

# LOINC and UCUM

Gunther Schadow,  
Regenstrief Institute  
Indiana University School of Informatics

# Disclosures / Disclaimer

- I am a recipient of LOINC as you are.
  - I am one of the early adopters of LOINC in 1996.
  - Extended LOINC for Blood Gas Analysis.
  - I support and Promote LOINC
- I do not represent LOINC
  - I do not speak authoritatively
  - I may see things differently
- I am also a member of the IUPAC C-NPU
  - A competitor of LOINC
  - My views on the merits of either system are as an adopter.
- I am, however, the author of UCUM and I believe in its merits and represent it.
  - I do not make money from UCUM, receive no financial support, and never had private contracts regarding UCUM.

# Warning

- Terminology is NOT sufficient.
- Even the best, most complete, terminology is just words (no matter how systematic.)
- Language is more than words:
  - Morphology (forms, lexemes)
  - Syntax (structure)
  - Semantics (meaning of structure)
  - Pragmatics (language as behavior)

# Anatomy of Observations

1. Observation.code (Act.code):
  - The action you need to do in order to make the observation.
  - E.g., Systolic blood pressure
2. Observation.value:
  - The result obtained in the observation action.
  - 120 mm[Hg]
    - Number x Unit
3. Time    4. Subject    5. Observer

# LOINC

- Logical Observation Identifiers, Names and Codes, Regenstrief Institute.
  - Was: “Laboratory” OINC
- Purpose:
  - Observation names
    - “name” as in “name = value pairs”
    - Not observation-values
- Systematic definitions
- Pre-coordinated

# Major LOINC Parts

- LOINC number
- System (formerly “Specimen”)
  - Serum/plasma, whole patient, etc.
- Component (formerly “Analyte”)
  - potassium, hemoglobin, body height
- Property (Kind-of-Quantity)
  - Length, mass, substance concentration...
- Scale type
  - Quantitative, ordinal, nominal
- Time aspect
  - Point in time (PT) vs. certain intervals
- Change, status, mapped-to.

# International Standard Principles of Pre-coordination

LOINC-Code := System  
x Component  
x Kind of Property

C-NPU-Code := System  
x Component  
x Kind of Property  
x Unit of Measure

“dedicated kind of property”

# LOINC Systems – Blood

- Serum (SER) – 8421
- Serum/Plasma (SER/PLAS) – 4654
- Plasma (PLAS) – 280
- Whole Blood (BLD) – 1984
- Capillary Blood (BLDC) – 110
- Arterial Blood (BLDA) – 64
- Venous Blood (BLDV) – 37
- Mixed-Venous Blood (BLDMV) – 22
- White Blood Cell (WBC) – 256
  - E.g., CD-antigens, ...
- Red Blood Cell (RBC) – 314
  - E.g., blood type, fragility, ...

# LOINC Systems (Other)

- Physiology
  - Whole Patient (PATIENT) – 2009 (Weight, Height)
  - (Whole) Fetus (FETUS) – 230
  - Heart (HEART) – 493 (For EKG)
- Other Fluids
  - Urine (UR) – 4540
  - Cerebrospinal Fluid (CSF) – 1250
  - Amnion Fluid (AMN) – 222
  - Gastric Fluid (GAST) – 206
  - Semen (SMN) – 201
  - Fluid, NOS (FLU) – 677
- Miscellanea
  - Isolate (ISLT) – 1255
  - Tissue (TISS) – 676
  - Blood or Tissue (BLD/TISS) – 642
  - Unspecified (XXX) – 1804 (no, no)

# LOINC System - Summary

- Above systems cover 70% of LOINC
- Pick the System that fits best
- Don't get hung up on Serum vs. Plasma
  - Physiologically relevant is plasma,
  - Serum vs. Plasma are Lab processing issues only.
  - Increasingly SER/PLAS is used.
- Check scale type (QN, ORD, NOM)
- Check time aspect (usually PT)
- Check not outdated (not "mapped-to")

# Scale Type

- Quantitative (QN)
  - The result of the test is a numeric value that relates to a continuous numeric scale. Reported either as an integer, a ratio, a real number, or a range. The test result value may optionally contain a relational operator from the set {<=, <, >, >=}. Valid values for a quantitative test are of the form "7", "-7", "7.4", "-7.4", "7.8912", "0.125", "<10", "<10.15", ">12000", "1-10", "1:256"
- Ordinal (ORD)
  - Ordered categorical responses, e.g. 1+, 2+, 3+ ; positive, negative; reactive, indeterminate, nonreactive. (Previously named SQ)
- Quantitative or Ordinal (ORDQN)
  - Test can be reported as either ORD or QN, e.g. an antimicrobial susceptibility that can be reported as resistant, intermediate, susceptible or as the mm diameter of the inhibition zone. (Previously named SQN) **We discourage the use of ORDQN in other circumstances.**
- Nominal (NOM)
  - Nominal or categorical responses that do not have a natural ordering. e.g. names of bacteria (reported as answers); categories of appearance that do not have a natural ordering, e.g. yellow, clear, bloody. (Previously named QL)
- Narrative (NAR)
  - Text narrative, such as the description of a microscopic part of a surgical papule test.
- “Multi” (MULTI), Document (DOC), Set (SET)

# Kind of Property

- **Basic Kinds of Quantities**

- Length (LEN) – 1 m - 557
- Elapsed Time (TIME) – 1 s - 498
- Mass (MASS) – 1 kg - 452
- Amount of Substance (SUB) – 1 mol - (few)
- Plane Angle (ANGLE) – 180° - 176
- Number (NUM) – 12 - 142

- **Common Physical Kinds of Quantities**

- Pressure (PRES) – 16 kPa, 120 mm Hg - 315
- Partial Pressure (PPRES) – 2 kPa, 20 cm H<sub>2</sub>O - 116
- Volume (VOL) – 1 L - 314
- Area (AREA) – 1 m<sup>2</sup> - 58
- Electrical Potential (ELPOT) – 1 V - 218
- Velocity (VEL) – 1 m/s - 168
- Areic Number (NARIC) – 1 /m<sup>2</sup> - 120
- Lineic Number (INVLEN) – 1/m - 94

# Kind of Property

- **Nominal Properties and Oddballs**
  - Finding (FIND) - 6830
  - Presence or Identity (PRID) - 2011
  - Susceptibility (SUSC) - 1280
  - Type (TYPE) - 585
  - Impression (IMP) - 465
  - Arbitrary (ARB) - 300
  - Instance Identifier (ID) - 241
  - Timestamp (TMSTP) - 233
  - Complex (CMPLX) - 180

# Kind of Property

- **Concentrations – Amount per Volume**
  - Arbitrary Concentration (ACNC) – iU/mL - 12749
  - Mass Concentration (MCNC) – mg/dL - 5887
  - Substance Concentration (SCNC) – mmol/L - 2017
  - Number Concentration (NCNC) – /nL - 553
  - Catalytic Concentration (CCNC) – U/L - 417
  - Mass or Substance Concentration (MSCNC) – \*\*\*\* - 84
  - Titer (TITR) – 1:32 - 1910
- Content – Amount per Mass
- Fraction – Amount per same Kind of Amount (part over whole)
- Ratio – Amount per Amount from a different System
- Rate – Amount per Time

# Kind of Property

- **Content – Amount per Mass**
  - Mass Content (MCNT) - mg/g (HGB) - 303
  - Catalytic Content (CCNT) - U/g (HGB) - 119
- **Fraction – Amount per same Kind of Amount (part over whole)**
  - Number Fraction (NFR) - % - 1084
  - Mass Fraction (MFR) - mg/g - 210
  - Catalytic Fraction (CFR) - U/U - 62
  - Volume Fraction (VFR) - %vol - 60
- **Ratio – Amount per Amount from a different System**
  - Mass Concentration Ratios (MCRT0) - 519
  - Substance Concentration Ratio (SCRTO) - 337
  - Any ratio (RATIO) - 221
  - Velocity Ratio (VELRTO) - 66
- **Rate – Amount per Time**
  - Mass Rate (MRAT) - g/s - 469
  - Volume Rate (VRAT) - mL/s - 270
  - Substance Rate (SRAT) - mol/s - 205
  - Number Rate (NRAT) - /min - 105

# How to find LOINC

- Download it:
  - <http://www.loinc.org> or
  - <http://www.regenstrief.org>
- LOINDB.TXT (text file)
  - Simple to search (e.g., in emacs)
  - Simple to import in database
- RELMA – LOINC mapping tool
  - Application which can be used for batch term mapping.
  - Lots of detail in the Access database, including hierarchically organized parts.

# LOINC and RELMA tour ...

# UCUM - Unified Code for Units of Measure

- Scope
  - All units of measures being contemporarily used in international science, engineering, and business.
- Purpose
  - To facilitate unambiguous semantically defined and computable communication of physical quantities with units between computer systems.
- Inspired by ISO 2955-1983, ANSI X3.50-1986, and HL7 ISO+.
  - Predecessors (now obsolete) had many defects
    - “a” for “year” and “are”
    - “cd” for candela and centi-day
    - ounce: Avoirdupois? Troy? Apothecaries’?
    - many missing units, e.g., mm[Hg]
- Specifies all units with computable semantics
  - Automatic conversion
  - No need for large tables

# UCUM is Easy and Precise

- Human-friendly Codes with Precise Semantics
  - Write units as you would when typing a scientific journal article draft in a plain-text email
    - ug/dL, not mcg/deciliters
    - g, kg, not gm, gms, kgs, etc.
    - cm<sup>3</sup> not cc
  - For standard units, you will be correct most of the time.
  - Only beware of customary units, jargon, non-units, and arbitrary units.

# UCUM Definitions

- Specification
  - Syntax Rules
  - Semantics Rules
  - Tables
    - Prefixes
    - Base Units
    - Derived Unit Atoms
- Various handy compilations of ready-made expressions for the confused.

# UCUM Syntax

- Unit atom: g, m, min, [in\_i], m[Hg]
- Simple unit: prefix \* atom
  - kg, mm, mm[Hg], not mmin, m[in\_i]
  - Prefixes only for “metric” units
- Unit terms
  - Exponents: m<sup>2</sup>, cm<sup>3</sup>
  - Multiplication: kg.m
  - Division: m/s
  - Combination: kg.m/s<sup>2</sup>
  - Numeric factors, Parentheses: mg/(12.h)
- Annotations:
  - kg{potatoes}, mg{creat}

# A Tour of UCUM Tables

# UCUM Semantics

- Unit is a product of integer-powers of base units:
  - $1 \text{ N} = 1 \text{ kg.m/s}^2 = 10^3 \text{ m}^1 \text{ s}^{-2} \text{ g}^1$
  - $1 \text{ dyn/s/cm}^5 = 10^8 \text{ m}^{-4} \text{ s}^{-1} \text{ g}^1$
  - $1 \text{ mmol/L} = 10^{-3} \text{ m}^{-3} \text{ mol}^1$
  - $1 \text{ U/L} = 1/60 \cdot 10^{-3} \text{ m}^{-3} \text{ s}^{-1} \text{ mol}^1$
- Represented as:
  - Factor x vector of exponents
    - E.g.,  $1/60 \cdot 10^{-3} \times [-3, -1, 0, 1, 0, 0, 0]$

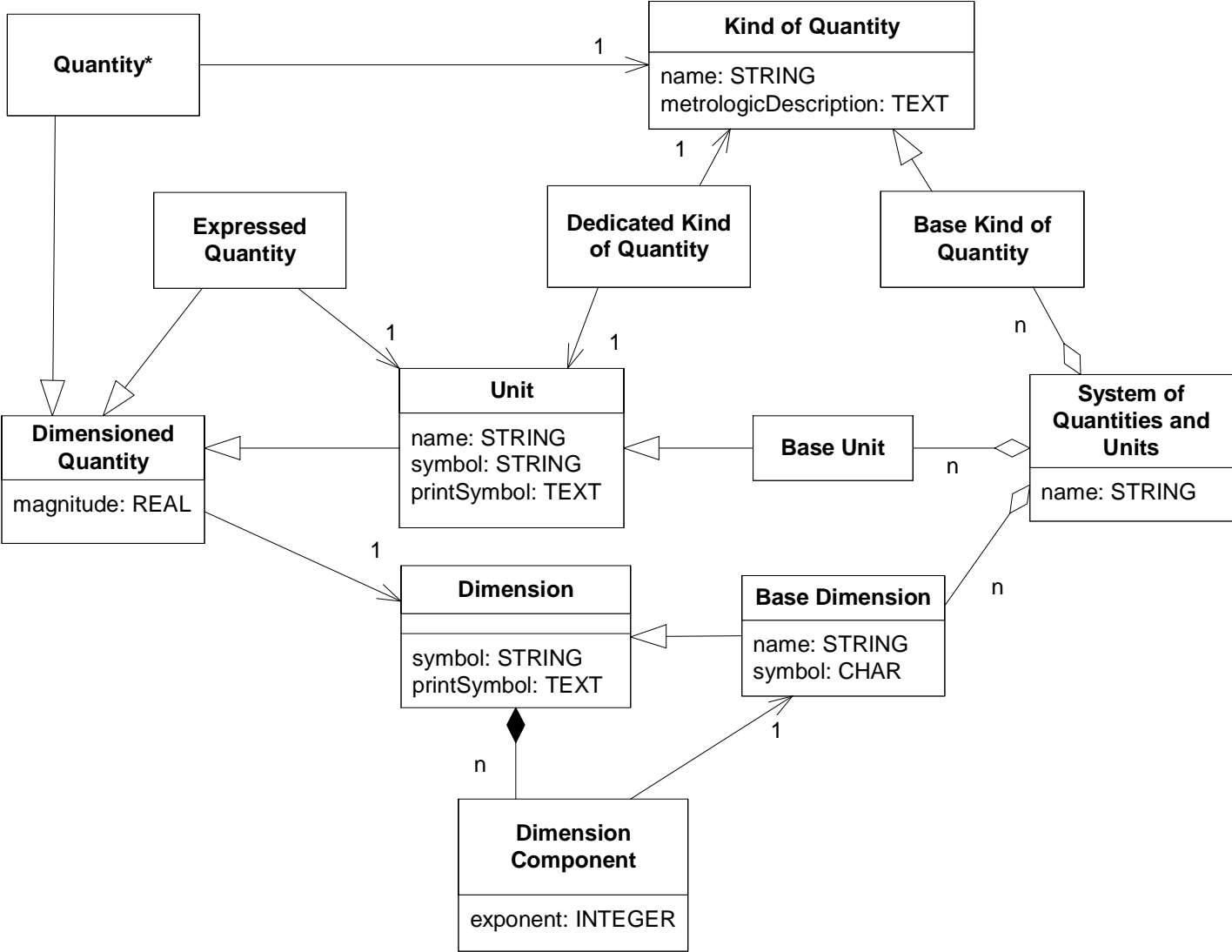
# UCUM Semantics

- $1 \text{ N} = 1 \text{ kg.m/s}^2 = 10^3 \text{ m}^1 \text{ s}^{-2} \text{ g}^1$ 
  - $10^3 \times [1, -2, 1, 0, 0, 0, 0]$
- $1 \text{ dyn/s/cm}^5 = 10^8 \text{ m}^{-4} \text{ s}^{-1} \text{ g}^1$ 
  - $10^8 \times [-4, -1, 1, 0, 0, 0, 0]$
- $1 \text{ mmol/L} = 10^{-3} \text{ m}^{-3} \text{ mol}^1$ 
  - $10^{-3} \times [-3, 0, 0, 1, 0, 0, 0]$
- $1 \text{ U/L} = 1/60 \text{ } 10^{-3} \text{ m}^{-3} \text{ s}^{-1} \text{ mol}^1$ 
  - $1/60 \text{ } 10^{-3} \times [-3, -1, 0, 1, 0, 0, 0]$

# Rules for What is a Unit

- Sufficient criterion:
  - Anything measured where there are multiple units with constant conversions.
  - Not sufficient that you can define the idea, there needs to be some conversion.
- Arbitrary units are a problem.
  - Bethesda Unit, GPL Unit, Todd Unit, even i.U.
  - Because they do not relate to anything else.
- Count-nouns are not units.
  - Whether “Erythrocytes”, “tablets”, “old shoes”, “heartbeats”, or “hick-ups”, these are just things (or events) and simple count numbers suffice
- Most detail goes into the observation code (LOINC), not the Unit.

# UCUM Semantic Model



# UCUM is Easy and Precise

- Human-friendly Codes with Precise Semantics
  - Write units as you would when typing a scientific journal article draft in a plain-text email
    - ug/dL, not mcg/deciliters
    - g, kg, not gm, gms, kgs, etc.
    - cm<sup>3</sup> not cc
  - For standard units, you will be correct most of the time.
  - Only beware of customary units, jargon, non-units, and arbitrary units.

# Thank you

- <http://www.loinc.org>
- <http://unitsofmeasure.org>