Digital Format for Publication of LOINC to Vendor IVD Test Results

Date: 6/01/2017

Authors: Rob Bush, Ed Heierman PhD, Andrzej Knafel PhD, Laurent Lardin, Clem McDonald

Email: info@ivdconnectivity.org

Background

Entities from government, industry, and academia have long recognized the essential role of semantic interoperability of in vitro diagnostic (IVD) test results in health care information technology. This discussion paper adopts the same definition of interoperability laid out by Office of the National Coordinator for Health IT (ONC) in its (draft) Shared Nationwide Interoperability Roadmap. Specifically, interoperability is intended to mean: the ability of a system to exchange electronic health information with and use electronic health information from other systems without excessive effort on the part of the user; and for semantic interoperability, the ability of this data to be shared with unambiguous meaning and without separate negotiations between sender and receiver. Many successful efforts have thus far made substantial contributions to different aspects of semantic interoperability, with LOINC® (Logical Observation Identifiers Names and Codes), SNOMED-CT (Systematized Nomenclature of Medicine – Clinical Terms), and UCUM (Unified Code for Units of Measure) perhaps most recognizable. With the increased use of software systems in the health care environment, it is now critical for IVD instruments and IVD software systems to have the capability to efficiently and unambiguously exchange IVD test results, regardless of their location or setting (e.g., hospital-based laboratories, reference laboratories, physician office laboratories, home use testing, etc.).

Recent public workshops focused on the advancement of the interoperability of IVD test results proposed promoting greater adoption of standardized codes and terminologies. The proposed work involved facilitating the following model:

1. Vendor IVD tests results would be associated with a set of predefined LOINC codes that identify the distinct observations produced by the test

2. Observations with numeric values would be associated with the UCUM representation of their reporting units

3. Observations with categorical (multiple choice) values would be associated with a response set that defined the possible values, with the response set drawn from appropriate code systems such as SNOMED CT

In addition, the workshops recognized that defining methods for distributing the standard codes associated with a measure could have an immediate impact on laboratory interoperability. For example, doctors often need to observe longtime behavior of laboratory results of their patients. In many cases, these laboratory results are from different IVD vendor tests and equipment. For doctors, it is therefore important to know whether a result was measured using the same material and the same method as the previous or the following result. Otherwise they will not be able perform a consistent interpretation of the test results in order to make a proper diagnosis and treatment recommendations.

In support of these concepts, this paper proposes an industry-defined format to publish the LOINC codes associated with the distinct observations that may be produced by an IVD instrument or through the execution of vendor-defined manual steps. IVD vendors would voluntarily adopt this format to establish IVD vendor test result to LOINC mappings in a standardized manner. Ultimately, this could reduce differences of coding between vendors for similar test results and align codes between labs using similar classes of systems in order to achieve operational outcomes.

Example benefits may include:

- Decreasing the time required for a lab's deployment of IVD instruments.
- Facilitating electronic clinician decision support on test outcomes from disparate sources.

The IVD Industry Connectivity Consortium (IICC) is publishing this paper in support of its mission:

To create and ensure adoption of an interoperable connectivity paradigm to reduce the complexity and variability of data exchange between IVD testing systems and healthcare informatics systems

IICC collaborated with the IHE Pathology and Laboratory Medicine (PaLM) domain to develop the Laboratory Analytical Workflow (LAW) Profile that defines the next generation interface between IVD Analyzers and Analyzer Managers. The LAW Profile establishes use cases, transactions, and message definitions based on the HL7® Messaging Standard v2.5.1. At the time of publication of this paper, the Clinical and Laboratory Standards Institute (CLSI) has established a Document Development Committee (DDC) to publish LAW as the CLSI AUTO16 standard for the exchange of analytical testing data between in vitro diagnostic instruments and health care informatics systems.

The LAW profile supports the transmission of LOINC, and IICC recognized the importance of this industry initiative for the adoption of standardized codes and terminologies. When possible, data elements discussed in this proposal were aligned with similar data elements defined by the LAW profile.

Scope

The objective of this analysis is to define an IVD industry format to facilitate the publication and exchange of LOINC codes for vendor IVD test results, based on either vendor IVD test transmission codes or manual test identification, for use by laboratory personnel or laboratory applications. It is not intended to cover information for other related activities, such as purchasing tests from a vendor. Expected systems include Laboratory Information Systems (LIS), clinical middleware applications, databases, and terminology servers.

This proposal will define a digital format that:

- Can be used as-is by IVD software systems to automate the mapping between vendor IVD test transmission codes and LOINC codes.
- Can be easily transformed into an alternate format, such as an Excel spreadsheet, to support the manual selection of LOINC codes for results produced by vendor IVD tests used by the laboratory.

Both vendor-defined IVD tests performed by a vendor IVD instrument and vendor-defined manual IVD tests are in scope.

This proposal will provide specific guidance on how the digital content should be structured i.e., recommendations for combining of test mapping records into aggregates.

Outcomes out of scope:

- This proposal does not address the mapping of IVD Test Orders, which requires additional data and alignment on a standardized coding system for orders. Although IVD Test Orders and IVD Test Results are related, information required for IVD Test Order mapping should be provided by a separate mapping table.
- This proposal does not address any long-term or common storage locations vendors may agree upon to host the published LOINC codes or regulatory impacts of vendors providing LOINC codes for their IVD tests.
- This proposal does not address the use of specific protocols or technologies that could be used to transmit the industry-defined digital content between IVD systems.
- This proposal does not include transmitting LOINC codes directly from IVD instruments, leaving that content to be represented by vendor-defined codes due to issues in achieving one-to-one appropriate LOINC codes, as discussed in the Data Definition section.
- This proposal does not address which LOINC codes vendors should choose for their tests, or what content is needed to make this decision. It only addresses the format used to publish these associations, for use by laboratory personnel or laboratory applications.
- This proposal does not address what information is required to automatically set up a configuration between an IVD instrument and an IVD software system.

Data Definition

The following data definition is proposed as the content for the publication of LOINC codes for vendor IVD test results. The data definition supports the following mappings:

- One vendor **IVD Test Result** to many **LOINC**s
    - This is a very common occurrence. For example, an IVD test for serum glucose could map to a LOINC code for a mass concentration (e.g. mg/dL) or one that defines a substance concentration (e.g. mol/L). Or, a urine albumin could map to a LOINC test for a 24 hour excretion rate with units of mg/(24.h), versus one for a random urine with unit of md/dL.
    - The structure of the data definition naturally supports this relationship.

- One **LOINC** to many vendor **IVD Test Result**s
    - This is a much less common occurrence.
        - For example, an IVD instrument may distinguish stat tests from routine tests by the IVD test code. In this case, the LOINC [13969-1] *Creatine kinase.MB [Mass/ volume] in Serum or Plasma* is associated with two **IVD Test Result**s, depending if the test is routine or stat (prioritized).
        - Or, consider a susceptibility test that has different IVD Test IDs based on the original specimen source. In this case, the LOINC [6932-8] *Penicillin [Susceptibility] by Minimum inhibitory concentration (MIC),* which is named for testing on the isolate, could be associated with multiple **IVD Test Result**s for one IVD Instrument depending on the clinical context. For example, the break points are different for suspected meningitis versus blood infections and to date LOINC has only distinguished test codes by suspected source of infection for some antibiotic susceptibility codes.
    - The structure of the data definition supports this relationship through repeating LOINC data content across multiple **IVD Test Result**s.

Data Definition Structure

The data definition structure is described using the HL7® message syntax of brackets ([…]) to identify optional items and braces ({…}) to identify repeatable items. The *italic* items are used to provide grouping and cardinality, while the **bold** items are actual data elements of the definition.

-- *IVD LOINC Publication* begin

    -- **Vendor Publication**

    -- {*Vendor Equipment Mapping* begin

        -- **Equipment**

        -- {IVD *Test Mapping* begin

            -- **IVD Test Result**

            -- [**LOINC**]

        -- IVD *Test Mapping* end}

    -- *Vendor Equipment Mapping* end}

-- *IVD LOINC Publication* end

Conventions

Conventions for the Data Definition
(k) Used to identify the elements that identify a unique **IVD Test Result** to **LOINC** mapping. Each element is a member of the composite key.

1..1	The item is mandatory, and only one occurrence of the item must be included.
1..*	The item is mandatory, and one or more occurrences of the items must be provided.
0..1	The item is optional. If provided, only one occurrence is included.
0..*	The item is optional. If provided, one or more occurrences of the item may be included.

Data Definition Types

The following types are used by the data definition content.

Vendor Publication

This information establishes the version for the publication.

- **Publisher** is the entity publishing the mapping information.
- **Publication Version ID** is human-readable information provided by the vendor that can be used to differentiate LOINC publication versions.
- **LOINC Version ID** is the version of LOINC that was used for the mapping.
- The LOINC License requires a statement of attribution and notice that LOINC content is copyrighted. The **LOINC Copyright** component holds the required attribution statement.
- **Localization** is the language used for this publication.
- **Region** is an optional vendor description for which geographic or administrative region this localization is valid, e.g. de-CH is self-explanatory, but not en-CH.

Component	Type	Card.	Reference	Comments
Publisher	String, 199	1..1		Vendor publishing the mapping
Publication Version ID	String, 199	1..1		Vendor-defined version
LOINC Version ID	String, 20	1..1	Regenstrief	e.g. LOINC 2.59
LOINC Copyright	String, 500	1..1	LOINC License	LOINC attribution statement[1]
Localization	String, 10	1..1	RFC5646	e.g. "en-US"
Region	String, 199	0..1		e.g. "applicable to the United States"

1 The Attribution statement required by LOINC License when LOINC content is included. This statement was approved by Regenstrief Institute.

Equipment

The equipment elements, types, and cardinality are aligned with values reported in LAW OBX-18 Equipment Instance Identifier.

UID and **UID Type** is capable of supporting the unique device identification system to identify medical devices through their distribution and use. When fully implemented, the label of most devices will include a unique device identifier (UDI) in human- and machine-readable form.

Component	Type	Card.	Reference	Comments
(k) Manufacturer	String, 50	1..1	LAW OBX-18.2	
(k) Model	String, 20	1..1	LAW OBX-18.1	Automated test: name of instrument Manual test: IVD Test Kit Name
UID	String, 199	0..1	LAW OBX-18.3	Can be used for equipment Unique Device Identifier (UDI)
UID Type	String, 6	0..1	LAW OBX-18.4	Use to identify the structure for the UID, e.g., FDA-accredited UDI[1] or an alternative structure

1 Specify if the UID represents the Device Identifier (DI) per the FDA unique device identification (UDI) system or an alternate type of device identification system. For additional information regarding the FDA UDI system and the FDA Global Unique Device Identification Database (GUDID), see https://www.fda.gov/MedicalDevices/DeviceRegulationandGuidance/UniqueDeviceIdentification/.

IVD Test Results

The IVD Test Result components are aligned with values reported in OBX-3 Observation Identifier as applicable. ***Vendor Specimen Description, Vendor Result Description***, and ***Vendor Comment*** are included to assist a laboratory in selecting the appropriate LOINC code(s) for the vendor IVD tests used by the laboratory. This information is not intended to be parsed by an IVD Software System that automates the mapping of vendor IVD transmission codes to LOINC codes. The inclusion of this information should reduce errors in the manual selection of LOINC codes by a laboratory.

- **Vendor Analyte Code** is one of two possible values:
  - For an automated test result, it contains **Vendor Transmission Code** used by the instrument when sending the test result to a health information system, such as an LIS.
  - For a manual test result, it is the **Vendor Analyte Identifier** for the test result produced by the Test Kit.
- **Vendor Analyte Name** is human-readable text the vendor used to identify the analyte. The text might be displayed by the instrument or could be used within an assay insert.
- ***Vendor Specimen Description*** is human-readable text that provides information about the specimen used for the test, such as "Serum or Plasma." The field is used to document the vendor description of the specimen used for the IVD test.
- ***Vendor Result Description*** is human-readable text that provides information about the result that is produced.
  - For non-numeric results, this field should describe the result by including one of the following:
    - **Binary** – pos/neg, reactive/non-reactive.
    - **Ordinal** – none, few, many.
    - **Nominal** – the test can report none found or one or more possibilities from a taxonomy of choices, such as organism names.
  - Numeric results and associated units of measure:
    - For numeric results, this field should describe the result by including a representative unit of measure, preferably represented as a UCUM unit.
    - If one unit of measure is reported, then include it in this field.
    - If multiple units can be reported that can be converted to one another by a multiplicative scale factor independent of the analyte (such as mg/L and ug/dL), select one of the units as a representative unit.
    - If multiple units can be reported that cannot be converted by an analyte-independent scale factor (such as mol/L and as mg/L), then define a mapping for each unit. These different types of numeric results require their own LOINC codes – one for the test reported as molar concentration and one for the test reported as mass concentration. Similarly, the results of a urine analyte (e.g. Sodium) reported as either mmol/L (spot urine) versus mmol/(24.h) (24 hour urine) have different LOINC properties and map to two different LOINC codes. The same is true for viral loads which can be reported in units of copies/mL, Log

(copies/mL), IU/mL and Log (IU)/mL; and none of which can be converted by a simple scale factor. These result types have different properties and thus different LOINC codes. In such cases, define a mapping for all units that are appropriate for this IVD test.

- In some cases, the same IVD Test may be reported as a **Binary** result, or a spot numeric result of the mass concentration, etc. In such instances, the same *IVD Test Result* will map to multiple *LOINC*s. The *Vendor Result Description* should be used to assist the laboratory in manually selecting the appropriate LOINC for their laboratory.

- **Vendor Reference ID** is an additional vendor identifier, such as an identifier that can be used to locate the associated assay insert published by the vendor.
- **Vendor Comment** is human-readable text clarification, such as "This is a STAT (prioritized) version of the test".

Component	Type	Card.	Reference	Comments
(k) Vendor Analyte Code	String, 20	1..1	LAW OBX-3.1	Automated test: Vendor Transmission Code used for identification through an instrument interface, such as LAW. Manual test: Vendor Analyte Identifier
Vendor Analyte Name	String, 199	1..1	LAW OBX-3.2	
Vendor Specimen Description	String, 199	1..1		Vendor description of specimen
Vendor Result Description	String, 199	1..1		Vendor description of the result
Vendor Reference ID	String, 20	0..1		Additional vendor reference
Vendor Comment	String, 199	0..1		Vendor comment

This information captures the LOINC information established by the vendor for the associated IVD Test Result.

- The LOINC parts are included so that laboratory personnel do not need additional tooling or references to interpret the content of the associated *LOINC Code*.
- The *LOINC Long Name* associated with the *LOINC Code* is included to assist the manual selection of the *LOINC Code* for the *IVD Test Result*.

Component	Type	Card.	Reference	Comments
(k) LOINC Code	String, 10	1..1	LOINC	
LOINC Long Name	String, 199	1..1	LOINC	Content defined by LOINC Users' Guide
Component	String, 199	1..1	Component /Analyte – 1st part	Content defined by LOINC Users' Guide
Property	String, 20	1..1	Kind of Property – 2nd part	Content defined by LOINC Users' Guide
Time	String, 20	1..1	Time Aspect – 3rd part	Content defined by LOINC Users' Guide
System	String, 50	1..1	System (Sample) Type – 4th part	Content defined by LOINC Users' Guide
Scale	String, 20	1..1	Type of Scale – 5th part	Content defined by LOINC Users' Guide
Method	String, 50	1..1	Type of Method – 6th part	Content defined by LOINC Users' Guide

Data Definition Content

- The **LOINC** element can be left null for the case where no **LOINC Code** is available for this specific **IVD Test Result**.
- The combination of **Manufacturer**, **Model**, **Vendor Analyte Code** (represents the **Vendor Transmission Code** or **Vendor Analyte Identifier**), and **LOINC Code** must be unique for based on the mandatory items identified for each element*.*
- The definition accommodates manual tests kits as well as automated IVD instruments. For a manual test, the following is required:
  - **Model** will be populated with the vendor Test Kit Name.
  - **Vendor Analyte Code** will be populated with **Vendor Analyte Identifier**.

The following table describes the data elements of the definition, which is considered to be one instance of the LOINC mapping publication for a particular vendor.

Element				Card.	Comments
IVD LOINC Publication				1..1	The mapping publication
	Vendor Publication			1..1	Vendor version information
	Vendor Equipment Mapping			1..*	Mappings may be defined for multiple equipment
		Equipment		1..1	The equipment or manual test
		IVD Test Mapping		1.*	One or more LOINC mappings
		IVD Test Result		1..1	Must provide a test result
		LOINC		0..1	LOINC is optional

Data Format

A table and digital format are defined.

Criteria

The following criteria were established for the format:

- Widely used and accepted
- Used internationally
- Common tooling available for producing and parsing the format
- Support human readable content
- Support exchange with or consumption by machines (LIS vendors, etc.)

Table Format Recommendation

A spreadsheet is recommended as the table format. Spreadsheets can be used to filter the publication content as part of a manual activity to select the LOINC codes. It is also possible to create the spreadsheet content based on the digital content described below. In addition, table content from multiple vendors can be merged into a single spreadsheet.

The spreadsheet will contain a worksheet with the following content:

- *Publisher*
- *LOINC Version*
- *LOINC Copyright*
- *Localization*
- *Region* (if applicable)

The spreadsheet will contain another worksheet containing the mapping content. The table is normalized following the Table Format Recommendations above. The table rows describe a unique IVD Test Mapping for a vendor IVD Test Result to LOINC relationship, with each row of the worksheet containing the following data definition content:

Column Header	Comments
Publication Version ID	
Manufacturer	Sortable column could be used if spreadsheet form multiple manufacturers are combined into one
Model	Name of instrument or IVD Test Kit Name
Equipment UID	Leave empty if no Universal ID
Equipment UID Type	Leave empty if no Universal ID
Vendor Analyte Code	Transmission Code or Analyte Identifier
Vendor Analyte Name	
Vendor Specimen Description	
Vendor Result Description	
Vendor Reference ID	Leave empty if no additional vendor reference
Vendor Comment	Leave empty if no vendor comment
LOINC Code	Leave empty if no LOINC mapping
LOINC Long Name	Leave empty if no LOINC mapping
Component	Leave empty if no LOINC mapping
Property	Leave empty if no LOINC mapping
Time	Leave empty if no LOINC mapping
System	Leave empty if no LOINC mapping
Scale	Leave empty if no LOINC mapping
Method	Leave empty if no LOINC mapping

Digital Format Recommendation

JSON (JavaScript Object Notation) was selected as the digital format. JSON was chosen because it provides the following benefits:

- Industry standard for describing digital content
- Human readable
- Lightweight
- Simple syntax
- Designed for data exchange
- Ease of use by IVD Systems and tooling
    - Consumption of JSON by IVD software systems
    - Conversion of JSON into spreadsheet format
    - Conversion of JSON into future FHIR® format
- International format that is not tied to any specific interoperability standard. The format could be easily integrated into or used by existing protocols and standards.

It was recognized that multiple formats, protocols, and standards exist that could be used to publish the LOINC for Vendor IVD Tests. The following possible options were considered, but not selected:

- eDOS – Electronic Delivery of Service
    - Does not support human readable (data at rest) representation
    - Includes message-level content

- SPL – Structured Product Labeling
  - Established for pharmaceutical products
  - Also used for GUID
- IHE PaLM Laboratory Code Set Distribution (LCSD)/HL7® v2.5.1Master Files
  - Does not support human readable (data at rest) representation
  - Includes messaging-level content
- CSV – Comma Separated Values
  - The combination of multiple vendor names with multiple LOINC will require a significant pivot table
- XML – Extensible Markup Language
  - Excellent for data representation (documents)
  - Cumbersome for data exchange
- FHIR® (Fast Healthcare Interoperability Resources®) Resource
  - Solid ontology-based analysis with a rigorous formal mapping for correctness
  - Support for light-weight RESTful architectures and also seamless exchange of information using messages
  - Structure and content are being defined

Digital Format Schema

The schema for the JSON Digital Format is also downloadable from this site.

LOINC Publication Example

Excel Table Format

The table format is useful when the publication is reviewed by a human. This Excel spreadsheet version was created using the *Table Format Recommendations* above. The rows in the LOINC Table Example worksheet describe a unique IVD Test Mapping for a vendor IVD Test Result to LOINC relationship. Filters have also been added to the table columns. The Excel table content can be constructed from the JSON Digital Format. An example Excel file is also downloadable from this site.

JSON Digital Format

The JSON digital format is useful when the publication will be consumed electronically by a system. An example JSON is also downloadable from this site.

Summary

This document proposes a data definition and digital format, for IVD vendors to use when publishing LOINC codes for their Vendor IVD Tests. The proposed format is human readable, and can be easily produced as a table format, such as Microsoft Excel, that further simplifies its use within a laboratory setting. In addition, the digital format is suitable for use by IVD software systems, such as a Laboratory Information System (LIS), that automate Vendor IVD Test to LOINC mappings.

By voluntarily adopting the format described here as an industry convention, IVD vendors will understand what data and in what format they should provide when publishing LOINC for their IVD Tests. By doing so, this work will significantly reduce the variability of the content and format of the multiple publications received by laboratory environments, further reducing the time and effort required by laboratories to review and integrate this information into their laboratory software systems. The format includes additional vendor information, such as a description of the result, used to easily discriminate between multiple LOINC codes for the same IVD Test.

Ultimately, it is expected that the LOINC codes selected by manufacturers would be reviewed by a common party (e.g. Regenstrief) for correctness and consistency across vendors, and also that the industry would establish conventions for the storage and access of the IVD vendor LOINC publications. The effort required for these objectives will also be reduced by having this standard publication format and associated content.

Authors

Rob Bush
Orchard Software
USA

Ed Heierman, PhD
Abbott
USA

Andrzej Knafel, PhD
Roche Diagnostics International, Ltd.
Switzerland

Laurent Lardin
bioMerieux
France

Clem McDonald
Lister Hill National Center for Biomedical Communications of the National Library of Medicine (LHNCBC/NLM)
USA

Participating Organizations

IICC and the authors of this document wish to recognize the following organizations that contributed their time and expertise to the development of this format.

Abbott Laboratories

Advanced Medical Technology Association (AdvaMed)

Association of Public Health Laboratories (APHL)

BD Life Sciences

bioMerieux

Cerner Corporation

Epic

Geisinger Health System

Health Level Seven® (HL7®)

IHE Pathology and Laboratory Medicine (PaLM) Technical Committee

Intelligent Medical Objects, Inc

IVD Industry Connectivity Consortium (IICC)

Medical Device Innovation Consortium (MDIC)

Orchard Software

Phast

Regenstrief Institute, Inc.

Roche Diagnostics International, Ltd

Swiss Laboratory Interoperability Interest Group (Joint Venture of FAMH.ch, IHE-Suisse.ch, HL7.ch, SULM.ch)

U.S. Centers for Disease Control and Prevention (CDC)

U.S. Food and Drug Administration (FDA)

U.S. National Laboratory of Medicine, National Institutes of Health (NLM/NIH)

Vernetzt, LLC