Improving the Codification of Hospital Discharges with an ICD-9-CM Single-page Application and its Transition to ICD-10-CM/PCS

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Abstract—**In recent years, in *Centro Hospitalar do Porto* (CHP), 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, so there was neither the centralization nor the 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 ICD-9-CM to support the clinical practice in healthcare units. It additionally included its subsequent transition to the newer ICD-10-CM/PCS coding version. In short, the codification of hospital discharge processes enables the grouping of episodes into diagnosis-related groups (DRGs). The main motivation for the implementation of this classification system is that it provides a financial and patient classification system 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, and it was subsequently updated to the ICD-10-CM/PCS coding version that predominantly improved specificity in describing clinical situations. 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 at CHP.**

Keywords—ICD-9-CM; ICD-10-CM/PCS; Hospital Discharge; Diagnosis-related Group; Single-page Application; Proof of Concept.

I. INTRODUCTION

The health sector represents a delicate situation for the professionals and the systems responsible for the storage and the processing of clinical data. The main problem with those processes is not in the lack of data but in the diversity and the complexity of the healthcare sector. Since an hospital offers a wide range of services for each patient and clinical condition, it leads to the creation of hundreds or even thousands of specific and unique situations for each one of them. It is then of utmost importance to find a way to measure a hospital productivity and aggregate the multiple activities performed at a healthcare unit.

This specific situation 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 diagnoses, procedures, external causes, and morphologies into universal codes like ICD-9-CM and ICD-10-CM/PCS, increasing the semantic interoperability and highly reducing the ambiguity of a discharge report. DRGs are clinically coherent and similar groups that are expected to use the same level of hospital resources.

The introduction of new Web frameworks and solutions for Web development resulted in a new wave of codification platforms for these types of coding systems. With modern layout and intelligent helping tools, it is possible to reduce considerably the codification errors, but also increasing the efficiency associated with the realization of those processes.

Therefore, 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 located in the north of the country – CHP [1]. On the other hand, it also includes its subsequent update to the newer ICD-10-CM/PCS coding version. This scientific research has been undergoing since the end of 2016.

Thereby, the focus of this paper is mainly to highlight the differences between the prior method (by hand) and the new one with a computerized clinical coding tool, and the transition of the system from the ICD-9-CM coding version to ICD-10-CM/PCS.

In Section II, the state of the art and similar works related to this topic are described. Thereafter, in Section III, the research methodologies adopted are presented in detail. Section IV – "Single-page Application" – presents the work developed and its main results regarding the two versions of the Web tool, followed by a brief Strengths Weaknesses Opportunities and Threats (SWOT) analysis in Section V. In Section VI, the conclusion and future work conclude briefly this paper.

II. STATE OF THE ART

The present section intends to highlight the main theoretical topics addressed throughout this manuscript, and the theory behind the realization of this work, as well as the main studies from the scientific community regarding medical codification, including the subsections "Diagnosis-related Groups", "ICD-

9-CM Clinical Coding", "ICD-10-CM/PCS Clinical Coding", and "Interoperability: AIDA and AIDA-PCE".

A. Diagnosis-related Groups

A patient classification system is a method in which the main objective is to group patients or disease episodes in order to make it possible to identify their similarities and differences, and therefore allowing that those who belong to the same class are treated similarly.

In this context, DRGs consist of a patient classification system of patients hospitalized in acute hospitals that was developed in response to the rising costs and waste in the healthcare industry [2]–[4]. It groups patients into classes that are clinically consistent and similar in terms of resource consumption [2], [5]. Developed at the Yale University in the United States of America (USA) in the 60's, it is used since 1983 by Medicare to calculate the compensation in cases of hospitalization [6].

This classification system allows defining the set of goods and services that each patient receives according to his needs and the pathology that led to his hospitalization, as well as the defined treatment process. Thus, it is possible to relate the type of patients treated with the resource consumption [2]–[4], [7].

On the other hand, the concept of clinical coherence defines that the pathologies of the patients included in each DRG are related to an organ or system, or even with the etiology, and that the care provided is similarly the same for all the patients in that DRG [7]. A predetermined amount of money is disbursed to hospitals for the treatment of patients belonging to a given DRG, regardless of actual costs associated with the healthcare services provided to them [3], [4], [6], [8].

Thereby, the main motivation behind the grouping of patients from health institutions into DRGs is that it provides a financial and patient classification system that uses the diagnoses, surgical interventions, age, gender, destination after discharge, and other related factors, as grouping criteria [2], [4], [8]. They were introduced in several countries, including Portugal, as a strategy for cost containment, planning, budgeting, management, and follow-up of the healthcare services provided to patients, reducing the disparities and errors [3], [6], [7].

The DRG requires a minimal dataset (MDS) in order to attribute one of the 25 main diagnosis categories to the discharge report [2]. So, the MDS includes, as follows [9]:

- The main diagnosis responsible for the patient admission;
- Other diagnoses;
- 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 [9].

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 a high quality of services [3].

Carina Fourie et al. 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 [6].

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 [4].

B. ICD-9-CM Clinical Coding

For the purpose of coding hospital discharges in terms of diagnoses and procedures, in order to allow the subsequent grouping of those episodes in DRGs, the clinical coding "ICD-9-CM" is applied [8]. In short, it consists of a set of diagnosis and procedure codes used for the classification and coding of the morbidity and mortality information for statistical purposes, and for the indexing of hospital records by disease and surgical interventions. The information is then used for storage and research purposes.

Thus, the DRG classification process is performed by a coding professional who must know the system and the classification structure of the ICD-9-CM clinical coding, understand the organization of the indexes and their use in the coding of diseases and procedures, as well as how to apply correctly the principles and rules of the clinical coding ICD-9-CM [8].

Each time a patient is discharged from a healthcare unit, a discharge report is issued from the daily logs by the physician in charge of the patient. The ICD-9-CM clinical coding is a perfect fit to encode diagnoses, medical procedures, external causes, and morphologies, consisting in a universal list of codes recognized in any country across the world.

As the name states, it is an adaptation of the ICD-9 codification system defined and implemented by the U.S. Department of Health in collaboration with the Medicare and Medicaid Service Centres [10]. With more than 13,000 diagnoses 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 al. in "A Coding Support System for the ICD-9-CM Standard" are examples of systems developed for codification purposes [11]. 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 [3]. Thereafter, the ICD-9-CM SPA coding tool was updated with the newer ICD-10-CM/PCS coding version, initially released in order to replace the ICD-9-CM version.

C. ICD-10-CM/PCS Clinical Coding

Firstly, it is important to note that ICD-10, unlike its precursor (ICD-9), is divided into two different parts, namely: [12], [13]

- ICD-10-CM for diagnosis coding;
- ICD-10-PCS for inpatient procedure coding.

When ICD-10 was defined, it was projected that ICD-10-CM would become a standard for all USA healthcare settings, whereas ICD-10-PCS would be required in inpatient settings only [12].

The ICD-10-CM/PCS clinical coding was mainly designed to offer notable advantages over ICD-9-CM, such as generating higher-quality clinical data. This would result in major improvements in the quality and the use of data in a significant number of healthcare settings, including driving a better healthcare management and improving significantly outcomes [12].

Supporters of ICD-10-CM/PCS defend that it incorporates greater specificity than its precursor in describing healthcare problems, but also clinical data, offers the addition of information relevant to ambulatory and managed care encounters, and impressively expanded injury codes that reflect the location of the injury [12], [14]–[16]. Thus, they praise its undeniable ability to provide a more detailed description of clinical situations, and substantially increasing the level of detail that can be captured [12], [13], [16], [17].

Furthermore, the structure of ICD-10-CM/PCS enables the possibility of greater expansion of code numbers, including risk factors that are regularly encountered in a primary care setting, instead of allowing the classification of diseases and injuries only [14].

In addition, while ICD-9 uses numeric codes (e.g., 001-999), ICD-10 uses an alphanumeric classification system which consists essentially of 1 letter followed by up to 3 numbers at a 4-character level (e.g., A00.0-Z99.9) [17], [18]. Thus, the alphanumeric format of ICD-10 offers a better structure than ICD-9, which allows a significant space for future revision without disruption of the numbering system [19].

On the other hand, the overall number of codes and diagnoses has increased significantly: about 17000 codes for ICD-9-CM to more than 155000 codes for ICD-10-CM/PCS [12], [13], [15]–[17], [20]. Thereby, the newer version includes previously unavailable codes since it enables a more detailed description of clinical situations, including for instance codes to distinguish between different types of diabetes or even the location on the patient's body of the health condition (e.g., left or right limb) [12].

Thus, while the main axis for ICD-9 is the nature of the health condition itself, the main axis of ICD-10 is the body region of the health condition with the highest level of specificity reachable [21].

In the long run, due to this improved level of detail, it is expected that ICD-10-CM will decrease medical fraud and abuse [12]. For instance, since even the location on the patient's body is registered in the codification process, it will reduce the possibility of coding professionals repeatedly reporting the same procedure on the same location of the body.

D. Interoperability: AIDA and AIDA-PCE

Nowadays, with the continuous growth of the clinical information stored into the hospital information systems (HISs), one of the major interests in the Medical Informatics field is to ensure interoperability between different information systems in health institutions [22], [23]. Thus, interoperability is increasingly considered a requirement in HISs rather than an option in order to implement an adequate communication and cooperation between distinct systems [24].

In short, the concept of interoperability can be defined as the ability of a system to communicate and share information with another system that arises in order to overcome the heterogeneity and distribution of several different sources of information. In the healthcare industry, the main goal of interoperability is to connect applications and data so that they can be shared across the organization and distributed to health professionals [22], [24].

Thereby, in this context, there is a need to implement dynamic platforms, such as multi-agent systems that allow the access and sharing of information between different information systems, in order to connect them, standardize distributed clinical systems, and thus reduce the delays normally generated in the process of sharing information [25].

The register of clinical information in CHP is ensured by a few HISs, namely the "*Sistema de Apoio ao Médico*" (SAM) – Medical Support System, the "*Sistema de Gestão de Doentes Hospitalares*" (SONHO) – Hospital Patient Management System, the "*Sistema de Apoio à Prática de Enfermagem*" (SAPE) – Nursing Support System, and the "*Processo Clínico Eletrónico*" (PCE) – Electronic Medical Record [23], [26].

In this context, the AIDA ("*Agência para Integração, Difusão e Arquivo de Informação Médica*") platform emerges. Some Portuguese health systems are equipped with the AIDA platform, including CHP, which uses proactive intelligent agents that ensure the interoperability between different and heterogeneous HISs, and other entities such as the complementary systems, including SAM, SONHO, SAPE, PCE, RIS ("Radiology Information System"), LIS ("Laboratory Information System"), DIS ("Department Information System"), and AIS ("Administrative Information System"), among others [22]–[26].

AIDA is a complex system consisting of simple and specialized subsystems, defined as intelligent agents, which are responsible for tasks such as the communication between heterogeneous systems, the sending and receiving of information (for example, clinical reports, medical images, and prescriptions), as well as the management and storage of data [22].

Thus, directly from AIDA it is possible to integrate, disseminate, and archive large sets of data from different sources (for example, services, departments, healthcare units, computers, and medical devices) [22]. In this way, the AIDA platform provides an easy access and sharing of registered information, facilitating medical research and the application and development of other computational tools, such as the ICD-9-CM and ICD-10-CM/PCS clinical coding tools described in this manuscript, in order to optimize the healthcare services provided by the health institution.

The electronic health record (EHR) is responsible for the safe and organized storage of all the information regarding a patient, from personal data to diagnoses and procedures [27]–[30].

The constant update is vital in this scenario, so the same research team from the Algoritmi Research Centre (University of Minho, Braga, Portugal) that developed AIDA put together the AIDA-PCE. Following the Problem Oriented Medical Record (POMR), all the patient information regarding symptoms, medical observations, diagnoses, and treatment plans are stored inside that structure.

Although these systems allow the insertion of 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, and subsequently the ICD-10-CM/PCS codes, into the EHR represents an important feature in order to accomplish a cross-border medical record. The storage of ICD-9-CM and ICD-10-CM/PCS coded discharge reports saves space on the AIDA-PCE databases, and reduces medical errors.

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, and its transition from the ICD-9-CM codification to the newer ICD-10-CM/PCS version, are 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, and its update to the newer ICD-10-CM/PCS version, which consisted essentially of a SWOT analysis (Section V).

Thereby, a brief description of these two research methodologies are presented in this section, namely Design Science Research and Proof of Concept, in subsections A and B, respectively.

A. *Design Science Research*

In the area of ITs, the main objective of the use of the research methodology Design Science Research is the construction and evaluation of objects, also called "artefacts", that allow professionals to process organizational information and develop actions to solve a problem [31], [32].

Thus, the methodology that drove the realization of this project is the DSR. It consists of a rigorous method of scientific research used to develop successful artefacts [33]. It focuses on the IT artefact with a high priority in its relevancy in its application domain. Thus, in the context of solving real-world business problems, it is critical to try to improve the relevance and usefulness of the artefact [34], [35]. The designed appliance must correspond to a viable technological solution for solving important and relevant business problems, and its usefulness, quality, and effectiveness must be rigorously demonstrated through well-executed evaluation methods. In addition, research should provide clear and verifiable contributions, and should be based on the application of rigorous methods in its construction and evaluation process [34], [35].

In Figure 1, the research methodology DSR is outlined, that is, its different interconnected steps that synthesize the steps to be followed through the DSR in the construction of scientific IT artefacts, namely the steps of “Identify Problem & Motivate”, “Define Objectives of a Solution”, “Design & Development”, “Demonstration”, “Evaluation”, and “Communication”. These are the phases adopted in the design of this case study.

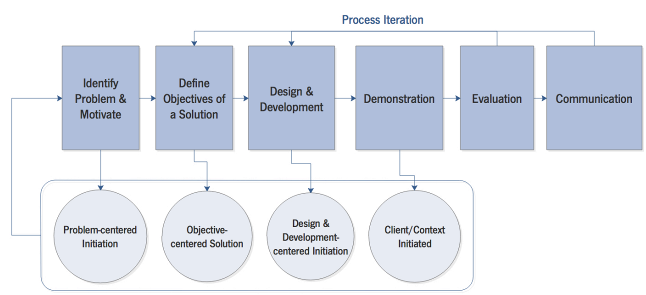

Figure 1. Schematic representation of the research methodology Design Science Research (adapted from [33]).

In short, in the first steps, the problem and the motivation are defined, as well as the objectives of the solution found. Then the artefact is designed and developed, directed to an important business problem to be solved that must be relevant to the solution of the same. Its development must follow a rigorous scientific process based on the knowledge and the theory already explored. Finally, the solution must be demonstrated, evaluated, communicated, and propagated efficiently to the target audience [31], [36].

Thus, the case study described in this manuscript follows the DSR research methodology because the IT solution defined meets the needs of health professionals of CHP, that is, a new clinical coding tool to support clinical practice assisting in their work, meeting the challenges currently existing at CHP's facilities.

Therefore, it provides the health institution with an appropriate and well-founded solution, based on methods and technologies that have already been explored and adapted to solve the problem in question, and also stimulate new knowledge for the organization and the scientific community. Thus, the development of this project additionally included the dissemination of the IT artifact to CHP's professionals, as well as the writing of scientific papers.

Finally, it is important to note that the clinical tool developed, including its update to the ICD-10-CM/PCS version, was duly evaluated through a SWOT analysis. It should also be pointed out that the application of the Proof of Concept research methodology to prove the feasibility, usefulness, and usability of the tool, which included a SWOT analysis, is briefly described in Subsection B.

B. *Proof of Concept*

The Proof of Concept research methodology consists of a practical model that can prove or validate the concept established through analysis or even technical articles. Hence, it goes on to verify whether a concept or theory is successful and feasible and, on the other hand, is thus susceptible of being exploited in a useful way [37].

Therefore, a PoC is often pointed out as one of the most important steps in the design, development, implementation, and proposal process of a prototype of a IT solution, mainly to establish if an IT solution fulfills its purpose, that is, it meets the requirements and defined objectives for which it was originally designed. On the other hand, it also allows the identification of potential failures or errors in the IT solution developed [38].

Summarizing, a PoC allows to demonstrate in practice the concepts, methodologies, and technologies involved in the elaboration of a given project and thus validate the proposed solution by proving its feasibility and usefulness for the purpose for which it is intended by defending its potential.

In this study, the defense of the viability and usefulness of the clinical coding tool for ICD-9-CM went through the application of the Proof of Concept research methodology, including its subsequent transition to the newer ICD-10-CM/PCS coding version. Thus, a SWOT analysis was carried out for the Web application.

The proof of concept of this project is briefly described in Section V of this article.

The next section presents the SPA developed and implemented for the ICD-9-CM coding version, as well as its transition to ICD-10-CM/PCS.

IV. Single-Page Application

The codification of the discharge reports was made manually in CHP, making the process too slow and with a high error probability. Therefore, it emerged the need to create a process that would reduce the codification time. Thus, it was developed a SPA through which the health professionals are able 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 where the patient was admitted.

The first version was created based on the ICD-9-CM coding version. However, there was a need to adopt a more advanced coding system, namely the ICD-10-CM/PCS codification.

A. *SPA Version 1*

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 is divided into five frames: diagnoses, external causes, procedures, tumor morphology, and observations. All the boards, with exception of the observations board, which is the only one that allows free text insertion, are composed by rows divided mainly in priority, description, and code.

The dynamic and aided search leads to a faster process than the already existing one. 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.

B. *SPA Version 2*

In the second version of the SPA, all the SPA architecture remained the same. The difference from the first version to the second was only the use of a different codification system, which consequently forced a layout change in the codification area. In this version, the codification area only presents three frames: diagnoses, procedures, and observations.

The dynamic and aided search is still present in this version.

Once the ICD-10-CM/PCS codification presents a hierarchical structure, it is easier to find a code since the order is followed, so, it was added the help button in the code insertion. When the user selects this button, it opens a new frame with dynamic search. This frame is divided into seven parts: section, body system, root operation, body part, approach, device, and qualifier. At first, all components are empty except for the component section. Since this is the root of coding, it represents the first character of the code. When the user selects a section, the body system is automatically filled with options that are related with the section selected. In turn, when the body system is selected, it automatically fills the root operation options. When the three components section, body system, and root operation are selected, a board with all the other components is filled. And after all seven parts have been selected, the code is finally complete and, thereafter, it is sent to the main frame to the row where the user clicked in the help button. It should additionally be noted that a process of validation for the code exists.

Although this second version also use MySQL as the RDBMS, the tables of the database needed to be changed in order to be able to store the new coding system.

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 [39].

With the update of the coding system for the ICD-10-CM/PCS codification, a weakness of the project was eliminated, thus, becoming a more up-to-date project. Therefore, it was made a SWOT analysis of the second version of the project.

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.

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, and its subsequent transition to the newer ICD-10-CM/PCS coding version. 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 professionals using the ICD-9-CM and ICD-10-CM/PCS clinical coding tools reported significant differences in time consumption and committed errors when using a computerized system to perform their tasks. It represents 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.

When comparing the SPA for ICD-9-CM codification with its update to the newer ICD-10-CM/PCS version, health professionals defend that the advantages are much greater, including a better specificity in describing clinical situations, leading to an improved level of detail. They also defend that it is easier to find a code in the new update due to the help bottom. Thus, they do not need to remember all the codes or their entire description, making it more intuitive.

Regarding future work, the addition of a Business Intelligence (BI) module in the clinical coding tool for ICD-10-CM/PCS is foreseen, that is, the addition of a module with clinical and performance indicators [40]. 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 health professionals at CHP.

Finally, in early 2018, the research team already began the implementation of the system in more health institutions in Portugal. It is thus confirmed our strong desire to continue to expand the system across the country due to its undeniable advantages, which were defended throughout this paper.

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