201943 Units of Measure for Laboratory Test Result Reporting in the UK (UCUM, FHIR and SNOMED)

Jay Kola, Colin Evans | NHS Digital (United Kingdom)

SNOMED CT Expo 2019
Kuala Lumpur | Oct 31-Nov 1

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Abstract

In the UK Three coordinated projects are working on:

1. A SNOMED-based Unified Test List (UTL)
2. A Generic Pathology Information Model for FHIR-based messaging
3. A new model for Units of Measure (UoM)

The Diagnostic UoM project has been investigating:

- The current use of UoM in Pathology reporting
- The requirements for computable UoM to support future needs

We describe the challenge of defining what *computable* units of measure means, and reactions from different actors to the perceived risks and benefits of machine interpretation of results. We describe a set of outline concerns and requirements for a future UoM implementation, and consider the strengths and weaknesses of SNOMED CT, UCUM, and another system as candidate solutions. Finally we suggest an option for using SNOMED CT as the "glue" that could link multiple alternative UoM representations together in a manageable way to mitigate some of the risks described.

Background

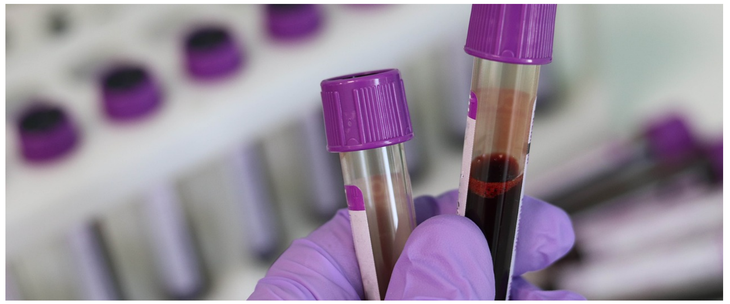
In the UK Pathology test results are commonly communicated from Labs to requesters electronically. The existing technology is based on multiple messaging standards including HL7v2/v3 within organisations and EDIFACT externally but the UoM data associated with a test result has typically been free text.

Policy directing future capabilities for the NHS puts an emphasis on improving both information sharing through IT systems and the adoption of technologies such as machine learning (ML). These goals all place an emphasis on machines being able to understand and act intelligently on *computable* results.

Aims

The overall aims of the project are to-

1. Understand current UK practice (particularly in EDIFACT messaging from Laboratories to requesters in primary care)
2. Investigate future requirements, and implementation options including continuing with current unstructured practice, or moving to an approach based on SNOMED CT, UCUM, FHIR or others
3. Propose a solution to deliver safe reliable communication of diagnostic results for both human (clinician) and computer interpretation, within the following constraints-
   - Do not compromise (and if possible improve) usability and clarity for clinicians and patients
   - Do not compromise (and if possible improve) patient safety
4. Propose a migration path from the current state to the future solution



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APPROACH and TACTICAL WORK

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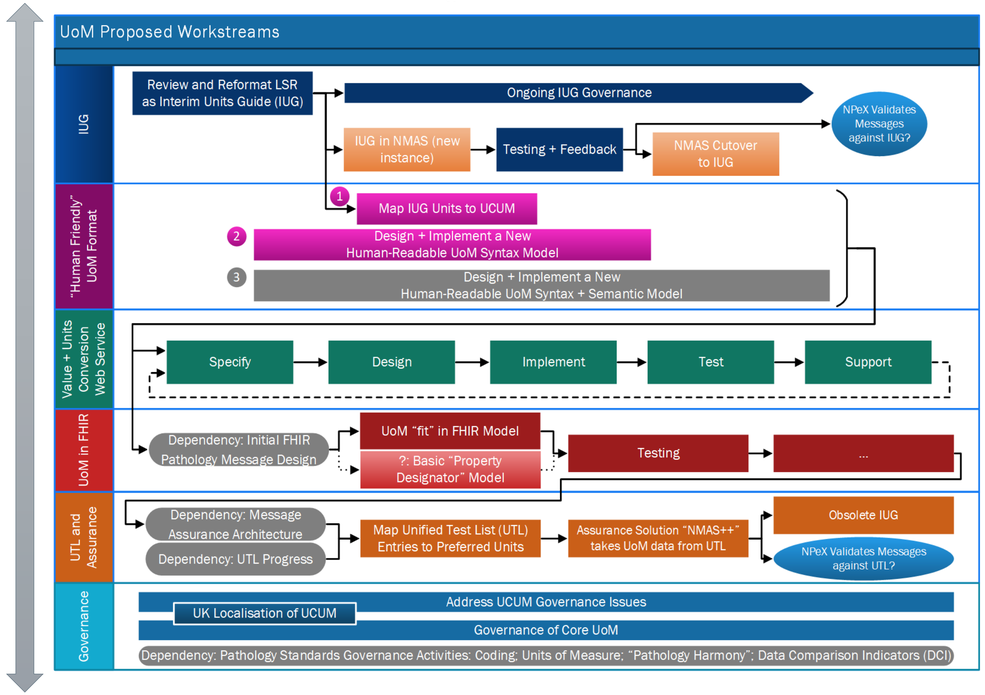
Our Approach

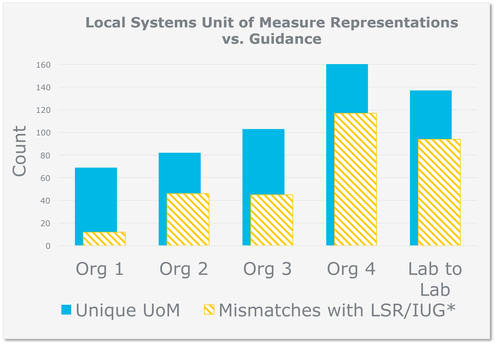
Tactical- Current State and Quick Wins



Strategic- Requirements, Review of Potential Solutions

Tactical Review- Findings

1. The extant guidance- the UK Laboratory Standardised Representation (LSR) is simply a spreadsheet of recommended unit representations with text descriptions. Computability was not a concern in its construction, there is no syntactic or semantic content.
2. LSR has not been published or updated since 2016.
3. Its use was not mandatory.
4. Analysis of a small sample of laboratory systems (LIMS) in NHS secondary care trusts and Lab-to-Lab communications showed conformance and data quality are highly variable



3. Interim guidance on UoM would be of immediate benefit. Improved conformance would also help with migration to future standards and the mapping of result data to alternate UoM representations

Response

- Updated UoM guidance based on LSR issued- the Interim Units Guide (IUG)
- In a subsequent update, IUG entries were mapped to UCUM (where possible) as a transitional tool to support the development and testing of FHIR message specifications

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Requirements

What are ***Computable*** Results?

The concept of a *measurement* forms part of a complex data model, but focusing on where values + units are used today, we propose a working model for considering levels of capability of particular solutions-

L0	No unit specification or constraints (free text)	Communication only. Data requires human interpretation
L1	Fixed list of acceptable units. No defined syntax or semantics	Can verify the UoM for a result is one of an approved set
L2	List of units with predefined relationships (e.g. synonyms, value conversion rules)	Verification. Conversion of units within the limits of the defined rule set
L3	A domain-specific language syntax (DSL) for unit and/or quantity. Unit based semantics	Expressivity not limited by predefined lists. Machine verification of unit syntax. "Type safe" calculations and conversions on quantities (within the limits of the unit model)
L4	Quantity DSL with an associated model for property aka. kind-of-quantity (KoQ)	As for L3 plus (in principle): • Type safe calculations on results outside the scope of unit analysis (e.g. dimensionless counts and ratios) • "Intelligent" interpretation based on the semantics of a property model

What do Users + Stakeholders Want or Expect ?

1. High expectations at strategy level for AI/ML will not be met if data cannot be understood by IT and processed intelligently

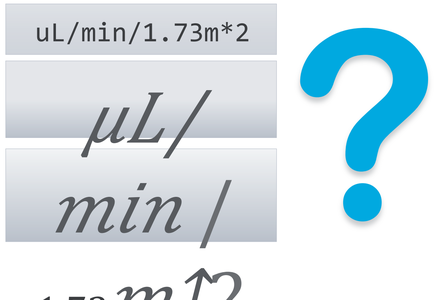
2. Secondary use "big data" environments (e.g. research, public health) are challenged by current messy and inconsistent data but have not (so far) clearly articulated their needs for something better

3. In direct patient care, computer processing and interpretation (e.g. value/unit conversion) is sometimes viewed with suspicion based on past incidents of error and potential harm. Naïve choices in numerical computation, including loss of precision and inappropriate rounding of results has been the root cause of some cases

   Some users may not always appreciate the layers of transformation unavoidably present in modern computer comms, however concerns over legal responsibility for decisions made after machine transformations of data are a real factor

4. User expectations are influenced by a 30+ year history of "dumb terminal" IT in diagnostics that is still mostly delivering plain text data in ASCII, or facsimiles of paper documents. In the case of UoM, users have historically had to work within the lowest common denominator of older systems, generally 7 bit ASCII text, and the potential for improvements in legibility and patient safety seems unexplored

   We have found little research on the ergonomics and error rates of different representations of units and measured quantities. Modern systems could display "print quality" representations. Would they be easier to read, less prone to errors and therefore safer for patients?



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OPTIONS, FUTURE DIRECTION

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Options Review

Three solutions were assessed against our draft requirements-

1. SNOMED CT contains some UoM terms, and is used in the UK to represent the UoM for Pharmacy / e-Prescribing
2. The Unified Code for Units of Measure (UCUM) is a DSL specification for units. SNOMED and UCUM are supported coding schemes in the FHIR specifications
3. UDUNITS2 is a software library for validation and processing of *quantities* (values+units) widely used in earth sciences

Results in summarised form-

Concern / Capability	SNOMED-CT	UCUM	UDUNITS2	Potential in Combination?
Governance	↑	↘	↓	✓
Restrictions on Use and Modification	→	↘	↑	?
Cost	↘	↑	↑	✓
Licensing	↘	↘	↑	?
Support	↑	↓	↘	?
Freedom to Modify or Extend	↑	↓	↗	✓
Availability of s/w Implementations	↑	↗	↘	?
SI Conformance	→	↘	↑	✓
Unit Coverage	↘	↑	↗	?
Semantic relationhips between Terms, incl. Synonyms	↑	↘	↗	✓
Espressive and Computational Power	↓	→	↗	✓
Property / Kind of Quantity Capability	→	↓	↓	?
Human-readable Syntax	→	↘	↗	✓
Numerical Computing Considerations	↓	↘	↘	?

The strengths + weaknesses shown here prompted us to consider the option of combining the semantic capability of SNOMED with the mathematical functions of another solution, possibly via RefSets and CrossMaps in SNOMED

Initial Conclusions

1. None of the options considered meet the expected future need in full
2. Combining SNOMED semantics with UCUM or UDUNITS2 for unit-aware processing could potentially be more capable than either solution alone
3. The range of clinically-relevant specialist UoM available in UCUM is a key advantage, however-
4. Governance, support and licensing terms are barriers to adoption of UCUM as a national standard, especially if a combined solution with other standards is required, and when localization and adaption are considered
5. Some areas of current FHIR specifications assume / mandate the use of UCUM. This has a potential impact on UK plans for adoption of FHIR

Even combining the power of two systems as suggested would leave gaps that need to be addressed-

Numerical Computing

1. Consideration of binary/decimal number representation issues (leading to rounding errors, loss of significance, and other undesirable behaviours)
2. Propagation and control of error bounds in calculations
3. Representation of accuracy and precision of measured results

Repeatability and Comparability of Diagnostic Results

4. The UK was an early leader in work on repeatability and comparability of test results. A renewed focus on this may be necessary for the benefits of data sharing and machine data analysis for direct patient care to be realised

References

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