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Improving Quality of Electronic Health Records with SNOMED

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Abstract

The use of classifications, standards and terminology proves to be of particular importance to classify therapist techniques, clinical and nursing procedures and formulate diagnoses. This work shows a different implementation than usual, the application developed doesn't depend of platform of medical record. The Department of pathological anatomy was chosen as a pilot service to enter the SNOMED system, to produce reports and to evaluate the benefits of its use in a real context. The successful implementation is directly related to the success of interoperability between information and the use of electronic health record systems. It is the first step to extend the system to the whole hospital and to the success of clinical research, to provide alerts and prevention systems and reduce medical errors.

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1. Introduction

Health Information Systems (HIS) arise in the context of the need to manage and to organize hospital information systems. They represent a hospital subsystem of socio-technological development that covers information processing, resources, flows and people [1]. Despite the efforts of clinicians to provide high quality

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services, the increasing influx of patients to hospital services allied to the large number of clinical procedures and actions, lead to the medical errors occurrence, due to the loss of important information or to the fact that they ignore of good practice standards.

The Electronic Health Record (EHR) is a result of the HIS's adoption that represents a significant step in the communication improvement and relevant data availability increase [2]. Adopting decision support tools to improve the healthcare quality depends on the use of standard terms and concepts in the health records, where the data standardization involves the underlying terminologies standardization, including classifications and nomenclatures. The use of techniques that allow expanding the structured and uniformed data throughout the EHR has been increasing, increasingly resorting to mechanisms that seek to facilitate the data collection and analysis [3].

Furthermore, the use of standards in the health record ensures better communication between health professionals and the interoperability between systems, allowing for some automation in the hospital records. These standards are divided in clinical information representation standards, communication standards and image standards. The use of these standards ensures that the EHR is to be understood by any health professional anywhere, also allowing the machines to interpret symptoms and assist physicians in diagnosis and treatment [1, 4].

This paper shows a different implementation of SNOMED and their benefits in a real context. This paper is organized in more six sections. On the second section, it is explained the need to become more homogeneous the information systems on healthcare. The third, is about how SNOMED can be useful in this issue. On the fourth section, is presented the platform of the medical record that was used, AIDA. On the fifth, you can find the whole process of implementation that is explained and finally at the sixth the outcome is presented and discussed.

2. Interoperability

In order to understand what is interoperability the Healthcare Information and Management Systems Society (HIMSS) published the following definition. Interoperability describes the extent to which systems and devices can exchange data, and interpret that shared data. For two systems to be interoperable, they must be able to exchange data and subsequently present that data such that it can be understood by a user [5]. This ability of joint work between different HIS is materialized into two levels: technical interoperability and semantic interoperability. The level of technical interoperability essentially refers to the integration between applications, being the intended when it comes to define architecture for EHR. The Service Oriented Architecture (SOA) is the latest development in the integration of applications. A service-oriented architecture enables the definition and creation of transversal processes supported by applications of different types. This is a seamless integration, where it is only required the knowledge of communication standards and standard language among services [6].

The critical issue for the health information exchange and interoperability is the adoption of electronic communication basic standards that allow to the integrated parts, transmitting, receiving, and storing data. For participants to manage and interpret the data in a meaningful way, the optimal interoperability requires the adoption of representation and communication and adequate image standards [6].

An interoperable EHR contributes to a more effective and efficient patient's care because this capability facilitates the process of retrieval and processing of information from different locations. Automatically transferring the patient's information between care locations speeds up the delivery and reduces duplication of tests and prescriptions. Automatic warnings reduce the occurrence of errors, improving productivity and beneficiating the patient's care [7]. The EHR interoperability is, then, the ability of communication and cooperation between different health organizations (doctors, hospitals or other healthcare facilities), enabled by information sharing and communication of EHRs among themselves, or with others HIS [8].

3. SNOMED

The Systematized Nomenclature of Medicine Clinical Terms (SNOMED CT), simply appointed in this article as SNOMED, is a comprehensive clinical terminology that provides clinical content and expressivity for clinical documentation and reports. This is a result from the junction of SNOMED Reference Terminology (SNOMED RT), developed by the College of American Pathologists (CAP), and Clinical Terms Version 3 (CTV3) developed by the National Health Service (NHS) in the United Kingdom, in 1999 [9,10]. The terminology is composed by concepts,

terms and relationships that allow an accurate representation of the clinical information on the entire healthcare sector [9]. The SNOMED enables a consistent way to capture, share and aggregate clinical information in specialties and care locations. Its use provides interoperable encoded data that enhance the implementation of evidence-based practice, facilitates decision support rules and contributes to improve the quality of care provided to patients [11].

As a standard of international representation, the SNOMED is a unique opportunity to meet the following guidelines [12]:

- The need for a global standard terminology for medicine and life sciences with the ability to cope with the immensity of clinical and scientific information;
- An impressive legacy of organized biomedical terminology;
- Efforts in order to the ontological grounding of the basic types of entities in the biomedical area;
- The increased availability of artifacts of reasoning based on logic indicated for large ontologies.

3.1. SNOMED structure

The version released in 2010 includes more than 291,000 active concepts and the descriptions associated with these concepts are more than 758,000 [13]. SNOMED has a division that includes the basic components (concepts, terms and relationships), attributes that characterize a given concept and hierarchies that result from the type of relationship between different concepts.

A concept is a clinical significance represented by a unique numeric identifier and the Fully Specified Name (FSN) which also isn't repeated. Each concept can be associated with multiple terms that represent different types of descriptions. A description is the FSN, which is unique for each concept, and may be synonyms and preferred terms, i.e. descriptions that represent the same concept but are preferred by clinicians to appoint it, these are not necessarily unique [9].

Relationships link SNOMED concepts among themselves. There are various types of relationships being the most widely used as characterizer of a concept the relation: “is a”, which defines a concept and highlights the granularity of the same; “finding site”, which shows the disease localization (topography); and ”morphology”, which describes the morphology that characterizes a particular disease. Following the links created by relationships we can have a hierarchy, or a textual representation, which defines the concept as is required by the service that uses this nomenclature Figure 1 is the classification result of a concept by the aforementioned relationships as the most used [9].

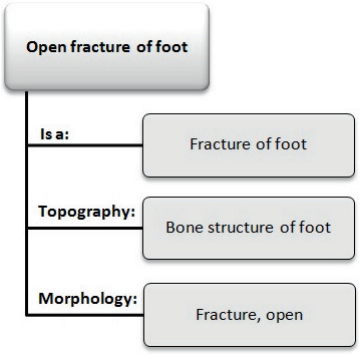

Fig. 1. “Open fracture of foot” concept classification.

In addition to the basic components, SNOMED includes over 50 attributes that define some of the existing categories in the conceptual model. Each attribute can be applied to one or more hierarchies that constitute the “domain” of this same attribute, which usually respects a limited set of values appointed as “range” of the attribute. The combination of these attributes to the hierarchies causes a clinical data retrieval more useful and relevant [9].

3.2. SNOMED adoption benefits

SNOMED works as a base on which healthcare organizations can develop effective data analysis applications for supporting the research results, evaluating the quality and the cost of care and designing effective treatment guidelines. The use of this clinic terminology helps healthcare providers making the information more accessible and complete, which is reflected in an improvement of the results for patients. The implementation of SNOMED as an integral part of a well-designed HIS is the key to trigger many of the potential benefits of EHR. The use of an international standard and the provision of a consistent terminology in all health fields enable physicians to communicate effectively and accurately across different clinical domains and throughout the time span of the patient registration [9].

The hierarchical structure of SNOMED translates the connection of the different concepts made by a type of relationship which classifies them. The large number of concepts and the association of the topography, morphology and definition of the category to which they belong, make SNOMED the most complete and effective clinical terminology in the register and statistics of the pathological anatomy Department.

4. AIDA

AIDA (Agency for Integration, Diffusion and Archive of Medical Information) is a platform that consists of a Multi-Agent System (MAS) and overcomes difficulties in achieving uniformity of clinical systems, as well as medical and administrative complexity of different Hospital information sources [1, 4]. AIDA was created by a group of researchers from the University of Minho, the Artificial Intelligence Group, and is currently installed at some major Portuguese hospitals. It is a good example of the successful cooperation between a University and hospitals. It is an electronic platform that provides employees with intelligence, the agents. This platform features a pro-active behavior in its main functions: communication between heterogeneous systems, storage management and hospital information; response to requests in time; sending and receiving information from hospital sources like laboratories (labs) (medical reports, images, prescriptions, etc.). Thus, AIDA enables interoperability between hospital subsystems, assuming a main role where it is installed [4]. AIDA has an easy access for your users, allowing the management of clinical information anywhere in the hospital. In addition, the platform enables the sending of messages via phone or e-mail. The same way, AIDA establishes connection with all Systems of medical information: EHR; Administrative Information System (AIS); Medical Information System (MIS); and Nursing Information System (NIS) [4, 14]. Figure 2 shows the central role of AIDA.

The AIDA's main goal on front-office is the register of medical exams. This platform covers all of each tasks needed to execute a medical examination. Table 1 shows all tasks, which occur during a whole process of medical examination, also it shows the responsible clinical professional of each task. AIDA covers all of these tasks [14].

Table 1. Medical examination execution process.[14]

Task	Clinical
Medical exam request	Requesting medic
Examination confirmation	Performer medic
Examination scheduling	Administrative staff
Patient receipt	Administrative staff
Performing	Performer nurse or technician
Executing report	Performer medic
Evaluation results	Requesting medic

At the same time, AIDA's agents ensure that information is shared with other hospital subsystems. Therefore, clinical professionals can also access all information through their specifics systems of record, i.e., in spite of this, clinical professionals can view information on AIDA platform, doctors, nurses and administrative staff can also find the same information at Medical Information System (MIS), Nurse Information System (NIS) and Administrative Information System (AIS), respectively [14].

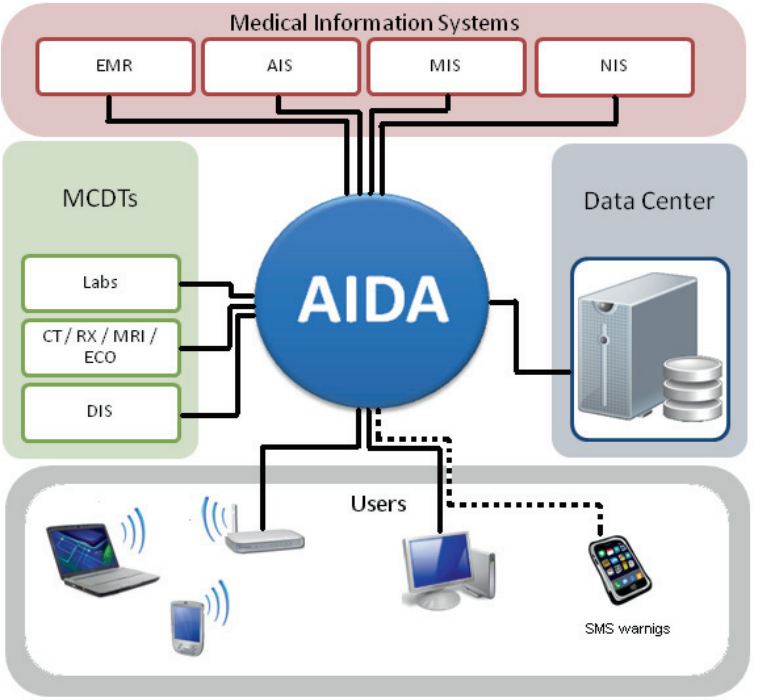

Fig. 2. The central role of AIDA [4].

4.1. AIDA-PCE

The AIDA-PCE is an EHR and was implemented in the Centro Hospitalar do Porto. The same creators from AIDA platform formed AIDA-PCE. The AIDA-PCE follows a problem-oriented organization suggested by Lawrence Weed in the 60's. In this type of organization, clinical information (annotations, therapeutic, diagnostic) should be recorded for specific problem solving, creating a list of issues organized in a tree structure, where each new problem derives from the main branch [15]. One's note that problems can be classified as active or inactive, in which active problems are those where the disease is still active or even when intervention is required immediately. On the other hand, inactive problems require no urgent action. In this EHR problems assets are monitored and recorded daily using a SOAP (Subjective, Objective, Assessment and Planning) framework. Thus, each record contains the patient's symptoms, a doctor's observation, an analysis of diagnosis and a treatment plan that the patient is subject to [1, 15].

The AIDA-PCE implementation follows a set of requirements that must be considered in order to be beneficial for the health staff job and patient health. The AIDA-PCE has many common features with PCP but it has a response, which is fast, reliable and safe. The structure of this EHR allows seamless integration with existing HIS by promoting the ubiquity of records between different specialties and services. The ubiquity of the AIDA-PCE allows access to mechanisms for monitoring alarm systems and decision support. The electronic record allows generation of documents and customized reports for specific purposes. It becomes easier to configure interfaces for registration and more. The information contained herein is standardized and uniform [1, 14]. In the hospitals where AIDA and AIDA-PCE systems were installed, it was made a substantial investment to ensure the availability, reliability and scalability of the system. However, in some situations, users may not have access to the system due to network problems, communications, electricity or local disasters [14].

5. Implementation

The application development was made respecting the six stages of software development life cycle: project planning, definition of requirements, project, development, integration and test and installation and acceptance; following the waterfall model. This was the adopted model in order to lead to the attainment of a quality product that meets the original intentions of the client [16].

5.1. Planning

At this stage it was made an overview of the application in order to establish a basic project structure, to evaluate the feasibility and to describe the appropriate technical approaches [16]. Here are edged the software objectives that include:

- Sort anatomical concepts using SNOMED;
- Finding SNOMED concepts;
- Diagnosis supporting in anatomic exams;

5.2. Definition of requirements

The gathering process of requirements was based on the objectives set out above. Thus, the requirements defined like main functions of the intended application are specified in Table 2:

Table 2. Application requirements.

Objective	Requirements
Classification of anatomical concepts	Searching in SNOMED database for the anatomical concepts included in (topography, morphology, etiology) and to classify the severity associated with morphology, when applicable;
Concepts searching	Providing to the user the possibility to obtain information about any SNOMED concept;
Diagnosis supporting	Using the relationships between SNOMED concepts to obtain a diagnostic suggestion according to topography and morphology previously introduced.

5.3. Project

Fig. 3. Model of application built.

The project phase defines the way that the application will be operated in terms of hardware, software, network infrastructure, user interface and needed databases [17]. On this stage, it was defined the model, like shown in the

figure 3. It was built a web application with a web page and web service. As a result, physician use the page to look for SNOMED concept and codify the report. Then the web service imports the concept chosen to the report and medical record platform. This model ensures the independence of medical record platform that is being used; in other words, this app could be installed on other platform without the need for encoding. This is the biggest difference among other implementations already published.

5.4. Development

The development phase corresponds to the encoding process and improvement project previously defined [17]. During this phase it is important to confirm with the client if the realization of the projection is the appropriate form to reform the same, in this case, the director of the pathological anatomy service provided it.

5.4.1. Languages and frameworks

For the development of intended web application it was used the programming language specifically designed for C sharp (C#) developers, the.ASP.NET. This language was developed to allow .NET programmers the creation of powerful and high quality Web applications [19]. Within the .NET environment also was used Asynchronous JavaScript and XML (AJAX). Regarding the activities related to the management of SNOMED database information it is used the Structured Query Language (SQL). The use of referred programming languages is provided by Visual Studio, that was the environment chosen to develop the application to meet the basic requirements.

5.4.2. Main components

The main goal of the application is to allow the classification of the pathological anatomy reports made through AIDA. Thus, this page has the function to classify a certain diagnosis that is suggested according to the location and morphology of the sample associated to it by the user who must be a physician who reports an analysis of pathological anatomy, for example.

The normal course of classification begins with the introduction of the sample site. In this step the physician selects by name of the place or of its SNOMED code. Physician can add more information, which it's associated through relationships “part of” and “laterality” with the local previously chosen. The second step of the classification should be to indicate the morphology detected in the sample. Such as the location, also in this step there is support to the user after the introduction of SNOMED code or the name of morphology. To finalize the classification process lack associated to these concepts the respective disease. At this step it is returned a list of all the concepts that, by following the relationships concerning the topography and morphology, represents a disease that encompasses information initially introduced. Besides this usual process of classification it is also possible to check which diseases associated only with a particular location or morphology, as well as enter the names or SNOMED codes of the disease and using the arrow to the left to check the list of locations and morphologies.

5.5. Integration

Now and at this point, it is performed all tests cases to verify the accuracy and completeness of the application. This is the most critical phase of implementation [16]. After some tests made by the service director where takes place the implementation verifies that the application is as intended, which confirms that their support was crucial in the previous phase.

5.6. Installation and acceptance

During the installation phase initially arose some mishaps related to the server version compatibility but these situations were solved with no major troubles. In order to demonstrate the good acceptance of this application there were made some interviews. This application was installed like an additional field on each examination report; the physicians decide if he will use the application or not.

6. Results and discussion

After 3 months of use and based on queries made directly in the database the results were very positive. The following table shows the number of reports published with the SNOMED classification and the total of Reports published by each doctor of pathological anatomy. The percentage of utilization is very high which shows the good acceptance of this application by clinical professionals.

Table 3. Number of published reports.

	Column A (*t*)	Column B (*t*)	Column B (*t*)
Total reports	1301	1671	519
Reports with SNOMED	1300	1667	517
Percentage	99,9%	99,8%	99,6%

The realization of this project and its implementation on AIDA allowed the automatisms of some important tasks. For example, after its installation, the AIDA platform started to send an email to the oncology service for each published report with one specific SNOMED code. This new AIDA feature is very important because it accelerates the process of patient treatment in case of some identified diagnoses, which can be vital for patient health. Other example of these automatisms is the importing of diagnosis for the alerts of medical record. A patient that has an examination result on pathological anatomy with report of the SNOMED, his results will be available on the medical record platform and all of the physician can have access to that report and their all diagnoses. Furthermore, after this implementation, physicians began making statistics by diagnosis more effectively.

Further results were obtained through interviews with staff of the Department of pathological anatomy. They all agree that this project has improved the quality of information, benefiting the service provided to the patient. For the administrative staff this implementation made the workflow easier whereas for the physician the most important improvements were to help prevent errors; to speed up the bureaucracy processing of the patient treatment; to avoid lost diagnoses and allow for statistics by diagnosis.

7. Conclusions

This paper presents a solution to improve the quality of information in the records of health institutions; being used the pathological anatomy service as a pilot service. The main goal was to prove how important it is to implement medical ontologies on record, showing various benefits. During this project it was implemented and installed a system for classifying medical examination results in a real hospital environment. The system usability and acceptance studies will continue throughout meetings and questionnaires and intermediate reports will be under construction.

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