Toward a Preliminary Layered Network Model Representation of Medical Coding in Clinical Decision Support Systems

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Abstract - The aim of this research is to describe the impact of Medical Codes (MC) on building a successful Clinical Decision Support System (CDSS) that helps in structuring a beneficial Information Model, we highlight a preliminary Architectural Layered network model to assist health care givers and researchers in representing their work in a unified manner. Via a descriptive methodology, we incorporate the relationship between (MC) and (CDSS), we discussed a brief state of art of (CDSS) as well as medical coding as a process of converting descriptions of medical diagnoses and procedures into universal medical codes and numbers. Integrated with CDSS, medical codes are illustrated as an advanced search engine in the framework of Health Information System (HIS). We revealed the factual influence of health electronic information and proved the necessity of computerizing health care practices through the harmonization between the two categories of medical coding, medical classification (statistics) and nomenclatures (terminologies), and clinical decision support systems. The originality of our study is engaging medical coding and clinical decision support under cohesive scope, which was lacking for investigation. We relied on a plain case study to corroborate the ability of merging different types of medical coding in transforming health information from unstructured to richly structured data, to be used in building the medical knowledge base of the CDSS.

Keywords: Medical Coding, Clinical Decision Support System, Layered Network Model, ICD, SNOMED CT, LOINC.

1 Introduction

Many technologies were invented and implemented in the human health domain in order to avoid falling in gaps since errors in such domain are extremely difficult to be corrected. The worldwide healthcare systems are facing many challenges, including scooting costs and failure in delivering the optimal patient care due to the increase in medical errors, poor trainings to human resources and their derivatives. Many studies were done on how to computerize medical processes, especially critical decisions in medical fields, using Artificial Intelligence. From these needs, Clinical Decision Support System (CDSS) and Medical classification or medical coding gave birth after the development of the Electronic Health Record (EHR) and the Computer-based Physician Order Entry (CPOE). CDSS is the key of success of clinical information systems designed to assist health care providers in decision making during the process of care. This means that a clinician would cooperate with a CDSS to help determine diagnosis, analysis of patient data.

A significant breach exists between genuine clinical practice and optimal patient care. Several studies have shown that the quality of health care is variable and often insufficient [1, 2]. To deal with these deficiencies in providing care, healthcare institutions are gradually more depending on computer aided solutions such as clinical decision support systems (CDSS) that provide clinicians with patient-specific assessments for recommendations to aid clinical decision making [3,4].

With the increased focus on the prevention of medical errors that has previously took place, computerized physician order entry (CPOE) systems, joined with CDSS, have been proposed as a key element of systems’ approaches to improving patient safety[5,6]. If used appropriately, CDSS have the possibility to change the approach in which medicine has been taught and practiced.

The lack of standards in collecting and maintaining data has been a key barrier to electronic connectivity and transmission in healthcare [7]. Coordination between standard clinical terminologies and classifications represent a common medical language, allowing clinical data to be efficiently utilized. Therefore, standard clinical terminologies and classifications, with maps to link them, must be incorporated into EHR systems to achieve system interoperability and effective CDSS. Therefore, medical coding, closely tied in with the process of medical billing,
an important feature to the health care industry and a well-structured knowledge base that contains accurate medical codes should be highly dependable to help CDSSs deliver appreciated outcomes.

This paper is a descriptive study that aims to illustrate the impact of Medical Codes (MC) on building a successful Clinical Decision Support System (CDSS) that helps in structuring a beneficial Information Model to assist health care providers and researchers in representing their work in a unified manner. The genuineness of our study is represented by fitting medical coding and clinical decision support system under cohesive scope, which was lacking for analysis. Illustrated by a case study, our objective is validating the ability of different medical coding types in transforming health information from unstructured to richly structured data. The assimilation done between medical codes from different categories leads to represent an integrated and hierarchal layered network representation consisting of five major layers.

In the first section, we will highlight the importance of Medical Coding. While in the second section, we will go over the integration of the Medical coding with Clinical Decision Support Systems to show its impact on having successful CDSS. A brief case study will be revealed in the third section, leading to the results and discussion in the fourth section.

2 Medical Coding: Classifications and Terminologies

Medical coding is the process of converting descriptions of medical diagnoses, clinical terms, tests observations, clinical findings and procedures into universal medical codes and numbers. The diagnoses and procedures are usually taken from a variety of sources within the patient health care record, such as the transcription of the physician's notes, laboratory results, radiologic results, and other sources. There are country specific standards and international classification systems.

Medical codes are mainly divided into 2 groups: Statistical Classifications and Nomenclatures or Terminologies. A statistical classification brings together similar clinical concepts and groups them into categories (Mainly according to the medical specialty: Circulatory System, Respiratory System, Nervous system, etc...). An example of this category is the International Statistical Classification of Diseases and Related Health Problems (known as ICD). For example, the ICD 9 code of Tachycardia is 785.0. In a nomenclature, there is a separate listing and code for every clinical concept. So, in the previous example, each type and concept of the tachycardia would have its own code. This makes nomenclatures cumbersome for compiling health statistics.

Terminologies and classifications are designed for distinctly different purposes and satisfy different user data necessities. Classification systems such as ICD-9-CM, ICD-10-CM, and ICD-10-PCS group together similar diseases and procedures and organize correlated entities for effortless retrieval. They are typically used for external reporting requirements or other uses where data aggregation is beneficial, such as measuring the quality of care, monitoring resource utilization, or processing claims for reimbursement. Statistical classifications are considered “output” rather than “input” systems and are not proposed or designed for the major documentation of clinical care. Moreover, medical classifications are used for many other aspects including but not limited to conducting research, epidemiological studies, clinical trials, setting health policy, designing healthcare delivery systems, managing care and disease processes and tracking public health and risks. [9, 10, and 11]

On the other side, reference terminologies or nomenclatures such as Systematized Nomenclature of Medicine--Clinical Terms (SNOMED-CT) are “input” systems and codify the clinical information gathered in an EHR during the patient care encounter. This type of medical coding can be used for mainly getting access to complete and clear clinical data with links to medical knowledge for real-time clinical decision support. It also facilitates information exchange between providers thus fastening care delivery and minimizing replica testing and prescribing. And it can be used in retrieving information to generate expert alerts (e.g., allergy alerts, warnings of potential drug interactions or abnormal test results). In addition to that, medical terminologies grants access to standards of care for benchmarking, improving quality of care, measuring outcomes, developing and monitoring pay-for-performance programs, and measuring performance. [10, 12]

Together, standard clinical terminologies and statistical classifications represent a common medical language, allowing clinical data to be effectively utilized and shared between EHR systems. Therefore, standard clinical terminologies and classifications, with plans to link them, must be incorporated into Electronic Health Record EHR systems, that are main components of successful CDSSs, to achieve system interoperability and the benefits of a national health information infrastructure.

3 How Medical Codes employed in CDSS

“CDSSs are typically intended to integrate a medical knowledge base, patient data and an inference engine in order to generate case specific advice to health care practitioners leading to improve health related outcomes”. Some key questions to ask when considering CDSSs are “whose decisions are being supported, what information is
presented, when is it presented, and how is it presented to the user?” [13]. Osheroff et al. put forward what they call the “five rights” of Clinical Decision Support System which provides a relevant summary of what is needed for effective release: “CDSS should be designed to provide the right information to the right person in the right format through the right channel at the right time.” [14]

CDSS are mostly composed of three main parts. These parts (figure 1) are the knowledge base, the inference or reasoning engine, and a mechanism or User Interface to communicate with the user. [15] The knowledge base consists of compiled information that is regularly, but not always, in the form of if–then rules. Other types of knowledge bases might include probabilistic relations of signs and symptoms with diagnoses, or known drug – drug or drug – food interactions. The second part of the CDSS is called the inference or reasoning engine, which contains the formulas for projecting the rules or associations in the knowledge base on the live patient data. Finally, there should be a mean of communication, which is defined by a way of getting the patient data into the system and getting the output of the system to the user who will make the actual decision. Output to the clinician may come in the form of a recommendation or alert at the time of order entry, or, if the alert was triggered after the initial order was entered, systems of email and wireless notification have been employed. [16, 17] Effective, well-implemented, well-used CDSS, along with quality assurance, feedback, and human management have been flourishing in reducing errors and adverse events, improving compliance with quality measures in many organizations and assisting clinicians at the point of care [18].

Accordingly one of the most important challenges to have a successful CDSS is the right data format. CDSSs functions include searches for specific diagnostic statements and exclusive anatomical site acronym terms and/or abbreviations within any document from any medical record outcome. Such documents can consist of structured data determined by healthcare providers documenting care in an organization’s EHR system(s) or formless data driven by healthcare providers documenting care in an organization’s opposite EHR systems, such as text data generated by an organization’s Dictation / Transcription / Speech Recognition (Voice / Text / Speech) systems. Such functions also include identifying both ICD-9-CM (the International Classification of Diseases, Ninth Revision, Clinical Modification) and/or ICD-10-CM/PCS (Procedure Coding Systems) obtainable on admission, principal, and secondary diagnoses and procedures for hospital inpatient documents, CPT-4 principal and secondary procedures for outpatient documents, and even nomenclature codes, such as SNOMED-CT, LOINC and RxNorm, for clinical, laboratory and pharmaceutical documents, respectively. [19] Linking the resulting, selected medical code(s) back to the source documentation supporting the code selection is important for providing full traceability. In addition, being able to have code suggestions occur at the point-of-care, as documentation is entered into the record, is remarkable. For instance, there were thousands of medication items from the NDC (National Drug Code) directory added to the medication table and over 68,000 problem items (derived primarily from ICD-10-CM) added to the problem table. The network model of the working database structure (figure 2) coupled with a database model are constructed to simplify data query, each item in the medication data dictionary and each item in the problem data dictionary are connected by a common key attribute, an indication. In medical field, the National Cancer Institute (NCI) defined an indication as “a sign, symptom, or medical condition that leads to the recommendation of a clinical treatment, a laboratory test, or a treating procedure”.

![Figure 1: Architecture components of CDSS.](image1)

Each medication can be linked with its associated indications that can be represented as a group of relevant clinical problems. [20] Every single problem/diagnosis item in the problem table can be traced to a unique ICD-10-CM code and every single medication item in the medication table can be traced to a unique drug number RxN. Therefore, each ordered medication can be easily mapped by computer algorithm to one or more clinical problem(s) using recognized medication prescribing standards. This tracing methodology facilitates building and maintaining medical knowledge management (knowledge base in figure 1) and speeds up clinical decision support systems since it positively affects knowledge, decision support and information delivery axes that represent the main structural components of CDSSs.

![Figure 2: Sample network model](image2)
4 Case study

In this clinical case study, we will demonstrate how we can benefit from mixing between the two types of medical coding in enriching our medical knowledge base to be used in CDSS. We will make use two statistical classification coding methods that are ICD 10 and LOINC, in addition to SNOMED CT terminology. As per the International Health Terminology Standards Development Organization (IHTSDO), SNOMED CT owner and distributor, SNOMED CT wide-ranging coverage includes: clinical findings, symptoms, diagnoses, procedures, body structures, organisms and other etiologies, substances, pharmaceuticals, devices and specimen. Similarly, the World Health Organization (WHO) enlarged ICD 10 to contain codes for diseases, signs and symptoms, abnormal findings, complaints, social circumstances, and external causes of injury or diseases. Likewise, and since its initiation by the American Clinical Laboratory Association (ACLA) and the College of American Pathologists (CAP), LOINC database has prolonged to take account of not just medical and laboratory code names, but: nursing diagnosis, nursing interventions, outcomes classification, and patient care data set as well.

Let us take the following sample physician note:

<< Mr. John Smith is a 27 years old male, with history of Dyslipidemia, came to the emergency department suffering of abdominal pain in the right lower quadrant. CT scan for abdomen and pelvis with IV contrast was performed. Patient was admitted to the hospital with Inflammatory Bowel Disease as admitting diagnosis. Colonoscopy with biopsy of colon was done showing ascending colon ulcer. After 24 hours, patient was discharged home, in a stable condition, on Lipanthyl 200mg one tab daily, according to Dyslipidemia medication review, and Flagyl 500 mgs two tabs daily for 5 days. >>

From the above scenario, and in just using 3 medical coding categories SNOMED CT, ICD 10 and LOINC, we can get up to 59 different medical code derived from the medical terms written by the physician. The below tables of codes have been extracted using three main medical coding categories SNOMED CT (Figure 3.a), ICD 10 (Figure 3.b) and LOINC (Figure 3.c) for clinical terminologies, statistical classification and laboratory terms respectively.
5 Results and discussion

From the previously illustrated examples, we can conclude that as we increment the number of medical coding methods (from both medical coding classes), in the process to medical coding, as we will be able to extract more codes from unstructured data and subsequently structuring most of the formless data. In such a way, we will be able to enrich and enlarge the knowledge base used in clinical decision support systems.

As a result, the assimilation done between medical codes from different categories leads us to a depth and breadth network model (figure 4) which in terms represents an integrated and hierachal layered network representation consisting of five major layers as follows: 1- Medical Coding Types, 2- Categories Coded, 3- Subcategories Coded, 4- Medical Terms Coded and 5- Protocols / Rules / Guidelines / Events ….The first layer represents the set of medical coding types from different categories to be merged (SNOMED CT, ICD 10, LOINC, etc…). Where the second layer stands for the set categories or classes to be coded using the coding types from the first layer (Findings, Body Structure, Diagnosis, Laboratory test, etc…). While the subcategories of the previously listed set of categories (in layer number 2) will fall in the third layer (for Laboratory tests: Pathology, Hematology, Bacteriology, Chemistry, etc…). Nevertheless, the fourth layer will correspond to the coded medical terms of each subcategory listed in the preceding layer (for Chemistry Subcategory: CBC, Chem10, RBC, etc…). Finally, to end with the set of Protocols / Rules / Guidelines / Events … in the fifth layer (if SC1=x and a=Y then Run [1, 2 and 3]).

These outcomes (Protocols / Rules / Guidelines / Events) generated within the fifth layer in our model represent the core assets in any knowledge based Clinical Decision Support System. Therefore, the more we have coded terminologies from unstructured health related information the more we can resourcefully influence the knowledge, the decision support and the information delivery axes that stand for the key structural components of CDSSs. Where if we use coded information, building and managing medical knowledge base will be easier, the Reasoning Method will speed up and the CDSS response time will be faster at the point of care.

6 Conclusion

The inclusion of clinical terminologies into electronic health record systems is a significant step in the creation of information systems capable of monitoring quality and leading the practice of evidence-based medicine. A standard clinical terminology provides standardization of clinical terms, thus supporting easy transmission of patient data across information systems. But the optimal value of the health information contained in an EHR system will only be grasped if both statistical classification and nomenclatures involved in the plan are up to date and accurately reflect the current practice of medicine. Together, standard clinical terminologies and classifications represent a common
medical language that allows clinical data to be shared between EHR systems. Therefore, standard clinical terminologies and classifications, with plans linking them, must be suited into EHR systems in order to attain system interoperability and fully benefit from CDSS, and that was discussed in the first two sections of our study. In the third and fourth sections, we revealed a case study to back up the capability of amalgamating different types of medical coding in renovating health information from unstructured to abundantly structured data, to be used in building the medical knowledge base of the CDSS. In the last section and after the harmonized combination done between medical codes from different categories, we architected an integrated and hierarchical five layered network model. This model showed that the breadth and depth of both terminology and classification permit faster, reliable, and consistent retrieval of strong clinical information based on flexible queries in order to be used in enriching the medical knowledge base that symbolizes the core asset in any CDSS. Finally, this synchronization between medical coding (Statistical Classifications and Terminologies) and clinical decision support systems let healthcare institutions unchain the real power of health electronic information.

7 References