Improving Diagnosis-related Groups with a Computerized Clinical Coding Tool for ICD-9-CM Codification

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***Abstract*—In recent years, in *Centro Hospitalar do Porto* (CHP), a major Portuguese hospital at the North of the country, there has been felt an increasing need for a computerized clinical coding tool to aid in the codification of the episodes of hospital discharges from patients admitted to its healthcare units. The process was slow and performed manually by the coding professionals, not having a centralization and unification of the information and processes associated with the clinical coding of a hospital discharge. Hereupon, in the context of this study, the aim of the present work was to design and develop a clinical coding tool for International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) to support the clinical practice in healthcare units. The coding of hospital discharge processes enables the grouping of episodes into diagnosis-related groups (DRGs) that correspond to clinically coherent and similar groups that are expected to use the same level of hospital resources. The main motivation for the implementation of this classification system is that it provides a financial and patient classification system, trying to contain the costs and waste associated with healthcare services. Thereby, a single-page application (SPA) for ICD-9-CM was designed in order to help health professionals of CHP in their daily work, namely the clinical coding of the episodes of hospital discharges. The main advantages and contributions of the development and use of this Web application are the centralization of information and tasks associated with the coding of hospital discharges, the increase of productivity and the reduction of wastes of time. Consequently, the ambition is sought to mainly improve the quantity and the quality of work performed by coding professionals.**

***Keywords*—ICD-9-CM; Diagnosis-related Groups; Hospital Discharges; Single-page Application; Proof of Concept.**

I. INTRODUCTION

The health sector represents a tricky situation for the people and systems responsible for the storage and processing of that kind of information. The problem is not in the lack of data but in the diversity and complexity of the health field. An hospital offers a wide range of services for each patient per clinical condition leading to hundreds or even thousands of specific and unique situations. It is then of extreme importance to find a way to measure the hospital productivity and aggregate the multiple activities performed at a healthcare unit. This led to the adaptation of the DRGs to this scenario. These kind of classification systems rely on a prior coding system that translates all the diagnostics, procedures, external causes and morphologies into universal codes like ICD-9-CM, increasing the semantic interoperability and reducing the ambiguity of a discharge report. The introduction of new Web frameworks and solutions for Web development resulted in a new wave of codification platforms for this kind of code systems. With modern layout and intelligent helping tools, it is possible to reduce the codification errors dramatically and increasing efficiency.

This paper presents an insight into the development, implementation and impact analysis of a Web application directed to the ICD-9-CM codification in a major Portuguese hospital in the North of the country – CHP. The focus of this paper is mainly to highlight the differences between the prior method (by hand) and the new one.

In Section II, the state of the art and similar works are briefly described. Thereafter, in Section III, the research methodologies adopted are presented. Section IV – "Single-page Application for ICD-9-CM Codification" – presents the work developed and its main results, followed by a brief Strengths Weaknesses Opportunities and Threats (SWOT) analysis in Section V. In Section VI, the conclusion and future work concluded this paper.

II. STATE OF THE ART

The present section intends to highlight the main topics addressed throughout the work as well as main studies from the scientific community regarding medical codification.

A. Diagnosis-related Groups

DRGs are a classification system for inpatients at acute healthcare units aggregating under the same code cases with similar resource consumption and clinical similarities [1][2]. Developed at the Yale University (U.S.A) in the 60's, it is used since 1983 by Medicare to calculate the compensation in cases of hospitalization [3]. Due to the immense success on that field, the system was adopted throughout the world in healthcare systems to improve the planning and allocation of funds reducing the disparities and the errors.

The DRG requires a minimal dataset (MDS) in order to attribute one of the 25 main diagnosis categories to the discharge report [1]. So, the MDS includes, as follows [4]:

- The main diagnosis responsible for the patient admission;
- Other diagnosis;

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- Procedures performed on the patient during the internment;
- Gender, age and height;
- Destination after discharge (transferred, death or discharged against medical order).

Each DRG group has an associated relative weight and weighting coefficient, as well as an exception threshold for the number of hospitalization days that helps convert each case into equivalent patients [4].

Wilm Quentin and colleagues in "Hospital Payment Based on Diagnosis-related Groups Differs in Europe and Holds Lessons for the United States" highlights the differences between the original DRG and the one that countries like France, England or even Portugal implement. This adaption is the basis of most European countries method to finance hospitals proving to be less cost worthy with high quality of services [2].

Carina Fourie et. all present in "Systematically Evaluating the Impact of Diagnosis-related Groups on Healthcare Delivery: A Matrix of Ethical Implications" a study of ethical implications and importance of the DRGs in diverse Swiss hospitals [3]. On other hand, in order to highlight the diversity of the subject, Yantao Xin presented a comparison of the amount of medical waste generated in major healthcare units using as basis the DRGs [5].

B. ICD-9-CM

Every time a patient is discharged from a healthcare unit a discharge report is issued with daily logs from the physician in charge of that patient. The ICD-9-CM is a perfect fit to encode diagnostics, medical procedures, external causes and morphologies, consisting in a list of codes recognized anywhere in the world. As the name states, it is an adaptation of the ICD-9 codification system performed by the U.S. Health Department in collaboration with the Medicare and Medicaid Service Centres [6]. With more than 13,000 diagnostics and 3,500 procedures, it is essential to develop tools or systems focused on the codification process. Some Web applications like "Find-A-Code" or the work of Marisa Teresa Chiaravalloti et. all in "A Coding Support System for the ICD-9-CM Standard" are examples of systems developed for codification purposes [7]. The late one processes text in natural language using text mining algorithms, returning a list of possible codes for each case.

After the codification process, every discharge report can be read and perfectly understood in every country that adopts the same terminology. For the purpose of the present work and as stated by international directives, the ICD-9-CM codes are the basis of the DRGs decision [2].

C. AIDA and AIDA-PCE

Some Portuguese systems are equipped with a platform called AIDA *(Agência para Integração, Difusão e Arquivo de Informação Médica*) that uses intelligent agent systems that ensure the interoperability between different and heterogeneous information systems (SAM, SONHO, PCE, SAPE, RIS, LIS, among others) [8][9]. The electronic health record (EHR) is responsible for the safe and organized storage of all the information about a patient, from personal data to diagnostics and procedures [10]–[13]. The constant update is vital in this scenario, so the same Algoritmi group from Minho University that developed AIDA put together the AIDA-PCE. Following the Problem Oriented Medical Record (POMR), all the patient information like symptoms, medical observations, diagnostics and treatment plans are stored inside that structure.

Although using free text and other non-universal information the AIDA and AIDA-PCE present innovative and novel solutions to accomplish interoperability. On the other hand, the incorporation of the ICD-9-CM codes into the EHR represents an important feature to accomplish a cross-border medical record. The storage of ICD-9-CM coded discharge report saves space on AIDA-PCE databases and reduces medical errors in near future.

The next section presents the main research methodologies followed to implement this work.

III. RESEARCH METHODOLOGIES

The realization of any study in the field of Information Technologies (ITs) includes the scrutinized research and analysis of the set of methodologies and technologies available and feasible in the design of the defined IT solutions. The choice of the most appropriate methods and tools is mostly based on the advantages pointed out, as well as on associated limitations and compliance issues with related systems.

Thus, the achievement of the SPA for ICD-9-CM is based on the research methodology Design Science Research (DSR), mostly used in the construction and evaluation of useful and rigorous IT solutions. Each of the design phases presented in this study included the choice and use of the most appropriate methodologies, technologies and tools for the definition and elaboration of the desired solution. Finally, a Proof of Concept (PoC) was also carried out corroborating the viability and usefulness of the clinical coding tool for ICD-9-CM designed and developed, which consisted essentially of a SWOT analysis (Section V).

The next section presents the SPA for ICD-9-CM codification developed and implemented.

IV. SINGLE-PAGE APPLICATION FOR ICD-9-CM CODIFICATION

The codification of the discharge reports was made manually in CHP, making the process too slow and with a high error probability. Thus, it emerged the need to create a process that would reduce the codification time. Therefore, a SPA was developed through which the health professionals are capable to perform the codification process, and at the same time to consult patients' data, such as the discharge report, the personal information and the hospital services were the patient was admitted.

The purposed layout in this scenario encompasses a solution with three main components: the patient information, the codification area and the discharge report. The codification area presents five frames: diagnosis, external causes, procedures, tumor morphology and observations. With

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exception of the observations board, which is the only one that allows free text insertion, all the other boards are composed by rows divided mainly in priority, description and code.

The main characteristic that makes this process faster than the already existing is the dynamic and aided search. When a word is typed in the description field a list of all the ICD-9-CM codes is presented, and when the user picks one of them on the description the respective code is automatically filled. On the other hand, when the user enters the code the description is also automatically filled.

When a codification is finished, the user sends it to an evaluator. If the codification fails in this evaluation phase for any reason, it is sent again to the list of codifications that needs to be done. Thus, the application was developed with three different modules. One to be used in the first codification, another to be used when a discharge report was already codified and for some reason failed in the evaluation phase, and one final module to be used when the user only has view permissions. In this last module, the users are not able to change any field present in the codification.

The application development leaned on the LAMP architecture. It uses Linux as the operative system, Apache as the Web server, MySQL as the relational database management system (RDBMS) and PHP as the object-oriented language.

In order to develop a fluid and dynamic application, the AngularJS framework greatly contributed. The modularity and extensibility of this JavaScript framework allows the development of diverse and futuristic applications.

The database storages all the data related to the codification codes, the discharge reports, user information, and all the information generated by the codification process. The RESTful Web service mediates the communication between the SPA and the database.

The next section presents the SWOT analysis of the Web application developed.

V. SWOT Analysis

To test the viability, the utility, the quality and the efficiency of the application a PoC was necessary, in this case, a SWOT analysis. This analysis allows to analysis the strengths, weaknesses, opportunities and threats of the application [14].

Strengths:

- High usability, intuitive and easy to learn (user-friendly);
- Easy access to the data of patients, as well as the hospital services in which the patient was;
- High scalability;
- Easy of reissue of coded discharge reports;
- Decrease of the codification time of the discharge reports;
- Decrease of human error;
- Easy adaptability to different health institutions.

Weaknesses:

- Requires internet connection;
- Use of ICD-9-CM instead of the more current ICD-10-CM version.

Opportunities:

- Modernization and organizational development;
- Increasing expectation of the hospital administration to obtain methods that facilitate the hospital financing calculation;
- Provide the tool to help in the calculation of the hospital financing.

Threats:

- Lack of acceptance to resort to new technologies by health professionals.

The next section presents the conclusion and future work of this study.

VI. Conclusion and Future Work

Finally, the realization of this case study allowed the development of a clinical practice tool, namely a user-friendly clinical coding tool for ICD-9-CM. The Web application is currently implemented in a production machine of CHP, and it is currently being used by the coding professionals of the hospital in order to perform the clinical coding of the episodes of hospital discharges from patients admitted to CHP. This will then facilitate the grouping of processes into DRGs, that is, a financial system that can manage the costs and waste associated with healthcare services. In the coming years, the expansion of the Web application is expected.

Trained professional using the ICD-9-CM clinical coding tool reported significant differences in time consumption and committed errors when using a computerized system to perform their tasks. It represents a valuable an asset to its users, since it facilitates the work of health professionals, and increases their capacity and speed of work by reducing the number of tasks required to perform a certain codification. In this way, the development of the clinical tool allows the centralization of a set of tasks and information in a SPA, greatly benefiting its users.

Regarding future work, the addition of a Business Intelligence (BI) module in the clinical coding tool for ICD-9-CM is foreseen, that is, the addition of a module with clinical and performance indicators [15]. Its principal aim is the visualization of indicators that show the association between the number of coded processes and each coding professional, as well as the temporal evolution of the number of processes encoded by each coding professional. Thus, the main objective of the insertion of this module is to study and analyze the performance of the coding professionals, that is, to identify, for example, the coding professionals who codify the most and also those who are coding the least. In this way, it is tried to encourage even more the increase of the production of the health professionals of CHP.

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Finally, at the end of 2016, we already began the update of the system from the ICD-9-CM codification to the newer ICD-10-CM version.

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