Conflict of Interest

Richard E. Biehl, Ph.D.

Ownership Interest: Richard is the sole proprietor of Data-Oriented Quality Solutions (DOQS), an IT/Quality consulting practice founded in 1988 and operating out of Orlando, Florida, USA.

Consulting Fees: Richard earns approximately 15% of his income from consulting engagements that involve the heuristics included in this presentation.

Other: The heuristics in this presentation can be immediately and directly implemented by attendees. Nothing has been held back that would necessitate engaging DOQS for implementation.
Learning Objectives

1. Demonstrate how the HIT human-machine interface relies on the semantic abilities of human participants
2. Categorize the three semantic layers relevant to clinical data warehouse design
3. Employ an ontological framework for mapping and modeling system-practice-phenotype data
4. Illustrate how semantic ontologies can resolve common problems in warehousing, using the ICD-9 to ICD-10 conversion problem as an example
5. Propose a reasoning-based warehouse design that can learn on behalf of human participants who are increasingly overwhelmed by the flow of big data
Mapping to STEPS™

Value Steps

Health IT creates five kinds of value of benefit to patients, healthcare providers and communities.

S - SATISFACTION
Patient, Provider, Staff, Other
Improved communication with patients, patient satisfaction score, and internal communication.

T - TREATMENT/CLINICAL
Safety, Quality of Care, Efficiency
Improved patient safety and scheduling, reduction in medical errors and readmissions.

E - ELECTRONIC INFORMATION/DATA
Evidence Base Medicine, Data Sharing and Reporting
Increased use of evidence-based guidelines, population health reporting, and quality measures reporting.

P - PREVENTION & PATIENT EDUCATION
Prevention, Patient Education
Improved disease surveillance and patient compliance, increased immunizations, longitudinal patient analysis.

S - SAVINGS
Financial/Business, Efficiency Savings, Operational Savings
Increased volume, reduction in days in accounts receivable, and reduced patient wait times.

http://www.himss.org/ValueSuite
Previous HIMSS Presentations

Fundamentals of Data Warehousing in Healthcare
2013 HIMSS Annual Conference, New Orleans

Implementing a Healthcare Data Warehouse in One year (Or Less)
2012 HIMSS Annual Conference, Las Vegas

Standardizing Data Dimensions of Healthcare Data Warehouses
2010 HIMSS Annual Conference, Atlanta

Success by Design: Effective Data Quality Measurements in a Hospital Data Warehouse
2008 HIMSS Annual Conference, Orlando
“Big Data” is about...

- New data base architectures and performance challenges,
- New analytical paradigms and ways of seeing the world through data,
- New design patterns for bringing together and using vast amounts of data,
- New social and ethical challenges that need to be addressed within all of these new opportunities,
- And all of the everyday mundane issues of systems and software engineering that we’ve always been challenged to address, writ large.
The Central Challenge

• “Big Data” increases the urgency of having strong control over our information.
• The human-machine interface relies on the semantic abilities of the human participant.
• We need to engineer controlled semantics into our systems…
• We want systems that can reason and learn on behalf of the human participant that is increasingly overwhelmed by the volume and flow of big data.
Semantic Layers in a Biomedical Data Warehouse

• **System**
  – What is in the *dataset* or *message*?

• **Practice**
  – What is the *provider* doing or thinking?

• **Phenotype**
  – What’s right or wrong with the *patient*?
An Ontological Framework

Basic Formal Ontology (BFO)

- Information Artifact Ontology (IAO)
- Ontology for Biomedical Investigation (OBI)
- Ontology of General Medical Science (OGMS)

Biomedical Syntax

Biomedical Semantics

- Hypotheses & Conclusions
- Observations

Biomedical Epistemology
Basic Formal Ontology

- Entity
  - Continuant
  - Occurrent
Basic Formal Ontology

- Continuant
  - Spatial Region
  - Independent Continuant
    - Material Entity
    - Object Boundary
    - Site
  - Dependent Continuant
    - Generically Dependent Continuant
    - Specifically Dependent Continuant
      - Quality
      - Realizable Entity
  - Dependent Continuant
    - Object Aggregate
    - Object
    - Fiat Object Part
    - Disposition
    - Function
    - Role
Basic Formal Ontology

Occurrent

- Processual Entity
  - Process
  - Fiat Process Part
  - Processual Context
  - Processual Boundary
- Spatiotemporal Region
- Temporal Region

Process Aggregate
Basic Formal Ontology

Standardizing Data Dimensions of Healthcare Data Warehouses
2010 Annual HIMSS Conference & Exposition, Atlanta, Georgia, USA

HIMSS10

HIMSS13
Basic Formal Ontology (BFO)

Information Artifact Ontology (IAO)

What is in the dataset or message?
Information Artifact Ontology (IAO)

Ontology for Biomedical Investigation (OBI)

What is in the dataset or message?

What is the provider doing or thinking?
Continuant

Independent Continuant

Dependent Continuant

Generically Dependent Continuant

Specifically Dependent Continuant

Role

Quality

Ontology for Biomedical Investigations (OBI)

Organism

Diagnosis

Patient Role

Biological Sex

Age

Alive

Basic Formal Ontology (BFO)
Basic Formal Ontology (BFO)

- Information Artifact Ontology (IAO)
  - What is in the dataset or message?

- Ontology for Biomedical Investigation (OBI)
  - What is the provider doing or thinking?

- Ontology of General Medical Science (OGMS)
  - What's right or wrong with the patient?
Continuant

Independent Continuant

Specifically Dependent Continuant

Occurrent

Processual Entity

Process Aggregate

Extended Organism

Disorder

Pathological Anatomical Structure

Sign or Symptom

Disease

Pathological Bodily Process

Disease Course

Extended Organism experiences Disease Course instance of a Disease resulting from a Disorder with disposition toward Pathological Bodily Process which produces Pathological Anatomical Structure recognized as Sign or Symptom
The three mid-level ontologies are mapped to each other through the common BFO framework. The values in the messages end up being at a different ontological level than the semantic meaning of those values, allowing for translation, harmonization, and quality control to intervene as systems data in messages is translated into clinical data in systems.

Inbound messages (e.g., CCD) are mapped as field-level information artifacts back to the clinical processes that evaluated the patient. The contents of those messages – the values of those information artifacts – are then mapped into a clinical picture of the patient.
Information Artifact Ontology (IAO)

Basic Formal Ontology (BFO)

Ontology for Biomedical Investigation (OBI)

Ontology of General Medical Science (OGMS)

Biomedical Syntax

Biomedical Semantics

SNOMED, ICD, CPT, RxNORM, LOINC, MeSH, etc.
Ontology-Based Design

- Source ETL analysis & mapping
- Warehouse logical database design
- Post-load spider processing
- Conducting queries & analysis
	<!-- US General Header Template -->
	<templateId root="2.16.840.1.113883.10.20.22.1.1" />
	<templateId root="2.16.840.1.113883.10.20.22.1.2"/>
	:id extension="TT988" root="2.16.840.1.113883.19.5.99999.1"/>
	<code codeSystem="2.16.840.1.113883.6.1" codeSystemName="LOINC" code="34133-9" displayName="Summarization of Episode Note"/>
	<title>Community Health and Hospitals: Health Summary</title>
	<effectiveTime value="201209150000-0400"/>
	<confidentialityCode code="N" codeSystem="2.16.840.1.113883.5.25"/>
	<languageCode code="en-US"/>
	<setId extension="sTT988" root="2.16.840.1.113883.19.5.99999.19"/>
	<versionNumber value="1"/>
	<component>
		<structuredBody>
			<section>
			<templateId root="2.16.840.1.113883.10.20.22.2.5" />
			<templateId root="2.16.840.1.113883.10.20.22.2.5.1" codeSystem="2.16.840.1.113883.6.96" codeSystemName="LOINC" code="445518008" displayName="Age At Onset"/>
			<statusCode code="completed"/>
			<value xsi:type="PQ" value="57" unit="a"/>
		</observation>
		</entryRelationship>
	</section>
	</component>
</clinicalDocument>
null
observation

<classCode> “OBS”
<templateID> 
<root> “2.16.840.1.113883.10.20.22.4.6”

<moodCode> “EVN”
<id> 
<root> “ab1791b0-5c71-11db-b0de-0800200c9a66”

code

<codeSystem> “2.16.840.1.113883.6.1”
<code> “33999-4”
<displayName> “Status”

statusCode <code> “completed”

effectiveTime

Low <value> “20080103”
High <value> “20090227130000+0500”

code

<type> “CD”
<codeSystem> “2.16.840.1.113883.6.96”
<code> “413322009”
<displayName> “Resolved”

entryRelationship <typeCode> “REFR”

entryRelationship

<typeCode> “SUBJ”
<inversionInd> “true”

observation

<classCode> “OBS”
<templateID>
<root> “2.16.840.1.113883.10.20.22.4.31”

<moodCode> “EVN”

code

<codeSystem> “2.16.840.1.113883.6.96”
<code> “445518008”
<displayName> “Age At Onset”

statusCode <code> “completed”

value

<type> “PQ”
<integer> “57”
<unit> “a”

HIMSS15
observation

<codeSystem> "2.16.840.1.113883.6.1"</codeSystem>
<displayName> "Health Status"

<classCode> "OBS"
<templateID <root> "2.16.840.1.113883.10.20.22.4.5"

<moodCode> "EVN"
<id <root> "ab1791b0-5c71-11db-b0de-0800200c9a66"

<codeSystem> "2.16.840.1.113883.6.96"
<displayName> "Alive and well"

<code> "81323004"
<codeSystemName> "LOINC"
<codeSystemName> "SNOMED CT"

<codeSystem> "2.16.840.1.113883.6.96"
<code> "81323004"
<displayName> "Alive and well"

<statusCode <code> "completed"

effectiveTime

Low <value> " 20080103"
High <value> " 20090227130000+0500"

value

<codeSystemName> "SNOMED CT"
<type> " CD"
<codeSystem> "2.16.840.1.113883.6.96"
<code> "81323004"
<displayName> "Alive and well"
Age Observation
  <value>

Problem Observation <start>

Problem Observation <stop>

Problem Observation <code>

Material Information Bearer

CCD XML

Information Content Entity

Generically Dependent Continuant
Complaint

Start Time

Stop Time

age_at_onset

date_high

date_low

ProblemSchema: coded diagnosis

type

Information Content Entity

Material Information Bearer

CCD XML

Age At Onset (445518008)

Start Time (398201009)

Stop Time (397898000)

Complaint (409586006)

“29”

“2006-03-22”

“2006-04-22”

“409586006” “Complaint”

Information Carrier

Specifically Dependent Continuant

Generically Dependent Continuant

SNOMED (Functional Classes)

35
Problem: 480.0 Pneumonia due to adenovirus

Complaint (409586006)

Start Time (398201009)

Stop Time (397898000)

Age At Onset (445518008)

Problem Observation <value>

Problem Observation <start>

Problem Observation <stop>

Problem Observation <code>

Information Carrier

Specifically Dependent Continuant

Generically Dependent Continuant

Information Content Entity

Material Information Bearer

CCD XML
Information Artifact Ontology (IAO)

ClinicalDocument/templateId/@root="2.16.840.1.113883.10.20.22.1.2"

//section/templateId/@root="2.16.840.1.113883.10.20.22.2.5.1"

//entry/@typeCode="DRIV"
//act/@classCode="ACT"
//@moodCode="EVN"
//templateId/@root="2.16.840.1.113883.10.20.22.4.3"
//code
//effectiveTime
//low
//high
@code
@value
//entryRelationship/@typeCode="SUBJ"
//observation/@classCode="OBS"
//@moodCode="EVN"
//templateId/@root="2.16.840.1.113883.10.20.22.4.4"
//code
@code
@codeSystem
@value
@codeSystem
@type
@value

Concern

"CONC"
"20070103"
"20070103"

Complaint

@code
@codeSystem
@value

Pneumonia

"409586006"
"2.16.840.1.113883.5.6"
"CD"
"233604007"
"2.16.840.1.113883.6.96"

InversionInd"true"

Age at Onset
57 years

Summarization of Episode Note

Information Content Entity

Information Carrier
Concern

Complaint

Resolved

Age at Onset
57 years

Problem List

Pneumonia

Asthma

Active

Resolved

Health Status

Alive & Well

Status
Concern

Status

Problem List

Summarization of Episode Note

Resolved

Age at Onset
57 years

Metadata Layer
Defines the meaning of the entryRelationship at the next highest layer

Contains entryRelationships with variable meaning

Classes can include classes below them in the ICE mappings

Class with related value

Class with embedded attribute value
Under this scenario, there would no longer be classes or tables for the various LOINC codes that define the semantics of each <entryRelationship>. They instead become the schema definition for the <entry> in which they are found.
Information Artifact Ontology (IAO)

ClinicalDocument/templateld/@root="2.16.840.1.113883.10.20.22.1.2"

//recordTarget//patientRole

Patient Role

Protected

Patient-related Identification code (422549004)

//Id

Id

@extension

@root

“MRN1234567”

Medical Record Number (MRN)

(2.16.840.1.113883.19.5.2)

CRID

Individual organism identifier

Information Carrier

Information Content Entity

Problem List

//section/templateld/@root="2.16.840.1.113883.10.20.22.2.5.1"
Secure any continuant that identifies something in which a protected role inheres, or anything extending or derived from such a continuant.
Simple Knowledge Organization System (SKOS)
Assertion:  \( XY \) closeMatch\(^1\) LM

Known:
- LM isA L
- LMN isA LM

Implied:
- L narrowMatch XY
- LMN broadMatch XY

By inverse rule:
- XY broadMatch L
- XY narrowMatch LMN

\(^1\) Any ontology edge that has been curated to closeMatch would have the same implications.
CPT 86900
“Blood typing; ABO”

CPT 86901
“Blood typing; Rh (D)”

LOINC 882-1
“ABO + Rh group, Blood”

LOINC 884-7
“ABO + Rh group, Blood Capillary”

LOINC 34474-7
“ABO + Rh group, Cord Blood”
79.21 ICD-9CM
Open reduction of fracture without internal fixation, humerus

78.12 ICD-9CM
Application of external fixator device, humerus

304.71 ICD-9CM
Application of external fixator device, monoplanar system

0PSC0BZ ICD10PCS
Reposition Right Humeral Head with Monoplanar External Fixation Device, Open Approach

0PSD0BZ ICD10PCS
Reposition Left Humeral Head with Monoplanar External Fixation Device, Open Approach

84.71 ICD-9CM Application of external fixator device, monoplanar system
Rosuvastatin

Crestor

Crestor . tradenameOf . Rosuvastatin  {broadMatch}
Rosuvastatin . hasTradename . Crestor  {narrowMatch}
The mess!
Refractory Migraine (423894005)

Lower Half Migraine (26150009)

Refractory Migraine (423894005)

Migraine (37796009)

Vascular Headache (128187005)

Headache Disorder (340461009)

has_definitional_manifestation

Headache (25064002)
has_definitional_manifestation

Headache Disorder (340461009)

Vascular Headache (128187005)

Migraine (37796009)

Lower Half Migraine (26150009)

Refractory Migraine (423894005)

Migraine (346)

Migraine, unspecified (346.9)

Headache (25064002)

Headache (748.0)
Refractory Migraine (423894005)

Lower Half Migraine (26150009)
Refractory Migraine (423894005)

Vascular Headache (128187005)
Migraine (37796009)

Migraine (346)
Migraine, unspecified (346.9)
Migraine, unspecified, not intractable (G43.909)
Cluster headache syndrome, unspecified (G44.00)

Other migraine (G43.8)

Lower half migraine

has_definitional_manifestation

Headache (25064002)
Headache (748.0)

Headache (R51)

excludes

synonymOf
Have a migraine?

ICD-10 excludes Lower Half Migraine from Migraine, but SNOMED still includes it.
Data Warehousing with Semantic Ontologies

- Inclusion and mapping of BFO, IAO, OBI, and OGMS ontologies
- Inclusion and mapping of additional domain ontologies of interest
- Continuous analysis of SKOS consistency and compliance
- Tailoring of query layer to incorporate governance-approved semantic mappings and exceptions
Mapping to STEPS™

Value Steps

Health IT creates five kinds of value of benefit to patients, healthcare providers and communities.

TOP STORY

Rural Independent Practice Named 2013 Davies Recipient
White River Family Practice located in White River Junction, Vermont has been named a 2013 Davies recipient by HIMSS.
© 10/01/2013

Read More

http://www.himss.org/ValueSuite
Questions

You are welcome to contact me with questions at any time:

- **Richard E. Biehl**, Ph.D.
  Data-Oriented Quality Solutions
- rbiehl@doqs.com
- LinkedIn: rbiehl
- Twitter: rbiehl