Interoperation and Analytics of EHR Data

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SNOMED International

Acknowledgements and Thank you

- Robert Wynne is a research programmer for the Lister Hill Center of the National Library of Medicine
- Jay Pedersen is research software engineer work on Nebraska Public Health Lab and UNMC PCORnet datamart development
- B2I staff led us through the details of implementing the NLM OWL database into RF2 datasets and fixed our mistakes
- Rory Davidson is Chief Information Officer for SNOMED International and provides support for this workshop
- Toni Morrison, Julie James and the Drug Model Working Group have done wonderful things developing drug and substance concept model extensions within SNOMED CT
- Pathology and Laboratory Medicine CRG has labored to bring new content to the worldwide informatics communities, and we have exciting news on LOINC-SNOMED CT!

Resources for this workshop

- ZOOM:
- Slide set:
- Readings and reference: ECL guide, SNOMED CT Editorial Guide, International Medicinal Product model, PCORnet common data model, Allergy implementation guide
- ECL_Queries_Portugal_Workshop.docx

Agenda

- Introductions
- Interoperation defined; relationship to SNOMED CT; Workshop SNOMED Tooling: MRCM, ECL and OWL
- SNOMED Clinical Findings and Interoperation use cases for Problem Lists
- SNOMED Substances, Medicinal and Pharmacologic Products Interoperation for Clinical Care and Decision Support
- SNOMED Observable entities Interoperation for Lab/Path test results and Decision support

Interoperability

"Semantic interoperability is **the ability of computer systems to exchange data with unambiguous, shared (computable) meaning**. Semantic interoperability is a requirement to enable machine computable logic, inferencing, knowledge discovery, and data federation between information systems."

-Wikipedia

- In healthcare, interoperability is key to achieving the vision of the Learning Healthcare System proposed by the Institute of Medicine and taken up by several SNOMED member countries. That was one stimulus for the modern EHR

Interoperation of EHR Information

- Information model (top level ontology)
- Vocabulary model: Terminology, Relationships, Descriptions (domain ontology)
- Data representation model

- The complete, unambiguous and consistent binding of these three standards-based elements among a community of users of EHR datasets supports semantic interoperation

Interoperation of EHR Information

- Information model: Global Digital Health Partnership(https:\\gdhp.health) - International Patient Summary
- Voca
  vocab
- Data

SNOMED and Interoperability: a Domain Ontology

- Historical model for SNOMED III was a controlled terminology with 5 hierarchically organized domains that could be used for computing monohierarchical calculation of subsumption
- SNOMED RT changed the model to a polyhierarchical network and added defining and qualifying attributes (relationships). Classifier was introduced to compute semantic equivalence. Computability was limited to hierarchical linkage and publication of refsets as valuesets for query support and mapping
- SNOMED CT changed to DL classifier and OWL formalisms for greater expressivity. Hard work by SNOMED community continues to pursue full semantic definition of concepts across domains
- Now with greatly expanded base of EHRs in healthcare employing SNOMED CT ontologies, there is a struggle to develop tooling to support interoperable SNOMED CT query functionality for data use and re-use

EHR Interoperability Re-Use Cases

- Clinical and Healthcare Enterprise
  - Enterprise business management
  - Clinical decision support
  - Healthcare process improvement
- Research
  - Adverse event monitoring and safety: FDA Sentinel
  - Clinical data research networks: PCORnet, OHDSI
  - Patient-powered research networks
- Public and Population Health
  - Morbidity and Mortality monitoring – PH Policy
- ~~Business community~~

SNOMED Concept Model & Interoperability

- Early experiments with post-coordination identified need for logical grammatical constraints in the use of defining attributes and valuesets
- 2009 - Machine readable concept model
- Editorial guide: MRCM documentation:confluence.ihtsdotools.org/display/DOCEG/
- MRCM documents and standardizes SNOMED concept model in promotion of interoperability: confluence.ihtsdotools.org/display/DOCMRCM/
- Today: Clinical findings (pp123-125), Substances (pp270-271), Pharmaceutical and biological products (pp205-208), Observable entities (pp 183-186)
- Provides a framework for designing and implementing tooling for interoperable URU analytics

SNOMED CT SI Tooling: ECL and OWL

https://browser.ihtsdotools.org/?

- 2013 - Expression Constraint Language: formalisms for computable query and manipulation of SNOMED CT metadata such as:

  Terminology binding

  Intensional reference sets (valuesets)

  Computable queries of databases using SNOMED CT as domain ontology

  Specification of SNOMED CT MRCM

- Introduction to ECL tooling for Clinical findings domain

Syntax Overview

The following table summarises the key symbols used in the Expression Constraint Language's brief syntax, with the ECL version in which each symbol was introduced. For more information about the version history of ECL, pl
Introduction.

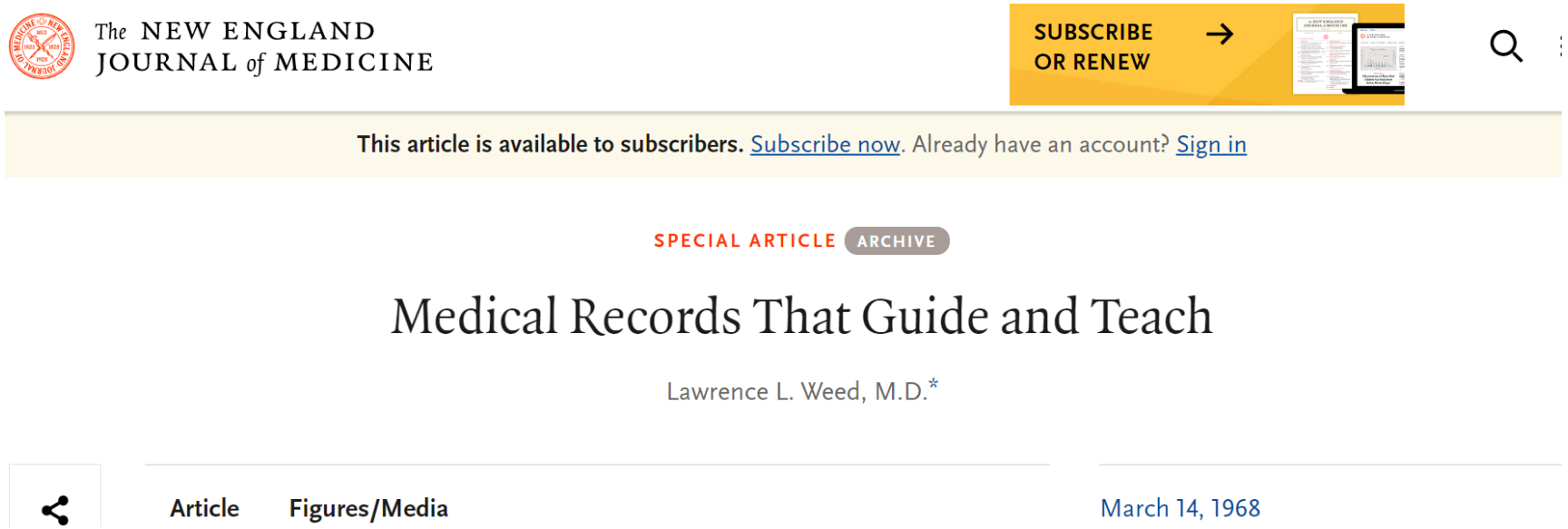
Symbol	Name	Version	Notes
|	Pipe	1.0	Used on either side of a concept's term for human readability
*	Any	1.0	Retrieves all concepts in the substrate
^	Member of	1.0	Retrieves the referencedComponentId of all (active) members of a reference set (or set of reference sets)
^ [A, B]	Member of (with field selection)	2.0	Retrieves the values of fields A and B of all (active) members of a reference set (or set of reference sets) that match the included Member filters (if applicable)
<	Descendant of	1.0	Retrieves all descendants (subtypes) of the specified concept *excluding* the concept itself
<<	Descendant or self of	1.0	Retrieves all descendants (subtypes) of the specified concept *including* the concept itself
<!	Child of	1.1	Retrieves all children (immediate subtypes) of the specified concept *excluding* the concept itself
<<!	Child or self of	1.4	Retrieves all children (immediate subtypes) of the specified concept *including* the concept itself
>	Ancestor of	1.0	Retrieves all ancestors (supertypes) of the specified concept *excluding* the concept itself
>>	Ancestor or self of	1.0	Retrieves all ancestors (supertypes) of the specified concept *including* the concept itself
>!	Parent of	1.1	Retrieves all parents (immediate supertypes) of the specified concept *excluding* the concept itself
>>!	Parent or self of	1.4	Retrieves all parents (immediate supertypes) of the specified concept *including* the concept itself
AND	Conjunction	1.0	Retrieves the intersection of the results of each sub-expressions
OR	Disjunction	1.0	Retrieves the union of the results of each sub-expressions
MINUS	Exclusion	1.0	Retrieves the members of the first expression and excludes the members returned by the second expression
:	Refinement	1.0	Used before one or more attribute-value pairs to refine the set of concepts retrieved
[1..3]	Cardinality	1.0	Used to indicate the minimum and maximum number of occurrences of attributes or relationship groups
R	Reverse flag	1.0	Retrieves the set of attribute values (i.e. destination concepts) of a specified attribute for a specified set of concepts
.	Dot notation	1.2	Retrieves the set of attribute values (i.e. destination concepts) of a specified attribute for a specified set of concepts

Problem List Use Case and Data Re-use for Administrative purposes

Kin Wah Fung

Problem-oriented Medical Record

- "*Each medical record should have a complete list of all the patient's problems, including both clearly established diagnoses and all other unexplained findings that are not yet clear manifestations of a specific diagnosis, such as abnormal physical findings, or symptoms*" – Lawrence Weed 1968
- The problem list, together with problem-oriented plans and problem-oriented progress notes becomes a fixture of paper, and later, electronic health records



The Electronic Health Record

- In the EHR, the use of problem list is not limited to direct patient care, it is often used to drive other functions e.g.,
  - Generation of billing codes
  - Healthcare statistics
  - Public health reporting
  - Research
- Since many of these functions require encoded data, the problem list is often the first (if not the only) place in which clinical information is encoded by a medical terminology

Problem list terminology

- In the US, SNOMED CT is the designated terminology for the problem list in the EHR
- Although ICD-10-CM codes are ubiquitous, SNOMED CT is much better suited for capturing clinical information
  - Comprehensive coverage
  - Clinical orientation
  - Better data entry and retrieval

Terminology vs. classification

	Terminology	Classification
Example	SNOMED CT	ICD-10-CM
Usage	General - clinical documentation	Specific - mortality statistics, population health, reimbursement
Goal	Capture of full meaning	Abstraction of data to facilitate aggregation, statistics and comparison
Structural features: Hierarchy	Polyhierarchy	Strict hierarchy (to avoid double counting)
Coding level	Use code at any level	Use only lowest (‘leaf’) level codes (needs ‘unspecified’/‘Not otherwise specified’ codes)
Overlap between concepts	Possible	Pairwise disjoint (‘pigeon hole’ approach – to minimize coding variability)
Exhaustiveness	Desirable but not essential	Jointly exhaustive (a code for everything, needs ‘Other’/‘Not elsewhere classified’ codes)

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Content coverage

- SNOMED CT has much better clinical coverage than ICD
- Number of codes:
  - SNOMED CT (Clinical finding): 120,000
  - ICD-9-CM: 14,000
  - ICD-10-CM: 68,000
- ICD's focus is statistical – less common diseases get lumped together in "catch-all" categories

	SNOMED CT	ICD-9-CM	ICD-10-CM
Congenital skin anomalies	205573006 Focal dermal hypoplasia 79468000 Familial benign pemphigus 5132005 Keratosis pilaris *… (total 21 codes)*	757.39 Other specified congenital anomalies of skin	Q82.8 Other specified congenital malformations of skin
Acidosis	59455009 Metabolic acidosis 12326000 Respiratory acidosis 91273001 Lactic acidosis *… (total 60 codes)*	276.2 Acidosis	E87.2 Acidosis
Brachial plexus disorders	72893007 Brachial neuritis 278065000 Pancoast's syndrome 78141002 Erb-Duchenne paralysis *... (total 33 codes)*	353.0 Brachial plexus lesions	G54.0 Brachial plexus disorders

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SNOMED CT is extensible

- ICD
  - no reproducible method for adding codes
  - Local extension codes are not shareable
- SNOMED CT – well-defined rules to extend or refine existing concepts (post-coordination) e.g.
  - New concept “Left kidney stone” can be created by modifying existing concept “Kidney stone” with laterality specification
- Advantages:
  - Post-coordinated expressions are shareable
  - Support semantic computation
    - equivalence of meaning – with future new concepts and other post-coordinated expressions
    - Subsumption (aggregation) - the ‘left kidney stone’ will be recognized as a sub-type of ‘kidney stone’

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Clinical orientation

- SNOMED CT terms are words that clinicians use in clinical discourse, but some ICD names are not
  - SNOMED CT: *29753000 Partial seizure*
  - *ICD-10-CM: G40.109 Localization-related (focal) (partial) symptomatic epilepsy and epileptic syndromes with simple partial seizures, not intractable, without status epilepticus*
- Excessive non-clinical detail in ICD e.g. external causes of injury
  - ICD-10-CM
    - *V30.2xxD Person on outside of three-wheeled motor vehicle injured in collision with pedestrian or animal in nontraffic accident, subsequent encounter* (ICD-10-CM)
  - public health perspective vs. patient perspective

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Data entry

- In ICD, special classification codes are needed to ensure that everything can be coded
  - NOS (Not otherwise specified) or Unspecified codes - cases with some missing information and cannot be classified to more specific codes e.g. *Viral pneumonia, unspecified*
  - NEC (Not elsewhere classified) codes - cases with more specific information not covered by available codes e.g. Pneumonia caused by Human metapneumovirus is codes as *Viral pneumonia, NEC*
- NOS and NEC codes can be confusing for clinical users
- SNOMED CT
  - no NOS or NEC codes
  - Can use codes at any level of specificity as warranted by the clinical situation

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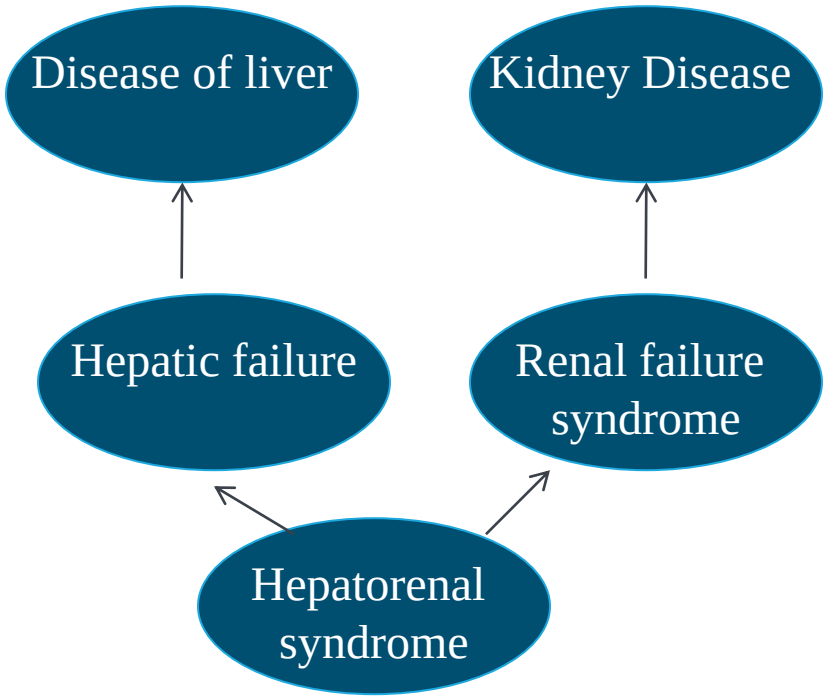
Data retrieval

- Data retrieval is easier in SNOMED CT
  - Poly-hierarchy
  - Logical definition

Poly- vs. Strict hierarchy

SNOMED CT (polyhierarchy)



ICD-10-CM (strict hierarchy)

K00-K95: Diseases of the digestive system

↑

K70-K77: Diseases of liver

↑

K76.7 : Hepatorenal syndrome

Easier to find codes in polyhierarchy

- ICD-10-CM
  - Not all codes for hypertension are covered by this code range: *Hypertensive diseases (I10-I16)*
  - Some codes found elsewhere
    - *O10-: Pre-existing hypertension complicating pregnancy, childbirth and the puerperium*
    - *P29.2 : Neonatal hypertension*
    - *I97.3 : Postprocedural hypertension*
- SNOMED CT
  - All codes for hypertension are descendants of *38341003 Hypertensive disorder*
  - can retrieve all codes by a simple query

Code retrieval using attributes

- SNOMED CT
  - Concepts defined by logical definition
  - Can retrieve concepts by attribute-based query e.g.
    - All diseases caused by arterial occlusion, except those affecting the intestines or kidneys
- ICD – need full search of index, liable to miss codes
- When source terminologies are updated
  - SNOMED CT – simply re-run query
  - ICD – repeat manual search

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Clinical finding concept model – defining attributes EdGuide pp 123-125

- Associated morphology
- Associated with
  - Causative agent
  - Due to
  - Temporally related to
    - After
    - Before
    - During
- Clinical course
- Has realization
- Episodicity
- Interprets
- Has interpretation
- Pathological process
- Occurrence
- Finding site
- Finding method
- Finding informer
- Severity

ECL exercise

1. All subtypes of pneumonia
2. All pneumonia caused by human coronavirus
3. All bacterial infectious diseases affecting the lung
4. All infectious diseases caused by Streptococcus
5. All acute diseases that have a clinical course relationship that has a value that is NOT a type of sudden onset and/or short duration
6. All diseases caused by arterial occlusion, except those affecting the intestines or kidneys
7. Chronic diseases with exactly 2 finding sites
8. All fractures with 2 or more body sites
9. Finding sites of any type of edema
10. Body sites affected by HIV

The CORE Problem list subset of SNOMED CT

- NLM's effort to facilitate adoption of SNOMED CT
- Problem list terms and usage frequencies were collected from 8 large-scale health care providers
  - Beth Israel Deaconess Medical Center
  - Intermountain Healthcare
  - Kaiser Permanente
  - Mayo Clinic
  - University of Nebraska Medical Center
  - Regenstrief Institute
  - Veterans Administration
  - Hong Kong Hospital Authority
- Data cover 17 million patients from all major medical specialties

CORE Problem list subset

- Most frequently used terms in each dataset covering 95% of usage are mapped to SNOMED CT
- Updated regularly to replace retired SNOMED CT concepts
- 2022 May release
  - Clinical finding : 5,320
  - Procedure : 567
  - Situation with explicit context : 193
  - Event : 62
  - ----------
  - Total : 6,142

Uses of the CORE Subset

- Implementation of SNOMED CT in EHR
- SNOMED CT quality assurance activities
- Inter-terminology mapping
- Terminology research

But ICD is not going away…

- ICD codes have been used for over a century to collect international health statistics
- In many countries, ICD codes serve important administrative functions e.g. reimbursement, case-mix, public health reporting, quality measure
- A map between SNOMED CT and ICD will enable
  - Re-use of clinical data to generate ICD codes (“code once, use many times”)
  - Data interoperability between clinical and administrative data bases
  - Better coding in either code systems

The Mapping Special Interest Group

- Started around 2006, the SIG worked on the problem of mapping between SNOMED CT and ICD
- This laid the foundation for two maps:
  - SNOMED CT to ICD map – maintained by SNOMED International
  - SNOMED CT to ICD-10-CM map – maintained by NLM

SNOMED CT to ICD-10-CM map

- Scope of mapping
  - Three SNOMED CT hierarchies (commonly used to populate the problem list)
    - Clinical finding
    - Event
    - Situation with explicit context (excluding Procedure with explicit context)
  - Total over 120,000 concepts
- Progress
  - First release in 2012 about 7,000 concepts mapped (mostly the CORE Subset)
  - Map gradually expanded, now covers all concepts in a previous SNOMED US release
  - Ongoing work
    - Map new SNOMED CT concepts (about 2,000 every 6 months)
    - Synchronize with new ICD-10-CM release (yearly)
    - QA of existing maps

Rule-based map

- Maps are often not one-to-one
- Two types of one-to-many maps
  - Some SNOMED CT concepts need more than one ICD-10-CM code (‘AND’)
  - Within each map group, there may be several alternative target ICD-10-CM codes (‘OR’)

Example of ‘AND’ – etiology and manifestation

- ICD-10-CM requires 2 codes, one for the underlying disease (etiology), one for the manifestation

Source concept: 307726001 Anemia in ovarian carcinoma (disorder)

Map group 1

Rule 1 → C56.9 Malignant neoplasm of unspecified ovary

Map group 2

Rule 1 → D63.0 Anemia in neoplastic disease

Example of ‘OR’ – gender

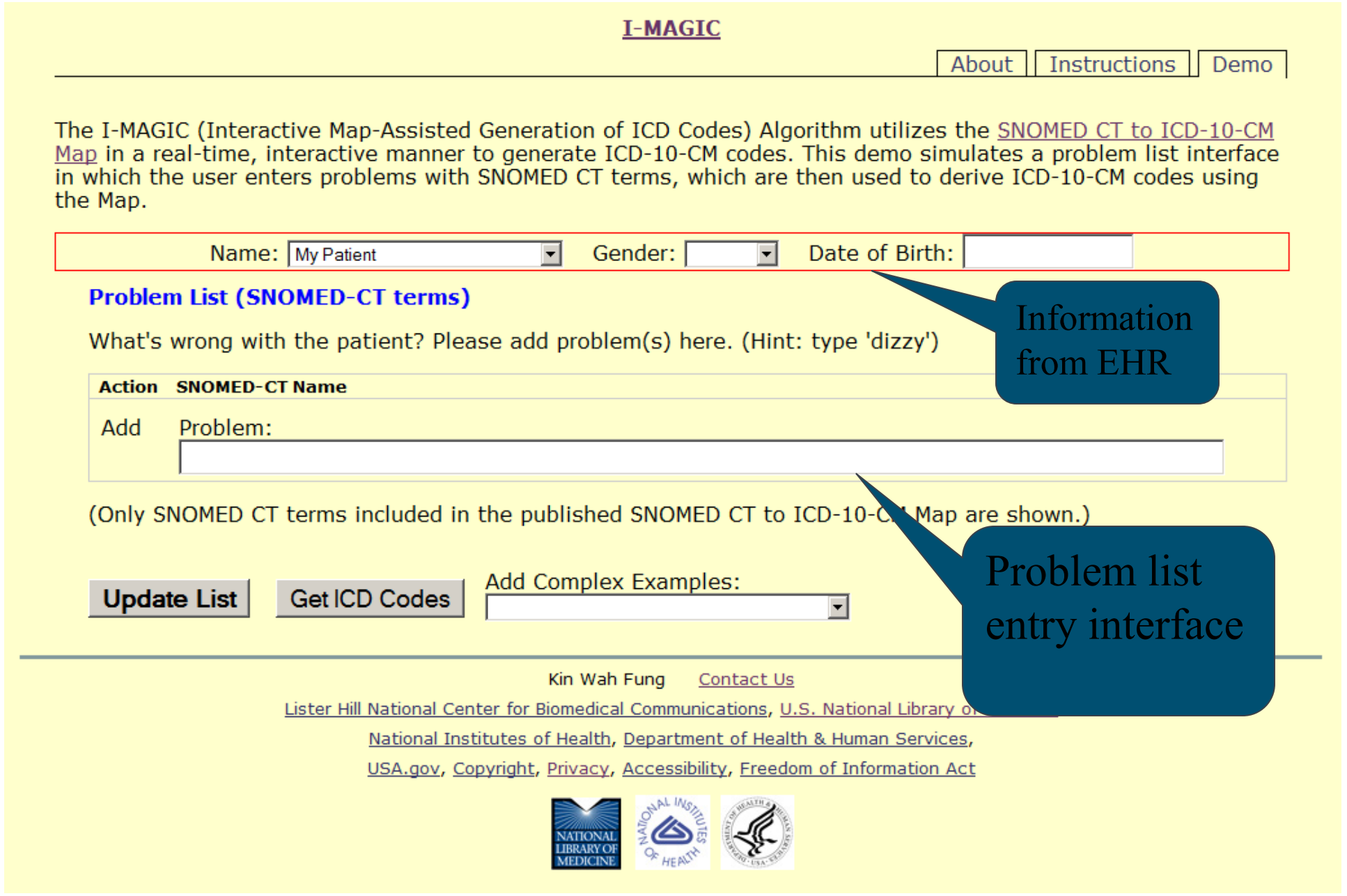
- Source concept: 237145004 Unexplained infertility (finding)
- Map group 1
  - Rule 1 IFA FEMALE (FINDING) | → N97.9 Female infertility, unspecified
  - Rule 2 IFA MALE (FINDING) | → N46.9 Male infertility, unspecified
  - Rule 3 OTHERWISE TRUE → NULL

I-MAGIC

- Interactive Map-Assisted Generation of ICD Codes
- Use case scenario
  - Dr Smith sees Ms Jones in clinic
  - In his clinic EHR, Dr Smith maintains a problem list (encoded in the background in SNOMED CT)
  - At the end of the consultation, after updating the problem list, Dr Smith clicks a button for possible ICD-10-CM codes for the encounter
  - Based on the encoded problems and other information in the EHR, a candidate list of map-generated ICD-10-CM codes is shown. Dr Smith may be prompted for additional input or possible refinement of the codes where appropriate
  - Dr Smith picks the codes to be used for insurance claims

I-MAGIC demo tool

- http://imagic.nlm.nih.gov/imagic/code/map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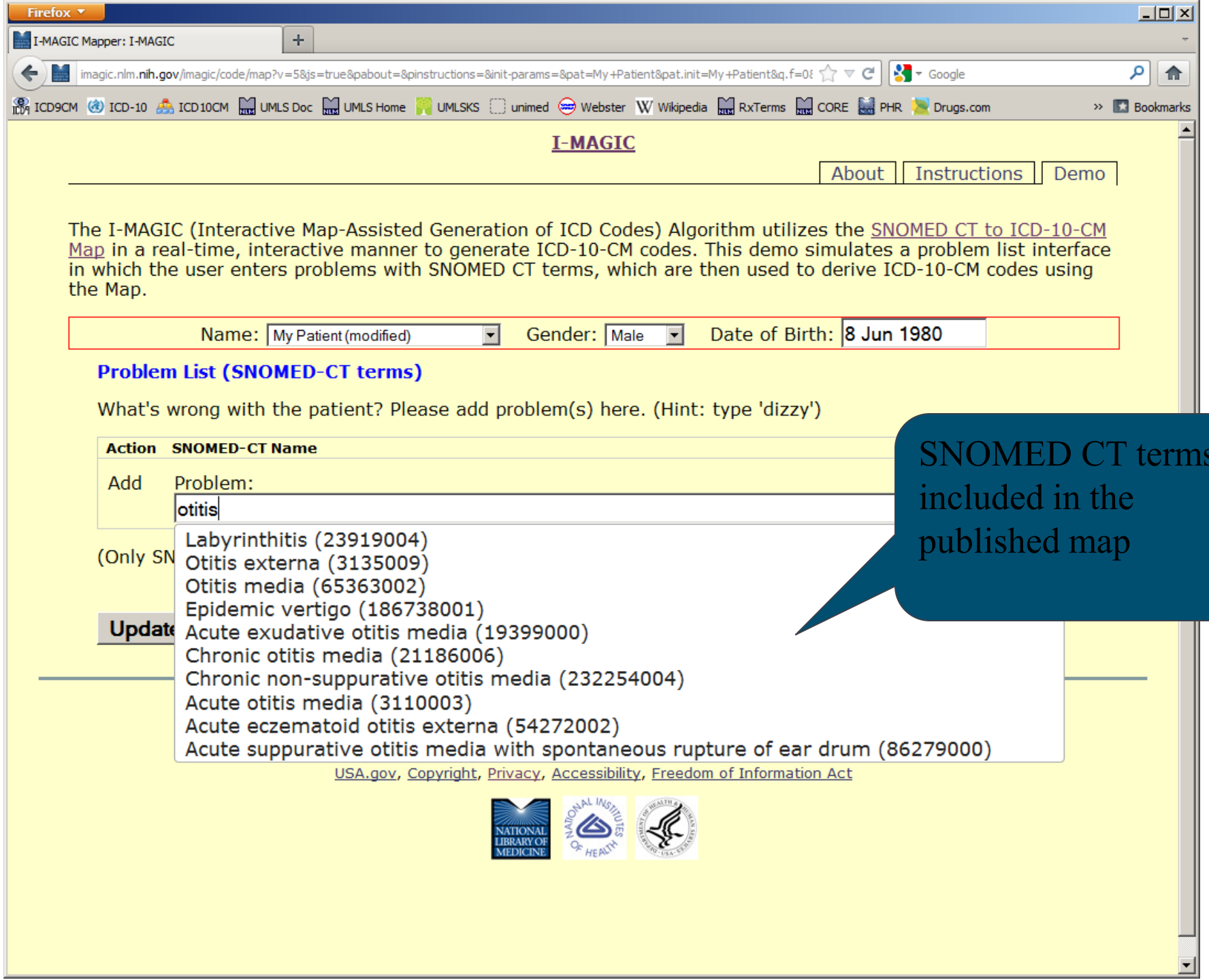
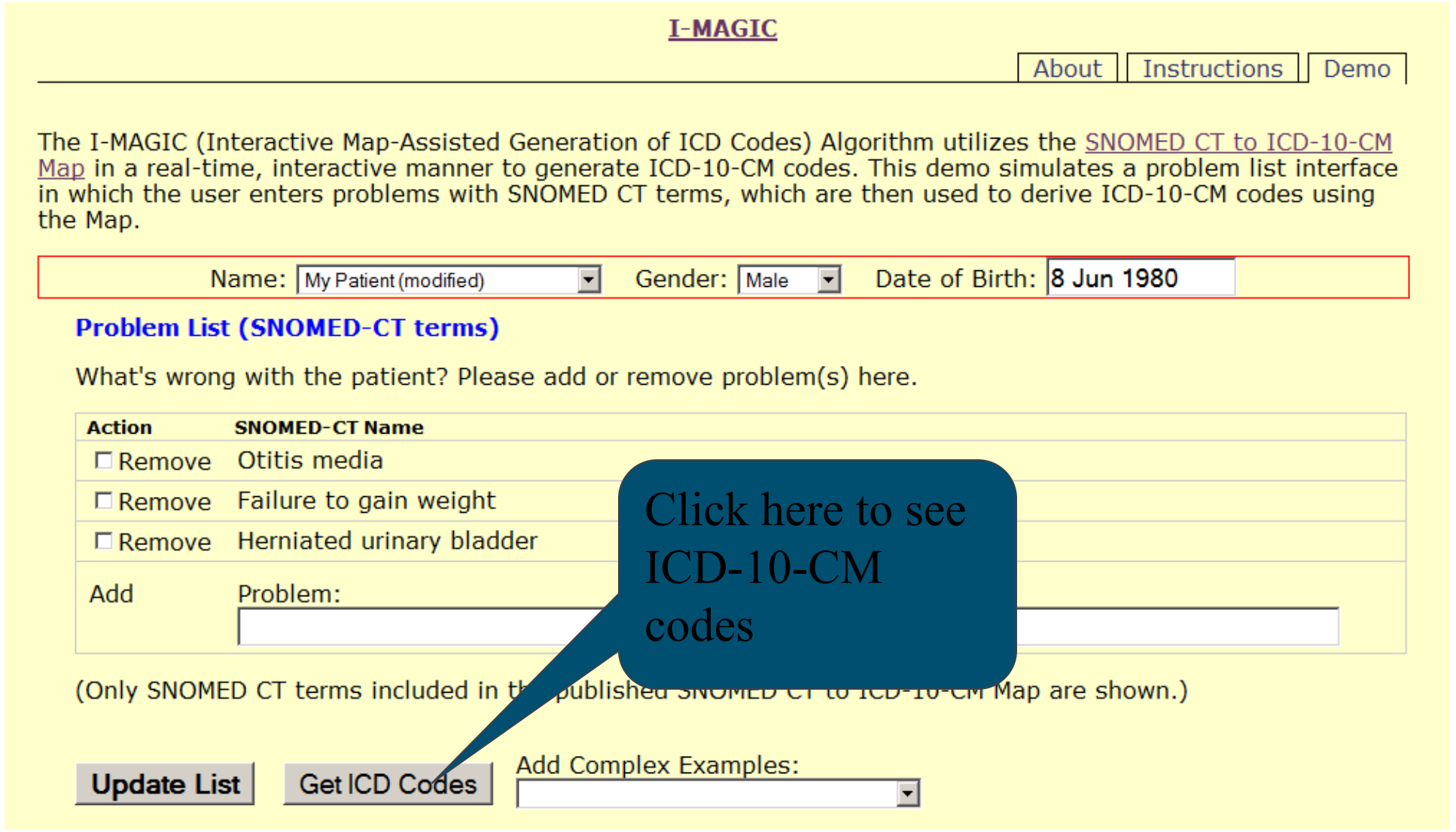
The I-MAGIC (Interactive Map-Assisted Generation of ICD Codes) Algorithm utilizes the SNOMED CT to ICD-10-CM Map in a real-time, interactive manner to generate ICD-10-CM codes. This demo simulates a problem list interface in which the user enters problems with SNOMED CT terms, which are then used to derive ICD-10-CM codes using the Map.
Name: My Patient
Gender:
Date of Birth:
Problem List (SNOMED-CT terms)
What's wrong with the patient? Please add problem(s) here. (Hint: type 'dizzy')
Action
SNOMED-CT Name
Add
Problem:
(Only SNOMED CT terms included in the published SNOMED CT to ICD-10-CM Map are shown.)
Update List
Get ICD Codes
Add Complex Examples:
Information from EHR
Problem list entry interface
Kin Wah Fung
Contact Us
Lister Hill National Center for Biomedical Communications, U.S. National Library of
National Institutes of Health, Department of Health & Human Services,
USA.gov, Copyright, Privacy, Accessibility, Freedom of Information Act



SNOMED CT terms included in the published map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Name: My Patient (modified)
Gender: Male
Date of Birth: 8 Jun 1980
Problem List (SNOMED-CT terms)
What's wrong with the patient? Please add or remove problem(s) here.
Action
SNOMED-CT Name
Remove
Otitis media
Remove
Failure to gain weight
Remove
Herniated urinary bladder
Add
Problem:
(Only SNOMED CT terms included in th published SNOMED CT to ICD-10-CM Map are shown.)
Update List
Get ICD Codes
Add Complex Examples:
Click here to see ICD-10-CM codes

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Name: My Patient (modified) Gender: Male Date of Birth: 8 Jun 1980

Mapping Problems to ICD-10-CM

SNOMED-CT	ICD-10-CM Code	ICD-10-CM Name	Optional refinement
Otitis media (65363002)			
	H66.90	Otitis media, unspecified, unspecified ear	Laterality / ICD notes
Failure to gain weight (36440009)			
	R62.7	Adult failure to thrive	
Herniated urinary bladder (410070006)			
	N32.89	Other specified disorders of bladder	

Submit Refinement | Back to Problem List

ICD-10-CM codes

Options to refine ICD-10-CM codes

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Name: My Patient (modified) Gender: Male Date of Birth: 8 Jun 1980

Mapping Problems to ICD-10-CM

SNOMED-CT	ICD-10-CM Code	ICD-10-CM Name	Optional refinement
Otitis media (65363002)			
	H66.90	Otitis media, unspecified, unspecified ear	Laterality, ICD notes
Failure to gain weight (36440009)			
	R62.7	Adult failure to thrive	
Herniated urinary bladder (410070006)			
	N32.89	Other specified disorders of bladder	

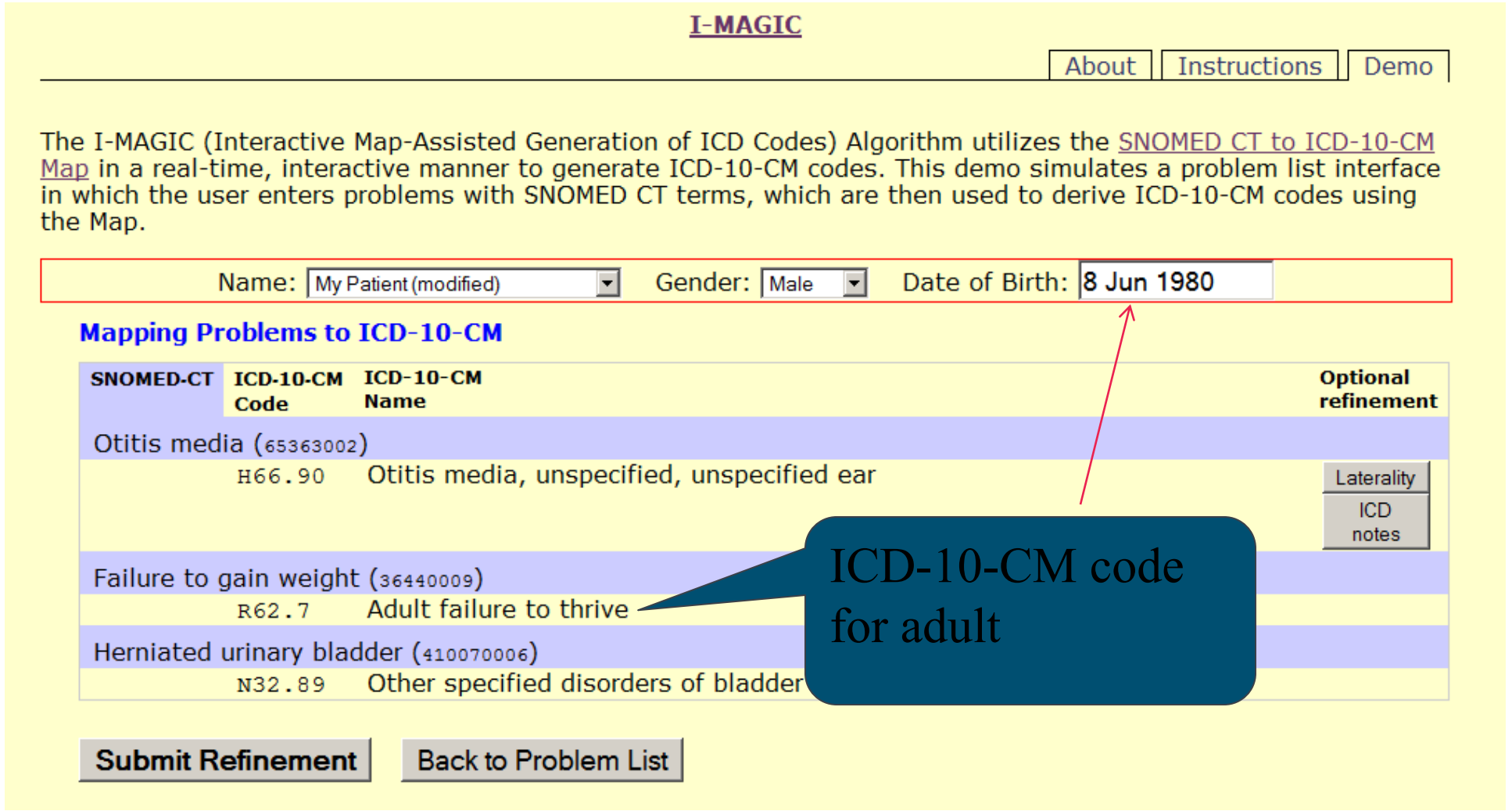
Laterality refinement

Refine "Otitis media, unspecified":

- Otitis media, unspecified, **unspecified ear**
- Otitis media, unspecified. **right** ear
- Otitis media, unspecified, **left** ear
- Otitis media, unspecified, **bilateral**

Laterality refinement choices

Submit Refinement | Back to Problem List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Name: My Patient (modified)
Gender: Male
Date of Birth: 8 Jun 1980
Mapping Problems to ICD-10-CM
SNOMED-CT
ICD-10-CM Code
ICD-10-CM Name
Optional refinement
Otitis media (65363002)
H66.90
Otitis media, unspecified, unspecified ear
Laterality
ICD notes
Failure to gain weight (36440009)
R62.7
Adult failure to thrive
Herniated urinary bladder (410070006)
N32.89
Other specified disorders of bladder
ICD-10-CM code for adult
Submit Refinement
Back to Problem List

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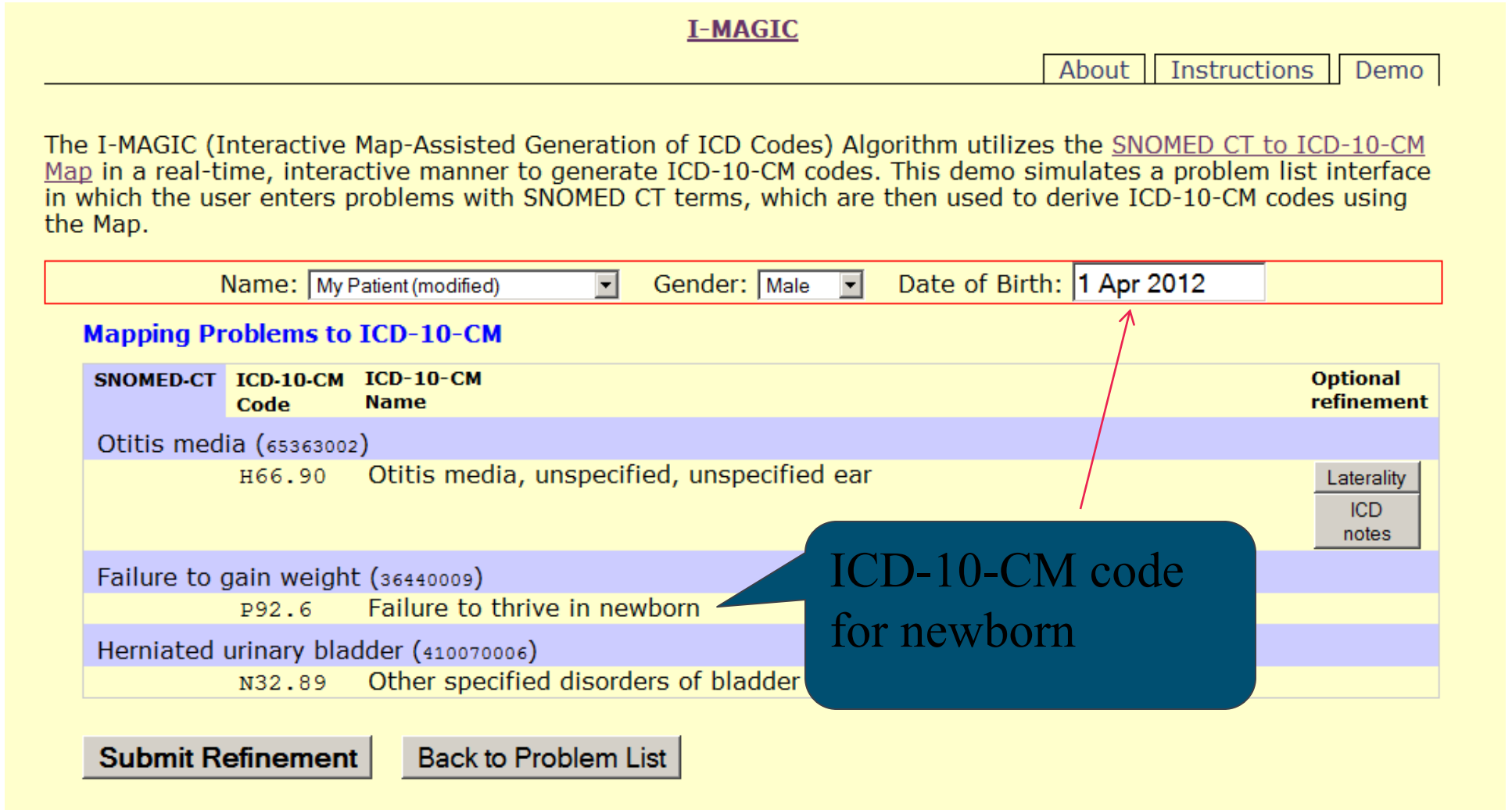
Name: My Patient (modified) Gender: Male Date of Birth: 8 Jun 2006

Mapping Problems to ICD-10-CM

SNOMED-CT	ICD-10-CM Code	ICD-10-CM Name	Optional refinement
Otitis media (65363002)			
	H66.90	Otitis media, unspecified, unspecified ear	Laterality, ICD notes
Failure to gain weight (36440009)			
	R62.51	Failure to thrive (child)	
Herniated urinary bladder (410070006)			
	N32.89	Other specified disorders of bladde	

ICD-10-CM code for child

Submit Refinement | Back to Problem List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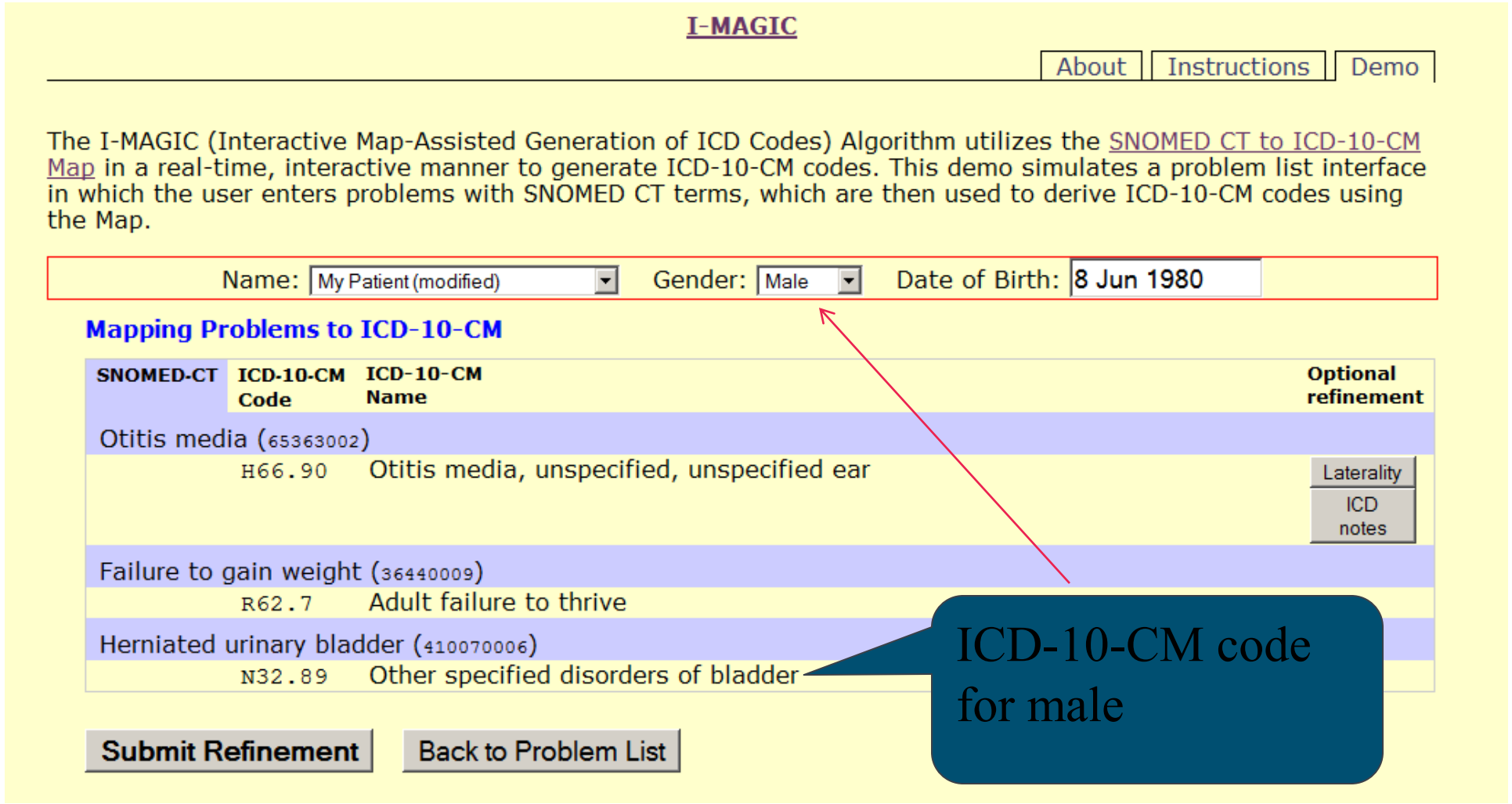
Name: My Patient (modified)
Gender: Male
Date of Birth: 1 Apr 2012
Mapping Problems to ICD-10-CM
SNOMED-CT
ICD-10-CM Code
ICD-10-CM Name
Optional refinement
Otitis media (65363002)
H66.90
Otitis media, unspecified, unspecified ear
Laterality
ICD notes
Failure to gain weight (36440009)
P92.6
Failure to thrive in newborn
Herniated urinary bladder (410070006)
N32.89
Other specified disorders of bladder
ICD-10-CM code for newborn
Submit Refinement
Back to Problem List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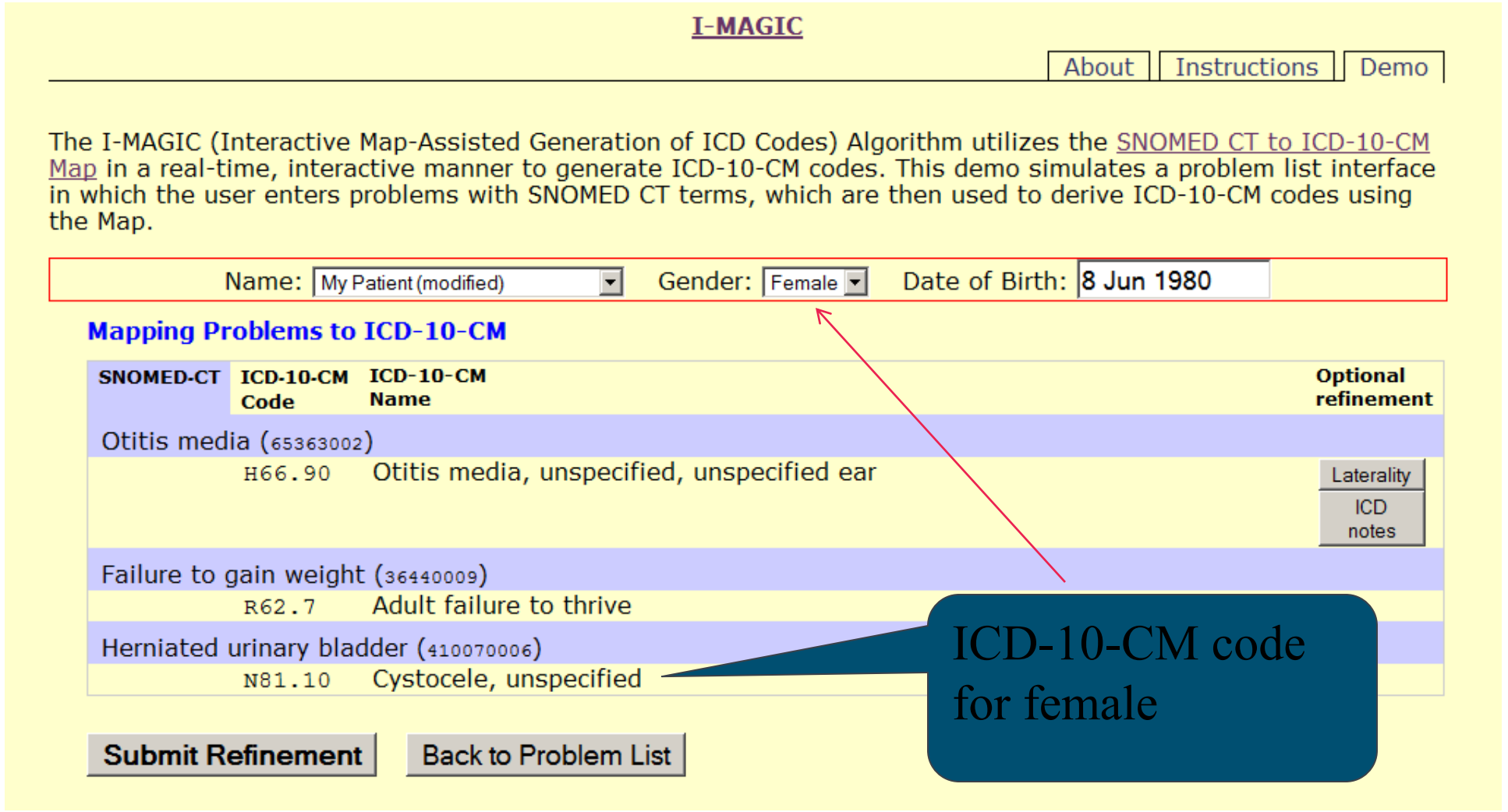
Name: My Patient (modified)
Gender: Male
Date of Birth: 8 Jun 1980
Mapping Problems to ICD-10-CM
SNOMED-CT
ICD-10-CM Code
ICD-10-CM Name
Optional refinement
Otitis media (65363002)
H66.90
Otitis media, unspecified, unspecified ear
Laterality
ICD notes
Failure to gain weight (36440009)
R62.7
Adult failure to thrive
Herniated urinary bladder (410070006)
N32.89
Other specified disorders of bladder
Submit Refinement
Back to Problem List
ICD-10-CM code for male


I-MAGIC
About
Instructions
Demo
The I-MAGIC (Interactive Map-Assisted Generation of ICD Codes) Algorithm utilizes the SNOMED CT to ICD-10-CM Map in a real-time, interactive manner to generate ICD-10-CM codes. This demo simulates a problem list interface in which the user enters problems with SNOMED CT terms, which are then used to derive ICD-10-CM codes using the Map.
Name: My Patient (modified)
Gender: Female
Date of Birth: 8 Jun 1980
Mapping Problems to ICD-10-CM
SNOMED-CT
ICD-10-CM Code
ICD-10-CM Name
Optional refinement
Otitis media (65363002)
H66.90
Otitis media, unspecified, unspecified ear
Laterality
ICD notes
Failure to gain weight (36440009)
R62.7
Adult failure to thrive
Herniated urinary bladder (410070006)
N81.10
Cystocele, unspecified
Submit Refinement
Back to Problem List
ICD-10-CM code for female

Accessing ICD-10 and ICD-10-CM maps from the SNOMED CT browser

- ICD-10 (International edition) https://browser.ihtsdotools.org/?perspective=full&conceptId1=38341003&edition=MAIN/2022-08-31&release=&languages=en
- ICD-10-CM (US Edition) https://browser.ihtsdotools.org/?perspective=full&conceptId1=4855003&edition=MAIN/SNOMEDCT-US/2022-09-01&release=&languages=en

ICD-11

- May 2019 – ICD-11 adopted by World Health Assembly
- Feb 2021 – ICD-11 became the official version of ICD
- 35 countries are already using ICD-11 for
  - Cause of death
  - Primary care
  - Cancer registry
  - Reimbursement

What's new in ICD-11?

- Incremental changes
  - More codes
  - Chapters added or re-arranged to reflect current knowledge
- Paradigm shifts
  - Foundation component
  - Code clustering (aka post-coordination)
  - Going digital

How big is ICD-11?

Code type	Chapters 1 - 25	Chapters 26, V, X
For navigation purposes	2432	1444
For coding purposes	14622	13662
Total	17054	15106

- Total number of ICD-11 codes = 32,160, but
  - 15,106 codes (47%) in 3 chapters that fall outside scope of ICD-10:
    - Chapter 26 - Supplementary Chapter Traditional Medicine Conditions
    - Chapter V - Supplementary Section for Functioning Assessment
    - Chapter X - Extension Codes (for post-coordination only)
  - Only leaf codes are used in coding
- Total usable ICD-11 codes = 14,622
  - 20% increase over ICD-10 with 12,187 codes used for coding purposes**

53

New chapters in ICD-11

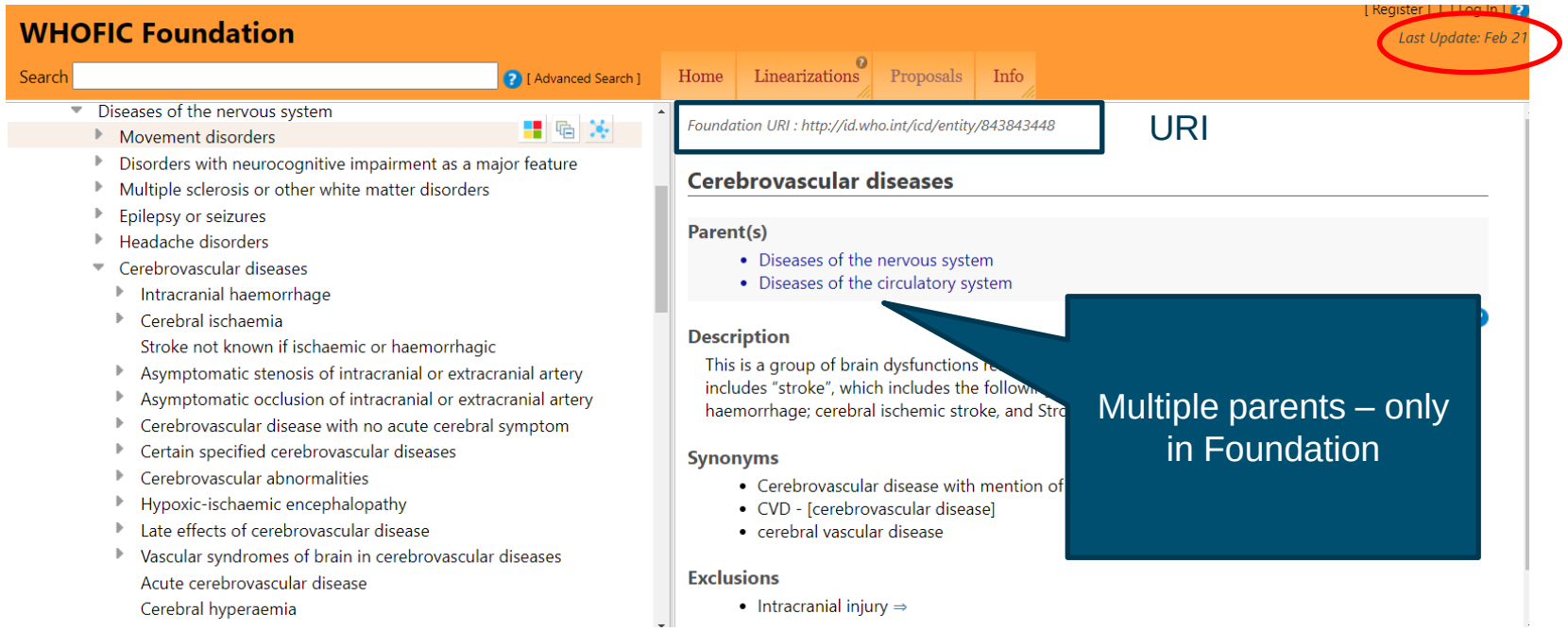
- Chapter 3 Diseases of the blood or blood-forming organs
- Chapter 4 Diseases of the immune system
- Chapter 7 Sleep-wake disorders
- Chapter 17 Conditions related to sexual health
- Chapter 26 - Supplementary Chapter Traditional Medicine Conditions
- Chapter V - Supplementary section for functioning assessment
- Chapter X - Extension Codes

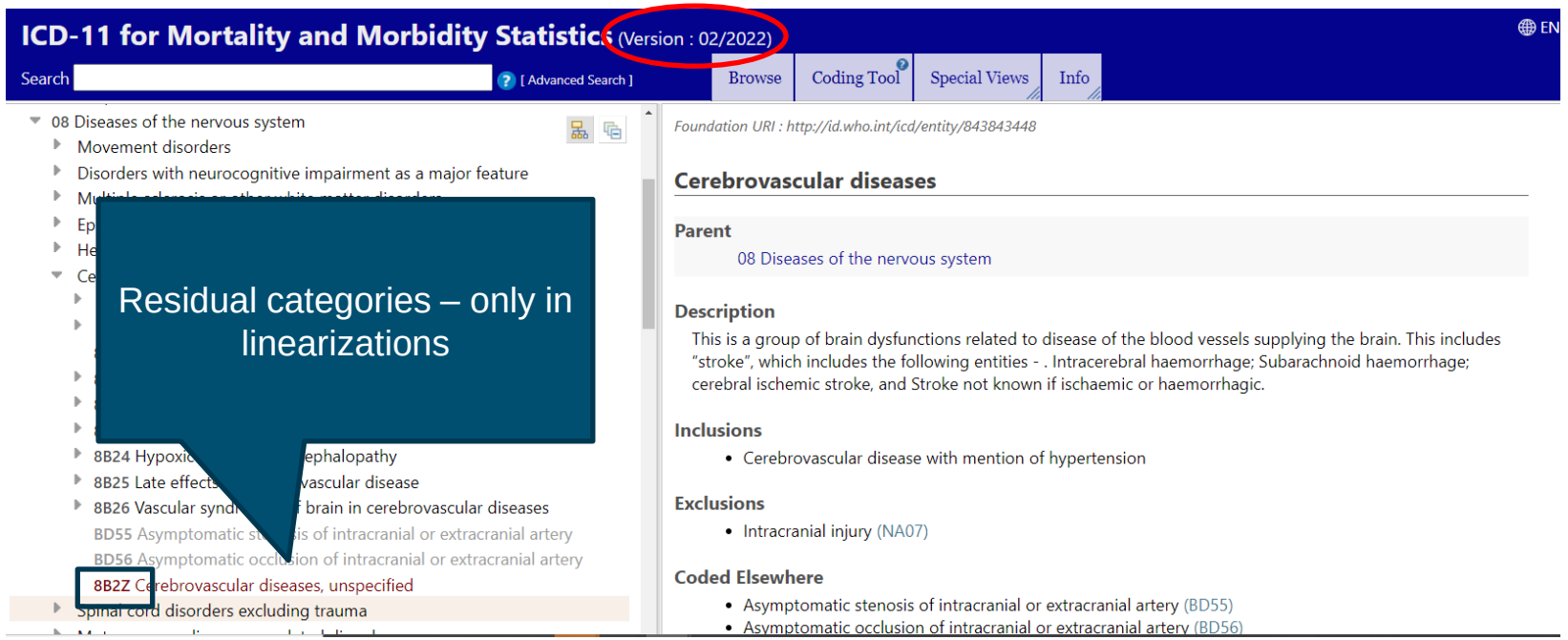
Split from Chapter III Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism

Not analyzed further

ICD-11 Foundation

- A knowledge base from which classifications (“linearizations”) are derived
  - Frequent updates (e.g., daily) to keep up with advances in science and medicine
  - Classifications generated as periodic releases (e.g., yearly) and are consistent with the knowledge base
- Structurally akin to an ontology/modern terminology, free from the constraints of classifications
  - Multi-parenting
  - No residual entities (e.g., “not elsewhere classified”, “not otherwise specified”, “unspecified”)


WHOFIC Foundation
Search
[Advanced Search]
Home
Linearizations
Proposals
Info
Last Update: Feb 21
Diseases of the nervous system
Movement disorders
Disorders with neurocognitive impairment as a major feature
Multiple sclerosis or other white matter disorders
Epilepsy or seizures
Headache disorders
Cerebrovascular diseases
Intracranial haemorrhage
Cerebral ischaemia
Stroke not known if ischaemic or haemorrhagic
Asymptomatic stenosis of intracranial or extracranial artery
Asymptomatic occlusion of intracranial or extracranial artery
Cerebrovascular disease with no acute cerebral symptom
Certain specified cerebrovascular diseases
Cerebrovascular abnormalities
Hypoxic-ischaemic encephalopathy
Late effects of cerebrovascular disease
Vascular syndromes of brain in cerebrovascular diseases
Acute cerebrovascular disease
Cerebral hyperaemia
Foundation URI : http://id.who.int/icd/entity/843843448
URI
Cerebrovascular diseases
Parent(s)
Diseases of the nervous system
Diseases of the circulatory system
Description
Synonyms
Cerebrovascular disease with mention of
CVD - [cerebrovascular disease]
cerebral vascular disease
Exclusions
Intracranial injury
Multiple parents – only in Foundation


ICD-11 for Mortality and Morbidity Statistics
(Version : 02/2022)
EN
Search
[Advanced Search]
Browse
Coding Tool
Special Views
Info
08 Diseases of the nervous system
Movement disorders
Disorders with neurocognitive impairment as a major feature
8B24 Hypoxic ephalopathy
8B25 Late effects vascular disease
8B26 Vascular syndr brain in cerebrovascular diseases
BD55 Asymptomatic s is of intracranial or extracranial artery
BD56 Asymptomatic occl ion of intracranial or extracranial artery
8B2Z Cerebrovascular diseases, unspecified
Spinal cord disorders excluding trauma
Residual categories – only in linearizations
Foundation URI : http://id.who.int/icd/entity/843843448
Cerebrovascular diseases
Parent
08 Diseases of the nervous system
Description
This is a group of brain dysfunctions related to disease of the blood vessels supplying the brain. This includes "stroke", which includes the following entities - . Intracerebral haemorrhage; Subarachnoid haemorrhage; cerebral ischemic stroke, and Stroke not known if ischaemic or haemorrhagic.
Inclusions
Cerebrovascular disease with mention of hypertension
Exclusions
Intracranial injury (NA07)
Coded Elsewhere
Asymptomatic stenosis of intracranial or extracranial artery (BD55)
Asymptomatic occlusion of intracranial or extracranial artery (BD56)

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Postcoordination in ICD-11

- Allows combination of codes (“code clustering”) to represent new meaning
- ICD-11 allows two kinds of post-coordination:
  - Two or more main (“stem”) codes (connected by “/”)
    Urinary tract infection due to Extended spectrum beta-lactamase producing Escherichia coli = GC08.0 / MG50.27
    - GC08.0 *Urinary tract infection, site not specified, due to Escherichia coli*
    - MG50.27 *Extended-spectrum beta-lactamase producing Escherichia coli*
  - Main (“stem”) codes with one or more extension codes (connected by “&”)
    Tuberculosis of prostate = 1B12.5 & XA63E5
    - 1B12.5 *Tuberculosis of the genitourinary system*
    - XA63E5 *Prostate gland*

Digital-friendly ICD-11

- Various web browsers –
  - Foundation browser
  - Browser for linearizations e.g.,
    - Mortality and Mobidity Statistics (MMS)
    - Primary Care Low Resource Setting Linearization
    - Ophthalmology Speciality Linearization
- Coding tool
- Web services and resources
  - API
  - Implementation or transition guide
  - Reference guide
  - Training videos
- Maintenance platform – can make comments or proposals

Rumor has it…

- ICD-11 may be the last major revision of ICD
  - Constant changes can be made in the Foundation and propagated to Linearizations, no need for disruptive major update
- National modifications (e.g., CM, AM, CA) may no longer be allowed
  - Licensing and copyright restrictions have not been announced
  - WHO may strongly encourage the derivation of national linearizations from the Foundation, rather than creating separate extensions

SNOMED CT and ICD-11

- Early efforts in using SNOMED CT concepts as the ICD-11 Foundation Component, later abandoned
- Renewed collaboration between SNOMED International and WHO to create a map between SNOMED CT and the ICD-11 Foundation
  - Pilot project created maps between the two systems (in both directions) for endocrine diseases
  - Results being analyzed
  - Future direction pending – stay tuned

Re-use of Problem List for Clinical Research

James Campbell

SNOMED CT EXPO 2022
SEPT 29-30, 2022
Lisbon, Portugal ✕ Virtual

SNOMED International

Clinical Data Research Networks Interoperation

- Dozens of CDRNs in the US since Y2K & MU
- Nebraska participates in PCORnet and OHDSI/OMOP
- Strict governance model managing sharing of limited data sets across 100+ datamarts
- Top level ontology == Common Data Model v6.0; relational table data specifications following loosely data classes of SENTINEL/HL7/USCDI; employing data standards of HHS
- CONDITION table stores problem list, past history and RFV; SNOMED CT Clinical findings is domain ontology
- Datamarts are managed by owners; PCORnet distributes data queries (SAS) for approved research projects to all participating sites; they run queries and return results which are consolidated and provided to investigator

pcornet

Common Data Model (CDM) Specification, Version 6.0

1 Table of Contents

Valuesets for CDRN interoperation

- “Patients with diabetes mellitus type 2”
- ??? ➔ CONDITION TABLE (SNOMED CT); CONDITION = “Diabetes”, CONDITION_STATUS = “Active”; CONDITION_STATUS = “Healthcare Problem List”
- What are the SNOMED CT codes for “Type 2 diabetes mellitus”?
- ??? ➔ CONDITION TABLE: CONDITION = “<<44054006”, CONDITION_STATUS = “AC”; CONDITION_STATUS = “HC”

“17 concepts”

- Datamarts have widely varying editions of SNOMED CT installed; research community has vanishingly little knowledge of vocabulary standards esp SNOMED CT

Computable Phenotypes and LHS

- **A Computable phenotype** refers to a set of clinical data that can be evaluated via a standardized computerized query to an EHR or clinical data research network”

Richesson RL, Smerek MM, Cameron CB. A Framework to Support the Sharing and Reuse of Computable Phenotype Definitions Across Health Care Delivery and Clinical Research Applications. eGEMs: 2016; Vol. 4: Issue 3, Article 2.

- A requirement for reproducible, accurate and valid scientific network research in healthcare

Use Cases: Computable Phenotypes

- **AlcohoL use disorder:** Bailey KL, Sayles H, Campbell JR,Khalid N, Anglim M, Ponce J, Wyatt T, McClay J, Burnham EL, Anzalone A, Hanson C. COVID-19 patients with documented alcohol use disorder of alcohol-related complications are more likely to be hospitalized and have higher all-cause mortality. Alcoholism Clin Exp Research 2022 Apr; 1:1-13.

- **Coro** osing in Cardiova

- **Colo** AD, Campbel ation of PCORne n Cancer Inform 2

Hypothesis: Adult patients with Alcohol use disorders that are infected with COVID-19 are more likely die from their illness.

Inclusion criteria: Adult patients (age > 18 years) with history of alcohol use disorder

Independent variables: Gender, race and ethnicity, comorbidities

Outcomes: Survival from onset of infection with COVID-19

Use Cases: Computable Phenotypes

- **Alcoholism:** Bailey KL, Sayles H, Campbell JR,Khalid N, Anglim M, Ponce J, Wyatt T, McClay J, Burnham EL, Anzalone A, Hanson C. COVID-19 patients with documented alcohol use disorder of alcohol-related complications are more likely to be hospitalized and have higher all-cause mortality. Alcoholism Clin Exp Research 2022 Apr; 1:1-13.

- **Coronary vascular disease:** Schuyler-Jones et all. Comparative Effectiveness of Aspirin Dosing in Cardiovascular Disease. NEJM; May 15, 2021. DOI: 10.1056/NEJMoa2102137

- **Colo** … AD, Campbe … ration of PCORn … lin Cancer Inform 2 …

Hypothesis: Patients with documented coronary vascular disease at high risk of complications are uncertain as to the best dose of aspirin for preventing MI.
Inclusion criteria: Adult patients (age > 18 years) with history of MI, CABG or stroke and risk factors for ASCVD
Independent variables: Gender, race and ethnicity, comorbidities
Outcomes: Survival to next MI, stroke or death

Use Cases: Computable Phenotypes

Hypothesis: Patients with advanced <u>colorectal carcinoma</u> residing in rural areas are less likely to be treated with molecular cancer therapies than those in urban areas.

Inclusion criteria: Adult patients (age > 18 years) with metastatic colorectal cancer

Independent variables: Gender, race and ethnicity, chemotherapy, molecular-guided therapies

Outcomes: N/A

- **Alc** ...tt T, McClay J, Burnl... ...e disorder of alcohol-... ...mortality. Alcohol...
- **Cor** ...Dosing in Cardiov...
- **Colorectal cancer:** Carnahan RM, Waitman LR, Charlton ME, Schroeder MC, Bossler AD, Campbell WS, Campbell JR, McDowell BD, Smith NC, Gryzlak BM, Chrischilles EA. Exploration of PCORnet data resources for assessing use of molecular-guided cancer treatment. JCO Clin Cancer Inform 2020 Aug;4:724-735.

Medicinal product Models for Interoperation of Medication Data

Olivier Bodenreider

SNOMED CT EXPO 2022
SEPT 29-30, 2022
Lisbon, Portugal ✕ Virtual

SNOMED International

ICBO 2018
Corvallis, Oregon
August 8, 2018

The New SNOMED CT International Medicinal Product Model

Olivier Bodenreider and Julie James

Lister Hill National Center
for Biomedical Communications
Bethesda, Maryland - USA

Bodenreider O, James J.
The new SNOMED CT international medicinal product model.
Proceedings of the 7th International Conference on Biomedical Ontology (ICBO 2018) 2018:
(electronic proceedings: http://ceur-ws.org/Vol-2285/ICBO_2018_paper_36.pdf).


*Each film-coated tablet contains amlodipine besylate, USP equivalent to 10 mg of amlodipine and atorvastatin calcium, USP equivalent to 10 mg of atorvastatin.
Usual Dosage: See accompanying prescribing information.
Keep this and all medication out of the reach of children.
Store at 20° to 25°C (68° to 77°F). [See USP Controlled Room Temperature.]
Manufactured for:
Mylan Pharmaceuticals Inc.
Morgantown, WV 26505 U.S.A.
Made in India
RMX4517H1
Mylan®
Mylan.com
NDC 0378-4517-93
Amlodipine Besylate and Atorvastatin Calcium
Tablets
10 mg/10 mg*
A A 8
PHARMACIST: Dispense the accompanying Patient Information Leaflet to each patient.
Rx only
30 Tablets
Dispense in a tight, light-resistant container as defined in the USP using a child-resistant closure.
Keep container tightly closed.
Code No.: MH/DRUGS/25/NKD/89
(27 x 12 mm)
Varnish Free area
for Coding
N 3 0378-4517-93 2
75056717

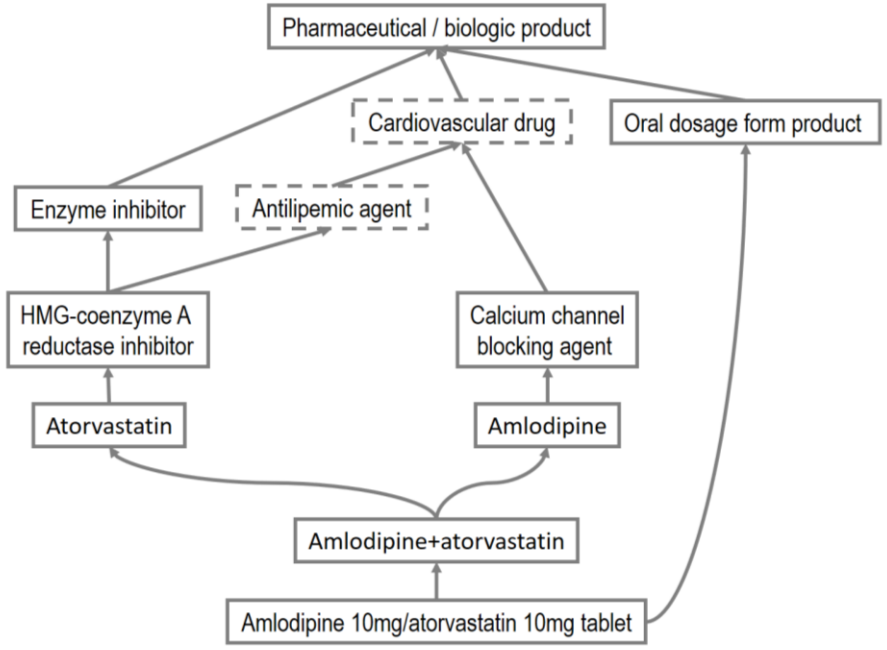
Original SNOMED CT model

Amlodipine 10 mg and atorvastatin 10 mg oral tablet

SubClass Of

'Amlodipine+atorvastatin (product)'
and ('Has active ingredient (attribute)' some 'Amlodipine besilate (substance)')
and ('Has dose form (attribute)' some 'Oral tablet (qualifier value)')

- Incomplete representation
  - *Missing ingredient*
  - *Missing strength*
- Incomplete definition
  - *No sufficient conditions*
- Lack of closure
  - *Existential restrictions*
- Therapeutic roles as ancestors of medicinal products
  - *Regulatory information*



Motivation

- Known issues with the representation of medicinal products in the original SNOMED CT model
  - Incomplete representation of clinical drugs
    - Primitive concepts
    - Missing attributes (strength, ingredients)
  - Wrong inferences due to therapeutic role groupers
    - Regulatory information vs. definitional knowledge
    - Medicinal products linked to therapeutic roles
  - Limited compliance with international standards
    - Lack of standardization in dose forms
    - Open vs. closed world for clinical drugs
- Development of a new medicinal product model

Medicinal products in SNOMED CT

- Medicinal products vs. substances
  - MPs have substances as ingredients
- Types of medicinal products
  - Ingredient + dose form + strength
  - Ingredient + dose form
  - Ingredient
  - Drug classes
- Limited scope
  - No packaging or brand information

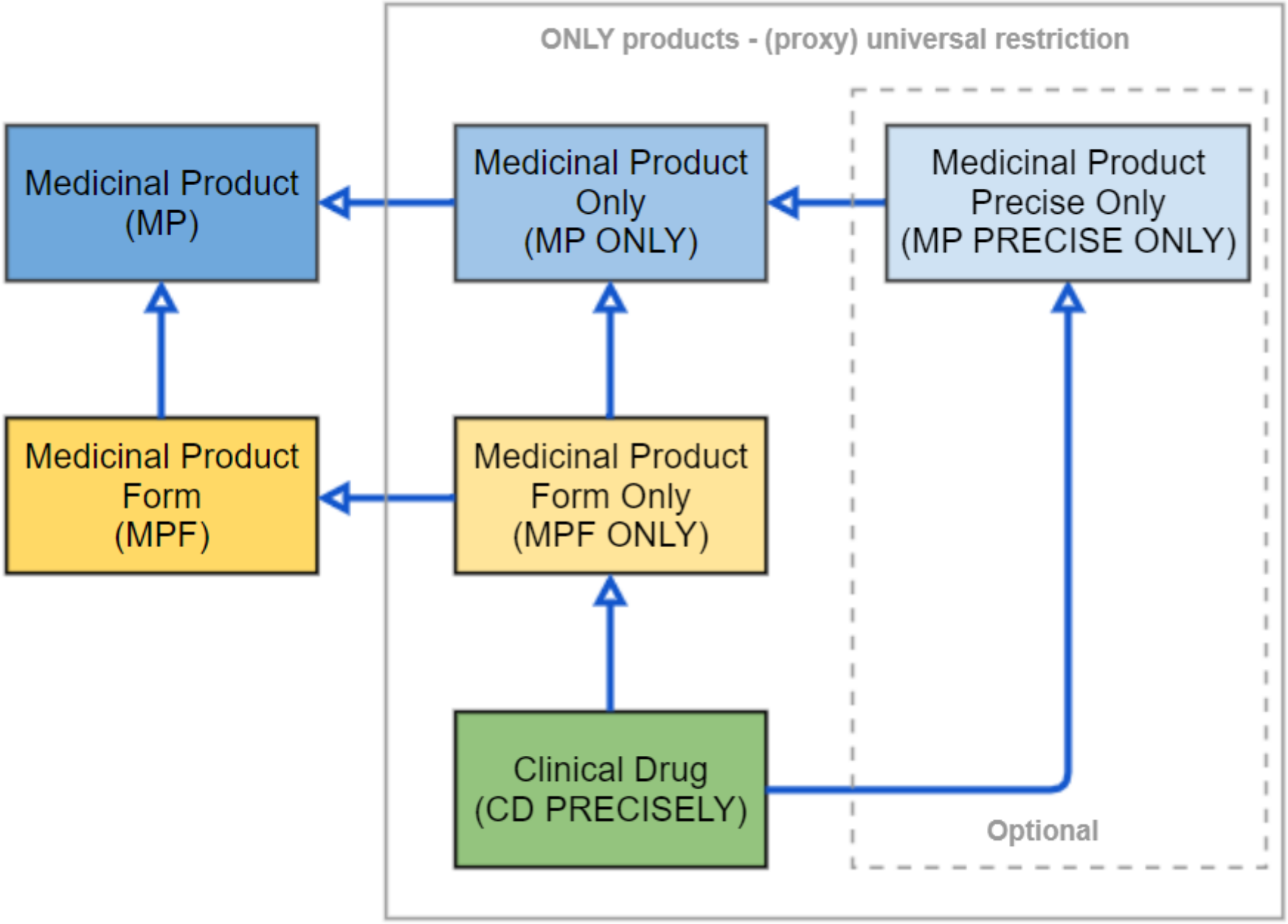
International Medicinal Product Model
https://confluence.ihtsdotools.org/display/DOCMPM/SNOMED+CT+Medicinal+Product+Model+Specification

Use cases

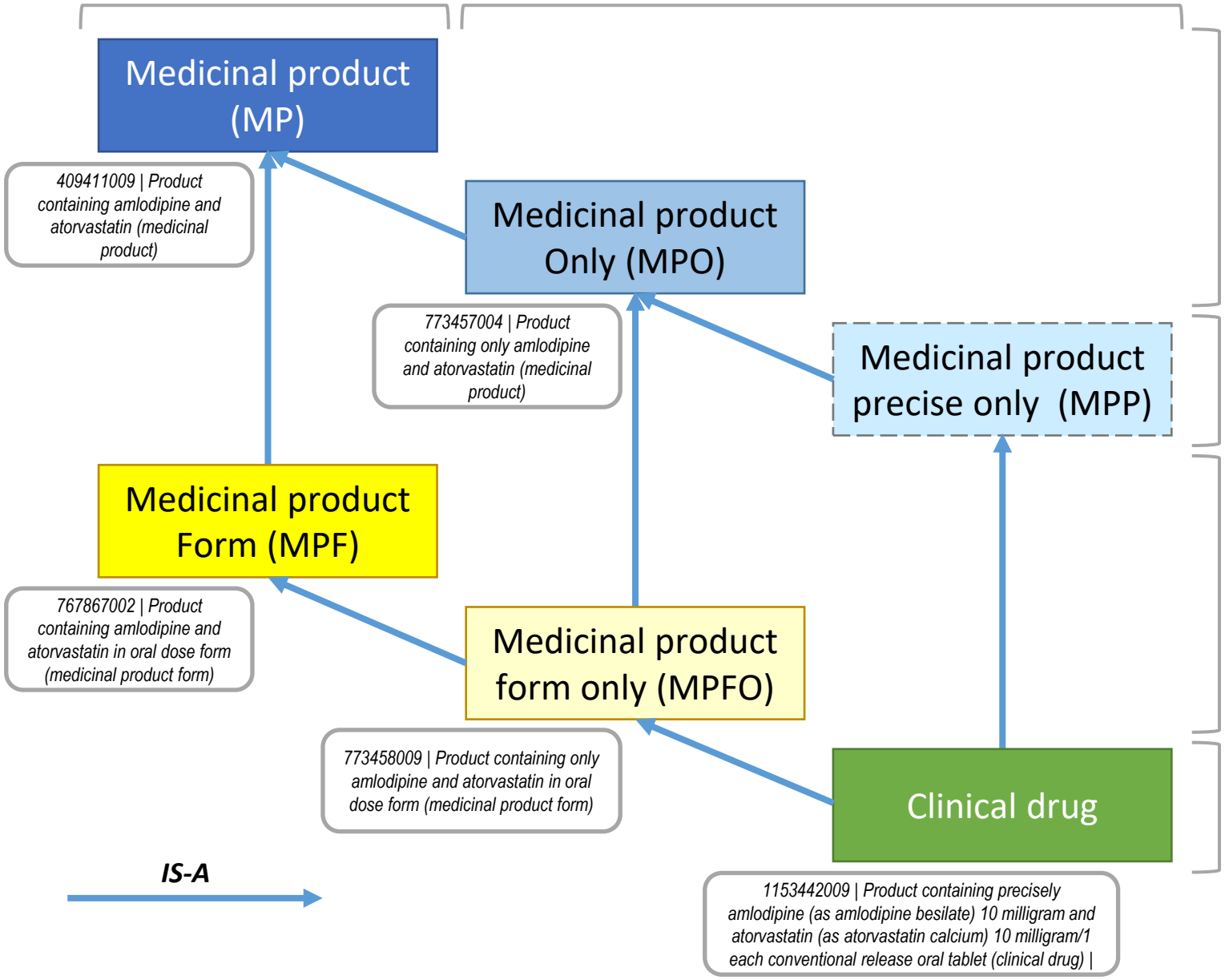
- To facilitate international interoperability of medication concepts
  - e.g., for use in patient summaries and for cross-border care
- To provide a strong foundation for member countries to develop their national medicinal product terminology
  - e.g., by adding package and branded product information
- To support medication analytics for research purposes
- To support the development of international medication decision support
  - e.g., allergy checking and duplicate therapy checking

Patterns for types of medicinal products

- Clinical drug
  - *Precise* ingredient + dose form + strength
- Medicinal product form
  - Ingredient + dose form
- Medicinal product form “only”
  - Ingredient + dose form, *with universal restrictions*
- Medicinal product
  - Ingredient
- Medicinal product “only”
  - Ingredient, *with universal restrictions*
- Medicinal product “only” [optional]
  - Precise ingredient, *with universal restrictions*


ONLY products - (proxy) universal restriction
Medicinal Product (MP)
Medicinal Product Only (MP ONLY)
Medicinal Product Precise Only (MP PRECISE ONLY)
Medicinal Product Form (MPF)
Medicinal Product Form Only (MPF ONLY)
Clinical Drug (CD PRECISELY)
Optional

Open-world entities | Closed-world entities | Definitional features



MP/MPO:
- Active ingredient (substance)

MPP:
- Precise active ingredient (substance)

MPF/MPFO:
- Active ingredient (substance)
- Dose form (pharmaceutical dose form)

CD:
- Precise Active ingredient (substance)
- Dose form (pharmaceutical dose form)
- Basis of strength (substance)
- Strength units (unit of measure)
- Strength values (numbers)
- Units of presentation (units of presentation)

Pattern for Clinical Drug

- Presentation strength
  - As opposed to normalized strength
    - To support the distinction among iso-concentration products
  - 4 discrete elements
    - Numerator (value and unit), denominator (value and unit)
- Basis of strength substance
  - Substance in reference to which strength is defined
- Dose form and unit of presentation
  - Harmonized with international standards

Pattern for Clinical Drug

- Closure axiom
  - Required to restrict a clinical drug to exactly its ingredients (only vs. some)
  - Should be implemented through universal restrictions
    - Has_ingredient SOME atorvastatin
    - Has_ingredient SOME amlodipine
    - Has_ingredient ONLY (atorvastatin OR amlodipine)
  - Universal restrictions not supported in EL++
  - Workaround: count of active ingredients
    - 2 active ingredients

New SNOMED CT model

1153442009 | Product containing precisely amlodipine (as amlodipine besilate) 10 milligram and atorvastatin (as atorvastatin calcium) 10 milligram/1 each conventional release oral tablet (clinical drug) |

Equivalent To

'Medicinal product (product)'
and ('Has manufactured dose form (attribute)' some 'Conventional release oral tablet (dose form)')
and ('Role group (attribute)' some
(('Has basis of strength substance (attribute)' some 'Atorvastatin (substance)')
and ('Has presentation strength numerator unit (attribute)' some 'milligram (qualifier value)')
and ('Has presentation strength denominator unit (attribute)' some 'Tablet (unit of presentation)')
and ('Has precise active ingredient (attribute)' some 'Atorvastatin calcium (substance)')
and ('Has presentation strength numerator value (attribute)' value 10)
and ('Has presentation strength denominator value (attribute)' value 1)))
and ('Role group (attribute)' some
(('Has basis of strength substance (attribute)' some 'Amlodipine (substance)')
and ('Has presentation strength numerator unit (attribute)' some 'milligram (qualifier value)')
and ('Has presentation strength denominator unit (attribute)' some 'Tablet (unit of presentation)')
and ('Has precise active ingredient (attribute)' some 'Amlodipine besilate (substance)')
and ('Has presentation strength numerator value (attribute)' value 10)
and ('Has presentation strength denominator value (attribute)' value 1)))
and ('Has unit of presentation (attribute)' some 'Tablet (unit of presentation)')
and ('Count of base of active ingredient (attribute)' value 2)

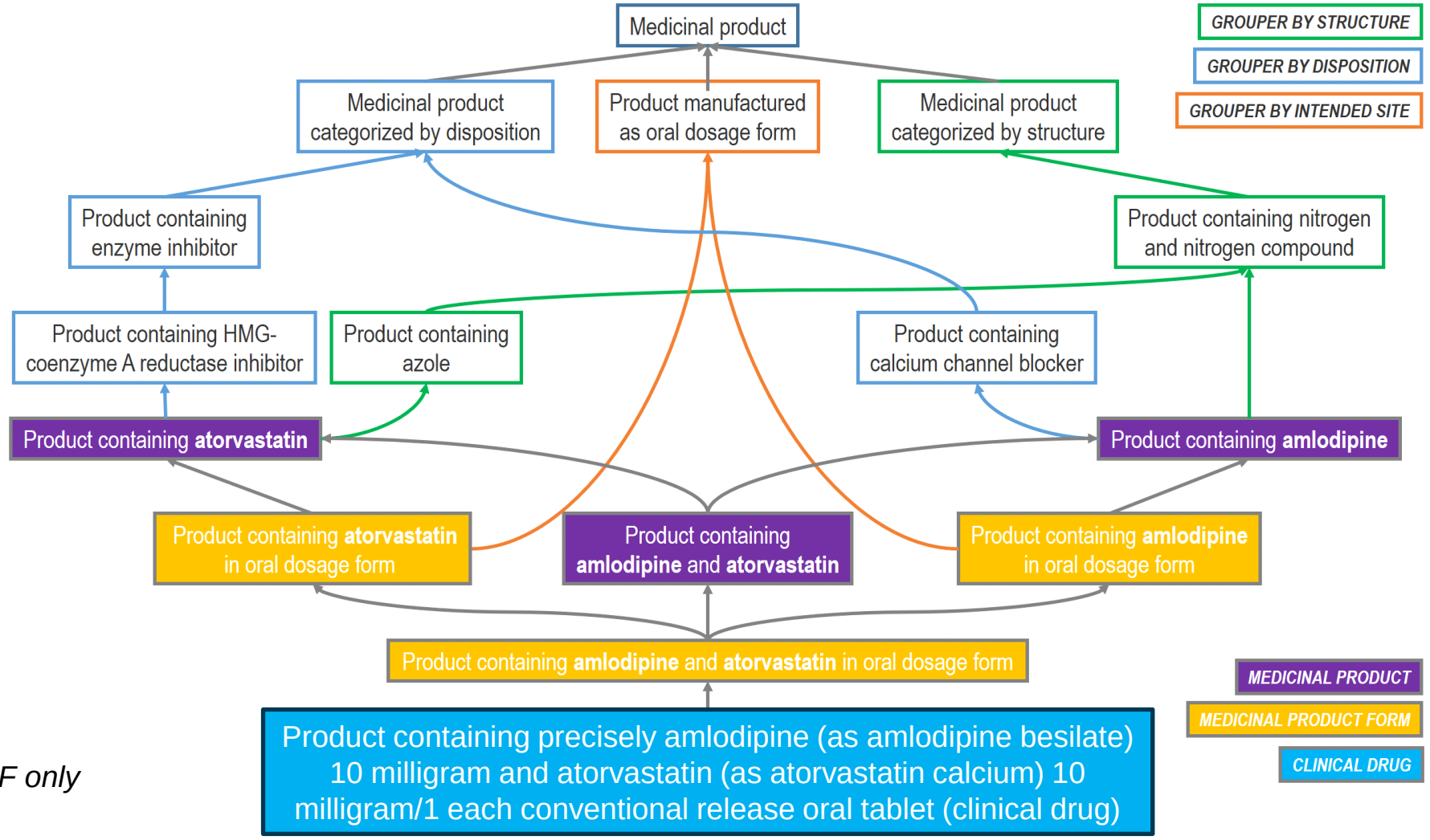
Drug classes (Groupers)

- Based on disposition
  - Product containing 3-hydroxy-3-methylglutaryl-coenzyme A reductase inhibitor
- Based on chemical structure
  - Product containing aminoglycoside
- Based on intended site of administration
  - Product manufactured as parenteral dosage form
- Based on therapeutic role
  - Conserved when intimately related to mechanism of action
    - Product containing antimalarial
  - Removed from the medicinal product hierarchy when purely regulatory information (non-definitional)
    - Antilipemic agent, Cardiovascular drug

Inference of product groupers from substance groupers

- Groupers *asserted* in the substance hierarchy
  - Amlodipine (substance)
    - SubClassOf Substance with calcium channel blocker mechanism of action [substance grouper]
- Groupers *inferred* in the product hierarchy
  - Product containing amlodipine (medicinal product)
    - SubClassOf Product containing calcium channel blocker [product grouper]
      - Has_ active_ingredient Substance with calcium channel blocker mechanism of action [substance grouper]

Medicinal product hierarchy (simplified*)



** MP only and MPF only entities omitted*

Discussion

- Benefits
  - More comprehensive representation of medicinal products (MPs)
  - Necessary and sufficient classes for all MPs
    - MP hierarchy completely inferred
    - Support identification of equivalent clases
      - Interoperability with national extensions
  - Strong foundation for developing national extensions
  - Distinction among types of groupers
  - Compliance with international standards

Discussion

- Limitations
  - Unorthodox closure axiom
    - Based on count of active ingredients
    - In the absence of universal restrictions in EL++
  - Partially implemented in the July 2018 release
    - Mostly oral solid dose form drugs
    - Ongoing work for oral solutions, parenteral drugs and topical drugs
  - Interoperability with national drug extensions not fully demonstrated yet
    - Ongoing work with RxNorm

Acknowledgments

- SNOMED International Drug Model Working Group
- Special thanks to
  - Jim Case
  - Yongsheng Gao
  - Emma Melhuish
  - Toni Morrison
  - Guillermo Reynoso
  - Phuong Skovgaard
  - Kai Kewley

Follow-along Activity

Exploring medications (Browser)

- Tooling: SNOMED CT Browser (https://browser.ihtsdotools.org/)
  - International edition
- Search for a clinical drug containing
  - 10 mg atorvastatin
  - 10 mg amlodipine
- Observe definitional features
- Observe ancestors
  - Medicinal product form
  - Medicinal product
  - Class groupers

Product containing precisely amlodipine (as amlodipine besilate) 10 milligram and atorvastatin (as atorvastatin calcium) 10 milligram/1 each conventional release oral tablet (clinical drug)

SCTID: 1153442009

1153442009 | Product containing precisely amlodipine (as amlodipine besilate) 10 milligram and atorvastatin (as atorvastatin calcium) 10 milligram/1 each conventional release oral tablet (clinical drug) |

en Product containing precisely amlodipine (as amlodipine besilate) 10 milligram and atorvastatin (as atorvastatin calcium) 10 milligram/1 each conventional release oral tablet (clinical drug)

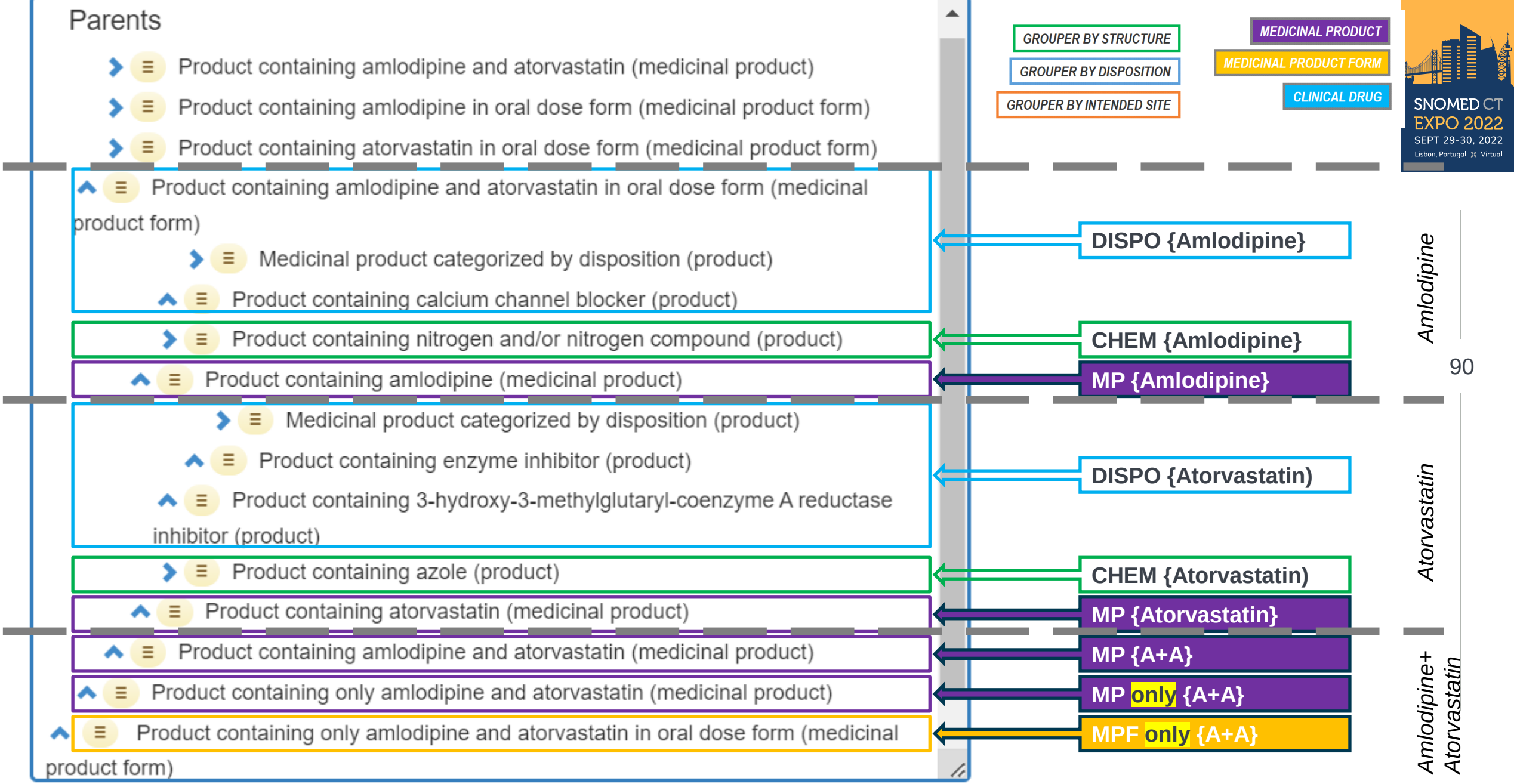
en Amlodipine (as amlodipine besylate) 10 mg and atorvastatin (as atorvastatin calcium) 10 mg oral tablet

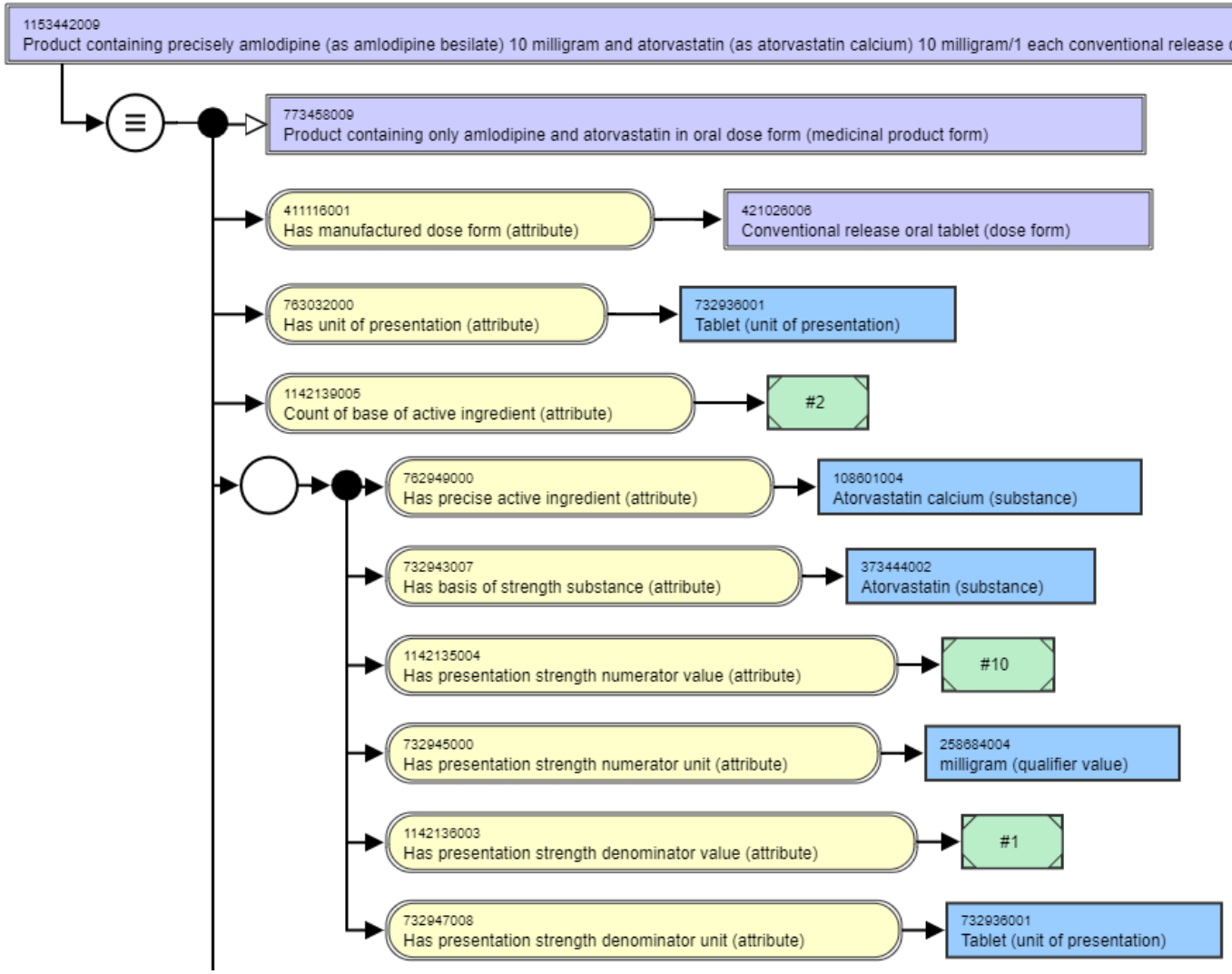
en Amlodipine (as amlodipine besilate) 10 mg and atorvastatin (as atorvastatin calcium) 10 mg oral tablet

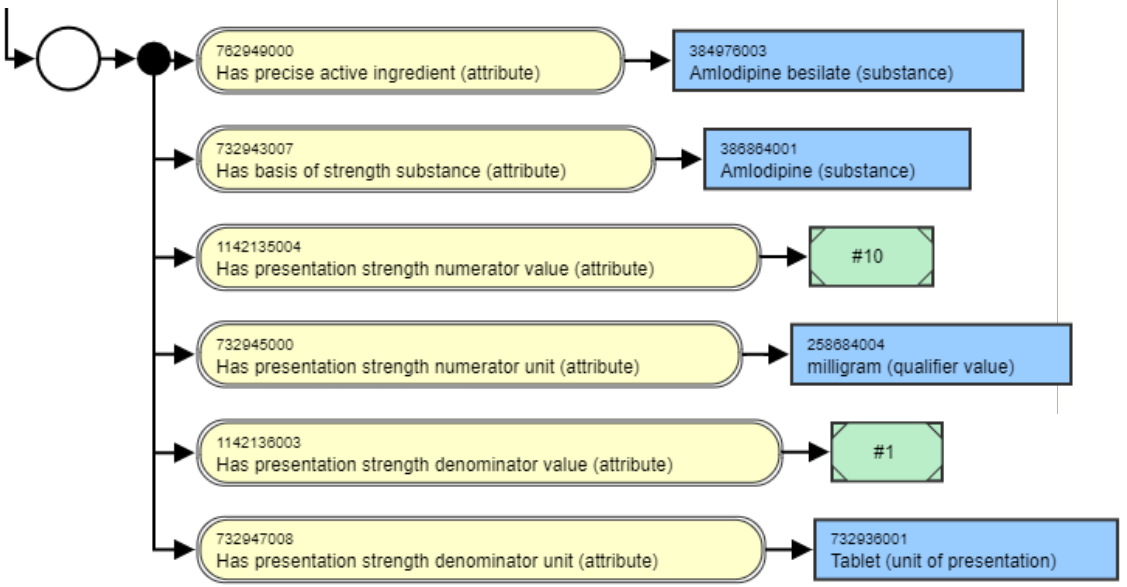
Has manufactured dose form → Conventional release oral tablet
Has unit of presentation → Tablet
Count of base of active ingredient → 2

Has precise active ingredient → Atorvastatin calcium
Has basis of strength substance → Atorvastatin
Has presentation strength numerator value → 10
Has presentation strength numerator unit → milligram
Has presentation strength denominator value → 1
Has presentation strength denominator unit → Tablet

Has precise active ingredient → Amlodipine besilate
Has basis of strength substance → Amlodipine
Has presentation strength numerator value → 10
Has presentation strength numerator unit → milligram
Has presentation strength denominator value → 1
Has presentation strength denominator unit → Tablet


Parents
Product containing amlodipine and atorvastatin (medicinal product)
Product containing amlodipine in oral dose form (medicinal product form)
Product containing atorvastatin in oral dose form (medicinal product form)
Product containing amlodipine and atorvastatin in oral dose form (medicinal product form)
Medicinal product categorized by disposition (product)
Product containing calcium channel blocker (product)
Product containing nitrogen and/or nitrogen compound (product)
Product containing amlodipine (medicinal product)
Medicinal product categorized by disposition (product)
Product containing enzyme inhibitor (product)
Product containing 3-hydroxy-3-methylglutaryl-coenzyme A reductase inhibitor (product)
Product containing azole (product)
Product containing atorvastatin (medicinal product)
Product containing amlodipine and atorvastatin (medicinal product)
Product containing only amlodipine and atorvastatin (medicinal product)
Product containing only amlodipine and atorvastatin in oral dose form (medicinal product form)
GROUPER BY STRUCTURE
GROUPER BY DISPOSITION
GROUPER BY INTENDED SITE
MEDICINAL PRODUCT
MEDICINAL PRODUCT FORM
CLINICAL DRUG
DISPO {Amlodipine}
CHEM {Amlodipine}
MP {Amlodipine}
DISPO {Atorvastatin)
CHEM {Atorvastatin)
MP {Atorvastatin}
MP {A+A}
MP only {A+A}
MPF only {A+A}
Amlodipine
Atorvastatin
Amlodipine+ Atorvastatin


1153442009
Product containing precisely amlodipine (as amlodipine besilate) 10 milligram and atorvastatin (as atorvastatin calcium) 10 milligram/1 each conventional release oral tablet (clinical drug)
≡
773458009
Product containing only amlodipine and atorvastatin in oral dose form (medicinal product form)
411116001
Has manufactured dose form (attribute)
421026006
Conventional release oral tablet (dose form)
763032000
Has unit of presentation (attribute)
732936001
Tablet (unit of presentation)
1142139005
Count of base of active ingredient (attribute)
#2
762949000
Has precise active ingredient (attribute)
108601004
Atorvastatin calcium (substance)
732943007
Has basis of strength substance (attribute)
373444002
Atorvastatin (substance)
1142135004
Has presentation strength numerator value (attribute)
#10
732945000
Has presentation strength numerator unit (attribute)
258684004
milligram (qualifier value)
1142136003
Has presentation strength denominator value (attribute)
#1
732947008
Has presentation strength denominator unit (attribute)
732936001
Tablet (unit of presentation)


762949000
Has precise active ingredient (attribute)
384976003
Amlodipine besilate (substance)
732943007
Has basis of strength substance (attribute)
386864001
Amlodipine (substance)
1142135004
Has presentation strength numerator value (attribute)
#10
732945000
Has presentation strength numerator unit (attribute)
258684004
milligram (qualifier value)
1142136003
Has presentation strength denominator value (attribute)
#1
732947008
Has presentation strength denominator unit (attribute)
732936001
Tablet (unit of presentation)

ICBO 2019
August 1, 2019
University at Buffalo

10th International Conference on Biomedical Ontology

Comparing the representation of medicinal products in RxNorm and SNOMED CT *Consequences on interoperability*

Jean-Noël Nikiema & Olivier Bodenreider

National Institutes of Health, Bethesda, Maryland, USA

Nikiema J-N, Bodenreider O.
Comparing the representation of medicinal products in RxNorm and SNOMED CT – Consequences on interoperability.
Proceedings of the 10th International Conference on Biomedical Ontology (ICBO 2019):
(electronic proceedings: http://ceur-ws.org/Vol-2931/ICBO_2019_paper_21.pdf)

Motivation

- Different drug terminologies use different models for the representation of medicinal products
- Based on similar definitional features
  - Active ingredient/BoSS — atorvastatin
  - Strength — 10 mg
  - Dose form — oral tablet
- Differences
  - Formalism
  - Compliance with international standards
  - Scope (e.g., country-specific information)
- Are the RxNorm and SNOMED CT drug models interoperable?

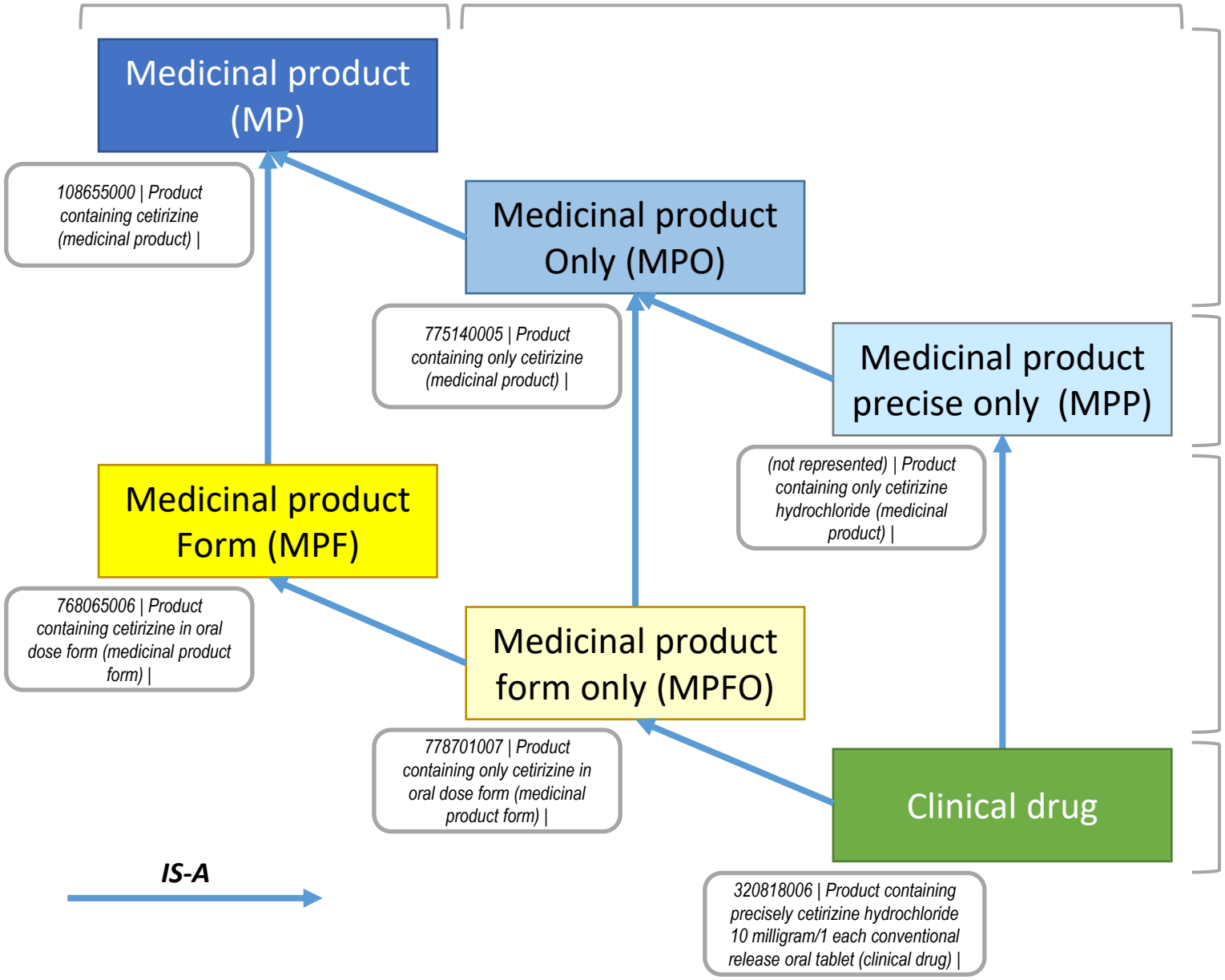
Objectives

- To compare the representation of medicinal products in RxNorm and SNOMED CT
  - To analyze their similarities and differences
  - To assess the consequences of these differences on interoperability between the two terminologies

Background: SNOMED CT

- Largest clinical terminology in the world
- Developed by a consortium of over 40 countries
- New model for the representation of medicinal products in 2018
  - Including drug-class membership information
- Integrates requirements from ISO standard IDMP – Identification of Medicinal Products
  - Clinical drugs represented in a closed worldview
  - Dose forms in reference to EDQM – European Directorate for Quality in Medicines
  - Units aligned with UCUM – Unified Code for Units of Measure
- Formalism: description logic
- Scope: generic drugs (excludes branded drugs and packs – country-specific)
- 6 types of entities, with 5 definitional features

Open-world entities | Closed-world entities | Definitional features



MP/MPO:
- Active ingredient (substance)

MPP:
- Precise active ingredient (substance)

MPF/MPFO:
- Active ingredient (substance)
- Dose form (pharmaceutical dose form)

CD:
- Precise Active ingredient (substance)
- Dose form (pharmaceutical dose form)
- Basis of strength (substance)
- Strength units (unit of measure)
- Strength values (numbers)
- Units of presentation (units of presentation)

Background: RxNorm

- U.S. standard for drug terminology
- Developed by the National Library of Medicine
- Simple model: ingredient + strength + dose form
  - Enriched over time with 2 optional features
    - Quantitative factor — 2 ML Furosemide 10 MG/ML Injection
    - Qualitative distinction — Abuse-Deterrent Oxycodone Hydrochloride 15 MG Oral Tablet
- Formalism: graph representation
- Scope: both generic and branded drugs, including packs
- 4 types of entities (for generic drugs), 5* definitional features

Examples

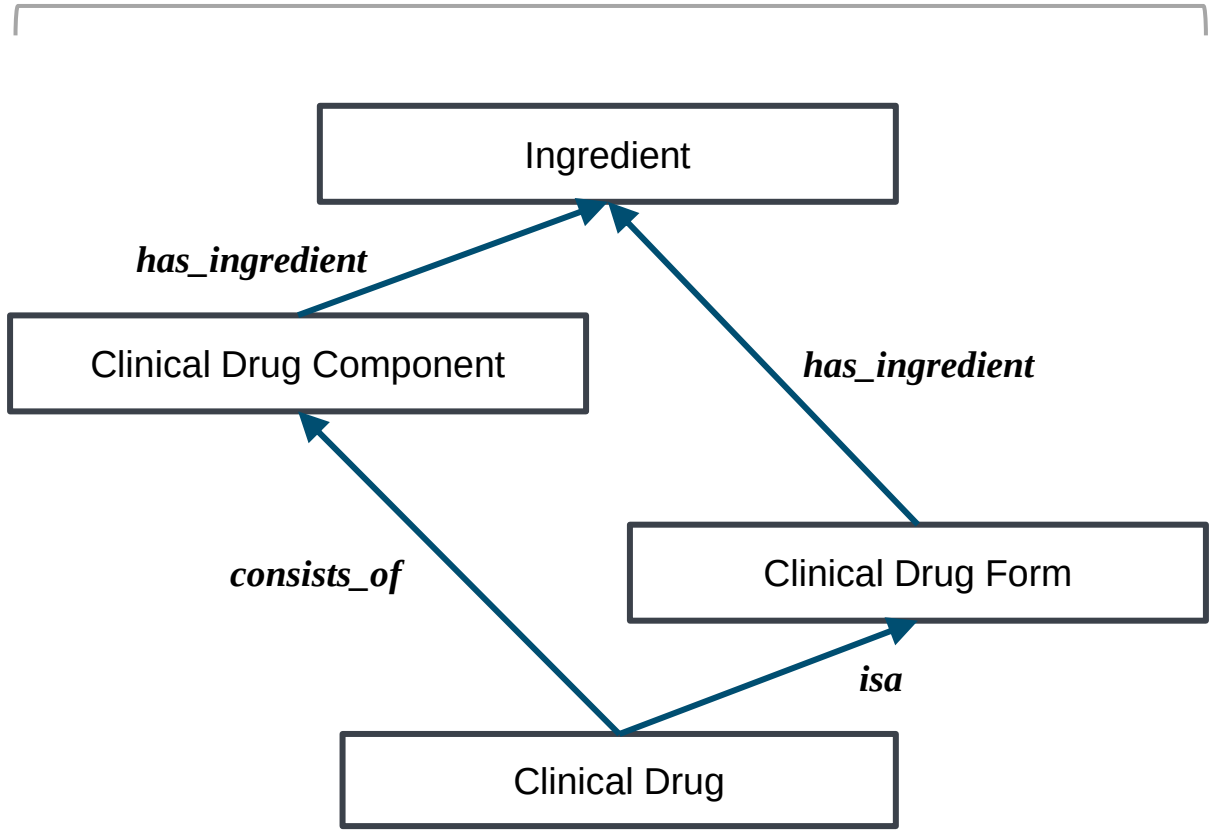
Cetirizine [RxCUI = 20610]

cetirizine hydrochloride 10 MG [RxCUI = 1011480]

Cetirizine Oral Tablet [RxCUI = 371364]

cetirizine hydrochloride 10 MG Oral Tablet [RxCUI = 1014678]

RxNorm generic drug entities



Definitional features

IN:
- Ingredient

SCDC:
- Ingredient
- Strength

SCDF:
- Ingredient
- Dose form

SCD:
- Ingredient/BoSS
- Strength
- Dose form
- Quantity factor (optional)
- Qualitative distinction (optional)

Similarities and differences: Overview

- Major definitional features are common to both models
  - Active ingredient
    - Substance vs. medicinal product; substance modification
  - Strength
    - Concentration strength vs. presentation strength
  - Dose form
    - Dose form vs. unit of presentation
- Specific features in SNOMED CT
  - Explicit closed worldview for clinical drugs
- Specific features in RxNorm
  - Optional qualitative distinction; materialized SCDC (for navigation)

Differences: Ingredients

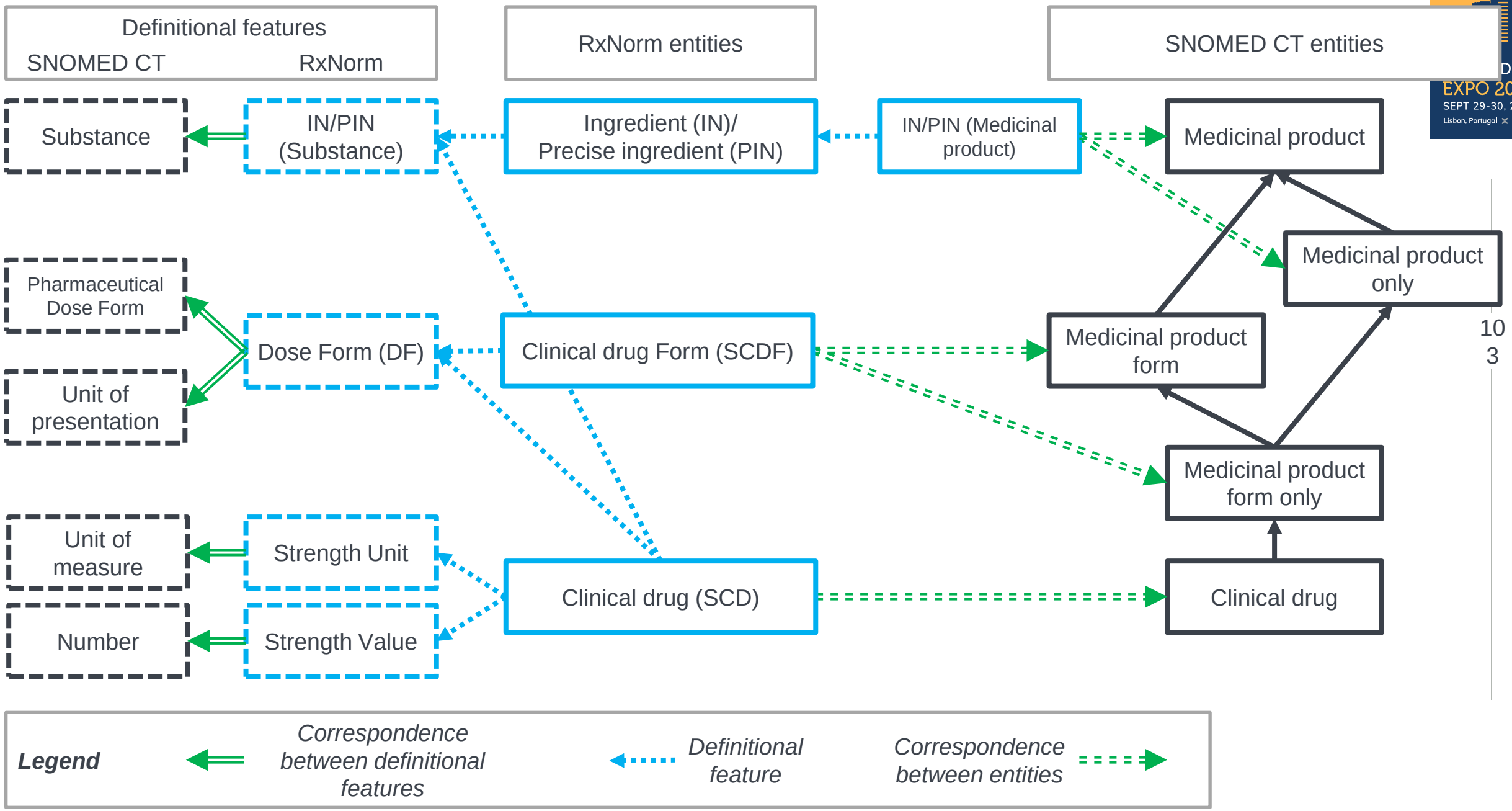
- Substance vs. medicinal product
  - RxNorm: single entity
    - Cetirizine
  - SNOMED CT: distinct entities
    - Medicinal product *has_active_ingredient* Substance
    - Medicinal product: Product containing cetirizine (medicinal product)
    - Medicinal product “only”: Product containing only cetirizine (medicinal product)
    - Substance: Cetirizine (substance)
- Substance modification
  - RxNorm: different types of entities (Ingredient vs. Precise ingredient)
    - PIN: Cetirizine hydrochloride *precise_ingredient_of* IN: Cetirizine
  - SNOMED CT: same kind of entity + *modification_of* relation
    - Cetirizine hydrochloride (substance) *modification_of* Cetirizine (substance)

Differences: Concentration vs. presentation strength

- RxNorm
  - Concentration strength (default)
    - 2 ML Furosemide 10 MG/ML Injection
  - Supports presentation strength through “prescribable name”
    - furosemide 20 MG in 2 ML Injection
  - Presentation strength can be computed with QF * concentration strength
    - 2 ML * 10 MG/ML = 20 MG/2 ML
- SNOMED CT (depending on unit of presentation)
  - Concentration strength (only) 10 MG/1 ML
  - Presentation strength (only) 20 MG/2 ML
  - Concentration strength + Presentation strength

Differences: Dose form vs. unit of presentation

- RxNorm
  - Dose form includes unit of presentation (implicitly) Oral Tablet
- SNOMED CT
  - Distinct dose form and unit of presentation
    - Dose form Conventional release oral tablet
    - Unit of presentation Tablet


Definitional features
SNOMED CT
RxNorm
RxNorm entities
SNOMED CT entities
Substance
IN/PIN (Substance)
Ingredient (IN)/ Precise ingredient (PIN)
IN/PIN (Medicinal product)
Medicinal product
Medicinal product only
Pharmaceutical Dose Form
Dose Form (DF)
Clinical drug Form (SCDF)
Medicinal product form
Unit of presentation
Medicinal product form only
Unit of measure
Strength Unit
Clinical drug (SCD)
Clinical drug
Number
Strength Value
Legend
Correspondence between definitional features
Definitional feature
Correspondence between entities

Findings: Similarities and differences

- SNOMED CT
  - More rigorous
  - Better aligned with international standards
  - Differences tend to be made explicit
  - More complex model
- RxNorm
  - Contains implicit knowledge, simplifications and ambiguities
  - Simpler model

Findings: Consequences on interoperability

- Can RxNorm be translated into SNOMED CT?
  - Yes, for the most part
- Specifically
  - Ingredients
    - Trivial disambiguation
  - Strength
    - Different editorial conventions for units (minor)
    - Presentation strength / Concentration strength / Both (depending on unit of presentation)
  - Dose form – requires detailed analysis to identify dose form and unit of presentation

Conclusions

- Similarities and differences between the representation of medicinal products in RxNorm and SNOMED CT
- Both models share major definitional features including ingredient (or substance), strength and dose form
- Subtle differences between the two models
- Translation of RxNorm into SNOMED CT is possible, but not straightforward

Follow-along Activity

Exploring medications (Browser)

- Tooling: RxNorm Browser (https://mor.nlm.nih.gov/RxNav/)
  - Current RxNorm version (Sept. 2022)
- Search for SCTID: 1153442009
  - 1153442009 | Product containing precisely amlodipine (as amlodipine besilate) 10 milligram and atorvastatin (as atorvastatin calcium) 10 milligram/1 each conventional release oral tablet (clinical drug) |
- Observe definitional features
  - Ingredient
  - Strength
  - Dose form
- Observe drug classes
  - Class View tab (e.g., DISPOS for SNOMED CT's Disposition classes)

amlodipine 10 MG / atorvastatin 10 MG Oral Tablet [RxCUI = 597987]

IN/MIN Ingredient (3)
- amLODIPine
- amLODIPine / atorvastatin
- atorvastatin

PIN Precise Ingredient (0)

BN Brand Name (1)
- Caduet

SCDC Clinical Drug Component (2)
- amLODIPine 10 MG
- atorvastatin 10 MG

SBDC Branded Drug Component (1)
- amLODIPine 10 MG / atorvastatin 10 MG [Caduet]

SCD/GPCK Clinical Drug or Pack (1)
- amLODIPine 10 MG / atorvastatin 10 MG Oral Tablet

SBD/BPCK Branded Drug or Pack (1)
- Caduet 10/10 MG Oral Tablet

SCDG Clinical Dose Form Group (2)
- amLODIPine / atorvastatin Oral Product
- amLODIPine / atorvastatin Pill

DFG Dose Form Group (2)
- Oral Product
- Pill

SBDG Branded Dose Form Group (2)
- Caduet Oral Product
- Caduet Pill

RxNav
Navigating RxNorm Drugs

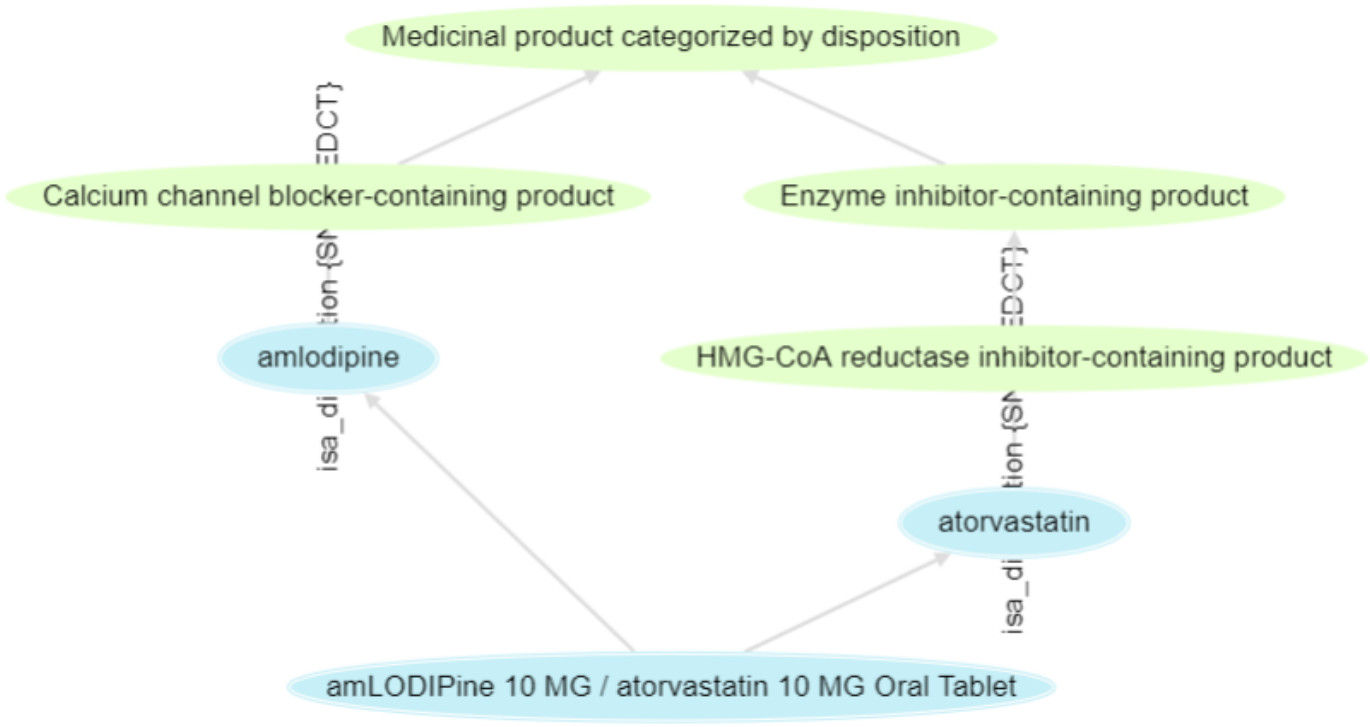
SNOMEDCT 1153442009

amlodipine 10 MG / atorvastatin 10 MG Oral Tablet [RxCUI = 597987]

RxNorm Graph | RxNorm Properties | NDC | RxTerms | Class View | Interaction View | Status

Views
- ATC
- MESH
- Disease
- CHEM
- MoA
- PK
- PE
- EPC
- VA
- TC
- DISPOS
- STRUCT
- THERAP

Hide Legend



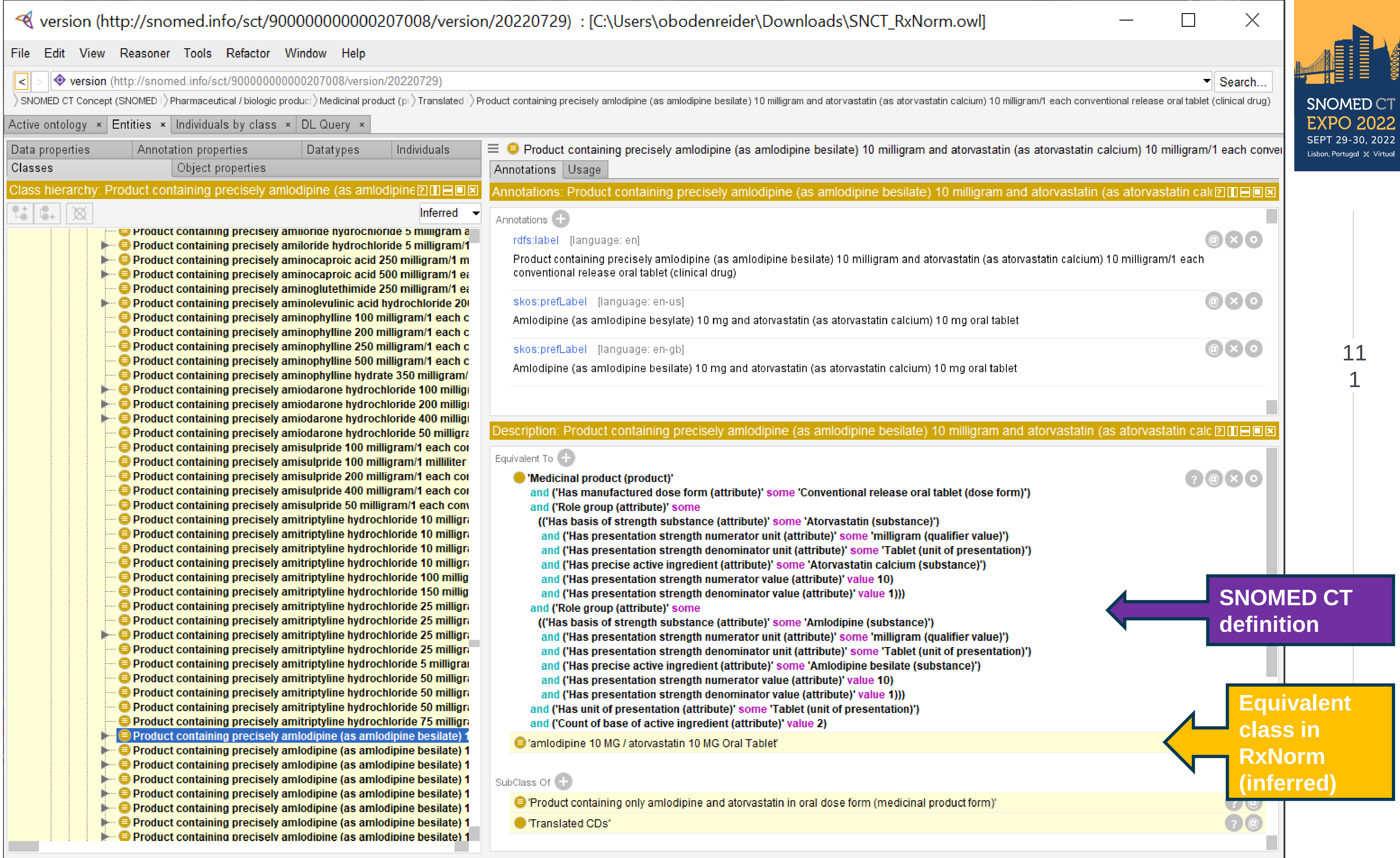
Legend

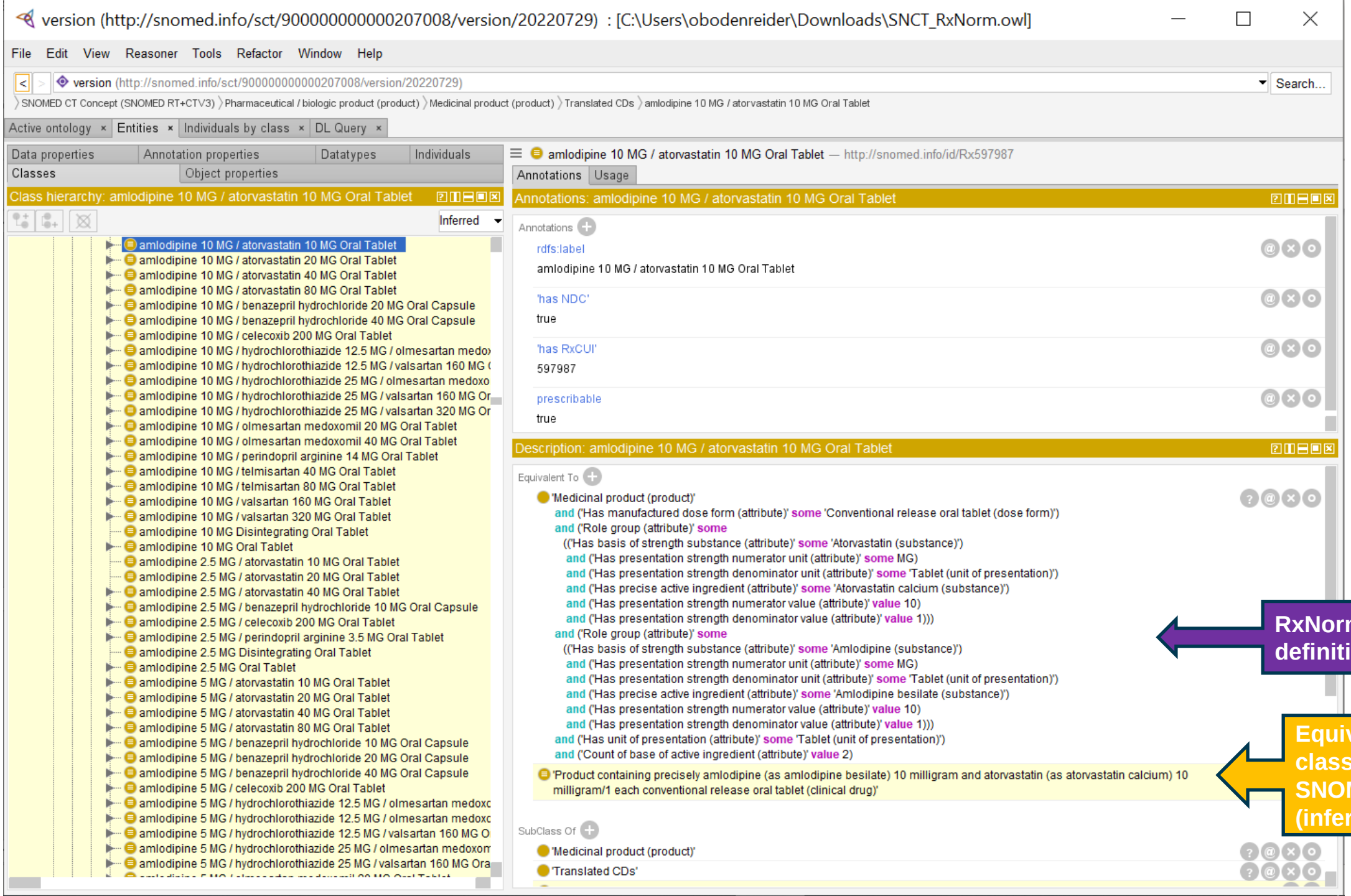
Drug related to Drug isa_diposition DISPOSITION isa DISPOSITION

Demo Activity

RxNorm translated to the SNOMED model

- Convert the RxNorm content to the SNOMED CT International drug model
- Add RxNorm definitions (OWL) to SNOMED CT's definitions (OWL)
- Classify the 2 sets of definitions together (ELK)
- Compare inferred equivalences to asserted equivalences (from the integration of SNOMED CT into RxNorm)




version (http://snomed.info/sct/900000000000207008/version/20220729) : [C:\Users\obodenreider\Downloads\SNCT_RxNorm.owl]
File Edit View Reasoner Tools Refactor Window Help
version (http://snomed.info/sct/900000000000207008/version/20220729)
Search...
SNOMED CT Concept (SNOMED RT+CTV3) Pharmaceutical / biologic product (product) Medicinal product (product) Translated CDs amlodipine 10 MG / atorvastatin 10 MG Oral Tablet
Active ontology Entities Individuals by class DL Query
Data properties Annotation properties Datatypes Individuals
Classes Object properties
Class hierarchy: amlodipine 10 MG / atorvastatin 10 MG Oral Tablet
Inferred
amlodipine 10 MG / atorvastatin 10 MG Oral Tablet
amlodipine 10 MG / atorvastatin 20 MG Oral Tablet
amlodipine 10 MG / atorvastatin 40 MG Oral Tablet
amlodipine 10 MG / atorvastatin 80 MG Oral Tablet
amlodipine 10 MG / benazepril hydrochloride 20 MG Oral Capsule
amlodipine 10 MG / benazepril hydrochloride 40 MG Oral Capsule
amlodipine 10 MG / celecoxib 200 MG Oral Tablet
amlodipine 10 MG / hydrochlorothiazide 12.5 MG / olmesartan medox
amlodipine 10 MG / hydrochlorothiazide 12.5 MG / valsartan 160 MG
amlodipine 10 MG / hydrochlorothiazide 25 MG / olmesartan medoxo
amlodipine 10 MG / hydrochlorothiazide 25 MG / valsartan 160 MG Or
amlodipine 10 MG / hydrochlorothiazide 25 MG / valsartan 320 MG Or
amlodipine 10 MG / olmesartan medoxomil 20 MG Oral Tablet
amlodipine 10 MG / olmesartan medoxomil 40 MG Oral Tablet
amlodipine 10 MG / perindopril arginine 14 MG Oral Tablet
amlodipine 10 MG / telmisartan 40 MG Oral Tablet
amlodipine 10 MG / telmisartan 80 MG Oral Tablet
amlodipine 10 MG / valsartan 160 MG Oral Tablet
amlodipine 10 MG / valsartan 320 MG Oral Tablet
amlodipine 10 MG Disintegrating Oral Tablet
amlodipine 10 MG Oral Tablet
amlodipine 2.5 MG / atorvastatin 10 MG Oral Tablet
amlodipine 2.5 MG / atorvastatin 20 MG Oral Tablet
amlodipine 2.5 MG / atorvastatin 40 MG Oral Tablet
amlodipine 2.5 MG / benazepril hydrochloride 10 MG Oral Capsule
amlodipine 2.5 MG / celecoxib 200 MG Oral Tablet
amlodipine 2.5 MG / perindopril arginine 3.5 MG Oral Tablet
amlodipine 2.5 MG Disintegrating Oral Tablet
amlodipine 2.5 MG Oral Tablet
amlodipine 5 MG / atorvastatin 10 MG Oral Tablet
amlodipine 5 MG / atorvastatin 20 MG Oral Tablet
amlodipine 5 MG / atorvastatin 40 MG Oral Tablet
amlodipine 5 MG / atorvastatin 80 MG Oral Tablet
amlodipine 5 MG / benazepril hydrochloride 10 MG Oral Capsule
amlodipine 5 MG / benazepril hydrochloride 20 MG Oral Capsule
amlodipine 5 MG / benazepril hydrochloride 40 MG Oral Capsule
amlodipine 5 MG / celecoxib 200 MG Oral Tablet
amlodipine 5 MG / hydrochlorothiazide 12.5 MG / olmesartan medoxc
amlodipine 5 MG / hydrochlorothiazide 12.5 MG / olmesartan medoxc
amlodipine 5 MG / hydrochlorothiazide 12.5 MG / valsartan 160 MG O
amlodipine 5 MG / hydrochlorothiazide 25 MG / olmesartan medoxom
amlodipine 5 MG / hydrochlorothiazide 25 MG / valsartan 160 MG Ora
amlodipine 10 MG / atorvastatin 10 MG Oral Tablet — http://snomed.info/id/Rx597987
Annotations Usage
Annotations: amlodipine 10 MG / atorvastatin 10 MG Oral Tablet
Annotations
rdfs:label
amlodipine 10 MG / atorvastatin 10 MG Oral Tablet
'has NDC'
true
'has RxCUI'
597987
prescribable
true
Description: amlodipine 10 MG / atorvastatin 10 MG Oral Tablet
Equivalent To
'Medicinal product (product)'
and ('Has manufactured dose form (attribute)' some 'Conventional release oral tablet (dose form)')
and ('Role group (attribute)' some
(('Has basis of strength substance (attribute)' some 'Atorvastatin (substance)')
and ('Has presentation strength numerator unit (attribute)' some MG)
and ('Has presentation strength denominator unit (attribute)' some 'Tablet (unit of presentation)')
and ('Has precise active ingredient (attribute)' some 'Atorvastatin calcium (substance)')
and ('Has presentation strength numerator value (attribute)' value 10)
and ('Has presentation strength denominator value (attribute)' value 1)))
and ('Role group (attribute)' some
(('Has basis of strength substance (attribute)' some 'Amlodipine (substance)')
and ('Has presentation strength numerator unit (attribute)' some MG)
and ('Has presentation strength denominator unit (attribute)' some 'Tablet (unit of presentation)')
and ('Has precise active ingredient (attribute)' some 'Amlodipine besilate (substance)')
and ('Has presentation strength numerator value (attribute)' value 10)
and ('Has presentation strength denominator value (attribute)' value 1)))
and ('Has unit of presentation (attribute)' some 'Tablet (unit of presentation)')
and ('Count of base of active ingredient (attribute)' value 2)
'Product containing precisely amlodipine (as amlodipine besilate) 10 milligram and atorvastatin (as atorvastatin calcium) 10 milligram/1 each conventional release oral tablet (clinical drug)'
SubClass Of
'Medicinal product (product)'
'Translated CDs'
RxNorm definition
Equivalent class in SNOMED CT (inferred)
SNOMED CT EXPO 2022
SEPT 29-30, 2022
Lisbon, Portugal Virtual

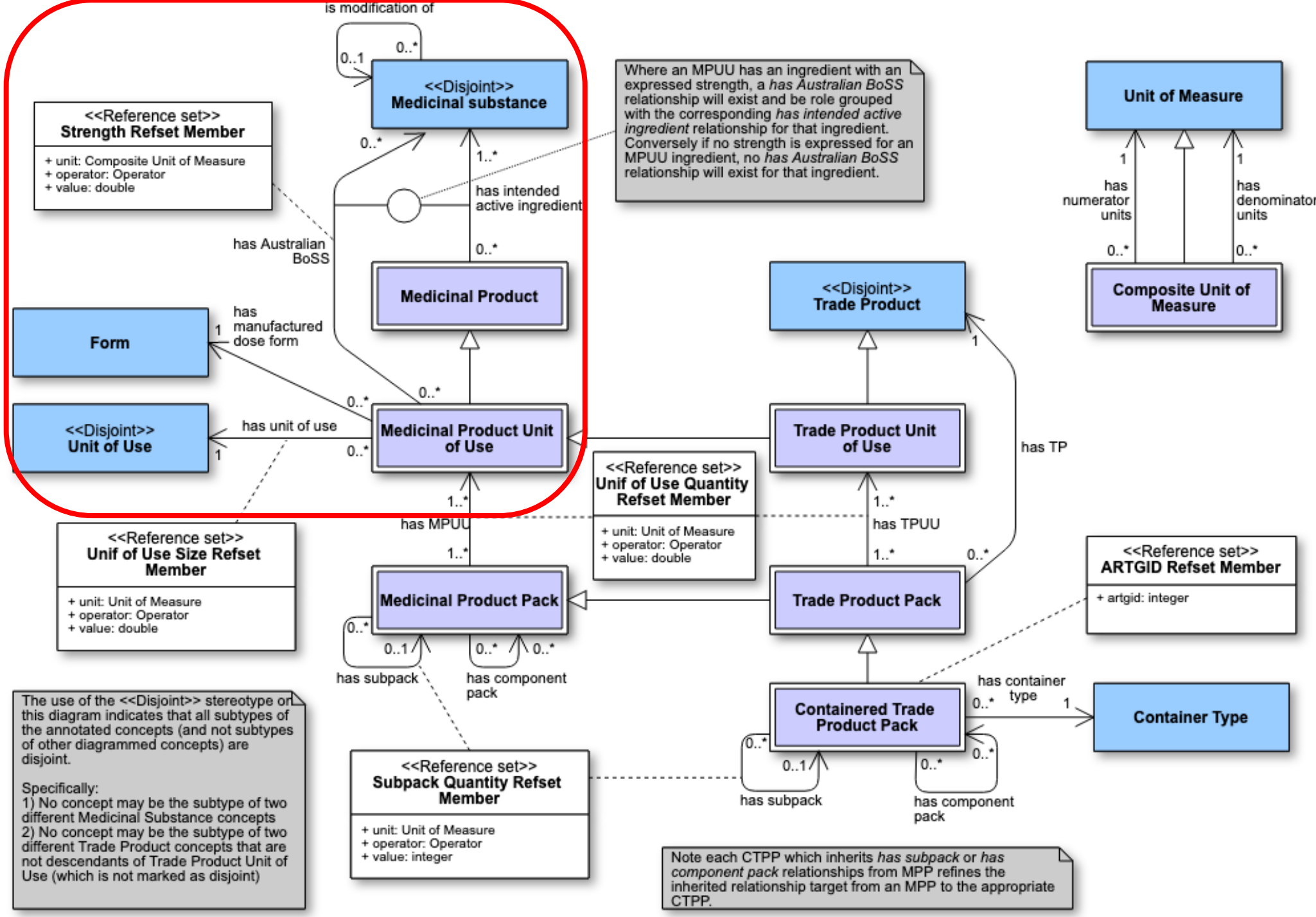
Medicinal product Models for Interoperation of AMT Medication Data

Dion McMurtrie

SNOMED CT EXPO 2022
SEPT 29-30, 2022
Lisbon, Portugal ✕ Virtual

SNOMED International

AMT Concept Model



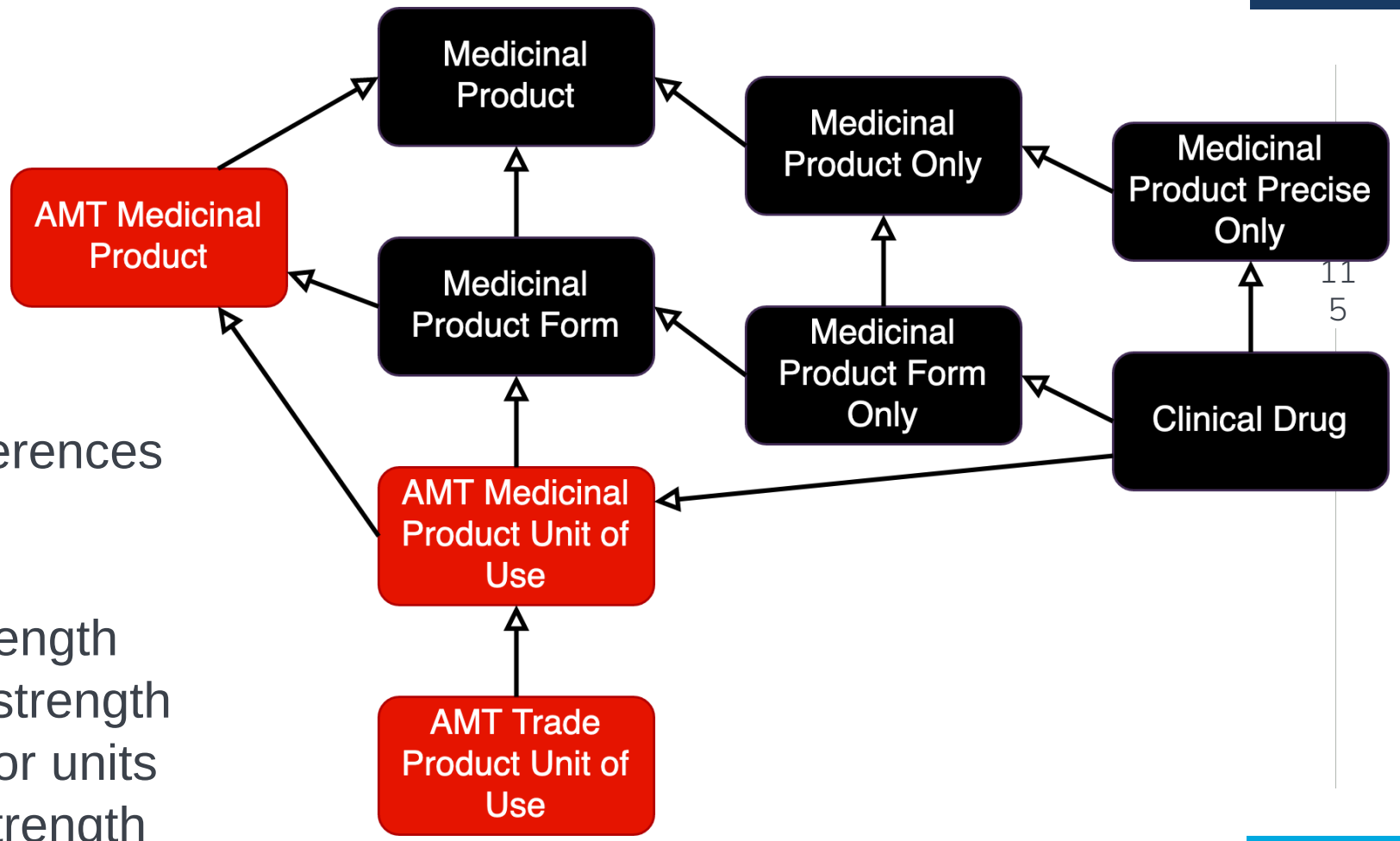
AMT Integration with SNOMED CT International

AMT and International content use different model

But describe essentially the same things

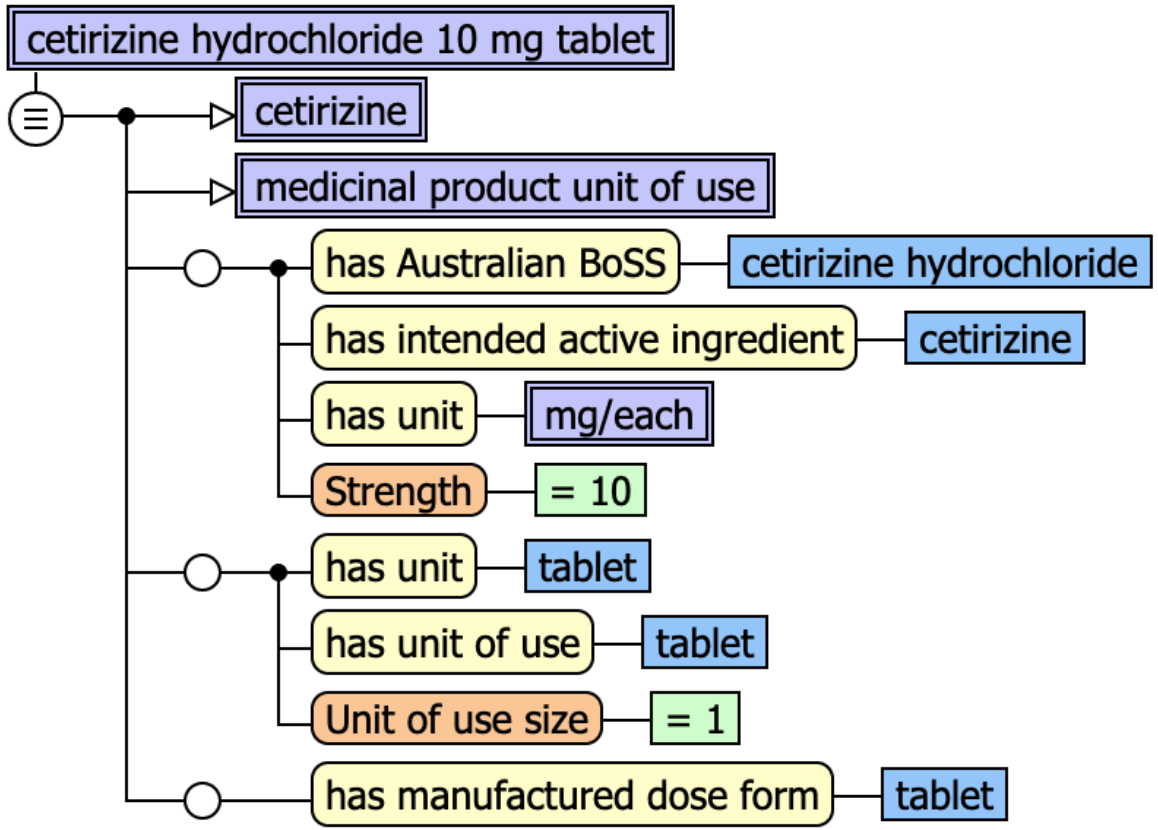
Key differences

- Unit of presentation/use differences
- Some/only semantics
- Route specific dose forms
- Unit of measure rules for strength
- Concentration/presentation strength
- Specific strength denominator units
- Normalisation/precision of strength

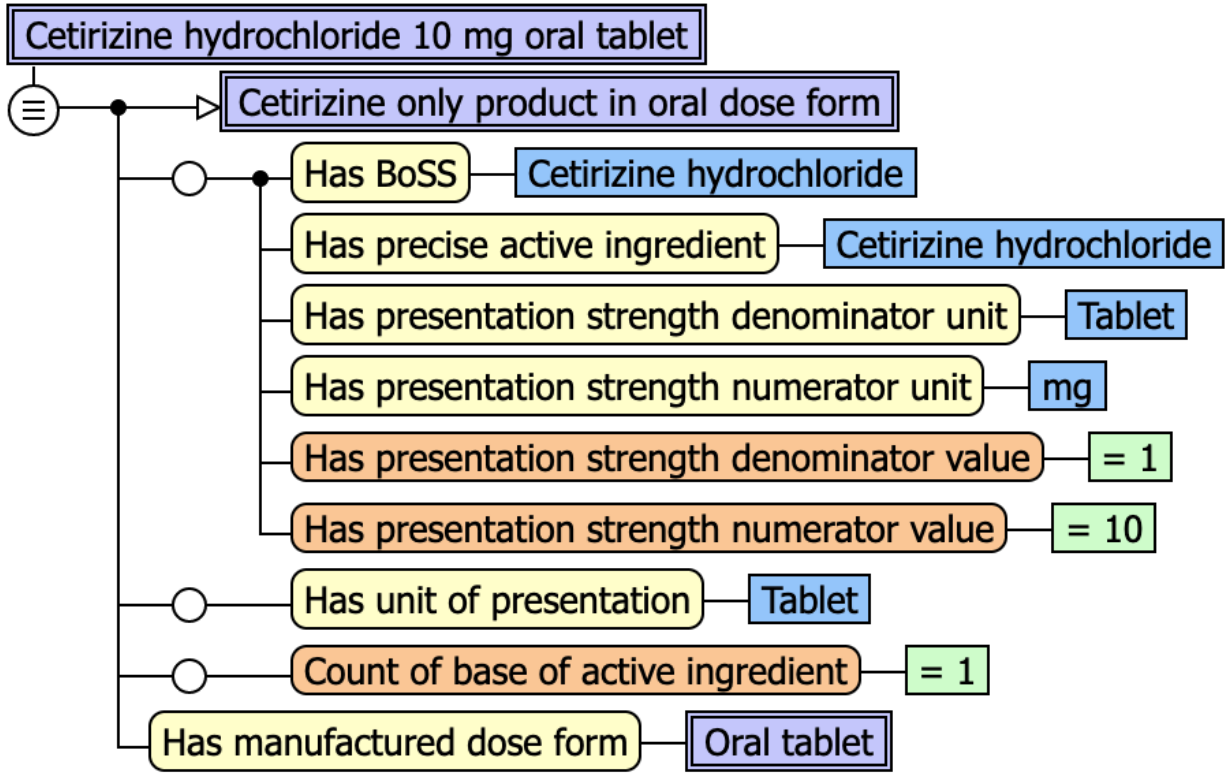


AMT Integration with SNOMED CT International

AMT

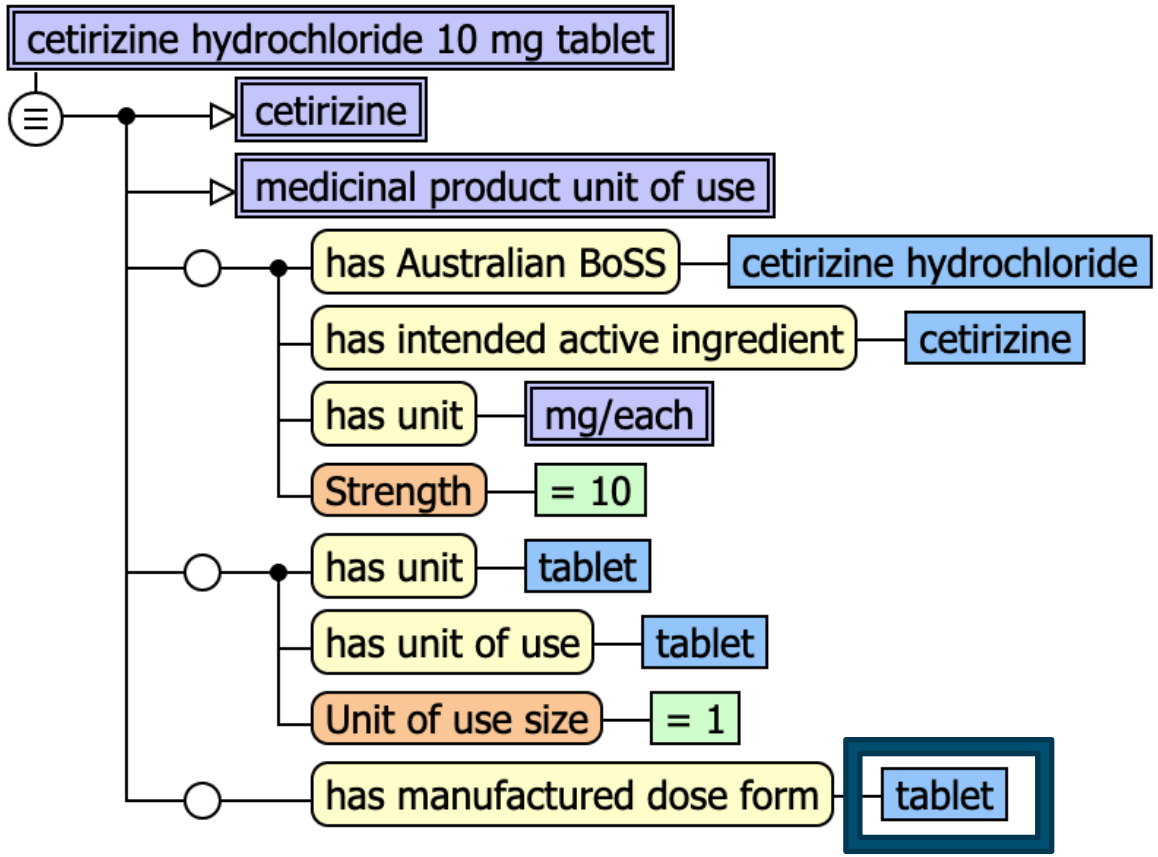


International

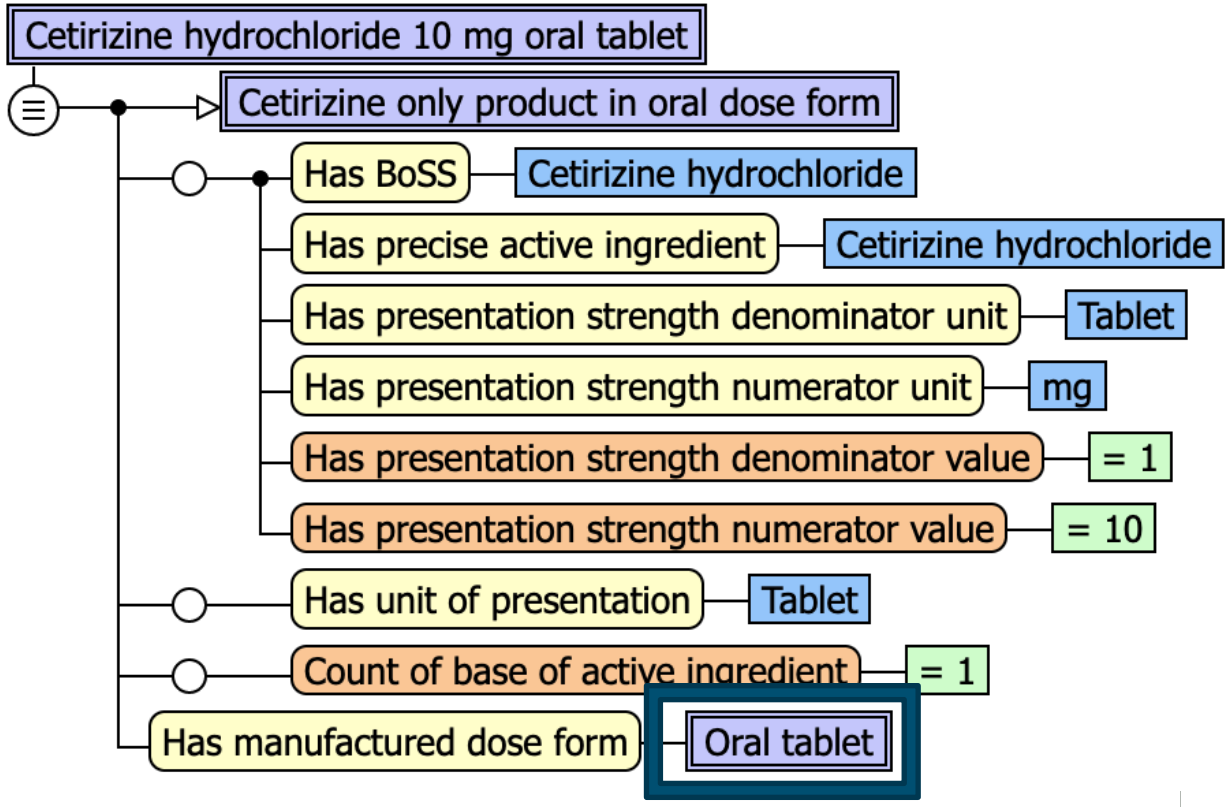


AMT Integration with SNOMED CT International

AMT



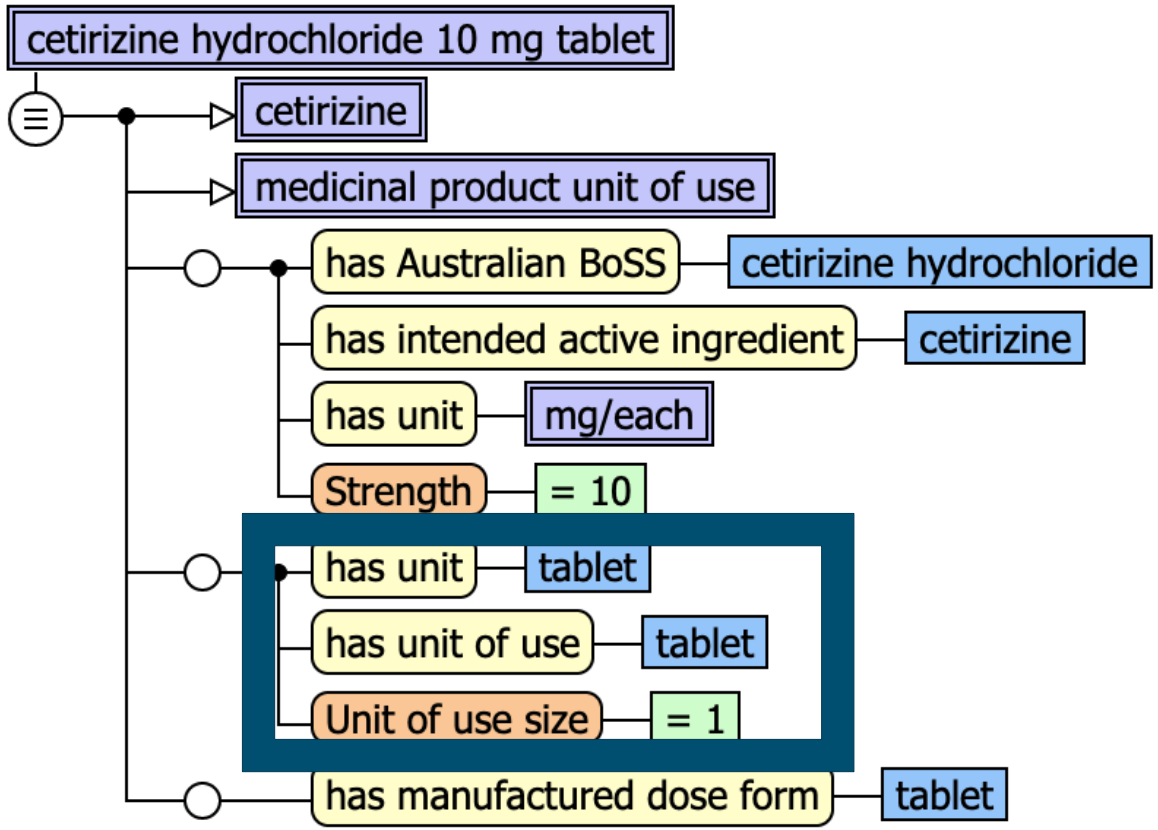
International



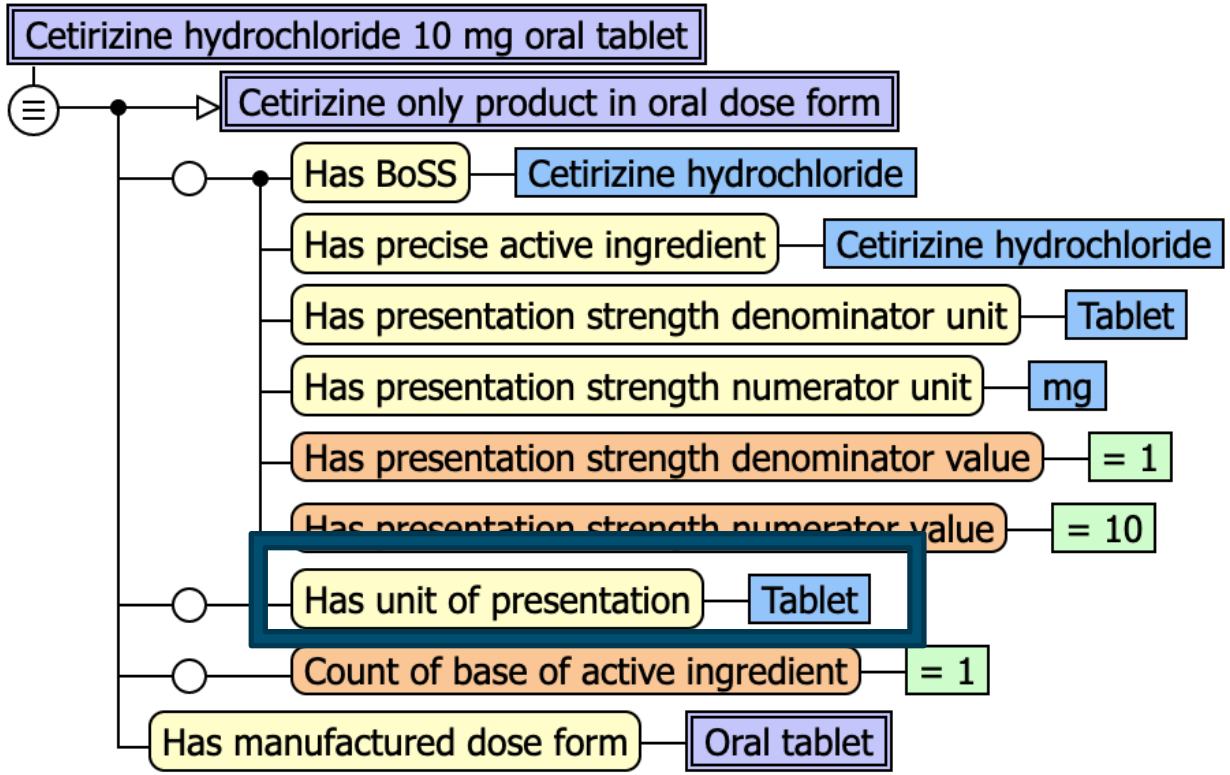
Mapped and replaced with route specific form in AMT
May not be correct!

AMT Integration with SNOMED CT International

AMT



International

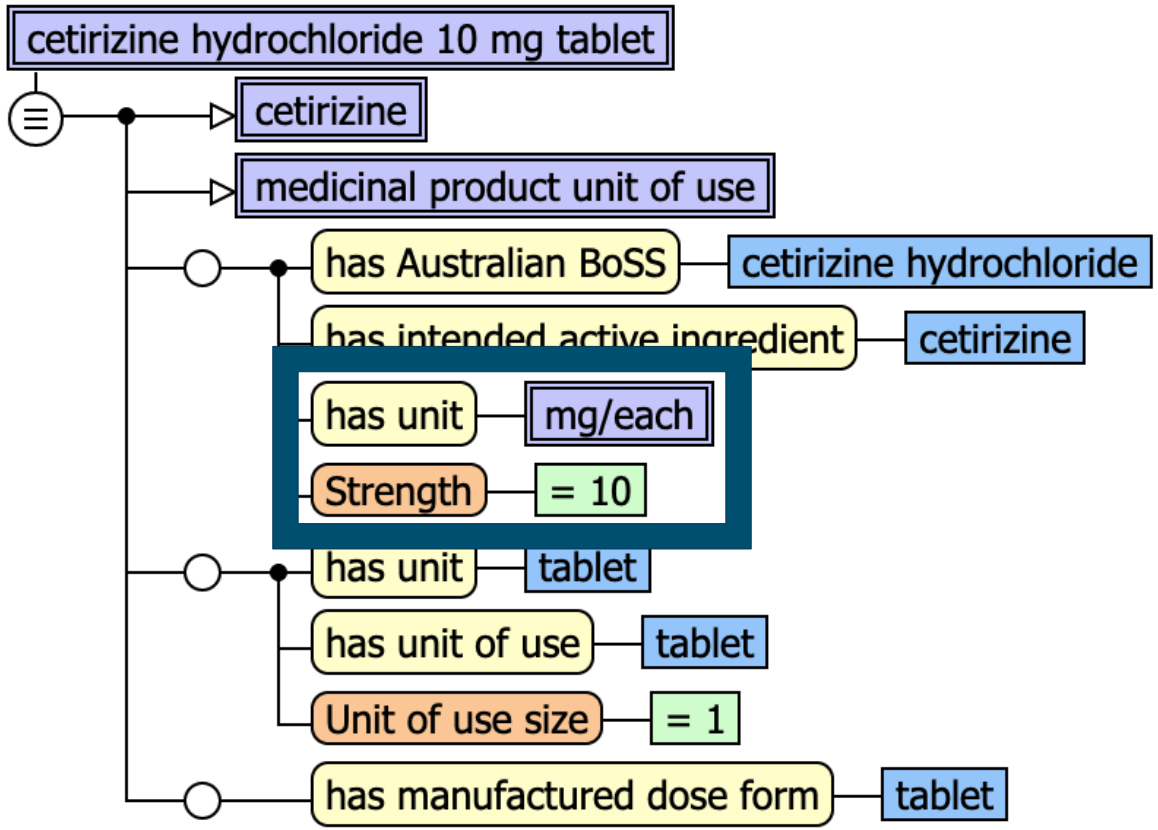


Translated AMT axiom for single “discrete” units to

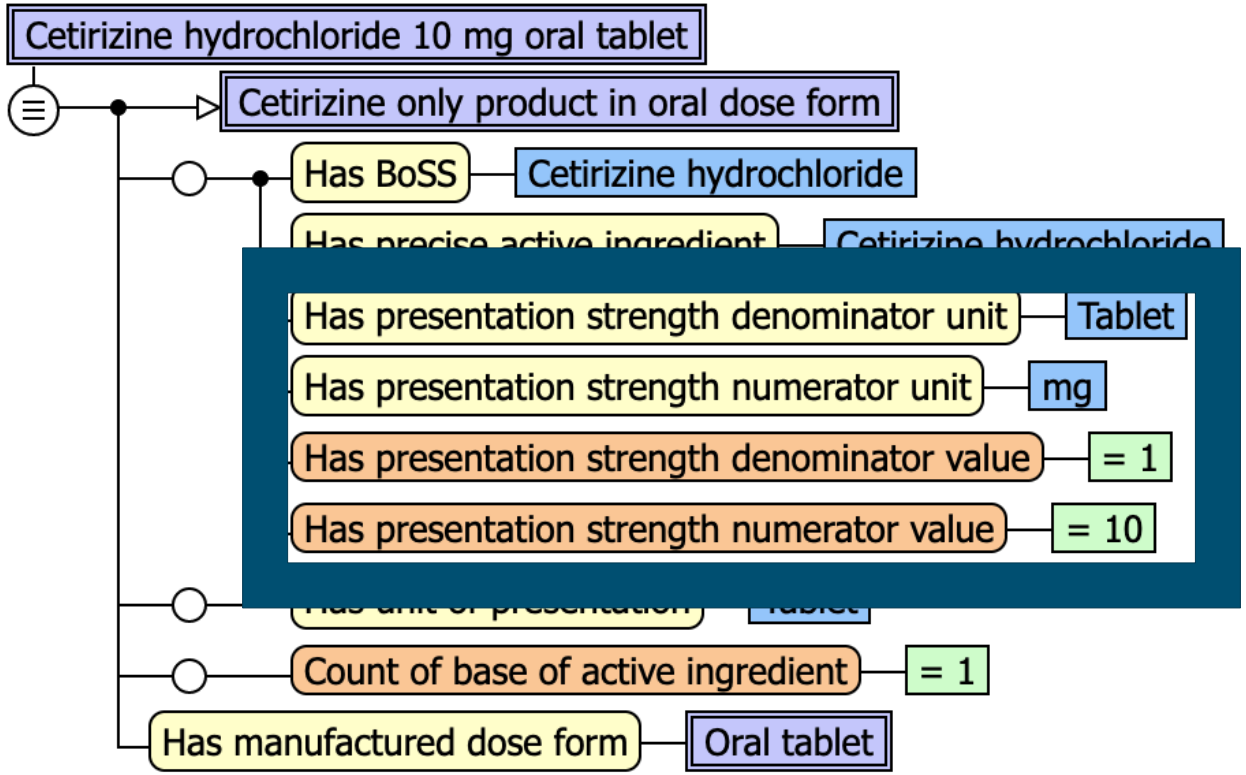
- drop unit and size
- map and replace AMT ”unit of use” with “unit of presentation” concepts

AMT Integration with SNOMED CT International

AMT



International



Generated axioms for these sub parts as equivalent anonymous concepts.
Note that this had to be done for every different denominator unit value

AMT Integration with SNOMED CT International

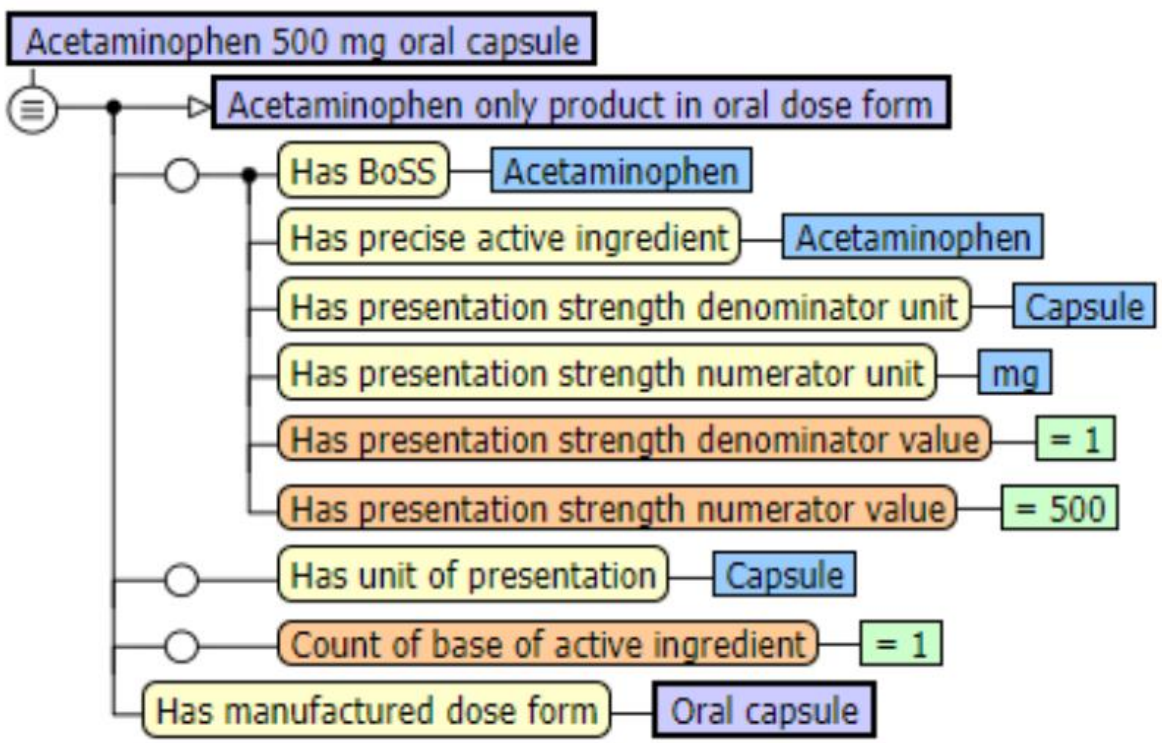
Subsumption incomplete

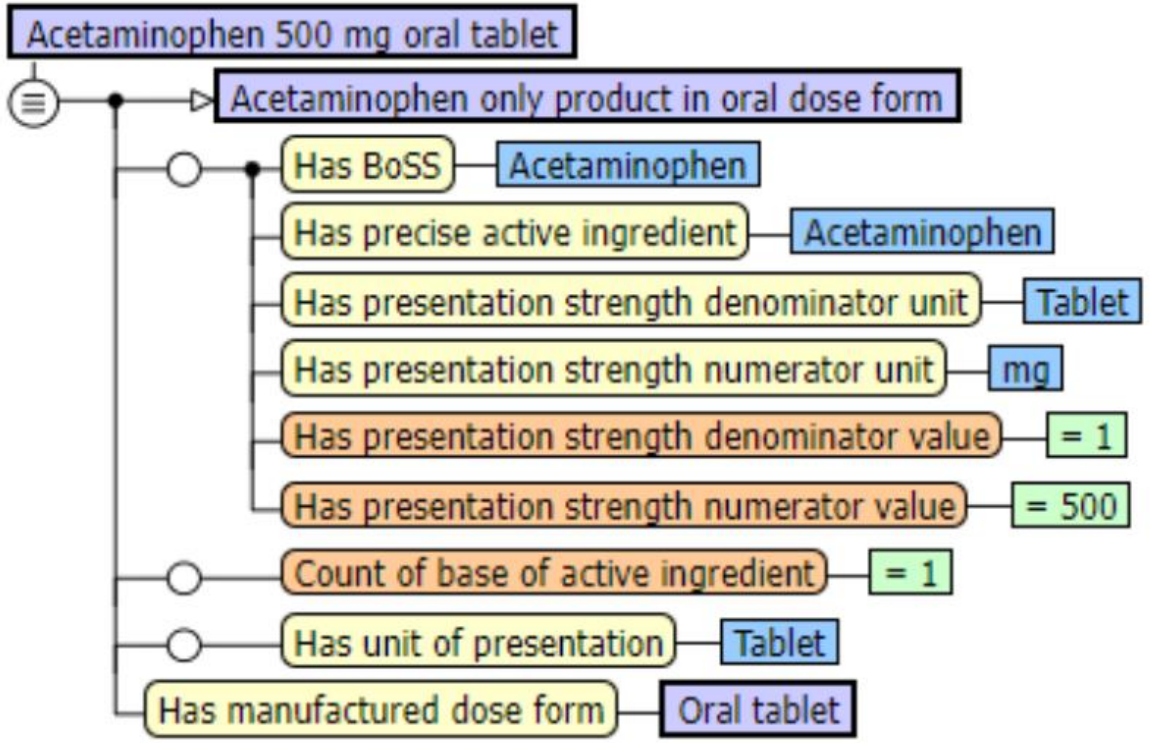
- Unit of presentation
- Strength denominator units
- Strength numerator unit consistency
- Rounding precision
- Form mismatches (even after mapping)

Where subsumption is correct

- NNF calculations passes through stated form only – omits other necessary conditions as redundant
- Unlike DL queries in OWL, to ECL, AMT still looks like AMT without logically true relationships matching international modelling

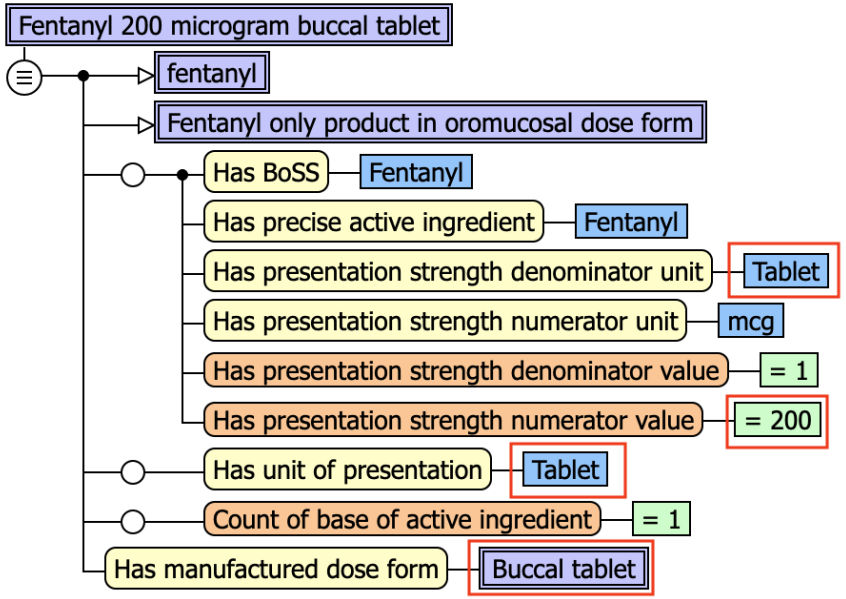
AMT Integration with SNOMED CT International

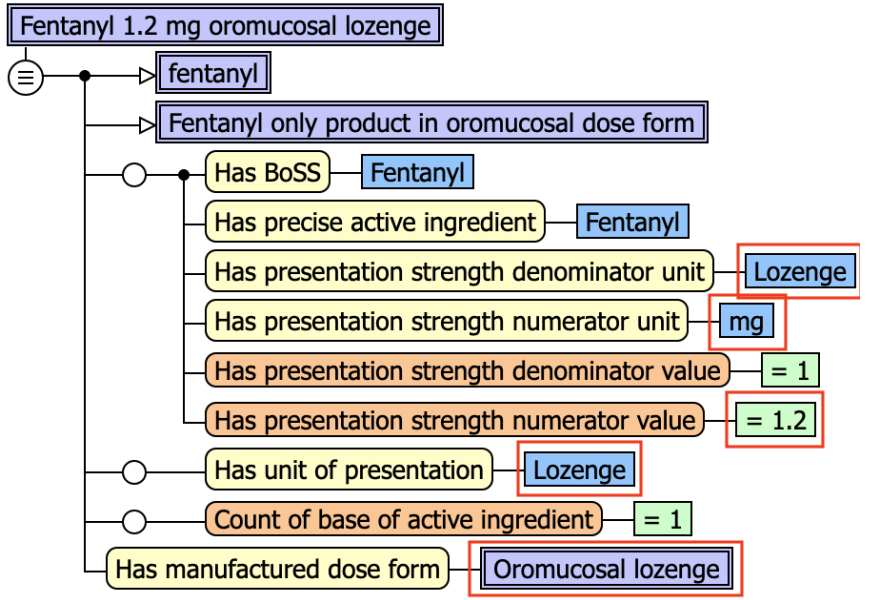


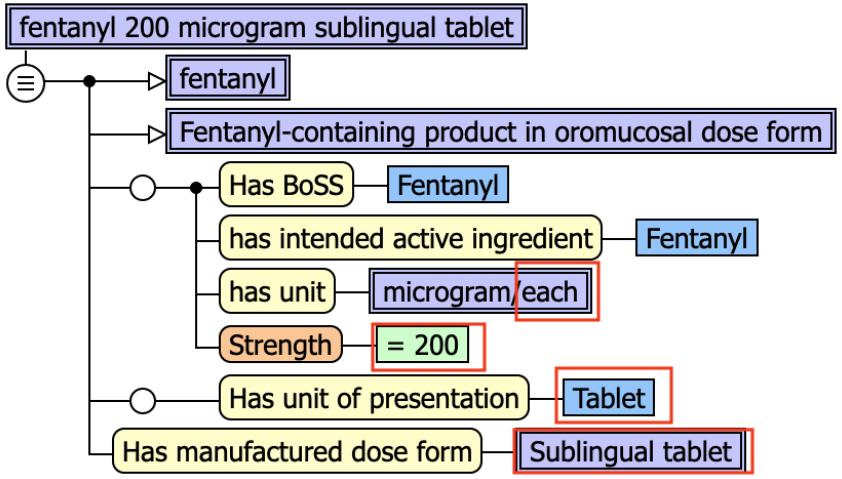


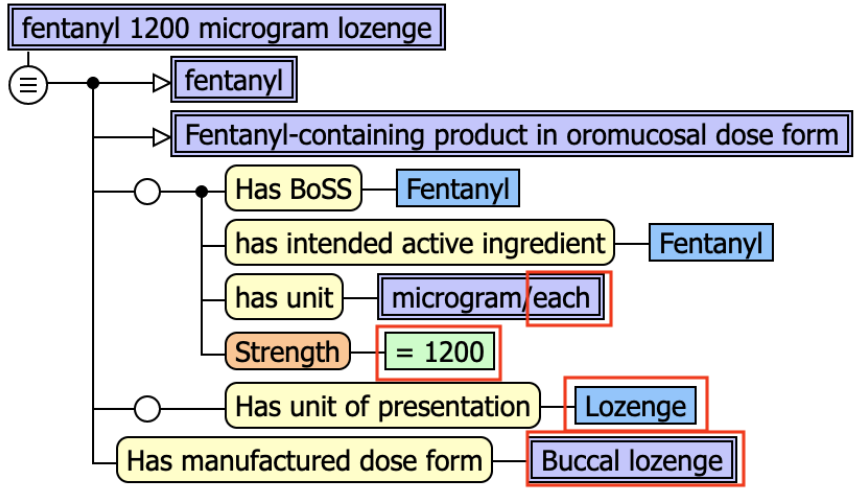
To the classifier 500mg/Capsule is **not equal** to 500mg/Tablet

AMT Integration with SNOMED CT International









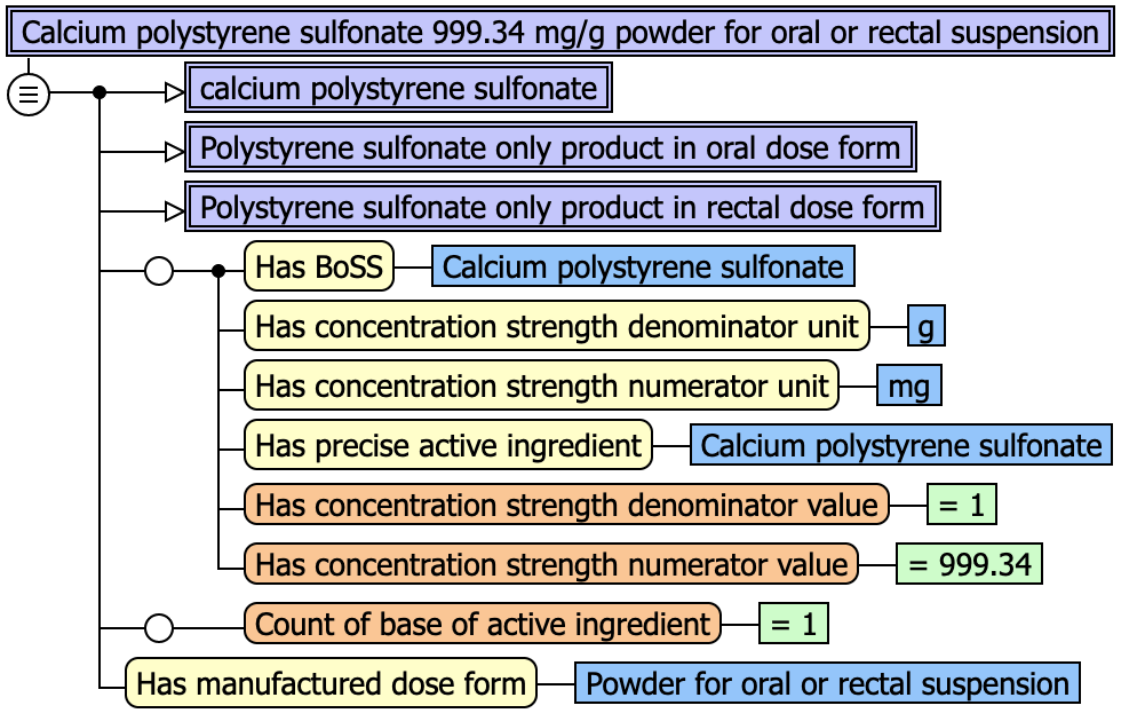
AMT enforces consistent units across ingredients in forms to make strength values

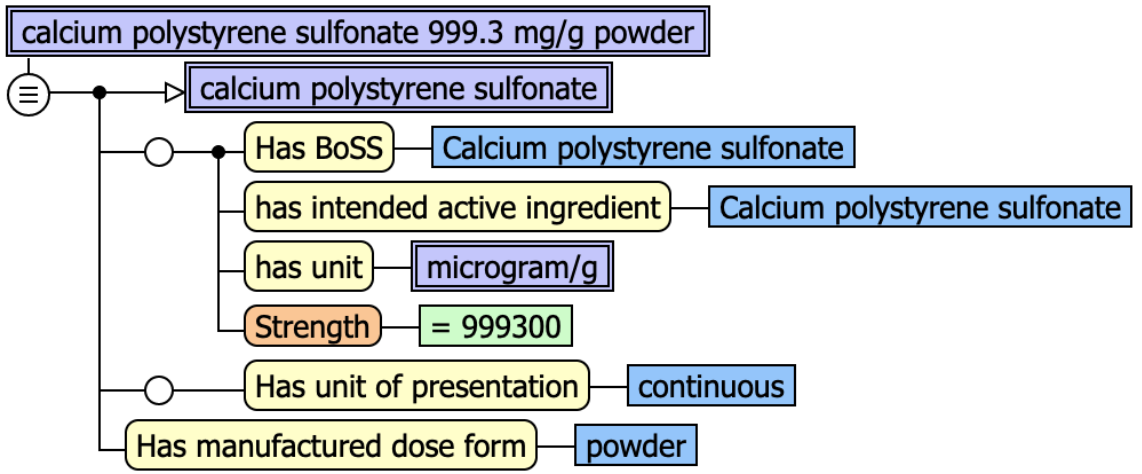
- Comparable by the classifier
- Comparable in ECL

e.g. all products containing more than 200mcg of fentanyl

International content does not apply this rule, causing AMT to inconsistently classify with it.

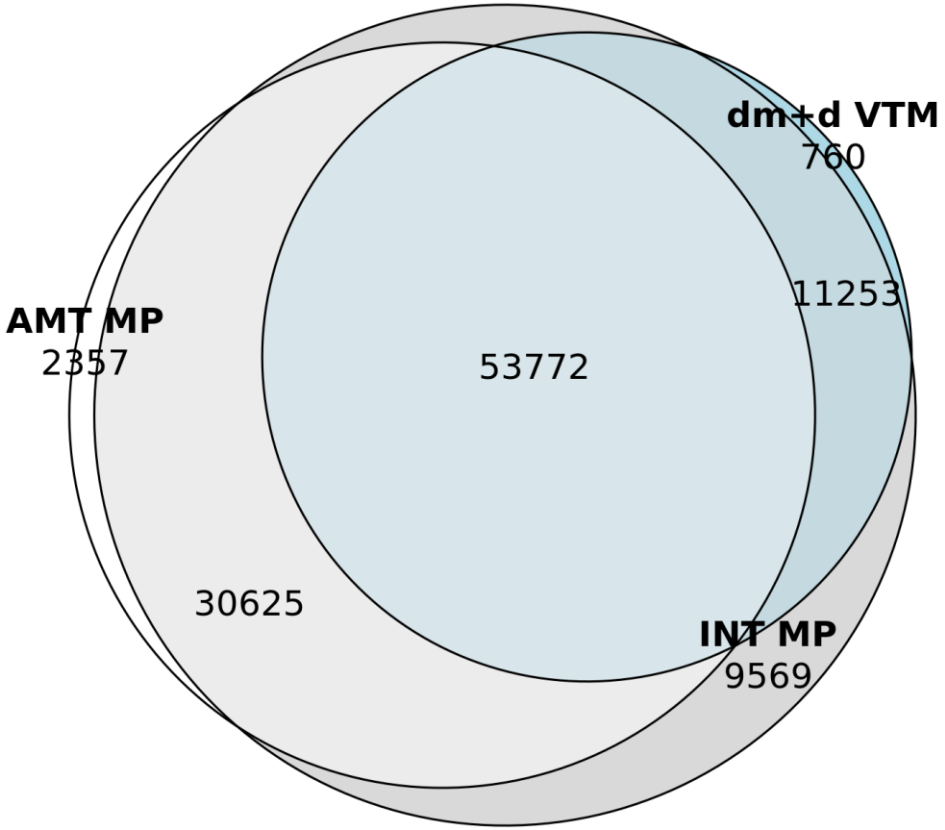
AMT Integration with SNOMED CT International

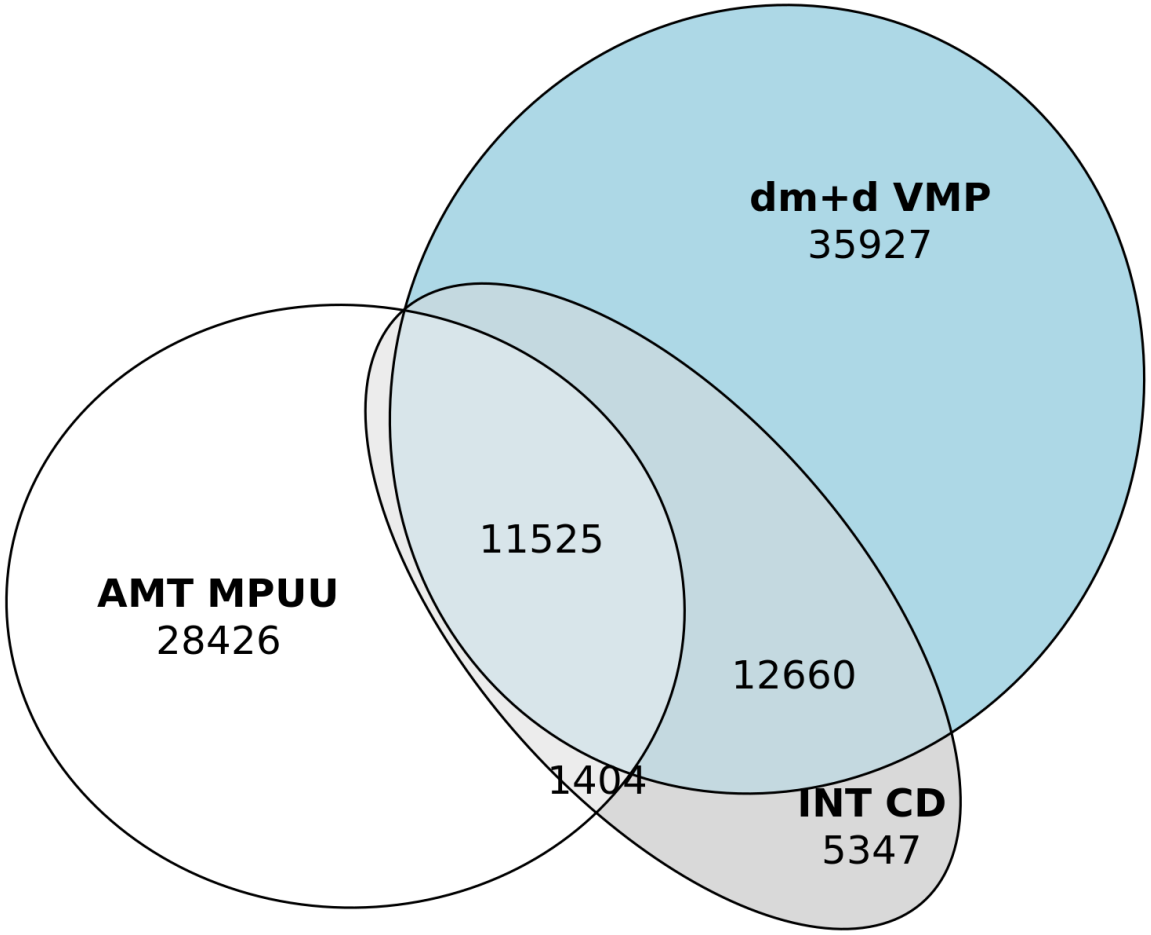




Differences are also present in rounding precision, and forms, which will also affect classification

AMT/dm+d Integration with SNOMED CT International





Subsumption is strong at the Medicinal Product level, but poor below that

Interoperation options for medicines list

Finding a medication via SNOMED CT integration can be done two ways

- By common SNOMED CT core ancestor
  1. Find extension X's proximal parent from SNOMED CT international
  2. Find extension Y's concepts subsumed by it
- ECL
  1. Generate ECL from the definition of extension X's concept, making it more general as needed (for example removing trade/brand properties)
  2. If necessary, translate the ECL from extension X's model to extension Y's (if both are using the same model this isn't necessary)
  3. Execute the ECL against extension Y

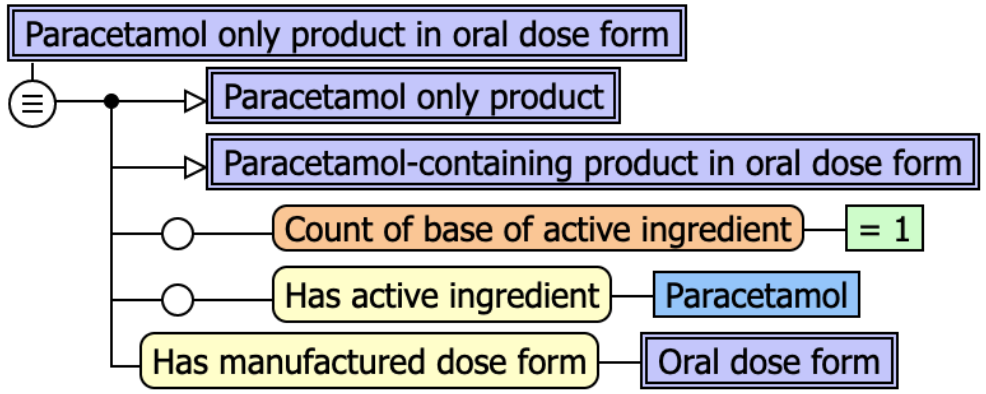
Each have their limitations and issues.

Interoperation options for medicines list – common ancestor

Using the following ECL pattern with 322280009 |Paracetamol 500 mg oral capsule| as an example

>322280009 {{ C moduleId = 900000000000207008 }}
MINUS
>(>322280009)

We find the concept



Unfortunately this will not subsume anything in AMT which uses “at least” rather than “only” semantics

Interoperation options for medicines list – ECL

Taking the ECL approach 322280009 |Paracetamol 500 mg oral capsule| can be written as

```
< 373873005|Pharmaceutical / biologic product| :
{
  << 127489000|Has active ingredient| = 387517004|Paracetamol|,
  << 732943007|Has BoSS| = 387517004|Paracetamol|,
  1142135004|Has presentation strength numerator value| = #500,
  732945000|Has presentation strength numerator unit| = 258684004|mg|,
  1142136003|Has presentation strength denominator value| = #1,
  732947008|Has presentation strength numerator unit| = 732937005|Capsule|
},
{
  763032000|Has unit of presentation| = 732937005|Capsule|
},
{
  1142139005|Count of base of active ingredient| = #1
},
411116001|Has manufactured dose form| = 420692007|Oral capsule|
```

Which matches this concept exactly.

Interoperation options for medicines list – ECL

This can be simplified with no loss to

```
< 373873005|Pharmaceutical / biologic product| :
{
  << 127489000|Has active ingredient| = 387517004|Paracetamol|,
  << 732943007|Has BoSS| = 387517004|Paracetamol|,
  1142135004|Has presentation strength numerator value| = #500,
  732945000|Has presentation strength numerator unit| = 258684004|mg|,
  1142136003|Has presentation strength denominator value| = #1,
  732947008|Has presentation strength denominator unit| = <<732935002|Unit of presentation|
},
{
  1142139005|Count of base of active ingredient| = #1
},
411116001|Has manufactured dose form| = 420692007|Oral capsule|
```

Generalising the strength denominator and removing the unit of presentation

Interoperation options for medicines list – ECL

This can be further simplified with no loss to

```
< 373873005|Pharmaceutical / biologic product| :
{
  << 127489000|Has active ingredient| = 387517004|Paracetamol|,
  << 732943007|Has BoSS| = 387517004|Paracetamol|,
  1142135004|Has presentation strength numerator value| = #500,
  732945000|Has presentation strength numerator unit| = 258684004|mg|
},
{
  1142139005|Count of base of active ingredient| = #1
},
411116001|Has manufactured dose form| = 420692007|Oral capsule|
```

Removing the strength denominator has no effect, as it is always a value of 1 and a denominator of a unit of presentation – **however it still won't match AMT**

Interoperation options for medicines list – ECL

Were the NNF calculation different the previous ECL would match. Converting the strength representation succeeds

```
< 373873005|Pharmaceutical / biologic product| :
{
  << 127489000|Has active ingredient| = 387517004|Paracetamol|,
  << 732943007|Has BoSS| = 387517004|Paracetamol|,
  700000111000036105|Strength| = #500,
  1776310000036102|Has unit| = 700000801000036102|mg/each|
},
411116001|Has manufactured dose form| = 420692007|Oral capsule|,
[0..0] << 127489000|Has active ingredient| = (<105590001|Substance| minus 387517004|Paracetamol|)
```

Note the additional clause to return “paracetamol only” products.

This can also be tripped be the exact strength – e.g. AMT doesn’t have 300 mg Paracetamol tablets

Interoperation options for medicines list – allergies and knowledge system links

While linking at the strength/form level is problematic for a number of reasons, subsumption at the MP level is not.

Either technique can be used to either

- **Find a Medicinal Product ancestor and find the descendants in another extension**
- **Create ECL renderings of a product at the Medicinal Product level that are portable**

< 373873005|Pharmaceutical / biologic product| :

<< 127489000|Has active ingredient| = 387517004|Paracetamol|

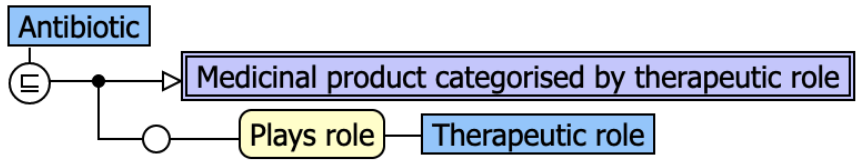
Interoperation options for medicines list – antibiotics

255631004|Antibiotic| is primitive, subsumes nothing

But there is 346325008|Antibacterial agent|

<346325008|Antibacterial agent|

{{ C moduleId = 900062011000036108 }}



5621011000036108	Abbocillin V 125 mg/5 mL oral liquid, 5 mL
35475011000036108	Abbocillin V 150 mg/5 mL oral liquid, 5 mL
5843011000036101	Abbocillin V 250 mg/5 mL oral liquid, 5 mL
6303011000036107	Abbocillin VK Filmtab 250 mg tablet
6304011000036109	Abbocillin VK Filmtab 500 mg tablet
86101000036102	acetic acid 0.94% + oxyquinoline sulfate 0.025% + ricinoleic acid 0.75% vaginal gel
798111000168108	Achromycin 250 mg capsule
86091000036106	Aci-Jel Balance vaginal gel
5219011000036100	Aclor 125 mg/5 mL powder for oral liquid, 5 mL

n=1488

Interoperation options for medicines list – Immunosuppressants

372823004|Immunosuppressant (substance)| can be used

(< 373873005|Pharmaceutical / biologic product| :

<< 127489000|Has active ingredient| = <372823004|Immunosuppressant (substance)|)

{{ C moduleId = 900062011000036108 }}

33635011000036100	abatacept
899671000168102	abatacept 125 mg/mL injection, pen device
2361000036100	abatacept 125 mg/mL injection, syringe
33663011000036106	abatacept 250 mg injection, vial
1541511000168103	Adakveo 100 mg/10 mL injection, 10 mL vial
817171000168103	Advagraf XL 1 mg modified release capsule
1376511000168106	Advagraf XL 3 mg modified release capsule
817421000168107	Advagraf XL 5 mg modified release capsule
818261000168102	Advagraf XL 500 microgram modified release capsule

n=514

Use cases and examples

- Example products taken from RxNorm through to SNOMED CT

SNOMED CT		AMT
1145421000 | Atorvastatin (as atorvastatin calcium) 40 mg oral tablet |	✓	22785011000036108 | atorvastatin 40 mg tablet |
786021000 | Levofloxacin anhydrous (as levofloxacin) 15 mg/mL eye solution |	✗	Only 500 and 250 mg tablets registered for use in Australia https://www.tga.gov.au/resources/artg?keywords=levofloxacin 2541011000036103 | ofloxacin 0.3% eye drops |
1149193009 | Voclosporin 7.9 mg oral capsule |	✗	No Voclosporin products in Australia https://www.tga.gov.au/resources/artg?keywords=Voclosporin 23050011000036103 | cyclophosphamide 50 mg tablet | ? 22943011000036106 | mycophenolate mofetil 250 mg capsule | ?
373994007 | Prednisone 5 mg oral tablet |	✓	22704011000036105| prednisone 5 mg tablet |
377263003 | Captopril 25 mg and hydrochlorothiazide 15 mg oral tablet |	✗	No multi-ingredient tablet in Australia 23162011000036104 | captopril 25 mg tablet | 23387011000036109 | hydrochlorothiazide 25 mg tablet |

Use cases and examples

1. Find corresponding AMT product concept from SNOMED CT IDs
2. Which of these these are antibiotics?
3. Which of these are cytotoxins?
4. Which of these are migraine prophylaxis?
5. Which of these are non-steroidal anti-inflammatories?
6. Which of these are immunosuppressants?
7. Which of these are glucocorticoids?
8. Which of these are thiazide diuretics?
9. Which of these are medications that treat or manage diabetes?

Use cases and examples - results

- Issues exist with alignment for classification at the Clinical Drug level
- AMT prototype is optimistic using route specific forms
  - dm+d prototype shows less alignment because of these forms
- Also product alignment issues across jurisdictions
  - Strengths and ingredient combinations
  - Some products not available in different jurisdictions
- Despite this
  - Many really useful features are added to AMT through integration with SNOMED CT
  - All delivered through integration at the substance and Medicinal Product level

Re-use of Observable Entities for Laboratory Results

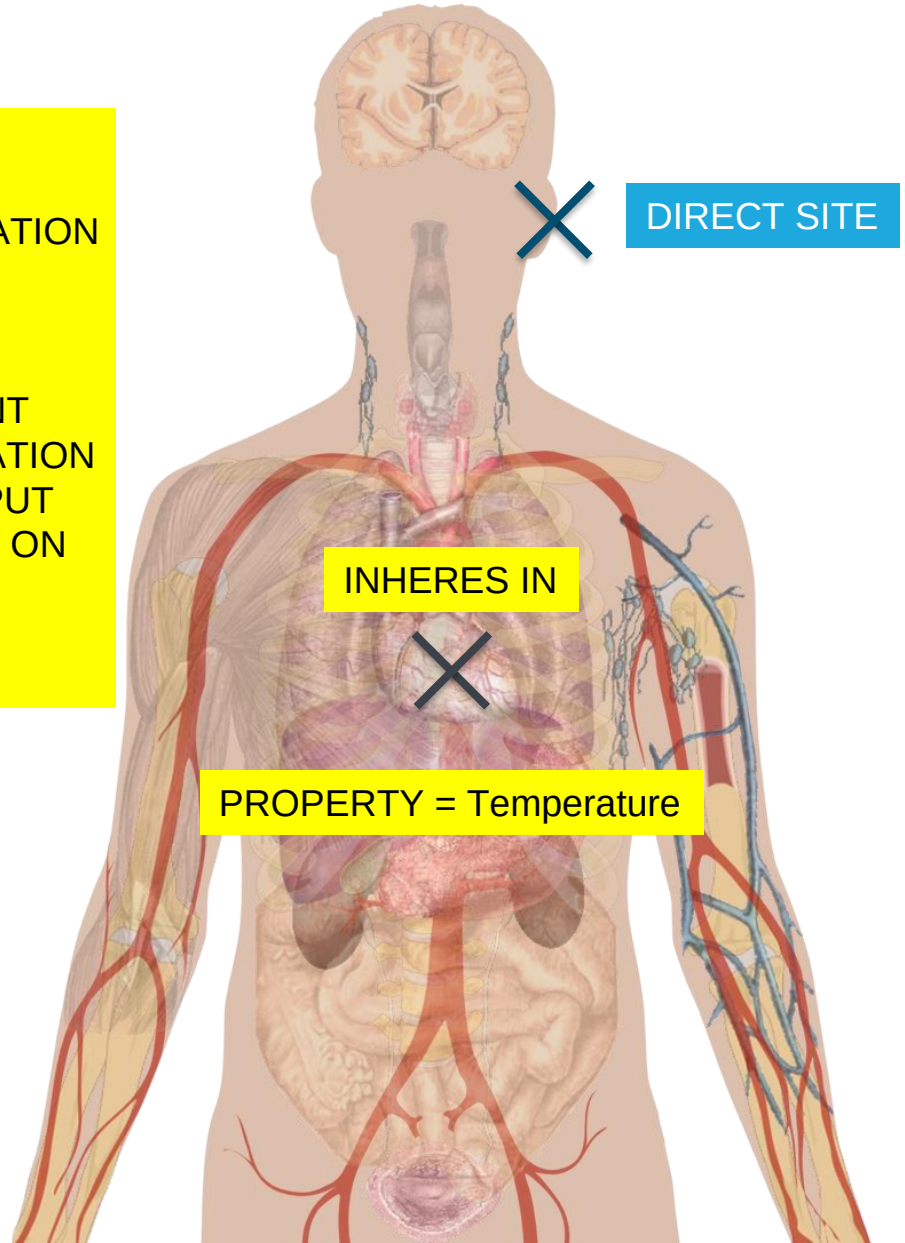
Daniel Karlsson

Observables overview

Observable entity

PROPERTY
INHERES IN
INHERENT LOCATION
COMPONENT
RELATIVE TO
CHARACTERIZES
PROCESS AGENT
PROCESS DURATION
PROCESS OUTPUT
PROCESS ACTS ON
HAS REALIZATION
TOWARDS
PRECONDITION

TECHNIQUE
SCALE TYPE
TIME ASPECT
UNITS
DIRECT SITE
USING DEVICE



DIRECT SITE

SCALE, UNITS

USING DEVICE

INHERES IN

PROPERTY = Temperature

PRECONDITION

Observables overview

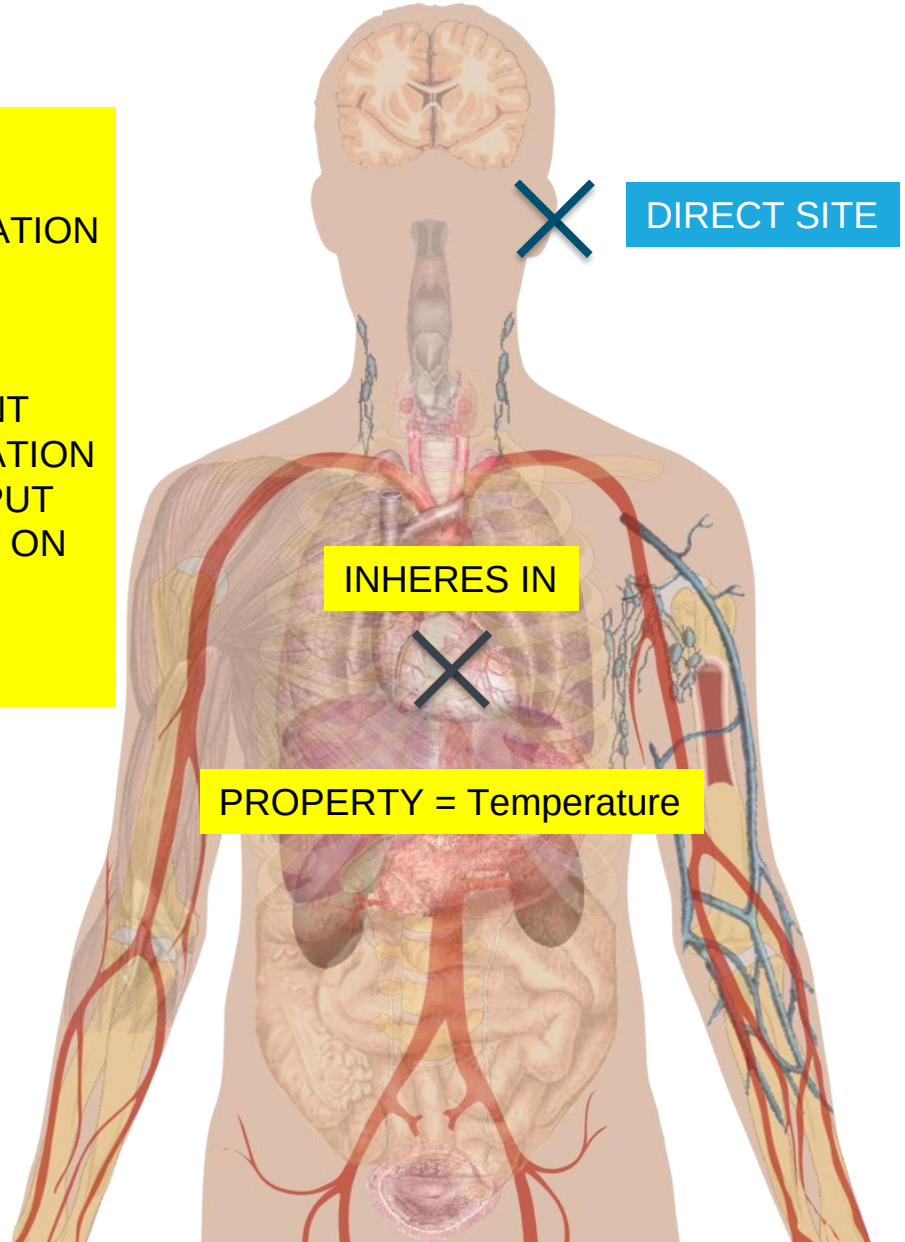
Observable entity

PROPERTY
INHERES IN
INHERENT LOCATION
COMPONENT
RELATIVE TO
CHARACTERIZES
PROCESS AGENT
PROCESS DURATION
PROCESS OUTPUT
PROCESS ACTS ON
HAS REALIZATION
TOWARDS
PRECONDITION

WHAT

TECHNIQUE
SCALE TYPE
TIME ASPECT
UNITS
DIRECT SITE
USING DEVICE

HOW



DIRECT SITE

SCALE, UNITS

USING DEVICE

INHERES IN

PROPERTY = Temperature

PRECONDITION

Observables overview

- 22 attributes allowed by current concept model
- Model is stable, but application to new domains requires re-evaluation and changes might be made to accommodate for new use cases

Four patterns with specific attributes have been identified

- Quality observable (including quantities, i.e. vast majority of use cases)
- Process observable (anything that is relative to time)
- Function observable (capacities)
- Disposition observable (predispositions e.g. susceptibility)

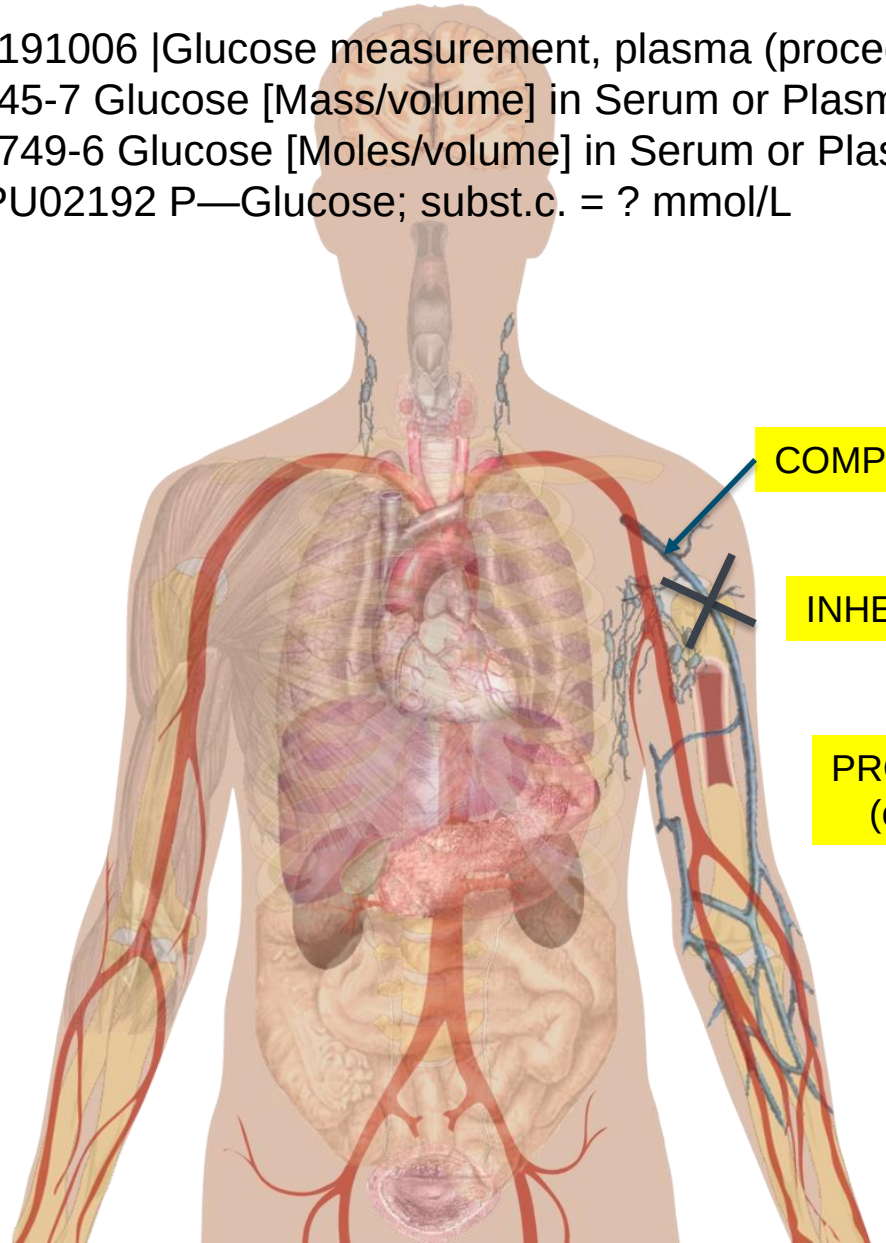
Quality Observable

Observable entity

- PROPERTY
- INHERES IN
  - INHERENT LOCATION
- COMPONENT
- RELATIVE TO
- CHARACTERIZES
  - PROCESS AGENT
  - PROCESS DURATION
  - PROCESS OUTPUT
  - PROCESS ACTS ON
- HAS REALIZATION
- TOWARDS
- PRECONDITION

- TECHNIQUE
- SCALE TYPE
- TIME ASPECT
- UNITS
- DIRECT SITE
- USING DEVICE

72191006 |Glucose measurement, plasma (procedure)|
2345-7 Glucose [Mass/volume] in Serum or Plasma
14749-6 Glucose [Moles/volume] in Serum or Plasma
NPU02192 P—Glucose; subst.c. = ? mmol/L



COMPONENT = Glucose

INHERES IN = Plasma

PROPERTY = Quantity concentration (or mass or substance)

DIRECT SITE = Plasma specimen

Continuous in-vivo glucose measurement?

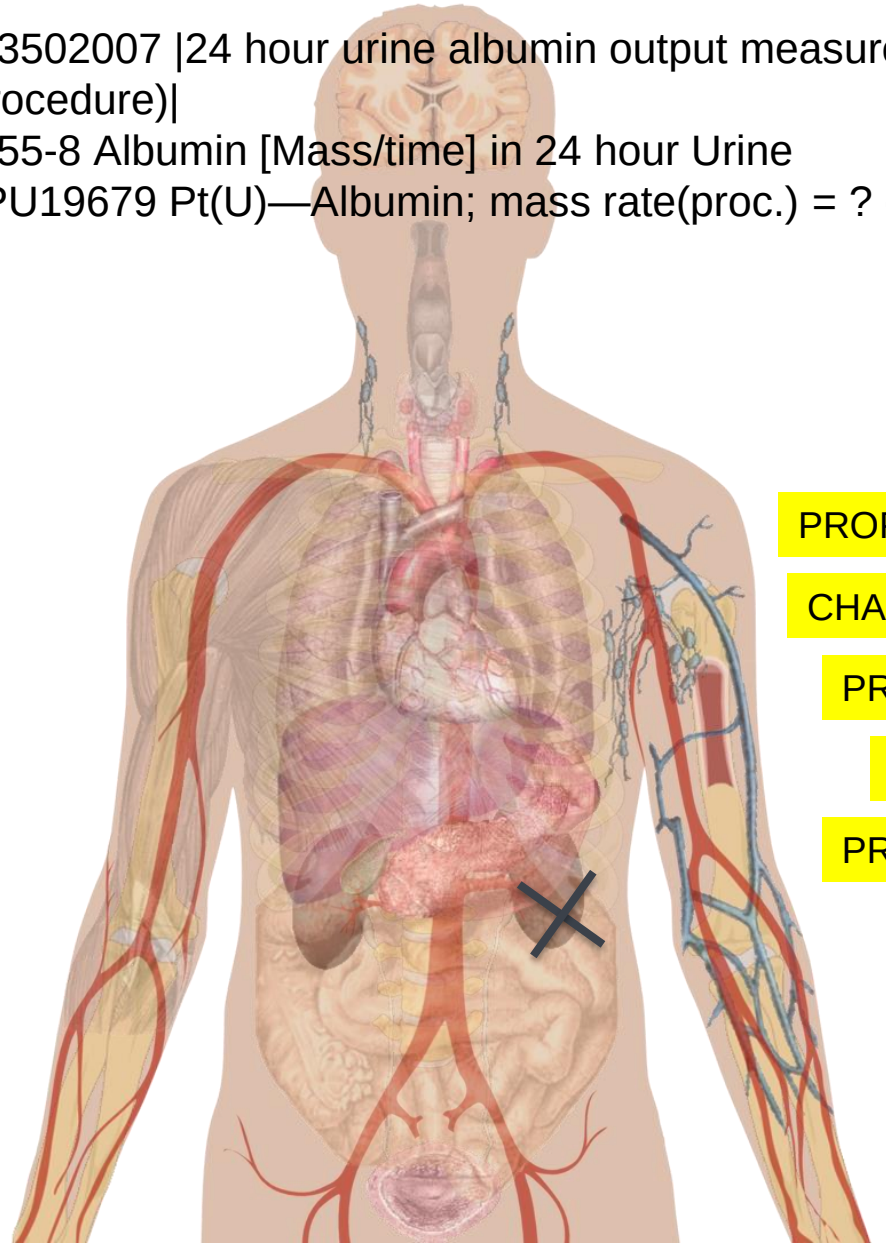
Process Observable

Observable entity

- PROPERTY
- INHERES IN
  - INHERENT LOCATION
- COMPONENT
- RELATIVE TO
- CHARACTERIZES
  - PROCESS AGENT
  - PROCESS DURATION
  - PROCESS OUTPUT
  - PROCESS ACTS ON
- HAS REALIZATION
- TOWARDS
- PRECONDITION

- TECHNIQUE
- SCALE TYPE
- TIME ASPECT
- UNITS
- DIRECT SITE
- USING DEVICE

313502007 |24 hour urine albumin output measurement (procedure)|
1755-8 Albumin [Mass/time] in 24 hour Urine
NPU19679 Pt(U)—Albumin; mass rate(proc.) = ? g/d



PROPERTY = Mass rate

CHARACTERIZES = Excretion

PROCESS OUTPUT = Albumin

PROCESS DURATION = 24 H

PROCESS AGENT = Kidney structure

DIRECT SITE = Urine specimen

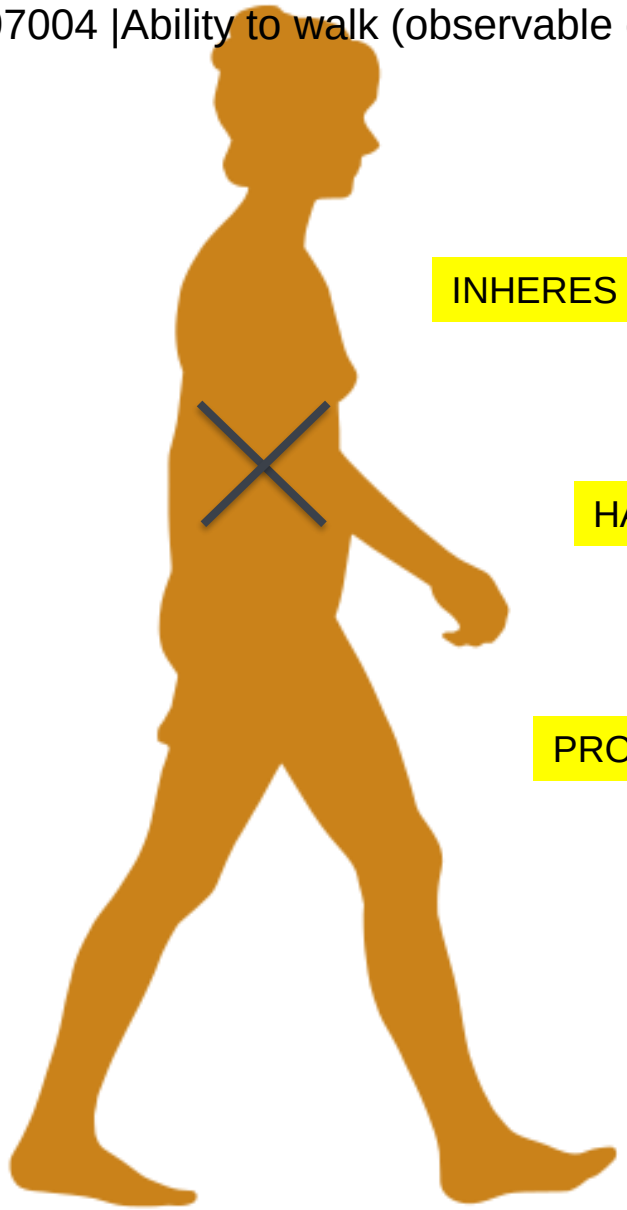
Function Observable

Observable entity

- PROPERTY
- INHERES IN
  - INHERENT LOCATION
- COMPONENT
- RELATIVE TO
- CHARACTERIZES
  - PROCESS AGENT
  - PROCESS DURATION
  - PROCESS OUTPUT
  - PROCESS ACTS ON
- HAS REALIZATION
- TOWARDS
- PRECONDITION

- TECHNIQUE
- SCALE TYPE
- TIME ASPECT
- UNITS
- DIRECT SITE
- USING DEVICE

282097004 |Ability to walk (observable entity)|



INHERES IN = Person

HAS REALIZATION = Walking

PROPERTY = Ability

Disposition Observable

Observable entity

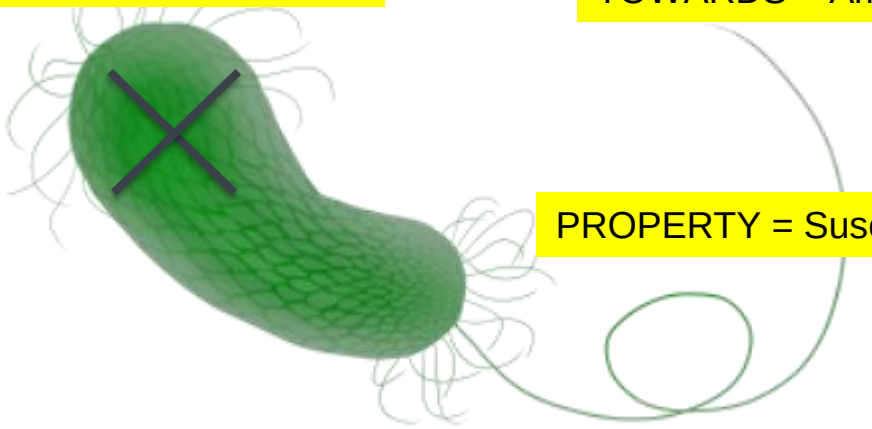
PROPERTY
INHERES IN
INHERENT LOCATION
COMPONENT
RELATIVE TO
CHARACTERIZES
PROCESS AGENT
PROCESS DURATION
PROCESS OUTPUT
PROCESS ACTS ON
HAS REALIZATION
TOWARDS
PRECONDITION

TECHNIQUE
SCALE TYPE
TIME ASPECT
UNITS
DIRECT SITE
USING DEVICE

18861-5 Amoxicillin [Susceptibility]
NPU06001 Syst—Amoxicillin; suscept. = ?

INHERES IN = Bacteria

TOWARDS = Amoxicillin



PROPERTY = Susceptibility

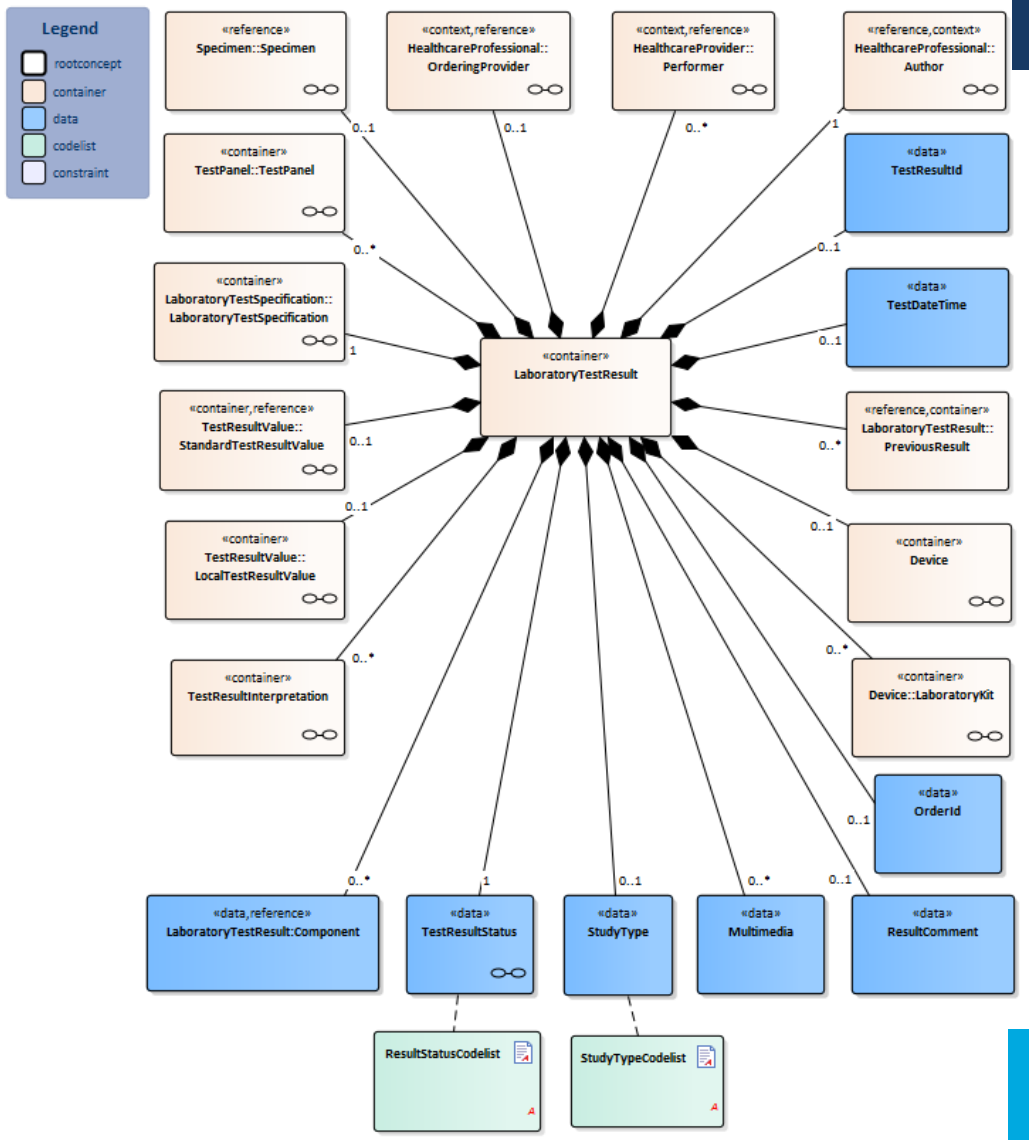
Laboratory Results Interoperation SNOMED, LOINC and the Information Model

- SNOMED CT in use outside of the test code
- Results of EU X-eHealth project
- Examples of Observables in lab medicine

Laboratory Results and SNOMED CT coding – X-eHealth

Many pieces of information go with a lab result, and some require coding with a terminology

- Specimen
- Specimen containers
- Study types
- Devices, kits
- Method
- Ordinal and nominal scale results
- Interpretation
- etc.



Laboratory Results and SNOMED CT coding – X-eHealth

Methodology

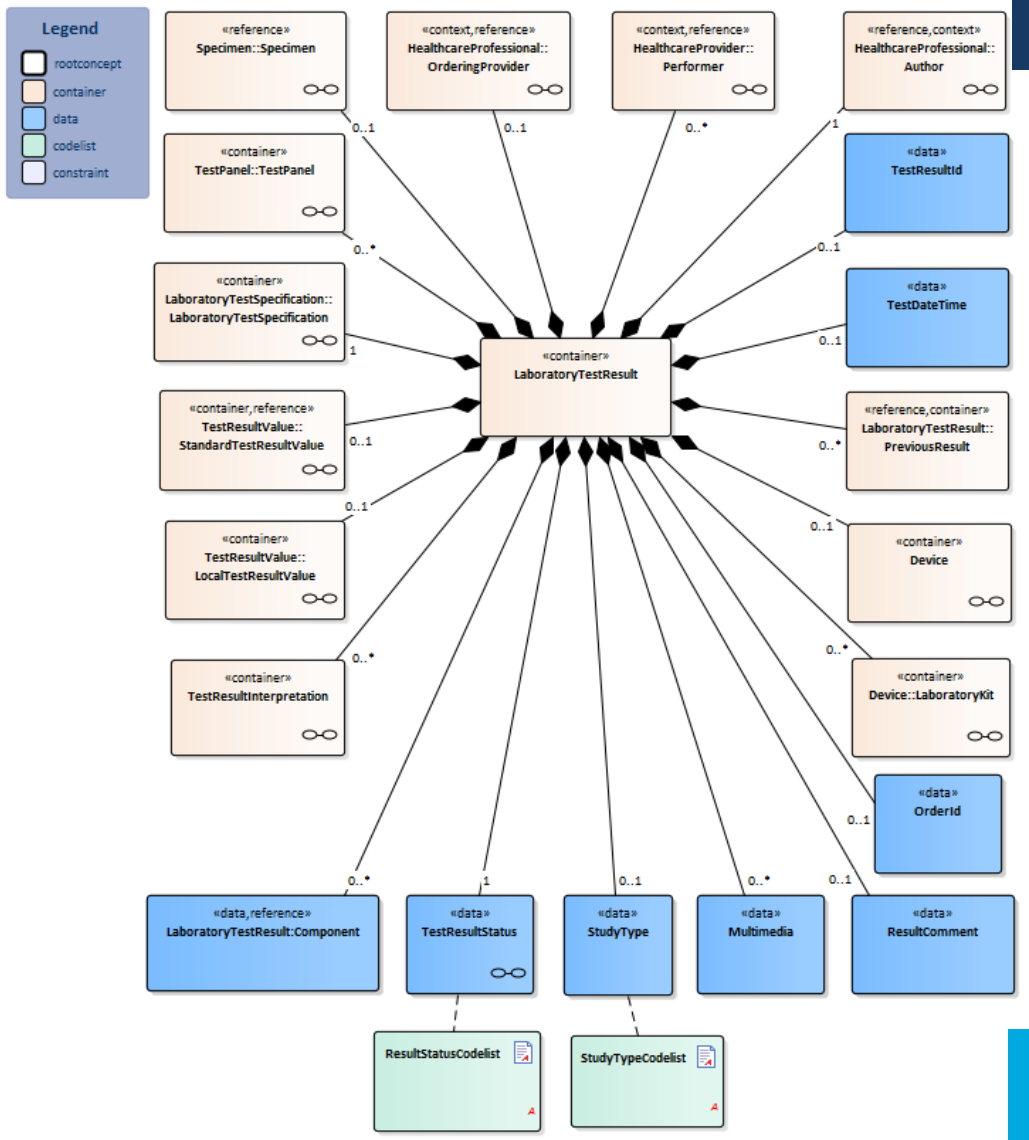
- Collection of concepts from EU member states
  - E.g. Specimen types from Austria, Czech Republic, Estonia, Netherlands, Sweden
- SNOMED CT coding when required and possible
- Establish pivot table with common concepts

	A	B	C	D	E
1	EU	(Multiple Items)			
2					
3	Code	SCT Concept	Display	Country	Count of Country
4	119376003	Tissue specimen			4
5	119359002	Bone marrow specimen			4
6	122571007	Pericardial fluid			4
7	119297000	Blood specimen			4
8	418564007	Pleural fluid			4
9	119303007	Microbial isolate			4
10	122554006	Capillary blood specimen			4
11	119326000	Hair specimen			4
12	258450006	CSF specimen			4
13	119327009	Nail specimen			4
14	119361006	Plasma specimen			4
15	119334006	Sputum specimen			4

Laboratory Results and SNOMED CT coding – X-eHealth

Tentative results:

- Specimen – SNOMED CT
- Specimen containers – SNOMED CT
- Study types – LOINC + SNOMED CT(?)
- Method – SNOMED CT
- Ordinal and nominal scale results – SNOMED CT
- Interpretation – HL7
- etc.



Example

Blood glucose

- Multiple LOINC/NPU/etc. codes are in use

Example: Querying over SNOMED CT and information model

Bacteria identification

- With or without method

Name	Flags	Card.	Type	Description & Constraints
Observation	N		DomainResource	Measurements and simple assertions *+ Rule: dataAbsentReason SHALL only be present if Observation.value[x] is not present* *+ Rule: If Observation.code is the same as an Observation.component.code then the value element associated with the code SHALL NOT be present* Elements defined in Ancestors: id, meta, implicitRules, language, text, contained, extension, modifierExtension
identifier	Σ	0..*	Identifier	Business Identifier for observation
basedOn	Σ	0..*	Reference(CarePlan | DeviceRequest | ImmunizationRecommendation | MedicationRequest | NutritionOrder | ServiceRequest)	Fulfills plan, proposal or order
partOf	Σ	0..*	Reference(MedicationAdministration | MedicationDispense | MedicationStatement | Procedure | Immunization | ImagingStudy)	Part of referenced event
status	?! Σ	1..1	code	registered | preliminary | final | amended + ObservationStatus (Required)
category		0..*	CodeableConcept	Classification of type of observation Observa
code	Σ	1..1	CodeableConcept	Type of LOINC (
note		0..*	Annotation	Comme
bodySite		0..1	CodeableConcept	Observed body part SNOMED CT Body Structures (Example)
method		0..1	CodeableConcept	How it was done Observation Metho
specimen		0..1	Reference(Specimen)	Specimen used for this observation
device		0..1	Reference(Device | DeviceMetric)	(Measurement) Device

Bacteria identified in Isolate (LOINC:42803-7)
Bacteria identified in Isolate by Culture (LOINC:43409-2)

702658000 |Microbial culture technique (qualifier value)|

Example: using the SNOMED CT hierarchies

Has there been a benzodiazepine test

Re-use of Pathology Results for Cancer Research

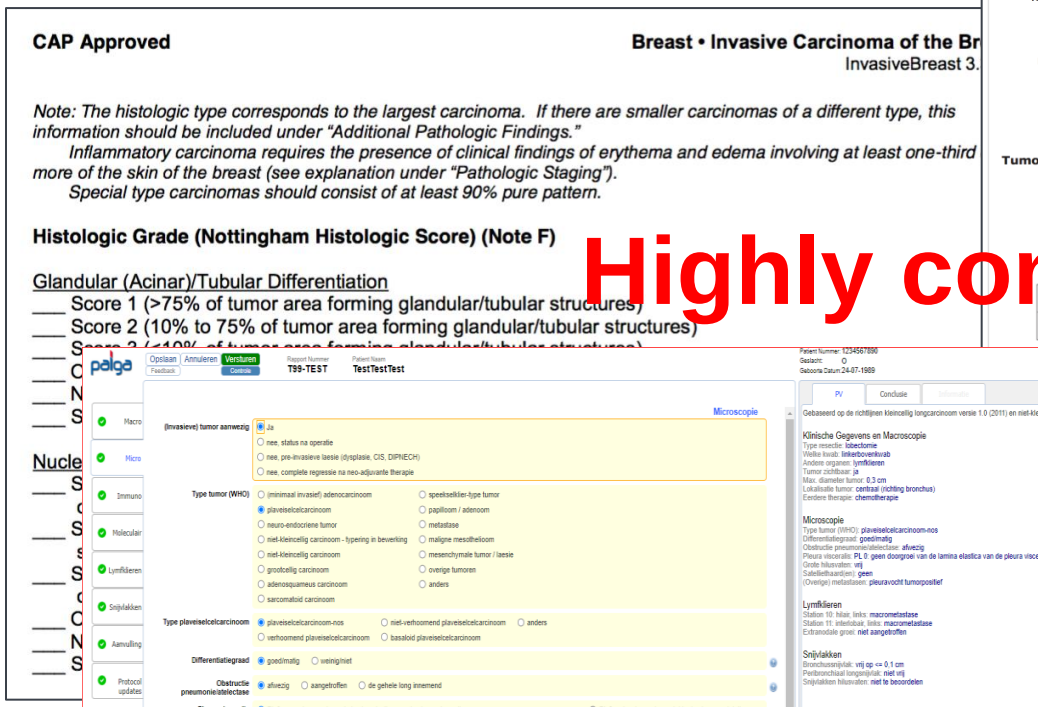
W Scott Campbell

SNOMED CT EXPO 2022
SEPT 29-30, 2022
Lisbon, Portugal ✕ Virtual

SNOMED International

Current pathology practice cancer reporting

US – College of American Pathologists



CAP Approved

Breast • Invasive Carcinoma of the Br
InvasiveBreast 3.

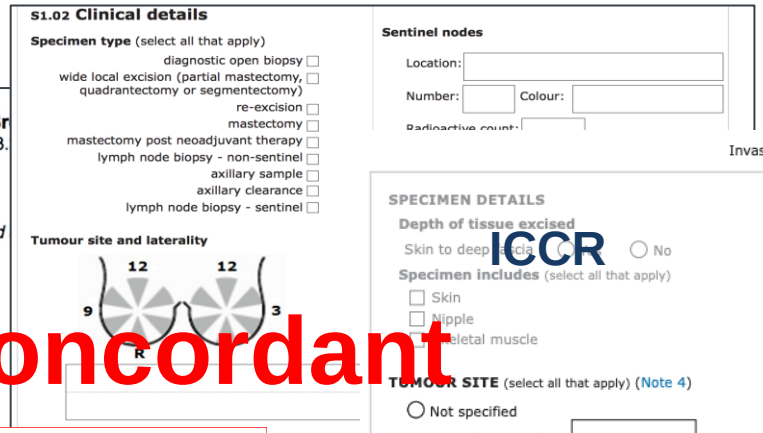
Note: The histologic type corresponds to the largest carcinoma. If there are smaller carcinomas of a different type, this information should be included under "Additional Pathologic Findings."
Inflammatory carcinoma requires the presence of clinical findings of erythema and edema involving at least one-third more of the skin of the breast (see explanation under "Pathologic Staging").
Special type carcinomas should consist of at least 90% pure pattern.

Histologic Grade (Nottingham Histologic Score) (Note F)

Glandular (Acinar)/Tubular Differentiation
___ Score 1 (>75% of tumor area forming glandular/tubular structures)
___ Score 2 (10% to 75% of tumor area forming glandular/tubular structures)

Nucle
___ S
___ S
___ S
___ C
___ N
___ S

Australasia- RCPA



S1.02 Clinical details

Specimen type (select all that apply)
diagnostic open biopsy
wide local excision (partial mastectomy, quadrantectomy or segmentectomy)
re-excision
mastectomy
mastectomy post neoadjuvant therapy
lymph node biopsy - non-sentinel
axillary sample
axillary clearance
lymph node biopsy - sentinel

Tumour site and laterality

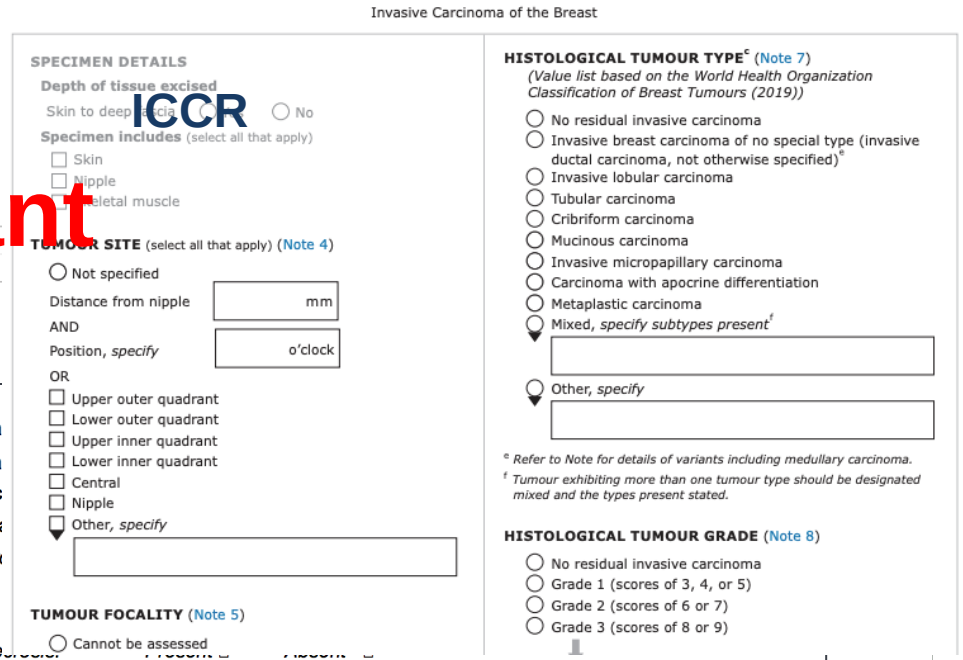
12 12 9 3 R

Sentinel nodes

Location:
Number: Colour:

Highly concordant

ICCR



Invasive Carcinoma of the Breast

SPECIMEN DETAILS

Depth of tissue excised
Skin to deep [illegible] No

Specimen includes (select all that apply)
Skin
Nipple
[illegible]eletal muscle

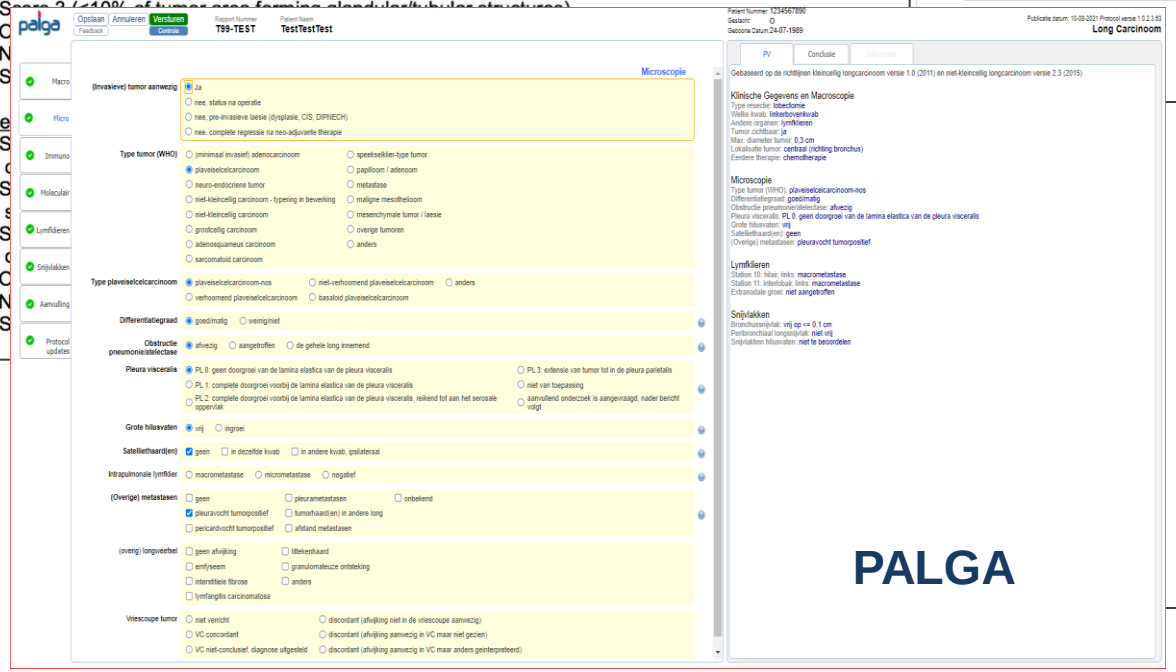
TUMOUR SITE (select all that apply) (Note 4)
Not specified
Distance from nipple mm
AND
Position, *specify* o'clock
OR
Upper outer quadrant
Lower outer quadrant
Upper inner quadrant
Lower inner quadrant
Central
Nipple
Other, *specify*

TUMOUR FOCALITY (Note 5)
Cannot be assessed

HISTOLOGICAL TUMOUR TYPE[c] (Note 7)
(Value list based on the World Health Organization Classification of Breast Tumours (2019))
No residual invasive carcinoma
Invasive breast carcinoma of no special type (invasive ductal carcinoma, not otherwise specified)[e]
Invasive lobular carcinoma
Tubular carcinoma
Cribriform carcinoma
Mucinous carcinoma
Invasive micropapillary carcinoma
Carcinoma with apocrine differentiation
Metaplastic carcinoma
Mixed, *specify subtypes present*[f]
Other, *specify*

[e] *Refer to Note for details of variants including medullary carcinoma.*
[f] *Tumour exhibiting more than one tumour type should be designated mixed and the types present stated.*

HISTOLOGICAL TUMOUR GRADE (Note 8)
No residual invasive carcinoma
Grade 1 (scores of 3, 4, or 5)
Grade 2 (scores of 6 or 7)
Grade 3 (scores of 8 or 9)



palga

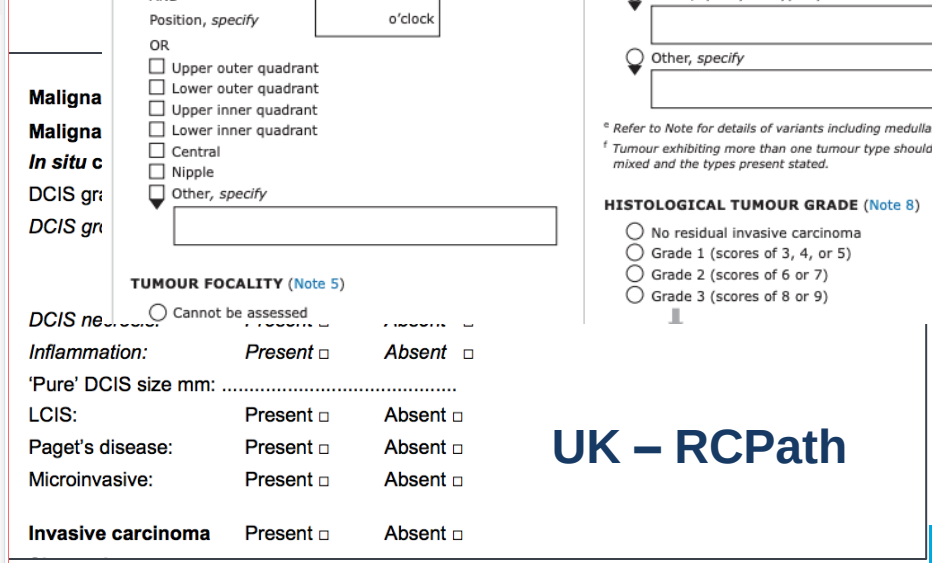
Opslaan Annuleren Versturen

Rapport Nummer TS9-TEST
Patient Naam TestTestTest

Microscopie

Long Carcinoom

PALGA



Maligna
Maligna
In situ c
DCIS gra
DCIS gr

DCIS ne[illegible]
Inflammation: *Present* ☐ *Absent* ☐
'Pure' DCIS size mm: .....
LCIS: Present ☐ Absent ☐
Paget's disease: Present ☐ Absent ☐
Microinvasive: Present ☐ Absent ☐

Invasive carcinoma Present ☐ Absent ☐

UK – RCPath

Use Case: Observables for Anatomic Pathology and Precision Medicine

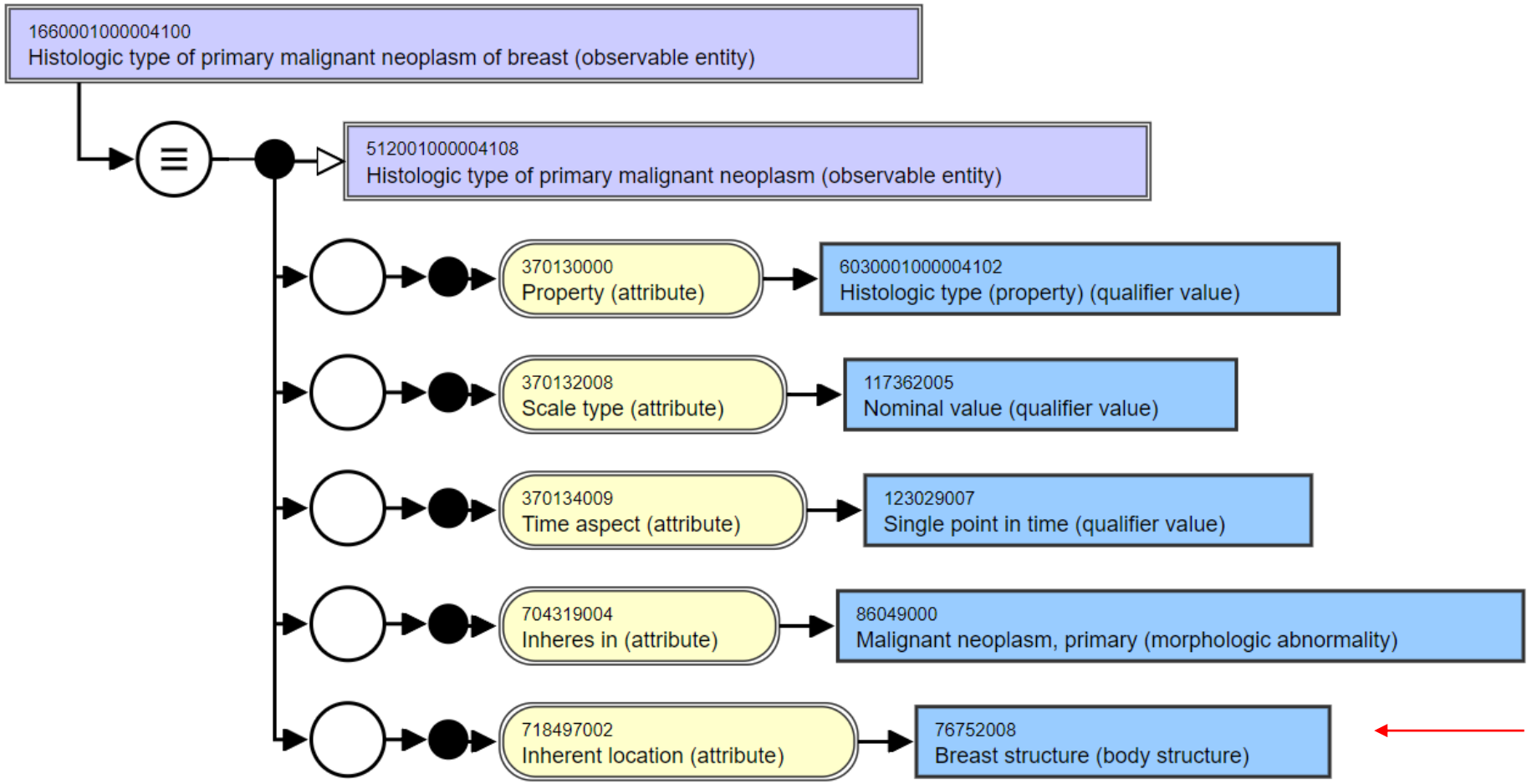
- UNMC began development of SNOMED CT content for use in pathology synoptic encoding in 2014 to align with the College of American Pathologists reporting protocols
- In 2019, at the specific request of Canada, Sweden and the UK, an official SNOMED CT project group was chartered and led by UNMC investigators.
- UNMC donated developed content to SNOMED International in 2020, and broadscale development began in earnest with collaborators from CAP (US), RCPath (UK), Sweden, the Netherlands.
- SNOMED International began to promote the pathology developments into SNOMED CT core beginning in July 2021. Content promotion is ongoing.
- Over 650 new and/or newly modeled concepts represent ~80% of adult solid tumor protocol elements are in publication.

Observable entity concepts used in pathology content

Key SNOMED CT attributes used in cancer synoptic content:

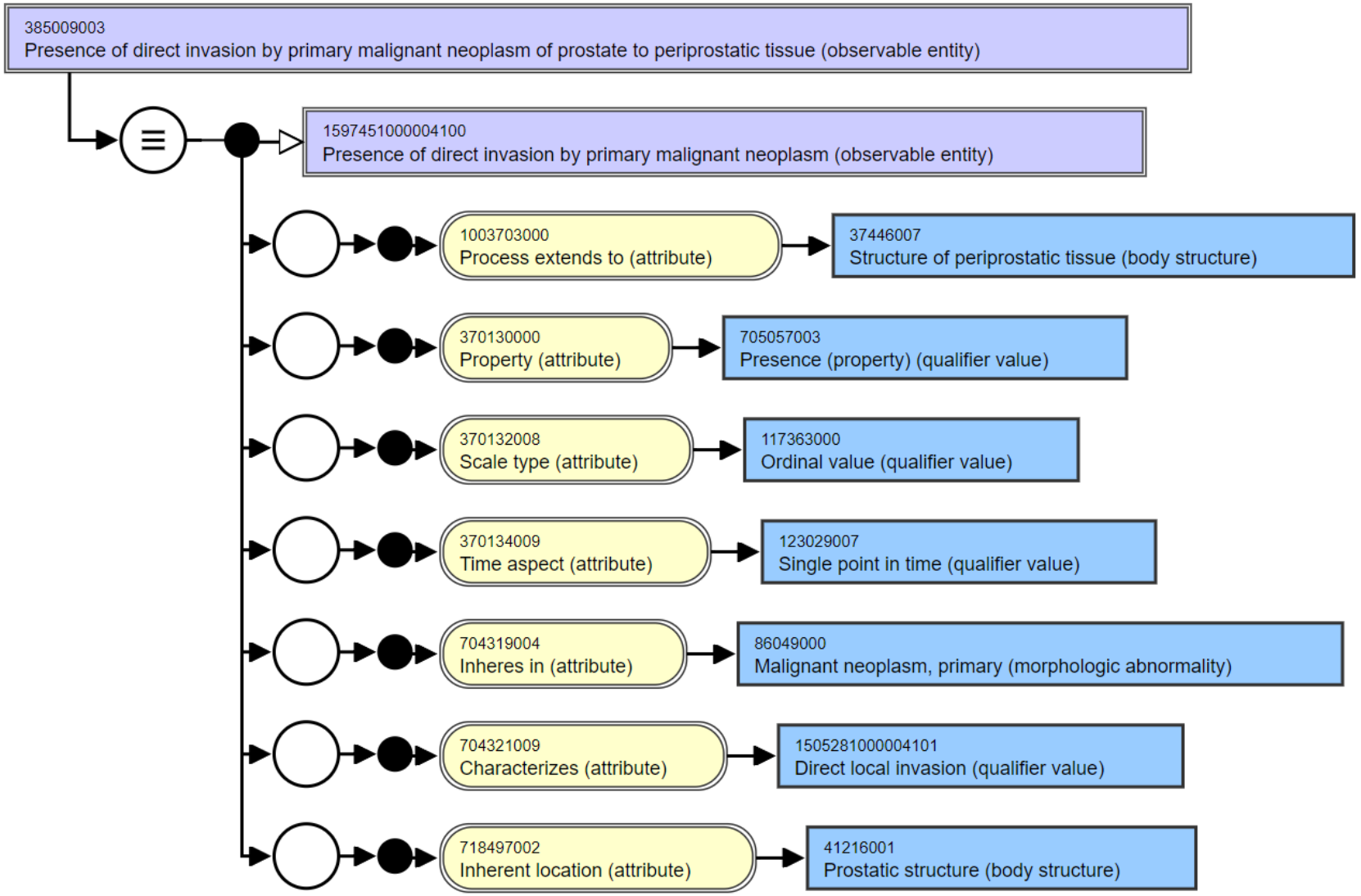
- 370130000 |Property (attribute)| - *WHAT* is being measured/assessed
  Examples: Presence, Anatomic location
- 704319004 |Inheres in (attribute)| - The “carrier” of the property
  Example: Malignant neoplasm
- 718497002 |Inherent location (attribute)| - Location of the “inheres in” carrier
  Example: Prostate, lung
- 704321009 |Characterizes (attribute)| - Process being measured
  Example: Direct local invasion
- 1003703000 |Process extends to (attribute)| - Endpoint of the process
  Example: Peritoneum
- 246093002 |Component (attribute)| - “Thing” being measured indirectly
  Example: Estrogen receptor

Example: Histologic type

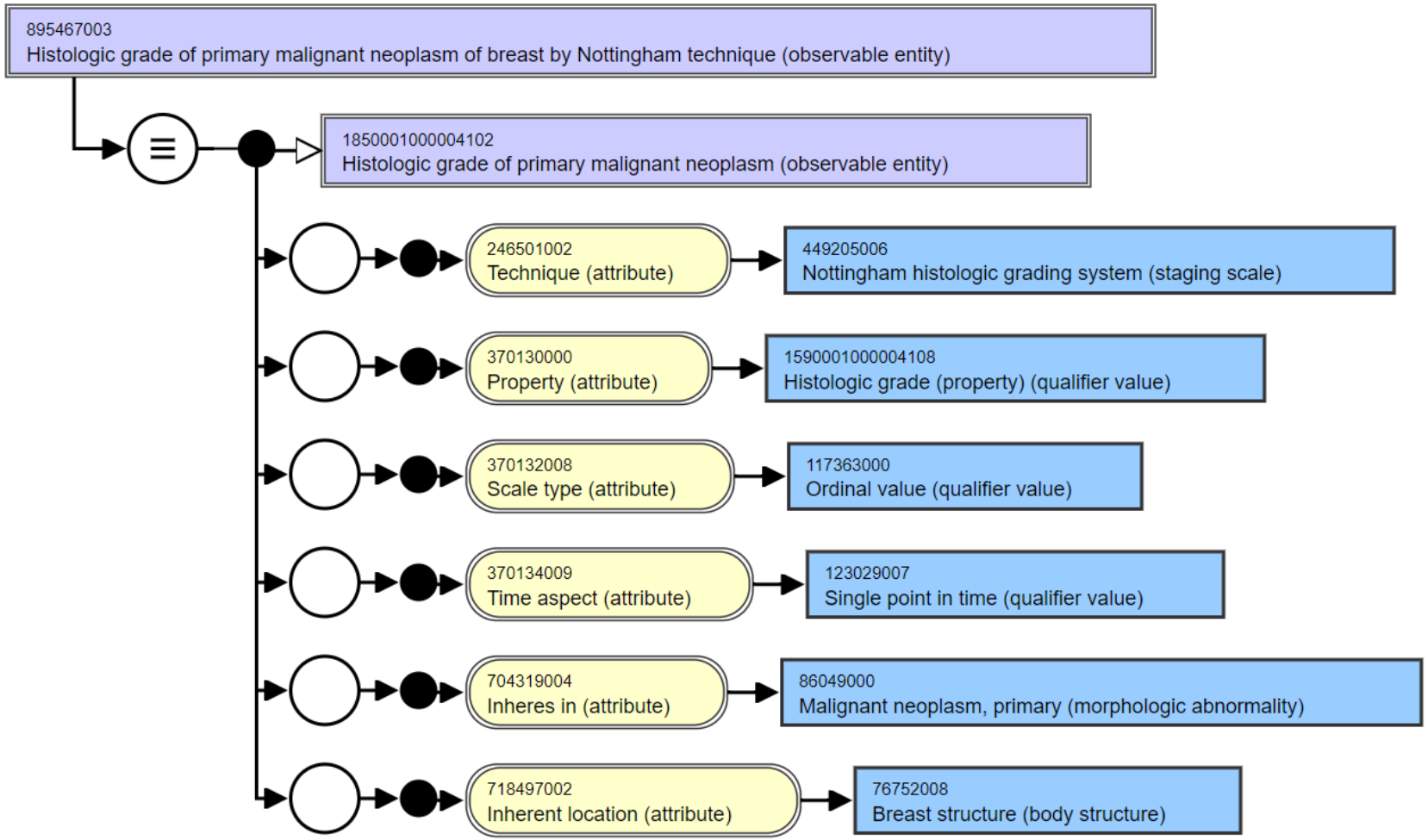


<<91723000 |Anatomical structure (body structure)|

Example: Direct local invasion



Example: Histologic grade



Technique matters

Use Cases – Histology and location

- Number of cases of primary malignancy in the digestive system
  - …Gastrointestinal system
  - …Colorectal cancer

- Example leverages the |Inherent location| attribute and the target |Anatomical structures| hierarchy

Use case – invasive cancer and grade

- Number of cases of locally invasive prostate cancer
  - …refine to exclude lymphovascular and perineural invasion
- Find grades of all prostate cancers
  - …by Technique

Take aways for Pathology Synoptic Data

- The question carries all context
- Question/Answer pairs maintain intended meaning apart from original synoptic report
- Complex queries may require common “key” for the synoptic panel
  - Must maintain link of independent data elements collected in synoptic “encounter”

SNOMED CT EXPO 2022
SEPT 29-30, 2022
Lisbon, Portugal ✕ Virtual

Re-use of EHR data for Clinical Decision Support

James Campbell

SNOMED International

Antimicrobial stewardship
“Right DRUG, right BUG, right TIME”

- LIS reports infecting organism (BUG) as SNOMED CT Organism via HL7
- Micro lab reports susceptibility of BUG to antibiotic DRUG class as part of final report; Susceptibility results report whether antibiotic class will kill organism identified in specimen
- Lab results have been textual til recently…
- Query of formulary will select all drugs of SENSITIVE classes that are available for treatment by the route selected by the clinician
- Susceptible drug list provided to clinician after removing agents identified in patient allergies/intolerance list

Antimicrobial stewardship
Culture results

MSH|||^~\&|SUNQUEST|SUNQUEST|EPIC||20160131141241219O9||ORU^R01^ORU_R01|20161230001524685|P|2.5.1|||AL|NE|||||LRI_NG_RN_Profile^^2.16.840.1.113883.9.2
ORC|RE|433304929|ZID_20160515154000|433304929^|||||||1111^RE^DACTED^N^||||^||||||^^^^|||||||||||||||||||||||||||||||
OBR|1|433304929|ZID_20160515154000|630-4^BACTERIA UR CULT^LN^URNCU^URINE CULTURE^SUNQSTEAP^^v1^URINE CULTURE|||201615155190O|||"1111^RE^D
TQ1|1|||||2016151551900|2016151551900|RT|||||||||||||||||||||||||||||||||||||||||||||||||
OBX|3|CWE|19091-8^COLONY COUNT^LN^CULT^Culture Result:^SQLRR^^v1^Culture Result:|1.1|"^^^KGT100^>100000 col/ml^L^^^>100000 col/ml"|^^^^^|||||F|||2016
OBX|4|CWE|41852-5^MICROORGANISM/AGENT XXX^112283007^Escherichia coli (organism)^SCT^ECOLI^Escherichia coli^L^^v1^Escherichia coli (organism)||||||F|||20
SPM|1|||122880004^Urine specimen obtained by clean catch procedure (specimen)^SCT^UCLN^Urine Clean Catch^L^^v1^Urine Clean Catch||||||||||||201615155190O|201
OBR|2|433304929|Z123_20160515154000|50545-3^BACTERIAL SUSC PNL ISLT MIC^LN^MIC^MIC^SUNQSTEAP^^1^METHOD|||201615155190O|||"1111^RE^DACTED^^^
OBX|1|SN|12-5^AMIKACIN SUSC ISLT^LN^AK^Amikacin^SQLRR^^v1^Amikacin|1.1|<=^8|^^^^^||SS|||F|||201615155190O|||50545-3^BACTERIAL SUSC PNL ISLT MIC^LN
OBX|2|SN|28-1^AMPICILLIN SUSC ISLT^LN^AM^Ampicillin^SQLRR^^v1^Ampicillin|1.1|<=^4|^^^^^||SS|||F|||201615155190O|||50545-3^BACTERIAL SUSC PNL ISLT MIC
OBX|3|SN|32-3^AMPICILLIN+SULBAC SUSC ISLT^LN^AS^Amp-Sulbactam^SQLRR^^v1^Amp-Sulbactam|1.1|<=^4^/^2|^^^^^||SS|||F|||201615155190O|||50545-3^BACTE
OBX|4|SN|44-8^AZTREONAM SUSC ISLT^LN^AZT^Aztreonam^SQLRR^^v1^Aztreonam|1.1|<=^4|^^^^^||SS|||F|||201615155190O|||50545-3^BACTERIAL SUSC PNL ISLT
OBX|5|SN|76-0^CEFAZOLIN SUSC ISLT^LN^CFZ^Cefazolin^SQLRR^^v1^Cefazolin|1.1|<=^4|^^^^^||SS|||F|||201615155190O|||50545-3^BACTERIAL SUSC PNL ISLT MIC^
OBX|6|SN|31142-3^CEFEPIME ISLT MIC^LN^CEP^Cefepime^SQLRR^^v1^Cefepime|1.1|<=^1|^^^^^||SS|||F|||201615155190O|||50545-3^BACTERIAL SUSC PNL ISLT MIC
OBX|7|SN|133-9^CEFTAZIDIME ISLT MIC^LN^CAZ^Ceftazidime^SQLRR^^v1^Ceftazidime|1.1|<=^1|^^^^^||SS|||F|||201615155190O|||50545-3^BACTERIAL SUSC PNL ISL
OBX|8|SN|141-2^Ceftriaxone Islt MIC^LN^CTX^Ceftriaxone^SQLRR^^v1^Ceftriaxone|1.1|<=^1|^^^^^||SS|||F|||201615155190O|||50545-3^BACTERIAL SUSC PNL ISLT MI
OBX|9|SN|145-3^CEFUROXIME SUSC ISLT^LN^CRM^Cefuroxime^SQLRR^^v1^Cefuroxime|1.1|<=^4|^^^^^||SS|||F|||201615155190O|||50545-3^BACTERIAL SUSC PNL IS
OBX|10|SN|185-9^Ciprofloxacin Islt MIC^LN^CP^Ciprofloxacin^SQLRR^^v1^Ciprofloxacin|1.1|<=^0.5|^^^^^||SS|||F||HIDE|201615155190O|||50545-3^BACTERIAL SUSC
OBX|11|SN|267-5^GENTAMICIN ISLT MIC^LN^GM^Gentamicin^SQLRR^^v1^Gentamicin|1.1|<=^2|^^^^^||SS|||F|||201615155190O|||50545-3^BACTERIAL SUSC PNL ISLT
OBX|12|SN|20396-8^LEVOFLOXACIN SUSC ISLT^LN^LVX^Levofloxacin^SQLRR^^v1^Levofloxacin|1.1|<=^1|^^^^^||SS|||F|||201615155190O|||50545-3^BACTERIAL SUS
OBX|13|SN|6652-2^MEROPENEM ISLT MIC^LN^MERZ^Meropenem^SQLRR^^v1^Meropenem|1.1|<=^1|^^^^^||SS|||F|||201615155190O|||50545-3^BACTERIAL SUSC PNL
OBX|14|SN|412-7^PIP+TAZO ISLT MIC^LN^PTZ^Pip/Tazo^SQLRR^^v1^Pip/Tazo|1.1|<=^16|^^^^^||SS|||F|||201615155190O|||50545-3^BACTERIAL SUSC PNL ISLT MIC^L
OBX|15|SN|18996-9^TOBRAMYCIN SUSC ISLT^LN^TO^Tobramycin^SQLRR^^v1^Tobramycin|1.1|<=^2|^^^^^||SS|||F|||201615155190O|||50545-3^BACTERIAL SUSC PNL
OBX|16|SN|516-5^TMP SMX ISLT MIC^LN^SXT^Trimethoprim-Sulfa^SQLRR^^v1^Trimethoprim-Sulfa|1.1|<=^2^/^38|^^^^^||SS|||F|||201615155190O|||50545-3^BACTERIA
OBX|17|SN|35801-0^ERTAPENEM ISLT MIC^LN^ERT^Ertapenem^SQLRR^^v1^Ertapenem|1.1|<=^0.5|^^^^^||SS|||F|||201615155190O|||50545-3^BACTERIAL SUSC PNL IS
OBX|18|SN|18993-6^TETRACYCLINE SUSC ISLT^LN^TE^Tetracycline^SQLRR^^v1^Tetracycline|1.1|<=^2|^^^^^||SS|||F||HIDE|201615155190O|||50545-3^BACTERIAL SU
SPM|1|||122880004^Urine specimen obtained by clean catch procedure (specimen)^SCT^UCLN^Urine Clean Catch^L^^v1^Urine Clean Catch||||||||||||201615155190O|201

Antimicrobial stewardship
BUG identification

Parents

- Microbiology laboratory observable (observable entity)

Microorganism identified in Unspecified specimen (LOINC:41852-5)

SCTID: 1372161000004101

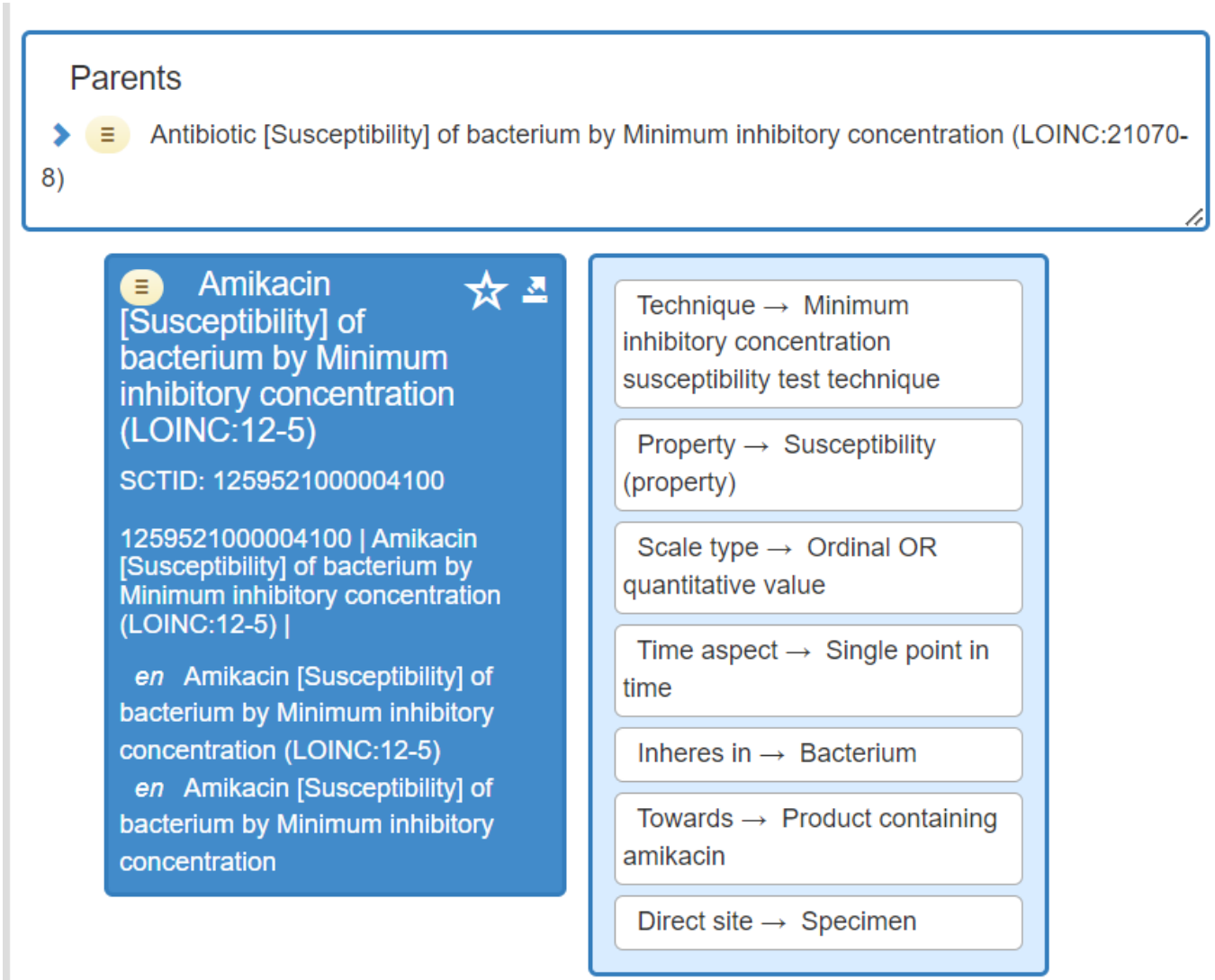
1372161000004101 | Microorganism identified in Unspecified specimen (LOINC:41852-5) |

en Microorganism identified in Unspecified specimen (LOINC:41852-5)

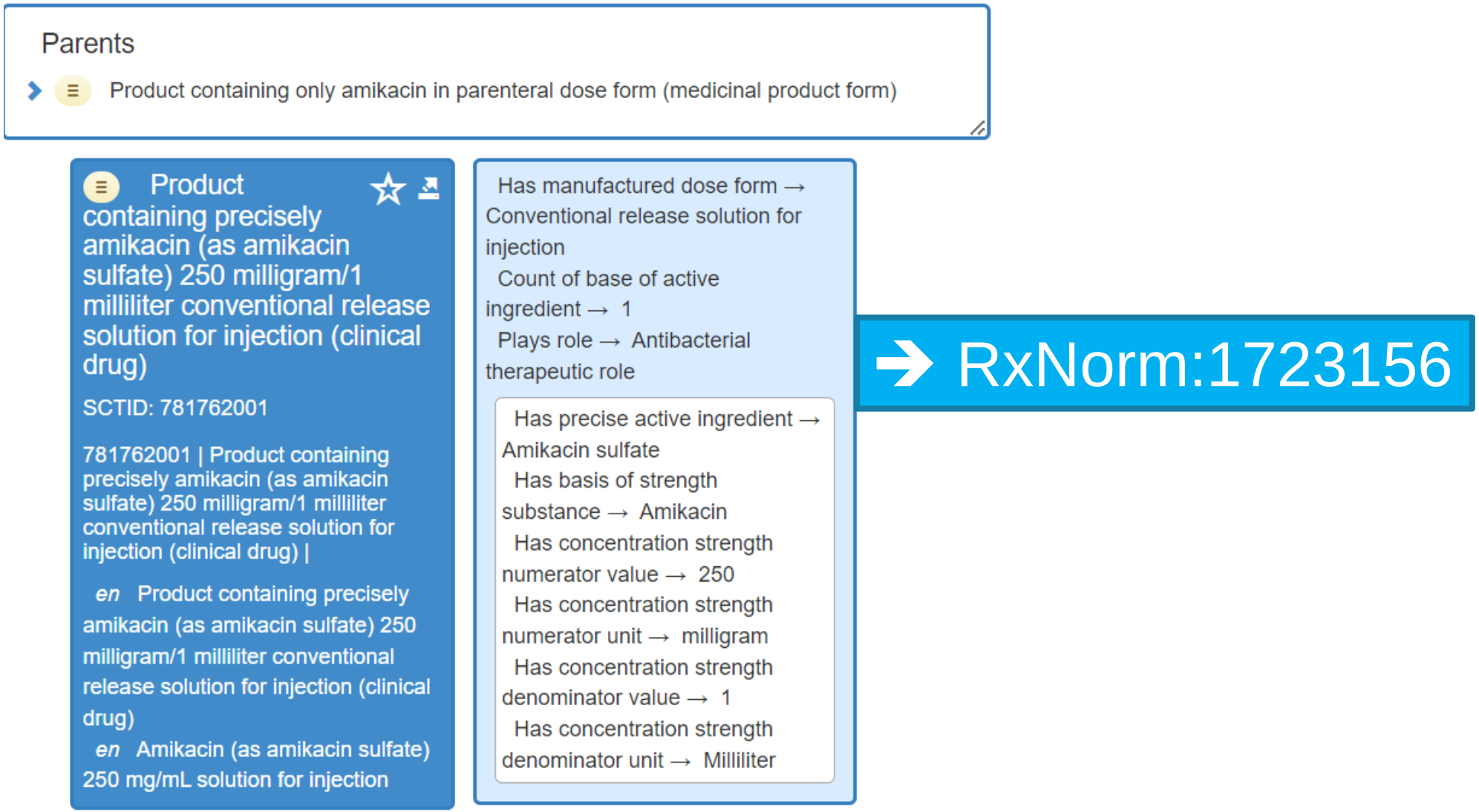
en Microorganism identified in Unspecified specimen

- Property → Presence OR identity (property)
- Scale type → Nominal value
- Time aspect → Single point in time
- Inheres in → Bacterium

Antimicrobial stewardship
Sensitive DRUG class identification



Antimicrobial stewardship
Identify available formulary DRUGs for treatment



➔ RxNorm:1723156

Antimicrobial stewardship
Epic® List of allergies/intolerances

ALLERGEN	ALLERGEN_TEXT	REACTION CODE	REACTION_DESCRIPTION
RxNorm:282388	IMATINIB	SNOMEDCT:62315008	Diarrhea adverse reaction to IMATINIB
RxNorm:26225	ONDANSETRON	SNOMEDCT:418290006	Itching adverse reaction to ONDANSETRON
RxNorm:26225	ONDANSETRON	SNOMEDCT:247472004	Hives adverse reaction to ONDANSETRON
RxNorm:282388	IMATINIB	SNOMEDCT:16932000	Nausea And Vomiting adverse reaction to IMATINIB
RxNorm:142442	NAPROXEN SODIUM	SNOMEDCT:95891005	Influenza-like illness adverse reaction to NAPROX...
RxNorm:7258	NAPROXEN SODIUM	SNOMEDCT:95891005	Influenza-like illness adverse reaction to NAPROX...
RxNorm:8588	POTASSIUM	SNOMEDCT:422400008	Vomiting adverse reaction to POTASSIUM
RxNorm:42316	TACROLIMUS	SNOMEDCT:386661006	Fever adverse reaction to TACROLIMUS
RxNorm:20481	CEFEPIME	SNOMEDCT:271807003	Rash adverse reaction to CEFEPIME
RxNorm:732	AMPHOTERICIN B	SNOMEDCT:386661006	Fever adverse reaction to AMPHOTERICIN B
RxNorm:42316	TACROLIMUS	SNOMEDCT:247472004	Hives adverse reaction to TACROLIMUS
RxNorm:19831	BUDESONIDE	SNOMEDCT:62315008	Diarrhea adverse reaction to BUDESONIDE
RxNorm:5690	IMIPENEM	SNOMEDCT:247472004	Hives adverse reaction to IMIPENEM
RxNorm:7052	MORPHINE	SNOMEDCT:37796009	Migraine adverse reaction to MORPHINE
RxNorm:10180	SULFAMETHOXAZ...	SNOMEDCT:51599000	Edema of larynx adverse reaction to SULFAMETH...
RxNorm:82122	LEVOFLOXACIN	SNOMEDCT:247472004	Hives adverse reaction to LEVOFLOXACIN

Antimicrobial stewardship

Screen for “Allergy” to substances in medicinal product

- Medication allergy data in the EHR is confusing in definition, presentation and EHR data context
- However, all certified US EHR vendors maintain “adverse reaction list to foods, meds and chemicals” in an “Allergy and Intolerance list”; coding of medications in this list is RxNorm Ingredients or Clinical drugs
- NLM supports OWL expression database which can be converted into a SNOMED CT extension defining RxNorm ingredients as substances and RxNorm clinical drugs as medicinal products
- Nebraska is creating medication module as part of SNOMED CT extension to introduce NLM axioms linking RxNorm ingredients to substances and clinical drugs as fully defined medicinal products

- Allergy Implementation guide v20220916.pdf

Questions