Data interchange standards in healthcare: semantic interoperability in preoperative assessment
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Citation for published version (APA):
Patient information systems improve the availability of information for healthcare professionals. However, the availability of information is not a key motivator for healthcare professionals to adopt a patient information system. Their motivation lies in saving time and improving medical decision making and that is where semantic interoperability of healthcare information comes into play. Semantic interoperability means that the meaning of information is unambiguously exchanged among patient information systems. It addresses issues of how to best facilitate the coding, transmission and use of meaning seamlessly across health services, providers and patients. The first step towards semantic interoperability is developing an agreed-upon dataset to improve communication among healthcare providers and between healthcare providers and patients. However, one of the biggest impediments to communication is that there may be multiple ways of describing a single concept. To overcome this, a standard terminological system is needed which meaningfully describes concepts.

For the preoperative assessment, in which the risks for a patient regarding a planned procedure and anesthesia technique are determined and minimized, semantic interoperability is important as different healthcare providers and different patient information sources such as previous patient healthcare documents and laboratory results are involved. An anesthesia information management system (AIMS), capturing preoperative assessment data, should interact correctly with other systems and the flow of information between different systems with the AIMS should be correct. Re-use of patient data within different patient information systems heavily relies on a shared set of data employed in the systems and represented in a standardized way. Developing a standardized preoperative assessment dataset contributes to reducing miscommunication and reassessment in case of patient referrals.

Therefore, in this project as a first step toward data standardization we developed a core dataset for the preoperative assessment. First to get insight into the collected data for preoperative assessment a systematic review was performed in the PubMed and CINAHL databases, the results of which are described in chapter two. From 41 included articles data items that were described as being part of the preoperative assessment were extracted. Five hundred forty one distinct data items were extracted. From the extracted data items only 6 data items were stated in 50% or more of the articles. The large diversity of data items collected during preoperative assessment indicates that there is no agreement about which data items should be collected during the preoperative assessment. To overcome the variety of data collected in different settings, defining a standardized core dataset seems necessary. The results of this systematic review showed that identifying essential data items in the preoperative assessment only through frequency of citation is not enough due to the observed variation in data collection.

Chapter three describes the development process of and the resulting preoperative assessment core dataset. First we established an expert committee to develop the first draft of a preoperative assessment dataset based on expert consensus. The major headings of the core dataset were determined, and committee subgroups formed to address the major headings. The subgroups determined data items for each major heading and shared them
with other members of the committee. Data items were discussed in five consensus meetings until agreement was reached. Based on the outcome of this consultative process a draft version of a national core dataset for preoperative assessment was created. Then the results of the systematic review (data items that were reported in more than 25% of the articles) were compared with the data items defined by experts. Eighty two data items were defined in the draft version of the core dataset by experts, of which 76% were covered by the systematic review. After the comparison 6 data items were deleted from the draft dataset, 17 new data items were added and 9 data items were modified. The final version of the core dataset included 93 data items. The comparison between the expert-based dataset and the result of the systematic review helped the committee to modify the dataset by adding disregarded data items and removing unnecessary items. Both methods proved to be valuable and complementary in designing the dataset. This dataset is intended to be implemented in anesthesia information management systems (AIMS), preferably by using SNOMED CT as the standard terminology system.

In chapter four we investigated whether SNOMED CT covers the terms used in preoperative assessment guidelines. We searched the websites of the (inter)national anesthesia-related societies to retrieve preoperative assessment guidelines. To facilitate data extraction from the retrieved guidelines, each guideline statement was rewritten as an “IF condition THEN action” statement and then the guidelines’ terms were extracted from these IF-THEN statements. The extracted terms were mapped to SNOMED CT concepts. Post-coordination was used when a pre-coordinated concept could not be found. The final mapping was given one of three scores: no match, partial match or complete match. To investigate why SNOMED CT does not completely cover the concepts used in the preoperative assessment guidelines, partially matching and non-matching concepts were evaluated against the principles and rules of SNOMED CT described in the editorial documentation of SNOMED CT regarding the content inclusion principles and process. The six retrieved guidelines were transferred into 24 IF-THEN statements. From 133 extracted terms from these statements 70% were completely mapped and 15% were partially mapped to SNOMED CT concepts. About 20% of all complete matches and 30% of all partial matches were achieved through post-coordination. In total, 68% of the partial and non-matches should not be represented by SNOMED CT because they violated at least one of the principles or rules of the SNOMED CT documentation. These concepts corresponded with underspecified concepts in the preoperative assessment guidelines. The results of this study showed that to facilitate the presentation of preoperative assessment guideline terms in AIMS by using SNOMED CT not only SNOMED CT needs to be extended, but also deficiencies in the guidelines’ use of terminology should be solved.

Chapter five describes a literature review and a survey on the use of standardized data and terminological systems in Clinical Decision Support Systems (CDSSs). The set of included articles of a former systematic review on CDSS was our starting point. This systematic review covers articles published from 1974 till September 2004. Articles published after 1995 were included in our study (n = 46). To consider articles published after September 2004 we included 31 identified articles on CDSSs from AMIA’s “Year in Review”. Each year during a “Year in review” session, AMIA identifies that year’s
Randomized Controlled Trials (RCTs) in the field of medical informatics. A data extraction form was designed and the required data items were extracted from the identified articles. Authors of the articles were contacted to check and complete the extracted data items from their articles and to answer a questionnaire. In total, 77 articles were included in the study. Twenty two percent of the included studies used only numerical data items in the CDSS. Studies that used coded data items in CDSSs applied local terminological systems to code the data items in about half of the cases. The most frequently used international terminological systems were those of the family of International Classification of Diseases (ICD) and Logical Observation Identifiers Names and Codes (LOINC). Authors of the included studies reported that in 58% of the cases they experienced problems with CDSS implementation. In 92% of these cases the problems were related to availability of standardized data required to develop a CDSS. The findings of this study showed that developers of CDSSs used different terminological systems to code the data items, hampering the shareability of information. Moreover, the survey revealed that data standardization is a critical success factor for CDSS development.

In chapter six we devised a generic approach for developing a domain-specific interface terminology on SNOMED_CT. The approach includes six sequential phases: domain analysis, mapping from the domain concepts to SNOMED CT concepts, creating the SNOMED CT subset guided by the mapping, extending the subset with non-covered concepts, constraining the subset by removing irrelevant content, and deploying the subset in a terminology server. We applied the proposed approach to the domain of intensive care. For the domain analysis phase of the approach we used the Acute Physiology and Chronic Health Evaluation (APACHE) IV classification, an existing standard in the intensive care domain as the starting point. Each of the 445 APACHE IV diagnostic categories was mapped to SNOMED CT concepts. In total, 89.2% of the diagnostic categories were completely mapped to SNOMED CT and the rest were partially mapped to SNOMED CT. The results of the mapping were used as target concepts to isolate the concepts related to the APACHE IV diagnostic categories and their subordinates and attributes by downward traversal from SNOMED CT. In the extension phase, for all concepts representing a diagnostic category from the APACHE IV classification, the APACHE IV term with the related APACHE IV code was added as the preferred term to the subset. Post-coordinated concepts were added as concepts and for partial matches, new pre-coordinated concepts were also added to the SNOMED CT subset. At the end, the hierarchical relations between the APACHE IV categories were added to the subset. Depending on the restriction of the depth of the graph traversal the number of disorder and procedure concepts ranges from 2% to 29% of all active SNOMED CT concepts. The interface terminology was deployed using a local terminology server. The proposed approach provides a framework for developers of interface terminologies based on a reference terminology. The application of the proposed approach to the domain of intensive care resulted in an interface terminology for registration of reasons for admission of patients hospitalized in the intensive care unit which can be used to facilitate sharing and aggregation of data for different purposes.

The research in this thesis provides fundamental steps towards semantic interoperability. It appears important to investigate both the application of a core dataset...
Summary

and use of terminological systems to achieve an interoperable system. Semantic interoperable systems are a promising way to improve healthcare outcomes and costs.