Construction of a semi-automated ICD-10 coding help system to optimize medical and economic coding

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Abstract. Introduction **:** In order to measure the medical activity in hospitals, physicians are required to code manually information concerning a patient's stay using ICD-10. This requires trained staff and a lot of time. We propose to help speed up and facilitate the tedious task of coding patient information. Methods: we show two methods. First, we propose an automated ICD-10-based coding help system using an automated MeSH-based indexing system and a mapping between MeSH and ICD-10 extracted from the UMLS metathesaurus. Secondly, we propose the use of drug prescriptions to complete the previous coding with the use of a mapping between a given prescription drug and the relevant ICD-10 codes (in compliance with the drug approval). Results **:** the results of a preliminary experiment indicate that the precision of the indexing system is 40% and the recall is 30% when we compare to an economic rules-based coding and to a descriptive coding. Discussion: moreover, we show that the use of prescription coding is relevant as the recall reaches 68% when the Vidal tool is used. Conclusion **:** Then, it is very interesting to complete the coding obtained automatically by the indexing/mapping system by the coding obtained from the prescriptions.
Keywords: Abstracting and indexing; ICD-10; MeSH; computerized Medical records systems.

1. Introduction

The PMSI (French equivalent to The Medicare Prospective Payment System (PPS)) was introduced by the French government in 1996, as a way to change hospital practice through financial incentives that encourage more cost-efficient management of medical care [1]. Each patient's stay is classified into a GHS (French equivalent to a Diagnosis Related Group (DRG)) [2] according to information documented by the physician in the Medical Record : diagnoses, Complications and Comorbidities, healthcare procedures etc…The hospital is paid a relative cost for the GHS.

Moreover information from a patient's stay are coded to allow an automatic processing. The nomenclatures are the International Classification of Diseases (ICD-10) [3] to code diagnosis and the Healthcare Common Procedure Coding System (HCPCS) to code healthcare procedures. These codes constitute the medical and economic coding of patients medical records. The coding process is extremely important, coding an

incorrect principal diagnosis or failing to code a significant secondary diagnosis can have a substantial impact on reimbursement for the hospital

Physicians are required to perform the coding manually or with the help of a navigation tool within a nomenclature or of a lexical research tool [4]. This requires trained staff with a good knowledge of the economic coding rules and of the classification used to code. As a result, coding is a time consuming activity and must be performed together with patient care that is and should remain a priority for medical staff.

In the framework of a French project, VUMeF [5], we built a semi-automated ICD-10 coding help system to code medical records in ICD-10. Physicians writing their patient record can use this tool to obtain a preliminary coding of the record. Then they can validate or specify some of the ICD-10 codes recommended. It will help reducing coding time and training time.

2. Material and Methods

2.1. An automated MeSH-based indexing system

The objective of this work is to extract the relevant diagnosis codes from an unstructured free text document namely a hospital summary report. Because an automated ICD-10-based indexing tool doesn't exist, less direct solutions have been developed using an indexing system based on a different terminology and a mapping to ICD-10 [6]. Then, we choose to use an automated MeSH-based indexing system developed in our laboratory [7].

MeSH (Medical Subject Headings) is the controlled vocabulary used by NLM to index articles from biomedical journals for the MEDLINE/PubMED® database. The French version of the thesaurus includes 22,995 terms and 61,000 synonyms (among which 4,000 were added by CISMeF), in its 2005 version. MeSH descriptors are organized in 15 thematic trees (e.g.: anatomic terms).

The indexing system can find textual elements referring to MeSH terms in a medical record. Then it allocates a score depending on the text length and the frequency of each term to each MeSH terms extracted. This score is called indexing score.

2.2. A mapping between MeSH and ICD-10

The mapping between MeSH and ICD-10 provides a list of ICD-10 terms from a list of MeSH terms supposed to be equivalent. This mapping was extracted from the UMLS metathesaurus (Unified Medical Language System) [3] which clusterizes more than 100 medical controlled vocabularies and classifications (MeSH, SNOMED, ICD-10…). It provides links between several vocabularies : some codes have the same concept unic identifier (CUI) in the two classifications (e.g : the MeSH term "Abdomen, acute" is mapped to the ICD-10 term "Acute abdomen" as they have the same CUI C0000727 in UMLS).

The goal of the ICD-10 classification is to make up the list of all the diagnoses. It's a five level hierarchy. On the first level ICD-10 contains 21 sections representing all the morbidities classified by functional apparatus and associated to a letter (e.g : E : Endocrine, nutritional, and metabolic disease). Each section is divided into groups, themselves divided into subgroups containing all the ICD codes in 3-character

categories and 4-character categories. The classification contains more than 18,000 alphanumerical codes and about 50,000 terms.

Our mapping contains 4,801 mapped terms among which 1598 distinct pairs MeSH CODE - ICD-10 CODE (a MeSH term and its synonyms are assigned the same MeSH code).

2.3. Taking drug prescriptions into consideration

A tool developed by Le Vidal company provides a mapping between a given drug prescription and the relevant ICD-10 codes (according to the drug approval). We used this mapping to determine the ICD-10 coding from the drug prescription.

Among all the relevant ICD-10 codes for each prescription drug, only a few codes correspond to the diagnosis contained in the summary report. We also proposed an ordering by relevancy score based on two ideas.

- the first idea is that if a large number of prescription drugs have for indication a same ICD-10 code, this code should probably be extracted by our system.

- the second idea is if this code is often coded by physicians, this code is more likely to be extracted. Therefore, we use the ICD-10's prevalence in the Rouen University Hospital. Formula [1] takes these parameters into account in the score calculation :

$$\text{Prescription Score } (C_{\text{ICD-10}}) = (\frac{x-1}{N} + \frac{p}{N}) * 100 \qquad [1]$$

$C_{\text{ICD-10}}$ *: a given ICD-10 code; x : number of prescription drugs that have $C_{\text{ICD-10}}$ as an indication; p : Prevalence (=frequency) of $C_{\text{ICD-10}}$ at the Rouen University Hospital; N : Number of drugs in the prescription.*

The higher the score the more likely a diagnosis is a diagnosis actually treated with the prescription and its code have to be coded for this hospital summary report.

2.4. Evaluation

2.4.1. Two evaluations

ICD-10 code	Indexing Score
J45.9	66,76
J46	33,33
O60	0,05
L50.5	0,00

Table 1. *Sample prescription coding of a summary report*

ICD-10 code	Prescription+indexing Score
R06.0	100
J44.9	73,85
J45.9	66,77
B44.9	25,42
O60	0,05
L50.5	0,00

Table 2. *Sample added coding of the same summary report*

Two evaluations have been carried out. First, we evaluated the coding provided by our system indexing/mapping (see table1). The automated coding was compared to two manual codings : a priori and a posteriori. First, we compare the coding which is a descriptive coding to an economic and medical coding which is the effective coding made by the physicians after having written the patient record (MC1). Secondly, we

compared the automated coding to another descriptive coding which is a re-evaluation of the automatic coding made a posteriori by a medical coding expert (MC2).

Secondly, we evaluated the coding of our system indexing/mapping taking drug prescriptions into consideration with the same references. Table 2 shows that we completed the list of ICD-10 codes extracted by our system with the ICD-10 codes found with the drug prescription. For each ICD-10 score we added the indexing score and the prescription score. We have considered that these scores have the same weight (each with a maximum of 100).

2.4.2. The corpus of Hospital Summary reports

A sample of 100 hospital summary reports written by physicians in the precedent year were used for this evaluation. 50 reports come from the cardiology service of the Hospital and 50 from the pneumology service. This choice was driven by the areas of expertise of the medical coding expert. They have been extracted through the electronic health record system of the Rouen University Hospital (1.080.384 patients and 182.808 summary reports in 2005). A hospital summary report details the disease history, the healthcare procedures and the drug prescription.

2.4.3. Evaluation methodology

We computed the precision and the recall for each coding comparison (automatic vs effective and automatic vs. re-evaluated) [8]. Precision and recall are the usual measures used in information science. Precision is the ratio of the number of relevant records retrieved (codes extracted by our system and by the reference) over the total number of irrelevant and relevant records retrieved (codes extracted by our system). Recall is the ratio of the number of relevant records retrieved over the total number of relevant records in the database (codes extracted by the reference). We have calculated precision and recall using the related codes (codes sharing the same parent in the ICD-10 hierarchy ex: A10.0 and A10.1 ; A10-A19 and A11). Taking these codes into consideration allows to determine the coding close proximity to the reference coding.

3. Results

We show in the two tables the results of the comparison between the automated coding to MC1 and MC2 before and after taking drug prescriptions into consideration.
The first table (Table 3) shows that our automated coding system as described in section 2.1 and 2.2 provides a precision of 43% and a recall of 30% if compared to MC1 and a precision of 38% and a recall of 30% compared to MC2. Our system is able to extract only a third of the reference codes which constitute themselves only a third of the automatic coding when we only take into consideration the coding performed by our system indexing/mapping.
Table 4 shows that the contribution of the ICD-10 codes extracted from the drug prescriptions as described in section 2.3 results in a precision of 5% and a recall of 61% if compared to MC1 and a precision of 4% and a recall of 68% compared to MC2. Thus we determine 61% of the economic and medical codes and 68% of the descriptive codes that should be coded for these summary reports.

Measures	Economic and medical coding (MC1)	Descriptive coding (MC2)
Precision	0.43	0.38
Recall	0.30	0.30

Table 3. *Results of the evaluation provided by our system indexing/mapping in comparison with the 2 references (MC1 and MC2)*

Measures	Economic and medical coding (MC1)	Descriptive coding (MC2)
Precision	0.05	0.04
Recall	0.61	0.68

Table 4. *Results of the evaluation provided by our system indexing/mapping taking drug prescriptions into consideration in comparison with the 2 references (MC1 and MC2)*

4. Discussion

4.1. System performance

The evaluations show in terms of recall that it is very interesting to take the prescriptions into consideration to code in ICD-10 the patient's stay as table 2 indicates that the contribution of the ICD10-codes extracted from the drug prescriptions results in significant increase of the recall of the summary reports coding. Unfortunately, only a less than 5% of the coding obtained in this case corresponds to the reference coding. Precision is very low as too many codes are presented to the physician (an average of 375 per report) compared to the number of ICD-10 codes coded by the expert (4). A possible explanation is that 29% of the prescription drugs are prescribed for an indication that is not indexed in the drug approval [9]. We have tested a method introducing a threshold (0, 5, 10 and 20) : if a ICD-10 code score is lower than the threshold, the code is not considered in the evaluation (not shown in this article). But we have not demonstrated that the noise decreases as the threshold increases. The results show that this automatic coding system needs several improvements to reduce the number of codes extracted and to allow an utilization in Hospitals.

4.2. Comparison to other systems

The results are encouraging as a similar work using SNOMED instead of the MeSH with the SNOCODE tool (MedSight Informatique Inc, 99) [6]. The SNOCODE tool provides a precision of 25% compared to MC1 and MC2 and a recall of 46% compared to MC1 (vs.61% for our system) and 46% compared to MC2 (vs. 68% for our system).

4.3. Indexing and mapping

Many factors have an influence on our system's performances. First of all, the indexing system provides a precision of 50% [7]. The MeSH/ICD-10 mapping is limited to 8% of the ICD-10 classification codes in contrast with physicians that can code with the whole classification. This limitation is due to the differences of structuration and goal of the classifications that provide a loss of information in the mapping. Nonetheless,

among the 1,000 ICD-10 codes most frequently coded in the Rouen Hospital, 53.5% are mapped into MeSH codes and belong to our MeSH/ICD-10 mapping.

Moreover, the wording of the reports can affect the results. Indeed, medical records are made to describe a patient's stay and enable the care continuity of the patient in contrast with the budgetary objective to measure the medical activity in hospitals. The education of the physicians (knowledge of the economic coding rules and of the classification used to code) can also affect the results.

4.4. Perspectives

We will proceed with the development of an automated SNOMED indexing system. With a mapping between SNOMED and ICD-10, it will provide an ICD-10 coding of summary reports. SNOMED International, the Systematized NOmenclature of MEDicine [9] is a terminology elaborated to index precisely medical records as SNOMED can describe diagnosis and healthcare procedures. To extend our work, we contemplate adding HCPCS coding to our tool, as a mapping between MeSH and HCPCS is being developed.

5. Conclusion

This evaluation study shows that our two approaches are complementary. Then, it is very interesting to complete the coding obtained automatically by the indexing/mapping system by the coding obtained from the prescriptions.

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