Report on the Project for Establishment of the Standardized Korean Laboratory Terminology Database, 2015

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The National Health Information Standards Committee was established in 2004 in Korea. The practical subcommittee for laboratory test terminology was placed in charge of standardizing laboratory medicine terminology in Korean. We aimed to establish a standardized Korean laboratory terminology database, Korea-Logical Observation Identifier Names and Codes (K-LOINC) based on former products sponsored by this committee. The primary product was revised based on the opinions of specialists. Next, we mapped the electronic data interchange (EDI) codes that were revised in 2014, to the corresponding K-LOINC. We established a database of synonyms, including the laboratory codes of three reference laboratories and four tertiary hospitals in Korea. Furthermore, we supplemented the clinical microbiology section of K-LOINC using an alternative mapping strategy. We investigated other systems that utilize laboratory codes in order to investigate the compatibility of K-LOINC with statistical standards for a number of tests. A total of 48,990 laboratory codes were adopted (21,539 new and 16,330 revised). All of the LOINC synonyms were translated into Korean, and 39,347 Korean synonyms were added. Moreover, 21,773 synonyms were added from reference laboratories and tertiary hospitals. Alternative strategies were established for mapping within the microbiology domain. When we applied these to a smaller hospital, the mapping rate was successfully increased. Finally, we confirmed K-LOINC compatibility with other statistical standards, including a newly proposed EDI code system. This project successfully established an up-to-date standardized Korean laboratory terminology database, as well as an updated EDI mapping to facilitate the introduction of standard terminology into institutions.

Keywords: LOINC; K-LOINC; Standard Terminology; Laboratory Medicine Terminology

INTRODUCTION

The National Health Information Standards Committee (NHISC) was established in 2004, under the Korean Ministry of Health and Welfare, in order to establish standardized laboratory terminology database in Korean language. Among the NHISC's 14 practical committees, the laboratory test terminology practical committee was placed for this purpose. Previously, no active master table existed that could be used to merge lab test results for databases collected from multiple facilities. Therefore, master tables were developed for unifying test results, such as Japan Laboratory Accreditation Cooperation 10 (JLAC10) and Logical Observation Identifier Names and Codes (LOINC) (1). We adopted the LOINC system developed by the Regenstrief Institute for Health Care at Indiana University, USA, in 1994 (2). Both LOINC and Regenstrief LOINC Mapping Assistant (RELMA), designed to assist the mapping of local test codes to LOINC codes, are available free of charge from http://www.regenstrief.org/loinc. LOINC provides a large, structured, and multiaxial (components, properties, times, systems, scales, and methods) coding system for clinical observations, with a primary focus on laboratory data. Previously published LOINC mapping projects have stated that the low effort required to define and maintain a full coverage of laboratory observations was a key factor in deciding to employ LOINC as a coding system (3). LOINC terminology covers at least 98% of the average laboratory tests, with the purpose of facilitating the sharing of

patient data (2).

This database of standardized terminology can be adopted as a basis for electronic medical records (EMRs), electronic health records (EHRs), a search engine for medical terminology, a national emergency patient information network, and for the practical use of individual health care smart cards. In an academic context, the database can help to improve communications between hospitals when endemic, epidemic, or rare diseases need to be studied and treated.

This report is on the project of Korean language implementation of the LOINC (K-LOINC) system, so that Korean language speakers will find it easy to cross reference to the same data system used by English speakers. Former products sponsored by the NHISC preferentially changed English to Korean language and standardization of Korean laboratory terminology was followed in the current product. Eventually, the purpose of K-LOINC system is to apply K-LOINC to the system of central or peripheral laboratory by means of electronic data interchange (EDI) codes as a mediation, leading to promote standardization of overall laboratory systems. In the first project regarding the laboratory terminology standardization process (December 2004 to May 2005) (4), we employed the structure of the LOINC system, which is based on 6 axial concept names. This included 7,508 laboratory concept names, mainly used in primary clinics, and a synonym database was established. However, the 6-axis structure was not compatible with the EDI codes established for the insurance task. The second stage of the study (January 2014 to September 2014) (5) integrated almost all laboratory concept names, including terminology used in tertiary hospitals and reference laboratories in Korea, and finally established K-LOINC. This third study phase (January 2015 to June 2015) has upgraded former products by reexamining all code names, establishing a database of synonyms, and inspecting the compatibility with other systems in order to maximize the utility of K-LOINC.

MATERIALS AND METHODS

K-LOINC was updated based on LOINC version 2.48 (6). Names of tests that are not in current use were excluded, and abbreviations that are frequently employed in the field were adopted. The naming principle followed the LOINC user manual (7). Terms that were newly added or modified were translated into Korean. Terminological expressions were based on the *English-Korean, Korean-English Medical Terminology* (8), published by the Korean Medical Association. To collect the opinions of experts, several meetings of laboratory doctors were held, which are reflected in the work. To maintain consistency, one test code was divided into 6 axes, translated into Korean, and then combined as 1 code again. The primary product was revised based on the opinions of relevant specialists. Next, we mapped EDI codes,

which were revised in 2014, to their corresponding K-LOINC codes. We also established a database of synonyms, and searched for alternative methods for the section regarding clinical microbiology, which presented difficulties regarding the EDI mapping. Finally, we investigated the compatibility of K-LOINC with the statistical standards for a number of tests.

Establishment of the synonym database

The origins of the database of synonyms introduced in this third project lay in the English synonym names in LOINC, Korean translations of these English names, laboratory codes of 3 Korean reference laboratories, and laboratory codes of four Korean tertiary hospitals. We also included the "long names" and "short names" from LOINC. We gathered opinions regarding these synonyms from relevant specialists and user groups, and incorporated them into the final version of this database.

Supplementation of K-LOINC's clinical microbiology section

We analyzed the structure of Korea University Guro Hospital's (Seoul, Korea) clinical microbiology laboratory codes, as a representative tertiary hospital system. The codes for microorganism identification and antibiotics susceptibility tests posed difficulties for mapping between K-LOINC and the laboratory codes based on EDI codes. Thus, we suggested alternatives for mapping these parts, and applied our strategy to the laboratory codes of a 300–400 bed hospital to determine its effectiveness.

K-LOINC's compatibility with other laboratory code systems

We investigated other laboratory code systems, in order to maximize the utility of K-LOINC. In particular, we analyzed the newly proposed EDI code system, sponsored by the Ministry of Health and Welfare, and examined the possibility of using K-LOINC in conjunction with this. We also explored the use of K-LOINC for the standardization of other laboratory statistics for a number of tests.

RESULTS

We named the Korean standard laboratory terminology system to the K-LOINC. A total of 48,990 laboratory codes from LOINC were adopted. Among these, 21,539 codes were newly added, and 16,330 codes were revised. Korean concept names were expressed as combinations of six-axis concept names: components (e.g. potassium), properties (e.g. mass concentration), time (e.g. a point in time), systems (e.g. blood), scales (e.g. ordinal), and methods (e.g. microscopy). The table of concept names consisted of management numbers, Korean Standard Terminology of Medicine (KOSTOM) numbers, new KOSTOM names, components, properties, times, systems, scales, methods, old

Table 1. Final products of the standardization for laboratory terminology

Database	Fields	No. of records
Concept name table	Management numbers, KOSTOM numbers, new KOSTOM names, components, properties, times, systems, scales, methods, old KOSTOM names, LOINC numbers, classes, and statuses	48,990
Synonym table	Management numbers, new KOSTOM names, LOINC names, synonyms (English synonym names of LOINC, Korean translation of English names, laboratory codes of 3 Korean reference laboratories, laboratory codes of 4 Korean tertiary hospitals), short names and long names from LOINC, LOINC numbers, classes, field names	190,552

KOSTOM = Korean Standard Terminology of Medicine, LOINC = Logical Observation Identifier Names and Codes.

KOSTOM names, LOINC numbers, classes, and statuses for 48,990 test observations (Table 1). The examples of concept names table and synonym table of K-LOINC were delineated in Supplementary Tables 1 and 2.

Establishment of the synonym database

The synonyms were entered in the "assym" column of LOINC, and encompass chemical name synonyms, alternative name synonyms, chemical formulae supplied by the Chemical Abstract Society, and so on. The number of codes that had synonyms was 2,374, from a total of 48,990, and 38,014 synonyms were assigned to these 2,374 codes. We translated all of the synonyms into Korean, resulting in the addition of 39,347 Korean synonyms. In addition, laboratory codes used in 3 reference laboratories and four tertiary hospitals in Korea were also added. We believe that these 21,773 synonyms enhance the utility of our database. The contents of the columns "long name" and "short name" from LOINC were also added as synonyms. After consulting specialists and user groups, we established the final version of the synonym database (Table 1). The synonym database will be uploaded to http://www.ssis.or.kr/, tentatively, to be downloaded for free.

Supplementation of K-LOINC's clinical microbiology section

Owing to the different granularities of the K-LOINC and EDI codes, the use of K-LOINC's clinical microbiology section was restricted when mapped by EDI codes. Thus, we investigated the structure of Korea University Guro Hospital's clinical microbiology codes as a pilot mapping project, and divided them according to K-LOINC's classes in order to map them using EDI codes. However, the codes for microorganism identification and antibiotics susceptibility tests were not mapped. Therefore, we analyzed K-LOINC's structure and suggested an alternative mapping plan. We tested this plan by applying it to the laboratory codes of a 300–400 bed hospital. The result was that the mapping rate increased from 45.3% to 95.7%.
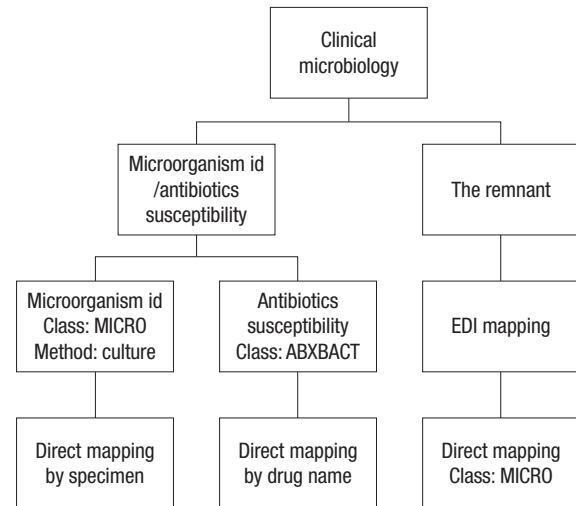

Fig. 1. The derived mapping plan for the clinical microbiology section. EDI = electronic data interchange.

The derived mapping plan for the clinical microbiology section (Fig. 1) was as follows:

1) After filtering clinical microbiology codes, classify them into microorganism identification, antibiotics susceptibility tests, and the remainder.
2) In general, the remaining codes can be mapped using EDI codes.
3) When a remaining code cannot be mapped to an EDI code, map it directly after selecting the K-LOINC class as "MICRO."
4) For microorganism identification, attempt to map directly using the specimen name, by selecting the appropriate "system" (e.g., sputum) and "method" (usually "culture") after filtering the K-LOINC class as "MICRO."
5) For an antibiotics susceptibility test, attempt to map directly using the drug name, by selecting the appropriate "method" (e.g., MIC) after filtering the K-LOINC class as "ABXBACT."

K-LOINC's compatibility with other laboratory code systems

The newly proposed EDI system, which was developed for insurance tasks, included the 6 axes of LOINC (components, properties, times, systems, scales, and methods). Therefore, we were able to confirm K-LOINC's compatibility with the newly proposed EDI code system. We also explored the possibility of employing K-LOINC as the standard in laboratory statistics for a number of tests. For this purpose, a task force team (TFT) was organized under the Korea Laboratory Medicine Foundation. This TFT classified the laboratory codes into 11 groups, after examining health insurance and medical care expenses. We confirmed that K-LOINC "classes" could be successfully matched to those 11 groups.

DISCUSSION

Long established coding systems, such as the International Classification of Diseases (ICD) and Current Procedural Terminology (CPT), are used for insurance reimbursement and other administrative purposes. Therefore, coding laboratory information is beyond the scope of such systems. LOINC and Systemized Nomenclature of Medicine Clinical Terms (SNOMED CT) are the 2 most comprehensive coding systems for lab test orders and information of results. LOINC includes both test orders and results, while no test orders use SNOMED CT codes (9). LOINC covers both laboratory tests and clinical observations, and the codes are updated twice a year to reflect changes in practices over time. A previous study found that despite cohort bias (9), 77% of test orders used LOINC code, while for the remainder either the codes were missing (17%) or adopted non-informative values (6%), and 33% of the test results were missing or non-informative. Almost a quarter of laboratory test orders and a third of test results were reported as missing or null codes. The authors of that study concluded that the use of LOINC for test results was more common and useful than that of SNOMED CT.

The hierarchy organization of K-LOINC was depicted in Supplementary Tables 1 and 2; the columns of components, properties, times, systems, scales, and methods were joined to 1 column, which was called as new KOSTOM name. Based on former projects regarding K-LOINC, the mappings of all terms were reviewed for correctness by relevant specialists. The goal of this 3rd project regarding the standardization of laboratory terminology was the virtual utilization of K-LOINC in laboratories, because LOINC was constructed from a viewpoint of academic classification of laboratory medicines. For this purpose, a synonym database with a robust number of test names and codes was established, in order to help match concept names to common terms used in the relevant fields.

Furthermore, because of differences in the granularities of K-LOINC and laboratory codes, especially in the clinical microbiology section, we conducted meetings with relevant experts from the Korean Society of Laboratory Medicine. A public hearing was conducted to derive the opinions of consumers, doctors, vendors, academic societies, and policy makers, and this focused on the technical applicability of K-LOINC to the field. Thus, we were able to propose alternative mapping strategies. Our strategy involved direct mapping, using the "filter" and "find" functions in Microsoft Excel (Microsoft Corp., Redmond, WA, USA). We confirmed an increased mapping rate by testing our approach in the microbiology laboratory of a 300–400 bed hospital. However, mapping with EDI codes was not possible. An EDI code does not differentiate test results and specimens between similar methods, resulting in standard codes mapping to EDI codes in an n:1 manner for a considerable portion of K-LOINC. In contrast, 1:n mapping exists in several tests as a set. Most cases result in unmatched K-LOINC codes, owing to the absence of concepts in the EDI system. Rather, the molecular biology section of LOINC constitutes the part into which is it required to incorporate the current rapidly growing collection of laboratory test observations (5).

In addition, we confirmed K-LOINC's compatibility with other laboratory code systems and statistics. We compared the granularity of K-LOINC with that of the newly proposed EDI system, and investigated the compatibility with this system. In general, the newly proposed EDI system included 6 K-LOINC axes, demonstrating the compatibility. For other laboratory statistics, there are different standards according to the type of statistics. In the current study, we matched K-LOINC classifications to other types of statistics with the goal of creating a statistical standard that simplifies the comparison of data among different institutions.

In this project, we established an up-to-date standardized Korean laboratory terminology database, including a synonym database. We also updated EDI mapping, to facilitate the easier exchange of data. The EDI mapping is a necessary step for the practicality of K-LOINC, because EDI codes are used for the billing of medical expenses in institutions. We also established better a mapping strategy in the clinical microbiology section, and attempted to match K-LOINC to statistical standards provided by the Korean Laboratory Medicine Foundation.

The LOINC system covers almost all laboratory observations, by reflecting changes in laboratory tests, and serves widely as the standard of information exchange between health institutions. More than 164 countries have used LOINC, and over 25 countries, including the United States, have adopted LOINC as a national standard (10). LOINC was developed by the civil institute, and Unified Medical Language System (UMLS) was developed by the United States government. Japan also has its own standard database (11), although this is still limited in its practical use. In this respect, the semantic interoperability of K-LOINC as a coding method for a laboratory data exchange can contribute to public health research, national biosurveillance programs, and eventually to global national competitiveness. Moreover, new laboratory tests have to be added yearly, in order to keep the mapping up to date. Increased completeness, effective management tool for translating local codes into LOINC, and increased participants are required for a virtual realization of K-LOINC.

DISCLOSURE

The authors have no potential conflicts of interest to disclose.

AUTHOR CONTRIBUTION

Conceptualization: Yoon SY. Data curation: Jung BK. Investigation: Kim J, Cho CH, Kim JY, Nam MH, Shin BK, Rho EY, Kim S,

Sung H, Kim S, Ki CS, Park MJ, Lee KN. Writing - original draft: Jung BK. Writing - review & editing: Yoon SY.

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Supplementary Table 1. The examples of concept names table

Management No.	KOSTOM No.	New KOSTOM name	검사항목	특성	시간	검체	단위	방법	Old KOSTOM name	LOINC No.	Class	상태
KS040890400	KS040890400	암피실린:감수성: 검사시점:분리주: 정량 or 순위척도: 우무확산	암피실린	감수성	검사 시점	분리주	정량 or 순위 척도	우무 확산	암피실린:감수성: 검사시점:분리주: 정량 or 순위척도: 우무확산	29-9	ABXBACT	유지
KS040890600	KS040890600	암피실린:감수성: 검사시점:분리주: 정량 or 순위척도: 최소억제농도	암피실린	감수성	검사 시점	분리주	정량 or 순위 척도	최소 억제 농도	암피실린:감수성: 검사시점:분리주: 정량 or 순위척도: 억제최소농도	28-1	ABXBACT	수정

In this table, column of EDI 2014 codes is omitted.

KOSTOM = Korean Standard Terminology of Medicine, LOINC = Logical Observation Identifier Names and Codes, EDI = electronic data interchange.

Supplementary Table 2. The examples of synonym table

Management No.	New KOSTOM name	LOINC name	Synonyms	Short name	Long name	LOINC No.	Class	Field
KS041989200	B형 간염 바이러스 DNA:임의농도:검사시점:혈청/혈장:정량:탐색자.증폭.표적	Hepatitis B virus DNA:ACnc:Pt:Ser/Plas:Qn:Probe.amp.tar	HBV DNA real-time PCR 정량, HBV DNA 정량 (Real-time PCR), HBV DNA 정량	HBV DNA SerPl PCR-aCnc	Hepatitis B virus DNA [units/volume] (viral load) in Serum or Plasma by Probe and target amplification method	42595-9	MICRO	미생물

KOSTOM = Korean Standard Terminology of Medicine, LOINC = Logical Observation Identifier Names and Codes.