

My experience with SNOMED CT

James R. Campbell MD

University of Nebraska Medical Center

Assess CT Workshop

Amsterdam, Netherlands

May 3, 2016



Disclosure

I have no financial conflict of interest in my discussion of vocabulary services and electronic health records I will describe during this talk



Requirements for effective Implementation of Clinical Terminology

- Expressive:
 - Comprehensive content
 - Unambiguous
 - Provides variable semantic granularity
 - Supports parochial expression and terms
- Permanence
- Decision analytical:
 - Supports aggregation of clinical reference groups
 - Includes relevant declarative domain knowledge
- Data re-use:
 - Clinical data record must support information needs of multiple user communities
- Interoperable:
 - Reliably supports machine-based transmission and integration of conceptual content (pre-coordinated AND post-coordinated)
- No financial or legal barriers



Experience with classifications

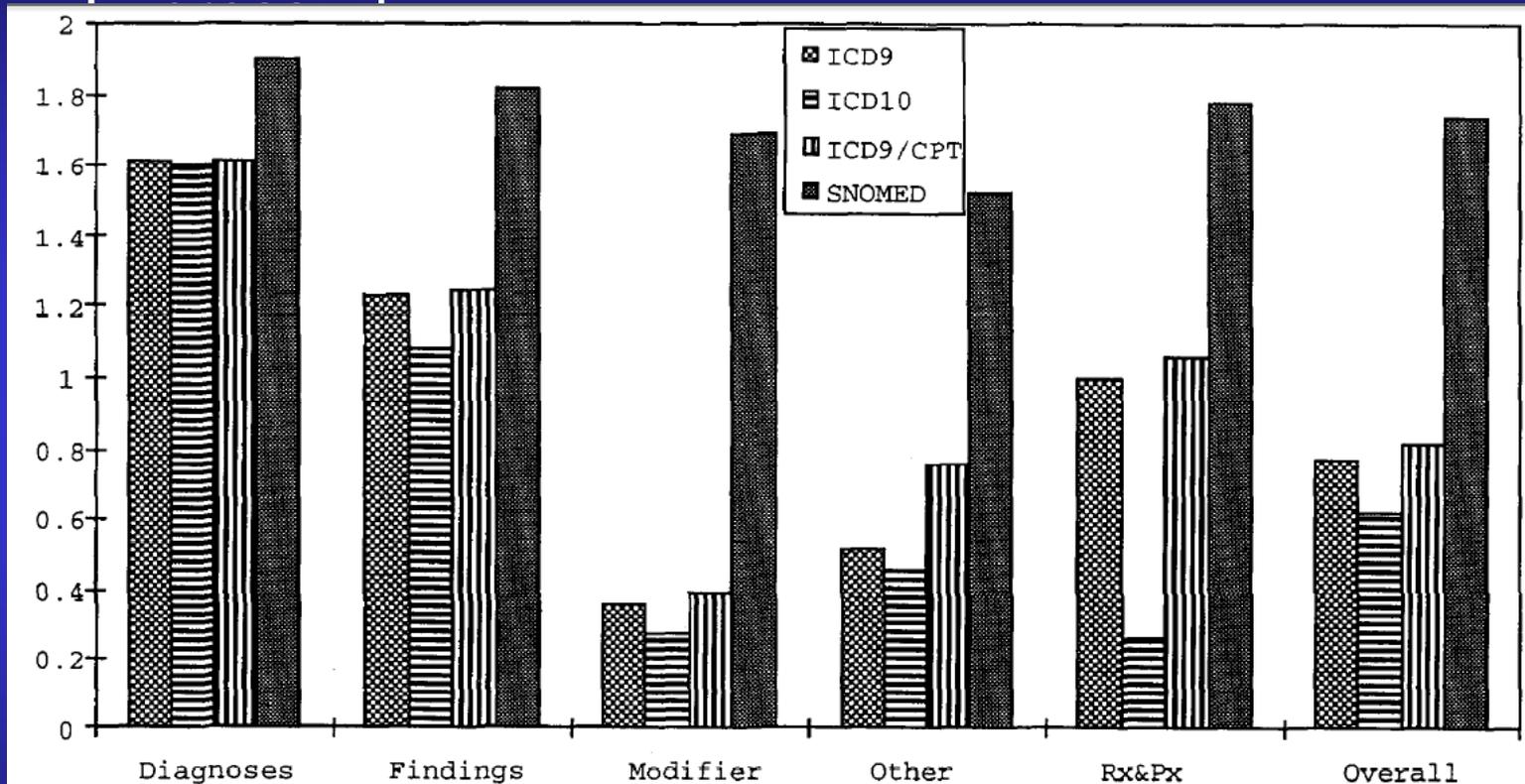


Figure 1 Scores by semantic group for major coding systems. Bar graph of mean scores over all concepts within each semantic domain and overall. Rx&Px = treatments and procedures. The 0-2 integer scaling reflects a subjective measure of concept capture, 0 = absent, 2 = complete. Classifications depicted are those considered well known or relevant to American health care. See text and tables for additional classification systems.

Chute CG, Cohn SP, Campbell KE, Oliver DE, Campbell JR. The content coverage of clinical classifications For The Computer-Based Patient Record Institute's Work Group on Codes & Structures. J Am Med Inform Assoc. 1996 May-Jun;3(3):224-33.

Experience with classifications

- Expressivity:
 - ICD-9-CM and CPT covered <65% of portions of clinical record content
- Permanence:
 - Elusive meaning of “NEC”

Average Score by Domain and Scheme (Confidence Intervals Employing Correction)

Domain	N	READ	SNOMED	UMLS	Statistical Summary
Demographics	18	3.70 (2.38–5.02)	3.39 (2.07–4.71)	3.02 (1.70–4.34)	R = S = U
Attributes	206	3.43 (3.04–3.81)	3.97 (3.59–4.36)	2.52 (2.13–2.91)	S > R > U
Interventions	465	3.91 (3.65–4.17)	4.36 (4.10–4.62)	4.06 (3.80–4.31)	S > U, R
Findings	613	3.79 (3.56–4.02)	4.31 (4.08–4.53)	3.44 (3.22–3.67)	S > R > U
Diagnoses/impressions	289	4.04 (3.70–4.36)	4.62 (4.29–4.95)	4.15 (3.82–4.48)	S > U, R
Plans	125	2.93 (2.43–3.43)	3.58 (3.08–4.08)	2.88 (2.38–3.38)	S > R, U
Equipment/devices	30	2.49 (1.47–3.51)	3.25 (2.23–4.27)	3.39 (2.37–4.41)	U, S > R
Events	3	2.93 (–.29–6.16)	3.2 (–.03–6.43)	2.53 (–.69–5.76)	S = R = U
Human anatomy	168	4.60 (4.17–5.03)	4.88 (4.44–5.31)	4.33 (3.90–4.76)	S, R > U
Etiologic agents	8	3.93 (1.95–5.90)	4.78 (2.80–6.75)	4.55 (2.57–6.53)	S = U = R
Agents	4	3.05 (.25–5.85)	4.05 (1.25–6.84)	1.55 (–1.25–4.35)	S = R = U

publication cycle

Campbell JR, Carpenter P, Sneiderman C, Chute CG, Warren JJ. Phase II Evaluation of Clinical Coding Schemes: Completeness, Taxonomy, Mapping, Definitions, and Clarity, for the CPRI Workgroup on Codes and Structures. JAMIA 1997 May-June; 4(3):238-251

My Experience with SNOMED

- 1996: NOT a classification
- 1997: Implementation of problem list with SNOMED International V3
 - No formal conceptualization
 - Confusion regarding management of context
 - Precoordinated comprehension ~ 80%
- 1999: SNOMED RT
 - First formalisms for concept model
- 2001: Nebraska Lexicon problem list support begun
- 2002: SNOMED CT
 - Precoordinated comprehension ~ 92%
 - Formalisms for interoperable use of semantic concept model
- 2012: SNOMED CT, IMO, Epic and meaningful use
 - Comprehension ~980/1000 of frequent problems
 - Extended semantic deployment in integrated information model



2016: Expressivity in Epic 20 years of Problem List data

Item	N
Patient records summarized	494,967
Problems recorded	3,044,011
Unique terms selected	59,845
Unique SNOMED CT IDs	21,137
Unique ICD-10-CM codes(7)	13,475
Unique ICD-9-CM codes(5)	10,375
Unique ICD-10 codes(4)	6,378

↑ Specificity ↑



2016 US SNOMED CT Report Card

- Expressive:
 - SNOMED CT is most comprehensive and expressive pre-coordinated clinical terminology worldwide
 - It supports multiple levels of granularity but is often deployed with interface term management for local terming
 - It is the only reference terminology supporting extensions for national/regional concept requirements; we have a number of these successfully deployed and are developing guidelines and protocols for management
 - Post MU, SNOMED CT is now in use in EHRs serving $\gg 10^8$ patients in the USA although unknown to most clinicians
 - Paradigms for decentralized, collaborative, responsive and interoperable vocabulary management are being developed
- Lesson learned: make a clear policy statement about standards after thoughtful deliberation and incentivize to deal with barriers to deployment



Evaluating Decision Support: the SAGE project

- As part of the SAGE guideline engine development, we evaluated utility of SNOMED CT and Lexicon problem list data for decision support
- Frame based knowledge modeling of CDC immunization guidelines was accomplished with Protégé
- An API linking the decision engine to the EHR information model (vMR) queried the database including Lexicon problem list
- Criteria were modeled within decision models which reproduced the source guideline logic



Characteristics of the Immunization Model

- Entire text of CDC Immunization Guideline distilled into 75 individual “IF-THEN” structured logic statements supporting three clinical scenarios
 - Vaccine advice at birth
 - Primary care office visit
 - Population based reminders
- 174 conceptual references were identified as required for decision making from the source guideline



Pre-coordinated Concepts by Semantic Class

SNOMED domain	n
Situation with explicit context	3
Disorder	51
Finding	23
Observable entity	10
Occupation	4
Organism	1
Person	1
Procedure	9
Product (clinical drug)	50
Qualifier	16
Racial group	1
Substance	5
Total	n = 174



Query Concept Inventory by Semantic Complexity

Category	n
Category 1 (Concept entity)	35 (17.8%)
Category 2 (Subsumption)	139 (70.5%)
Category 3 (Boolean constructions)	12 (6.1%)
Category 4 (Post coordination)	11 (5.6%)
Total	n = 197



2016 US SNOMED CT Report Card

- Decision analytical:
 - Binding of SNOMED CT subtype (IS-A) relationships has appeared within EHR decision support systems nationwide serving a majority of US population
 - ONC Guideline specifications addressing quality outcomes are being published employing suite of terminology standards (SNOMED CT, LOINC, ICD*, CPT)
 - Incorporation of other features of the SNOMED CT concept model into decision analytical tools are limited at this time



2016 US SNOMED CT Report Card

- Permanence:
 - History files released in RF2 format support version management of SNOMED CT but operationally vendors/customers are not always staying current with releases nor managing change carefully
 - Tooling and protocols for history management between systems are needed

Lesson: NRCs should be developing understandable guidance to vendor community regarding protocols and expectations of change management; possibly including version management expectations of vendors

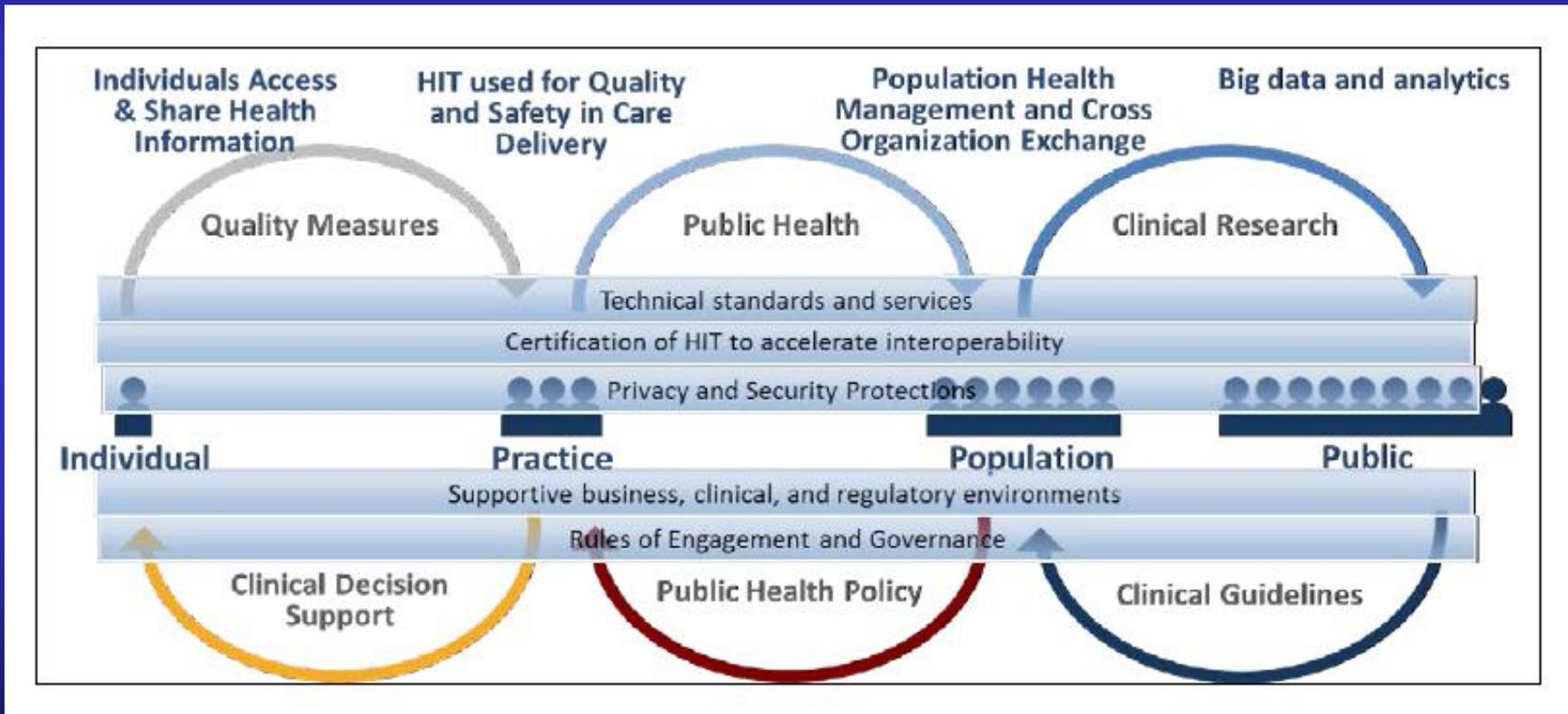


2016: Office National Coordinator Objectives of Interoperability

- Facilitate transitions of care
- Engage patients and families in managing their health
- Promote free flow of results data
- Support Public Health
- Enhance clinical research within Learning Healthcare Environment



Interoperable Learning Health System



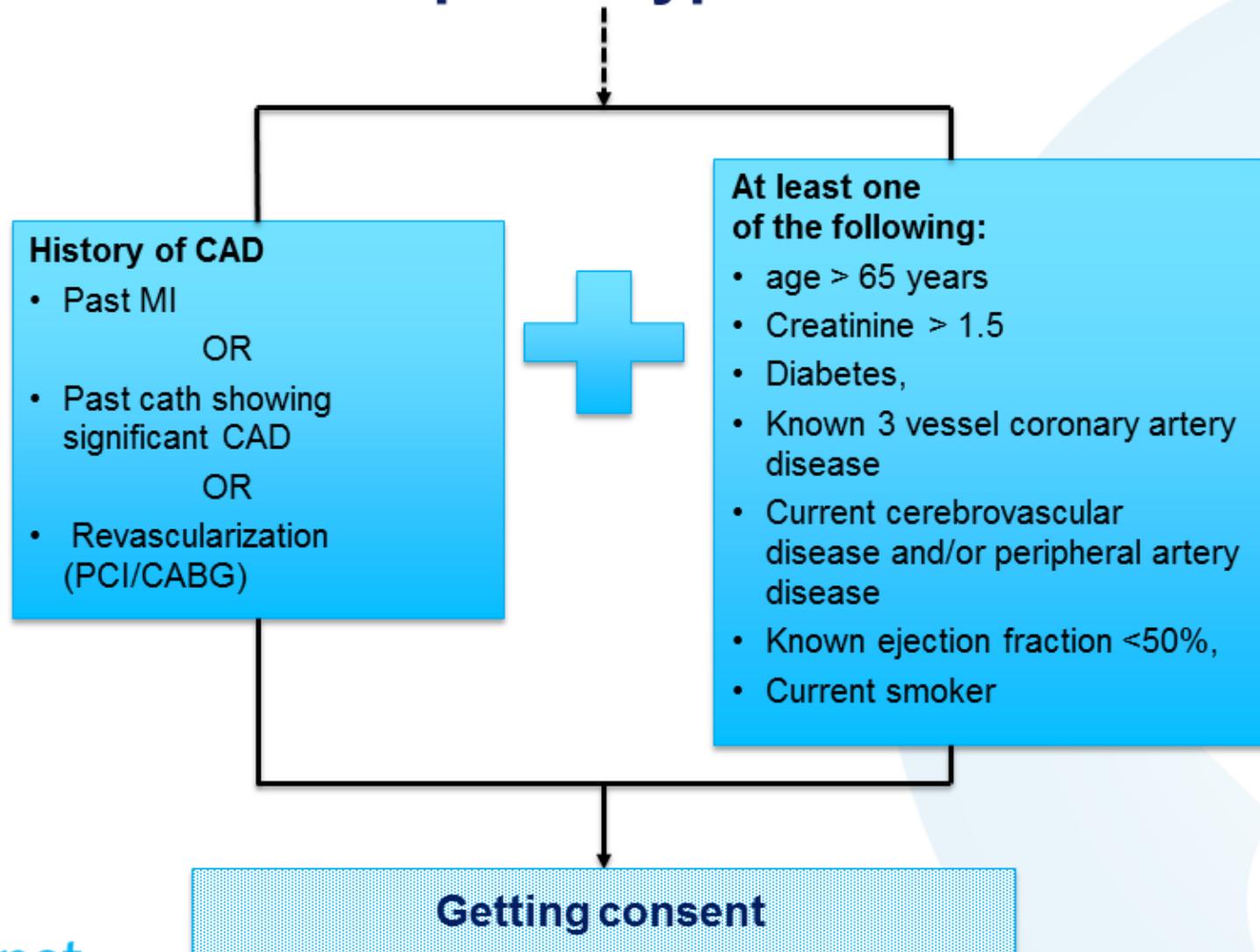
PCORnet: the National Patient-Centered Clinical Research Network

The **goal** of PCORI's National Patient-Centered Clinical Research Network Program is to **improve the nation's capacity to conduct CER** efficiently, **by creating a large, highly representative, national patient-centered clinical research network** for conducting clinical outcomes research.

The **vision** is to support a learning US healthcare system, which will allow for **large-scale research** to be conducted with **enhanced accuracy and efficiency**.

PCORnet will function through a **single, interoperable data research network**, the PCORnet DRN.

Computable phenotype



2016 US SNOMED CT Report Card

- Data reuse:
 - The Nationwide Health Information Network (aka the Learning Health System) is becoming a reality guided by the Standards and Interoperability framework of ONC
 - In the era of MU stage 3, SNOMED CT is appearing across many domains of the EHR beyond the problem list at directions of ONC
 - Data networks are springing up serving both collaborative research and public health objectives, employing standardized structured data residing in nationwide EHRs
 - These data are now being extracted and are appearing in network datamarts for research, quality assurance and public health
 - Protocols for the systematic extraction and interpretation of structured health data (computable phenotypes) are being studied and deployed in clinical trials



Interoperability of the EHR

- 1) **Functional**: physical link establishes communication
- 2) **Transactional**: sharing message data
- 3) **Semantic**: sharing data meaning
 - a) Token: unique reference tag for a concept
 - b) Definitional: specification of meaning maintained within computable conceptualization
 - i) Taxonomic; ii) Full ontologic conceptualization

Semantic interoperability refers to the ability of computer systems to exchange data in such a way that the defining features of the data are software accessible and the system can employ the information meaningfully



Meaningful Use Stage 3 Vocabulary Requirements for Semantic Interoperability

Lucy! Personal Health Summary, as of Apr. 28, 2016



James R Campbell (Male, born Oct. 28, 1946)



6030 COUNTRY CLUB OAKS PLA
OMAHA, NE 68152



4025710428 (Home)
4025596253 (Work)
4028881230 (Pager)
campbell@unmc.edu

Note from Nebraska Medicine (formerly known as The Nebraska Medical Center)

This document contains information that was shared with James R Campbell, MD. It may not contain the entire record from Nebraska Medicine (formerly known as The Nebraska Medical Center).

Allergies

AMPICILLIN (Diarrhea) - Low Severity

CELECOXIB (Urticaria)

IODINE (Rash) - High Severity

Current Medications



2015: Study in interoperability of problem lists

- **University of Nebraska Medical Center; Omaha, NE, USA**

UNMC is a tertiary care center for the midwest US with general and specialty practice community care clinics in Omaha and through nebraska and western Iowa.

- **Hospital Italiano; Buenos Aires, Argentina**

Hospital Italiano is a non-profit university hospital, associated with a large network of ambulatory care services, located in Buenos Aires, Argentina.



2015: Methods

- Select the top 1,000 concepts by frequency of use in the problem list of each center
- Evaluate the semantic interoperability of each extension using the SNOMED CT concept model and a Description Logic classifier
- Perform exhaustive analysis on ~250 extension concepts from each site to evaluate for compliance with SNOMED CT concept model, identification of modeling errors and to discover classification errors



DL Equivalence (True positive HIBA - Neb)

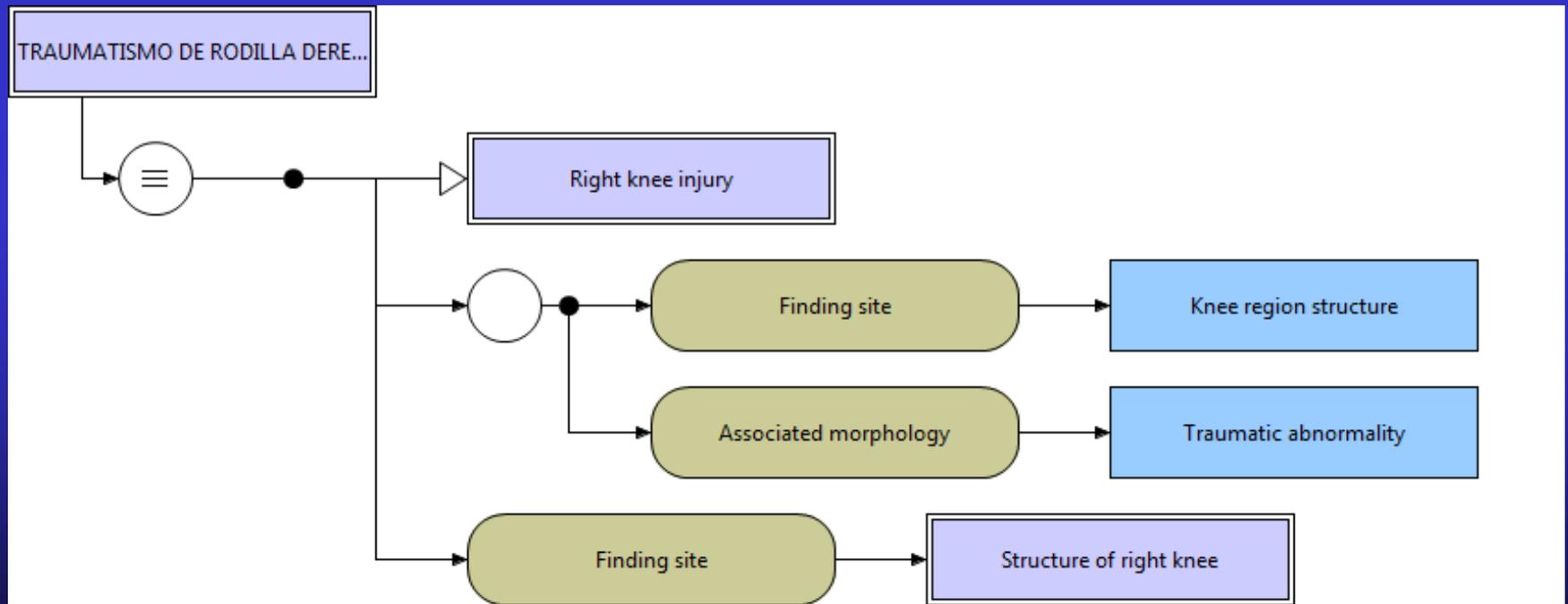
187351000999104|Traumatismo de rodilla derecha|

187351000999104|Traumatismo de rodilla derecha|:

363698007|Finding site| = 6757004|Structure of right knee|

{ 363698007|Finding site| = 72696002|Knee region structure|,

116676008|Associated morphology| = 19130008|Traumatic abnormality|}



DL Equivalence

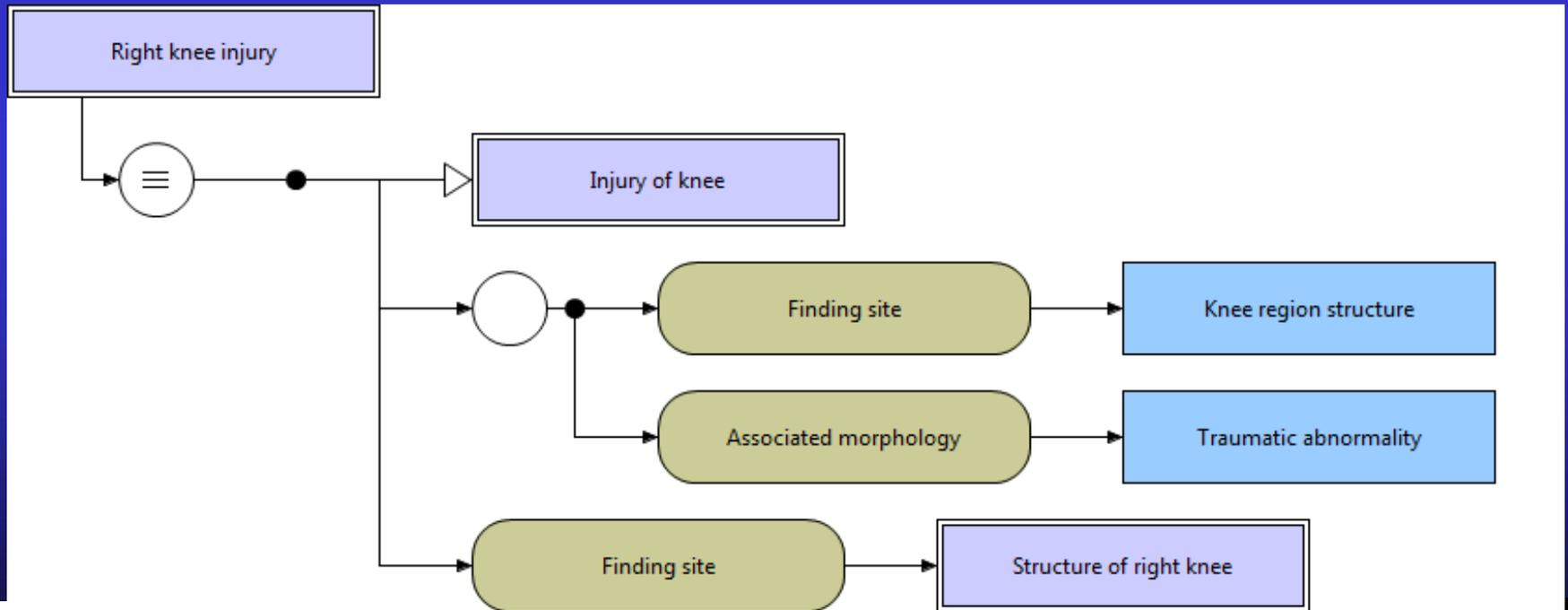
13260001000004100|Right knee injury|

125601008|Injury of knee|:

363698007|Finding site| = 6757004|Structure of right knee|

{ 363698007|Finding site| = 72696002|Knee region structure|,

116676008|Associated morphology| = 19130008|Traumatic abnormality|}



2015 Interoperation post-coordination scorecard

Precision \geq .96

Recall \geq .87

F-score = .91

	True Positives	False Positives	False Negatives
HIBA Extension → Neb	205	4	32
Neb Extension → HIBA	16	3	1



2016 US SNOMED CT Report Card

- Interoperable:
 - Interoperable exchange of (pre-coordinated) clinical data employing HL7 CDA and ONC terminology standards has been serving clinical and patient needs now for more than 2 years with significant results
 - SNOMED CT concept model supports DL computation of equivalence and subsumption for post-coordinated data exchange between NRCs or service vendors who are committed to full semantic interoperability
 - Additionally, SNOMED CT and LOINC are harmonizing their concept model to support semantic interoperability of observational data with demonstration projects underway



2016 US SNOMED CT Report Card

- Cost:
 - Is always an issue
 - In the US we consider this part of our strategy for dealing with the most expensive (and not always the most effective) health care system in the world
 - Research, some done here in Europe, has demonstrated improved efficiency when information is freely accessible across care sites (and countries?)
 - My experience with Nebraska Lexicon and rollout of US extension has demonstrated to my satisfaction that extension management is scalable, tractable and affordable given a will to do so



Thank you!

