



"A collaborative project to
develop a universal framework for
encoding and disseminating electronic clinical guidelines"

The SAGE Project

Standards-Based Sharable Active Guideline Environment

Integration Point: Immunization Guideline Vocabulary Issues



**Managing vocabulary needs
for guideline decision logic
is complicated!**

SAGE Development Procedures

- Analyze guideline for clinical impact
- Select recommendation sets
- Create enterprise implementation scenarios
- Develop the model
 - Analyze decision logic and data recording
 - Create the vocabulary inventory
 - Model the workflow and decision logic with Protege®
- Create the interoperable knowledge base

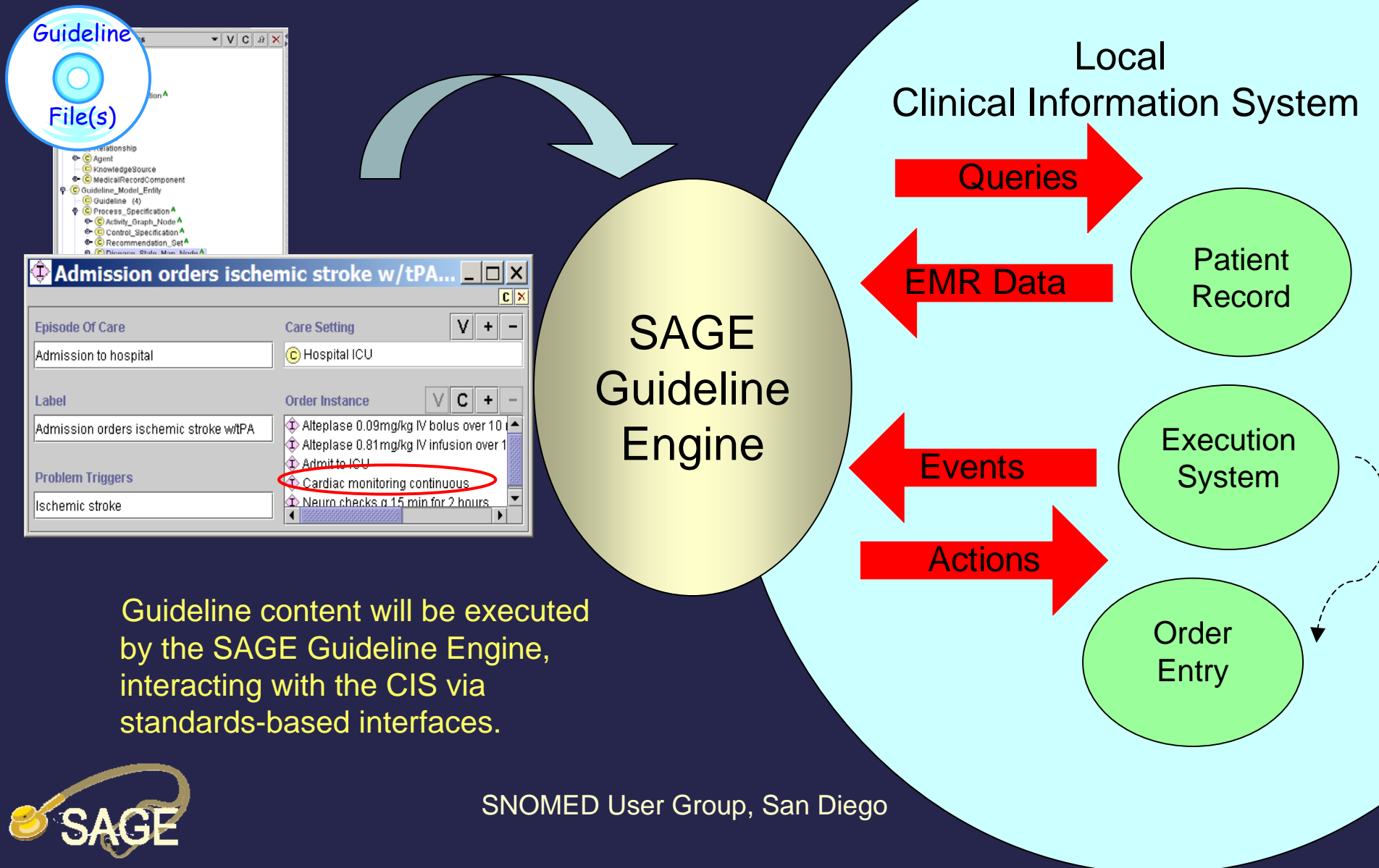


SAGE Deployment Features

- Import the SAGE knowledge base
- Select scenarios for installation
- Import and localize the scenarios
 - Vocabulary mapping
 - Enterprise resource identification
 - Scenario tailoring
- Bind the knowledge to the clinical information system using the vendor's own SAGE compliant engine



SAGE Guideline Execution: Deployment Concepts





Health Care Guideline

A Recommendation set....

Hepatitis B high-risk groups:

- All infants, both full-term and premature, of Hepatitis B positive mothers should receive Hepatitis B Immune Globulin (HBIG) and the first dose of Hepatitis B vaccine within 12 hours of birth, a second dose at 1 month of age and a third dose at 6 months of age. (Schedule 1 on the Algorithm.) A serologic test to prove immunity should be obtained in this group 1 to 3 months after the third immunization.



To the nursery scenario...

Newborn w/ Hep B Positive Mother

Baby Boy Jones

- ✓ 2229 gram
- ✓ 34 week gestation neonate
- ✓ delivered by emergency C-section due to placental abruption
- ✓ His 20 year old mother received no prenatal care.
- ✓ Mother's urine drug screen was positive for methamphetamines.
- ✓ Mother's HBsAg serology was positive.
- ✓ Problem listed: "newborn exposure to Hepatitis B"



Newborn w/ Hep B Positive Mother

Baby Boy Jones

- ✓ Admission to hospital
- ✓ SAGE monitor triggered
- ✓ Patient record queried
- ✓ SAGE evaluates guideline criteria and communicates with clinical information system
- ✓ Nurse alerted to obtain consent and complete database
- ✓ Automated orders issued to attending physician for confirmation



Creation of basic guideline logic

Rule 1: First dose, infant of mother with HBSAG+ or uncertain serologic status

```
IF      NO CONTRAINDICATION TO HEP B
      AND
      NO REASON FOR DEFERRAL
      AND
      NUMBER OF HEP B VACCINE DOSES = 0
      AND
      MOTHER HEPATITIS B+
      AND
      AGE =< 7 DAYS
THEN
      ADVISE MONOVALENT HEP B VACCINE DUE
      AND
      ADVISE HBIG IM DUE
      AND ORDER HbsAG AND anti-HBs levels AT 9 MONTHS OF AGE
```



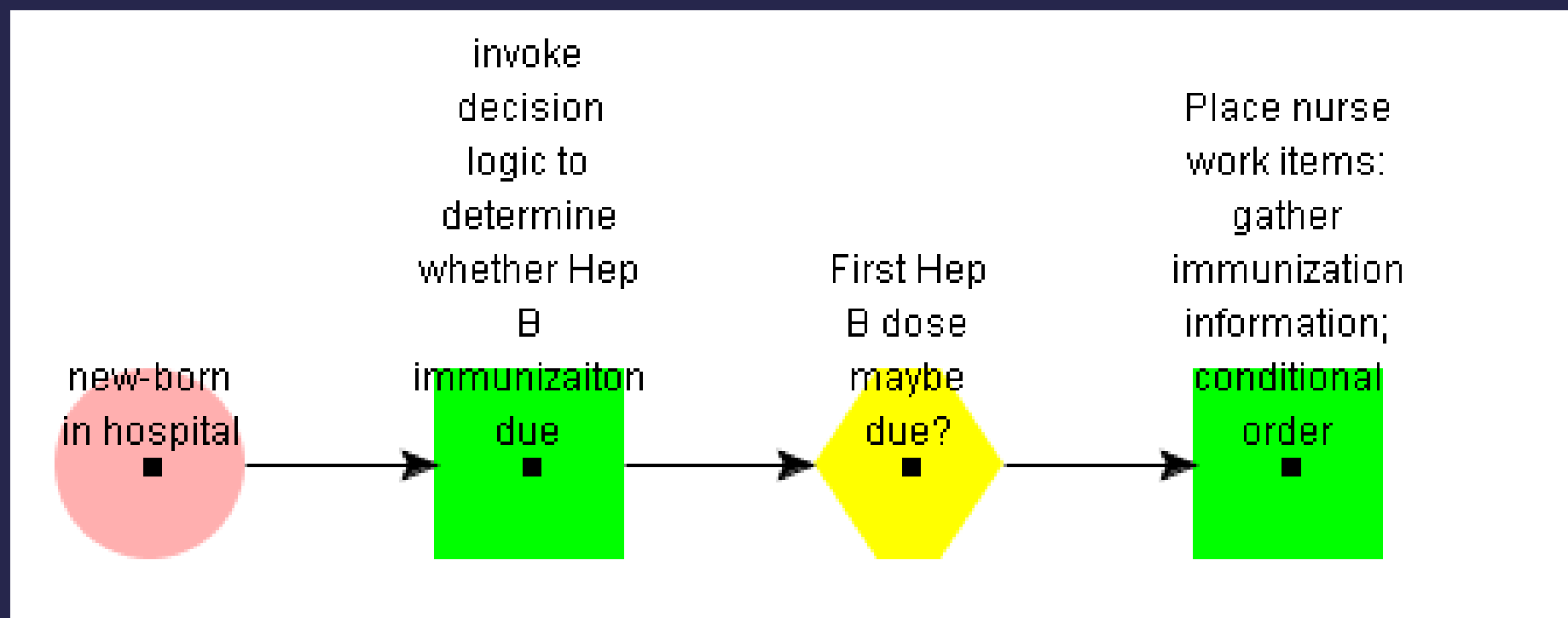
Identify concept requirements of logic

Rule 1: First dose, infant of mother with HBSAG+ or uncertain serologic status

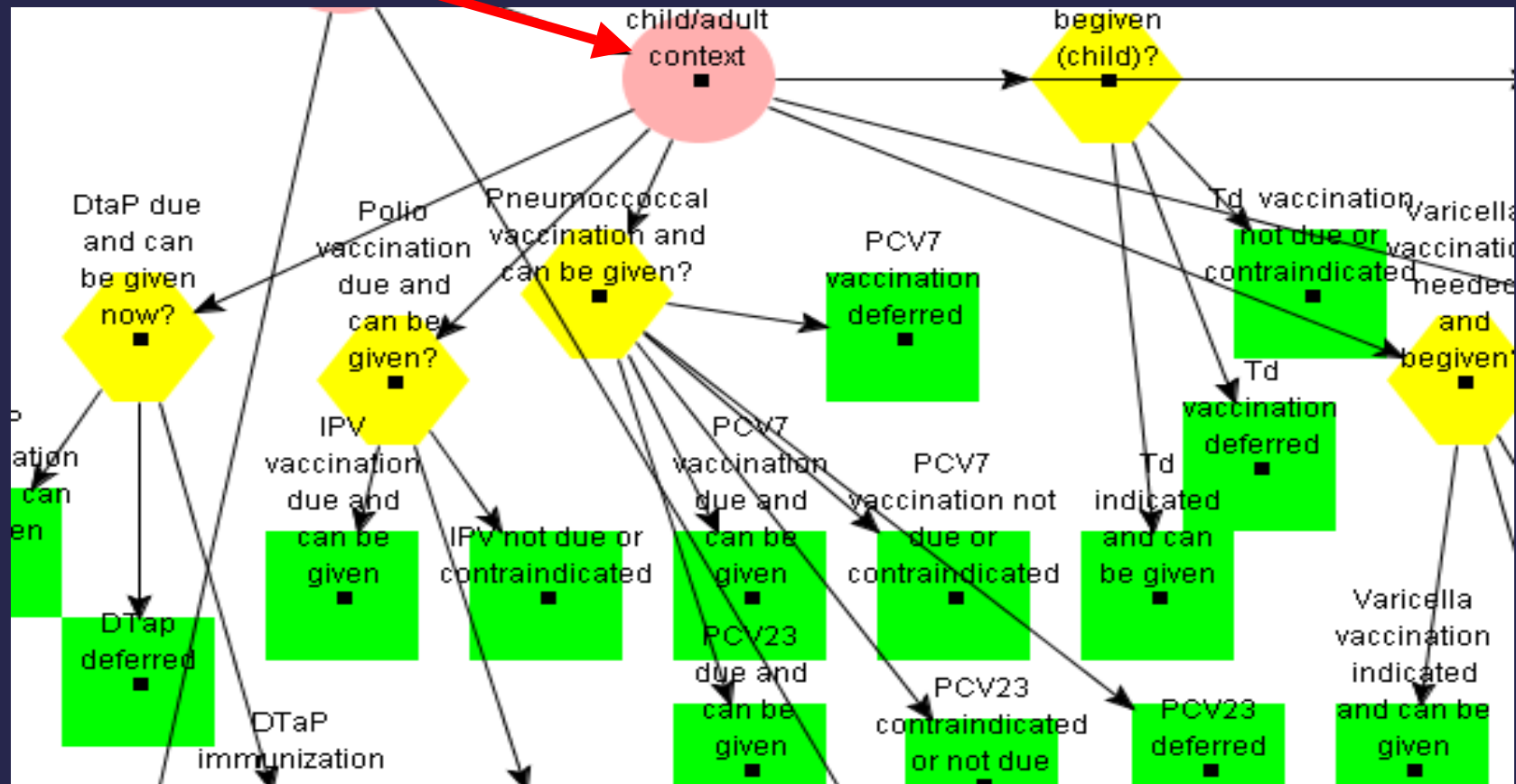
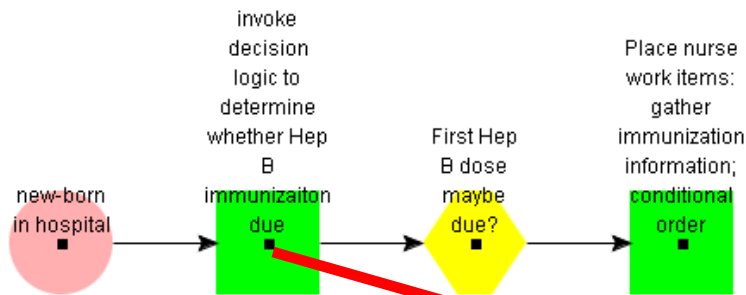
IF NO [REDACTED]
AND
NO REASON FOR DEFERRAL
AND
NUMBER OF [REDACTED] DOSES = 0
AND
[REDACTED]
AND
[REDACTED]
THEN
ADVISE MONOVALENT HEP B VACCINE DUE
AND
ADVISE HBIG IM DUE
AND ORDER HbsAG AND anti-HBs levels AT 9 MONTHS OF AGE

Immunization

Create Protege® Model



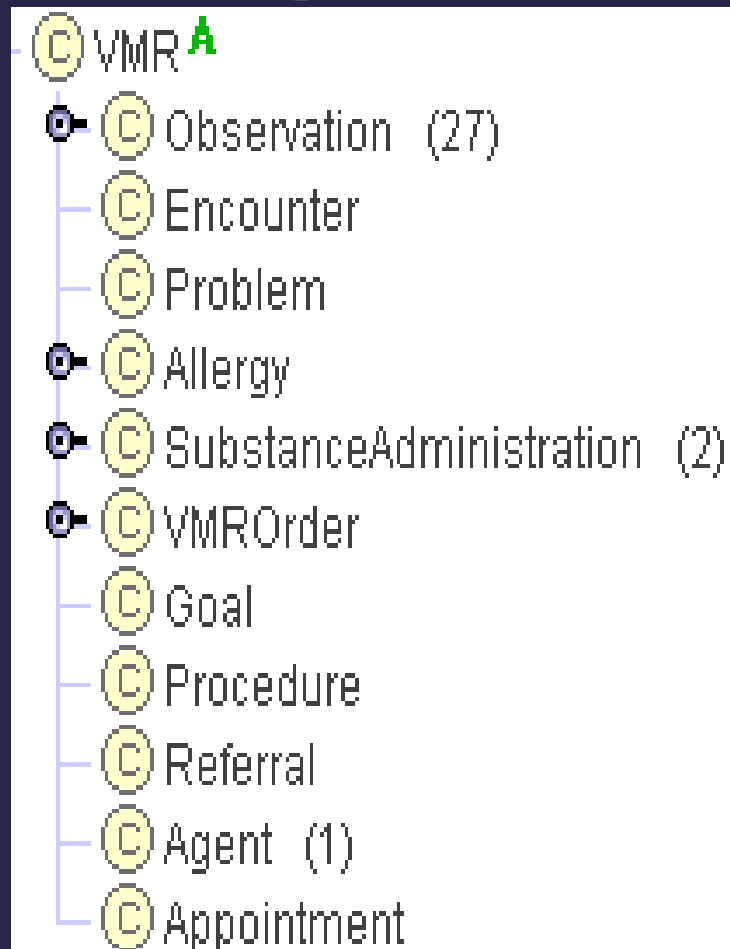
Immunization Decisions



vMR

Information Model Assumptions

- Protégé classes “**define**” web-services through which SAGE communicates with the CIS
- Attributes of these vMR classes control the ways requests are modeled in the guideline and, thus, the way that calls to the CIS are composed.



Vocabulary Inventory

Hepatitis B						
Contraindications	Anaphylactic reaction to Hepatitis B	Allergy	\code=	Vaccines allergy	and	
				294640001		
			\allergen	Hepatitis B virus vaccine		
				34689006		
			\reaction	anaphylaxis		
				39579001		
	Hepatitis B vaccine	Substance administration	\code =	Hepatitis B virus vaccine		
				34689006		
Indications	Mother is hepatitis B positive	Problem (neonate)	\code=	"Child born of HBsAg positive mother"		
		Problem (maternal)	\code=	Hep B surface antigen positive		
				165806002		
		Observation (maternal)	\code=	Hep B surface antigen level		
				315131000		
				LOINC: 5195-3; 5196-1;		
	Patient age	Observation(neonate)	\code =	Date of birth(observable)		
				184099003		



Post-coordination of new concepts

\code=	Vaccines allergy	and		
	294640001			
\allergy	Hepatitis B virus vaccine			
	34689006			
\reaction	anaphylaxis			
	39579001			
\code=	"Child born of HBsAg positive			
	199199001			
\code=	Hep B surface antigen positive			
	165806002			
\code=	Hep B surface antigen level			
	315131000			
	LOINC: 5195-3; 5196-1;			
\code =	Date of birth(observable)			
	184099003			

James R. Campbell:

{"Child born of HBsAg positive mother"
isa Maternal viral disease during
pregnancy - baby delivered
199199001
isa Hepatitis B contact
281638009}

SAGE Model

Vocabulary Service layers

- Reference terminology layer
 - I - SNOMED concept layer: Concept of “Date of birth”, “Infantile spasms”
 - II – SNOMED post-coordination: Concept of “Child born of Hep B+ mother”
- Guideline vocabulary services layer
 - III – Boolean formulation [AND, OR, NOT]: Problem of “Progressive encephalopathy”
 - IV – Clinical expression model (CEM): restrictions upon one or more vMR classes: “Refusal of vaccination consent”
 - V – CEM with complex calculations: “Age > 7 years”; “Orthostatic blood pressure > 10 mm”



Neonate w/ HepB positive mother

Step by step with the clinician

- Baby Boy Jones will be admitted.
- SAGE will be notified.
- SAGE will determine that an immunization is due. Many SAGE / CIS interactions are required to support this.
- Pending orders will be placed.
- Inbox messages will be sent through the CIS.



SNOMED User Group, San Diego

Neonate w/ HepB positive mother

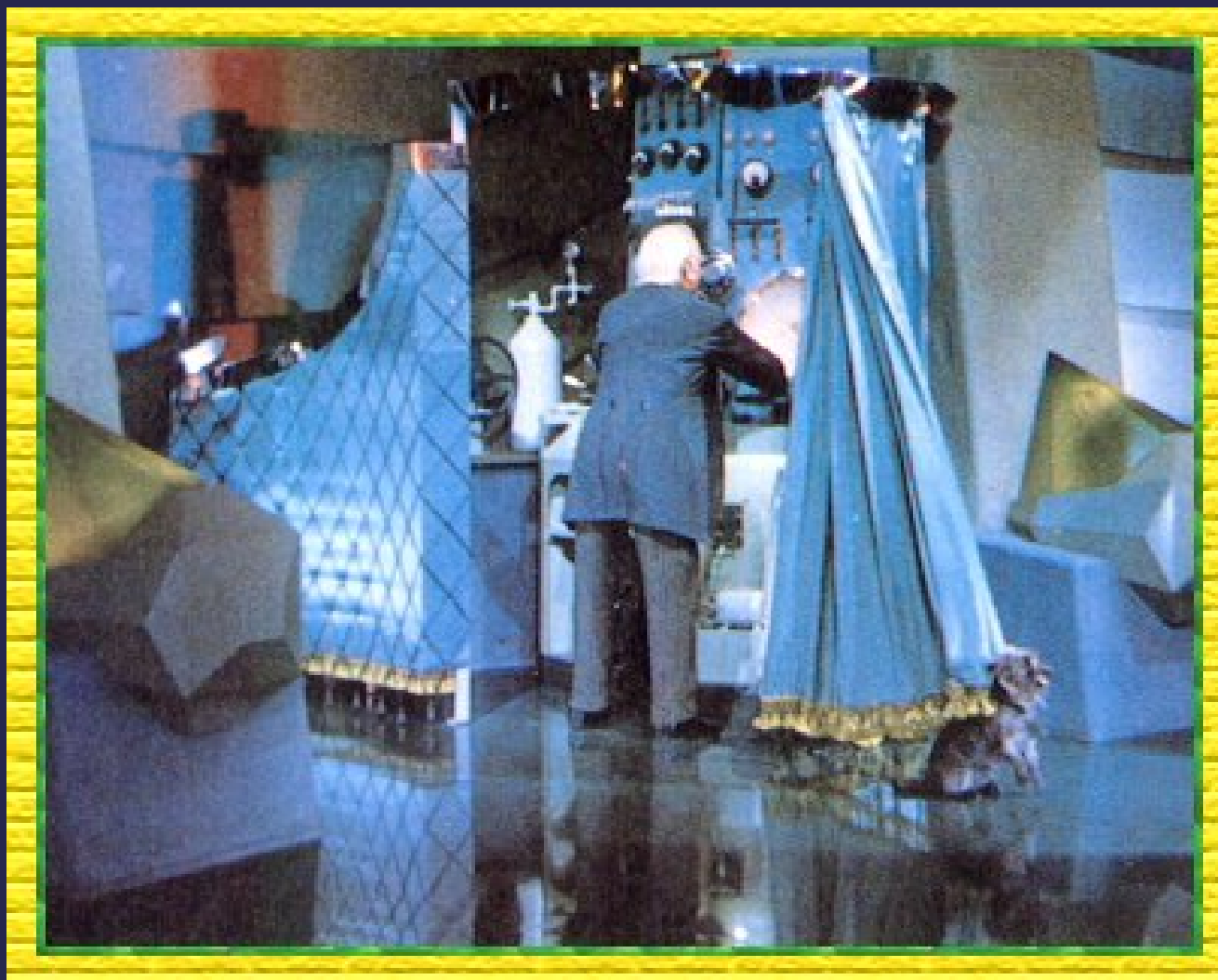
Baby Boy Jones

Expected SAGE Behavior (4 orders):

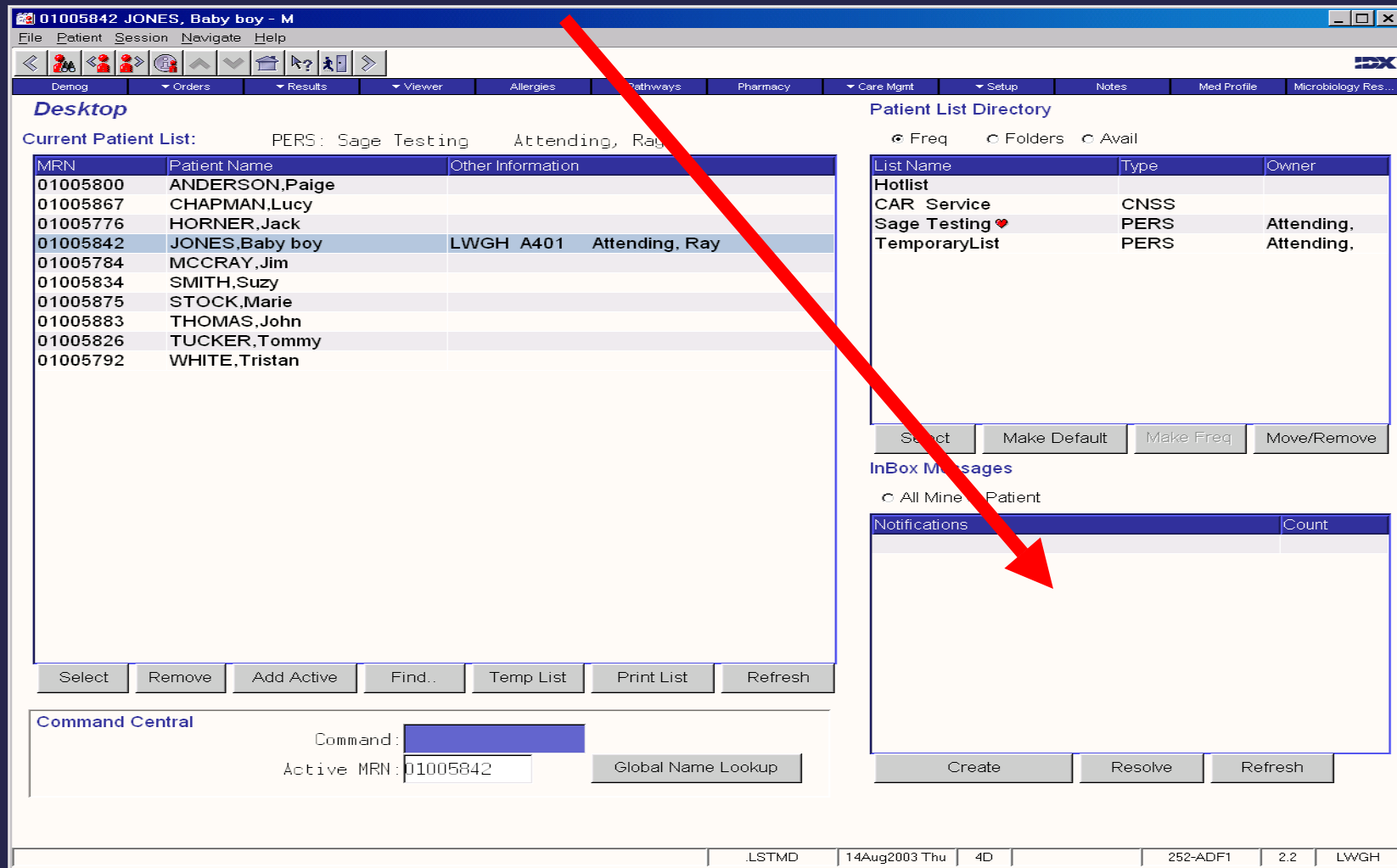
- **2 Substance administrations**
due immediately
 - Hepatitis B vaccine injection
 - Hepatitis B Immune Globulin (HBIG)
- **2 Serologic tests**
due 9 months in the future
 - Hepatitis B core antibody levels (anti-HBc)
 - Hepatitis B surface antigen levels (HBsAg)



Pay No Attention to that Man Behind the Curtain!



MD Screen for Jones with No Inbox entries



The screenshot shows a medical software interface with a title bar for patient 01005842 JONES, Baby boy - M. The interface includes a menu bar (File, Patient, Session, Navigate, Help), a toolbar, and a tabbed interface with tabs for Demog, Orders, Results, Viewer, Allergies, Pathways, Pharmacy, Care Mgmt, Setup, Notes, Med Profile, and Microbiology Res... The main content area is divided into three sections: Desktop, Patient List Directory, and Inbox Messages.

Desktop

Current Patient List: PERS: Sage Testing Attending, Ray

MRN	Patient Name	Other Information
01005800	ANDERSON, Paige	
01005867	CHAPMAN, Lucy	
01005776	HORNER, Jack	
01005842	JONES, Baby boy	LWGH A401 Attending, Ray
01005784	MCCRAY, Jim	
01005834	SMITH, Suzy	
01005875	STOCK, Marie	
01005883	THOMAS, John	
01005826	TUCKER, Tommy	
01005792	WHITE, Tristan	

Buttons: Select, Remove, Add Active, Find.., Temp List, Print List, Refresh

Command Central

Command:
Active MRN: 01005842 Global Name Lookup

Patient List Directory

Freq Folders Avail

List Name	Type	Owner
Hotlist		
CAR Service	CNSS	
Sage Testing	PERS	Attending,
TemporaryList	PERS	Attending,

Buttons: Select, Make Default, Make Freq, Move/Remove

Inbox Messages

All Mine Patient

Notifications	Count
---------------	-------

Buttons: Create, Resolve, Refresh

Footer: .LSTMD 14Aug2003 Thu 4D 252-ADF1 2.2 LWGH



Registration Screen w/ DOB

01005842 JONES, Baby boy - M

File Patient Session Navigate Help

Demog Orders Results Viewer Allergies Pathways Pharmacy Care Mgmt Setup Notes Med Profile Microbiology Res...

Change Patient Demographics (1 of 2)

Patient Name	Demographic	Care Provider
Last Name: JONES	Sex: M DOB: 24Aug2003	Reg Care Fac: LWGH <input type="checkbox"/> New Prov?
First Name: Baby boy MI:	Race: 1 Marital:	Reg Provider: ATTENDING, RAY 755000
Birth Name:	Religion: Cong:	Specialty Prov:
<input type="checkbox"/> Registration Update Alias?	Soc Sec #: Handicap? Interpreter?	Specialty Prov:
Mailing Address	Employer	Referral Agency:
Street:	Emp Code: Status:	Unregistered Referral
City: SEATTLE	Employer:	Last Name:
State: WA Zip: 98104	Street:	First Name: MI:
County:	City:	
Night Phone:	State: Zip:	
Day Phone:	Phone:	
IP: OP: C	Occupation:	Flags
Alternate ID #:	Emp ID #:	Registration: UR: (Flag4):
Alternate ID2 #:		Financial: Local10Only HMA Excl:
		Debt: (Flag2): Adv Dir:
		Legal: (Flag3): PLS: 1
		Reg Flags To ADT
		DNA? VIP: (Flag5a):
		IFD: (Flag4a): (Flag6a):
		Save Data and Continue

CREG1 14Aug2003 Thu 4D 252-ADF1 0.3 LWGH





Desktop

Current Patient List: PERS: Sage Testing Attending, Ray

MRN	Patient Name	Other Information
01005800	ANDERSON, Paige	
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01005842	JONES, Baby boy	LWGH A401 Attending, Ray
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01005834	SMITH, Suzy	
01005875	STOCK, Marie	
01005883	THOMAS, John	
01005826	TUCKER, Tommy	
01005792	WHITE, Tristan	

Select Remove Add Active Find.. Temp List Print List Refresh

Command Central

Command:
Active MRN: Global Name Lookup

Patient List Directory

☒ Freq ☐ Folders ☐ Avail

List Name	Type	Owner
Hotlist		
CAR Service	CNSS	
Sage Testing ♥	PERS	Attending,
TemporaryList	PERS	Attending,

Select Make Default Make Freq Move/Remove

InBox Messages

☐ All Mine ☒ Patient

Notifications	Count
Unsolicited	
- You have saved order sessions	4
- Message from SAGE Engine	2

Create Resolve Refresh



My Saved Order Sessions

Patient	Mrn	Previous Owner	Save Date Time	Comment
JONES, Baby boy	01005842	ATTENDING, R	15Aug2003 10:41	Hep B surface antige
JONES, Baby boy	01005842	ATTENDING, R	15Aug2003 10:41	Hepatitis B core ant
JONES, Baby boy	01005842	ATTENDING, R	15Aug2003 10:41	Hepatitis B Vac Reco
JONES, Baby boy	01005842	ATTENDING, R	15Aug2003 10:41	Hepatitis B Immune G

Activate

Details

Forward

Issue

Delete

Cancel



Demog

▼ Orders

▼ Results

▼ Viewer

Allergies

▼ Pathways

Pharmacy

▼ Care Mgmt

▼ Setup

Notes

Med Profile

Microbiology ...

Patient Problem List

☒ All ☐ ActiveAdd:

Status	Problem Description	Gde
A	Newborn exposure to maternal h...	

Guidelines

Update Problem

Patient Order List

Expand

Change Context

Prefs

Save Session

Current order	ST	Sub ST	Start Date	Problem
Hepatitis B Vac Recombinant Inj inj	U	READY	15Aug2003	

Modify

D/C

Issue

Dept Buttons

Common

Order Sets

Search

Meds

Personal

Prescriptions

Common Orders

MEDICATIONS

Order Selection

- ☐ Order is Historical
☐ Order is Prescription

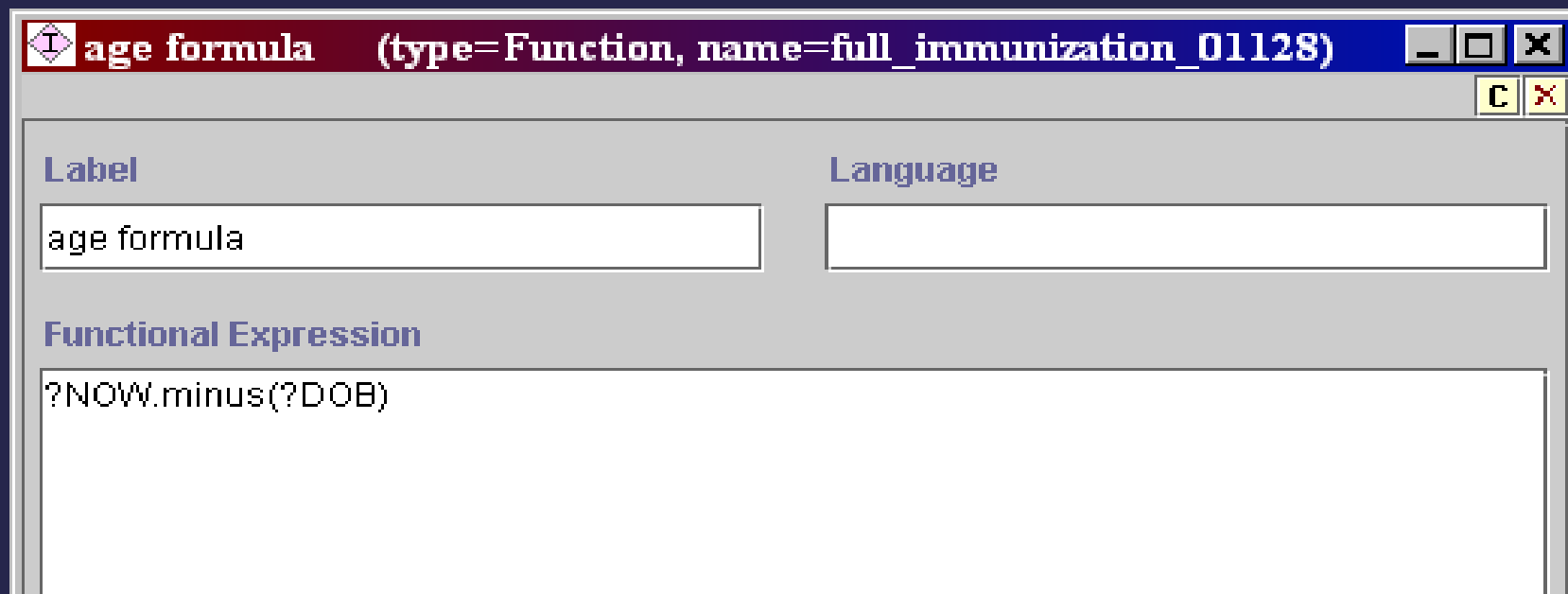
Select Order

Button Dept: MED

Order Text Search:

Age is a Variable in Protégé

The variable has a formula:



The screenshot shows a dialog box titled "age formula" with a subtitle "(type=Function, name=full_immunization_01128)". The dialog has three main sections: "Label", "Language", and "Functional Expression". The "Label" section contains a text box with "age formula". The "Language" section is empty. The "Functional Expression" section contains a text box with the formula "?NOW.minus(?DOB)".

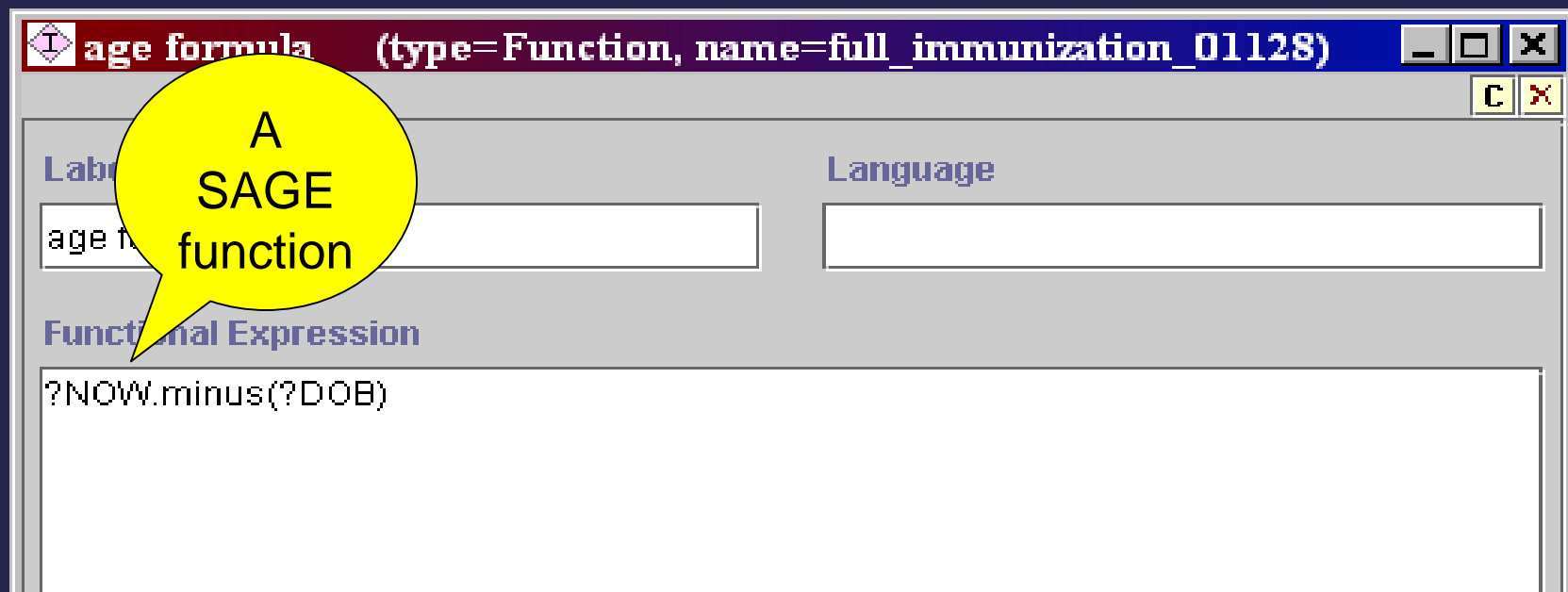
Label	Language
age formula	

Functional Expression

?NOW.minus(?DOB)

Age is a Variable in Protégé

The variable has a formula:



The screenshot shows a window titled "age formula (type=Function, name=full_immunization_01128)". Inside the window, there are two input fields: "Label" and "Language". Below these is a section titled "Functional Expression" containing the text "?NOW.minus(?DOB)". A yellow speech bubble with the text "A SAGE function" points to the "Functional Expression" field.

Label	Language
age formula	

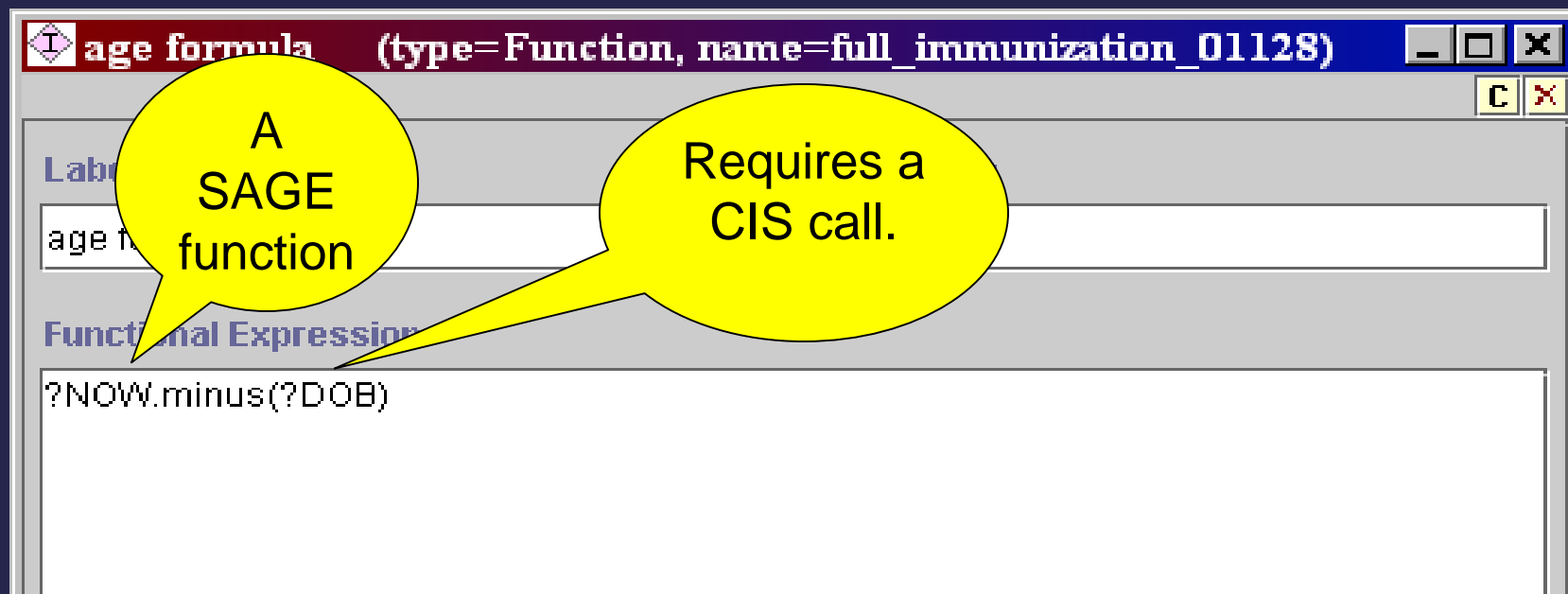
Functional Expression

?NOW.minus(?DOB)



Age is a Variable in Protégé

The variable has a formula:



How is Age computed

Date of birth (type=Variable, name=GuidelineMode)	
Label	Prompt
Date of birth	
Datatype	Referenced As
<input checked="" type="radio"/> PointInTime	?DOB
Update Expression	Derivation Expression
	<input checked="" type="checkbox"/> date of birth

date of birth (type=VMR_Query, name=GuidelineMo..)	
Label	Selection Attribute
date of birth	<input checked="" type="checkbox"/> value
Aggregation Operator	Vmr Specification
most_recent	<input checked="" type="checkbox"/> Birth date

SNOMED-CT
code = 184099003



Allergy_Presence_Criterion: anaphylaxis reaction to DtaP

anaphylaxis reaction to DTaP (type=Allergy_Presence_Criterion, ...)

Label	Vmr Class
anaphylaxis reaction to DTaP	<input checked="" type="radio"/> Allergy
Presence	Code
true	<input checked="" type="radio"/> vaccine allergy ^A
Allergen	Valid Window
<input checked="" type="radio"/> DTaP vaccine ^A	
Reaction	Severity
<input checked="" type="radio"/> anaphylaxis	

Temporal_Comparison_Criterion: 1st Hep B given within 7 days of birth

1st Hep B given within 7 days of birth (type=Temporal_Comparison_Criterion, ...)

Label 1st Hep B given within 7 days of birth	Aggregation Operator first
Code Hepatitis B virus vaccine	Vmr Class SubstanceAdministration
Valid Window	Time Attribute effectiveTime
Operator before	Time For Comparison 7 days after birth

Hepatitis B virus vaccine (type=CodedValue)

Name Hepatitis B virus vaccine	Documentation	Constraints
Role Abstract		
Code 34689006	DisplayName	
CodeSystemName SNOMED CT	CodeSystem	
CodedSystemVersion		

Hep B Anaphylaxis

anaphylaxis reaction to Hep B vaccine (type=Allergy_Presence_Criterion, nam...

Label

anaphylaxis reaction to Hep B vaccine

Presence

true

Allergen

V C + -

Hepatitis B virus vaccine^A

Reaction

V C + -

anaphylaxis

anaphylaxis reaction to Hep B vaccine (type=Allergy_Presence_Criterion, nam...

Code

V + -

allergic reaction^A

Valid Window

V C + -

Severity

V C + -

This type of criteria checks for presence|absence of a temporal interval (valid window)

anaphylaxis (type=CodedValue)

Name

anaphylaxis

Role

Concrete

Code

39579001

CodeSystemName

SNOMED CT

CodedSystemVersion

Documentation

Constraints

DisplayName

CodeSystem

V C + -

Counting Previous Vaccinations: Processed using SubstanceAdministration

The screenshot shows a window titled "# of hep B doses = 0 (type=Comparison_Criterion, name=ful...)". It contains several fields and buttons:

- Label:** A text box containing "# of hep B doses = 0".
- Vmr Class:** A dropdown menu showing "SubstanceAdministration".
- Aggregation Operator:** A dropdown menu showing "number_of".
- Code:** A dropdown menu showing "Hepatitis B virus vaccine".
- Valid Window:** A text box with buttons "V", "C", "+", and "-" next to it.
- Operator:** A dropdown menu showing "equals".
- Assume:** A dropdown menu showing "no_assumpti...".
- Value:** A text box containing "0" with buttons "V", "C", "+", and "-" next to it.

- Get subsumption for Code (HepB vaccine)
- Sets valid window (begin, end) = start of time through NOW
- Calls VMR Service method **getSubstanceAdminCount()**
 - Passes in getSubstanceAdminCountRequest
 - Includes set of codes subsumed
 - Returns getSubstanceAdminCountResponse (integer)
- Compares returned value against "Value" (0) using "Operator" (equals) and Criterion returns True/False



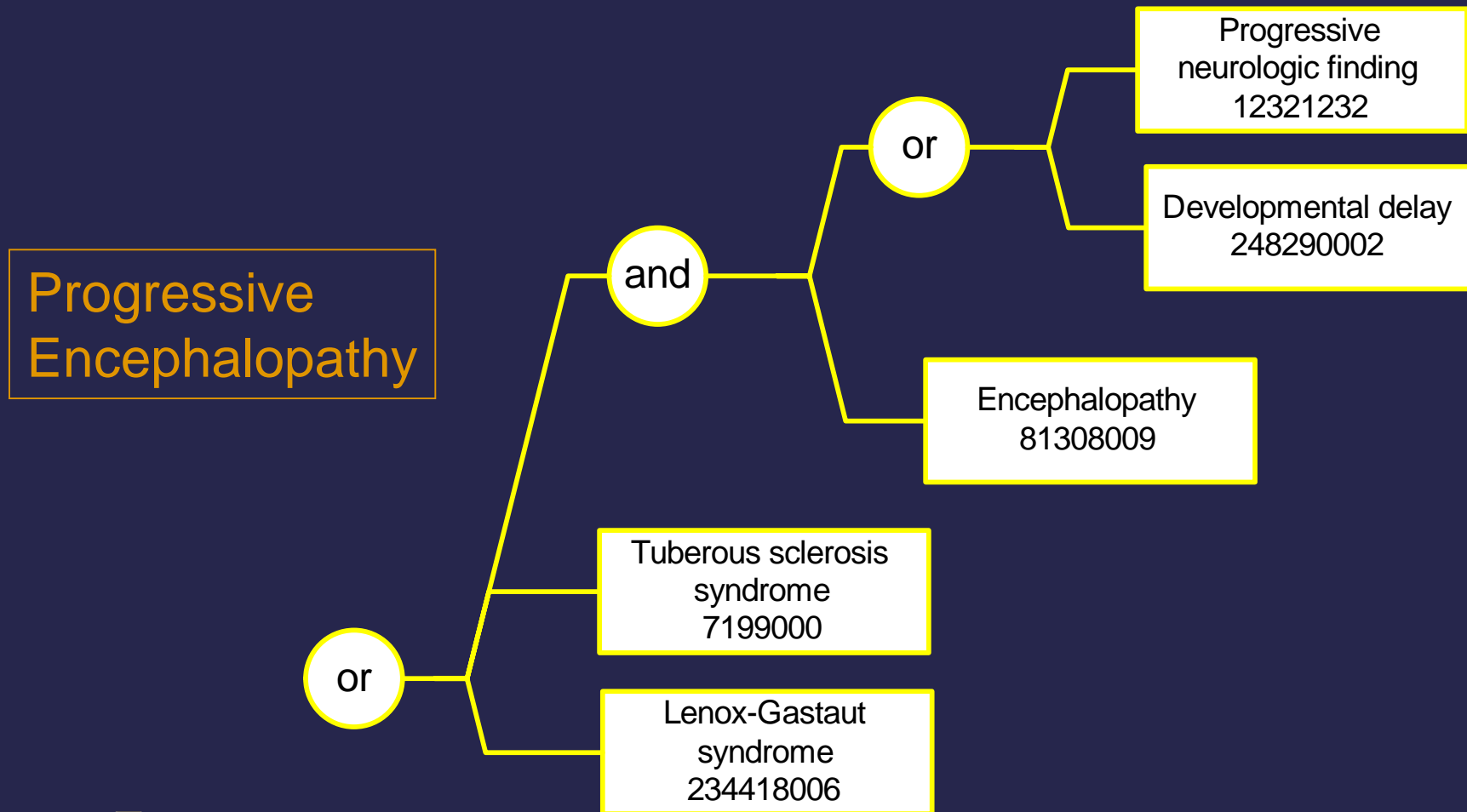
Concept Expressions

- Progressive Encephalopathy is encoded as

The image displays three overlapping windows from the SNOMED CT editor, illustrating the hierarchical construction of the concept 'Progressive encephalopathy'.

- Top Window: 'Progressive encephalopathy' (type=ConceptExpression)**
 - Name:** Progressive encephalopathy
 - Role:** Abstract ^A
 - Boolean Connective:** OR
 - Concepts:** A list containing:
 - Tuberous sclerosis syndrome ^A
 - Lennox-Gastaut syndrome ^A
 - Encephalopathy, progressive or with developmental delay ^A (highlighted)
- Middle Window: 'Encephalopathy, progressive or with developmental delay' (type=ConceptExpression)**
 - Name:** Encephalopathy, progressive or with developmental delay
 - Role:** Abstract ^A
 - Boolean Connective:** AND
 - Concepts:** A list containing:
 - encephalopathy ^A
 - progressive neurological finding or developmental delay ^A (highlighted)
- Bottom Window: 'progressive neurological finding or developmental delay' (type=ConceptExpression)**
 - Name:** progressive neurological finding or developmental delay
 - Role:** Abstract ^A
 - Boolean Connective:** OR
 - Concepts:** A list containing:
 - Progressive neurologic finding ^A
 - Developmental delay ^A (highlighted)

Boolean using SNOMED-CT codes

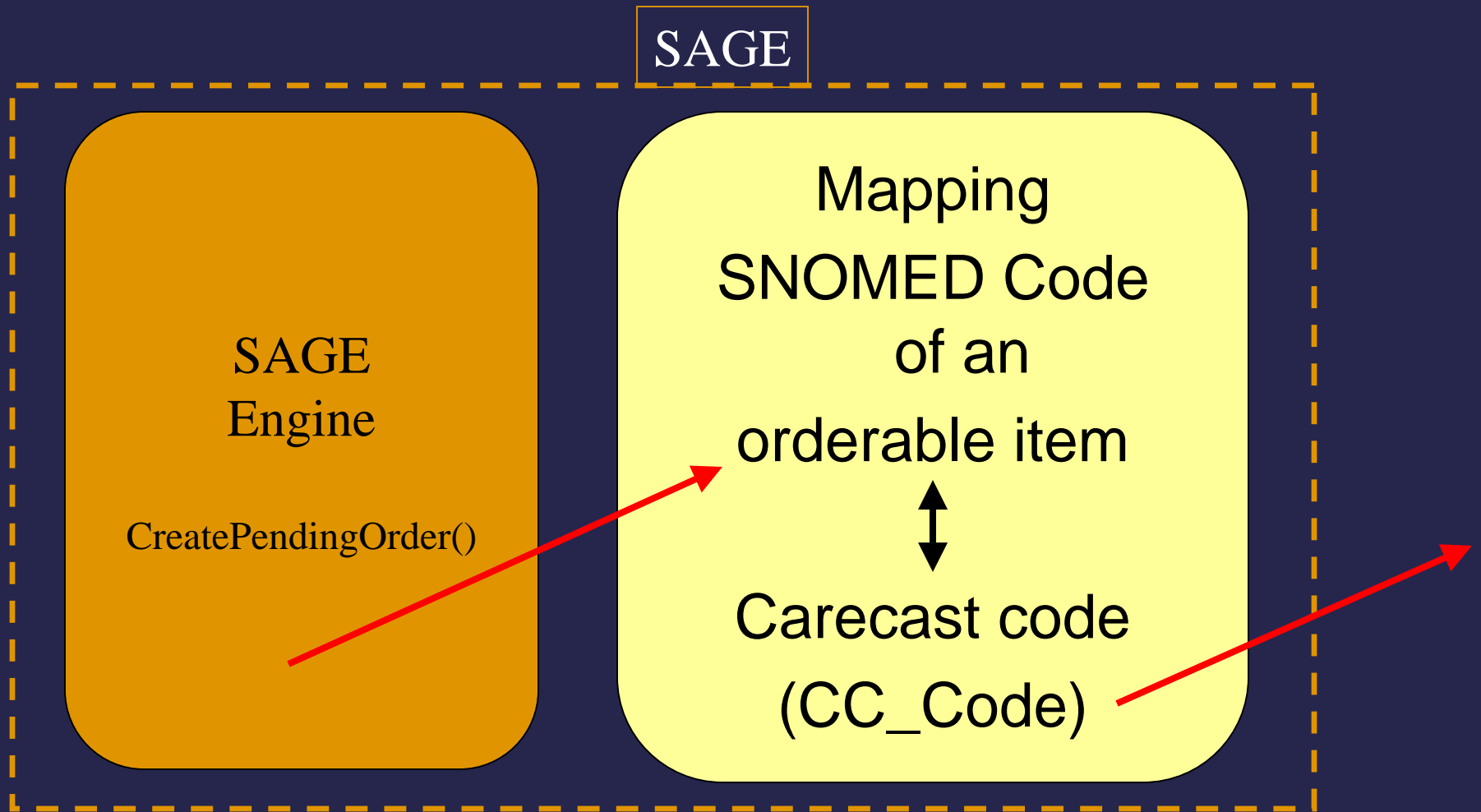


Concept Expressions

- Process
 - Assemble list of concept codes specified in the concept expression using “Boolean Connectivity” specified
 - Pass the list to VMR class specified in criterion
 - Evaluate the returned values from the CIS (True or False, here, since we are dealing with Presence_criterion)
- This is similar to how other single Concept codes are processed
 - Subsumption will be provided by terminology service



Mapping inside SAGE (now)



Post-coordination examples for Immunization Guideline

- Progressive encephalopathy
- Reason for vaccine deferral
- VIS was given to patient
- Child born of HBsAG positive mother
- Sexual contact HIV positive
- Lives with family member has HIV
- PMH thrombocytopenic purpura
- PMH thrombocytopenia
- Severe wound lesion
- Contaminated wound lesion

Should Findings have Severity qualifiers?

Findings list:

- P 63670007 myocardial imaging for infarct, planar technique
- P 161502000 H/O: myocardial infarct at less than 60
- P 161503005 H/O: myocardial infarct at greater than 60
- P 275941002 FH: MI - Myocardial infarct at less than 60
- P 275901006 FH: MI - Myocardial infarct at greater than 60
- P 41486009 myocardial imaging for infarct with ejection fraction, first
- P 22298006 myocardial infarction
- P 1755008 old myocardial infarction
- P 266897007 FH: Myocardial infarction
- P 164865005 ECG: myocardial infarction
- P 394710008 first myocardial infarction
- P 57054005 acute myocardial infarction
- P 194815007 aborted myocardial infarction
- P 233843008 silent myocardial infarction
- P 113155009 myocardial infarction education
- P 194856005 subsequent myocardial infarction

Details: Distributed relationships

Fully defined by ...

- 116880003 Is a
 - D 128599005 structural disorder of heart
 - D 57809008 myocardial disease
- Group-1
 - 116876008 Associated morphology
 - D 55841003 infarct
 - 363698007 Finding site
 - D 74281007 myocardium structure
- Qualifiers-0
 - 246100006 Onset
 - D 385315009 sudden onset
 - D 61751001 gradual onset
 - 246112005 Severity
 - 246456000 Episodicity
 - 260908002 Course

Find: wound lesion Words - any order

P 239155007 wound lesion

Details: Distributed relationships

ConceptStatus Current

Descriptions

- F 628133010 wound lesion (finding)
- P 358445015 wound lesion

Primitive

- 116880003 Is a
 - D 225552003 wound finding
- 363698007 Finding site
 - D 20795001 structure of skin region
 - D 386045008 hair structure
 - D 72651009 nail structure

Legacy codes

- SNOMED: F-40150
- CTV3ID: X50Km



Should a “Short sleeper” be considered to have an “Encephalopathy”?

The screenshot displays the SNOMED CT browser interface. The search bar at the top contains the term "encephalopathy". The left pane shows a list of concepts related to encephalopathy, including "encephalopathy" (S81308009) and "short-sleeper (disorder)" (F575768016). The right pane shows a list of concepts related to "Short-sleeper", including "Short-sleeper" (C192007009) and "disease of brain" (C81308009). The bottom pane shows the details for the "Short-sleeper" concept, including its status as "Current", its descriptions, and its primitive relationships.

Find: encephalopathy **Words - any order** **Hierarchy:** Subtype hierarchy

Left Pane (Concepts related to encephalopathy):

- P55623006 toxic encephalopathy due to mercury
- P230360009 encephalopathy due to radiation damage
- P230352008 encephalopathy due to vitamin deficiency
- P73935008 toxic encephalopathy due to hydroxyquinoline
- P78938004 infantile encephalopathy AND lactic acidosis
- P74267005 toxic encephalopathy due to carbon tetrachloride
- P39925003 juvenile myopathy, encephalopathy, lactic acidosis AND :
- P230429005 early infantile epileptic encephalopathy with suppression
- S81308009 encephalopathy
- S51399001 lead encephalopathy
- S230192003 limbic encephalopathy
- S230361008 septic encephalopathy
- S2776000 acute encephalopathy
- S74351001 Reye's encephalopathy
- S95644001 lupus encephalopathy
- S70884002 allergic encephalopathy

Right Pane (Concepts related to "Short-sleeper"):

- C118934005 disease of head
- C23853001 disease of the central nervous system
- C81308009 disease of brain
- C192007009 "Short-sleeper"
- C253128003 abnormality of neurogenesis
- C4088009 acquired hydrocephalus
- C230351001 acquired metabolic and toxic encephalopathies
- C359624005 acquired periventricular cyst
- C359621002 acquired periventricular cysts of newborn
- C193071004 adhesions - cerebral meninges
- C4448006 allergic headache
- C75076004 Amyelencephalus
- C204039001 anomalies of cerebrum
- C44875002 Balo's concentric sclerosis
- C254977002 benign tumor of optic nerve and sheath
- C46263000 cataplexy
- C204052006 Cebocephaly
- C27405005 central sleep apnea syndrome
- C241994005 cerebellar decompression injury
- C312372003 cerebral akinetopsia
- C253162003 cerebral arachnoid cyst
- C28634005 cerebral ataxia
- C278849000 cerebral atrophy
- C17944005 cerebral calcification
- C241993004 cerebral decompression injury
- C192795000 cerebral degeneration in Hunter's disease
- C192796004 cerebral degeneration in mucopolysaccharidoses
- C87227007 cerebral depression in newborn
- C276721005 cerebral dysgenesis
- C2032001 cerebral edema
- C34209003 cerebral hemiplegia
- C240312009 cerebral injury due to birth trauma
- C276596008 cerebral irritation
- C276599001 cerebral leukomalacia

Details: Distributed relationships

ConceptStatus: Current

Descriptions:

- F575768016 short-sleeper (disorder)
- P295427011 "Short-sleeper"

Primitive:

- E116680003 Is a
 - D39898005 sleep disorder
 - D81308009 disease of brain
- E363698007 Finding site
 - D280369009 brain tissue structure
- E246100006 Onset
 - D385315009 sudden onset
 - D61751001 gradual onset
- E246112005 Severity
 - D371923003 mild to moderate
 - D255604002 mild

Problems Facing Guideline Vocabulary Use

- Expansion of syntax options for post-coordination
- Rapid response from CAP on post-coordination needs for non-specialized concepts
- Accuracy of subsumption relationships
- Should quality control of SNOMED relationships interact with projects such as SAGE?

