

# Issues in the Standardization of Clinical Laboratory Results

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## Disclaimer

- The ideas and positions expressed here are my own and do not necessarily represent those of NLM, NIH or HHS.



## NLM-Supported Vocabulary Standards

- ❑ NLM has long (27+ year) interest in standard vocabularies.
- ❑ Has supported electronic medical record and medical research in general for same duration -- long before it was “popular”
- ❑ It directly supports 3 clinical vocabulary systems:
  - ❖ LOINC – identifies laboratory tests, clinical variables, and survey instruments.
  - ❖ RxNorm - identifies the “clinical drug” and its component, ingredients, dose form, etc.
  - ❖ SNOMED CT- Identifies atomic entities such as chemicals, diagnoses, findings, anatomic sites, and organisms.

## Today

- ❑ Meaningful use regulations have had a galvanizing the use of all of these NLM-supported vocabulary standards.
- ❑ Will focus mostly on LOINC and laboratory issues because is what I know best, and we are identifying issues as instrument, test vendors and other organizations request new LOINC terms.

# Brief Overview of LOINC



## What is LOINC?

- ❑ A database with universal codes and names for 70,000 observations -- identifying laboratory tests, clinical measures, and survey instruments.
- ❑ Carries much information about each test and measurement -- description, units of measures, answer lists, synonyms, and references.
- ❑ Comes with downloadable browsing and mapping program.
- ❑ Offers a web-based search engine as well.
- ❑ No charge, and perpetual license.

# Blood count results in HL7 message – With LOINC codes for the question and numeric values for the answers

## Patient level

```
PID|||0999999^6^M10||TEST^PATIENT^||19920225|F|
||B|4050 SW WAYWARD BLVD |
```

## Order/report level

```
OBR|||H9759-0^REG_LAB|58410-2^Complete blood
count (Hemogram) panel - Blood by Automated
count^LN
```

## Discrete Results

```
OBX|2|NM||789-8^RBC^LN||4.9|10*6/uL|4.0-5.4|||F|
OBX|3|NM||718-7^HGB^LN||12.4|g/dL|12.0-5.0|||F|
OBX|4|NM||20570-8^HCT^LN||50|%|35-49|H||F|
OBX|5|NM||30428-7^MCV^LN||81|fL|80-94|||F|
```

## An international standard

- ❑ Users in almost every country (150).
- ❑ At least 10 countries (e.g. Australia, Canada, France, Germany) define it as their national standard.
- ❑ Translated into 14 languages (or dialects).
- ❑ 6000 new user registrations per year.

# How do *you* say glucose?

Glucose

葡萄糖

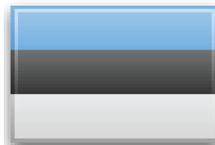
Glükoos

Glucose

Glucose

Gluc|kose

Glukose



# LOINC

the *lingua franca* of clinical observation exchange



Γλυκόζη

Glucosio

포도당

Glicose

Glucosa

Glucosa

Glucosa





# http://search.loinc.org

Options ▾ Help ▾ [loinc.org](http://loinc.org)


   / 28  

LOINC	LongName	Component	Property	Timing	System	Scale	Method	exUCUMunits	exUnits	Rank	S
<a href="#">718-7</a>	Hemoglobin [Mass/volume] in Blood	Hemoglobin	MCnc	Pt	Bld	Qn		g/dL	g/dL	2	2
<a href="#">789-8</a>	Erythrocytes [# /volume] in Blood by Automated count	Erythrocytes	NCnc	Pt	Bld	Qn	Automated count	10*6/uL	10*12/L	9	9
<a href="#">786-4</a>	Erythrocyte mean corpuscular hemoglobin concentration	Erythrocyte mean corpuscular	MCnc	Pt	RBC	Qn	Automated count	g/dL	g/L;g/dL	10	1
<a href="#">785-6</a>	Erythrocyte mean corpuscular hemoglobin [Entitic mass] by	Erythrocyte mean corpuscular	EntMass	Pt	RBC	Qn	Automated count	pg	pg	11	1
<a href="#">4544-3</a>	Hematocrit [Volume Fraction] of Blood by Automated count	Hematocrit	VFr	Pt	Bld	Qn	Automated count	%	L/L;%	14	1
<a href="#">6690-2</a>	Leukocytes [# /volume] in Blood by Automated count	Leukocytes	NCnc	Pt	Bld	Qn	Automated count	10*3/uL	10*9/L	15	1
<a href="#">787-2</a>	Erythrocyte mean corpuscular volume [Entitic volume] by	Erythrocyte mean corpuscular volume	EntVol	Pt	RBC	Qn	Automated count	fL	fL	17	1
<a href="#">777-3</a>	Platelets [# /volume] in Blood by Automated count	Platelets	NCnc	Pt	Bld	Qn	Automated count	10*3/uL	10*9/L	18	1
<a href="#">788-0</a>	Erythrocyte distribution width [Ratio] by Automated count	Erythrocyte distribution width	Ratio	Pt	RBC	Qn	Automated count	%	%	24	2

# LOINC descriptions

## 70260-5 Triglyceride in peritoneal fluid/Triglyceride in serum

### NAME

Fully-Specified Name:

**Component**

Triglyceride.periton fld/Triglyceride.serum

**Property**

RelRto

**Time Aspect**

Pt

**System**

Periton  
fld+Ser/Plas

**Scale**

Qn

**Method**

### TERM DEFINITION/DESCRIPTION(S)

Peritoneal fluid to serum tryglyceride ratio is determined to distinguish cirrohotic (non-malignant) versus malignant ascites.

Source: Regenstrief LOINC

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Source: Regenstrief LOINC

### BASIC ATTRIBUTES

Class/Type:

CHEM/Lab

Last Updated:

2012/10/16

Order vs. Obs.:

Both

Status:

Active

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Generated from LOINC version 2.42.



## Where LOINC is required for EHR “Meaningful Use”

- ❑ Meaningful use regulations require LOINC for identifying the **variable (the test name)** in:
  - ❖ Structured laboratory results in Electronic Health Records;
  - ❖ HL7 laboratory messages from hospital labs to outside providers;
  - ❖ HL7 messages from providers to tumor registries carrying North American Association of Central Cancer Registries, Inc. (NAACCR) content; and in
  - ❖ HL7 messages from laboratories to public health about reportable conditions; and SNOMED CT is required for the coded values (e.g. for blood culture results) in these messages.
  - ❖ Lab results in many other kinds of observations in patient care summary reports.



## Where LOINC used in reporting to CDC

- ❑ Serves as the question (measure/variable) almost everywhere.

# Relation between LOINC and SNOMED CT

- ❑ LOINC is the question (name of the variable).
- ❑ SNOMED CT is the answer for questions with coded or multiple choice answers.
- ❑ Getting a standard code for the question (variable) is the first order of business. Without one, receiving systems cannot know where to store observations they get from outside of their organization.
- ❑ LOINC and SNOMED CT are close to a tight collaboration agreement.

## Referral laboratories and LOINC

- ❑ Today, most large referral labs can deliver HL7 result messages with LOINC codes identifying the tests in the message.
- ❑ Some deliver the mappings from their local codes to LOINC on their websites, as follows.

# LOINC mappings featured on laboratory web sites (2 examples)



Home

New User?

Sign In

PRINT PAGE EMAIL PAGE

Test Utilization

Test Catalog

Policies

Setup Information

AOE Codes

LOINC Codes

Units of Measurement

Reflex Tests

Test Code Mapping

Critical Values and Semi-Urgent Results

Referred Tests

NYS Informed Consent Test List

Performing Locations

## Logical Observation Identifiers Names and Codes (LOINC®)

LOINC is clinical terminology important for laboratory test orders and results, and is one of a suite of designated standards for use in U.S. Federal Government systems for the electronic exchange of clinical health information.

In 1999, LOINC was identified by the HL7 Standards Development Organization as a preferred code set for laboratory test names in transactions between health care facilities, laboratories, laboratory testing devices and public health authorities. In the future, LOINC is likely to become a HIPAA standard for certain segments of the Claims Attachment transaction.

Mayo Medical Laboratories has been systematically assigning LOINC codes to its assays, as provided in the following spreadsheet. See [Terms of Use and Legal Restrictions](#) for conditions.

[LOINC codes spreadsheet](#)

Updated: 6/4/2012

**NOTE:** This spreadsheet is accurate as of the published date. Detailed setup files in the online [Test Catalog](#) now include available LOINC codes for individual tests and are recommended for new builds. For a list of test catalog changes resulting from the 11/18/2011 LIS replacement, see the [Test Catalog Updates](#).

### RELATED

- Other Content:
  - [Billing - Business Office](#)

## CPT & LOINC

The American Medical Association provides for information published annually to confirm CPT codes to the billing party. ARUP

- 2013 CPT Updates
- 2013 Molecular
- 2013 CPT Updates

## LOINC Codes

The Logical Observation Identifier Names and Codes (LOINC) database provides a universal code system for reporting laboratory and other clinical observations. LOINC codes are used by large reference laboratories and federal agencies (e.g., the CDC and the Department of Veterans Affairs) and are part of the Health Insurance Portability and Accountability Act (HIPAA) attachment proposal. ARUP has been systematically assigning LOINC codes to its assays, as provided in the spreadsheet below.

Additional questions about LOINC may be emailed to [loinc@aruplab.com](mailto:loinc@aruplab.com) or routed through ARUP Client Services.

[LOINC codes spreadsheet \(updated February 5, 2013\)](#)

LOINC database changes are now included in a spreadsheet tab.

- Testing Information
- Laboratory Test Directory
- Hot Lines—Quarterly
- Hot Lines—Immediate Changes
- ARUP Consult® Physician's Guide
- Critical Values
- Technical Bulletins New Test Highlights
- Consent Forms
- Patient History Forms
- Quality & Compliance
  - Compliance Statement
  - HIPAA Compliance
  - Quality Assurance
  - Privacy Practices
  - Licensure & Accreditations
- Testing Turnaround Time
- CPT/LOINC Codes
- Medicare Coverage



## A surge of interest from another and important industry

- ❑ Instrument and test kit vendors are also now on board.
- ❑ They are busily mapping the LOINC codes to their reported test measures.
- ❑ And they will report the LOINC code(s) for each result in their promotional material/web site/package insert.

## IVD vendors adopting LOINC, too

- ❑ All of the 8 largest (by sales) international in vitro device (IVD) companies, and lots of smaller ones, have mapped their instrument test codes to LOINC. We have hand-reviewed the mappings from 4 of them.
- ❑ They are in a big hurry. We asked why?
  - ❖ The answer: “all of our customers want it and all of our competitors are doing it.”
- ❑ This will help the little hospitals and labs immensely – they don’t have the personnel to map them by themselves.

# What we have run into responding to requests for LOINC codes



## Variation causes lots of problems

- ❑ LOINC *could* accommodate more than one conceptualization.
  - ❖ And often does, esp. if more than one of the conceptualizations are deeply-seated in the industry.
- ❑ But having 2-5 ways of organizing the same data increases the work of setting up EMRs, and mapping from external labs, proportionately.
- ❑ Multiple conceptualizations:
  - ❖ confuse the clinician,
  - ❖ make it difficult to impossible to present data in a flowsheet, and
  - ❖ make automatic interpretation of results much more difficult for clinical decision support and for public health analysis.
- ❑ Would be good to reduce/eliminate them.

# Some examples follow...



## Examples - Influenza A and B test reporting methods

- ❑ One test report may only say whether A and or B is present, *but not which is present*:
  - Answer 1: Pos for either Either A &/or B
  - Answer 2: Neg for A & B
  - These cause no problems.
  
- ❑ Another test report has more complicated answers, and says *which* one is present:
  - Answer 1 : Neg for A & B
  - Answer 2 : Pos for A
  - Answer 3 : Pos for B
  - Answer 4 : Indeterminate (probably really pos for A&B)
  
- ❑ Another test report gives the same answers from one dipstick report as two separate test results:
  - ❖ Influenza A
    - Answer 1 : Pos
    - Answer 2 : Neg
  - ❖ Influenza B
    - Answer 1 : Pos
    - Answer 2 : Neg

→ Should pick one consistent way to report these lab test results.

- (Last is probably best because it is not ambiguous.)



## Meq and Mmol for calcium and magnesium

- ❑ Some times reported as mMol/L
- ❑ Sometimes as Meq/L
  - ❖ (also sometimes as mg/dL)
- ❑ We should abolish the use of Meq for bivalent electrolytes -- creates lots of confusion and big potential for misinterpreting results.

## Toxicology

- ❑ Screen for abusable drugs lab test whose package insert includes both quantitative (Qn) and qualitative (QI) results in intended use:
  - ❖ Qn probably used when only reporting to another lab to do confirmatory Mass Spec.
  - ❖ Probably never reported back to requester as a Qn.
  - ❖ One IVD vendor said this was the case for their drugs of abuse tests. Trying to clarify and get consensus from the big IVD vendors whether that is always true.
  - ❖ If so, LOINC would flag the Qn alternative as discourage for routine clinical use (with an appropriate text explanation).

## Toxicology –multiple ways to report the cut off.

- ❑ Alternative 1- two separate “test results”
  - ❖ Amphetamine Ur Scrn: : neg
  - ❖ Amphetamine Ur Scrn cut off : 1000 ng/mL
- ❑ Alternative Alternative 2 – one test result
  - ❖ Amphetamine urine Scrn 1000 ng/ml : neg
- ❑ Alternative 3 – one result with big comment
  - ❖ Amphetamine Ur Scrn : neg
  - ❖ Comment: cut off for urine amphetamine is 1000ng/mL.

## Timed urines

- ❑ Most labs report start and stop time (or duration), collection volume, and concentration
  - ❖ Example: 24-hour urine sodium lab tests:
- ❑ They are all ordered as 24-hour urine sodium
- ❑ But it's hard to collect *precisely* 24 hours worth.
- ❑ So some (most?) labs adjust the value to 24 hours and call it Sodium 24H with units mmol/24h.
- ❑ Some give units of "mmol/Collected volume."
- ❑ But can never be sure what they mean and what they are reporting.
- ❑ Need one way to do it.
- ❑ Maybe always adjust to 24 hours -- and report amount/24 hours because normals are usually only defined for 24-hour collections.
- ❑ But need rule for how far it could be off before doing so.

## Timed urines – many confusing patterns

Name of ordered test	Name of resulted test	Collection duration	What is reported	Reporting units	Normal range
Na -24H Ur	Na 24 hour Ur	24H sort of	NA adjusted to 24 hour	mMol/24H	24 H normals
Na -24H Ur	Na Timed urine	24H sort of	Amount in collection	mMol/total volume	?? 24H normals
Na -24H Ur	Na 24 hour urine	24H sort of	Not sure	mMol/total volume	?? 24 H normals

## Nailing the analyte

- ❑ Sometimes difficult to get crystal clear information about the analyte.
- ❑ Lots and lots of examples. Here are a few:
  - ❖ PTH – really need to know which fragments are being measured to nail differences.
  - ❖ DNA tests for susceptibility – name needs to be more specific than “mycobacterium fluoroquinolone resistance gene.” The name should say which gene(s), e.g. Mycobacterium tuberculosis fluoroquinolone resistance (*gyrA*) gene.
  - ❖ Request for code for *C. immitis* IgG Ab from Arizona, but *C. posadasii* is the prevalent species. And the kit they used does not distinguish between the two, so they really needed to code as “*Coccidioides species*.”

## Different ways to report HCV resistance mutations

- ❑ Question per codon – answer is a specific mutation
  - ❖ Hepatitis B virus codon 181
    - Possible answers: A181, T181, V181
- ❑ Question per mutation – answer is present/absent
  - ❖ Hepatitis B virus codon A181T
  - ❖ Hepatitis B virus codon A181V
  - ❖ Hepatitis B virus codon A194T
- ❑ Question per coding region – answer identifies mutations found (using HGVS-like naming):
  - ❖ Second question that tells what mutations were looked for (if method not sequencing).

## Alleles

- ❑ Name the location and have two questions – for Allele1 and Allele2 – with answers that specify what was found in each allele.
- ❑ Name the allele – e.g. CYP1A2 gene mutations – and describe both positions in the answer:
  - CYP1A2\*1C/\*1C
  - CYP1A2\*1F/\*1F
  - CYP1A2\*1F/\*1K
  - CYP1A2\*1K/\*1C

## Commercial tests vs. internally-developed

- Commercial test kit – very clear package insert
  - ❖ Intended use identifies what exactly is being measured, the specimens for which the test is valid, and whether it is quant or qual test.
  - ❖ Specific guidance about how to report results and its interpretation.
  - ❖ Have a few quibbles with some commercial test kit package inserts, but mostly they are very good and are reference sources for clinical vocabulary standards developers that clarifies what are often confused requests for new LOINC tests (when a LOINC code for the test already exists).

## Internally-developed tests (1)

### □ Problems

- ❖ Big referral labs usually provide pretty clear and rich narratives about the test, what it measures, and why.
- ❖ However, some developers of sophisticated patented tests obfuscate what analyte and property is really being measured.
- ❖ Some labs declare their method is an internal one, but we find it is really an FDA approved kit. Submitter did not know or did not make a serious effort to find out.
- ❖ We ask for internal protocols for locally-developed tests, but the responses are spotty.

## Internally-developed tests (2)

- ❑ Requests from public health can be difficult and sometimes diverge from the pattern set by FDA-approved tests that measure the same analyte.
  - ❖ So we find titered EIA tests, some of which are based on qualitative commercial EIA tests. This creates one more conceptualization.
  - ❖ Would like some clarity as to whether such titers really make sense.
- ❑ Public health often leaves specimen out of the test name.
  - ❖ So they might propose using the same test code for Coccidioides Abs whether measured in serum or CSF and anything else.
  - ❖ Whereas FDA-approved tests are usually very specific about the specimen, and LOINC always distinguishes tests done on CSF versus serum.
  - ❖ Need help in the ground rules.

# Big variation in the string expression of units of measure



## Units standardization (1)

- Units strings in computer reports are very messy.
  - ❖ Many variations.
  - ❖ Inconsistent formatting.
  - ❖ Makes it difficult to use the information from many systems and compute with it.
  - ❖ Makes it difficult to validate LOINC mappings.

## Units standardization - 2

- ❑ Possible at three levels:
  1. Standardize the string representation for a given unit concept (e.g. - **10\*3/uL** or **10^3/uL** or **1000/uL** or **Thou/uL**)
  2. Standardize the variant ways to say a given unit string (e.g. - **10\*3/uL** vs. **10\*9/L**).
  3. Standardize the units that go with a specific test (e.g. decide that Hemoglobin always reported as **g/dL** which is the rule)
  
- ❑ First two are “easy” and should be our first aim.

## Units standardization - 3

- Units of measure strings in computer reports are very messy:
  - ❖ Many string variations for the same Units of Measure.
  - ❖ (See handout for more WBC and RBC units strings.)
- Without standardized units of measure it is very difficult to use the information from many systems and/or to compute with it.

### Some examples of Units strings for WBC counts:

/cumm  
 /mm3  
 10\*12/L  
 10^12/L  
 tril/L  
 x 10e12/L  
 x10 12/L  
 x10\*12/L  
 10 3 10pw3  
 X 10\*3  
 X(10)3  
 X10 3  
 x10(3)  
 X10\*3  
 X1000 T/l  
 Thous/mL  
 x10~3/uL  
 10 3/MM  
 thou/mm (10)3  
 /uL  
 10 3/UL  
 10/3 CU/MM  
 10^3/uL  
 1000/CUMM

## UCUM – What is it?

- ❑ Unified Code for Units of Measure
  - ❖ Full specification available from: <http://unitsofmeasure.org/>
  - ❖ Table of UCUM units of measure "codes" needed for routine laboratory and clinical measures is available for download from <http://loinc.org/usage>
- ❑ A computable syntax for defining units of measures. Includes units conversion program.
  - ❖ Can automatically convert between units of equivalent dimensions.
  - ❖ Includes a big matrix of conversion coefficients and software.
  - ❖ Adopted by HL7, IEEE, and DICOM.

## UCUM is good choice for step one

- ❑ Specifies string for reporting base units, and multipliers.
  - ❖ For metric units they are what we are used to.
  - ❖ Accommodates every kind of “conventional” unit as well.
- ❑ Specifies algebraic syntax for combining the single dimension units e.g. - mg and uL → mg/uL
- ❑ It eliminates the collisions found in the standard metric system (e.g. - pa =picoampers and pa = Pascal).
- ❑ Provides tools for converting values expressed in one UCUM Unit of Measure (UoM) to any other UCUM UoM of the same dimension.

## UCUM Look and usage

- ❑ For metric units, it standardizes way to say them
  - ❖ **mg/dL**
  - ❖ **ug/mL**
    - **Not** micgm/ml
- ❑ For US conventional units some look different:
  - ❖ **[in\_i]** – international inch
- ❑ Adornments like mol/mg creatinine are written:
  - ❖ **Mol/mg{creat}**
- ❑ The “display” units can be what ever the user wants and sent in the print text part of the HL7 message.

## UCUM unit table (<http://loinc.org/usage>)

320	ug/L/(24.h)	microgram per liter per 24 hour
321	ug/mg	microgram per milligram
322	ug/mg{creat}	microgram per milligram of creatinine
323	ug/mL	microgram per milliliter
324	ug/mL{class}	microgram per milliliter class
325	ug/mL{eqv}	microgram per milliliter equivalent
326	ug/mmol	microgram per millimole
327	ug/mmol{creat}	microgram per millimole of creatinine
328	ug/min	microgram per minute
329	ug/ng	microgram per nanogram

342	umol/(24.h)	micromole per 24 hour
343	umol/(8.h)	micromole per 8 hour
344	umol/d	micromole per day
345	umol/dL	micromole per deciliter
346	umol/dL{GF}	micromole per deciliter of glomerular filtrate
347	umol/g	micromole per gram
348	umol/g{creat}	micromole per gram of creatinine
349	umol/g{Hb}	micromole per gram of hemoglobin
350	umol/h	micromole per hour
351	umol/kg	micromole per kilogram

The Unified Code for Units of Measure (UCUM) Copyright © 1999-2011 Regenstrief Institute, Inc. and The UCUM Organization, Indianapolis, IN. All rights reserved. This table of examples does not include all possible UCUM codes. It does include those needed for routine laboratory and clinical measures. See <http://unitsofmeasure.org> for the full UCUM specification. This table was compiled by the National Library of Medicine, National Institutes of Health, U.S. Department of Health and Human Services with content contributions from Intermountain Healthcare and the Regenstrief Institute.



## HL7 and UCUM resources

### □ HL7

- ❖ Standards: <http://www.hl7.org/implement/standards/>
- ❖ HL7/CDC Race and Ethnicity Code Set: [www.cdc.gov/nchs/data/dvs/Race\\_Ethnicity\\_CodeSet.pdf](http://www.cdc.gov/nchs/data/dvs/Race_Ethnicity_CodeSet.pdf)
- ❖ HRSA/NLM Newborn Screening Coding & Terminology Guidance re: Constructing Newborn Screening HL7 Messages <http://newbornscreeningcodes.nlm.nih.gov/HL7>

### □ (Computable) Unified Code for Units of Measure (UCUM)

- ❖ <http://unitsofmeasure.org>
- ❖ <http://loinc.org/usage/units>



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**Biomedical Communications**  
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**Thank you!**  
*Questions?*



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