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Facilitating pre-operative assessment guidelines representation using SNOMED CT

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ABSTRACT

Objective: To investigate whether SNOMED CT covers the terms used in pre-operative assessment guidelines, and if necessary, how the measured content coverage can be improved.

Pre-operative assessment guidelines were retrieved from the websites of (inter)national anesthesia-related societies. The recommendations in the guidelines were rewritten to "IF condition THEN action" statements to facilitate data extraction. Terms were extracted from the IF–THEN statements and mapped to SNOMED CT. Content coverage was measured by using three scores: no match, partial match and complete match. Non-covered concepts were evaluated against the SNOMED CT editorial documentation.

Results: From 6 guidelines, 133 terms were extracted, of which 71% ($n = 94$) completely matched with SNOMED CT concepts. Disregarding the vague concepts in the included guidelines SNOMED CT's content coverage was 89%. Of the 39 non-completely covered concepts, 69% violated at least one of SNOMED CT's editorial principles or rules. These concepts were categorized based on four categories: non-reproducibility, classification-derived phrases, numeric ranges, and procedures categorized by complexity.

Conclusion: Guidelines include vague terms that cannot be well supported by terminological systems thereby hampering guideline-based decision support systems. This vagueness reduces the content coverage of SNOMED CT in representing concepts used in the pre-operative assessment guidelines. Formalization of the guidelines using SNOMED CT is feasible but to optimize this, first the vagueness of some guideline concepts should be resolved and a few currently missing but relevant concepts should be added to SNOMED CT.

1. Introduction

Clinical guidelines are effective tools to reduce practice variation and improve the quality of care [1,2] by summarizing and describing best practices for specific patient conditions. However, guidelines are frequently developed and implemented on paper. This reduces their availability at the point of care [3]. Paper-based guidelines require physicians to interrupt their workflow to locate, read, and process the guidelines. Therefore, although many guidelines have been developed to assist physicians in different clinical situations, adherence to guidelines, even those that are broadly accepted, is often low [4,5]. The excessive and growing number of guidelines makes it hard for physicians to remember, find, and appropriately apply guidelines. To help physicians in this regard, guidelines should be provided at the point of care.

Providing guidelines at the point of care can be facilitated by integrating them into a decision support system (DSS) or clinical information system. Integrated guidelines help physicians to deliver evidence-based care to patients. By providing patient-specific reminders and advice, a DSS can influence the physicians' behavior [6–9] to increase adherence to guidelines [6,7,10–12] thereby improving patient care significantly [7].

A success factor for DSS implementation is the integration into workflow and information infrastructure [7]. To enable this, guidelines should be represented in a format that enables automated inference based on patient data stored in the clinical information systems. Furthermore, guideline-based DSSs must be able to interact correctly with any clinical information system to enable broad adoption. This can be realized by using a standard information model and standard terminology in both the automated guideline and the clinical information system.

In the Netherlands, anesthesiologists intend to adopt SNOMED CT[1] as a standard terminology in the domain of pre-operative assessment [13]. SNOMED CT will be used to record pre-operative assessment patient data in a standardized way in order to be able to reuse the data for multiple applications including a guideline-based DSS. Therefore, in this study we will investigate whether SNOMED CT can be used for this purpose, by answering the

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[1] http://www.ihtsdo.org/

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following questions: (1) to what extent does SNOMED CT cover the terms used in commonly used pre-operative assessment guidelines? (2) If necessary, how can the measured content coverage be improved?

2. Background

2.1. Guideline composition and guideline representation

In general, a guideline consists of the description of the task that has to be performed, eligibility criteria that may evoke the guideline or parts of it, and abort criteria that may cancel following (parts of) the guideline. Furthermore, guidelines have validation attributes such as strength of evidence, which indicate whether a guideline or a task in a guideline is supported by the literature or by expert opinions.

Whereas most guidelines are formulated as unstructured text or as a simple flowchart, there is a growing need to create interoperable guidelines [14]. To this end, guidelines should be formalized. Efforts have been made toward formalizing guidelines and creating interoperable clinical guidelines and knowledge-based DSSs during recent years [15–20]. These formalizations are generally based on a logical statement that is activated by some relevant event, such as entering or storing patient data. The logical statement will be activated if the patient data is recognized as satisfying the eligibility criteria of a guideline or of a task in the guideline.

2.2. The use of terminologies in guideline representation

An important step in creating interoperable guidelines is the binding of terminology used in the clinical information system to terminology used in guideline representation.

In some guideline representations, such as old versions of the Arden syntax, institution-specific terms must be mapped to the specific terms used in the representation in order to activate a logical statement in the guideline [18]. This kind of guideline representation cannot support different synonyms used by different care providers for a clinical concept, e.g., K+, or serum potassium. Therefore, as the naming of patient data varies among institutions, patient data elements defined in the formalized guideline will need to be changed when the guideline is shared [18]. In the Arden syntax this problem has become known as the "curly braces problem", because the data-acquisition statements of Arden syntax contain non-standardized data names and expressions in curly braces [21]. To overcome problems caused by use of different terminology, the GLIF (guideline interchange format) formalization used a list of acceptable synonyms for each data element [16]. In EON, which is a component-based architecture for building guideline-based decision support systems, and Asbru, which is a machine-readable language used for guideline representation, specific domain ontologies are defined [15,20]. Patient data should be first mapped to these domain ontologies designed for guideline representation.

Recent researches have focused on increased interoperability using standard terminologies in guideline representation and clinical information systems [22,23]. Achour et al. [22], used the Unified Medical Language System (UMLS) to create a domain ontology and thereby facilitate interoperability and reusability of the guideline representation expressed by the Arden syntax. GLIF3 adopted a version of HL7 v3 RIM (Health Level 7 version 3 Reference Information Model) as its data model and used controlled terminologies such as ICD-9 and SNOMED [24]. Guidelines elements model (GEM) is an XML-based guideline document model intended to facilitate translation of natural language guideline documents into a format that can be processed by computers. GEM promotes this translation by describing concepts pertinent to guideline representation, attributes of those concepts, and relationships among the concepts. GEM also has an element called "definition" which stores important guideline terminology as well as the meaning of the terms [25].

Another application of standard terminologies in the context of guideline formalization was in the SAGE (Standards-based Shareable Active Guideline Environment) project in which a framework for encoding and disseminating guidelines has been developed [26]. A set of reference terminologies including SNOMED CT, LOINC,[2] National Drug File – Reference Terminology,[3] and RxNorm[4] was used to support semantic interoperability [23]. SAGE obtains patient data from the local clinical information systems to activate the logical statements in the guideline. Therefore, standards-based coded content in a SAGE guideline must be mapped to corresponding codes used in the clinical information systems. Bernstein and Andersen in their work describe how the guideline system and the electronic health records can be integrated by the use of archetypes and SNOMED CT [27].

To eliminate the process of context-specific mapping of data between the guideline and the patient data in the anesthesia information management systems, in our project we will use SNOMED CT as a standard terminology for recording patient data as well as within guideline representation.

3. Methods and materials

3.1. SNOMED CT

SNOMED CT is a comprehensive clinical healthcare terminology that can be used as the foundation for electronic medical records and other applications. It is constantly updated and its revisions are released twice a year. In this study, the July 2008 release was used. It contains more than 315,000 active concepts with unique meanings, about 807,000 descriptions, including synonyms of defined concepts, and approximately 1,236,000 relationships between the concepts. Concepts in this terminology are defined based on description logic and organized into hierarchies with multiple levels of granularity. This representation enables documentation of very detailed clinical data and, when required, aggregation on a more general level. SNOMED CT is a concept-based system that supports post-coordination. Post-coordination is the ability to express new concepts by combining pre-coordinated (pre-defined) ones. This provides the possibility of creating new concepts by qualifying pre-coordinated concepts [28].

SNOMED CT, with these possibilities, may have good coverage of terms used in the guidelines, because of the varying level (from very high to very low) of aggregation of terms used in the guidelines.

3.2. Selection of pre-operative guidelines

To perform this study, we retrieved (inter)national guidelines related to pre-operative assessment. As our goal was not to find a complete set of pre-operative assessment guidelines, but to retrieve widely accepted guidelines, extensive searches through the websites of the (inter)national anesthesia-related societies were performed. Table 1 shows a complete list of the websites explored. Guidelines were included if they completely or partially dealt with the pre-operative assessment.

3.3. Data extraction

The retrieved pre-operative assessment guidelines consisted of narrative text. To evaluate the content coverage of SNOMED CT

[2] http://loinc.org/
[3] http://www.nlm.nih.gov/research/umls/sourcereleasedocs/2008AB/NDFRT/
[4] http://www.nlm.nih.gov/research/umls/rxnorm/