



Terminology Needs in Clinical Decision Support

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



Acknowledgement

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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

Vaccine	Age	Birth	1 month	2 months	4 months	6 months	12 months	15 months	18 months	24 months	4-6 years	11-12 years	13-18 years
Hepatitis B ¹		HepB #1	HepB #2		HepB #3			HepB Series					
Diphtheria, Tetanus, Pertussis ²			DTaP	DTaP	DTaP		DTaP			DTaP	Td	Td	
Haemophilus influenzae type b ³			Hib	Hib	Hib	Hib							
Inactivated Poliovirus			IPV	IPV	IPV					IPV			
Measles, Mumps, Rubella ⁴						MMR #1				MMR #2	MMR #2		
Varicella ⁴						Varicella			Varicella				
Pneumococcal ⁵			PCV	PCV	PCV	PCV				PCV	PPV		
Influenza ⁶						Influenza (Yearly)				Influenza (Yearly)			
Hepatitis A ⁷										Hepatitis A Series			

Vaccines below red line are for selected populations

“Activating Guideline Content”

Guideline recommendations integrated into a nurse care flowsheet

- View suggested orders
- Process suggested orders

The screenshot shows a web-based nurse care flowsheet for a patient named Carlos O'Kelly. The patient's information includes MRN 3 303 999, DOB 1-22-2003, SSN 123-45-6789, Sex M, Age 4 Months, and Phone (507) 555-1234. The flowsheet is titled "Care Reminders Flowsheet" and "Immunizations". A table lists immunizations with columns for Selected, Item, Info, Status, 3.17.2003, and 1.22.2003. The table shows that DTaP, IPV, PCV7, Hib, and Hep B are due, while MMR and Varicella are due in 2004. A yellow arrow points from a text box to the "Info" column of the DTaP row. A pop-up window titled "DTPa - Microsoft Internet Explorer" provides detailed information about the Diphtheria, Tetanus, and Pertussis Vaccine, including its schedule (2 mo, 4 mo, 6 mo, 12-15 mo, 4-6 yr, 12 yr (adult Td)), contraindications, and a note to defer DTaP until neurological status is clarified and stabilized. A yellow box at the bottom right of the screenshot states "Real time access to reference information".

Selected	Item	Info	Status	3.17.2003	1.22.2003
<input checked="" type="checkbox"/>	DTaP	i	Due	Given	
<input checked="" type="checkbox"/>	IPV	i	Due	Given	
<input checked="" type="checkbox"/>	PCV7	i	Due	Given	
<input checked="" type="checkbox"/>	Hib	i	Due	Given	
<input checked="" type="checkbox"/>	Hep B	i	Due 7-22-2003	Given	Given
<input type="checkbox"/>	MMR	i	Due 1-22-2004		
<input type="checkbox"/>	Varicella	i	Due 1-22-2004		

Real time access to reference information



JNC VII Guideline for Management of Hypertension

Table 10. Oral antihypertensive drugs*

CLASS	DRUG (TRADE NAME)	USUAL DOSE RANGE IN MG/DAY	USUAL DAILY FREQUENCY*
Thiazide diuretics	chlorothiazide (Diuril)	125-500	1-2
	chlorthalidone (Gedon)		
	hydrochlorothiazide (HydroDIURIL)		
	polythiazide (Renese)		
	indapamide (Lozol)		
	metolazone (Mykrolon) metolazone (Zaroxin)		
Loop diuretics	bumetanide (Bumex)		
	furosemide (Lasix)		
	torseamide (Demador)		
Potassium-sparing diuretics	amiloride (Midamor)		
	triamterene (Dyrenene)		
Aldosterone receptor blockers	eplerenone (Inspra) spironolactone (Aldactone)		
BBs	atenolol (Tenormin)		
	betaxolol (Kerlone)		
	bisoprolol (Zebeta)		

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 for drug classes

COMPELLING INDICATION*	RECOMMENDED DRUGS						ACC/AHA HYPERTENSION CLASSIFICATION
	DIURETIC	BB	ACEI	ARB	CCB	ALDO ANT	
Heart failure	•	•	•	•		•	ACC/AHA HYPERTENSION CLASSIFICATION: HF, HFrEF, HFpEF, COPE



ATHENA HTN advisory

ATHENA Hypertension Advisory

Patient SSN: _____ Name: _____ Patient Summary

Most Recent BP in Database: 158/85 Date: 6-25-2007

ENTER a New BP: _____ Date: 6-4-2007 Update Advisory Update & Save BP to CPRS

Guideline Goal: SBP < 140 and DBP < 80 [presence of diabetes mellitus]
BP apparently NOT UNDER CONTROL, based on most recent available BP.

Recommendations Precautions Assumptions Lifestyle Adherence Glossary BP-Prescription Graphs

Recommend ADDING antihypertensive medication: BP ELEVATED based on most recent available BP; F up 1 month.
RECOMMENDATIONS DO NOT APPLY TO PREGNANT WOMEN (or women likely to become pregnant or nursing mother).

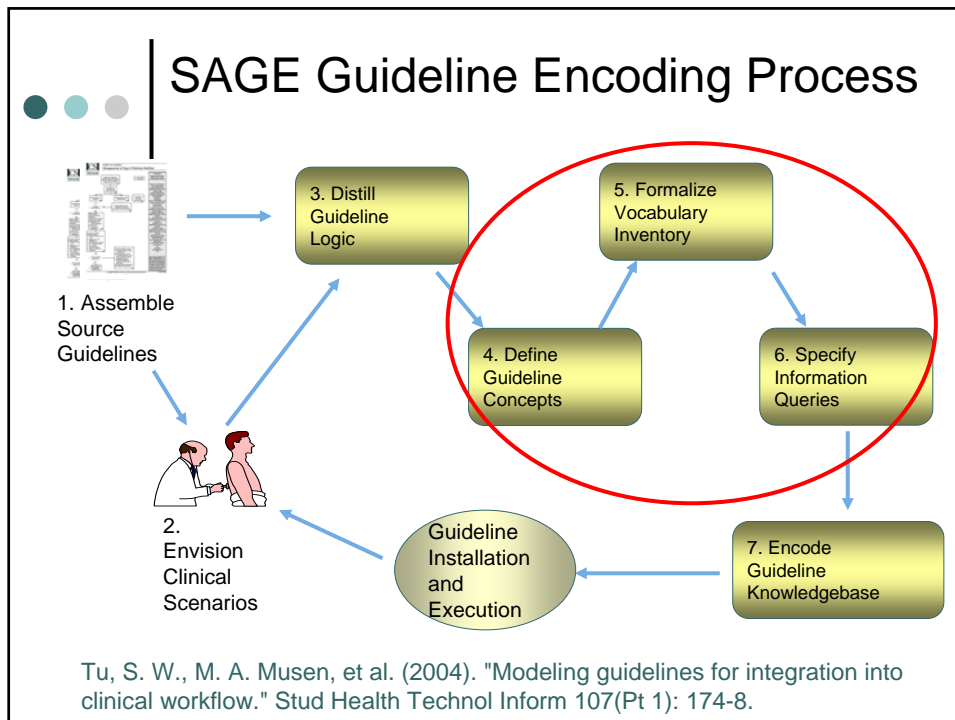
Compelling Indication
 Relative Indication
 Strong Contraindication
 Relative Contraindication
 Adverse Events

Consider one of the following therapeutic possibilities:	Click here for important ...	Reasons	Click here to provide ...
Add Thiazide Diuretic (HCTZ)	Info	<input checked="" type="checkbox"/> Diabetes <input checked="" type="checkbox"/> 1st line drug for hypertension	Feedback
Add ACE Inhibitors (lisinopril)	Info	<input checked="" type="checkbox"/> Diabetes_Mellitus	Feedback
Add Cardioselective Beta Blocker (atenolol)	Info	<input checked="" type="checkbox"/> Diabetes_Mellitus	Feedback
Add DHP Calcium Channel Blocker (felodipine, nifedipine)	Info	<input checked="" type="checkbox"/> Diabetes_Mellitus	Feedback
Add Angiotensin II Receptor Blocker (irbesartan)	Info	<input checked="" type="checkbox"/> Diabetes_Mellitus	Feedback

Your comments for the Guidelines Team (optional and welcome!)

Do not display Advisory for this clinic visit again.

Complete clinical information may not be available through the computer system. Please use all the information that you have about the patient together with your clinical judgment to decide on the best therapy for this patient.



Clarifying Concept Definition...

Pneumococcal Polysaccharide Vaccine Recommendations

- Adults ≥ 65 years of age
- Persons ≥ 2 years with
 - chronic illness
 - anatomic or functional asplenia
 - immunocompromised (disease, chemotherapy, steroids)
 - HIV infection
 - environments or settings with increased risk
 - cochlear implant

➤ Anatomic or functional asplenia?

➤ **Clinical Definition**

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



“Functional or anatomic asplenia”

5. Formalize Vocabulary Inventory

➤ Clinical Definition

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

➤ SNOMED CT Concept

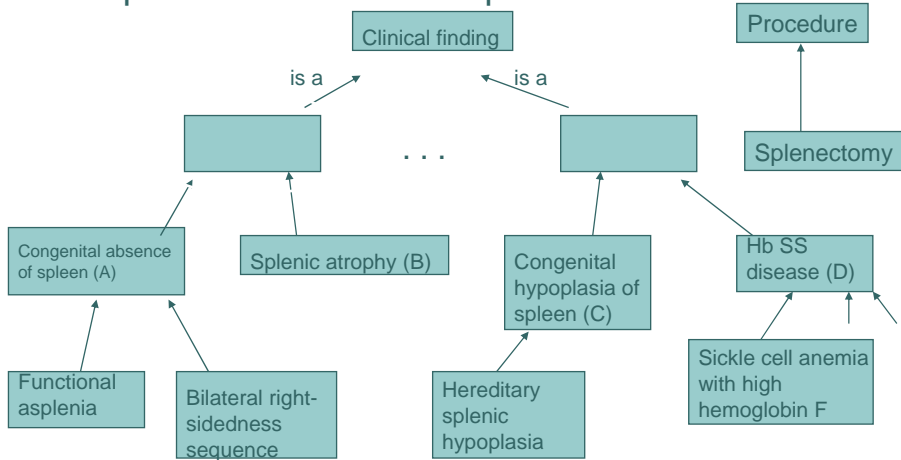
- 93030006
- 93292008
- 234319005 (Procedure)
- 82893001
- 127040003 (Hemoglobin S disease)



Are Subclasses OK?

5. Formalize Vocabulary Inventory

Specialization of terms part of definition



● ● ● | What do the concepts mean in terms of available data?

6. Specify Information Queries

- 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

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● ● ● | Sometimes Have to Define Terms through Post-Coordination

Suprarenal Artery Embolus
297143008

Pre-Coordinated

Post-Coordinated

or

Occlusion of Artery	2929001
Associated Morphology	116676008
Embolus	55584005
Finding Site	363698007
Suprarenal Artery	89500000

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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 Terminology project harmonizing HL7 RIM with SNOMEDCT

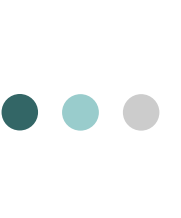


Use of SNOMED CT in Immunization Guideline Terminology

Table 3- Concept inventory by complexity

Category	<i>n</i>
Category 1 (Concept entity)	35 (17.8%)
Category 2 (Subsumption)	139 (70.5%)
Category 3a (Boolean with OR)	8 (4.1%)
Category 3b (Boolean with AND)	2 (1.0%)
Category 3c (Boolean with negation)	2 (1.0%)
Category 4 (Post coordination)	11 (5.6%)
<i>Total</i>	<i>n = 197</i>

Hrabak KM, Campbell JR, Tu SW, McClure R, Weida T. Creating Interoperable Guidelines: Requirements of Vocabulary Standards in Immunization Decision Support. In: Medinfo; 2007; Brisbane, Australia; 2007.



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 neurone 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
 - ⊞ metyrosine
 - ⊞ other antihypertensives
 - ⊞ pargyline
 - ⊞ rauwolfia alkaloid
 - ⊞ vasodilating agent
- ⊞ 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

- ⊖ [CV400] ANTIHYPERTENSIVE, COMBINATIONS
- ⊖ [CV490] ANTIHYPERTENSIVES, OTHER
 - ⊕ CLONIDINE PREPARATION
 - ⊕ CRYPTENAMINE PREPARATION
 - ⊕ DESERPIDINE PREPARATION
 - ⊕ DIAZOXIDE PREPARATION
 - ⊕ GUANABENZ PREPARATION
 - ⊕ GUANADREL PREPARATION
 - ⊕ GUANETHIDINE PREPARATION
 - ⊕ GUANFACINE PREPARATION
 - ⊕ HYDRALAZINE PREPARATION
 - ⊕ MECAMYLAMINE PREPARATION
 - ⊕ METHYLDOPA PREPARATION
 - ⊕ METYROSINE PREPARATION
 - ⊕ MINOXIDIL PREPARATION
 - ⊕ PARGYLINE PREPARATION
 - ⊕ RAUWOLFIA PREPARATION
 - ⊕ RESCINNAMINE PREPARATION
 - ⊕ RESERPINE PREPARATION
 - ⊕ SODIUM NITROPRUSSIDE PREPARATION
 - ⊕ TRIMETHAPHAN PREPARATION
- ⊕ [CV500] PERIPHERAL VASODILATORS
- ⊕ [CV600] SCLEROSING AGENTS
- ⊕ [CV700] DIURETICS



NDF-RT 'may_treat Hypertension'

- LISINOPRIL 10 MG
 - Code: C69874
 - ID: 69875
 - Namespace: NDF-RT (Ontylog, Subscription, Read-Only)
 - Properties
 - Superconcepts
 - Subconcepts
 - Roles
 - has_PE: Decreased Renal K+ Excretion
 - may_treat: Hypertension ←
 - may_treat: Heart Failure, Congestive
 - has_MoA: Angiotensin-Converting Enzyme Inhibitors
 - may_prevent: Hypertrophy, Left Ventricular
 - CI_with: Pregnancy
 - CI_with: Hyperaldosteronism



Results

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

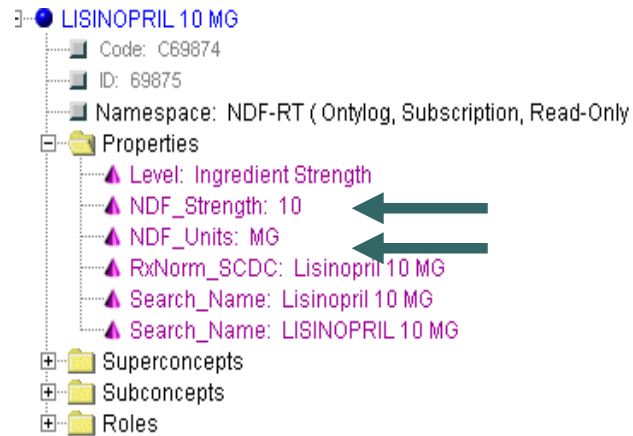


Comparison: Dosing Data

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



Dosage Calculation



Results

- Dosage calculation
 - NDF-RT: 97% present for data set
 - SNOMED CT: Not present



Summary Results of Analysis

	Drug Class Identification	Therapeutic Indication	Dosage Calculation
SNOMED	72%	45%	0%
NDF-RT	60%	90%	97%



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

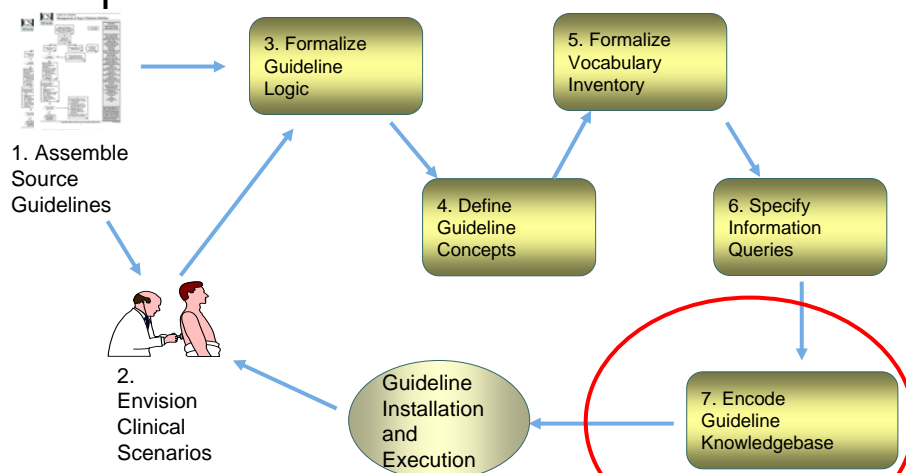


Plan for Encoding

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



SAGE Guideline Encoding Process



Tu, S. W., M. A. Musen, et al. (2004). "Modeling guidelines for integration into clinical workflow." *Stud Health Technol Inform* 107(Pt 1): 174-8.



Terminology Services for Guideline Encoding

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

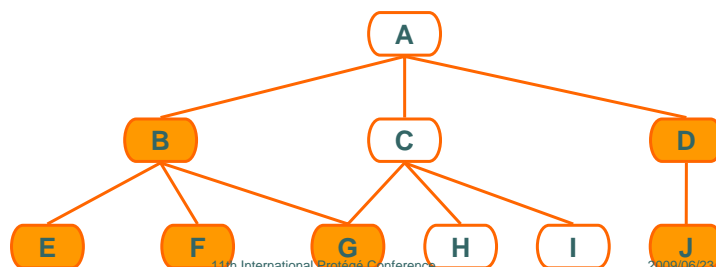


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Concept Expressions

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

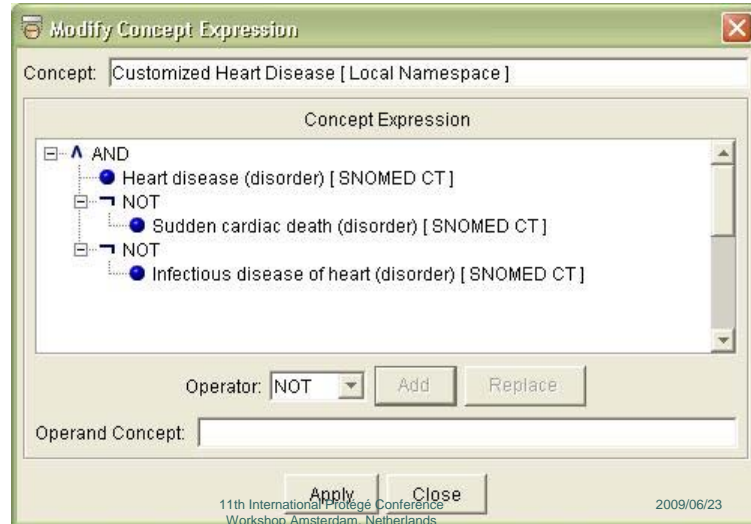


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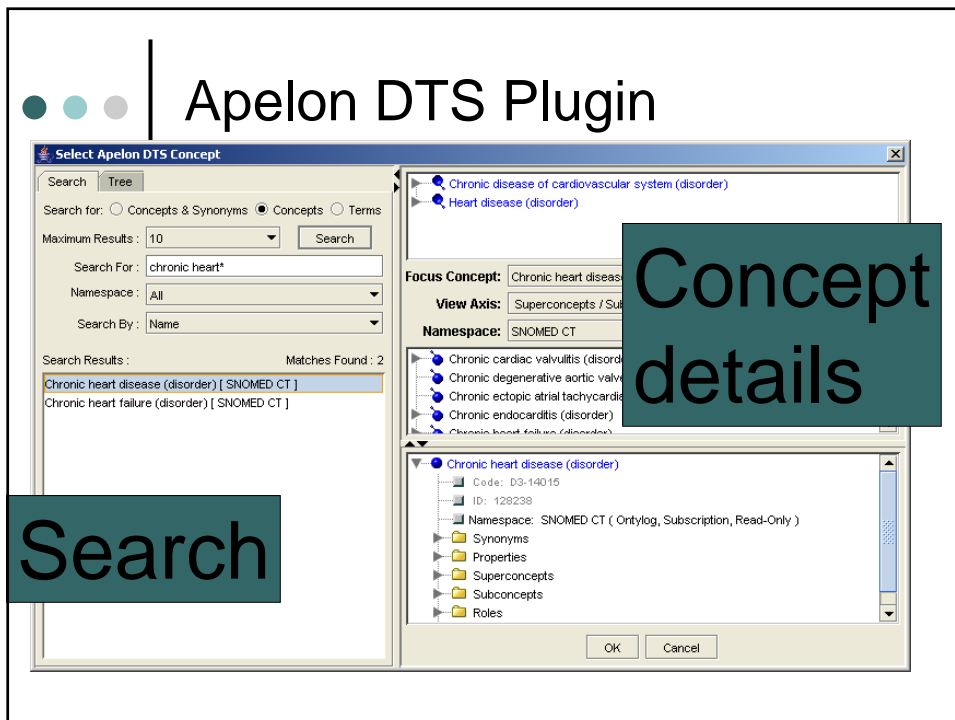
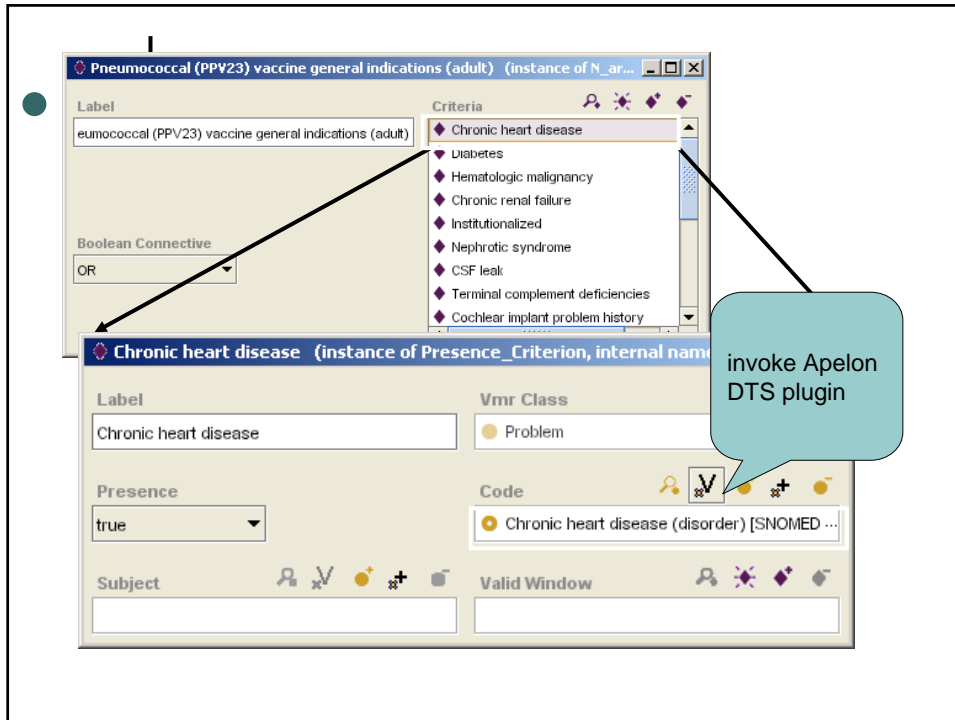
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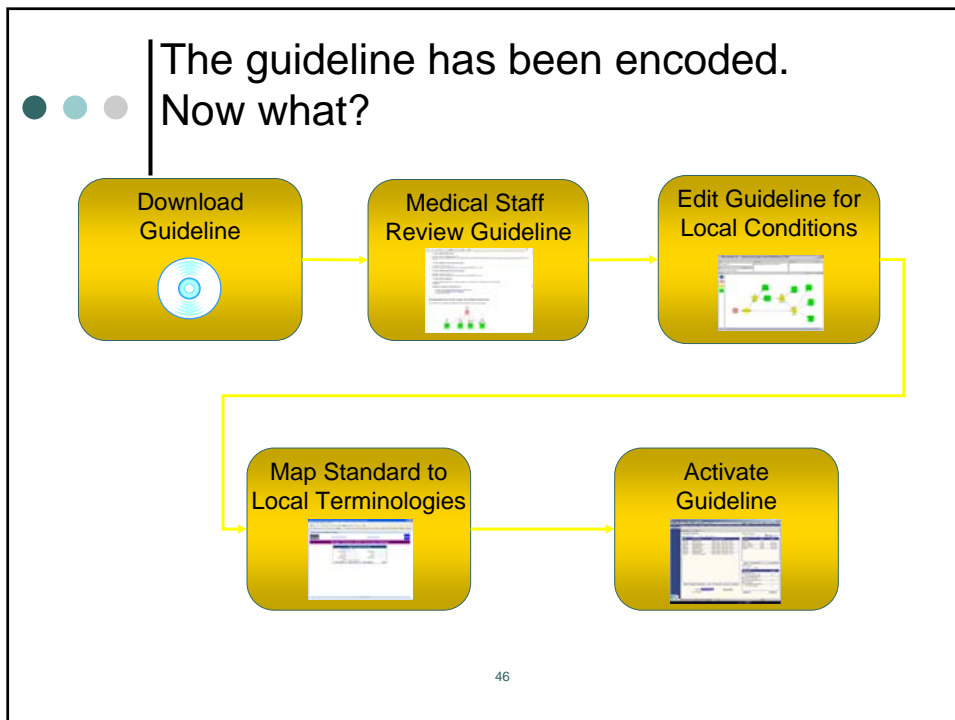
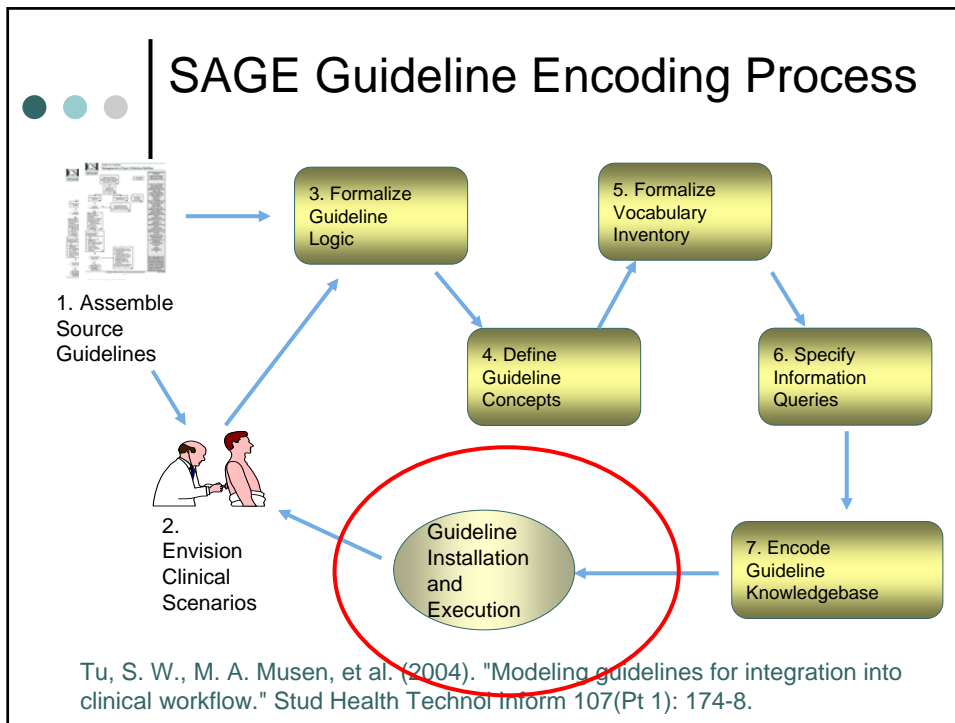


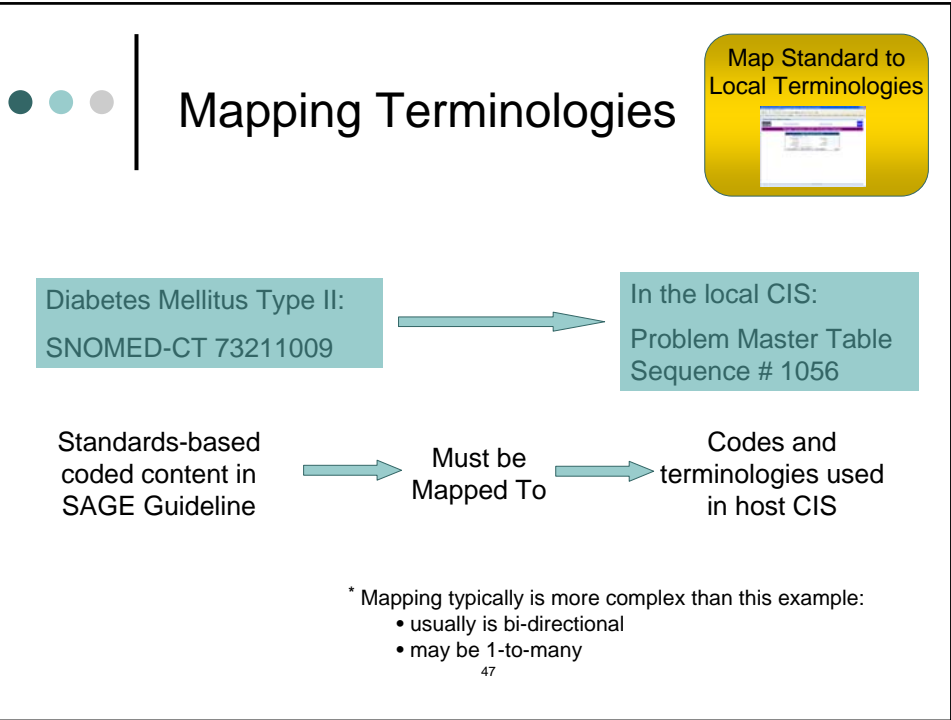
DTS Plug-in for Browsing External Terminologies

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










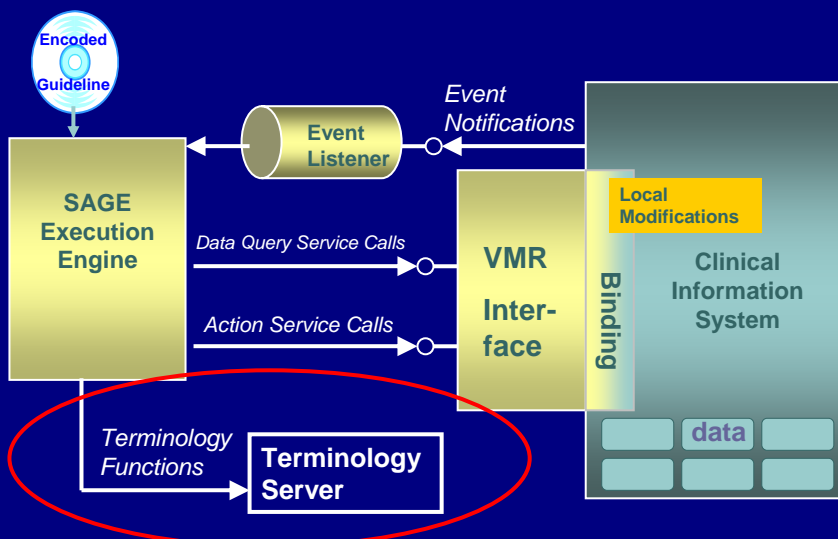
Mapping Terminologies

Map Standard to Local Terminologies



VMR Context	From concept	From concept label	Mayo label	Mayo lab code	Mayo Concept
Problem	SNOMED: 73211009	Diabetes mellitus	DM		2202566
Problem	SNOMED: 46635009	Diabetes mellitus type 1	DM type 1		2202569
Problem	SNOMED: 44054006	Diabetes mellitus type 2	DM type 2		2202567
Observation	LOINC: 25514-1	Rubella Virus Ab	Rubella Abs, IgG Only, S	8172-ROCLIS	6109703
Observation	LOINC: 5195-3	Hepatitis B Virus Surface Ag	Hepatitis Bs Ag (HBsAg),S	9013-ROCLIS	6102663
			Hepatitis Bs Ag (HBsAg)	2622-ROCLIS	6101226

SAGE Guideline Deployment System Execution Architecture



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