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Mapping Equivalence of German Emergency Department Medical Record Concepts with SNOMED CT After Implementation with HL7 CDA

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Abstract. Introduction: The German Emergency Department Medical Record (GEDMR) was created by medical domain experts and healthcare providers providing a dataset as well as a form. The trauma module of GEDMR was syntactically standardized using HL7 CDA and semantically standardized using different terminologies including SNOMED CT, LOINC and proprietary coding systems. This study depicts the mapping accuracy with aforementioned syntactical and semantical standards in general and especially the content coverage of SNOMED CT. Methods: The specification of GEDMR (V2015.1) concepts with eHealth-standards HL7-CDA, LOINC, SNOMED CT was analyzed. A content coverage assessment was made using the ISO TR 12300 rating scheme, following descriptive analysis. Results: The trauma module of GEDMR contains 489 concepts, with 202 concepts expressed via HL7 CDA structure. It is possible to code 89 % of the remaining concepts via SNOMED CT. 79 % provide an advanced level of semantic interoperability, as they represent the source information either lexically or as an approved synonym. Discussion: The terminology binding problem is relevant when combining different standards for syntactic and semantic interoperability with best practice documents and reference specifications providing guidance. A national license and extension for SNOMED CT in Germany as well as an ongoing effort in contributing to the International Version of SNOMED CT would be necessary to gain full coverage for concepts in German Emergency Medicine and to leverage the associated standardization process.

Keywords. health information exchange, SNOMED CT, Health Level Seven, Logical Observation Identifiers Names and Codes, Emergency Medicine

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1. Introduction

Syntactical and semantical interoperability is an essential prerequisite in the developing eHealth domain [1]. In this context, HL7 Clinical Documentation Architecture (HL7 CDA) is a leading document markup standard for creating syntactical and semantical standardized clinical documents [2]. Primarily, the standard provides the structure for syntactic interoperability, which is specified in the underlying HL7 Reference Information Model (RIM) [3]. Semantic interoperability can be achieved by reference terminologies like SNOMED CT used within CDA. Since the RIM specifies internal vocabularies for some structurally essential coded attributes, there are overlaps between CDA and SNOMED CT, which are resolved by guidance documents [4]. As there is no comprehensive adaption of SNOMED CT in Germany, national experiences with eHealth implementations combining HL7 CDA and the terminology are very limited [5].
The professional association the "German Interdisciplinary Association of Critical Care and Emergency Medicine" (DIVI), released a standard record for emergency departments in 2010 defining data standards. This German Emergency Department Medical Record (GEDMR) [6] was created by medical domain experts and healthcare providers defining a dataset and a form as technical artifact. As part of the governmental funded research project "Improvement of Health Services Research in Emergency Care in Germany by Establishment of a National Emergency Registry" two modules (basic and trauma) of the six-module GEDMR were syntactically standardized using HL7 CDA and semantically standardized using different terminologies including SNOMED CT, LOINC and proprietary code systems. The trauma module is to be investigated in this study.
Aim of this study is the actual realisation of the GEDMR-concepts with the differently named syntactical and semantical standards in general and especially the degree of equivalence of GEDMR concepts mapped with SNOMED CT.

2. Methods

The final implementation of the GEDMR (V2015.1) was analyzed. A HL7 CDA Release 2 specification of the trauma module was created, using the terminologies SNOMED CT and LOINC as well as HL7 Codes and proprietary codes when not coded otherwisely. The specification process was supported using the ART-DECOR® tool suite (http://www.art-decor.org) for collaboration between healthcare providers, terminologists and architects.
After extraction of all used concepts from the ART-DECOR database, their representation within the HL7 CDA was categorized. Used categories were "representation by HL7 CDA", "representation by LOINC" according to HL7 CDA recommendations, "representation by SNOMED CT" and "representation by proprietary codes" if no matching codes were found otherwise. For all concepts categorized "representation by SNOMED CT", a content coverage assessment was made using the ISO TR 12300 rating scheme "Degree of equivalence between source and target" [7]. As there is no valid German version of SNOMED CT available at present, concepts of the GEDMR had to be translated into English language for coding. No ethical vote was needed as neither humans nor personal data were included in this study.

3. Results

The trauma module of GEDMR contains 202 concepts with 287 sub-concepts in choice list items. Of these 489 concepts, 3 concepts were represented by pure CDA structure namely patient name, sex and date of birth. They are represented by XML-tags like <name> within the <patient> element of the record target. Further 199 concepts within the CDA were represented through Boolean expressions (yes/no), amounts of fluids/substances and timestamps. Of the remaining 287 concepts to be coded, Table 1 shows the chosen coding system according to best practice coding hierarchy HL7 CDA, LOINC, SNOMED CT.

Table 1. Analysis of terminology system used for concept coding within CDA (n=287)

Terminology System	Number of concepts	Percentage
Representation by HL7 CDA codes	8	3 %
Representation by LOINC	84	29 %
Representation by SNOMED CT	174	61 %
Representation by proprietary codes	21	7 %

While 92 concepts are represented by HL7 CDA or LOINC, 195 concepts are left for represention by SNOMED CT. Table 2 shows the contextual representation accuracy concerning these concepts, referring to the ISO TR 12300 rating. Concepts with no match in SNOMED CT were represented by proprietary codes (Table 1).

Table 2: Representation accuracy of SNOMED CT concepts suitable for the trauma module HL7 CDA (n=195)

Rating	Interpretation	Number of concepts	Percentage
1	Complete lexical match	129	66 %
2	Synonyme	25	13 %
3	Source broader than target	13	7 %
4	Target broader than source	7	3 %
5	No match	21	11 %

Assuming a direct comparison between source and target concept, there is a complete lexical match between 129 concepts, e. g. “Thoraxdrainage” (source), which means “chest drain” in English language, and |258643002|chest drain (physical object)| (target). Synonyms have been noted in 25 cases, e. g. “Analgosedierung”, which means “analgosedation” in English, and |241712003|sedation with analgesic adjunct (procedure)|. The source concept has been found broader than the target concept in 13 cases, e. g. “Defibrillation”, which means “defibrillation” in English, and |308842001|direct current defibrillation (procedure)|. The target concept has been noted broader than the source concept in 7 cases, e. g. “Kristalloide Infusionslösung”, which means “crystalloid infusion solution” in English, and |51644004|electrolytic agent (substance)|.

Of chosen SNOMED CT concepts, 79 % percent provide either a complete lexical match or a synonyme respective the eligible GEDMR source concepts. 11 % of the chosen SNOMED CT concepts show broader expressions from both viewpoints, from source to target or from target to source. Thus, a successful coding rate of 89 % could be reached using SNOMED CT International for GEDMR concepts not coded with CDA or LOINC.

4. Discussion

Implementing data standards published by professional medical associations with HL7 CDA is one of the intended use cases [8]. For secondary reuse and machine processability of concepts, the underlying HL7 CDA structures and data types [2] as well as the usage of reference terminologies like LOINC and SNOMED CT are utilized in the CDA specifications. When implementing data standards in CDA, it is not directly obvious which coding system should be used for concept coding under certain circumstances. This terminology binding problem [9] is relevant when trying to achieve syntactic and semantic interoperability. HL7 provides guidance by best practice documents and reference specifications. For example, LOINC acts as an industry standard for encoding CDA Document Types for interoperability purposes according to the LOINC document ontology [10]. Further LOINC usage in CDA implementation guides refers to section heading codes (CDA Level 2). But also in the machine-readable clinical content (CDA entries), recommendations and reference specification practice are followed. Colloquially spoken, LOINC is the coding system used for asking questions ("which type of observation"), while SNOMED CT is used for coding clinical data being the answer to this question ("what coded result") [11].

As syntactic and semantic interoperability evolves world-wide, Germany has serious drawbacks without a national terminology for semantic interoperability being available to all participants of the health care system. SNOMED CT is the growing semantic interoperability standard in Europe and beyond. Many European countries are members of SNOMED International including 6 out of 9 direct neighbours to Germany.

Currently, of the concepts not coded by CDA or LOINC, 89 % can be coded successfully via SNOMED CT. 79 % provide an advanced level of semantic interoperability. Thus, a high coverage of GEDMR concepts with SNOMED CT lacking any national adaption is already possible. A German adaption including National Extensions to SNOMED CT is necessary for non-codeable concepts, with new questions arising. E. g., the *Severity score for illness or trauma* of the National Advisory Committee on Aeronautics (NACA) is used in the German Emergency Medical Service as well as in different European countries including member states of SNOMED International [12]. Adding the concept to a National Extension alone would not be sufficient as other countries may want to use this code as well. In other words, coordination is also desired on an European level.

As SNOMED CT human readable terms are primarily in English, sufficient competence regarding language and cultural differences is necessary to properly map German terms to English SNOMED CT concepts. For this work, a research license of SNOMED CT is available but the resulting CDA with SNOMED CT codes is intended to go in live-operation in at least 15 project hospitals. As Germany has no national license of SNOMED CT and thus a substantial license fee is involved for every participating hospital, we decided to replace all 174 sucessfully SNOMED CT-coded concepts with proprietary codes, until there is a national license available in Germany.

Therefore, for introduction of SNOMED CT in Germany, three prerequisites need to be fulfilled:

1. At least, a German license of SNOMED CT would be necessary on a national level to support the eHealth infrastructure.
2. A German extension of SNOMED CT including a translation would be necessary; this includes quality assurance methodologies and a national endorsement mechanism.

3. The remaining 11 % not matchable concepts have to be incorporated into SNOMED CT either as a German Language Reference Set, German National Extension or within the international core.

5. Conclusion

Coding of concepts within a HL7 CDA is subject to a hierarchical set of partly best practice rules. While some concepts are coded by CDA structure or coding system, section headings are usually coded using LOINC. The remaining clinical concepts were in 89 % successfully coded via SNOMED CT, with a high level of representation accuracy. A national license and extension for SNOMED CT in Germany as well as an ongoing effort in contributing to the International Version of SNOMED CT would be necessary to gain full coverage for concepts in German Emergency Medicine and sharing these concepts with other contributing countries.

Conflict of Interest

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