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Ontology Evaluation Across the Ontology Lifecycle

Quality assurance of biomedical ontologies (and derived artifacts) in the era of Meaningful Use



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OUTLINE

- Meaningful Use
- Standard vocabularies in Meaningful Use
- Value sets for clinical quality measures
- Quality assurance of biomedical terminologies
- Quality assurance of value sets



MEANINGFUL USE



“Meaningful Use”

- ◆ Health Information Technology for Economic and Clinical Health (HITECH) Act
 - Eligible health care professionals and hospitals can qualify for Medicare and Medicaid incentive payments when they adopt certified EHR technology and use it to achieve specified objectives
- ◆ Two sets of regulations
 - *Incentive Program for Electronic Health Records Medicare and Medicaid Services (CMS)*
 - *Standards and Certification Criteria for Electronic Health Records*
Office of the National Coordinator (ONC)



Meaningful Use stages

Stage 1 2011-2012 Data capture and sharing	Stage 2 2014 Advance clinical processes	Stage 3 2016 Improved outcomes
Stage 1: Meaningful use criteria focus on:	Stage 2: Meaningful use criteria focus on:	Stage 3: Meaningful use criteria focus on:
Electronically capturing health information in a standardized format	More rigorous health information exchange (HIE)	Improving quality, safety, and efficiency, leading to improved health outcomes
Using that information to track key clinical conditions	Increased requirements for e-prescribing and incorporating lab results	Decision support for national high-priority conditions
Communicating that information for care coordination processes	Electronic transmission of patient care summaries across multiple settings	Patient access to self-management tools
Initiating the reporting of clinical quality measures and public health information	More patient-controlled data	Access to comprehensive patient data through patient-centered HIE
Using information to engage patients and their families in their care		Improving population health



Fact Sheets

Details for: CMS MEDICARE AND MEDICAID EHR INCENTIVE PROGRAMS: STAGE 2 FINAL RULE

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For Immediate Release: Thursday, August 23, 2012

Contact: [CMS Office of Public Affairs](#)
202-690-6145

CMS MEDICARE AND MEDICAID EHR INCENTIVE PROGRAMS: STAGE 2 FINAL RULE

On August 23, 2012, the Centers for Medicare & Medicaid Services (CMS) announced a final rule to govern Stage 2 of the Medicare and Medicaid Electronic Health Record (EHR) Incentive Programs. The rule specifies the Stage 2 criteria that eligible professionals (EPs), eligible hospitals, and critical access hospitals (CAHs) must meet in order to continue to participate in the EHR Incentive Programs.

Rule Provisions

Through the Stage 2 requirements of the Medicare and Medicaid EHR Incentive Programs, CMS seeks to expand the meaningful use of certified EHR technology. Certified EHR technology used in a meaningful way is one piece of a broader health information technology infrastructure needed to reform the health care system and improve health care quality, efficiency, and patient safety. Highlights of the rule's provisions follow.

Stage 2 Timing

In the Stage 1 meaningful use regulations, CMS established an original timeline that would have required Medicare providers who first demonstrated meaningful use in 2011 to meet the Stage 2 criteria in 2013. The Stage 2 rule gives providers more time to meet Stage 2 criteria. A provider that attested to Stage 1 of meaningful use in 2011 would attest to Stage 2 in 2014, instead of in 2013. Therefore, providers are not required to meet Stage 2 meaningful use before 2014.

The table below illustrates the progression of meaningful use stages from the first year a Medicare provider begins participation in the program.



Clinical Quality Measures (CQMs)

Measure Sets and Reporting

The rule finalized that:

- EPs must report on 9 out of 64 total clinical quality measures (CQMs)
- Eligible hospitals and CAHs must report on 16 out of 29 total CQMs

In addition, all providers must select CQMs from at least 3 of the 6 key health care policy domains from the Department of Health and Human Services' National Quality Strategy:

- Patient and Family Engagement
- Patient Safety
- Care Coordination
- Population and Public Health
- Efficient Use of Healthcare Resources
- Clinical Processes/Effectiveness



ONC Fact Sheet: 2014 Edition Standards & Certification Criteria (S&CC) Final Rule

Summary

The 2014 Edition S&CC final rule completes the Office of the National Coordinator for Health IT's (ONC) second full rulemaking cycle to adopt standards, implementation specifications, and certification criteria for EHR technology. This final rule complements the newly released Centers for Medicare & Medicaid Services (CMS) final rule which establishes Stage 2 of the Medicare and Medicaid Electronic Health Record (EHR) Incentive Programs, updates Stage 1, and includes other program modifications.

The 2014 Edition S&CC final rule reflects ONC's commitment to reduce regulatory burden; promote patient safety and patient engagement; enhance EHR technology's interoperability, electronic health information exchange capacity, public health reporting, and security; enable clinical quality measure data capture, calculation, and electronic submission to CMS or States; and introduce greater transparency and efficiency to the certification process.



NLM'S LONG RANGE PLAN 2006-16

Goal 3. Integrated Biomedical, Clinical, and Public Health Information Systems that Promote Scientific Discovery and Speed the Translation of Research into Practice

Continue/enhance standards work in response to U.S. government priorities and feedback from “real” use in electronic health records

- e.g., Unified Medical Language System (UMLS), key clinical terminologies (SNOMED CT, LOINC, RxNorm)

STANDARD VOCABULARIES

**(Biomedical terminologies
and ontologies)**



London Bills of Mortality

LONDON'S Dreadful Visitation:
Or, A COLLECTION of All the
Bills of Mortality
For this Present Year:
Beginning the 27th of December 1664. and
ending the 19th of December following:
As also, The GENERAL or whole years BILL:
According to the Report made to the
KING'S Most Excellent Majesty,
By the Company of Parish-Clerks of London. &c.

LONDON:
Printed and are to be sold by E. Cotes living in Aldersgate-street.
Printer to the said Company 1665.

A generall Bill for this present year,
ending the 19 of December 1665. according to
the Report made to the KING'S most Excellent Majesty.
By the Company of Parish Clerks of London, &c.

The Diseases and Casualties this year.

A Bortive and Stillborne	617	Executed	21	Palfie	30
Aged	1545	Flux and Small Pox	655	Plague	68596
Aque and Peaver	5257	Found dead in Streets, fields, &c.	2	Plaster	6
Appoplex and Suddenly	116	French Pox	86	Plurisie	19
Bedric	10	Frighted	23	Pox Solida	2
Bedrid	9	Gout and Sciatica	27	Quintic	35
Bleeding	16	Grief	26	Rickets	117
Bloody Flux, Scouring & Flux	187	Gripping in the Guts	1238	Killing of the Lights	197
Burnt and Scalded	8	Hang'd & made away themselves	7	ll. pinte	34
Colicere	2	Head mouldshot & Meale fallen	14	Scurvy	109
Cancer, Gangrene and Fiftula	56	jaundies	100	Shingles and Swine pox	2
Canker, and Thrush	720	Imposume	227	Sores, Ulcers, broken and heilled	2
Childbed	625	Kild by severall accidents	46	Limbs	22
Christomes and Infants	1258	Kings Evill	88	Spleen	14
Cold and Cough	65	Leptotic	2	Spotted Fever and Purples	1929
Collick and Winde	134	Lethargy	14	Stopping of the stomack	324
Consumption and Tiflick	4808	Livergown	21	Stops and Stranguy	38
Convulsion and Morice	1052	Meazrom and Headach	12	Sudor	122
Distraited	7	Measles	7	Teeth and Worms	1014
Drownd and Tempany	1476	Mothered and Shot	9	Vomiting	54
Drownd	3	Overjard & Starved	455	Verru	7
		Cholick	5114		
		Cholick of Females	4855	Buried	
		In all	9567	Males	48569
				Females	48717
				In all	97286
				Of the Plague	68596

Increased in the Burials in the 130 Parishes and at the Pest-houses this year. ————— 79009
Increased of the Plague in the 130 Parishes and at the Pest-houses this year. ————— 68596

Many biomedical terminologies

- Diagnoses / Diseases / Conditions
 - ▶ International classification of diseases (ICD)
 - ▶ SNOMED CT
- Procedures
 - ▶ Current Procedural terminology (CPT)
 - ▶ ICD10-PCS
 - ▶ SNOMED CT
- Drugs
 - ▶ RxNorm
- Laboratory tests
 - ▶ LOINC

Standard vocabularies for Meaningful Use

- Diagnoses / Diseases / Conditions
 - ▶ International classification of diseases (ICD)
 - ▶ SNOMED CT
- Procedures
 - ▶ Current Procedural terminology (CPT)
 - ▶ ICD10-PCS
 - ▶ SNOMED CT
- Drugs
 - ▶ RxNorm
- Laboratory tests
 - ▶ LOINC

SNOMED Clinical Terms



SNOMED CT Characteristics (1)

- ◆ Current version: January 31, 2013 (2 annual releases)
- ◆ Type: Reference terminology / ontology
- ◆ Domain: Clinical medicine
- ◆ Developer: IHTSDO
- ◆ Funding: IHTSDO
- ◆ Availability
 - Publicly available: Yes* (in member countries)
 - Repositories: UMLS
- ◆ URL: <http://www.ihtsdo.org/>



SNOMED CT Characteristics (2)

- ◆ Number of
 - Concepts: ~300,000 active concepts (Jan. 31, 2013)
 - Terms: ~1.1M active “descriptions”
- ◆ Major organizing principles:
 - Utility for clinical medicine (e.g., assertional + definitional knowledge)
 - Model of meaning (incomplete)
 - Rich set of associative relationships
 - Small proportion of defined concepts (many primitives)
- ◆ Formalism: Description logics (EL++)

SNOMED CT Top level

Hierarchy	Subtype hierarchy
↳	138875005 SNOMED CT Concept
+ C	362981000 qualifier value
+ C	106237007 linkage concept
+ C	370115009 special concept
+ C	48176007 social context
+ C	419891008 record artifact
+ C	363787002 observable entity
+ C	308916002 environment or geographical location
+ C	123038009 specimen
+ C	254291000 staging and scales
+ C	123037004 body structure
+ C	272379006 event
+ C	78621006 physical force
+ C	404684003 clinical finding
+ C	260787004 physical object
+ C	410607006 organism
+ C	71388002 procedure
+ C	373873005 pharmaceutical / biologic product
+ C	243796009 situation with explicit context
+ C	105590001 substance

SNOMED CT Example

Hierarchy Subtype hierarchy

27010001	partial excision of large intestine
8613002	operation on appendix
80146002	appendectomy
82730006	incidental appendectomy
49438003	appendectomy with drainage
174036004	emergency appendectomy
174045003	interval appendectomy
6025007	laparoscopic appendectomy
235313004	non-emergency appendectomy
235314005	inversion appendectomy
1299000	excision of appendiceal stump

Definition: Fully defined by ...

- is a
 - partial excision of large intestine
 - operation on appendix
- Group
 - method
 - excision - action
 - procedure site - Direct
 - appendix structure
- Qualifiers
 - access
 - surgical access values
 - priority
 - priorities

appendectomy - Definition

Concept Status: **Current**

Descriptions

- appendectomy (procedure)
- appendectomy
- excision of appendix
- appendicectomy

Codes

- Original SnomedId : P1-57450
- Read Code (Ctv3Id) : X20Wz



RxNorm

RxNorm Characteristics (1)

- ◆ Current version: April 1, 2012 (monthly releases)
- ◆ Type: Controlled terminology
- ◆ Domain: Drug names
- ◆ Developer: NLM
- ◆ Funding: NLM
- ◆ Availability
 - Publicly available: Yes*
 - Repositories: UMLS
- ◆ URL: <http://www.nlm.nih.gov/research/umls/rxnorm/>



RxNorm Characteristics (2)

- ◆ Number of
 - Concepts: 213,500 drug entities (April 2013)
 - Terms: ~1.3 term per concept
- ◆ Major organizing principles:
 - Generic vs. brand
 - Combinations of Ingredient / Form / Dose
 - No hierarchical structure
 - Links to all major US drug information sources
 - No clinical information
- ◆ Formalism: UMLS RRF format

RxNorm Normalized form

Strength

4mg/ml

Ingredient

Fluoxetine

Dose form

Oral Solution

Strength

Semantic clinical drug component

Ingredient

Ingredient

Semantic clinical drug form

Dose form

Strength

Semantic clinical drug

Ingredient

Dose form



Rx Norm Generic vs. Brand

◆ Generic

- Ingredient (IN)

- Clinical drug form (SCDF)

- Clinical drug component (SCDC)

- Clinical drug (SCD)

◆ Brand

- Brand name (BN)

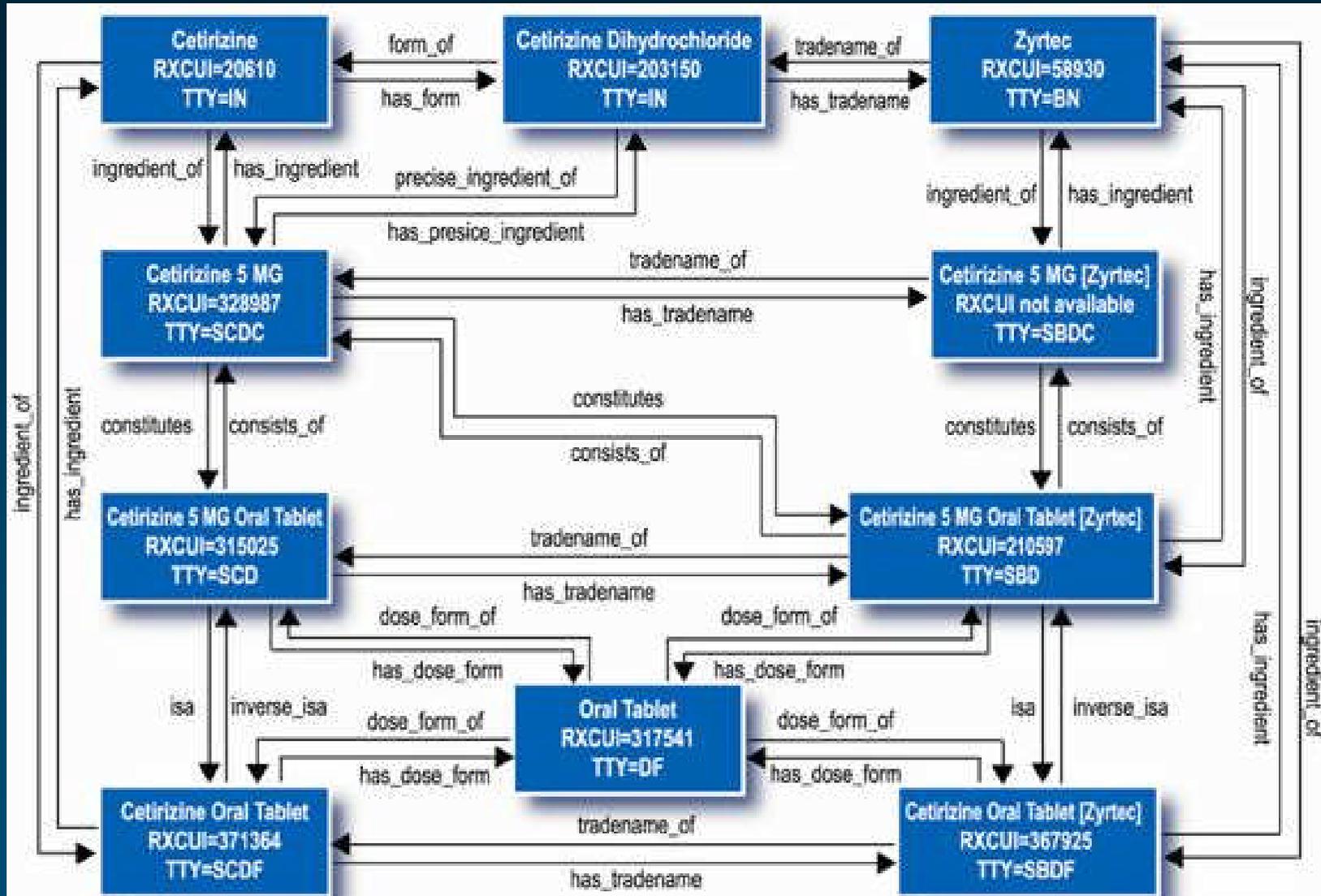
- Branded drug form (SBDF)

- Branded drug component (SBDC)

- Branded drug (SBD)

tradename_of

RxNorm Relations among drug entities



Logical Observation Identifiers, Names and Codes (LOINC)



LOINC Characteristics (1)

- ◆ Current version: 2.42 (Dec. 2012)
- ◆ Type: Controlled terminology*
- ◆ Domain: Laboratory and clinical observations
- ◆ Developer: Regenstrief Institute
- ◆ Funding: NLM
- ◆ Availability
 - Publicly available: Yes
 - Repositories: UMLS
- ◆ URL: www.regenstrief.org/loinc/loinc.htm



LOINC Characteristics (2)

- ◆ Number of
 - Concepts: ~70k active codes (2.42)
(2 annual releases)
 - Terms: n/a*
- ◆ Major organizing principles:
 - No hierarchical structure among the main codes
 - 6 axes
 - Component (analyte [+ challenge] [+ adjustments])
 - Property
 - Timing
 - System
 - Scale
 - [Method]
- ◆ Formalism: “DL-like”



LOINC Example

- ◆ *Sodium:SCnc:-Pt:Ser/Plas:Qn*
[the molar concentration of sodium is measured in the plasma (or serum), with quantitative result]

Axis	Value
Component	Sodium
Property	SCnc – Substance Concentration (per volume)
Timing	Pt – Point in time (Random)
System	Ser/Plas – Serum or Plasma
Scale	Qn – Quantitative
Method	--

QUALITY ASSURANCE OF STANDARD VOCABULARIES



Analytical framework for QA research

- ◆ Special issue of JBI on “Auditing terminologies”
- ◆ Zhu et al. JBI 2009 review article
- ◆ Analytical framework
 - What is analyzed
 - Which source of knowledge
 - Which method

Zhu, X., J.W. Fan, D.M. Baorto, C. Weng, and J.J. Cimino, *A review of auditing methods applied to the content of controlled biomedical terminologies. J Biomed Inform, 2009. 42(3): p. 413-25.*

What is analyzed

- ◆ Term/concept
 - Coverage (missing terms/concepts)
 - Wrong synonymy relation
 - Redundant concepts
- ◆ Relation
 - Missing relations
 - Inaccurate relations
- ◆ Categorization
 - Wrong categorization

Which source of knowledge

- ◆ Intrinsic – the terminology itself
 - Terms/Concepts
 - Relations
 - Categorization
- ◆ Extrinsic – external resources
 - Corpus
 - Text corpus – identify terms in text
 - Annotation corpus – identify relations from co-occurring terms
 - Mapping

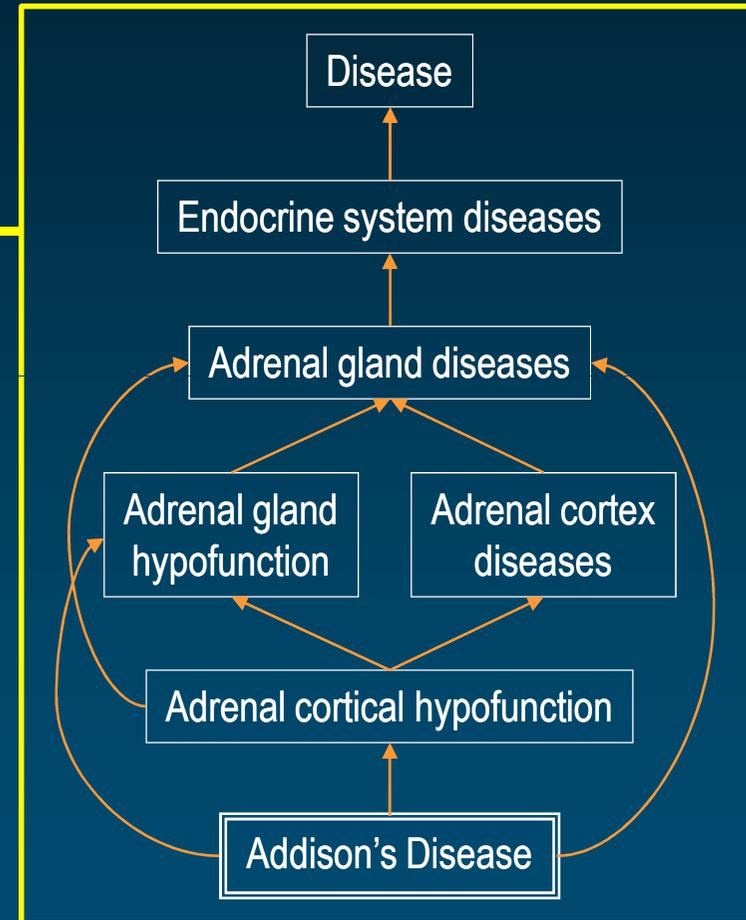
Which method Main categories

- ◆ Lexical
 - Properties of the term
- ◆ Structural
 - Properties of the organizational structure (relations)
- ◆ Semantic
 - Semantic properties of the concept (semantic type)
- ◆ Statistical
 - Associations among entities

	Ischemic enteritis
Acute	Ischemic enteritis
Chronic	Ischemic enteritis
Modifier	Head

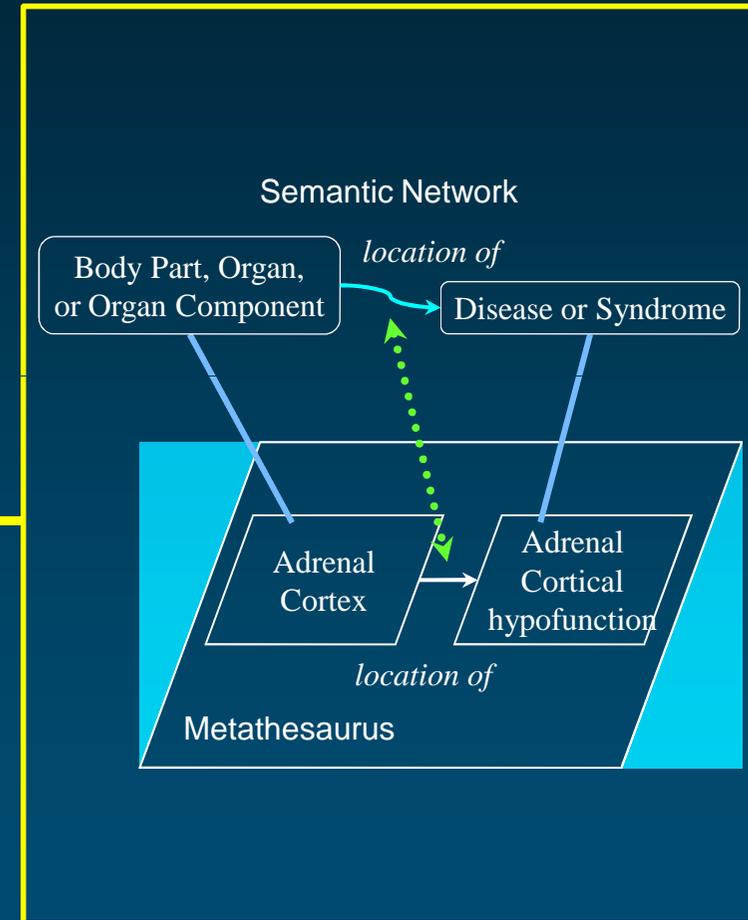
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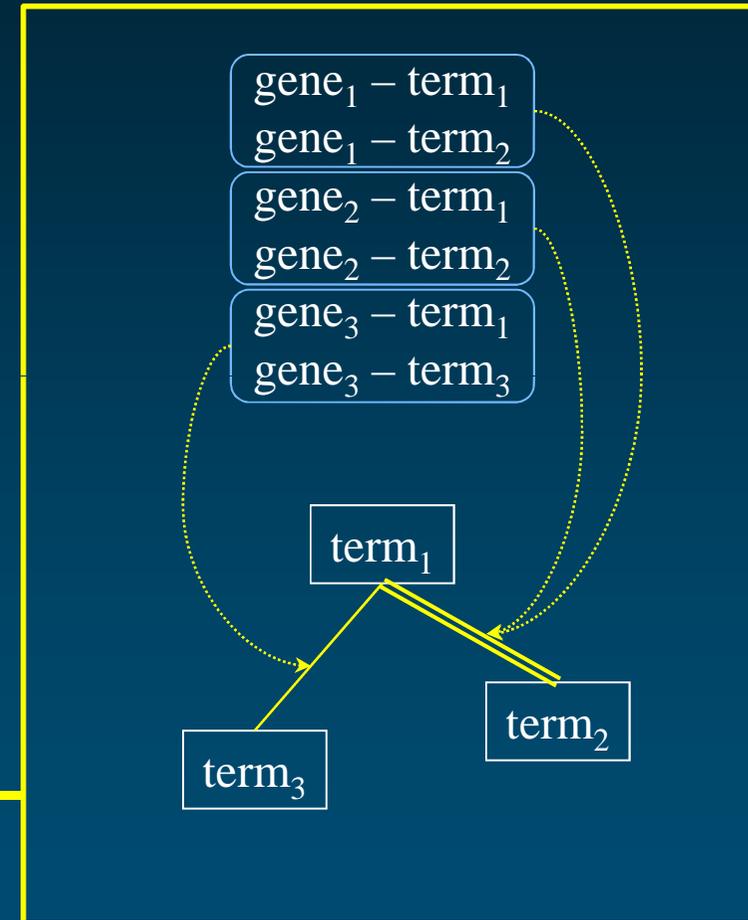
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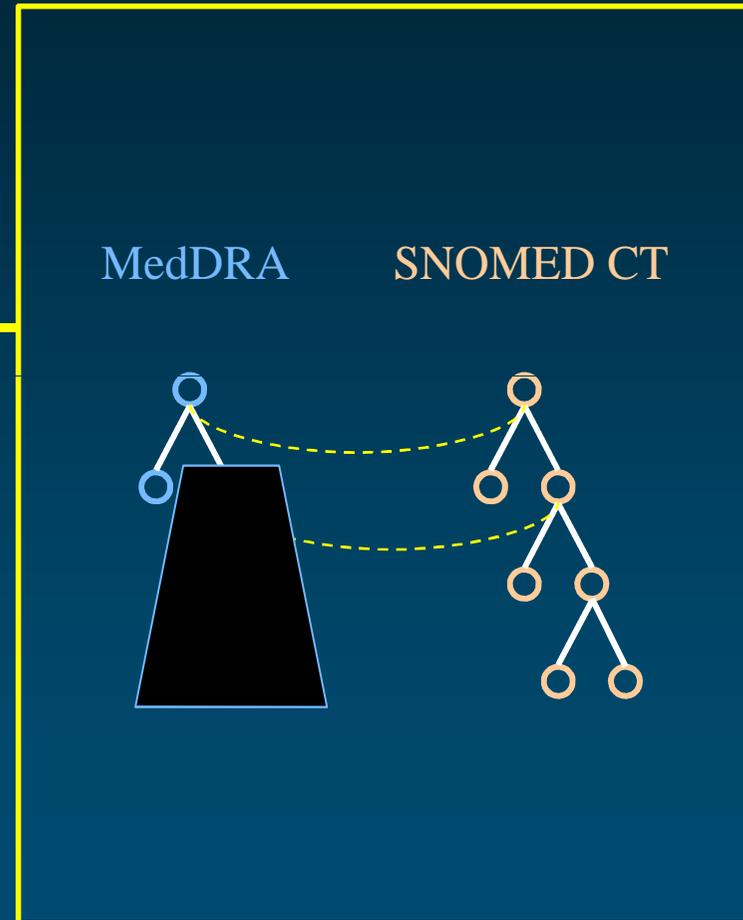
Which method Additional methods

- ◆ Compliance with ontological principles
 - Operational definitions
- ◆ Comparative
 - Comparisons between ontologies (mapping)
- ◆ Transformative
 - Representation formalism
- ◆ Use in an application

“Each concept, except for the root, must have (at least) one parent concept”

Which method Additional methods

- ◆ Compliance with ontological principles
 - Operational definitions
- ◆ Comparative
 - Comparisons between ontologies (mapping)
- ◆ Transformative
 - Representation formalism
- ◆ Use in an application



Which method Additional methods

```
Heart in OWL DL
<owl:Class rdf:ID="Heart">
  <owl:equivalentClass>
    <owl:Class>
      <owl:intersectionOf rdf:parseType="Collection">
        <owl:Class rdf:about=
          "#Organ_with_cavitated_organ_parts"/>
        <owl:Restriction>
          <owl:onProperty
            rdf:resource="#constitutional_part" />
          <owl:someValuesFrom
            rdf:resource="#Wall_of_heart" />
        </owl:Restriction>
        ...
      </owl:intersectionOf>
    </owl:Class>
  </owl:equivalentClass>
  <rdfs:subClassOf>
    <owl:Restriction>
      <owl:onProperty rdf:resource="#bounded_by"/>
      <owl:someValuesFrom
        rdf:resource="#Surface_of_heart"/>
    </owl:Restriction>
  </rdfs:subClassOf>
  <rdfs:subClassOf>
    <owl:Restriction>
      <owl:onProperty rdf:resource="#arterial_supply"/>
      <owl:someValuesFrom
        rdf:resource="#Right_coronary_artery" />
    </owl:Restriction>
  ...
</owl:Class>
```

logical

```
Heart in Protégé frames
Metaclass
(defclass Heart
  (is-a Organ_with_cavitated_organ_parts)
  ...
)
Class (Instance of Metaclass)
([Heart]
 of Organ_with_cavitated_organ_parts
 (constitutional_part
  Wall_of_heart
  Cavity_of_left_atrium
  Cavity_of_right_ventricle
  Cavity_of_left_ventricle
  Right_coronary_artery
  Left_coronary_artery
  ...
 (bounded_by
  Surface_of_heart)
 (arterial_supply
  Right_coronary_artery
  Left_coronary_artery)
  ...
)
```

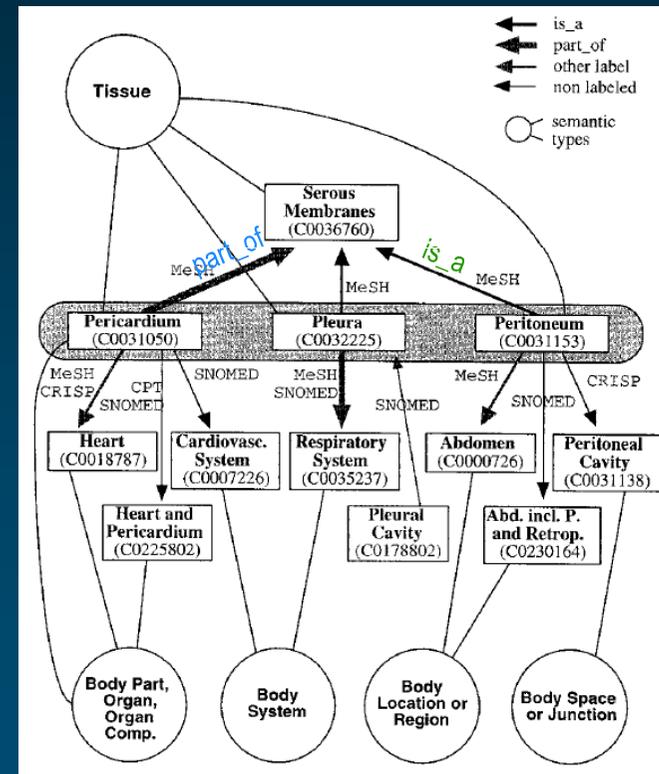
n



Which method Additional methods

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- ◆ Use in an application

MAOUSSC: Using UMLS for the description of medical procedures



Identifying errors in SNOMED CT

Rector AL, Brandt S, Schneider T, *Getting the foot out of the pelvis: modeling problems affecting use of SNOMED CT hierarchies in practical applications. J Am Med Inform Assoc, 2011. 18(4): p. 432-440.*

Alan Rector's motivation

- Knowledge source for clinical applications (industrial collaboration)
 - Retrieval of clinical records for a given diagnosis
 - Decision support
 - Eligibility for clinical trials
- Development of ICD 11 (WHO Health Information Modelling TAG)
 - Ontological component for ICD 11
 - ICD hierarchies derived from SNOMED CT

Investigation methods

- Technology-assisted review by domain experts
 - With focus on the CORE problem list (clinical relevance)
- Methods
 - Leveraging description logics (stated version converted to OWL, module extraction, OWL classifiers, scripting against OWL API)
 - Lexically suggest-logically refine (association between words from labels and roles)
 - Navigation (up and down the hierarchies for missing/extraneous ancestors/descendants)

Findings – Qualitative (1)

- Errors of omission
 - Primitive concepts
 - Ischemic heart disease: *due to ischemia*, but not defined
 - Missing axioms
 - Morphology
 - acute endocarditis (disorder): not *clinical course* = acute; morphology: acute inflammation
 - Other
 - Myocardial infarction: not *due to ischemia*

Findings – Qualitative (2)

- Errors of commission
 - Wrong
 - Diabetes mellitus *isa* Disease of the exocrine pancreas (true of type I, not type II)
 - Subdural hemorrhage: *finding site* Subdural space structure (intracranial is implied by usage, but not formally represented)
 - Wrong (but only indirectly)
 - Hypertension *isa* disorder of soft issue
 - Hypertension: *finding site* Systemic arterial structure (→ soft tissue) (not clinically thought of as a disorder of soft tissues)
 - Neoplasm of cranial nerve: *isa* Neoplasm of cranial nerve: *isa* Neuropathy (neuropathy denotes functional disorder of nerve)
 - Anatomy (branches inherit from root)
 - Structure of right popliteal artery *isa* [...] *isa* Structure of pelvic region (“getting the knee out of the pelvis”)

Consequences

Incorrect inferences

- By omission
 - Search on **Ischemic heart disease** fails to retrieve **Myocardial infarction**
- By commission
 - Search on **Disorder of pancreas** retrieves all cases of diabetes mellitus, including type II
- Missing equivalences from post-coordination
 - acute endocarditis (disorder):
 - Pre-coord: *morphology*: **acute inflammation**
 - Post-coord: *clinical course* = **acute**; *morphology*: **inflammation**

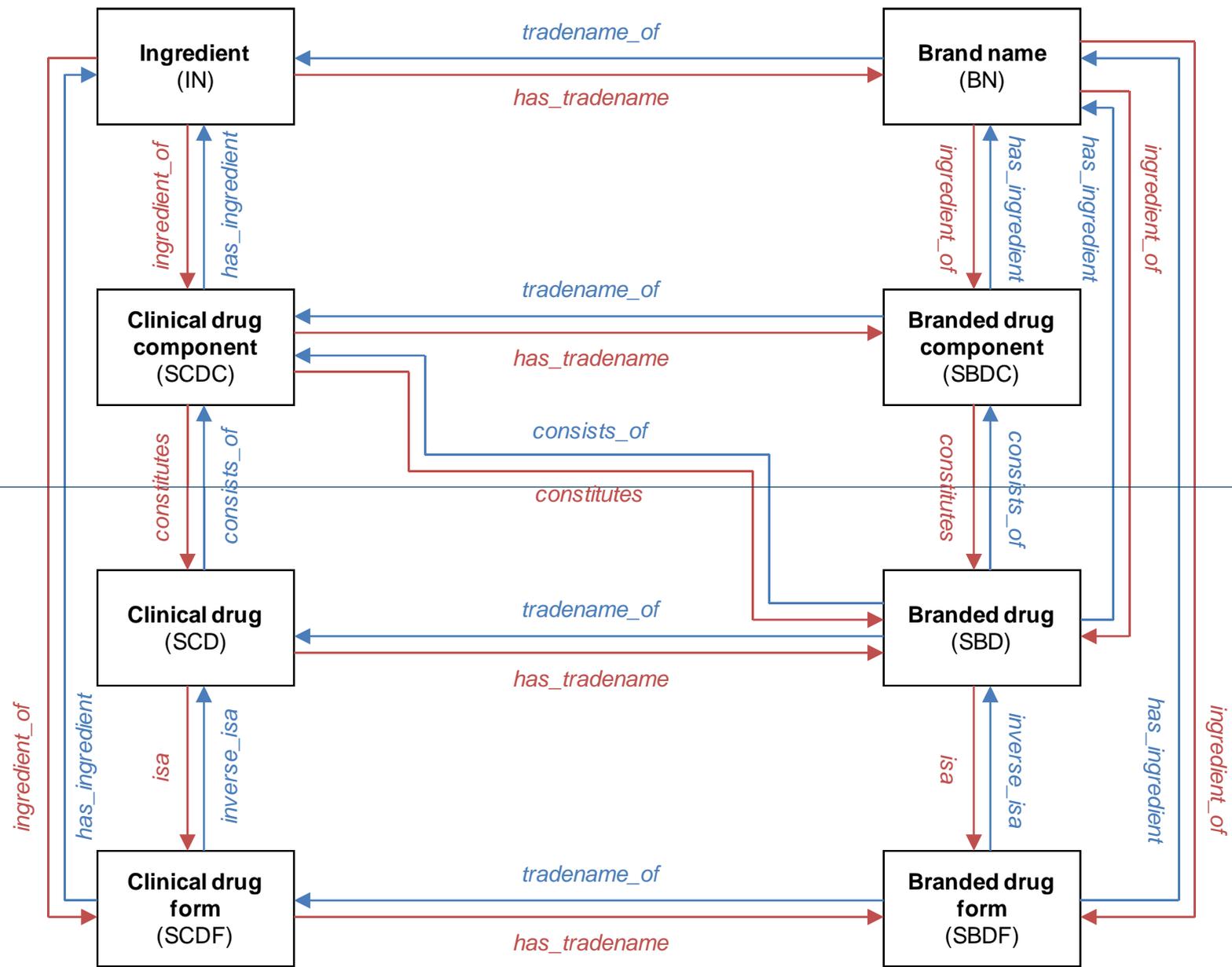
Identifying errors in RxNorm

Bodenreider, O. and L.B. Peters, *A graph-based approach to auditing RxNorm. Journal of Biomedical Informatics, 2009. 42(3): p. 558-570.*

Motivation

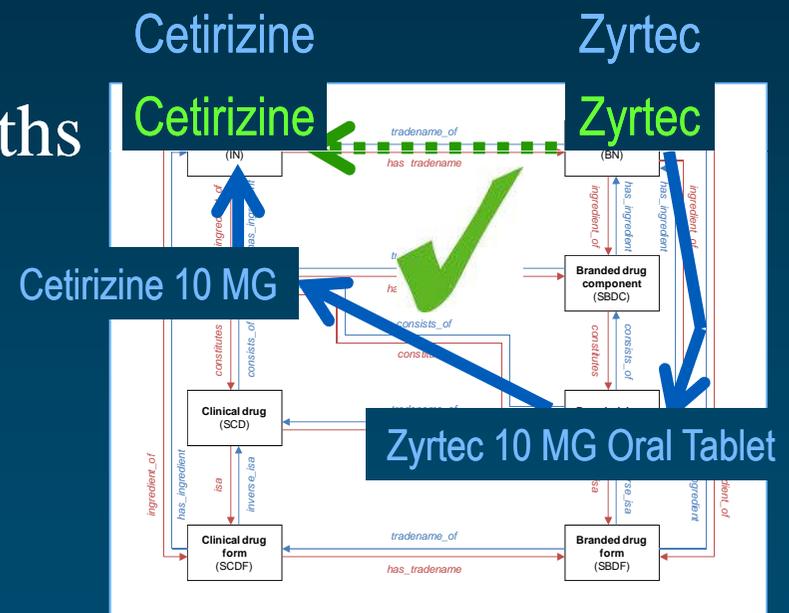
- ◆ Large terminology
- ◆ Relies heavily on human editors
- ◆ High quality

- ◆ Systematic evaluation
- ◆ Exploiting the graph structure



Methods

- ◆ Normalize multi-ingredient drugs
- ◆ Define “meaningful” paths between 2 nodes
- ◆ Instantiate all meaningful paths
- ◆ Compare alternate paths
 - Alternate (meaningful) paths are expected to be functionally equivalent

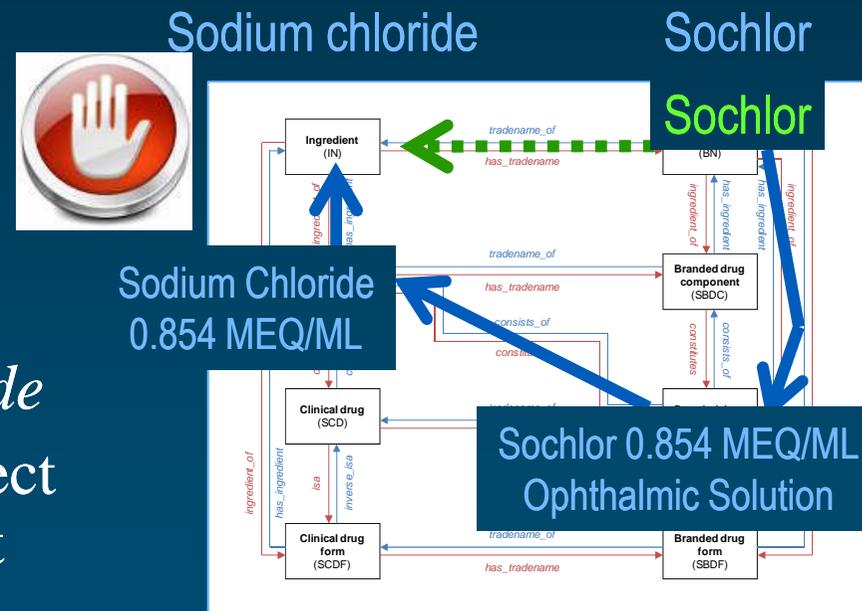


Results

- ◆ 348 inconsistencies identified (April 2008)
- ◆ Reported to the RxNorm team
- ◆ 215 (62%) fixed (January 2009)

- ◆ Example (fixed)

- missing link
Sochlor → *Sodium chloride*
- Brand name without a direct relation with an ingredient



VALUE SETS
IN
CLINICAL QUALITY MEASURES



CLINICAL QUALITY MEASURES (CQMs)

Tools that help measure and track the quality of healthcare services provided by eligible professionals, eligible hospitals and critical access hospitals within our health care system

CQMs measure many aspects of patient care including: health outcomes, clinical processes, patient safety, efficient use of healthcare resources, care coordination, patient engagements, population and public health, and clinical guidelines

[[cms.gov](https://www.cms.gov)]



93 CLINICAL QUALITY MEASURES

in 2014 Meaningful Use criteria

64

for

**ELIGIBLE
PROVIDERS**

(NEED TO REPORT ON 9)

29

for

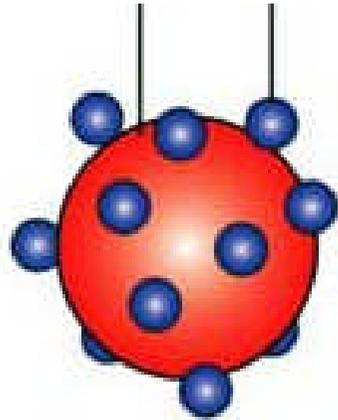
**ELIGIBLE
HOSPITALS**

(NEED TO REPORT ON 16)

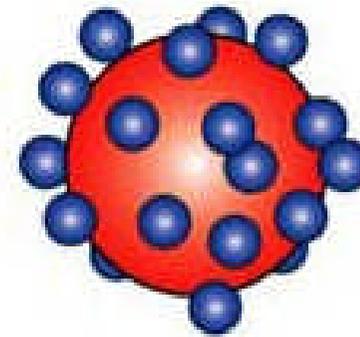
CLINICAL QUALITY MEASURE (example)

Hemoglobin A1c Test for Pediatric Patients

Hemoglobin Sugar



Normal glucose levels in blood
Low HbA1c concentration



High glucose levels in blood
High HbA1c concentration

CLINICAL RECOMMENDATIONS

1. American Association of Clinical Endocrinologists (2002): Recommends that **a glycosylated hemoglobin be performed during an initial assessment and during follow-up assessments**, which should occur at no longer than three-month intervals.
2. American Diabetes Association (2006): Recommends **obtaining a glycosylated hemoglobin during an initial assessment and then routinely as part of continuing care**. In the absence of well-controlled studies that suggest a definite testing protocol, expert opinion recommends glycosylated hemoglobin be obtained at least twice a year in patients who are meeting treatment goals and who have stable glycemic control and more frequently (quarterly assessment) in patients whose therapy was changed or who are not meeting glycemic goals.

CLINICAL QUALITY MEASURE (simplified)

Hemoglobin A1c Test for Pediatric Patients

diabetic patients [age 5-17] *tested for HbA1c*

=

diabetic patients [age 5-17]

CLINICAL QUALITY MEASURE (details)

Hemoglobin A1c Test for Pediatric Patients

Tests for HbA1c

diabetic patients [age 5-17] *tested for HbA1c*

=

diabetic patients [age 5-17]

- Type 1 or Type 2 diabetes
- Excludes gestational diabetes

- Requires date of birth

CLINICAL QUALITY MEASURE (implementation)

Hemoglobin A1c Test for Pediatric Patients

List of LOINC codes

Tests for HbA1c

diabetic patients [age 5-17] *tested for HbA1c*

=

diabetic patients [age 5-17]

- Type 1 or Type 2 diabetes
- Excludes gestational diabetes

- Requires date of birth

Data element

List of SNOMED CT or ICD 10 codes



ANATOMY OF A CLINICAL QUALITY MEASURE

Population criteria

- **Initial Patient Population =**
 - AND: "Patient Characteristic Birthdate: birth date" >= 5 year(s) starts before start of "Measurement Period"
 - AND: "Patient Characteristic Birthdate: birth date" <= 17 year(s) starts before start of "Measurement Period"
 - AND: "Diagnosis, Active: Diabetes" starts before or during (MOST RECENT : "Occurrence A of Encounter, Performed: Diabetes Visit" during "Measurement Period")
 - AND: "Encounter, Performed: Diabetes Visit" >= 12 month(s) starts before start of "Occurrence A of Encounter, Performed: Diabetes Visit"
- **Denominator =**
 - AND: "Initial Patient Population"
- **Denominator Exclusions =**
 - AND NOT: "Occurrence A of Diagnosis, Active: Gestational Diabetes" ends before start of "Measurement Period"
 - AND: "Occurrence A of Diagnosis, Active: Gestational Diabetes" starts before or during "Measurement Period"
- **Numerator =**
 - AND: "Laboratory Test, Result: HbA1c Laboratory Test (result)" during "Measurement Period"
- **Denominator Exceptions =**
 - None

Data criteria (QDM Data Elements)

- "Diagnosis, Active: Diabetes" using "Diabetes Grouping Value Set (2.16.840.1.113883.3.464.1003.103.12.1001)"
- "Diagnosis, Active: Gestational Diabetes" using "Gestational Diabetes Grouping Value Set (2.16.840.1.113883.3.464.1003.103.12.1010)"
- "Encounter, Performed: Diabetes Visit" using "Diabetes Visit Grouping Value Set (2.16.840.1.113883.3.464.1003.103.12.1012)"
- [REDACTED]
- "Patient Characteristic Birthdate: birth date" using "birth date LOINC Value Set (2.16.840.1.113883.3.566.1003.103.12.1001)"

Value set = List of
LOINC codes for
HbA1c tests



ASSOCIATED VALUE SET

Metadata	Name: HbA1c Laboratory Test	OID: 2.16.840.1.113883.3.464.1003.198.12.1013
Measure	Type: Grouping	Developer: National Committee for Quality Assurance
Grouping	Note:	

Value Set Members Expansion

Expanded Code List

View Toggle Clear Page 1 of 1 20 View 1 - 3 of 3

Code	Descriptor	Code System	Version
17855-8	Hemoglobin A1c/Hemoglobin.total in Blood by calculation	LOINC	2.40
17856-6	Hemoglobin A1c/Hemoglobin.total in Blood by HPLC	LOINC	2.40
4548-4	Hemoglobin A1c/Hemoglobin.total in Blood	LOINC	2.40



Meaningful Use Criteria - 2014

93
CQMs

Developed by some
20 measure
developers

3,011
value sets

1,520 unique

199,521
codes

83,723 unique

CURATING VALUE SETS

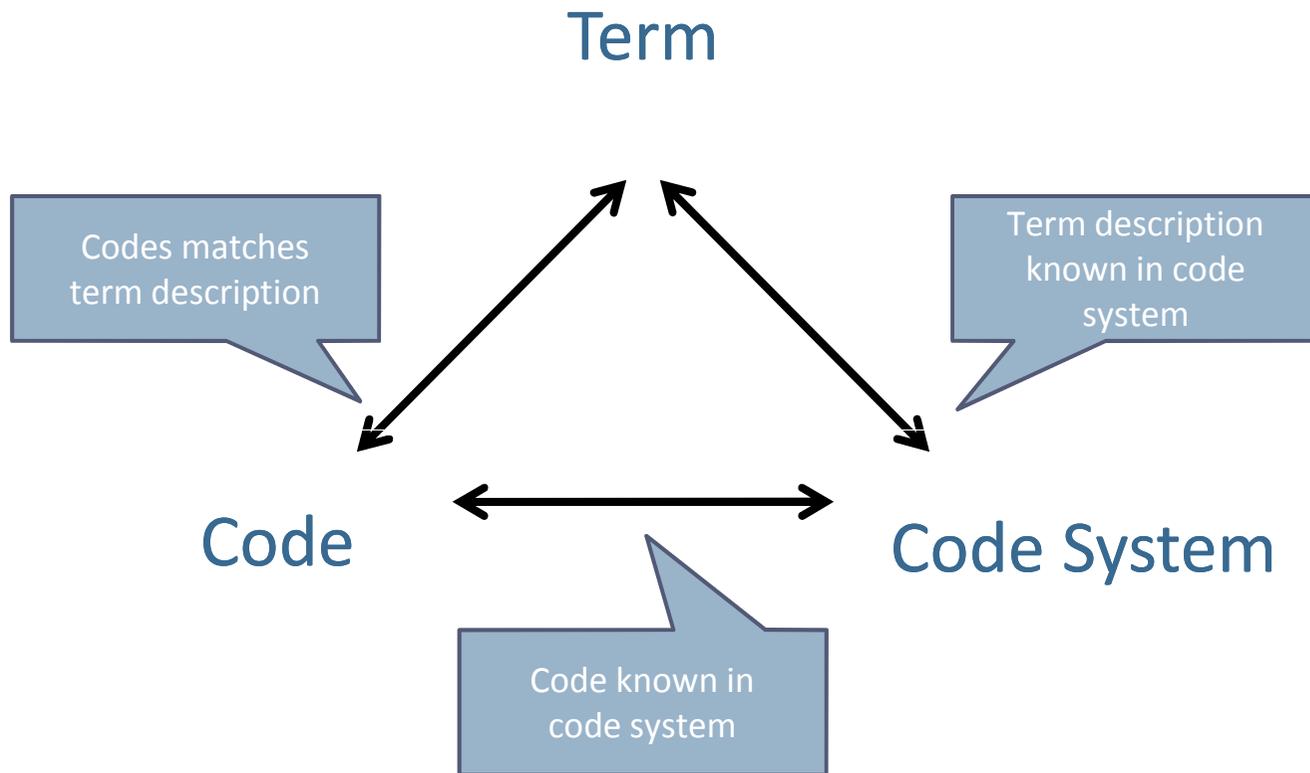
The NLM Value Set Authority Center



OBJECTIVES OF CURATION

- Ensure **referential integrity**
 - ▶ All codes in a VS are valid codes in the corresponding code system
 - ▶ Update VSs when the code systems are updated (no “stale” codes)
- Avoid **duplication**
 - ▶ Find value sets having similar members
- Ensure **correctness** and **completeness**
 - ▶ Compare intensional and extensional definitions

CODE VALIDATION USING TRIANGULATION



Using terminology services to compare codes to reference terminologies

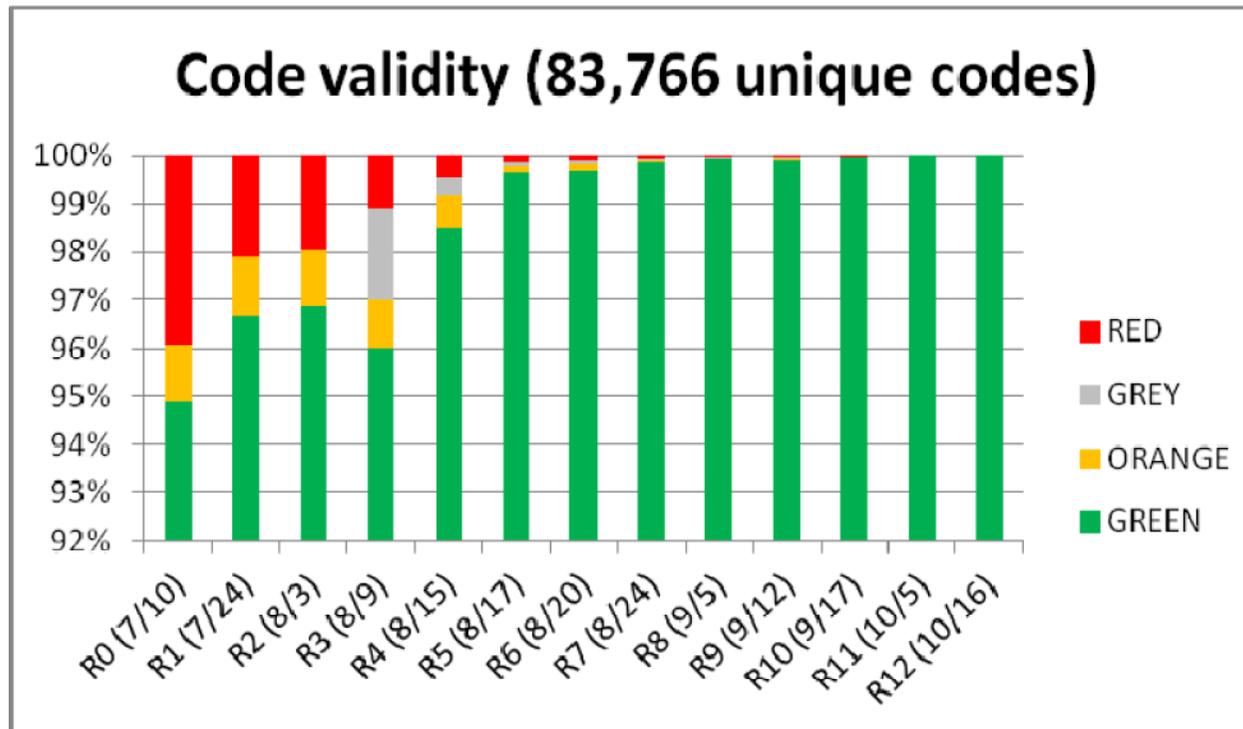
TYPES OF ERROR FOUND IN THE CODES

- Obsolete codes
 - ▶ Remap to the current code
- Typo / formatting issue in the code
 - ▶ Reformat
- Wrong code system listed
 - ▶ Fix code system
- Code/description mismatch
 - ▶ Small mismatch: Assign preferred term
 - ▶ Large mismatch: Send back to developers

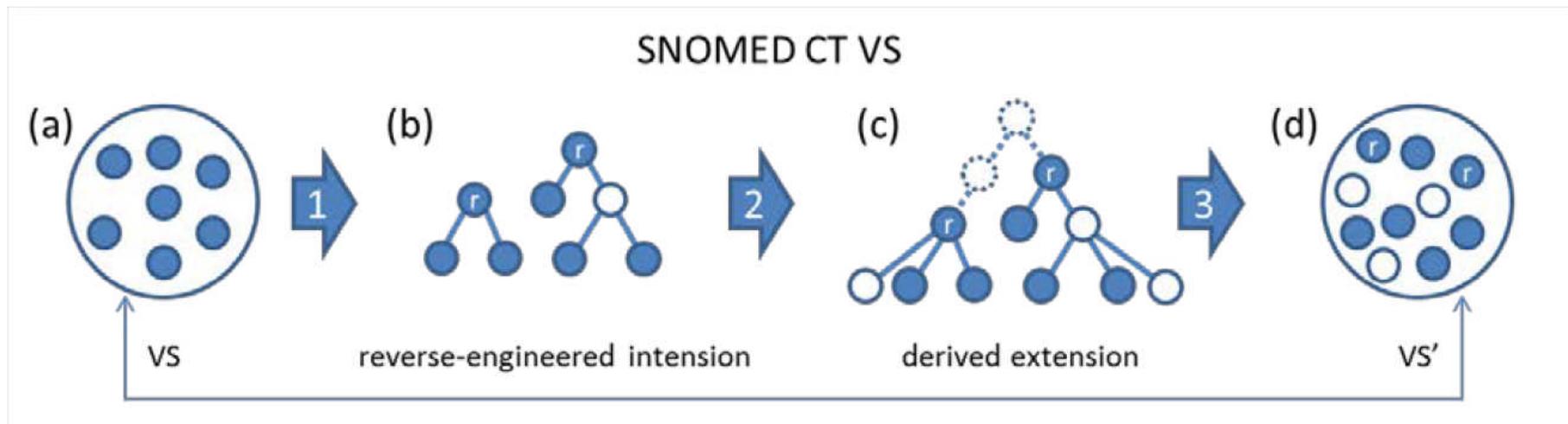
IMPACT ON CLINICAL QUALITY MEASURES

Iterative Analysis

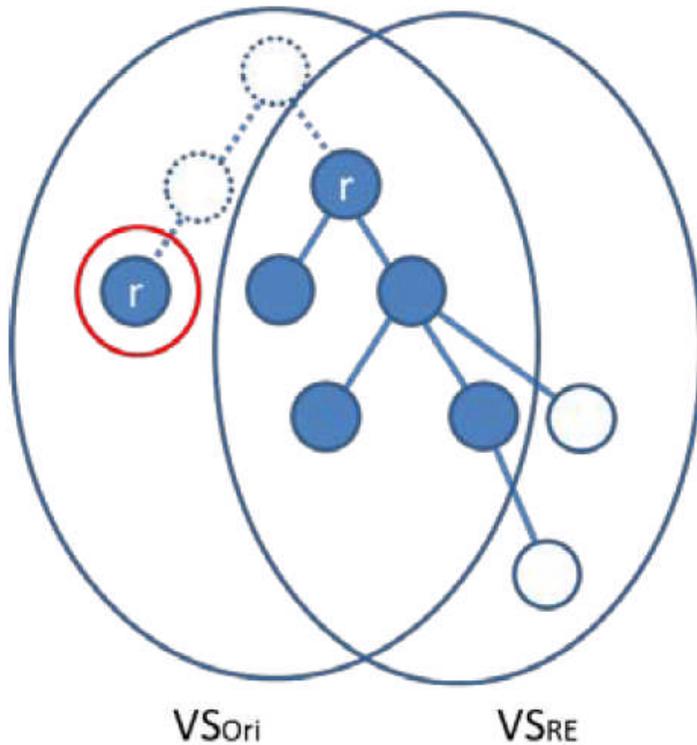
- 13 rounds over 4 months
- Reports provided to measure developers
- Orange codes fixed automatically by NLM
- Red codes fixed by measure developers (and rechecked)
- ~4000 errors
- Affecting 70% of the value sets
- And 100% of the measures
- All fixed by October 2012



REVERSE-ENGINEERING OF THE INTENSION



QUALITY METRICS FOR VALUE SETS



Completeness

$$Compl(VS_{Ori}) = |VS_{Ori} \cap VS_{RE}| / |VS_{RE}|.$$

Correctness

$$Correct(VS_{Ori}) = |VS_{Ori} \cap VS_{RE}^*| / |VS_{Ori}|,$$

where $VS_{RE}^* \subseteq VS_{RE} \setminus \{\text{singleton nodes}\}$.



Welcome

Search Value Sets

Help

Apply Filters Clear Filters

Search the NLM Value Set Repository

Query: Enter value set id, codes, words...

Search

Narrow search results by selecting from pull-down menus below:

CMS eMeasure (NQF Number)

CMS102v1 (0441)

Quality Data Model Category

Select

Value Set Developer

Select

Meaningful Use Measures

Select

Search Results

Value Set Details

Export Search Results (Excel)

Matched Value Sets

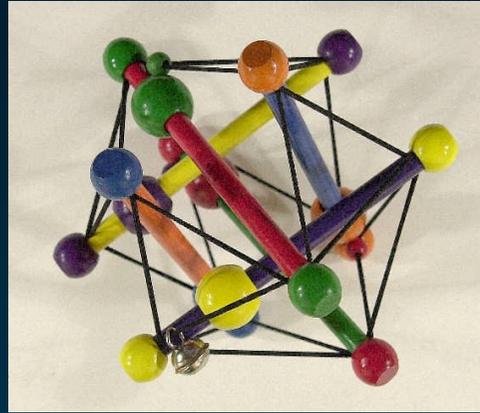
Download View

Page 1 of 2 20

View 1 - 20 of 21

<input type="checkbox"/>	Name	Type	Code System	Developer	OID
<input type="checkbox"/>	birth date	Extensional	LOINC	NQF	2.16.840.1.113883.3.560.100.4
<input type="checkbox"/>	Carotid Intervention	Grouping	ICD10PCS ICD9CM SNOMEDCT	Joint Commission	2.16.840.1.113883.3.117.1.7.1.204
<input type="checkbox"/>	Discharge To Another Hospital	Extensional	SNOMEDCT	Joint Commission	2.16.840.1.113883.3.117.1.7.1.87
<input type="checkbox"/>	Discharged to Health Care Facility for Hospice Care	Extensional	SNOMEDCT	Joint Commission	2.16.840.1.113883.3.117.1.7.1.207
<input type="checkbox"/>	Discharged to Home for Hospice Care	Extensional	SNOMEDCT	Joint Commission	2.16.840.1.113883.3.117.1.7.1.209
<input type="checkbox"/>	Discharged to Rehabilitation Facility	Extensional	SNOMEDCT	Joint Commission	2.16.840.1.113883.3.117.1.7.1.132
<input type="checkbox"/>	Emergency Department Visit	Grouping	SNOMEDCT	Lantana	2.16.840.1.113883.3.117.1.7.1.293
<input type="checkbox"/>	Ethnicity	Extensional	CDCREC	CDC NCHS	2.16.840.1.114222.4.11.837
<input type="checkbox"/>	Hemorrhagic Stroke	Grouping	ICD10CM ICD9CM SNOMEDCT	Joint Commission	2.16.840.1.113883.3.117.1.7.1.212
<input type="checkbox"/>	Inpatient Encounter	Extensional	SNOMEDCT	Joint Commission	2.16.840.1.113883.3.117.1.7.1.23

<https://vsac.nlm.nih.gov/>



Medical Ontology Research

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