Terminology Needs in Clinical Decision Support

Samson Tu
Senior Research Scientist
Center for Biomedical Informatics Research
Stanford University

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Outline

- Context: Clinical decision support for guideline-based care
- Need for terminology content
  - Diagnostic: Finding, …
  - Therapeutic: Drug
- Need for terminology services

Clinical decision support for guideline-based care: SAGE Project

- Collaborative research and development project to develop a standards-based technology to enable encoding and dissemination of guidelines in executable format
- Guideline deployment technology will present guideline content to clinicians through active, patient-specific recommendations

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Immunization Guideline Schedule

Recommended Childhood and Adolescent Immunization Schedule UNITED STATES • 2005

<table>
<thead>
<tr>
<th>Vaccine</th>
<th>0 months</th>
<th>1 month</th>
<th>2 months</th>
<th>3 months</th>
<th>4 months</th>
<th>5 months</th>
<th>6 months</th>
<th>12 months</th>
<th>24 months</th>
<th>4-6 years</th>
<th>11-12 years</th>
<th>13-18 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hepatitis B</td>
<td>HepB #1</td>
<td>HepB #2</td>
<td>HepB #3</td>
<td>HepB Series</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
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<tr>
<td>Diphtheria, tetanus, pertussis</td>
<td>DTP</td>
<td>DTP</td>
<td>DTP</td>
<td>DTP</td>
<td>DTP</td>
<td>DTP</td>
<td>Td</td>
<td>Td</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Haemophilus influenzae type b</td>
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<td>Hib</td>
<td>Hib</td>
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<td></td>
<td></td>
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<td>Inactivated polio</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Mumps, rubella, varicella</td>
<td>MMR #1</td>
<td>MMR #2</td>
<td>MMR #2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Varicella</td>
<td></td>
<td>Varicella</td>
<td></td>
<td>Varicella</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Pneumococcal</td>
<td>PCV</td>
<td>PCV</td>
<td>PCV</td>
<td>PCV</td>
<td>PCV</td>
<td>PCV</td>
<td>PPV</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Influenza</td>
<td>Influenza (Yearly)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hepatitis A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Guideline recommendations integrated into a nurse care flowsheet:
- View suggested orders
- Process suggested orders

Real time access to reference information

“Activating Guideline Content”
### JNC VII Guideline for Management of Hypertension

#### Table 10. Oral antihypertensive drugs

<table>
<thead>
<tr>
<th>CLASS</th>
<th>DRUG (TRADE NAME)</th>
<th>USUAL Dose RANGE in mg/day</th>
<th>USUAL DAILY FREQUENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thiazide diuretics</td>
<td>chlorothiazide (Diuril)</td>
<td>125–500</td>
<td>1-2</td>
</tr>
<tr>
<td></td>
<td>chlorthalidone (Thalitone)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>hydrochlorothiazide (Hygroton)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>metolazone (Zem canceled)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>indapamide (Lozol)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loop diuretics</td>
<td>bumetanide (Bumex)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>furosemide (Lasix)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>torsemide (Demadex)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potassium-sparing diuretics</td>
<td>amiloride (Midamor)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aldosterone receptor blockers</td>
<td>spironolactone (Aldactone)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bis</td>
<td>azatadine (Tenormin)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Compelling Indications

Hypertension may exist in association with other conditions in which there are compelling indications for use of a particular treatment based on clinical trial data demonstrating benefits of such...

#### Table 12. Clinical trial and guideline basis for compelling indications

<table>
<thead>
<tr>
<th>COMPELLING INDICATION</th>
<th>RECOMMENDED DRUGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart failure</td>
<td></td>
</tr>
</tbody>
</table>

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### ATHENA HTN advisory

- **Guideline Name**: JNC VII Guideline for Management of Hypertension
- **Recommendation**: This guideline provides evidence-based recommendations for the treatment of hypertension, including the use of oral antihypertensive drugs.
- **Purpose**: To help healthcare providers make informed decisions about the management of hypertension in their patients.
SAGE Guideline Encoding Process

1. Assemble Source Guidelines
2. Envision Clinical Scenarios
3. Distill Guideline Logic
4. Define Guideline Concepts
5. Formalize Vocabulary Inventory
6. Specify Information Queries
7. Encode Guideline Knowledgebase

Guideline Installation and Execution


Clarifying Concept Definition...

- Anatomic or functional asplenia?

**Clinical Definition**
- Congenital asplenia
- Congenital hypoplasia of spleen
- Splenectomy
- Splenic atrophy
- Sickle cell disease
“Functional or anatomic asplenia”

- **Clinical Definition**
  - Congenital asplenia
  - Congenital hypoplasia of spleen
  - Splenectomy
  - Splenic atrophy
  - Sickle cell disease

- **SNOMED CT Concept**
  - 93030006
  - 93292008
  - 234319005 (Procedure)
  - 82893001
  - 127040003 (Hemoglobin S disease)

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**Are Subclasses OK?**

Specialization of terms part of definition

- Congenital absence of spleen (A)
- Splenic atrophy (B)
- Congenital hypoplasia of spleen (C)
- Hb SS disease (D)
- Functional asplenia
- Bilateral right-sidedness sequence
- Hereditary splenic hypoplasia
- Sickle cell anemia with high hemoglobin F

- Clinical finding
- Procedure
- Splenectomy
What do the concepts mean in terms of available data?

- Functional or anatomic asplenia is Presence of clinical finding at any time
  - Congenital asplenia or
  - Congenital hypoplasia of spleen or
  - Splenic atrophy or
  - Sickle cell disease
- OR
  - Record of splenectomy in the past

Sometimes Have to Define Terms through Post-Coordination

Suprarenal Artery Embolus

297143008

Pre-Coordinated

Post-Coordinated

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2929001</td>
<td>Occlusion of Artery</td>
</tr>
<tr>
<td>116676008</td>
<td>Associated Morphology</td>
</tr>
<tr>
<td>55584005</td>
<td>Embolus</td>
</tr>
<tr>
<td>363698007</td>
<td>Finding Site</td>
</tr>
<tr>
<td>89500000</td>
<td>Suprarenal Artery</td>
</tr>
</tbody>
</table>
Reviewing Concept Inventory: Binding to Standard Vocabulary

- A term used in a guideline may correspond to:
  - A single term in a standard vocabulary
  - A term and its is-a descendants
  - A Boolean (AND, OR, NOT) combination of terms and its is-a descendants
  - A post-coordinated term

- Rules of using terminologies with information models should be clear
  - e.g., HL7 Terinfo project harmonizing HL7 RIM with SNOMEDCT

Use of SNOMED CT in Immunization Guideline Terminology

<table>
<thead>
<tr>
<th>Category</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category 1 (Concept entity)</td>
<td>35</td>
</tr>
<tr>
<td>(Subcategory)</td>
<td>(17.8%)</td>
</tr>
<tr>
<td>Category 2 (Subcategory)</td>
<td>139</td>
</tr>
<tr>
<td>(Subcategory)</td>
<td>(70.5%)</td>
</tr>
<tr>
<td>Category 3a (Boolean with OR)</td>
<td>8</td>
</tr>
<tr>
<td>(Subcategory)</td>
<td>(4.1%)</td>
</tr>
<tr>
<td>Category 3b (Boolean with AND)</td>
<td>2</td>
</tr>
<tr>
<td>(Subcategory)</td>
<td>(1.0%)</td>
</tr>
<tr>
<td>Category 3c (Boolean with negation)</td>
<td>2</td>
</tr>
<tr>
<td>(Subcategory)</td>
<td>(1.0%)</td>
</tr>
<tr>
<td>Category 4 (Post-coordination)</td>
<td>11</td>
</tr>
<tr>
<td>(Subcategory)</td>
<td>(5.6%)</td>
</tr>
<tr>
<td>Total</td>
<td>197</td>
</tr>
</tbody>
</table>
Drug Vocabulary Needs for Support of Clinical Guidelines

Karen Hrabak MS
Jim Campbell MD

University of Nebraska Medical Center

Identified Issues

- Encoding of antihypertensive medications needed to support the Diabetes guideline
- No standard drug terminology available
- Evaluation of available reference terminologies necessary
- SNOMED CT and NDF-RT candidate terminologies
Requirements for Drug Encoding

- Drug superclass identification (i.e. thiazide diuretics)
- Identification of clinical/therapeutic indications
- Entities for ordered drug calculation (i.e. units and strength)
- Clinical drug form (ingredient AND form or strength)

Semantic Analysis

- Which reference terminology will provide subsumption for decision logic needs of the guideline
- Compare SNOMED CT and NDF-RT
- Identify strengths and deficiencies
Drug Resources

- VII Joint National Committee:
  - Anti-hypertensive drugs
  - Classes
  - Usual dose ranges
- Micromedex:
  - Clinical drug forms

Results: Drug Superclass

- Drug superclass agrees with JNC 7 category:
  - SNOMED CT: 72%
  - NDF-RT: 60%
Therapeutic Indications

Comparison

- Specific reference as hypotensive agent or treating hypertension
- SNOMED CT Therapeutic Superclass
- NDF-RT Roles

Therapeutic Indications:
SNOMED CT

- SNOMED CT: classification as a 'hypotensive agent'
- 'Is_a' description
### SNOMED CT Hypotensive Agent Classification

- hypotensive agent
  - adrenergic neuron blocking drug
  - angiotensin II receptor antagonist
  - angiotensin II receptor antagonist+diuretic
  - angiotensin-converting enzyme inhibitor agent
  - antihypertensives+barbiturates
  - calcium-channel blocker+angiotensin-converting enzyme inhibitor
  - centrally acting antihypertensive drug
  - centrally acting hypotensive agent
  - ganglion-blocking drug
  - imidazoline receptor agonist
  - mexiteline
  - other antihypertensives
  - quinidine
  - quinidine alkaloid
  - reuptake inhibitor
  - central nervous system agent

### Therapeutic Indications: NDF-RT

- NDF-RT maintains information in several different roles:
  - Has_MoA (mechanism of action)
  - Has_PE (physiologic effect)
  - May_treat hypertension
NDF-RT Antihypertensives Classification

NDF-RT ‘may_treat Hypertension’

- Lisinopril 10 mg
  - Code: 065874
  - Id: 63075
  - Namespace: NDF-RT (OnlyLog, Subscription, Read-Only)
  - Properties
  - Supercategory
  - Subcategory
  - Roles
    - has_PE: Decreased Renal K+ Excretion
    - may_treat: Hypertension
    - may_treat: Heart Failure, Congestive
    - has_MeA: Angiotensin-Converting-Enzyme Inhibitors
    - may_prevent: Hypertrophy, Left Ventricular
    - CLwith: Pregnancy
    - CLwith: Hyperaldosteronism
Results

- Therapeutic Indications Classification
  - SNOMED CT: 45%
  - NDF-RT: 90%

Comparison: Dosing Data

- Presence in reference terminology:
  - Drug ingredient
  - Drug strength
  - Drug units
Dosage Calculation

- **Lisinopril 10 MG**
  - Code: C9874
  - ID: 8075
  - Namespace: NDF-RT (Only logs, Subscription, Read Only)
  - Properties:
    - Level: Ingredient Strength
    - NDF_Strength: 10
    - NDF_Units: MG
    - RefNorm_SCDC: Lisinopril 10 MG
    - Search_Name: Lisinopril 10 MG
    - Search_Name: LisinoprilAR 10 MG

- **Supercategories**
- **Subconcepts**
- **Roles**

Results

- Dosage calculation
  - NDF-RT: 97% present for data set
  - SNOMED CT: Not present
Summary Results of Analysis

<table>
<thead>
<tr>
<th>Drug Class Identification</th>
<th>Therapeutic Indication</th>
<th>Dosage Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>SNOMED</td>
<td>72%</td>
<td>45%</td>
</tr>
<tr>
<td>NDF-RT</td>
<td>60%</td>
<td>90%</td>
</tr>
</tbody>
</table>

SNOMED CT Analysis

- Drug superclass identification: 72%
- Therapeutic indications: 45%
- Subsumption capabilities
- Dosaging capabilities absent
NDF-RT Analysis

- ‘May_treat hypertension’ role: 90%
- Drug Class Identification: 60%
- Clinical drug forms: 97%
- Combining semantic roles (may_treat, MoA, and PE): 98%

Discussion...

- SNOMED CT and NDF-RT have different and complementary strengths
- Solution for needs of SAGE encoding
Plan for Encoding

- Augment NDF-RT subsumption with needed categories of interest
- Use Runtime classification tool to create new concepts
- Store concepts in the local SAGE namespace

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Terminology Services for Guideline Encoding

- Defining new concepts
  - Post coordination
  - Concept expressions (Boolean combinations) editor
- Support for concept browsing and selection

Concept Expressions

- Arbitrary subsets of taxonomies
- Defined with logical operators
- A and (not B) and (not D)
Apelon Expression Editor

DTS Plug-in for Browsing External Terminologies

- Terminology services
  - Browse, search and inspect concepts
    - Standards: SNOMED, LOINC
    - Emerging terminologies: NDF-RT
    - Extensions proposed by SAGE
  - Map selected concepts to Protégé classes
Invoke Apelon DTS plugin

Apelon DTS Plugin

Search

Concept details
SAGE Guideline Encoding Process

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Guideline Installation and Execution


The guideline has been encoded. Now what?

Download Guideline
Medical Staff Review Guideline
Edit Guideline for Local Conditions
Map Standard to Local Terminologies
Activate Guideline
Mapping Terminologies

**Diabetes Mellitus Type II:**
SNOMED-CT 73211009

In the local CIS:
Problem Master Table Sequence # 1056

Standards-based coded content in SAGE Guideline

Must be Mapped To

Codes and terminologies used in host CIS

* Mapping typically is more complex than this example:
  - usually is bi-directional
  - may be 1-to-many

<table>
<thead>
<tr>
<th>VMR Context</th>
<th>From concept</th>
<th>From concept label</th>
<th>Mayo label</th>
<th>Mayo lab code</th>
<th>Mayo Concept</th>
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</thead>
<tbody>
<tr>
<td>Problem</td>
<td>SNOMED: 73211009</td>
<td>Diabetes mellitus</td>
<td>DM</td>
<td>2202566</td>
<td></td>
</tr>
<tr>
<td>Problem</td>
<td>SNOMED: 46635009</td>
<td>Diabetes mellitus type 1</td>
<td>DM type 1</td>
<td>2202569</td>
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<tr>
<td>Problem</td>
<td>SNOMED: 44054006</td>
<td>Diabetes mellitus type 2</td>
<td>DM type 2</td>
<td>2202567</td>
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<tr>
<td>Observation</td>
<td>LOINC: 25514-1</td>
<td>Rubella Virus Ab</td>
<td>Rubella Abs, IgG Only, S</td>
<td>8172-ROCLIS</td>
<td>6109703</td>
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<td>Observation</td>
<td>LOINC: 5195-3</td>
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<td>Hepatitis Bs Ag (HBsAg), S</td>
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<td></td>
<td>Hepatitis Bs Ag (HBsAg)</td>
<td>2622-ROCLIS</td>
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</table>
SAGE Guideline Deployment System
Execution Architecture

- **Encoded Guideline**
- **Event Notifications**
- **VMR Interface**
- **Clinical Information System**
- **Local Modifications**
- **Data Query Service Calls**
- **Action Service Calls**
- **Terminology Functions**
- **Terminology Server**

**Runtime Terminology Services**

- Mapping (if guideline KB not reformulated in local terms)
- Subsumption checking
Summary

- For encoding decision support domain terminology
  - Rigorous subsumption hierarchies
  - Mechanisms for defining new terms
  - Orthogonality with information model
  - Mechanism for user-defined abstractions
- For encoding & localizing decision support knowledge
  - Browsing, searching & selecting terms from terminologies
  - Mechanisms for specifying mapping to local terminologies
- For run-time application
  - Terminology mapping
  - Subsumption checking