Data interchange standards in healthcare: semantic interoperability in preoperative assessment
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Chapter 7

General discussion
The main objective of this thesis is the identification and development of a core dataset and the application of standardized data and terminological systems in patient information systems. We focused on the preoperative assessment domain and on the application of SNOMED CT for representing concepts used in the preoperative assessment guidelines. Four research questions were formulated that were addressed in chapters two to six.

- Which data should be collected during preoperative assessment?
- Can SNOMED CT be used to represent concepts required to implement preoperative assessment guidelines?
- Do clinical decision support systems (CDSSs) described in the literature use standardized data, and which terminological systems were used by CDSSs for coding data?
- How can an interface terminology on SNOMED CT be constructed?

This chapter summarizes and discusses the work presented in the previous chapters. It puts forward the principle findings and addresses the strengths and weakness of our work in relation to other studies. Finally, it discusses implications of the study and directions for future research.

7.1. Principal findings

7.1.1. Development of a core dataset in preoperative assessment

The first research question was answered in the chapters two and three. In chapter two we carried out a systematic review to identify data collected during preoperative assessment. The results of this study revealed that a large diversity exists in the data items that are collected for evaluation of patients undergoing a procedure. The diversity of data indicates that almost each health care setting collects a different dataset for preoperative assessment. This diversity is an obstacle e.g., in case of patient referral to other health care settings, and hence limits the utility of the data [1, 2]. To overcome this problem a standard dataset is required. A standard dataset that is feasible, relevant and accessible to its end users would improve the quality of clinical care and would provide the possibility of carrying out multicentre research [1].

The results of the second chapter provided us with insight about which data items are collected during preoperative assessment. However, we could not design a standard dataset based on these results because the observed diversity was too high. Therefore, we combined the obtained results of chapter two with the consensus of experts to develop a core dataset for preoperative assessment. The experts developed a draft preoperative assessment dataset and subsequently this dataset was compared with the results of the literature review. The combination of literature review and expert consensus appeared to be a good approach for designing this dataset. The development process and the resulting dataset were presented in chapter three. Comparing the draft dataset with the results of the literature review helped experts to add missing data items to the dataset and, if required, modify other data items. In total, 6 data items were deleted from the draft dataset, 17 data items were added and 9 data items were modified. Finally, 93 data items were identified and divided into four categories: patient history, physical examination, supplementary examination and
consultation, and final judgment. Each identified data item can get different values, e.g. different types of cardiovascular diseases such as congestive heart failure or heart valve stenosis can be considered as values for the data item “cardiovascular diseases”.

7.1.2. Representation of concepts in preoperative assessment guidelines by SNOMED CT
The second research question was answered in chapter four. The data from the dataset are intended to be used for multiple purposes, including clinical decision support. As this requires a standardized representation, in chapter four we investigated to what extent SNOMED CT covers the concepts used in preoperative assessment guidelines. In this study six (inter)national guidelines were reviewed. All terms used in one of the six guidelines were mapped to SNOMED CT concepts. The International Health Terminology Standards Development Organization (IHTSDO) developed an editorial guideline that describes what should and what should not be included in SNOMED CT [3]. To investigate why not all preoperative guideline concepts were covered by SNOMED CT concepts we evaluated the non-covered concepts against this editorial documentation. Part of the non-covered concepts was vague and therefore not included in SNOMED CT. It was concluded that it is feasible to use SNOMED CT to represent the preoperative assessment guideline concepts after solving the problem of vague terms and after a small set of currently missing but relevant concepts is added to SNOMED CT. To present the recommendations of these guidelines at the point of care the guidelines have to be implemented in CDSSs.

7.1.3. Data standardization in clinical decision support systems
Data standardization is essential to implement guideline-based decision support systems that can be integrated with different information systems. Therefore, in chapter five we answered the third research question whether existing CDSSs used standardized data, and which terminological systems were used by CDSSs for coding data. It was found that many CDSSs were using numerical data, which is a relatively easy way of standardization, and if they used coded data items they applied different terminological systems to code these data. This diversity hampers the possibility of sharing and reasoning with data within different systems. Moreover, about half of the coded data were coded using a local terminological system which will negatively affect these possibilities. A survey among authors of articles included in this study revealed that the lack of standardized data is a major obstacle for CDSS implementation. This study showed that there is ample room for developing interoperable CDSSs.

7.1.4. Creating an interface terminology on SNOMED CT
To capture standardized data in patient information systems the use of a standard terminological system is required. It is impractical to implement a large comprehensive terminological system like SNOMED CT into the user interface of systems, because of the large number of included concepts and its complexity. Instead, an interface terminology could shield users from this complexity by tailoring it to a specific domain. The development process of an interface terminology on SNOMED CT was described in chapter six. In this study we defined a generic approach for developing an interface
terminology that included six sequential phases: domain analysis, mapping the domain concepts to SNOMED CT concepts, creating the SNOMED_CT subset guided by the mapping, extending the subset with non-covered concepts, limiting the subset by removing irrelevant content, and deploying the subset in a terminology server. To illustrate the developed approach we applied it to develop an interface terminology for reason for admission to the intensive care unit (ICU).

7.2. **Strengths and weaknesses of the study and related research**

Interoperability of patient information systems requires at least a standard set of data with standard semantics. A standard dataset would ease the flow of data among different but interconnected systems, and thereby maximize useful information interchange [4].

The strength of our research is that we investigated the means to standardize the data in the preoperative assessment, focusing both on data collection during the assessment and on the application of the standardized data in guideline-based decision support systems. The methodologies that we applied to develop a dataset, formalize guidelines by using SNOMED CT and develop an interface terminology can be applied to other domains than preoperative assessment or intensive care. In this project we also showed to what extent current CDSSs can benefit from data standardization and the application of terminological systems.

7.2.1. **Development process of the dataset**

Other studies where a core dataset was developed [1, 5-8] either used expert consensus or reviewed a limited number of sources (e.g. reviewing 3 existing datasets) while we applied an extensive search strategy and combined it with expert consensus to arrive at a core dataset for preoperative assessment. Our approach showed that relying only on a literature review is not adequate. We retrieved a large number of data items of which only a few percent was reported in a majority of the studies. Also, as the articles on preoperative assessment may not report all data items that are collected during preoperative assessment, due to their irrelevance in the context of the study, we might not have obtained all data items that are clinically important. To overcome this limitation we could have reviewed the data items that are currently collected in different hospitals in the Netherlands. However, as this project is part of an international project on standardization of perioperative data, which is carried out by the International Organization for Terminology in Anaesthesia (IOTA), we preferred a literature review to obtain an overview of internationally collected data. Moreover, collecting datasets from different hospitals is a labor-intensive task and to determine a core dataset is complex as some data items may only be used in one hospital while others may be used in multiple hospitals. A data item that is collected routinely in multiple hospitals may still be considered clinically irrelevant by experts. Due to lack of clear criteria it is hard to decide which data items are to be included in the core dataset. Thus instead of collecting data from hospitals, we decided to involve a large number of experts in consensus meetings to propose a core data set and to compare this set with the results of the literature review in order to arrive at a valid and concrete dataset.
To store information about the meaning, relationships to other data, usage, and format of each data item a “data dictionary” is required. Although a data dictionary was created afterwards, creating it concurrently with the dataset would improve data validity and reliability within, across, and outside the development setting [9]. Developers of the dataset should define what they want to know about each concept and how they want to present the concepts into the system. Moreover, we could have used SNOMED CT already during the development of the core dataset. This would have supported the experts to clearly define and name the concepts. For instance, the expert group defined the data item “pacemaker”. One may think that this data item refers to the device, but the experts wanted to represent the SNOMED CT concept “patient with cardiac pacemaker”.

7.2.2. Representation of guidelines using SNOMED CT

Data collected during the preoperative assessment should also be available for use in automated guideline-based decision support systems. It is important that all the data needed by the decision support system are available in a standardized format in the information system. We evaluated the content coverage of SNOMED CT regarding preoperative assessment guidelines terms. Compared to other studies on content coverage of terminological systems [10-13] our study was the first to evaluate the reasons why a concept could not be represented by SNOMED CT. This approach will help guideline developers with the selection of the terms that they want to use in the guidelines. Applying this approach will also help others to clearly distinguish between deficiencies attributable to concepts in the evaluated domain or to gaps in SNOMED CT. This will inform them where to put their efforts to further improve the content coverage of SNOMED CT for the evaluated domain. In this study we evaluated a small number of guidelines. Further evaluation with inclusion of more guidelines, such as national and local guidelines, is required to show whether, after solving the guideline deficiencies, SNOMED CT can cover all guideline concepts in the preoperative assessment domain. The main limitation of our project is that we first developed the preoperative assessment core dataset based on the literature and expert consensus and only as a separate and subsequent project extracted and evaluated the terms used in preoperative assessment guidelines to be included in the SNOMED CT subsets. Ideally experts should also have consulted the preoperative assessment guidelines when determining the content of the core dataset. Preliminary analysis shows that over 90% of the terms extracted from the guidelines were already included in the core dataset. Although this does not affect the final result, the remainder should be added to the dataset, and consideration of the guidelines could have made the process of development of the dataset shorter.

To extend the preoperative SNOMED CT subsets with the required guideline concepts we applied a simple concept mapping to SNOMED CT. We did not consider how these concepts would be presented in an AIMS. Considering concepts in the context of the information model will provide insight in the way these concepts should be presented in the interface terminology. For instance, how should the term “metabolic disorders” extracted from a guideline be presented in the user interface? For example, the information model can have a slot “metabolic disorders” with a subset of SNOMED CT concepts presenting the
different types of this disease as slot filler. Using the information provided in this slot healthcare providers can choose e.g., from a drop down menu the type of disease that a patient has.

7.2.3. Data standardization in CDSSs

In chapter five we investigated obstacles, especially data standardization problems, for implementing CDSSs. To date little is known about the use and the importance of standardized data and terminological systems in CDSSs [14-17]. Our study is a first step in filling this gap. The results of our study provide a valuable foundation for the CDSS developers with respect to data standardization and the application of terminological systems. In our study we could not find information regarding information models underlying CDSSs. The reason might be that we included randomized controlled trials that evaluated the application of CDSSs in practice rather than studies reporting on the development process of CDSSs. These latter studies might explain whether and how they made use of standard information models. However, information regarding the development process of systems is not often part of scientific publications. In the studies included in this review there was no study conducted in the domain of preoperative assessment. This might be due to the low number of patient information systems used in perioperative care and the lack of data standardization in this domain [18-21]. Therefore, there is room for improvement concerning availability and exchangeability of data in the preoperative assessment domain. Our project regarding standardization of data in this domain by application of a shared dataset and standard terminological systems is a step in this direction.

7.2.4. Creating an interface terminology

To create an interface terminology for documenting reasons for ICU admission we used the Acute Physiology and Chronic Health Evaluation IV (APACHE IV) classification as a starting point for selection of the concepts from the reference terminology SNOMED CT. The reason for admission is registered based on the APACHE IV classification and is an important data item in the Dutch National Intensive Care Evaluation (NICE) dataset. The APACHE IV classification is an aggregated terminology that lacks the detail and structure needed for an unambiguous description of health problems. The developed interface terminology, described in chapter six, allows users to register detailed diagnosis information. At the same time information to be used for other purposes can be retrieved at an aggregated level. Limitations of the approach for developing an interface terminology are that it is still relatively labor-intensive, and that adequate tools to support the development process are lacking. Furthermore, the method can still lead to overly large interface terminologies when applied to broad domains such as reasons for admission. Application of the method in other, more focused, areas, and in the context of preoperative assessment will be needed to further demonstrate the applicability of the method.
7.3. Implications of the study

Of the 3.7 million patients undergoing surgical procedures between 1991 and 2005 in the Netherlands 67,879 died postoperatively [22]. The postoperative mortality not only depends on the surgical procedure itself but also on the presence of co-morbidities or other conditions of the patient that can be identified during preoperative assessment. Patients who had an inadequate preoperative assessment had a six-fold increase in mortality compared to those who had been thoroughly assessed [23]. Communication problems are an important factor contributing to anesthesia incidents [24]. Patient records are not always available to the anesthetist at the time of surgery and often relevant information is difficult to access because of incompatibility of software or the use of paper-based records. Communication problems are the reasons that planned processes are not followed. A study carried out in the Netherlands showed that 6.3% of the planned procedures was cancelled [25]. The Anesthesia Patient Safety Foundation reported that there is a lack of standards in data collection for preoperative assessment. They are of the opinion that the needed data should be defined precisely and that the right amount of data, depending on the user and the circumstances, should be collected [21]. Lack of credible data may result in incorrect information about the intra- and postoperative mortality and morbidity. Automated and standardized perioperative data collection is needed to learn about the true details of critical incidents and disasters [21]. This type of information can be used to improve patient care.

Creating a standardized dataset for preoperative assessment not only facilitates both intra- and inter-hospital exchange of data but also provides all required data, which healthcare providers need during and after surgical procedures. It will improve the communication between patient and anesthetist and help physicians not to forget to ask the needed information from the patient. Developing a core dataset that also covers the required concepts implemented by guideline-based decision support systems will facilitate providing evidence-based advice at the point of care. Using an interface terminology based on a standard reference terminological system reduces the variability of data capture and encoding and facilitates interoperability. The research presented in this thesis provides valuable insight in the development of a standardized dataset, and the use of standardized data and the application of terminological systems in AIMS and CDSS.

7.4. Future research

There is still a lot to be done to create standardized data in AIMS for preoperative assessment. The core dataset should be extended to also cover all concepts used in all relevant guidelines. Furthermore, SNOMED CT subsets including all values of the identified data items in the core dataset should be created.

The generic approach regarding creation of a SNOMED CT subset described in chapter six should be applied for the creation of SNOMED CT subsets for preoperative assessment. The application of a generic approach for designing the SNOMED CT subsets in the preoperative assessment domain will prove the merits of this approach and shed light on possible points for improvements and extensions of the approach. As healthcare providers do have limited time for documenting patient information an efficient graphical user
interface should be developed. An approach should be developed and applied regarding the creation of an efficient structured data entry interface based on existing standard information models such as the Health Level 7 (HL7) Reference Information Model (RIM).

IOTA intends to define an international standardized perioperative dataset to be implemented in AIMSs. The work of IOTA is now creating the anesthesia subset of concepts for SNOMED CT. The dataset defined in this thesis should be integrated in IOTA’s dataset.

The existing way of data collection and the one presented in this thesis should be compared to gain insight in the effectiveness and efficiency of the designed dataset. It should be evaluated to what extent the application of this standardized dataset will improve adherence to preoperative assessment guidelines and increase patient care quality.

The literature review on CDSSs in this thesis showed that the application of standardized data in CDSSs might improve the physician’s performance. However, more research is needed to be able to gain more insight in whether and how the use of standardized data and terminological systems increases the effectiveness of a CDSS in preoperative assessment. It should be evaluated to what extent the application of a shared dataset and standard terminological systems can play a role in improving the quality of care.
References


