

ELR, LOINC, SNOMED, and Limitations in Public Health

R Wurtz MD, MPH

Introduction

There are many significant advantages to electronic lab reporting (ELR)—the direct, automated messaging of reportable communicable disease reports from clinical lab information management systems (LIMS) to the appropriate public health (PH) jurisdiction’s information system. Advantages include more complete reporting [1], faster reporting [2], and less paperwork for both PH and laboratory personnel. There are significant obstacles as well. Many labs do not have comprehensive electronic information systems. For those that do, a large proportion use local codes rather than standardized vocabulary (LOINC and SNOMED), syntax and messaging protocols (HL7). Even when a LIMS incorporates LOINC and SNOMED codes, these code systems are idiosyncratic.

This paper reviews some of the problems in applying LOINC, SNOMED and the Nationally Notifiable Conditions Mapping Tables (NCMT) to public health reporting.

LOINC

In the early 1990s, seven US labs (hospital-associated and freestanding commercial labs) combined their local

lab codes to list all possible clinical laboratory tests. A LOINC (Logical Observation Identifiers Names and Codes©) number was then assigned to each test. Unfortunately, local codes—and the subsequent LOINC codes—were originally developed in order to bill for the test, not to convey information about the purpose or result of the test. Thus, there are many limitations as we try to apply the LOINC system to ELR and public health. Table 1 contains a small *part* of the LOINC codes relating to HIV testing and will be used to illustrate the examples.

- LOINC codes were not assigned in any systematic or hierarchical way, so the actual number is meaningless. Current numbers range from 23-2 to 34590-0.
- In some cases, the same test was assigned different LOINC numbers when different labs wanted to maintain their own systems for billing. Item numbers 1 and 11 are the same test, but because the test names—“HIV 1” and “HIV 1 Ab”—were different at 2 different labs, each got its own LOINC number.

Item number	LOINC number	Test name	Specimen type	Method
1	21009-6	HIV 1	Serum	Immune blot
2	33866-5	HIV 1 Ab	Blood.Capillary	Enzyme immunoassay
3	16974-8	HIV 1 Ab	Fluid.CSF	[Method not specified]
4	29327-4	HIV 1 Ab	Fluid. Unspecified body fluid	[Method not specified]
5	34591-8	HIV 1 Ab	Fluid. Unspecified body fluid	Enzyme immunoassay
6	34592-6	HIV 1 Ab	Fluid. Unspecified body fluid	Immune blot
7	14092-1	HIV 1 Ab	Serum	Immune fluorescence
8	22356-0	HIV 1 Ab	Serum	[Method not specified]

9	29893-5	HIV 1 Ab	Serum	Enzyme immunoassay
10	5220-9	HIV 1 Ab	Serum	Enzyme immunoassay
11	5221-7	HIV 1 Ab	Serum	Immune blot
12	7917-8	HIV 1 Ab	Serum	[Method not specified]

Table
1.
Partial

LOINC table for HIV 1 antibody testing.

- Distinct LOINC codes were assigned based on the specimen type (e.g., “ser” = serum, CSF, stool, xxx = type not specified). Items 3 (16974-8) and 4 (29327-4) are the same test, performed on different body fluids.
- Distinct LOINC codes were assigned based on the method of the test. Items 7, 8, and 9 test the same fluid (serum) for the same thing (HIV antibody) by different methods, and thus have different LOINC numbers. LOINC distinguishes tests by the method *only if* the method “has an

important affect on the interpretation of the result.” Thus, two tests by slightly different methods might have the same LOINC code—or they might not.

- Distinct LOINC codes were assigned based on the way the results are formatted. Item numbers 9 and 10 test the same fluid for the same thing by the same method, but the result for item 10 is reported on a quantitative scale (e.g., 31 mg/dl) while the result for item 9 is reported on an ordinal scale (e.g., the quantitative result has been interpreted and is presented as “positive,” “negative,” or “indeterminate”).
- A LOINC code can describe a very specific test, such as a test for an antigen, the result of which will be “positive,” “negative,” or “indeterminate.” The SNOMED name, id, or code may not be given in the OBX-5 segment, because the word “positive” reflexively names the disease.
- A LOINC code can describe a very specific test, the result of which will be positive or negative, but for which additional information is needed before the nationally notifiable disease (aka “condition” in some CDC documents) can be assigned. This is particularly true for syphilis

and HIV, where there are different NND codes for primary, secondary, and tertiary syphilis (among other forms of syphilis) and pediatric and adult HIV, respectively. Thus, if you receive an HL7 message with OBX-3 = “21009-6” and OBX-5 = “positive” you must know the case’s age before assigning the Nationally Notifiable Disease condition code, 10561 (pediatric HIV) or 10562 (adult HIV).

- Although some of the codes describe a test for which the result format is ordinal (e.g., positive or negative, present or absent, yes or no), most LOINC codes name tests where there are many possible results. Some codes describe tests (e.g., blood cultures) for which the result is “nominal:” the name of one of thousands of possible bacteria that could grow in a blood culture. In the most complete mapping of LOINC “orders” to SNOMED “results” and nationally notifiable conditions, the Nationally Notifiable Conditions Mapping Tables (NCMT), the LOINC code 600-7 (for blood culture) appears hundreds of times in association with different outcomes (that is, a different organism grew in the culture). See Table 2. In order to address the

LOINC num	Concatenated name	Condition
600-7	Microorganism identified : Prld : Pt : Bld : Nom : Blood culture	Haemophilus influenzae, invasive disease
600-7	Microorganism identified : Prld : Pt : Bld : Nom : Blood culture	Legionellosis

LOINC num	Concatenated name	Condition
600-7	Microorganism identified : Prld : Pt : Bld : Nom : Blood culture	HIV infection, pediatric
600-7	Microorganism identified : Prld : Pt : Bld : Nom : Blood culture	Enterohemorrhagic Escherichia coli (EHEC) shiga toxin+ (not serogrouped)

Table 2. Portion of NCMT

one-to-many mapping for LOINC-coded tests with named (nominal) results, the LOINC Users' Manual (p. 31) suggests that a standardized list of microorganism names be used to represent the result (for instance, in the HL7 message result segment, OBX-5). Acceptable standardized lists include SNOMED and Euzeby's list of bacterial names.

SNOMED©

Pathologists were among the first doctors to recognize that they needed a standardized way to refer to diagnoses, partly for comparison purposes—one pathologist's diagnosis of "diffuse histiocytic lymphoma" needed to be the same as another pathologist's (not unlike a case definition for a communicable disease)—and partly for billing purposes. In the mid-1960s, pathologists began to systematize diagnostic concepts. The original "Systematized Nomenclature of Pathology" gave rise to "The Systematized Nomenclature of Medicine" (SNOMED) which has gone through several versions and subset versions (e.g., SNOMED-CT or SNOMED-Clinical Terminology) since then. The current SNOMED version contains ~ 875,000 concepts and ~2 million terms gathered from 100 different standardized terminologies or "vocabularies." SNOMED distinguishes concepts for the condition (e.g.,

pertussis) and the causative organism's name (*Bordetella pertussis*). In addition there are several terms for each SNOMED concept (the SNOMED ID, SNOMED name, and SNOMED code).

In July 2003, the federal government announced that it would purchase a perpetual license for SNOMED® and make it available to US users at no cost through the National Library of Medicine. More information is available at http://www.nlm.nih.gov/research/umls/Snomed/snomed_main.html.

Nationally Notifiable Conditions Mapping Tables

In May 2004, the CDC published the "Nationally Notifiable Conditions Mapping Tables" (http://www.cdc.gov/PHIN/data_models). These tables, successors to the Dwyer Tables, are exhaustive mappings of LOINC (the test) codes to nationally notifiable (and some state notifiable) diseases or conditions. In separate tables, the SNOMED concepts (the test results) are mapped to the same diseases and conditions. Table 3 contains a portion of a table (combined from two NCMT tables) with LOINC codes mapped to SNOMED concepts for pertussis and the organism which causes it, *Bordetella pertussis*.

Although there are 43 LOINC codes for tests for pertussis, only two tests are commonly done to diagnose pertussis in humans: LOINC 548-8 and 549-6. Each one appears twice in the table, in order to map it to two results, the SNOMED IDs for the organism (*Bordetella pertussis*) and the condition (“pertussis”). Although dozens of other tests appear, they are all antibody tests,

are almost never performed, and alone, are not diagnostic of either the presence of the organism or the condition “pertussis.” The result for these tests would be something like “positive” or “31 mg/dl,” which are not SNOMED concepts, and so, no SNOMED ID or concept number is entered in the NCMT.

Table 3. All of the permutations of pertussis tests from the NCMT

Pertussis example			
LOINC Number	Concatenated name*	SNOMED ID	SNOMED concept
9364-1	Bordetella pertussis Ab.IgM : ACnc : Pt : Ser : Qn :		
9363-3	Bordetella pertussis Ab.IgG : ACnc : Pt : Ser : Qn :		
9362-5	Bordetella pertussis Ab.IgA : ACnc : Pt : Ser : Qn :		
6316-4	Bordetella pertussis Ab : Titr : Pt : Ser : Qn : CF		
6315-6	Bordetella pertussis Ab : Titr : Pt : Ser : Qn : Aggl		
6314-9	Bordetella pertussis Ab : Titr : Pt : xxx : Qn : IF		
550-4	Bordetella pertussis Ag : ACnc : Pt : xxx : Ord : IF		
549-6	Bordetella pertussis : ACnc : Pt : xxx : Ord : Organism specific culture	390793003	L-12808
549-6	Bordetella pertussis : ACnc : Pt : xxx : Ord : Organism specific culture	5247005	L-12801
548-8	Bordetella pertussis : ACnc : Pt : Thrt : Ord : Organism specific culture	5247005	L-12801
548-8	Bordetella pertussis : ACnc : Pt : Thrt : Ord : Organism specific culture	390793003	L-12808
5059-1	Bordetella pertussis Ab : ACnc : Pt : Ser : Qn : EIA		
29674-9	Bordetella pertussis Ab.IgG : ACnc : Pt : Ser : Ord :		
29673-1	Bordetella pertussis Ab.IgM : ACnc : Pt : Ser : Ord :		
29672-3	Bordetella pertussis Ab.IgA : ACnc : Pt : Ser : Ord :		
29659-0	Bordetella pertussis Ab.IgG : ACnc : Pt : Ser : Ord : EIA		
29658-2	Bordetella pertussis Ab.IgM : ACnc : Pt : Ser : Ord : EIA		
29657-4	Bordetella pertussis Ab.IgA : ACnc : Pt : Ser : Ord : EIA		
25353-4	Bordetella pertussis Ab.IgM : Titr : Pt : Ser : Qn : IF		

Pertussis example			
LOINC Number	Concatenated name*	SNOMED ID	SNOMED concept
25352-6	Bordetella pertussis Ab.IgG : Titr : Pt : Ser : Qn : IF		
25332-8	Bordetella pertussis Ab.IgM : Titr : Pt : Ser : Qn :		
25331-0	Bordetella pertussis Ab.IgG : Titr : Pt : Ser : Qn :		
24130-7	Bordetella pertussis.secretory Ab.IgA : ACnc : Pt : xxx : Ord : EIA		
24129-9	Bordetella pertussis.toxin Ab.IgM : ACnc : Pt : Ser : Qn : EIA		
24128-1	Bordetella pertussis.toxin Ab.IgA : ACnc : Pt : Ser : Qn : EIA		
24127-3	Bordetella pertussis.toxin Ab.IgG : ACnc : Pt : Ser : Qn : EIA		
24035-8	Bordetella pertussis.filamentous hemagglutinin Ab.IgM : ACnc : Pt : Ser : Qn : EIA		
24034-1	Bordetella pertussis.filamentous hemagglutinin Ab.IgA : ACnc : Pt : Ser : Qn : EIA		
24033-3	Bordetella pertussis.filamentous hemagglutinin Ab.IgG : ACnc : Pt : Ser : Qn : EIA		
23832-9	Bordetella pertussis.toxin Ab.IgM : ACnc : Pt : Ser : Qn :		
23831-1	Bordetella pertussis.toxin Ab.IgG : ACnc : Pt : Ser : Qn :		
23830-3	Bordetella pertussis.toxin Ab.IgA : ACnc : Pt : Ser : Qn :		
23829-5	Bordetella pertussis.filamentous hemagglutinin Ab.IgM : ACnc : Pt : Ser : Qn :		
23828-7	Bordetella pertussis.filamentous hemagglutinin Ab.IgG : ACnc : Pt : Ser : Qn :		
23827-9	Bordetella pertussis.filamentous hemagglutinin Ab.IgA : ACnc : Pt : Ser : Qn :		
23826-1	Bordetella pertussis DNA : ACnc : Pt : xxx : Ord : Probe.Amp.Tar		
22117-6	Bordetella pertussis Ab : Titr : Pt : xxx : Qn :		
22116-8	Bordetella pertussis Ab : Titr : Pt : Ser : Qn :		
20992-4	Bordetella pertussis Ab : ACnc : Pt : xxx : Ord :		
16474-9	Bordetella pertussis Ab : ACnc : Pt : Ser : Qn : CF		
11585-7	Bordetella pertussis Ab : ACnc : Pt : Ser : Qn :		

* concatenated name refers to the “assembled” elements of the test named by the LOINC code, including, among others, the test description, the specimen type, the methodology, and the result format.

HL7, LOINC, ELR and public health
 HL7 is a set of messaging standards—the syntax for the message—

designed to impose interoperability on various clinical information systems.
 HL7 was developed to serve the clinical

care needs of individual patients and doesn't necessarily transfer easily for use in public health applications. How does HL7 use LOINC and SNOMED for ELR? Many LIMS continue to use local codes for both the test name and the test result. However, if the system uses standardized vocabulary, there are two places that a LOINC code may appear. The OBR segment is analogous to a lab request form: "here is the specimen, please do this test (LOINC number)." The OBX segment reports the test results. The LOINC code may be found again, in the OBX-3 segment (the Observation Identifier Field), to let the receiver know which test was done. The actual result of the test is indicated in OBX-5 by a SNOMED ID, a result value ("positive" or "31 mg/dl"), or the name of an organism written—and potentially misspelled—in any of a number of ways ("*Staphylococcus aureus*," "*Staph aureus*," or "*S. aureus*").

In 2003, the federal government required that software programs built or purchased by the federal government to exchange health laboratory information must use LOINC codes. The CDC PHIN specifies that the format and content for ELR of reportable diseases must use HL7 v2.3, LOINC, and SNOMED, so despite the fact that these "standards" and vocabularies don't function particularly well in public health applications, we are going to have to use them.

References

1. Effler P, Ching-Lee M, Bogard A, Jeong M-C, Nekomoto T, Jernigan D. Statewide system of electronic notifiable disease reporting from clinical laboratories. *JAMA* 1999;282:1845-1850
 2. Waller K. Use of the PA-NEDSS system in managing a large-scale hepatitis A outbreak: local and state perspectives. 2nd Annual Public Health Information Network Stakeholders' Conference, May 2004, Atlanta GA.
-