Global applicability of a local physical examination template

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Abstract

Achieving semantic interoperability is a challenge due to the complexity and variability of health care and clinical information systems. Applying locally developed templates in other organisations and in standardisation work requires that the local templates have a global applicability. Therefore, the aim of this paper is to examine the global applicability of a physical examination template from Odense University Hospital. This was done by comparing the content of the template with an international text book description of a physical examination as well as 42 clinical findings derived from randomly chosen international clinical notes from physical examinations. To quantify differences and similarities between clinical notes and the template, SNOMED CT was used for analysis. The study showed that approximately ¾ of the 42 clinical findings could be represented in the Odense Template. This suggests that local templates, at least for well defined clinical processes, have a global applicability.

Keywords: Computerized medical records, SNOMED CT

Introduction

The heterogeneity of existing systems is said to be a major challenge when aiming at semantic interoperability in health care. Semantic interoperability means “ensuring that the precise meaning of exchanged information is understandable by any other system or application not initially developed for this purpose”[1]. Semantic interoperability is a prerequisite if benefits of electronic health records like e.g. shared care, quality assessment and research should be achieved. Heterogeneity is a challenge at different levels, firstly, from a technical viewpoint, different systems with a variety of underlying information models and proprietary terminology requires massive re-design to be able to support semantic interoperability. Secondly, from a clinical viewpoint, local clinical workflows and documentation might hinder the homogenisation that interoperability requires.

Local templates for clinical documentation have typically been adapted to local practices, and stepwise improvements have continuously been implemented in paper-based charts. Thus local templates typically become heterogeneous and are thus thought difficult or impossible to use in similar departments elsewhere. However, medicine as a discipline is international and so are many clinical standards. Thus, if local templates support a “global” clinical practice, there is a possibility that local work can serve as an input to standards development in medical informatics.

Typically in standards development, experts join to formulate the clinical content of standards e.g. in the openEHR community.[2] Similar examples of experts formulating the clinical content of standards can be found in the scientific literature.[3] These standards development initiatives often consider completeness and accuracy as the important quality criteria and leaves implementation to separate implementation groups or the users of the standards. In contrast, standards developed from analyzing local documentation and templates might ease standards implementation in local projects because the point of departure is clinical templates in use. This would be a step towards improved semantic interoperability between clinical information systems, especially if the clinical standard (e.g. a physical examination) was expressed using standardized information models (like HL7 v.3 RIM and templates/CDA or ISO13606 RM and archetypes/templates) and standardized terminology (like SNOMED CT).[4]

The objective of this study was to investigate how general a clinical template is in a global perspective. This was done by examining the “global” applicability of the local “Physical Examination template” developed at Odense University Hospital. The content of this local template was compared with an international procedural description of a physical examination and the content of international clinical notes regarding physical examination. Part of the comparison was done using SNOMED CT as reference. Hereby the differences and similarities of the content can be compared in detail in terms of their meaning and not only the terms used, because closeness of related terms in SNOMED CT can be a measure of how different or how similar the terms are.
Materials and Methods

Firstly, the physical examination is categorized using a text book description, MTSamples notes and a template from Odense University Hospital. Secondly, this material is analyzed using SNOMED CT.

Materials

The physical examination template from Odense University Hospital was collected in January 2011, and is a template in everyday use. The template was developed as part of an electronic health record (EHR) project based on a detailed requirement engineering process and with emphasis on standardisation within the organisation. Odense University Hospital has implemented Cambio Cosmic. This EHR-system is customizable, i.e. for each well-defined workflow a local template can be designed to support structured documentation. An earlier study has shown that the Odense University Hospital requirement engineering process consisted of two steps. First a clinical reference group with representatives from relevant specialties and with different clinical educations formed an overall documentation approach developing a number of standard workflows to describe e.g. the general medication and admission. As a second step each department in the hospital had the opportunity to add special cases from their local workflows to the standard workflows and special fields to the general templates. [5]

MTSamples[6] is a collection of clinical notes made available via internet as a resource. The notes from MTSamples do not have a well-defined source and they are provided by various users and the accuracy and quality of the notes is not guaranteed. However, an earlier study that used MTSamples notes together with notes from two hospitals has shown that 77% of statement types in the social history section could be found from MTSamples alone[7]. Therefore, the types of clinical statements in the physical examination section are expected to have a similar quality and thus be useful for the purpose of representing typical concepts and terms in physical examination notes.

MTSamples contains 491 notes in the category “Consult - History and Phy” where “Phy” is short for physical examination. 40 of these were randomly selected and the physical examination part was extracted if present. 6 notes did not have a physical examination which left 34 notes for further analysis.

For a global description of a physical examination the well-cited textbook, Clinical Methods: The history, physical and laboratory examinations, was used. In this textbook, the physical examination is summarized in 11 steps and ordered in a table. [8]

Categorization of a physical examination

For comparison the structure of the Odense template and the MTSamples notes were itemised in accordance with the textbook table.

Analysis of the information content in physiological examination notes

To obtain an overview of the content of the MTSamples physical examination notes a word-count on similar words (not case sensitive, no numbers) was performed ignoring common English words (like, are, and etc.). The resulting list was analyzed from the most frequent words to the least frequent. From this list concrete clinical findings were identified. For this study both actual clinical findings like “lymphadenopathy” and findings related to a specific part of the body like “Heart” was considered concrete clinical findings. To identify these findings, firstly, non-clinical findings was taken away (like patient, supple.), then unspecific clinical findings were analyzed. Unspecific clinical findings were e.g. normal, vital, bilateral and sounds. Going back to the original text, if the term was always used in the same (or a few) context(s), the context was specified. For example vital was always used in “vital signs” and therefore “vital” and “signs” was linked together for the word count. Also sound was used in two contexts namely “bowel sounds” and “breath sounds”, the correct context was specified in the word count. If the term was used in many different contexts like “normal” it was deleted from the word count. When the top 42 terms in the list were all concrete clinical findings, these terms were sorted according to the structure given by the textbook.

Comparison using SNOMED CT

To be able to compare the content of the clinical notes from MTSamples with the Odense template; all terms were mapped to SNOMED CT and structured in terminology-trees as illustrated in figure 1. Afterwards, it was analyzed how the terms from MTSamples were linked to the Odense template terms through the hierarchical relationships in SNOMED CT. This was done by analysing the terminology trees i.e. exact matches was identified as the concepts present in both the Odense template and MTSample derived clinical findings. Partial matches were identified in two groups. The first group consisted of concept pairs where MTSample derived clinical findings were children of Odense terms. The second group consisted of concept pairs where Odense terms were children of MTSample derived clinical findings. Also, unmatched terms were identified. Hereby, the analysis answered what information from the clinical notes could be expressed in the Odense template.

This was done for each of the 11 categories in textbook description of the physical examination. All negative findings from MTSamples were mapped to the corresponding positive finding, since SNOMED CT cannot handle negations systematically.
Figure 1 The figure shows a SNOMED CT tree for the first of 11 steps in a physical examination. The dark grey boxes are Odense template terms, the light grey boxes are MTSamples terms. The dark grey boxes with dotted lines are found in the Odense template as well as the MTSamples examples.

Results

In table 1, the text book categorization of the physical examination is described in the first column. The second column contains the terms from the Odense template, and the right column contains the findings identified in the physical examination notes from MTSamples.

In terms of similarities between the Odense template and the text book description it is clear that both are physiological examination descriptions mentioning organ systems systematically from head to toe with many similar terms e.g. eyes, neck, thorax and abdomen. When looking at the differences, it is clear that templates are much less process oriented than the text book description. For example, the text book description contains patient comfort and position whereas the template focuses on the organ systems that the findings are related to. In short, where the text book is process oriented, the template is information oriented. This is a predictable consequence of comparing a textbook on how to perform a physiological examination with a documentation template. However, there is some indication that the template is also sometimes a process support tool both when it comes to the sequence of the terms but also when a term includes a method e.g. cardiac auscultation and otoscopy. This creates other differences as well. For example motor strength, reflexes and proximal lower extremities are mentioned at different places in the text book description. However, the Odense template only has one field, namely, “limbs” that could possibly include information from all tree clinical areas. Another notable difference is template fields that are not mentioned as areas of interest in the text book description like “psychological”, “laboratory test results” and “additional” and vice versa, e.g. salivary glands and pelvic examination.
<table>
<thead>
<tr>
<th>Textbook categorization</th>
<th>Odense template keywords</th>
<th>MTSamples physical examination notes findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comfort</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Optimal environment</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Vital signs and general inspection</td>
<td>Vital signs reference, General clinical state, WHO Performance score, ASA score, Psychological, Nutritional status</td>
<td>Vital signs, Temperature, Pulse, Blood pressure, Respiratory rate, General, Distress, Alert, Weight</td>
</tr>
<tr>
<td>Head (Eyes, Ears, ophthalmoscopy, nose, mouth, face)</td>
<td>Skull and face, eyes, otoscopy, mouth and pharynx</td>
<td>HEENT (Head, Eyes, Ears, Nose, and Throat), Pupils, Head, Head atraumatic, Normocephalic</td>
</tr>
<tr>
<td>Neck (e.g. Lymph nodes, salivary glands and thyroid)</td>
<td>Neck, Lymph nodes, thyroid</td>
<td>Neck, Lymphadenopathy</td>
</tr>
<tr>
<td>Anterior torso (e.g. breast and heart)</td>
<td>Cardiac auscultation, Respiratory auscultation</td>
<td>Lungs, Heart, Cardiovascular, Heart Rhythm, Heart Rate, Murmur, Auscultation</td>
</tr>
<tr>
<td>Posterior torso (e.g. vertebral column)</td>
<td>Back</td>
<td></td>
</tr>
<tr>
<td>Completion of the “sitting” portion of the examination (motor strength, reflexes, pulse and sensation)</td>
<td>Neurological, Thorax, Breast finding, Abdomen, limbs</td>
<td>Pulses, Reflexes, Motor, Muscle strength, Chest, Abdomen, Abdomen nondistended, Bowel sounds, Extremities, Extremities cyanosis, Extremities edema, Extremities clubbing</td>
</tr>
<tr>
<td>With the patient supine (Thorax, abdomen, proximal lower extremities)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>With the patient standing (external genitalia of male, station and gait)</td>
<td>Genitals, Gait</td>
<td>Motion</td>
</tr>
<tr>
<td>Pelvic and rectal examination</td>
<td>Exploration of rectum</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Skin, Additional, Laboratory test results</td>
<td>Skin</td>
</tr>
</tbody>
</table>

Table 1. The table lists a textbook categorization of a physical examination in the first column. The second column contains the terms from the Odense University Hospital template, and the third column contains the findings identified in the physical examination notes from MTSamples.

| Exact matched terms | General finding of observation of patient, Vital signs finding, eye/vision finding, Ear and auditory finding, finding of neck region, General finding of abdomen, finding of region of thorax, finding of limb structure, finding of skin |

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### Table 2: The table presents the results of the analysis of how the content of the physical examination notes from MTSamples relates to the terms in the Odense University Hospital template according to the common reference, SNOMED CT.

<table>
<thead>
<tr>
<th>MTSamples terms children of Odense terms</th>
<th>General finding of observation of patient (Weight finding, vital signs finding)</th>
<th>Vital signs finding (Pulse finding, Body temperature finding, Blood pressure finding, finding of rate of respiration)</th>
<th>Psychological finding (feeling upset, mental alertness finding)</th>
<th>Cardiac auscultation finding (Heart murmur)</th>
<th>Finding of face (Nose finding)</th>
<th>Skull finding (head normal shape, fracture of skull)</th>
<th>Mouth and/or pharynx (Pharyngeal finding)</th>
<th>Eye/vision finding (Pupil finding)</th>
<th>Cardiac auscultation finding (Heart murmur)</th>
<th>Neurological finding (Motor nervous system finding, O/E motor sensory, O/E neurological reflexes)</th>
<th>Finding of Limb structure (Blue extremities, edema of extremity, finger clubbing)</th>
<th>General finding of abdomen (Swollen abdomen, finding of bowel sounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Odense terms children of MTSamples terms</td>
<td>Head finding (Mouth and/or pharynx, finding of face, skull finding)</td>
<td>General finding of observation of patient (Vital signs finding, Finding of ASA physical status classification)</td>
<td>finding by auscultation (Respiratory auscultation finding, Cardiac auscultation finding)</td>
<td>Cardiovascular finding, Cardiac finding (Cardiac auscultation finding)</td>
<td>Respiratory finding (Respiratory auscultation finding)</td>
<td>Finding of region of thorax (Breast finding)</td>
<td>Finding related to ability to move (finding related to ability to walk)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unmatched Odense terms</td>
<td>Finding of lymph node, finding of thyroid gland, WHO performance status finding, finding of nutritional status, Endoscopy of ear, Finding of back, Genital finding, rectum finding</td>
<td>Unmapped: Additional, Laboratory test results</td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Unmatched MTSamples terms</td>
<td>Lymphadenopathy of head and/or neck , finding of heart rate, finding of heart rhythm, finding of power of skeletal muscle, finding of peripheral pulse</td>
<td></td>
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</tbody>
</table>

Table 2 shows that the physical examination content of MTSamples and the Odense template is highly interrelated. The terms that are exact matches mean that similar content is found in both places. “MTSamples terms children of Odense terms” describe when there is an IS-A relationship between an Odense and MTSample term with the MTSample term being the subsumer. So, according to SNOMED CT Pulse finding, Body temperature finding, Blood pressure finding and finding of rate of respiration from MTSamples can be documented in the Odense template in the field vital signs finding, which makes perfect sense. Other examples are less operational e.g. it is doubtful that anyone would document weight finding and vital signs finding in a field called “General finding of observation of patient”.

“Odense terms children of MTSamples terms” describe when there is an IS-A relationship between an Odense and MTSamples term with the Odense term being the subsumer. In this category, the MTSample terms resembles coarse grained information compared to the Odense terms. This means that the information from MTSamples cannot be expressed in the Odense template unless the granularity level of the Odense template is slightly altered.

The unmatched Odense terms means that there are fields in the Odense template, which would never be instantiated if the 34 MTSample terms were representative for all findings in the physical examination. So the terms could possibly be candidates for deletion or coarser granularity. However, the textbook description clearly mentions several of the unmatched Odense terms, so the evidence level is insufficient in terms of recommending deletion.

The unmatched MTSamples terms means that it is clinical notes that cannot be documented in any fields in the Odense template. However, as in the other categories (but most notable here), the conclusions are not any more valid than the validity of the relationships in SNOMED CT. E.g. in SNOMED CT Lymphadenopathy of head and/or neck is not a finding of lymph node, which it obviously could be in the context of the physical examination. Another example, showing a general challenge when using standardised terminology is finding of heart rate and finding of heart rhythm. In the context of a physical examination these are probably found by cardiac auscultation. So, in the physical examination, heart rate and finding of heart rhythm could be children of cardiac auscultation, but this would not be true in other contexts, as they could be found by ECG or other more sophisticated methods.

The analysis shows that approximately ¾ of the findings extracted from MTSamples can be represented in the Odense template without any changes in the Odense design nor the semantic relationships in SNOMED CT.
Discussion

The use of SNOMED CT to analyze information match between notes and template have both benefits and shortcomings. Benefits include the possibility of linking together terms with different granulation level, relying on an international standard instead of personal judgement. If this method of analysis was used when evaluating proposed templates, there might also be a possibility to correct the granulation level of the template to match the content of actual clinical notes by reducing the template terms that are children of terms from clinical notes. The shortcomings include missing relationships e.g. between Lymphadenopathy of head and/or neck and finding of lymph node and relationships unfit for registration purposes e.g. “weight finding” and “vital signs finding” in “General finding of observation of patient”.

In this study very simple Natural language processing (NLP) techniques are used. More advanced NLP has been used for analysis of clinical notes[9], as well as manual categorization [7]. For this study, we did not aim at a complete list of clinical findings, but a list of common clinical findings. Therefore, the simple method was regarded sufficient for this purpose. Also, if the method was to be used in a clinical setting to evaluate proposed templates, the simplicity of the method might increase the probability that an analysis is performed on existing clinical notes before implementing the template.

Using clinical templates from similar organizations and analyzing them using local clinical notes could possibly reduce time spend on local requirement engineering. However, exploiting the global applicability of local templates to develop standards might support new template development even better. The global applicability of the local Odense template is notable, as the terms used are highly related to both text book descriptions of and clinical notes regarding the physical examination. This indicates that local templates where the underlying clinical process is well-defined could be very useful in standardisation work. However, the complexity of using existing templates changes when having two or more templates describing the same procedure from different organisations or different clinical specialties. Imagine one physical examination template having a “cardiac auscultation” field and another having a field called “Cardiovascular findings”. The terms are clearly related, but the granulation level is different. E.g. findings related to heart rhythm would fit into both fields, whereas the finding “Abdominal aorta is not palpable” would only fit into the latter category. The implications of reaching interoperability between the two sites are obvious. Examining the challenge of using multiple templates in standardisation work will be a priority in future works.

Conclusion

Achieving semantic interoperability is a challenge due to the complexity and variability of health care and clinical information systems. Therefore re-use of material from other institutions compose a promising point of departure. This study shows that a local physical examination template has the ability to structure common physical examination clinical findings from another context. This suggests that templates, at least for well defined clinical processes, have a global applicability. Of course, this claim should be examined further for other clinical processes, other templates and other clinical notes. Global applicability would make local templates useful in standardisation projects.

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