German Medical Data Sciences: Shaping Change – Creative Solutions for Innovative Medicine
R. Röhrig et al. (Eds.)

doi:10.3233/SHTI190806

Implementing LOINC – Current Status and Ongoing Work at a Medical University

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Abstract. The Logical Observation Identifiers, Names and Codes (LOINC) is a common terminology used for standardizing laboratory terms. Within the consortium of the HiGHmed project, LOINC is one of the central terminologies used for health data sharing across all university sites. Therefore, linking the LOINC codes to the site-specific tests and measures is one crucial step to reach this goal. In this work we report our ongoing efforts in implementing LOINC to our laboratory information system and research infrastructure, as well as our challenges and the lessons learned. 407 local terms could be mapped to 376 LOINC codes of which 209 are already available to routine laboratory data. In our experience, mapping of local terms to LOINC is a widely manual and time consuming process for reasons of language and expert knowledge of local laboratory procedures.

Keywords: LOINC, Terminology, Medical Coding, Quality Control, Data Sharing, Health Information Interoperability

1. Introduction

The heterogeneity of hospital information systems is a major challenge for sharing and reusing routinely collected health data. Increased efforts to make health data shareable and interoperable in recent years have led to increased efforts towards standardized data capture and management. Interoperability is typically subdivided into four tiers: organizational, semantic, syntactic and structural. In particular, semantic interoperability aims at establishing exchange of data with unambiguous and shared meaning between computer systems. For this purpose, classification systems such as nomenclatures or taxonomies (e.g. ICD-10, OPS, ATC or SNOMED) are used.

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In Germany, projects such as the German Biobank Alliance (GBA) [1], or the Medical Informatics Initiative (MI-I) [2], both funded by the German Federal Ministry of Education and Research (BMBF), are aiming at national architectures for semantically interoperable exchange of biological and health data. International projects (e.g. the Electronical Health Record for Clinical Research – EHR4CR [3]) rely on semantic standards as well. HiGHmed, one of the BMBF-funded consortia within the MI-I, is a collaboration of eight large German university hospitals and the German Cancer Research Center [4]. In HiGHmed, multilocal and heterogeneous data will be structured and integrated in local Medical Data Integration Centers (MeDICs) based on internationally accepted, open standards (openEHR). In a second step, HiGHmed will establish an IHE infrastructure for the cross-institutional exchange of medical data. The cross-institutional exchange of medical data is expected to improve patient care and research opportunities. Therefore, data must be interoperable at each MeDIC. To resolve the problems of the semantic interoperability, the hospital specific codes (such as laboratory terms) need to be harmonized by using international terminologies.

Conditions and necessary measures for interoperability and interchangeability of the data are coordinated across the consortia by the national working groups Interoperability and Data Sharing. In the MI-I core dataset, LOINC was defined for coding of laboratory analyses [5].

The Logical Observation Identifiers, Names and Codes (LOINC) nomenclature is, besides SNOMED and RxNorm, one of the three most-used standard terminologies for laboratory values worldwide [6,7]. Most analyses, tests and parameters can be expressed in LOINC codes. In Germany, LOINC is provided by the DIMDI (German Institute of Medical Documentation and Information) and freely accessible, why the implementation of codes can be conducted easily at each site. Within the MI-I, a list of 300 commonly used LOINC codes was compiled, which is then shared across the consortia for harmonization.

2. Objectives

This paper aims to give an insight into the implementation of LOINC codes into the laboratory information system (LIS) of the Hannover Medical School (MHH) and into the research data warehouse of the MHH as well as the current state of development and application of LOINC in research projects. Furthermore, we describe the challenges we were facing in several implementation rounds, our solutions and lessons learned for the community.

3. Methods

3.1. The Enterprise Clinical Research Data Warehouse and the pilot project

The Enterprise Clinical Research Data Warehouse (ECRDW) is an interdisciplinary data integration and analysis platform for research-relevant issues at the MHH that has been available enterprise-wide since July 2013. ECRDW incrementally integrates heterogeneous data sources and currently (as of 05/2019) contains data of more than 2,2 million distinct patients with more than 1.9 billion single data points (e.g. diagnoses, lab results, medical records and metadata to linked data (bio samples, images)) [8].

In a collaborative research project between the University of Applied Sciences Hannover and the MHH a prototype platform for the analysis and evaluation of leukemia data from the ECRDW has been developed [9]. One of the main challenges was to map relevant local laboratory analysis codes to LOINC in order to assure semantic interoperability so that data can be used for research purposes across different institutions. For this pilot project 28 relevant analysis codes have been mapped to LOINC.

3.2. Definition of the most frequently performed laboratory tests and implementation phase

For this study, the above mentioned laboratory tests mapped in the first step were used. We analyzed these tests recorded to the ECRDW within the first 60 days after the operation start-up of the new central laboratory. The initial snapshot covers routine data from April to June, 2018. The snapshot covers the 1,658 different laboratory analyses recognized by the ECRDW, whereas the number of performed laboratory tests was 2,031,646 in this period. Using the LIS analysis database, a Masterfile containing all local analysis codes was generated as an excel file. The file contains 3512 lines, each line representing one local analysis dataset as recorded to the LIS. This file contained columns with the local code, local name, material and unit. It was imported into the Regenstrief LOINC Mapping Assistant (RELMA®) [10,11] tool and mapping was performed manually, since the automapping function revealed confusing or incomplete results depending on whether the “current linguistic preference” was set to English (Regenstrief) or German (DIMDI), respectively. Mapping occurred stepwise and in a first step, mapping of the most often used laboratory tests was conducted, culminating in a first set of 209 LOINC codes assigned to local terms.

Following manual revision and correction rounds by laboratory experts these mapped codes were implemented by the according LIS manufacturer. To implement the codes to our Hospital information system (HIS) we had to adapt the ETL (extract, transform, load) processes to and from our communication server as well. This included the extension of the HL7-OBX segment to the triplet LOINC code [12], used terminology and text. Accordingly, ETL processes to the ECRDW needed to be adapted as well and the official LOINC Regenstrief catalogue was integrated.

3.3. Evaluation

Our first approach for quality management was to check the names of the analytes in the ECRDW and match them to those in the Regenstrief LOINC database and RELMA®. Since the LIS is a data source of laboratory data for the ECRDW, the ECRDW contains the LIS specific classification system of analytes (naming, units of measure, sample type). The second approach was to check the units of measures in all analytes, whereby the same data sources were examined. All these checks were done independently from the coder. Other approaches for quality management were to check the expected data types as given in the Regenstrief LOINC database, e.g. the check for comments or numbers.

4. Results

After initial mappings, we implemented the first LOINC codes to our LIS by August, 2018. To date (May 2019) we mapped up to 451 of the total of 1,658 (26.7 %) local terms stored in ECRDW to LOINC. However, still only the initial set of 209 LOINC codes is implemented in the LIS and thus available for the evaluation of routine data transferred from the LIS to the ECRDW.

Regarding ECRDW, the 451 local terms are represented by 373 LOINC codes, as some laboratory analyses use the same code due to minor protocol changes. For example alanine aminotransferase can be analyzed from serum or plasma derived from heparinized blood. For either observation a dataset is contained in the LIS but both have the same LOINC code. Actually, a total of 9,676,469 laboratory tests were performed (August 2018 - May 2019), of which 3,651,891 (37.7%) tests were performed with LOINC code. Some of the codes mapped but not yet used are for example due to the HiGHmed use cases or are not documented in our LIS. In **Table 1**, some tests with their corresponding codes are listed.

Table 1. Laboratory analyses and their corresponding LOINC codes and, if applicable, their number of performances at the MHH

Name of laboratory analyses	unit	Corresponding LOINC code	Number of performance
Hemoglobin in whole blood	g/dl	718-7	181082
Creatinine with serum	µmol/l	14682-9	153649
C reactive protein with serum	mg/l	1988-5	140212
Coagulation surface induced (APTT)	sec	14979-9	130556
Potassium with serum	mmol/l	2823-3	120479
Sodium with serum	mmol/l	2951-2	117781
…	…	…	…
Coagulation tissue factor induced.INR	(ratio)	6301-6	Cardio use case
Body weight	kg	29463-7	Not in LIS

According to a first round of quality assurance, about 65 of the assigned codes will need review due to misleading or missing units or reference intervals (data not shown). About 10 codes out of first 209 needed to be revised yet as they escaped the first round of manual expert revision and due to rearrangements in the laboratory processes. The mapped LOINC codes were and will constantly be implemented into the LIS datasets of the according laboratory analyses as mapping of the total inclosed observations evolves. Thus, we are available for cross platform communication already but mapping is not completed yet.

5. Discussion

In previous works, the benefits and challenges of using and implementing LOINC are well-discussed [6,7,13]. Two benefits of a standardized laboratory analyses terminology are patient safety because of a consistent test result interpretation and reduction of test costs respectively. Nevertheless, implementing LOINC within the HIS remains challenging, especially for small hospitals, since mapping is time consuming and, more importantly, LOINC mapping specialists are rare. This paper summarizes our approaches and experiences of implementing LOINC to our LIS and HIS. Although there are already approaches in mapping LOINC codes automatically using machine learning (e.g. [14,15]), this is not yet fully tested for the German vocabulary and thus was not used due to the comparatively low precision. As mentioned above, the semi-automatic mapping tool could not be used due to the German test short names within the LIS, in contrast to e.g. Zunner et al [16].

Indeed, the implemented LOINC codes are actually used and planned to be used in several research projects. Although HiGHmed was the accelerating project, LOINC codes are used in projects like GBA, EHR4CR and the according InSite platform [17] and its proceeding project EHR2EDC [18] as well, not to mention any research project in need of laboratory test results. As a service for our researchers, one may filter for specific laboratory analyses via a search engine based on SharePoint BDC and thus request specific results per LOINC for the ECRDW.

In adapting the new terminology on a technical level, we planned to consider placeholders for other terminologies as well, e.g. SNOMED CT, which is also recommended for future use [19].

5.1. Lessons learned

It might be trivial, but to our surprise the most important point in implementing the new terminology was to organize an interdisciplinary group of medical computer scientists, technical staff and, above all, laboratory experts. In the very beginning, it took some discussions on how to start before assigning a single code. To our experience, codes can partly be pre-assigned by technical staff using the RELMA tool, but the evaluation has to be carried out by the laboratory domain experts. The assignments of the first codes proved to be comparatively simple, but due to multiple codes and units for one single analysis, the assigner needs some time in finding the correct code and expert knowledge of the laboratory site. In summary it can be stated that the mapping of LOINC codes is very time consuming and it cannot be processed automatically.

Other crucial points were the quality assurance procedures, which were discussed in the group but, in the end, evaluated by the laboratory professionals as well. Thus, our conclusion is that implementing of LOINC codes to the LIS at a site is more an organisational and time-consuming problem than a professional one. A large portion of the codes could easily be implemented in a comparatively short time, given an initiation point and an interdisciplinary group to work together.

5.2. Limitations

It cannot be excluded that in the first phase analyses with different initial codes are actually the same laboratory analyses. We still are facing some challenges in assigning codes due to multiple units or reference intervals for the same tests, which is also already addressed in two other works [20,21]. Since the exemplified units within the LOINC table are most often not used at on-site, but on-site units meet the criteria of the PROPERTY column, this leads to confusion. To our understanding the major determinant for LOINC mapping is to meet the PROPERTY criteria. Thus conversion mechanisms and strategies need to be explored. However, reference intervals do not need to be considered for LOINC mapping in our opinion. Furthermore, we started with domain experts from clinical chemistry department. For future implementations of e.g. microbiology terms to LOINC, using special LOINC datasets or the IHE PaLM domain is to be discussed, as well as using the SNOMED CT terminology [7].

We want to explicitly mention that each LIS and HIS has its own procedures, thus each hospital might establish own procedures for mapping and implementation. Last but not least, the on-site available LIS needs to support LOINC application with a corresponding data field.

As mentioned in 3.2, the LOINC code is transferred from LIS into our HIS and into the ECRDW within HL7 messages. Although there are first developing approaches for FHIR profiles for laboratory use in Germany, we do not plan to implement FHIR in the foreseeable future.

6. Acknowledgement

The LOINC working group was initialized because of the project "HiGHmed" as part of the German Medical Informatics-Initiative (MI-I). The project is funded by the German Federal Ministry of Education and Research (BMBF, grant id: 01ZZ1802C). We acknowledge all members of the LOINC working group at the MHH, who are participating in this work, partially without any further funding.

The full list of our mapped codes will be published online under doi:10.17632/fjbzbymbc4.1.

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