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Standardizing Germany's Electronic Disease Management Program for Bronchial Asthma

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Abstract. Disease management programs coordinate and manage treatment between physicians and across sectors of the healthcare system. The aim is to reduce existing care deficits (overuse, underuse and misuse) and thus improve the quality and cost-effectiveness of care. To facilitate the treatment of chronic diseases such as asthma, it is important to continuously document a patient's medical history. For this purpose, it is necessary to be able to integrate and exchange data from and between multiple different information systems. Aiming to ensure interoperability across electronic documentation systems, this paper proposes the standardization of the KBV's (*National Association of Statutory Health Insurance in Germany*) specification for the electronic Disease Management Program (eDMP) for bronchial asthma. Therefore, international standards like SNOMED CT, LOINC and UCUM were chosen to encode clinical information, while evaluating their suitability with the scoring system ISO/PRF TR 21564. The resulting analysis showed that most of the terms had either a complete or partial equivalent term in one of the terminology systems. Therefore, future implementations of the eDMP for bronchial asthma that utilize standard terminologies could benefit from data integration from different sources like electronic health records and reduce redundancies in data capture and storage.

Keywords. Asthma, SNOMED CT, LOINC, interoperability, standardization

1. Introduction

In 2005 the KBV (*Kassenärztliche Bundesvereinigung*) introduced a specification for the electronic Disease Management Program (eDMP) for patients with bronchial asthma. DMPs are an approach to facilitate coordination and communication between stakeholders and thus improve the quality of care for chronically ill patients. The objective is to manage care between providers and across inpatient and outpatient

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sectors of the healthcare system. According to Mehring et al. [1], a retrospective five-year analysis of the asthma DMP showed promising results for improvement of care, especially concerning pharmacotherapy and hospitalization. Exchange and access to information is vital in DMPs so that general practitioners, specialists and hospitals etc. can work together in close interaction. Still, the eDMP does not utilize terminology standards, which is a crucial factor to improve communication between medical information systems and bring forward semantic interoperability in German healthcare.

Standards are key resources, ensuring that data can be unambiguously interpreted and understood. Today, some terminology standards have been widely adopted [2]. For example, the Systematized Nomenclature of Medicine Clinical Terms (SNOMED CT) is a controlled clinical terminology that is used as a reference terminology in electronic health records and medical information systems [3]. SNOMED CT concepts provide a stable mechanism to capture information and support data integration. When used as a reference terminology, SNOMED CT can be utilized as an intermediary between interface terminologies or classification systems [4]. Moreover, Logical Observation Identifiers, Names and Codes (LOINC) is a code system for identifying measurements, observations and documents. LOINC is used in laboratory testing and also for clinical measurements like vital signs or assessment instruments. A LOINC term is a representation of a question about a clinical phenomenon that can be observed or measured [5]. In addition to that, the Unified Code for Units of Measure (UCUM) is a code system that provides units of measures to facilitate unambiguous electronic communication of quantities together with their units [6].

Previous research has shown the broad coverage and suitability of SNOMED CT in various clinical use cases [7, 8]. This paper aims to evaluate whether these findings can be adopted for the clinical content of the KBV eDMP for bronchial asthma and if the interface specification can be realized using international terminology standards to foster semantic interoperability. Hereby, an analysis of the suitability of selected standards was carried out.

2. Material and Methods

The KBV eDMP bronchial asthma data model (V4.44) [9] uses the Standardized Communication of Information Systems in Physician Offices and Hospitals using XML (Sciphox) format for data exchange [10]. Data is contained in building blocks of type *observation*, which in Sciphox are called Small Semantic Units (SSU). Each observation-SSU captures data in pairs of *parameter* and *value* elements. The parameter stores what is being observed, i.e. *Co-morbid conditions*. The *value* contains the actual result of the observation, i.e. *Coronary arteriosclerosis, Dyslipidemia, Diabetes mellitus,* etc. Values can also be of numerical type and include the numerical value and its corresponding unit of measure.

A similar approach to what has previously been proposed by Brammen et. al [11] was chosen. All concepts for parameters and values were extracted from the specification. Administrative data was excluded from the annotation. The resulting dataset contains 66 unique concepts, which were annotated with SNOMED CT, LOINC and UCUM respectively.

The distribution of roles in our mapping team was loosely based on the *Workforce* determinant of the ISO/PRF TS 21564 [12], which defines five role groups: Map decision maker/sponsor, Map project leader, Map specialist, Map implementer and

Map governance team member. Our mapping team consisted of a Map decision maker, a Map project leader and three Map specialists.

We mapped every data element to all three chosen systems to then decide, which code system was best suited for each individual concept. Usually, LOINC codes can be used for the questions, while SNOMED CT refers to the corresponding answers. However, the eDMP dataset has a couple of "questions" that are better covered by SNOMED CT, such as *Respiratory corticosteroid (substance)*. Table 1 shows the final distribution of the dataset within the chosen coding systems.

Table 1. Distribution of single data elements within the chosen systems: SNOMED CT, LOINC and UCUM.

Code System	# of Data Elements	Percentage (%)
SNOMED CT	50	76%
LOINC	12	18%
UCUM	4	6%

The annotation was first carried out by two of our map specialists, and then reviewed and discussed with a further map specialist and the map project leader. As a last step, these were reviewed by the map decision maker. An example of the mapping is shown in Table 2.

Table 2. Mapping examples from eDMP to SNOMED CT, LOINC and UCUM respectively.

eDMP	Code	Term	Code System
Asthma bronchiale	195967001	Asthma (disorder)	SNOMED CT
Körpergröße	8302-2	Body height	LOINC
m	m	Meter	UCUM
Asthma-Schulung empfohlen (bei aktueller Dokumentation)	401135008: 260686004= 424900004	Asthma education (procedure): Method (attribute)= Recommendation – action (qualifier value)	SNOMED CT

The mapping results were then rated and classified referring to the ISO/PRF TS 21564 [12]. This rating scheme was used to measure the degree of equivalence between the dataset and target concepts of the selected code systems. The selected ISO standard distinguishes five degrees of equivalence (Table 3). To assess mapping quality, the average mapping equivalence score was determined.

3. Results

All in all, the mapping results were relatively high with an average ISO 21564 equivalence assessment score of 0.73. 59% of the data elements had a completely equivalent reference term in the chosen international standards. Only 6% of the terms had multiple target elements, meaning that 94% of concepts had a specific respective code. Every data element has a match in either of the used systems (Table 3).

Table 3. ISO 21564 Equivalence Assessment score: ~0.73

Rating	Description	Number of concepts	Percentage (%)
0	Equivalent meaning	39	59%
1	Source is wholly included in target	10	15%
2	Source is partially included in target	13	20%
3	Source is mapped however there were many options. Source map is the best comparison rather than the actual correspondence	4	6%
4	No overlap	0	0%

4. Discussion

The results show that the combination of SNOMED CT, LOINC and UCUM is well suited for the annotation of the eDMP asthma specification, which is quite impressive when mapping a dataset that was developed without taking their compatibility with such standards into consideration. LOINC performs well for observations, like expressing body height or smoking status in a structured format. Additionally, LOINC offered well-suited solutions for rather specific questions from the eDMP, such as the questions concerning the frequency of usage of the prescribed medication or frequency of asthma daytime symptoms during the last four weeks. Clinical findings for co-morbidities like diabetes or COPD were successfully mapped to SNOMED CT concepts with equivalent meaning. While LOINC and SNOMED CT covered a great majority of the available data elements, UCUM was applied for the units of measure, as recommended by Benson et al. [3]. Still, the annotation of the dataset presented some challenges. For example, there were a few very specific data elements such as "*Asthma education completed before the enrollment for the DMP*", for which we had to build a post-coordinated SNOMED concept as shown in Figure 1. There is arguably still room for interpretation, if that expression is an unambiguous representation of the source. A further challenge was the imprecise annotations for 26% of the data elements, where the concepts were either not wholly included in the target system or there were multiple mapping options. One of these cases is the unit of measure for FEV1 (*Forced Expiratory Volume*), where the closest annotation was the respective UCUM for a percentage value, leaving aside what the unit actually represents, which is the relative deviation of the measured FEV1 from the predicted desired value.

```
401135008|Asthma education (procedure)| :
        { 260686004|Method (attribute)| =
          424900004|Recommendation - action (qualifier value)|,
          370134009|Time aspect (attribute)| =
          255594003|Complete (qualifier value)| }
```

Figure 1. Post-coordinated SNOMED CT Expression

The time and workforce required for such annotations should not be underestimated. The annotators need to have a certain understanding of clinical terminologies and the applied coding systems. Our mapped dataset was rather small compared to others, such as the one used by Bramen et. al [11] which consisted of 287 different concepts. For these cases, it would be advisable to apply modern NLP

(*Natural Language Processing*) approaches, as proposed by Kate et. al [13]. We propose to apply machine learning approaches to create a first annotation proposal and then let mapping specialists review and correct the results. This should at least significantly reduce the human resources required for such a tedious task.

The transport format seems to be a limiting factor as well. The KBV specification uses Sciphox XML, which restricts the data model to observation-value tuples. The application of more flexible data modelling strategies, such as HL7 FHIR (*Fast Healthcare Interoperability Resources*) [3] or the Sciphox successor HL7 CDA (*Clinical Document Architecture*) [14], would not only enable the application of multiple coding systems, such as a combination of LOINC, SNOMED CT and UCUM as applied for our purposes, but it would also provide resources to represent more complex data structures. Future implementations of the eDMP for bronchial asthma that use standardized terminologies could integrate data from different sources like electronic health records and reduce redundancies in data capture and storage. Thus, eDMPs could become an integrated part of an interoperable eHealth landscape.

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