ORIGINAL REPORT

Developing SNOMED-CT for Decision Making and Data Gathering: A Software Prototype for Low Back Pain

Radin Maheronnaghsh[1], Saeed Nezareh[2], Mohammad-Kazem Sayyah[1], and Vafa Rahimi-Movaghar[1,3]

[1] Sina Trauma and Surgery Research Center, Tehran University of Medical Sciences, Tehran, Iran

[2] Digital Preservation Laboratory in Central Library, Tehran, Iran

[3] Department of Neurosurgery, Shariati Hospital, Tehran University of Medical Sciences, Tehran, Iran

Received: 7 Sep. 2012; Received in revised form: 5 Jan. 2013; Accepted: 23 Feb. 2013

Abstract- The issue of medical errors is currently a global concern which places a heavy financial and emotional burden on communities. A clinical decision support system (CDSS) is an electronic system designed to support clinical decision making. Considering the increasing importance and use of Systematized Nomenclature of Medicine-Clinical Terms (SNOMED-CT), we developed SNOMED-CT to implement it more efficiently in making smart history taking, decisions to perform lab tests and imaging, diagnosis and recommendations. To evaluate these capabilities in real clinical problems, a new CDSS was compiled, aimed at supporting decisions on patients with a chief complaint of low back pain (LBP). A number of LBP differential diagnoses as well as some recommended indications and contraindications published by guidelines, were inputted to the database. Future software based on this model would help physicians to do necessary assessments and recommendations and might improve patients' safety.

Acta Medica Iranica, 2013; 51(8): 548-553.

Keywords: Clinical decision support system; Diagnostic decision support system, Low back pain; Systematized Nomenclature of Medicine-Clinical Terms

Introduction

The issue of medical errors is currently a global concern. In one study, Weingart *et al.* demonstrated that medical errors are responsible for 44,000-98,000 preventable deaths each year (1). Additionally, a follow-up study by Institute of Medicine (IOM) showed that medication and prescription errors were the most important kinds of medical errors till 2006, to the extent that 40,000 preventable medication errors occur in hospitals each year. The number might be 530,000 in outpatient care and 800,000 in long term care (2). A summary of medical errors and their classification is given in table 1 (3).

Clinical decision support system (CDSS) is an electronic system designed for supporting clinical decision making which offers essential assessments and recommendations to physicians based on patient information (4). Regarding the enormous cost of medical errors, these systems are cited as an appropriate solution to improve patients' safety (5). To design an efficient decision support system, it is inevitable to use a standard model for categorizing health care data and terminology and relating these data to each other. Systematized Nomenclature of Medicine-Clinical Terms (SNOMED-CT) is a comprehensive computer processable collection of medical terms providing codes, terms, synonyms and definitions covering diseases, findings, procedures, microorganisms, substances, etc. (6). Rules derived from SNOMED-CT would provide the opportunity of arriving at more responsive and complicated decision support systems (7).

One important limitation of SNOMED-CT-based software is lack of learning. The problem is studied in detail by Ciolko *et al.* (8). Moreover, the mere addition of machine learning capabilities would not entirely solve the deficit, as this method has its own shortcomings. For instance, machine learning algorithms need a lot of examples to work effectively. Besides, predicting what has been learnt by a computer is not always straightforward (9). Consequently, the accuracy of what is presented by computer would be dependent on previous actions of the operator. To overcome the limitations of machine learning and simultaneously

Corresponding Author: Vafa Rahimi-Movaghar
Department of Neurosurgery, Sina Trauma and Surgery Research Center, Tehran University of Medical Sciences, Tehran, Iran
Tel: +98 915 3422682, Fax: +98 21 66757009, E-mail: v_rahimi@sina.tums.ac.ir

retain capabilities of SNOMED-CT in the field of data registration and decision support, we added some new features to SNOMED-CT and implemented it in a new CDSS. To evaluate these capabilities in real clinical problems, the application was compiled, aimed at supporting decisions on patients with chief complaint of low back pain (LBP).

Table 1. Classification of preventable adverse events in primary care.

Diagnosis
Related to symptoms
Misdiagnosis
Missed diagnosis
Delayed diagnosis
Related to prevention
Misdiagnosis
Missed diagnosis
Delayed diagnosis
Treatment
Drug
Incorrect drug
Incorrect dose
Delayed administration
Omitted administration
Non-drug
Inappropriate
Delayed
Omitted
Procedural complication
Preventive services
Inappropriate
Delayed
Omitted
Procedural complication

Materials and Methods

We studied the technical and user guide of SNOMED-CT (published in January 2012) to extract the infrastructure of this model. Subsequently some new features were added to this thesaurus. A number of LBP differential diagnoses as well as some recommended indications and contraindications published by LBP guidelines, were inputted to the database. Software codes were written in C# 4.0 programming language. The database was designed using Microsoft Office Visio 2010 and was implemented using SQL Express in Visual Studio 2010.

Results

The core database design of SNOMED-CT is shown in figure 1 (6). To preserve its usability, the main design was retained but two new features, namely “value” and “concept type”, were added with the aim of speeding up information retrieval and processing. The core design is compromised of the following parts:

1. Concept
2. Concept type
3. Relation type
4. Value
5. Concept collection

Concept

Concept is a meaningful term which is used in health care. It has a unique identifier (ID) which never changes. “Low back pain”, “disk herniation” and “methocarbamol” are all examples of concept.

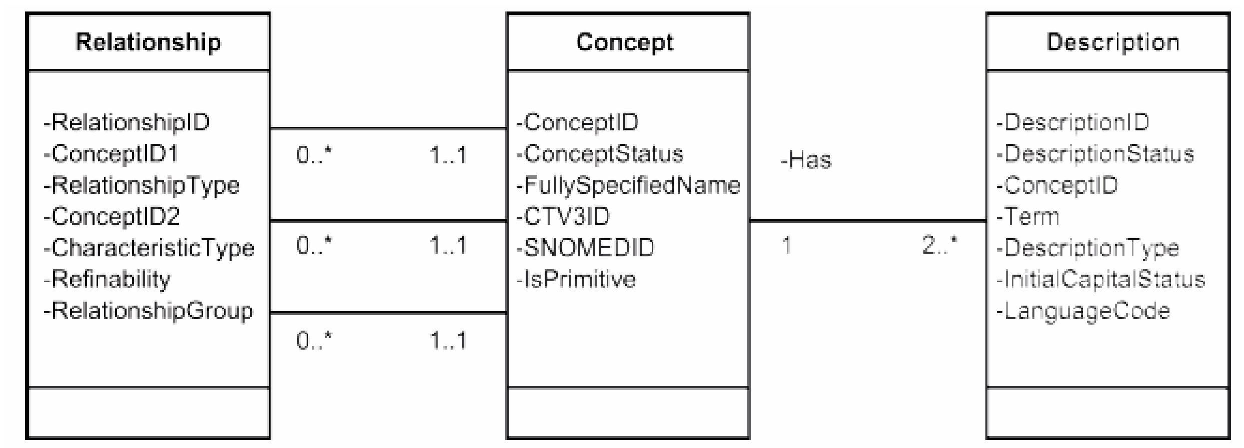

Figure 1. SNOMED-CT database design.

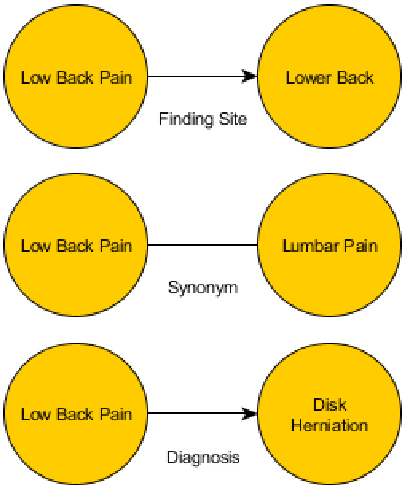

Figure 2. Relation types.

Concept type

Concept type is a term for categorizing concepts based on their clinical usage. For instance, “sign/symptom” is the concept type of “low back pain” and “disease/disorder” is the concept type of “disk herniation”. By adding this method of classification to the one already in use in SNOMED-CT (which is hierarchical), it would be possible to speed up data retrieval from database.

Relation type

Every concept could have meaningful relations with other ones. There would be two general types of relations, diagnostic and non-diagnostic. Diagnostic relations show that a factor such as a symptom would change the probability of a specific differential diagnosis. For example “low back pain” would increase the probability of “disk herniation”. Non-diagnostic relations describe a specific concept in more detail. For instance “lower back” describes the location of “low back pain”, or “lumbar pain” is the synonym of “low back pain” (Figure 2).

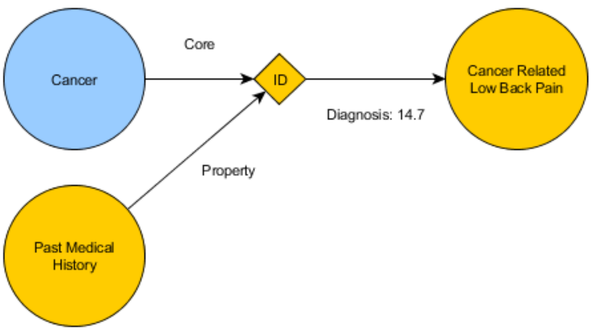

Figure 3. Relation and value.

Value

Each relation could be given a value which demonstrates the degree to which the relationship between two concepts is potent. There are two approaches to assign a value:

1. Subjective: Here, the assigned values (which are between one to five) are qualitatively significant, with number one indicating no remarkable relation and number 5 indicating deterministic relation. For instance “fecal incontinence” in a patient with LBP as chief complaint would be suggestive for “cauda equina syndrome”. The subjective value for this relation would be 4 or 5.
2. Objective: Here, the values are compiled through a statistical analysis to obtain likelihood ratio (LR) between two concepts. For instance, the analysis of patient’s data showed that the positive LR between past medical history of malignancy and a malignancy as etiology of LBP is 14.7 (10). It means that a history of cancer makes it 14.7 times more likely that the present LBP is due to an existing malignancy (Figure 3).

Concept collection

By relating a collection of concepts to a specific ID, it would be possible to establish a relation among group of concepts. Relationship could thus be defined in two levels, namely simple and complex. So we would generally assert that low back pain and disk herniation are diagnostically related (Figure 4).

It is obvious that the data would be rendered useless if details are overlooked. Hence a detailed level of presentation of information would be essential. The core concept here is “low back pain”, as we are going to describe the details of this symptom. The core concept along with its details is connected to an ID, the whole of which will connect to the desired condition or disease. Figure 5 shows the diagram of a patient with a progressive low back pain, relieved by bending forward which is diagnostically related to spinal stenosis.

With the general features of the model enumerated above, we now can proceed to its application in clinical practice. Here we explain how to use this model to implement clinical indications.

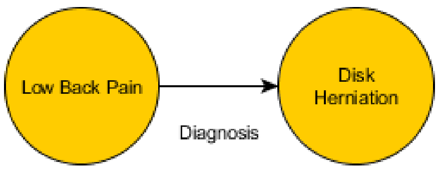

Figure 4. Simple relation.

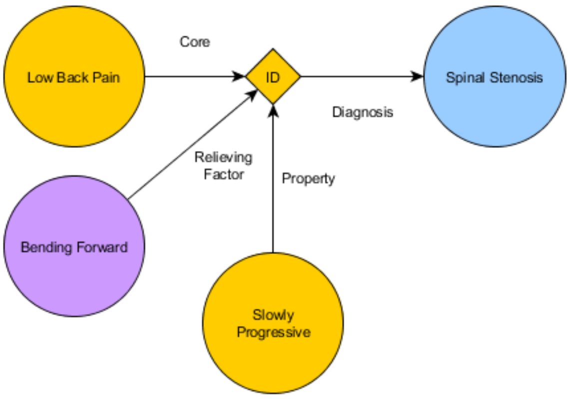

Figure 5. Complex relation.

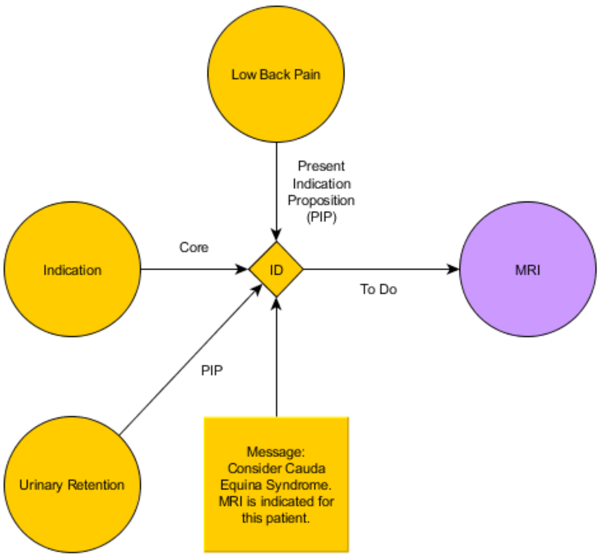

Figure 6. Implementing a clinical indication.

Clinical indications

Using this model, it would be possible to easily store all simple and complicated propositions of a clinical indication in the database. The software would then recommend the best next step for a specific patient, based on the model discussed above. For instance, magnetic resonance imaging (MRI) of spinal cord is necessary for a patient who is suffering from LBP and simultaneously has urinary retention because such a patient should be screened for cauda equina syndrome (11). In such cases, indication propositions are connected to an ID and the collection then gets related to the desired treatments or recommendations. Moreover, it is possible to display a message for the physician with respect to the indication (Figure 6). Based on this model when a patient has all of the necessary propositions for a specific indication, which is connected by “present indication proposition” relation to an ID, the software would deduce that a specific intervention, which is connected by “To Do” relation to that ID, is essential for the patient. A similar structure could be used for contraindications, screening and immunization.

Now we can see how this software would work. When LBP as chief complaint is entered to the system, based on the relations of LBP to diseases in the database, a form will be generated to gather more data related to differential diagnoses (Figure 7). The picture below displays that in a patient with LBP and fecal incontinence, MRI should be alerted to the physician. Moreover, the right column of the page is asking the physician to elaborate LBP for better decision making. Other parts of history taking such as past medical history, drug history, paraclinic, etc. are also implemented as the same format which is shown in figure 7.

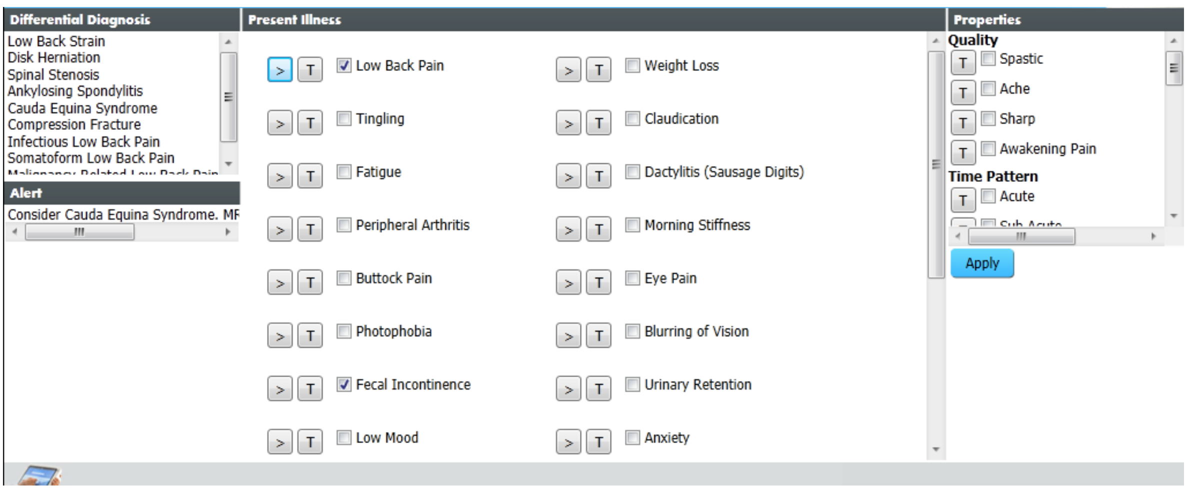

Figure 7. Final software.

Discussion

"Concept" and "relation" have been appropriately used in the design of SNOMED-CT. The structure, however, is a classification of health related information (6). To support decision making, it is imperative that meaningful relationships are established between concepts. For instance, we would have the concept "fever" in SNOMED-CT but as it is mere classification, information such as what conditions are accompanied by fever and what will the indications and contraindications be if fever is accompanied by other symptoms are not defined. As another example, "straight leg rising" (SLR) and "disk herniation" are both incorporated in the database of SNOMED-CT without any defined meaningful clinical relationship between them. In the newly developed database, on the other hand, SLR and disk herniation would be diagnostically related.

In addition to decision support, history taking and structured data entry (SDE) is another important function of the newly developed software and model. In contrast to the original SNOMED-CT, here all signs, symptoms and diseases are related to one another and when the chief complaint of the patient is entered as input, all of the questions which should be asked from the patient and all of the differential diagnoses are called from database and displayed in real time. This method of history taking is much faster than traditional data gathering and besides, it is much less susceptible to miss critical data. So the new capabilities of this model and the software which is developed based on it would be summarized in this manner:

1- The system uses the existing database of the original SNOMED-CT and there is no need for the health related information to be collected and classified again.
2- It incorporates smart history taking, SDE and decision making: patients' information including paraclinic results , orders, notes, etc. would be registered by a smart-phone, laptop, desktop personal computer (PC) or a personal digital assistance (PDA) and can be displayed, edited and used by health care workers, if necessary. Through using standard databases such as that of SNOMED-CT and the establishment of meaningful relationships between concepts, we can arrive at a system of valid and reliable data recording. This system would, through meaningful relationships, provide doctors with packages of recommendations and thus contribute to better recording of information and diagnosis, and reduction of medical errors. Such a system with respect to its function in clinical practice would be complaint-oriented. In other words, when chief complaint is entered to the system as input, a form is automatically generated by the software. Because the information needed by the physician is already in the database, the doctor could just select concepts and there is no need for typing the patient's history into the system. Indeed speed and accuracy will be both dramatically improved.
3- All possible differential diagnoses based on the available relations in the database will be presented.
4- Diagnostic indications and contraindications based on patient's conditions will be accessible.
5- The training aspect of this software should also be considered. A medical student would use the system discussed above to, for instance, study differential diagnoses in a patient with low back pain, low grade fever and negative medical history of malignancy.
6- Since the model presented here has a conceptual structure (as SNOMED-CT does), patients' information registered based on it, could be easily used for epidemiological and statistical purposes.

Compared to machine learning techniques, the most important limitation of the system described here is the cost and time consumed for establishing meaningful relations between concepts in the first version of the database. There will also be costs for updating those relations and values. Further evaluations of this new CDSS and its information model are needed to assess its capabilities and limitations.

The CDSS and model discussed above would enable physicians to simultaneously take advantage of capabilities of SNOMED-CT and decision support system. Among advantages attributable to this new approach, several points can be cited: ability to update health care information such as medical guidelines, indications and contraindications, smart and accurate data gathering, medical training and absence of necessity for designing a whole new classification of health care information and terminology.

Acknowledgment

This work was supported by Sina Trauma and Surgery Research Centre, Tehran University of Medical Sciences (TUMS). The authors would like to thank all colleagues and students who contributed to this study. We are grateful to Hassanbake Maheronnaghsh for his collaboration during developing the software, and to Reihaneh Yousefi, who assisted us with data gathering for low back pain.

References

1. Weingart SN, Wilson RM, Gibberd RW, Harrison B. Epidemiology of medical error. BMJ 2000;320(7237):774-7.
2. Office of News and Public Information News from the National Academies, National Academy of Sciences Medication errors injure 1.5 million people and cost billions of dollars annually: Report offers comprehensive strategies for reducing drug-related mistakes. 2006. Available from: www8.nationalacademies.org/onpinews/newsitem.aspx?RecordID=11623.
3. Elder NC, Dovey SM. Classification of medical errors and preventable adverse events in primary care: a synthesis of the literature. J Fam Pract 2002;51(11):927-32.
4. Kawamoto K, Houlihan CA, Balas EA, Lobach DF. Improving clinical practice using clinical decision support systems: a systematic review of trials to identify features critical to success. BMJ 2005;330(7494):765.
5. Bright TJ, Wong A, Dhurjati R, Bristow E, Bastian L, Coeytaux RR, et al. Effect of Clinical Decision-Support Systems: A Systematic Review. Ann Intern Med 2012;157(1):29-43.
6. SNOMED CT User Guide. The International Health Terminology Standards Development Organisation (IHTSDO). 2012; Available from: http://ihtsdo.org/fileadmin/user_upload/doc/ug/index.html.
7. Elevitch FR. SNOMED CT: electronic health record enhances anesthesia patient safety. AANA J 2005;73(5):361-6.
8. Ciolko E, Lu F, Joshi A. Intelligent clinical decision support systems based on SNOMED CT. Conference proceedings : Annual International Conference of the IEEE Engineering in Medicine and Biology Society IEEE Engineering in Medicine and Biology Society Conference 2010:6781-4.
9. Hoffmann AG. General Limitations on Machine Learning. European Conference on Articial Intelligence 1990:345-7.
10. Deyo RA, Diehl AK. Cancer as a cause of back pain: frequency, clinical presentation, and diagnostic strategies. J Gen Intern Med 1988;3(3):230-8.
11. Chou R, Qaseem A, Snow V, Casey D, Cross JT, Jr., Shekelle P, et al. Diagnosis and treatment of low back pain: a joint clinical practice guideline from the American College of Physicians and the American PainSociety. Ann Intern Med 2007;147(7):478-91.