Data interchange standards in healthcare: semantic interoperability in preoperative assessment
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Chapter 2

Data collection variation in preoperative assessment

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Abstract

Introduction: This study is a systematic literature review to identify data collected in the preoperative assessment.

Methods: The PubMed and CINAHL databases were searched for articles published from 1997 to 2007. From the included articles data items that were described as part of the preoperative assessment were extracted. Identified data items were categorized into 13 categories originating from SNOMED CT.

Results: Forty-one relevant articles were found. Preoperative assessment was equally performed in outpatient clinics and in-hospitals. The assessment was performed between the day of surgery and 30 days before surgery by anesthesiologists (51%) and/or nurses (39%) and/or other professionals (34%). The included articles described 541 data items. The two largest categories of data were “past history of clinical finding”, and “physical examination procedure” with 212 and 75 data items. Only 6 data items “age”, “diabetes”, “ECG”, “cardiovascular diseases”, “hypertension”, and “cigarette smoking and other use of tobacco” were stated in 50% or more of the articles.

Conclusion: This study revealed a high diversity of data being collected during the preoperative assessment. Because of the diversity of patients one undisputed preoperative assessment dataset is hard to define. However, to solve the problem of data exchangeability, professionals should at least use a common core dataset.
2.1. Introduction

The purposes of preoperative assessment are to estimate and to reduce, based on the patient’s condition, the morbidity and mortality risks associated with surgery, and to determine the required anesthesia and equipment for the anesthesia and operation [1]. Accurate identification of the patient’s problems before surgery will support patient’s optimization for anesthesia and surgery, and determine indications for the requirement of postoperative intensive or critical care [2-4]. However, there is no agreement about the detailed information which should be collected during preoperative assessment to identify patients’ problems [5, 6].

To reduce hospitalization, the emphasis these days is on ambulatory surgery and same-day admission, which makes it impossible to perform the required preoperative assessment on the day before surgery [7]. Therefore, the assessment is often done some days or weeks before surgery by an anesthesiologist, not necessarily the one that will provide anesthesia, or collaboratively by other professionals such as specialized nurses [8], and sometimes partially based on a patient self-administered screening questionnaire. This results in decreased personal contact between the actual anesthesia care provider and the patient. Consequently, the decreased contact requires increased reliance on information that is obtained by non direct care providers during the preoperative assessment. This multidisciplinary preoperative assessment setting requires appropriate, accurate and timely data to enhance communication between healthcare providers. Although, it is impossible to have a fixed preoperative assessment dataset for all patients undergoing surgery due to diversity in patient conditions, it is important to have an agreed-upon core dataset for all surgical patients. Variation in data collection impedes the use of patient data by different care providers at different locations and therefore often results in reassessment.

Data in the preoperative assessment should be collected in a structured and standardized way to facilitate effective communication and reuse of these data for secondary purposes such as clinical research. Standardization of data increases cost-effectiveness in patient referral, because reassessment is prevented.

We performed a systematic literature review to identify data collected in the preoperative assessment. This review functions as a first step towards determining which data items should be collected in the preoperative assessment and provides a basis for designing a core dataset for preoperative assessment. By this review, we will determine the most common used data items in the preoperative assessment. The result of this review will be discussed in an expert committee for defining a core dataset for the preoperative assessment. Because the preoperative assessment differs for different groups of patients, this core dataset will be extended accordingly. This study is part of a larger effort to define an international standardized perioperative dataset, and carried out in collaboration with the International Organization for Terminology in Anesthesia (IOTA) with members from the Canadian, British and American anesthesiology-related societies [9]. IOTA’s mission is to create a standardized terminology for the global anesthesia community. IOTA was created
by the Data Dictionary Task Force (DDTF) of the Anesthesia Patient Safety Foundation (APSF) in the USA [9].

2.2. Methods

In order to find all relevant articles describing preoperative-assessment data collection, the PubMed and CINAHL databases were searched for papers published between January 1997 and June 2007. Only English language articles which fulfilled the identified search terms related to pre-operative, assessment, history taking, physical examination, diagnostic test and anesthesia were included. The keywords of a review article [6] about the role of history taking and physical examination in the preoperative evaluation were the basis for the search strategy. The keywords were extended; for instance, not only “pre operative”, but also “pre anesthesia”, and “pre surgery” were used as keywords, in order to increase the possibility of retrieving more articles and to obtain three relevant articles selected beforehand [10-12]. Finally, four sets of relevant key words and Medical Subject Headings (MeSH) terms were used. First, the search was carried out in both databases using sets 1, 2 and 3. Set 1 included terms related to preoperative care, set 2 contained assessment-related terms, and set 3 referred to possible ways of or sources for data collection in the preoperative assessment. To reduce the large number of hits, the titles of the first 300 retrieved articles were reviewed by two reviewers to determine the common terms used in the titles of the relevant articles. Set 4 containing these common terms was added to the search strategy to increase the specificity of the retrieved articles. The search terms were combined using “OR” within the sets and “AND” among them (figure 2.1). The retrieved articles from the PubMed and CINAHL databases were compared to remove duplicates. To determine the recall of the search strategy we compared our search results with the references of the above mentioned review article [6].

Two reviewers (LA and NdK) independently judged all titles and abstracts, and interobserver reliability was assessed by Cohen's kappa. Disagreements were discussed with a third reviewer (RC) and the final decision reflected consensus of all three reviewers. In the absence of an abstract or when inclusion of an article could not be decided upon on the basis of the abstract, full texts of the articles were reviewed.

Articles were selected based on the following inclusion and exclusion criteria. All articles describing routinely collected preoperative assessment data were considered. Reviews as well as original studies were included when they focused on collecting data applicable to all kind of preoperative assessment patients. With “reviews” we refer to conceptual papers and opinion papers in which authors present their views and opinions, as opposed to “original papers”. To prevent duplication, we only collected data items from these “reviews” if the authors did not refer to other studies already included in our study. Articles were included if they described the preoperative assessment data in general or for one or more general categories of diseases, e.g. the preoperative assessment for cardiovascular or pulmonary patients undergoing a surgical procedure. As in this study we were looking for common data items in the preoperative assessment, articles about the preoperative assessment of any specific surgery such as thyroidectomy or thoracotomy...
were excluded as they might describe data which are only applicable to those specific surgeries. Articles describing data for a specific patient population such as obese patients, children, or diabetes patients were excluded for the same reason. Moreover, articles that describe data collected for patients with a specific condition, e.g. patients using a herbal medication which interacts with anesthesia agents, and articles about patients at risk for specific complications such as post-operative bleeding, were excluded. Evaluation studies on the necessity of specific tests, or on specific parts of the physical examination, and impact of different treatments or methods on risk factors, mortality, and morbidity were excluded. Finally, editorials and letters were excluded.

**Figure 2.1:** Distinct phases in the process of collecting relevant publications and their results.

Next to the data items collected in the preoperative assessment, some additional data about the time between the preoperative assessment and the operation; about the disciplines involved in the preoperative process; and about the location, where data were collected, were extracted from all included articles.
To extract the data items, the full text of the included articles, i.e. text, tables, forms, and appendices were reviewed. All preoperative-assessment data items mentioned by the authors were included. For the extraction of the data items, we focused on each data item separately and counted each data item independently. We did not aggregate the data items (e.g. aggregate “myocardial infarction” as a “cardiovascular disease”). For instance, if authors mentioned the term “angina pectoris” it counts as “angina pectoris” not as “cardiovascular disease”; if authors referred to a generic term “cardiovascular disease” we just counted it as “cardiovascular disease. To facilitate data presentation, the extracted data items collected in the preoperative assessment were initially classified into seven categories based on the existing literature [12, 13]. As the number of the data items within each category was large, the categories were extended to 13 categories according to the consensus of authors to have better presentation of the data items. The category “demographic history detail” was separated from the category “administrative information”, the category “family history” was separated from “past history of clinical finding”, the category “diagnostic procedure” from “laboratory test”, the category “functional finding” from “patient status observation”, and the category “preoperative evaluation, anesthesia” from “physical examination procedure”. In this way five other categories were added to the initial categories. The categories were determined and extended so that all extracted data items could be placed in one category without any ambiguity. In categorizing data, we did not pay attention to the classification of data items in the reviewed articles but followed our consensus categorization. For example, some articles considered “alcohol drinking” as a “past history” data item, but we categorized it as “behavior finding”. Standard names for the categories originated from preferred terms of Systematized Nomenclature of Medicine-Clinical Terms (SNOMED CT)\(^1\). For example, terms such as “past medical history”, “history of problems”, “history of past illness”, and “past medical problems” are all synonymous terms for the category “past history of clinical finding”, the name of which was chosen based on SNOMED CT.

Each data item was collected, and categorized into one of the 13 categories without considering any extra information, such as qualifiers or values related to it and also without considering the way how these data were collected (question, multiple choice and so on). For example, we chose the term “cigarette smoking and other use of tobacco” for the different ways which this data item was presented without considering the number of pack years. Likewise the data item “myocardial infarction” was selected regardless of the time of occurrence (e.g. within 3 months before surgery). Although this extra information about the data items is important in the preoperative assessment, it is considered a further specification of the data items, which is disregarded in this research. These further specifications will be considered in the core dataset which we are going to design. Each reported item, from a general term such as “cardiovascular disease” to a specific term such as “aortic stenosis”, was collected.

\(^1\) [http://www.ihtsdo.org/snomed-ct/](http://www.ihtsdo.org/snomed-ct/)

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2.3. Results

The search strategy using 1, 2, and 3 sets of the key words resulted in 5212 articles in PubMed and 2469 in CINAHL. The search results, after adding the fourth set of keywords, are presented in figure 2.1. A total of 41 articles met our inclusion criteria. The interobserver reliability calculated by Cohen’s kappa for the articles selection was 0.87. The recall of the search strategy was checked against references of another review article [6]. Eight references of this article were relevant and 6 (75%) of them were retrieved by our search strategy.

The detailed characteristics of the included articles are presented in table 2.1. Forty nine percent of the articles described preoperative assessment data collection for all patients undergoing a surgical procedure, 15% of the studies focused on patients undergoing non-cardiac surgeries, 10% described data collection for surgeries carried out in outpatient clinics and the rest explained preoperative assessment data for specific groups of patients. For example, one article described preoperative assessment data for all types of general surgeries excluding cardiac, thoracic, neuro- and vascular surgeries and emergency operations.

Table 2.1: Characteristics of the included articles

<table>
<thead>
<tr>
<th>Details of the included articles</th>
<th>No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Publication year</strong></td>
<td></td>
</tr>
<tr>
<td>1997-2000</td>
<td>13 (32)</td>
</tr>
<tr>
<td>2001-2004</td>
<td>16 (39)</td>
</tr>
<tr>
<td>2005-2007</td>
<td>12 (29)</td>
</tr>
<tr>
<td><strong>Study design</strong></td>
<td></td>
</tr>
<tr>
<td>Experimental study</td>
<td>7 (17)</td>
</tr>
<tr>
<td>Randomized control trial</td>
<td>1 (2)</td>
</tr>
<tr>
<td>Non-randomized trial</td>
<td>6 (15)</td>
</tr>
<tr>
<td>Observational study</td>
<td>9 (22)</td>
</tr>
<tr>
<td>Cross sectional study</td>
<td>4 (10)</td>
</tr>
<tr>
<td>Case control study</td>
<td>3 (7)</td>
</tr>
<tr>
<td>Cohort study</td>
<td>2 (5)</td>
</tr>
<tr>
<td>Descriptive study</td>
<td>25 (61)</td>
</tr>
<tr>
<td><strong>Country of study</strong></td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td>24 (59)</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>5 (12)</td>
</tr>
<tr>
<td>France</td>
<td>2 (5)</td>
</tr>
<tr>
<td>Brazil</td>
<td>2 (5)</td>
</tr>
<tr>
<td>Other countries [Canada, Hong Kong, India, Italy, Kuwait, The Netherlands, New Zeeland and Thailand]</td>
<td>8 (19) [each country one study]</td>
</tr>
</tbody>
</table>
Preoperative assessment was performed between 30 days before surgery and the day of surgery. Anesthesiologists (mentioned in 21 (51%) articles), nurses (mentioned in 16 (39%) articles), and other professionals such as surgeons and consultants (mentioned in 14 (34%) articles), were involved in the preoperative assessment. In half of the cases more than one discipline was involved in the preoperative assessment. For example, of 21 articles mentioning the involvement of anesthesiologists in the preoperative assessment, 8 articles reported the cooperation between anesthesiologists and nurses, and 6 reported cooperation with another discipline. The cooperation between nurses and other disciplines was stated in 2 articles. In 5 articles, disciplines involved in the preoperative assessment were not mentioned. Eighteen articles (43%) mentioned that the preoperative assessment was done in an outpatient clinic, 6 articles (15%) reported that the assessment was performed in hospitals and in 17 articles (42%) the location was not mentioned.

In total 541 distinct data items were extracted and 13 categories were used to classify the items: demographic history detail; past history of clinical finding; functional finding; behavior finding; family history; patient status observation; review of medication; physical examination procedure; laboratory test; diagnostic procedure; preoperative evaluation, anesthesia; surgical procedure; and administrative information. The complete list of the data items can be obtained from the authors. Table 2.2 shows per category the number of articles mentioning the category or at least one data item belonging to that category, and the number of the data items included in the category. The right column in this table shows as an example the 3 data items within a category that were most frequently reported by the authors. About 40% of the data items (n=212) were related to the category “past history of clinical finding”. Categories “physical examination procedure” and “review of medication” with 75 and 72 data items respectively were the second and third largest categories.

None of the data items were reported in all of the articles. Four hundred and ninety four data items were mentioned in at most 25% of the articles, while only 6 data items were stated in more than 50% of the articles. Those six data items were “age” (n=29), “diabetes” (n=28) “ECG” (n=26) “cardiovascular diseases” (n=23), “hypertension or high blood pressure” (n=22), and “cigarette smoking and other use of tobacco” (n=22). The categories “demographic history detail”, “past history of clinical finding”, “behavior finding” and “diagnostic procedure” were the only categories including data items reported in more than 50% of the articles. Most of the data items (73%) were reported in 1 to 4 articles and more than one third of the data items were mentioned in only one article. As depicted in figure 2.2, the number of times that data items were mentioned varied. In all 41 articles, 197 data items were mentioned once, 92 data items were mentioned in 2 different articles and 1 data item was mentioned in 29 articles.
Table 2.2: Frequency of collected data items as explicitly reported by authors of the included studies per category

<table>
<thead>
<tr>
<th>Category</th>
<th>Number of articles (references)</th>
<th>Nr. of data items in category</th>
<th>Three most frequently mentioned data items (number of articles mentioning the data item)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographic history detail</td>
<td>33[2, 5, 8, 10, 13-41]</td>
<td>12</td>
<td>Age (29), Sex (16), Weight/BMI (12)</td>
</tr>
<tr>
<td>Past history of clinical finding</td>
<td>40[2, 5, 8, 10, 12-47]</td>
<td>212</td>
<td>Diabetes (28), Cardiovascular diseases (23), Hypertension/high blood pressure (22)</td>
</tr>
<tr>
<td>Functional finding</td>
<td>22[5, 8, 10, 12, 13, 15-19, 24, 29, 31-33, 35-39, 45, 47]</td>
<td>13</td>
<td>Exercise tolerance (12), Functional capacity (11), Prosthesis (7)</td>
</tr>
<tr>
<td>Behavior finding</td>
<td>25[10, 12-20, 24, 26, 28, 29, 31-37, 39-41, 47]</td>
<td>4</td>
<td>Cigarette smoking and other use of tobacco (22), Alcohol drinking (21), Illicit drugs (10)</td>
</tr>
<tr>
<td>Family history</td>
<td>18[2, 10, 12, 15-18, 24, 29, 31-33, 35, 36, 40, 41, 45]</td>
<td>8</td>
<td>Anesthesia-related problems (10), Malignant hyperthermia (6), Surgical-related complications (2)</td>
</tr>
<tr>
<td>Patient status observation</td>
<td>25[5, 8, 10, 12-16, 19, 21-23, 26, 28, 29, 31-35, 37, 39-41, 47]</td>
<td>24</td>
<td>Pregnancy (11), Comorbidities (9), Current illness (cold, cough,…) (4)</td>
</tr>
<tr>
<td>Review of medication</td>
<td>33[2, 5, 8, 10, 12-19, 21, 22, 24-26, 28-41, 46, 47]</td>
<td>72</td>
<td>Anticoagulant medications (18), Aspirin-containing medications (15), Herbal medications (14)</td>
</tr>
<tr>
<td>Physical examination procedure</td>
<td>35[2, 5, 8, 12-24, 26, 27, 29-39, 41-44, 46, 47]</td>
<td>75</td>
<td>Cardiovascular examinations (16), Respiratory examinations (14), Blood pressure (13)</td>
</tr>
<tr>
<td>Laboratory test</td>
<td>34[2, 8, 10, 12-27, 30-38, 41-44, 46, 48]</td>
<td>51</td>
<td>Glucose (18), CBC (17), PT, PTT (16)</td>
</tr>
<tr>
<td>Diagnostic procedure</td>
<td>30[2, 8, 12-27, 31-33, 35, 37, 38, 41-44, 46, 48]</td>
<td>8</td>
<td>ECG (26), Chest x ray (18), Echocardiography and pulmonary function tests (6)</td>
</tr>
<tr>
<td>Surgical procedure</td>
<td>30[2, 5, 8, 10, 12, 13, 15, 16, 18-22, 24-26, 28-39, 45, 47]</td>
<td>11</td>
<td>Planned operation (17), Diagnoses (10), Risk of surgery/anesthesia (10)</td>
</tr>
<tr>
<td>Preoperative evaluation, anesthesia</td>
<td>34[2, 5, 8, 10, 12-24, 26-29, 31-37, 39-41, 45-47]</td>
<td>31</td>
<td>Anesthesia-related problems or complications (15), Airway examinations (13), Obesity (13)</td>
</tr>
<tr>
<td>Administrative information</td>
<td>20[5, 13, 15, 16, 19, 20, 24, 31-33, 35-37, 39, 41, 46]</td>
<td>20</td>
<td>Informed consent (12), Family or other support after surgery and during hospitalization (10), Information about how to contact with patient’s family after surgery (5)</td>
</tr>
<tr>
<td>Total</td>
<td>41</td>
<td>541</td>
<td></td>
</tr>
</tbody>
</table>
Figure 2.2: Occurrence of data items in the 41 included articles

2.4. Discussion

The large number of different data items found in this study supports the assumption that there is no agreement about which data items should be collected during the preoperative assessment. Large variation in data collection in the preoperative assessment impedes data exchangeability and emphasizes the need for standardization of pre-operative data collection. Standardization in a multidisciplinary setting like the preoperative assessment improves better communication and increases quality of care [49, 50].

Based on the data collected in the preoperative assessment, for some patients, physicians need time to optimize the patient’s condition preferably without disrupting surgical schedules [51]. Our study showed that this time period varies from the day of surgery to 30 days before surgery. This finding can not be generalized as the report rate on this data item was very low (44%) and some of the articles described this data ambiguously (“date separate from surgery” or “before admitting to hospital”), making it impossible to correctly calculate the variability. Moreover, the reported time period might be influenced by some socio economical aspects such as the number of available anesthesiologists and the number of patients on the waiting list. The ASA practice advisory has proposed that for all elective surgeries the anesthesiologist has to be informed properly about patient’s conditions before the day of surgery [52].
Although in this study we focused on data collection applicable to all preoperative assessment patients, and we excluded data collection for specific patient categories, our result revealed a large diversity of data items. Whereas each healthcare setting focuses on a limited set of data in the preoperative assessment, we retrieved 541 distinct data items in 13 categories. Although data collected during the preoperative assessment can be diverse depending on patient conditions, our inclusion criteria for selecting articles limited the patient diversity. Therefore, we expected to be able to identify a common set of data consisting of items mentioned in most (e.g. 90% or 95%) of the included articles. However, our review showed a large diversity which is illustrated by the fact that none of the data items was described in more than 75% of articles and only 6 data items were considered in more than 50% of the articles.

The categories “past history of clinical finding”, “physical examination procedure”, and “review of medication” contained the largest number of data items. This can be explained by the fact that collecting data about these three categories reveals important pre-existing patient conditions without requiring costly tests. The frequency of the reported data items in categories such as “laboratory test” and “preoperative evaluation, anesthesia” was a little higher than the frequency of the reported data items in the category “past history of clinical finding”. The ASA practice advisory has stated that pre-anesthesia physical examination at least should include airway, pulmonary and cardiovascular examination [52]. These were among the frequent data items in our study. This practice advisory also mentioned that the preoperative assessment should include review of medical records and patient interview to get information about current diagnoses, treatments and medical conditions but it does not explicitly describe which data items should be collected [52]. Frequently mentioned data items included in this literature review which can be obtained from medical record review or patient interviews were “age”, “diabetes”, “cardiovascular diseases”, “hypertension or high blood pressure”, “cigarette smoking and other use of tobacco”, “alcohol drinking”, and “pulmonary diseases”.

There are some limitations in this study. First, some studies may have been missed, because of existing limitations in MeSH terms (e.g. lack of preoperative assessment as a MeSH term) and defined keywords indexing in PubMed and CINAHL; and because our search was restricted to those articles that somehow refer to the preoperative assessment in the title. We used the keywords of a previous review [6] as the basis of our search strategy and expanded them to 4 sets of keywords. The recall of our search strategy was 75%, estimated by determining which relevant references of the review article[6] were retrieved. Given the extensive search strategy and the recall of 75% it is likely that most of the relevant articles have been found. Furthermore, inclusion of more articles will most likely merely strengthen the conclusion that there is a large diversity in the preoperative assessment data collection. Second, because we only addressed studies describing data applicable for the general preoperative patient population, we may have missed some studies which were about specific patient population but described the general preoperative assessment data. Third, authors of the included articles may not have mentioned all data items, but may have reported only those that are of interest to them or to the context of that article. Some data items are routinely collected in all cases and are important parts of the
preoperative assessment such as allergies, history of surgeries, vital signs, and NPO status. However, they were not frequently reported in all included articles probably because they were not relevant in the context of that paper and therefore they are not presented in table 2.2 as frequent data items. Authors are likely to consider some data items irrelevant for reporting e.g. data from the categories “demographic history detail” and “administrative information”. Therefore the included articles may not report all preoperative-assessment-related data and specifically figures on these categories have to be interpreted with caution.

The diversity of data collected by this review indicates that almost each health care setting collects a different dataset. Designing a standard dataset seems necessary to overcome the variety of data collected in different settings and will result in more effective communication in multidisciplinary settings such as the preoperative assessment setting. The majority of cancelled surgeries resulted from inadequate communication between disciplines involved in the preoperative assessment [53]. The study of Kluger showed that deficiencies in data in medical records were the most common cause of failures in communication [53]. Although it is difficult to introduce a comprehensive dataset for the preoperative assessment, because of its wide domain and diversity of patients undergoing on operation, there is a need for it. Such a dataset would give involved professionals a similar understanding of patients’ conditions and facilitate patient referrals across health care settings, thus increasing the quality of care.

Another issue that can be solved by such a standard dataset is potential miscommunication between patients and physicians. Patients commonly forget to mention important information (e.g. using Warfarin) to caregivers or caregivers forget to ask for it [5, 53]. A structured preoperative interview supports the transfer of all necessary information, from patient to anesthesiologist and vice versa. Using a standardized dataset will not only provide a structure for health care professionals in providing and obtaining all necessary data but it will also improve the recording of data which may lead to an improved patient outcome [5, 53]. Based on their clinical needs, institutions could extend the core dataset with more specific data items, e.g. preoperative pulse oximetry for patients with pulmonary disorders [54].

Our study was carried out to get insight into contemporary individual data items that are collected in the preoperative assessment as a basis to design a core (inter)national preoperative dataset. As identifying essential data items in the preoperative assessment only through frequency of citation is not enough, in parallel with this study an expert committee was established to design a draft of the dataset based on expert consensus. The defined data items in this draft were compared with the frequently mentioned data items (data items mentioned at least in more than 25% of the included articles) extracted in this review study. The development process of designing this preoperative assessment dataset can be found in [55]. The designed dataset can be obtained from the authors. The next step will be the design of an anesthesia information management system (AIMS) to collect and present data in a standardized and structured way, so that the exchangeability of data across different settings is facilitated.
We recommend using standard terminological systems such as SNOMED CT, and Logical Observation Identifiers Names and Codes (LOINC)\(^2\) to standardize the semantics of the data items and their values within the AIMSs. SNOMED CT is a reference terminology designed for documenting patient data and contains concepts, descriptions, and relationships between the concepts. It offers flexibility in expressing clinical concepts, and enables documentation of very detailed clinical data and, when required, aggregation on a more general level [56, 57]. LOINC covers clinical observations and laboratory tests which are part of the preoperative assessment.

Moreover, to standardize the architecture of the AIMSs to facilitate data flow among different systems, we recommend using information models such as Health Level 7 Reference Information Model (HL7 RIM) [58]. The systems should also be designed in such a way to help health care providers to find, perceive and interpret data in the system easily [59].

This study demonstrated the diversity in collected pre-operative assessment data and revealed the most frequently used data elements and the core categories of the preoperative assessment data. This diversity would result in lack of effective communication, impeding continuity of care and create an obstacle to reuse the data for other applications. The observed diversity demonstrates the necessity of defining a standard preoperative dataset, in order to enable adequate data availability in the multidisciplinary preoperative assessment setting.

\(^2\) [http://loinc.org/](http://loinc.org/)
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