context of archetypes and templates to build a clinically valid knowledge base?
- What are the major challenges associated with developing the proposed solution? How were these overcome?
- How will the proposed system improve the quality of health information systems in CHUP?

3.3. Proposed Methodology

The proposed methodology is based on an observational study on OpenEHR standard and current technological state of hospital infrastructure and support. Thence, the process of adopting OpenEHR standard at Centro Hospitalar Universitário do Porto (CHUP) is characterized by five stages, as shown in Fig. 2.



Fig. 2. Main stages of the process

Clinical Market Study

The first phase is represented by exploiting existing solutions in clinical market according to the needs previously identified. For this, a survey and comparison of current solutions at the national and international level for CHUP's health information systems were carried out. That said, OpenEHR was the chosen approach that best fits the requirements set. After selecting the standard, an in-depth study was carried out to better understand and plan its correct implementation in the current hospital technological ecosystem, identifying the existing and missing resources, as well as the risk analysis of their implementation.

Planning

In this phase, account was taken of necessary human and technological resources, a stipulated average time and ensuring compliance with previously identified requirements. Regarding the definition of the intervening parts of the process, a modelling team was created for OpenEHR clinical data modelling. In parallel, a technical team was also created to support this new structure ensuring interoperability as intended. For the success of this implementation, communication strategies were established between both teams to synchronize work, guiding it to phases, tasks and time. In addition, some important security and access criteria have been considered in work organization.

Formalization

Based on project planning, this phase focuses on its completion in phases and time. Due to protocols and information systems currently established by Portugal National Health System (SNS), strategies for integrating existing system where defined. In order to support the work developed followed by the OpenEHR standards, new technologies have been proposed both in terms of clinical and technical support.

Development

According to the defined roll out, a new interoperable environment will be developed to support the new OpenEHR system and integrate it with the current structure. Consequently, this integration must guarantee the different levels of interoperability between the new and the actual system, so that the history of clinical records is accessed through the new structure. Withal, the modelling team will develop clinical solid and coherent forms, selecting archetypes and templates from the OpenEHR repository aggregated to a set of rules according to the clinical purpose.

Testing and Refinements

After the integration of the new structure in the current system, tests will be carried out at both technological and administrative levels. First off, operational tests will be carried out to analyze the system load and detect possible failures or errors. On the other hand, it will be important to check users' satisfaction with the new structure, which can be assessed through interviews or questionnaires.

3.4. Impact Assessment

In order to analyze the pros and cons of the proposed approach, a SWOT analysis was made, highlighting an internal and external perspective. In the internal environment, strengths and weaknesses are identified, and in relation to the external environment their opportunities and threats are identified.

Table 1. SWOT analysis

Internal Environment		External Environment	
Strengths		Opportunities	
Competitive advantages;		Standardization of clinical records on a large scale;	
Use of a globally recognized clinical approach;		Positive aspects of the environment with the potential to grow the proposed solution;	
Structured clinical data;		Collaboration with other OpenEHR modelling groups and sharing their structures standardization of clinical records on a large scale;	
Available data for a better development of clinical decision support systems;		Training and integration of clinical modelling of these structures in training of health professionals and/or higher health courses;	
Decrease of obsolete data and poorly inserted records without clinical value.		Development of a worldwide repository for the association of clinical structures OpenEHR.	
Weaknesses		Threats	
Internal disadvantages of the proposed solution compared to competing solutions;		Negative aspects of the environment with the potential to compromise the proposed solution;	
Proposed solution based on a standard with its own guidelines;		External development of more efficient solutions;	
In the medium/long term, the community of clinical modelers will have to increase.		Appearance of a new standard with better conditions.	
		Reduced number of professionals trained in clinical modelling in OpenEHR, making it more time-consuming.	

4. Results

This being a research study based on the adoption of a new approach to clinical records, the project results are based on the answers to previously selected research questions, such as:

- What is the importance of structured information at the level of health information systems?

Structured information from different Electronic Health Record (EHR) systems is important for health IT professionals to improve their interaction, aggregation and analysis. These structured data are able to coherently feed new systems to support clinical decision and knowledge discovery, in real time.

- What are the reasons for using globally recognized standards?

For a health institution to be able to obtain the maximum of structured clinical records, the adoption of a certain clinical methodology is emerging. The importance of widespread clinical models such as OpenEHR, enhance sharable and ubiquitous clinical content, through open repositories of archetypes and system specifications.

- What is the initial context of archetypes and templates to build a clinically valid knowledge base?

Archetypes proposed by OpenEHR standard constrain the reference model, allowing data to be stored in a standardized structure that represents clinical concepts from the real world. Templates constrain archetypes, providing data points adjusted to the context of practice. Having a formal way to capture reality, increase the feasibility to aggregate data and, therefore, reuse data for secondary uses of an Electronic Health Record.

- What are the major challenges associated with developing the proposed solution?

Increased interoperability at technical, semantic, organizational and international levels; The standardization of concepts; Access to structured and meaningful data in real time; Clinical modelling by domain experts.

- How will the proposed system improve the quality of health information systems in CHUP?

The proposed system reduces the effort of the information systems, improving its performance and, consequently, decreases the workload at the level of IT experts. In addition, the quality of information increases significantly, with record data structured, without raising ambiguities in concepts and terminologies.

5. Conclusion and Future Work

This case study aimed to explore the OpenEHR standard in order to provide clinical knowledge, improving health care quality and to support decision-making at Centro Hospitalar Universitário do Porto (CHUP). Thus, this article describes the adopted methodology of the open knowledge acquisition of a two-level modelling approach on clinical data.

As a result of separating clinical records into information and knowledge, a set of archetypes and templates are modelled using a common controlled vocabulary to represent clinical concepts and terms in a structured form. This set of activities grant clinical knowledge in an organized and standardize way, aggregating templates in visual forms followed by a clinical purpose.

In terms of interoperability, this standard meets the project's expectations for avoiding communication failure and loss and, on the other hand, for providing universal semantic understanding. That is, with this approach, the patient's historic is easily extracted and understood by any system worldwide. Furthermore, as CHUP is a university hospital, this new approach to structuring clinical record will also benefit in terms of academic training.

Overall, this standardization will allow the entire electronic clinical process of the healthcare facility to be interoperable, organized, fast and easy to use. Furthermore, since OpenEHR is an open standard, it is possible for professionals without clinical knowledge to intervene and contribute to the modelling and structuring of forms for health information systems.

To sum up, the clinical decision support activity complements a simple EHR system, providing clinical guidelines and documented models, to find suitable standards for representing clinical data in order to achieve decision support benefits in healthcare.

Future work focuses on the full implementation of the new OpenEHR approach throughout the healthcare facility. Another subject will be the automation of the process of modelling and versioning forms developed through the OpenEHR open repository by selecting archetypes and templates.

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