

Migrating post-coordinated SNOMED CT between systems

A case study: GE and Epic

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Disclosure

My employer, the University of Nebraska, currently receives financial support from General Electric for provision of vocabulary services



Agenda

- Requirements for successful use of clinical terminology
- History of SNOMED CT use at Nebraska
- Just-in-time (post)(pre)-coordination and Nebraska Lexicon©
- What is an extension namespace?
- Maintaining a SNOMED extension in GE
- Migrating Nebraska Lexicon© to EPIC
- Experiences and observations regarding the US vendor market



Requirements for Successful Implementation of Clinical Terminology in the EHR

- Expressive:
 - Comprehensive content
 - Unambiguous
 - Provides variable semantic granularity
 - Supports parochial expression and terms
- Permanence
- Data re-use:
 - Clinical data record must support information needs of multiple users especially revenue, research and epidemiology
- Decision analytical:
 - Supports aggregation of clinical reference groups by relevant semantics
 - Includes relevant declarative domain knowledge
- Interoperable:
 - Reliably supports machine-based transmission and integration of conceptual content
- FREE OF CHARGE



SNOMED CT operational features

- Studies of content document best clinical comprehension and expression
- Well designed history management scheme
- Core content supported by many subsets and maps to classifications
- Model of meaning has become more mature
- Formalisms for testing of equivalence and subsumption have been developed and tested experimentally
- Free for use in the US



Fifteen years of experience with SNOMED

- 1982: Implementation of COSTAR problem-oriented record with structured vocabulary
- 1997: Conversion to SNOMED International V3
 - No formal model of meaning
 - Confusion regarding management of context
 - Comprehension ~ 80%
- 1999: SNOMED RT
 - First formalisms for model of meaning
- 2002: SNOMED CT
 - Comprehension ~ 92%
 - Formalisms for interoperable use of semantic definitional model



Nebraska Lexicon© for GE

- Implementation principles:
 - Fully capture and encode content of any clinical utterance requested by clinicians employing SNOMED formalisms; use pre-coordinated content when available, otherwise post-coordinate as required
 - Employ pragmatic set of SNOMED terms for lookup and expand entrance (interface) terms as required by the clinician for ease of clinical navigation and selection
 - Maintain maps from each diagnostic concept to ICD-9-CM for billing and epidemiological reporting
- Post-coordination at the user interface has been managed using “Just-in-time” administrative protocols



“Just-in-time pre(post)-coordination”

- If clinician cannot identify the required clinical phrase when making an entry into the problem list; records “Unlisted problem” in the record with a full text description
- Clinical coding team obtains weekly report of entries
- Clinical utterance is evaluated:
 - Disambiguated; term list expanded
 - Compared to SNOMED pre-coordinated content
 - Mapped to ICD-9-CM
- New terms are added to the interface and pointed to the SNOMED CT concept identifier in the dictionary tables
- New concepts are modeled as extensions to SNOMED CT in an extension namespace which is maintained within a terminology database
- The “Unlisted problem” pointer in the database is updated to a dictionary reference with the complete and accurate content
- The problem list history files maintain a record of the original entry in addition to the fully modeled and coded content now in the record



What is an Extension?

A SNOMED CT extension has two main defining characteristics.

- First, it consists of SNOMED CT components that are identified by SCTIDs that have a unique identifying namespace, which is the namespace identifier of the extension.
- Second, the extension and its SCTID namespace are controlled and managed by a single organization that has the responsibility of maintaining the extension and following certain rules associated with the creation and distribution of the identifiers and other SNOMED CT compatible structures in the extension.

**Nebraska Lexicon© post-coordinated content has been maintained as an Extension namespace since formalization of the process in 2005
Namespace ID 1000004**



Lexicon Semantic Classes

Status:

- Active problems
 All problems
 Entered in error

Search:

At this time, we will no longer be adding new vocabulary to Centricity. Unlisted Problem no longer available.

Prb#	2nd	Sta...	Category	...	Problem and Modifier	Onset	.. Last Upd	Last Prvd	
1		A	Hlth Mt	P	Health care maintenance		...13Aug98	SCHMIDT, D...	
10		A	Hlth Mt	P	Family history of breast cancer		...20Sep97	Thierfelder,	
59		A	Hlth Mt	D	History of colon polyps	20APR00	...23Feb09	Brand, Randa	
265		A	Hlth Mt	D	DO NOT RESUSCITATE	07Apr10	...21Jun10	Wierda, Sara	
9		A	History	P	Lumbar diskectomy with arthrodesis		...20Sep97	COCHRAN, ...	
29		A	History	P	Cataract removal, OS	23JAN98	...30Jan98	Yablonski, M	
37		A	History	P	Exercise echocardiogram, DSE	29MAR19	...30Mar99	Khankirawata	
39		A	History	D	Egd with biopsy, Gastric atrophy	11/15/7	...21Nov07	Schafer, Dan	
61		A	History	D	Colonoscopy, Sigmoid diverticulosis	11/15/7	...22Aug09	Schafer, Dan	
103		A	History	D	Ulnar nerve decompression	1/8/03	...31May03	Nystrom, Nil	
244		A	History	D	Bilateral salpingoophorectomy	Aug08	...10Aug09	Campbell, Ja	
259		A	History	D	Aortic valve replacement	09Mar10	...7-Apr10	Dorheim, Tra	
2		A	Ongoing	D	Bronchiectasis		...20Jun07	Carlson, Rod	
20		A	Ongoing	P	Cystoid macular degeneration, OS	17Oct97	...12Jul04	Eye vis fiel	
26		A	Ongoing	P	Cervical stenosis	10Dec97	...24Sep04	Carlson, Rod	
43		A	Ongoing	P	Coronary arterial disease	28Jun99	...15Aug05	Carlson, Rod	
51	43	A	History	D	Cardiac catheterization, Nonobstructive CAD; severe AS	1/27/10	...8-Feb10	Campbell, Ja	

Add

Update/Resolve

Review

Remove in Error

Audit Trail

Assoc Visits

Set Preferences..

Previous Screen...



Lexicon Semantic Classes

- Health maintenance and risk
- Family history
- Past medical history
- Procedure history
- Findings
- Diagnoses
- Events

Status: Active problems All problems Entered in error Search:

At this time, we will no longer use new vocabulary for Centricity. Problem no longer available.

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10		A	Hlth Mt	P	Family history of breast cancer			20Sep97	Th
59		A	Hlth Mt	D	History of colon polyps	20APR00		23Feb09	Br
265		A	Hlth Mt	D	DO NOT RESUSCITATE	07Apr10		21Jun10	Wi
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29		A	History	P	Cataract removal, OS	23JAN98		30Jan98	Ya
37		A	History	P	Exercise echocardiogram, DSE	29MAR19		30Mar99	Kh
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103		A	History	D	Ulnar nerve decompression	1/8/03		31May03	Ny
244		A	History	D	Bilateral salpingoophorectomy	Aug08		10Aug09	Ca
259		A	History	D	Aortic valve replacement	09Mar10		7-Apr10	Do
2		A	Ongoing	D	Bronchiectasis			20Jun07	Ca
20		A	Ongoing	P	Cystoid macular degeneration, OS	17Oct97		12Jul04	Ey
26		A	Ongoing	P	Cervical stenosis	10Dec97		24Sep04	Ca
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Lexicon Semantic Classes

Centricity Enterprise

- Health maintenance and risk
- Family history
- Past medical history
- Procedure history
- Findings
- Diagnoses
- Exposures and occurrences

SNOMED CT Root

- Clinical findings
- Situation with exp context
- Situation...
- Procedure (situation...)
- Clinical findings
- Disease
- Events



Lexicon Examples

Centricity Enterprise

- Health maintenance and risk
- Family history
- Past medical history
- Procedure history
- Findings
- Diagnoses
- Exposures and occurrences

Terms

- Risk for aspiration
- FHx of glioblastoma
- PH of gastric ulcer
- ORIF right clavicular fracture
- Right carotid stenosis;
Secondary pneumonia
- Cadmium exposure



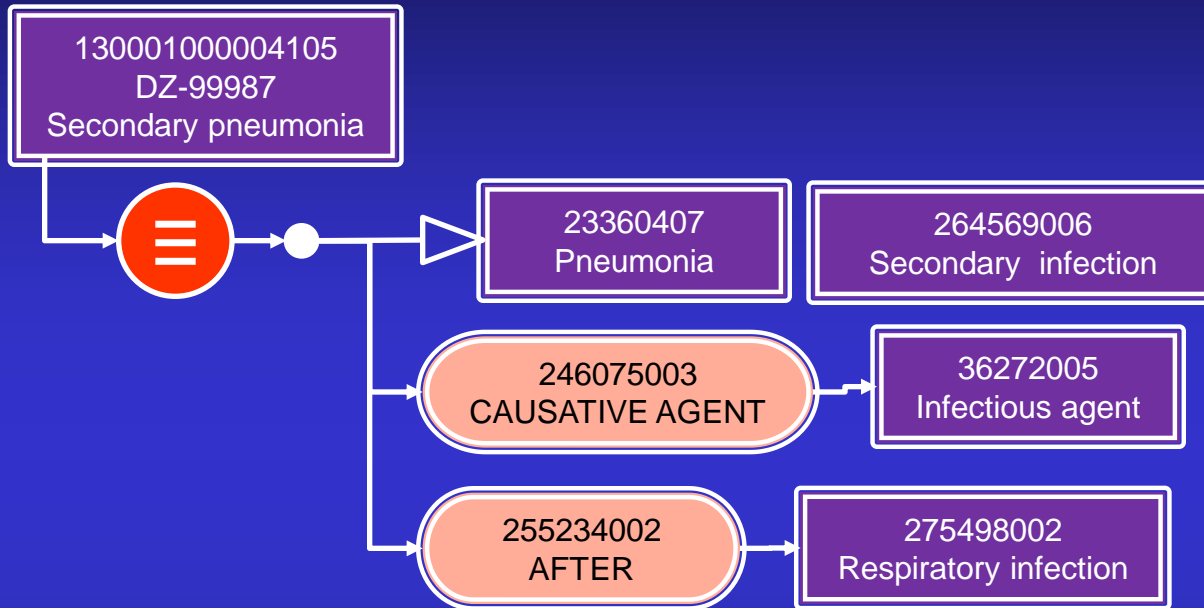
“Secondary pneumonia”

▼ Pt. Info & Misc.	▼ Orders	▼ Notes	▼ Procedures	▼ Lab	▼ Ancillary	▼ Inpatient View	▼ Outpatient View	▼ Meds	▼ Flowcharts
Patient Name:			Primary: Attending: Current User: CAMPBELL, JAMES		DOB / AGE: Day Ph #: Night Ph #:		Room Bed:		
<p><i>Table 22: Vocabulary</i></p> <p>Function (Add, Change, Display): <input type="text" value="D"/></p> <p>Sequence #: <input type="text" value="8586"/></p> <p>Look-up Code: <input type="text"/></p> <p>Diagnosis: <input type="text" value="Secondary pneumonia"/></p> <p>Alternate 1: <input type="text" value="Pneumonia occurring as secondary infection"/></p> <p>Alternate 2: <input type="text"/></p>									
<p>Coding Schemes</p> <p>ICD9 Code: <input type="text" value="486"/></p> <p>ICD9(2) Code: <input type="text"/></p> <p>CPT-Code: <input type="text"/></p> <p>CPT Modifier: <input type="text"/></p>			<p>SNO-Med Definitions</p> <p>Finding/Indication: <input type="text" value="02-99987"/></p> <p>Procedure: <input type="text"/></p> <p>Assoc-Function: <input type="text"/></p> <p>Assoc-Topo: <input type="text"/></p> <p>Assoc-Morph: <input type="text"/></p> <p>Assoc-Etiology: <input type="text"/></p> <p>Chemical: <input type="text"/></p> <p>Agents: <input type="text"/></p> <p>Context: <input type="text"/></p> <p>Social: <input type="text"/></p>			<p>UMLS Codes</p> <p>UMLS-LUI: <input type="text"/></p> <p>UMLS-SUI: <input type="text"/></p> <p>UMLS-CUI: <input type="text"/></p> <p>Type: <input type="text"/></p> <p>Discipline: <input type="text"/></p>			
<p>Problem Related Fields</p> <p>Default category: <input type="text" value="4"/></p> <p>Valid problem: <input type="text" value="Y"/></p> <p>Secure problem: <input type="text"/></p> <p>Auto Resolve days: <input type="text"/></p>			<p>Age/Sex Definitions</p> <p>Fully-qualified ICD9 Code (Y/N): <input type="text"/></p> <p>Sex-specific Diagnosis: <input type="text"/></p> <p>Age-specific to Range: <input type="text"/> - <input type="text"/></p>			<p>Preferred Synonym: <input type="text"/></p> <p>Active/Inactive (A/I): <input type="text" value="A"/></p>			
						L076435	0.0	S	DICT22



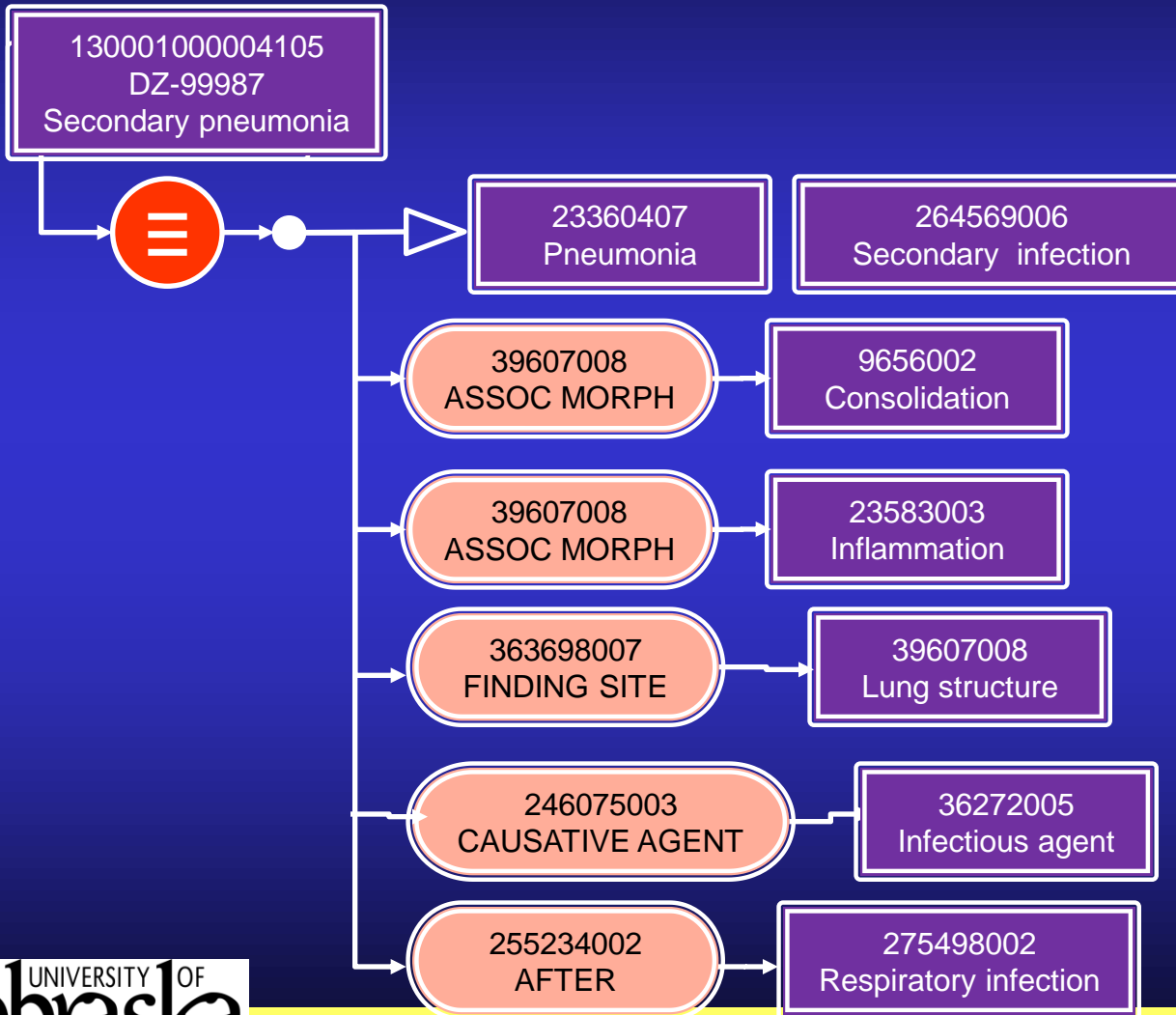
“Secondary pneumonia”

Modelled (stated) form



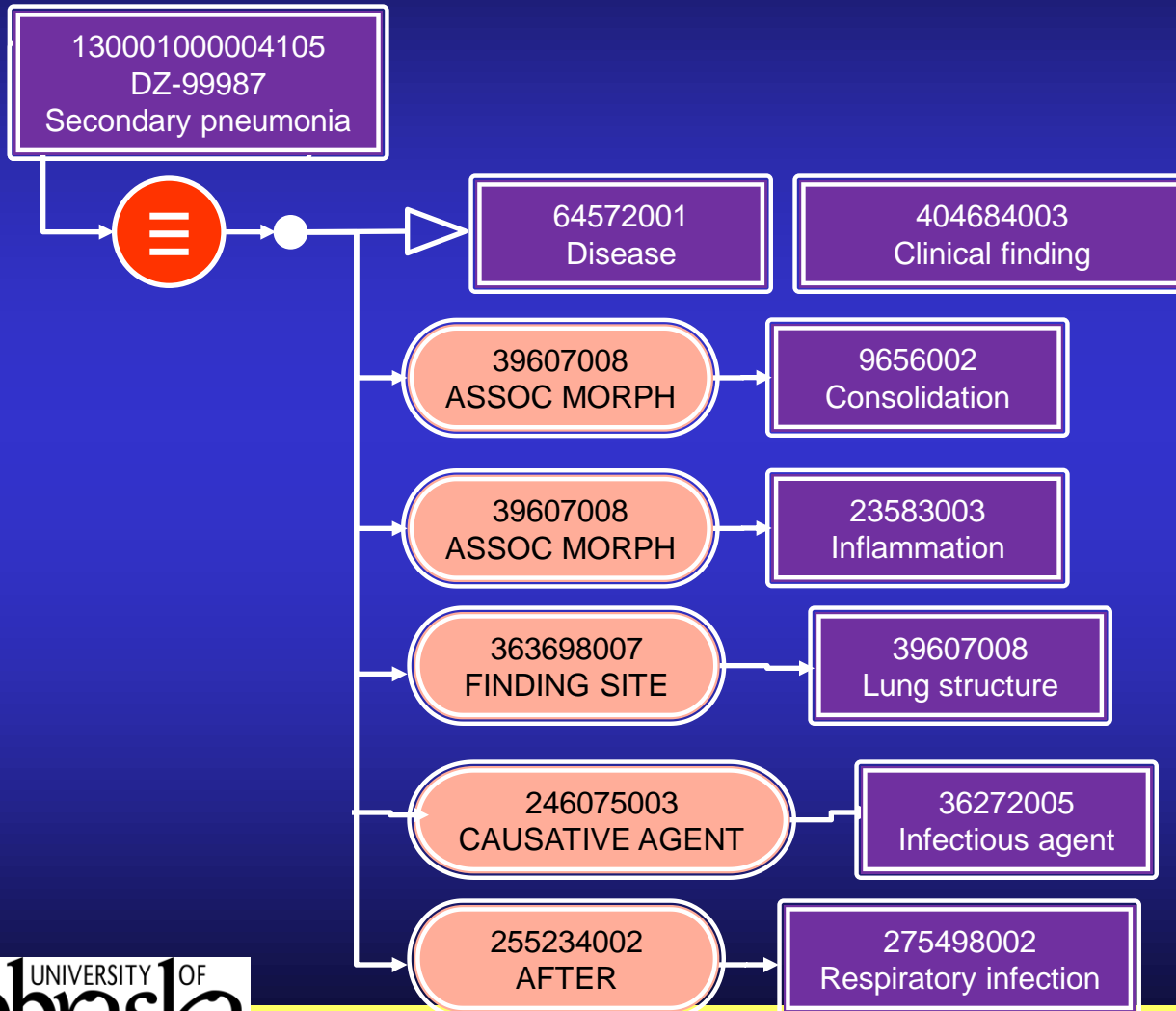
“Secondary pneumonia”

Normal form



“Secondary pneumonia”

What would be Normal form if concepts were fully defined



Lexicon© Facts and Figures: 2012

- 2838 post-coordinated concepts:
 - 463 Findings
 - 1040 diseases
 - 1002 procedures
 - 303 situations
 - 23 events
- 7203 descriptions (terms)

Failures of Clinical Expression

- Majority of post-coordination issues for problem list are required for statements of clinical specialization:
 - “Increased wound drainage”
 - “History of fecal impaction”
 - “Cervicobrachial chest pain”

Majority of primitive Lexicon concepts relate to infrequent deficiencies in SNOMED model of meaning:

- “HOMOZYGOUS C6777T METHYLENETETRAHYDROFOLATE REDUCTASE DEFICIENCY (DISORDER)”
- “PATIENT HAS BEDTIME ROUTINE (FINDING)”
- “HOME NASAL BIPAP USE (PROCEDURE)”

Lexicon contains only 5% primitives

Permanence: SNOMED CT History Management

- Each SNOMED release cycle exposes editorial revisions:
 - New pre-coordinated content must be compared against extension namespace content
 - Editorial changes participating in definitions of post-coordination must be reviewed
- Clinical definition of any problem list entry must never be allowed to change, although the SNOMED concept identifier may do so
- Average annual retirement of post-coordination 6%



Evaluating Decision Support

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



Guideline Concept Inventory by Semantic Complexity

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

GE Limitations

- Data dictionary tables created in the era of SNOMED III support only SNRT identifiers, one defining concept per semantic root and no role groups
- Integration of SNOMED ontology (concepts and relationships) into data dictionary never completed
- Binding of SNOMED concept space (including extension) to decision support and clinical queries never completed



Lexicon© GE Report Card

- Expressivity:
 - Primary reason for continued success of Lexicon implementation is timely delivery of meaningful terms within a consortium of shared use
 - Authoring of post-coordinated concepts are a secondary and tractable issue
- Data re-use:
 - Complete and current map to ICD-9-CM has been an ongoing requirement and important to implementation at all US sites
 - Contention between clinical and reimbursement use cases is largest ongoing editorial problem; managed only with tight control
- Permanence:
 - Managed within SNOMED CT history mechanisms and extension management utilities created on-site; not integrated into GE
- Decision analytical:
 - Preliminary experiments employing SNOMED extension integrated with clinical record have demonstrated superior utility of deployment
 - GE not equipped to employ semantics in decision engine
- Semantic interoperability:
 - Challenges are substantial and relate to deployment of full SNOMED model within a consistent information model; Tag level interoperation supported
- Costs:
 - Acceptable and well managed by resources within community of shared use

EPIC conversion

- 2011 NMC signed contract with Epic for comprehensive implementation of software and conversion of GE EHR
- Structured clinical data from Centricity to be converted including SNOMED data which Epic “supports” and encourages
- Epic recommended IMO for vocabulary conversion and maintenance; we elected to employ them for problem list/encounter diagnoses and procedure history; expecting to convert allergy, PMH, FH SNOMED data ourselves



EPIC Conversion

- EPIC loads SNOMED CT international release subsumption (hierarchical) relationships periodically into master file to support concept groupers
- Agreement with IMO negotiated to:
 - 1) map or add term space from Lexicon to IMO lexicals
 - 2) supply all mappings to ICD* integrated within Epic,
 - 3) convert post-coordinated concepts with associated terms from Lexicon into Epic installing stated form relationships as additional “mappings” in master file



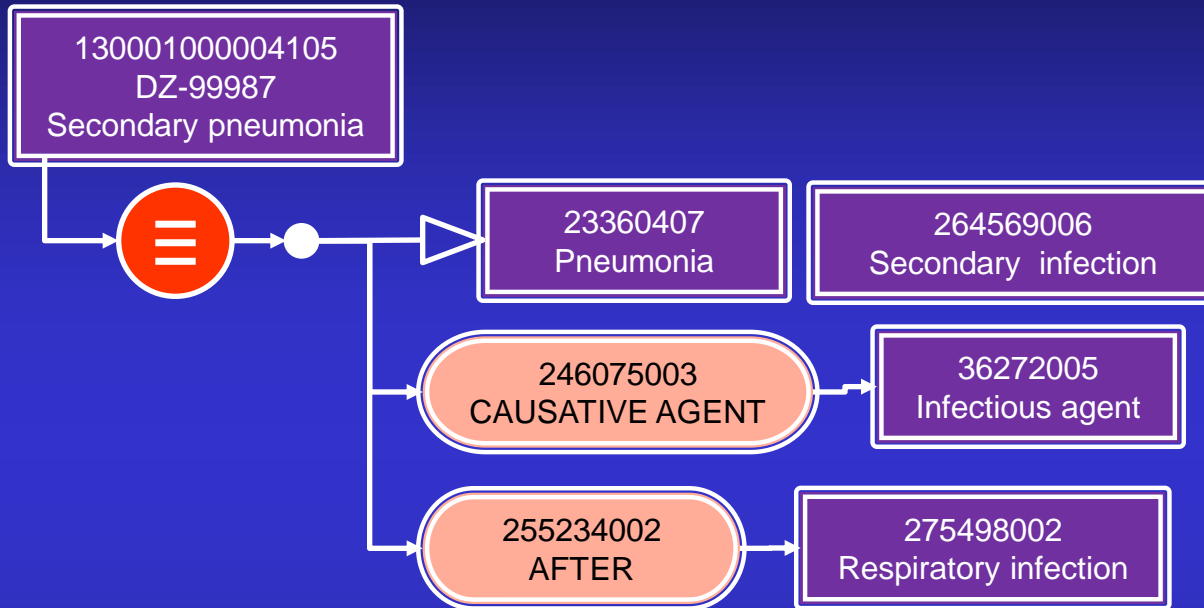
EPIC Conversion

- Very short timeline for implementation led to adherence to EPIC model system
- Conversion mappings provided by IMO were not provided with sufficient understanding of Epic database to work seamlessly
- Terms and ICD mappings for problem list were excellent out of the box
- Procedure history could not be converted due to pressure of implementation scheduling
- Lexicon port-coordinated data (defining relationships) were not implemented



“Secondary pneumonia”

Modelled (stated) form



“Secondary pneumonia”

Concept Mappings

External Concept Mappings

Entity

INI: EDG [Diagnosis Mast] Item: .1 [DIAGNOSIS ID] ID/Category: Secondary pneumonia

- EDG - Diagnosis Master
 - .1 - DIAGNOSIS ID
 - 638043 - Secondary pneumonia
 - More Records
 - .2 - DIAGNOSIS DESCRIPTION
 - 5 - RECORD STATE
 - 6 - NAME HISTORY
 - 7 - NAME - MIXED CASE
 - 9 - LOGICAL OWNER
 - 10 - CONTACT NUMBER
 - 11 - COMMUNITY ID
 - 12 - CID DESCRIPTOR
 - 13 - TEMPORARY NAME EDIT
 - 15 - UNIQUE CONTACT IDENTIFIER
 - 16 - UCI COMMUNITY DESCRIPTOR
 - 17 - PHYSICAL OWNER
 - 20 - CONTACT DATE
 - 21 - CONTACT OWNER
 - 30 - TYPE OF CONTACT
 - 35 - CONTACT COMMENT
 - 40 - EXTERNAL ID
 - 45 - DIAGNOSIS STATUS - DISCONTINUED
 - 46 - EFFECTIVE DATE FROM
 - 47 - EFFECTIVE DATE TO
 - 50 - DIAGNOSIS SYNONYM
 - 51 - DIAGNOSIS SYNONYM CONCEPT ID
 - 52 - DIAGNOSIS SYNONYM IMO ID
 - 55 - SURGICAL PROCEDURE
 - 60 - ALTERNATE CODE
 - 70 - NORMAL LENGTH OF STAY

Concept mapped to the entity:

	Mapping Type	Concept
1	Reference Concept [1]	PNEUMONIA [SNOMED#233604007]
2	Reference Concept [1]	SECONDARY INFECTION [SNOMED#264569006]
3		

Details

View only --- The mapping is standard.

Entity Info

INI: EDG - Diagnosis Master
Item: .1 - DIAGNOSIS ID

Terminology Info

Id: 3513727
Name: PNEUMONIA
Concept id: SNOMED#233604007

Lexicon EPIC Report Card

- Expressivity:
 - IMO added substantially to terms available for capture of structured clinical data; well received clinically
 - Turn-around and responsiveness of clinical term additions yet to be tested
- Data re-use:
 - IMO mappings to ICD-9-CM and ICD-10-CM have eased Nebraska on-site management requirements and appear sound
- Permanence:
 - Nebraska maintenance of post-coordination required; not integrated into EPIC
- Decision analytical:
 - EPIC deployment of extension semantics is developmental and not supported at this time by IMO updates
 - Integration into EPIC grouper aggregation tools is limited to subsumption (although EPIC utilities suggest more to come)
- Interoperability:
 - “Tag” level semantic interoperability (SNOMED concept ID) supported in EPIC Care Everywhere
- Costs:
 - To be evaluated incrementally in addition to IMO yearly contract costs



Observations

- SNOMED concept ID binding to vendor data dictionaries has been fueled by MU requirements
- Mappings to classifications are supporting re-use of clinical data and are central to success in US
- Emergence of tag level semantic interoperation in EHR communication (again fueled by MU)
- These US vendors do not understand expressivity of SNOMED model of meaning and are spending little to employ defining relationships in query/decision support
- Variety of information models and architectures means that there is no standard tooling for support of extensions at enterprise level



Discussion?

