OpenCDS: an Open-Source, Standards-Based, Service-Oriented Framework for Scalable CDS

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Presentation Overview

- **Background**
  - Clinical decision support (CDS) - definition, examples, evidence of effectiveness
- **Problem**
  - Need for scalable CDS
- **Potential Solution**
  - Standards-based, open-source CDS services
- **OpenCDS**
- **Discussion**

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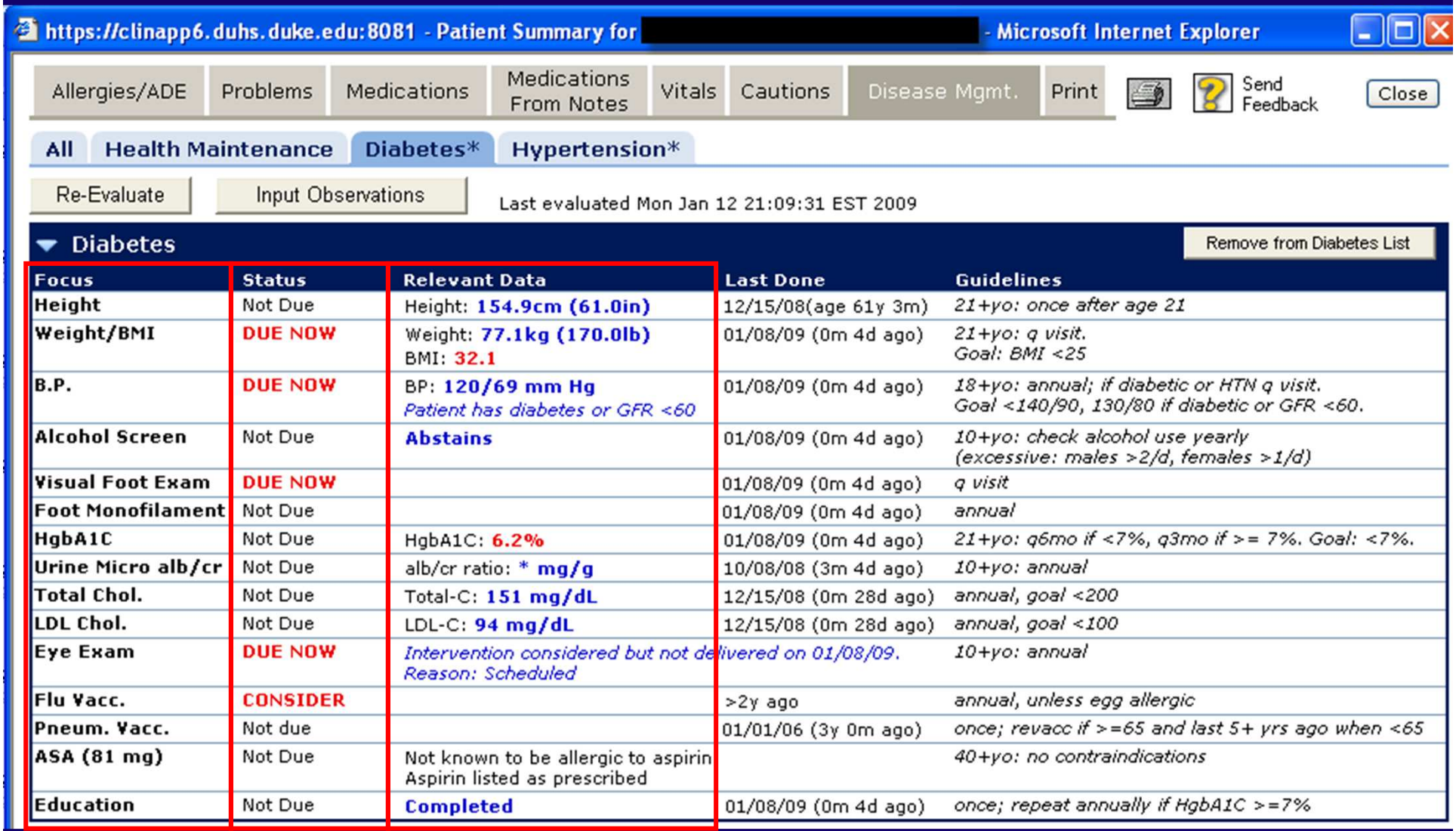
Clinical Decision Support (CDS)

- The act of **providing clinicians, patients and other healthcare stakeholders** with **pertinent knowledge and/or person-specific information**, intelligently filtered or presented at appropriate times, to **enhance health and health care** (Osheroff, *J Am Med Inform Assoc*, 2007)

Example Disease Management Reminders



Focus	Status	Relevant Data	Last Done	Guidelines
Height	Not Due	Height: **154.9cm (61.0in)**	12/15/08(age 61y 3m)	*21+yo: once after age 21*
Weight/BMI	DUE NOW	Weight: **77.1kg (170.0lb)** BMI: **32.1**	01/08/09 (0m 4d ago)	*21+yo: q visit.* *Goal: BMI <25*
B.P.	DUE NOW	BP: **120/69 mm Hg** *Patient has diabetes or GFR <60*	01/08/09 (0m 4d ago)	*18+yo: annual; if diabetic or HTN q visit.* *Goal <140/90, 130/80 if diabetic or GFR <60.*
Alcohol Screen	Not Due	**Abstains**	01/08/09 (0m 4d ago)	*10+yo: check alcohol use yearly* *(excessive: males >2/d, females >1/d)*
Visual Foot Exam	DUE NOW		01/08/09 (0m 4d ago)	*q visit*
Foot Monofilament	Not Due		01/08/09 (0m 4d ago)	*annual*
HgbA1C	Not Due	HgbA1C: **6.2%**	01/08/09 (0m 4d ago)	*21+yo: q6mo if <7%, q3mo if >= 7%. Goal: <7%.*
Urine Micro alb/cr	Not Due	alb/cr ratio: * **mg/g**	10/08/08 (3m 4d ago)	*10+yo: annual*
Total Chol.	Not Due	Total-C: **151 mg/dL**	12/15/08 (0m 28d ago)	*annual, goal <200*
LDL Chol.	Not Due	LDL-C: **94 mg/dL**	12/15/08 (0m 28d ago)	*annual, goal <100*
Eye Exam	DUE NOW	*Intervention considered but not delivered on 01/08/09.* *Reason: Scheduled*		*10+yo: annual*
Flu Vacc.	CONSIDER		>2y ago	*annual, unless egg allergic*
Pneum. Vacc.	Not due		01/01/06 (3y 0m ago)	*once; revacc if >=65 and last 5+ yrs ago when <65*
ASA (81 mg)	Not Due	Not known to be allergic to aspirin Aspirin listed as prescribed		*40+yo: no contraindications*
Education	Not Due	**Completed**	01/08/09 (0m 4d ago)	*once; repeat annually if HgbA1C >=7%*

Source: Duke University Health System. Lobach DF, Kawamoto K, et al. Medinfo. 2007;861-5.

Example Care Quality Reporting

DukeMedicine

Clinic Summary
Patients

Chronic Disease
Population Management

Clinic Group: DPC | Clinic: DPC-Creedmoor Rd | PCP: [redacted]

Condition: Diabetes

Guidelines

	A1c				Aspirin Therapy	BP	Eye Exam	Flu Vaccine	Foot Monofilament Exam	LDL		Urine Micro alb/cr	Weight
Patient Name	<7	>9	Done	Done 2X	Prescribed	<130/80	Done	Done	Done	Done	LDL < 100	Done	BMI < 25
XXXXXXXX, XXXXX	No	Yes	Yes	Yes	No	Yes	No	No	No	Yes	Yes	No	No
XXXXXXXX, XXXXX	No	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	No	No
XXXXXXXX, XXXXX	Yes	No	Yes	Yes	No	No	No	Yes	No	Yes	Yes	No	No
XXXXXXXX, XXXXX	Yes	No	Yes	Yes	No	No	No	No	No	No	No	Yes	No
XXXXXXXX, XXXXX	No	No	Yes	No	No	No	No	No	No	Yes	No	No	No
XXXXXXXX, XXXXX	No	No	Yes	Yes	No	No	No	No	No	Yes	Yes	No	No
XXXXXXXX, XXXXX	No	Yes	Yes	No	No	No	No	No	No	Yes	Yes	No	No
XXXXXXXX, XXXXX	No	Yes	Yes	Yes	No	No	No	Yes	No	Yes	Yes	No	No
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XXXXXXXX, XXXXX	Yes	No	Yes	No	No	No	No	No	No	No	No	No	No
XXXXXXXX, XXXXX	Yes	No	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	No	No

Source: Duke University Health System.

Example Care Manager Alert

COACH Alerts for Ms. Jenny Rawlings
Document ID: 24
08/08/05 (Mon)

If you have any questions or concerns, please contact Ken Kawamoto, M.D.-Ph.D. candidate, Duke University (kawam001@mc.duke.edu; 919-684-2340).

Patients requiring attention (highest priority patients listed first):

1. [redacted], [redacted] (COACH link). 23 yr. old Caucasian female, DOB [redacted]/82.
Medicaid #: [redacted] Duke MRN: [redacted] Priority: 23.0
[redacted], Durham, NC 27[redacted] Home #: 919-[redacted]

ED visits that may require follow-up:

☐ **3+ ED visits in 90 days, most recent in past month:** The patient was seen at the Duke Hospital ED on 7/9/05. This visit was at least the 3rd ED visit in 90 days. Including this visit, the patient has had 18 ED visits in the past 6 months.

General preventive care needs:

☐ **DUE NOW - Chlamydia test:** Sexually active women between the ages of 16 and 26 should be tested for Chlamydia once every year. We have no record of the patient having received a Chlamydia test in the past 2 years.

☐ **DUE NOW - Pap smear:** Women between the ages of 21 and 64 should have a Pap smear at least once every 3 years to screen for cervical cancer. We have no record of the patient having received a Pap smear in the past 3 years.

2. [redacted], [redacted] (COACH link). 8 mo. old Caucasian male, DOB [redacted]/04.
Medicaid #: [redacted] Duke MRN: [redacted] Priority: 19.5
[redacted], Hillsborough, NC 27[redacted] Home #: 919-[redacted]

ED visits that may require follow-up:

☐ **Low-severity ED visit in past month:** The patient appears to have had a low-severity ED visit at the Duke Hospital ED on 7/19/05. The ED visit was deemed to be low-severity because none of the diagnoses made during the visit appeared to be indicative of a true emergency. Including this visit, the patient has had 3 low-severity ED

Source: NC Medicaid. Lobach DF, Kawamoto K, et al. AMIA Annu Symp Proc. 2007;473-7.

Example Patient Reminder Letter

Durham Community Health Network

REGIONAL PEDIATRIC Associates, P.A.

Lincoln Community Health Center – Duke University Medical Center – Durham County Department of Social Services
Durham County Health Department – Durham Pediatrics – Regional Pediatric Associates – Central Family Practice

August 9, 2005

To the parents of Jane Doe,

We are sending you this letter to address your child's health care needs. Based on our records, it appears your child may be due for the following services:

Diabetes services that may be due:

- ☐ **Hemoglobin A1c test:** This test is recommended every 6 months for patients with diabetes.
- ☐ **Cholesterol test:** This test is recommended every 12 months for patients with diabetes.
- ☐ **Urine protein test:** This test is recommended every 12 months for patients with diabetes.

Please call our office at (919) 477-2202 to schedule an appointment, so that the doctor can check to see if your child is in need of these services. Also, please bring this letter with you to the appointment and show it to the doctor. We look forward to seeing you soon!

Sincerely,

Your Care Team

Your Care Team
Regional Pediatric Associates
A Member of the Durham Community Health Network

Source: NC Medicaid. Lobach DF, Kawamoto K, et al. Proc / AMIA Annual Symp. 2007;473-7.

Example Medication Management Report

Medication Summary Report (provided for Medicaid patients through a grant from AHRQ)

Patient: [redacted] (Duke MRN [redacted]) Duke Family Medicine — Appt date: [redacted]2009
DOB: [redacted]/1979 Gender: F — Provider: Harriet N Hansell — Appt time: [redacted]:15

PLEASE NOTE: The information below was generated from claims data and may be inaccurate or incomplete.
Please verify the information, as the provider is acknowledged as the final authority for all care decisions.

If the suggestions above are inappropriate for this patient, please let us know using the accompanying feedback form.

IOM PRIORITY CONDITIONS DETECTED FROM BILLING DATA FOR THIS PATIENT disease (first detection date):
Diabetes mellitus (*Jan, 2005*); Hypertension (*May, 2005*); Hyperlipidemia (*Aug, 2007*)

Prescriptions filled in 12 months prior to 08 / 13 / 2009 :

	% days covered	08 S	O	N	D	09 J	F	M	A	M	J	J	A
Anti-hypertensive agent	!! 25%												
lisinopril oral tablet 20 mg	25%						▬		▬				
insulin, metformin, oral hypoglycemic, or thiazolidinedione (TZD)	! 59%												
insulin glargine, human recombinant analog subcutaneous insulin pen 300 unit/3 ml	44%	▬				▬			▬	▬			
insulin lispro subcutaneous insulin pen 100 unit/ml	5%												▬
insulin lispro subcutaneous vial (sdv,mdv or additive) 100 unit/ml	18%		▬			▬							
metformin hcl oral tablet 850 mg	16%								▬				

EVIDENCE-BASED MEDICATION MANAGEMENT SUGGESTIONS FOR IOM PRIORITY CONDITIONS:

1. **Consider prescribing a Lipid-lowering drug unless contraindicated.** For example, pregnancy, LDL < 100 mg/dL, or other contraindications.
   Indications that apply specifically for this patient:
   - age betwen 18 and 40
   - diabetes mellitus
   - hyperlipidemia

Source: Del Fiol G, Kawamoto K, et al. AMIA Proceedings, 2010.

Evidence of CDS Effectiveness

- **Evidence from systematic reviews**
  - Actionable, computer-generated CDS provided automatically at the point of care significantly improved care quality in >90% of RCTs (Kawamoto, *BMJ*, 2005)
  - CDS generally more effective than other QI approaches – including CME, audit and feedback, EBM guideline creation & dissemination, & financial incentives
- **Examples of effectiveness**
  - 86% reduction in serious medication errors at Brigham and Women's Hospital (Bates, 1999)
  - 93.8% compliance with NCEP guidelines vs. 35.2% compliance in academic cardiology clinic (Stamos, 2001)

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The Problem

- Despite demonstrated effectiveness, CDS is not widely available
- The lack of CDS availability is due in part to the **tight coupling of CDS** capabilities with **specific institutions and health IT systems**

The Need

- **Application-independent CDS resources that can be efficiently leveraged by diverse healthcare systems and health IT settings to improve patient health**

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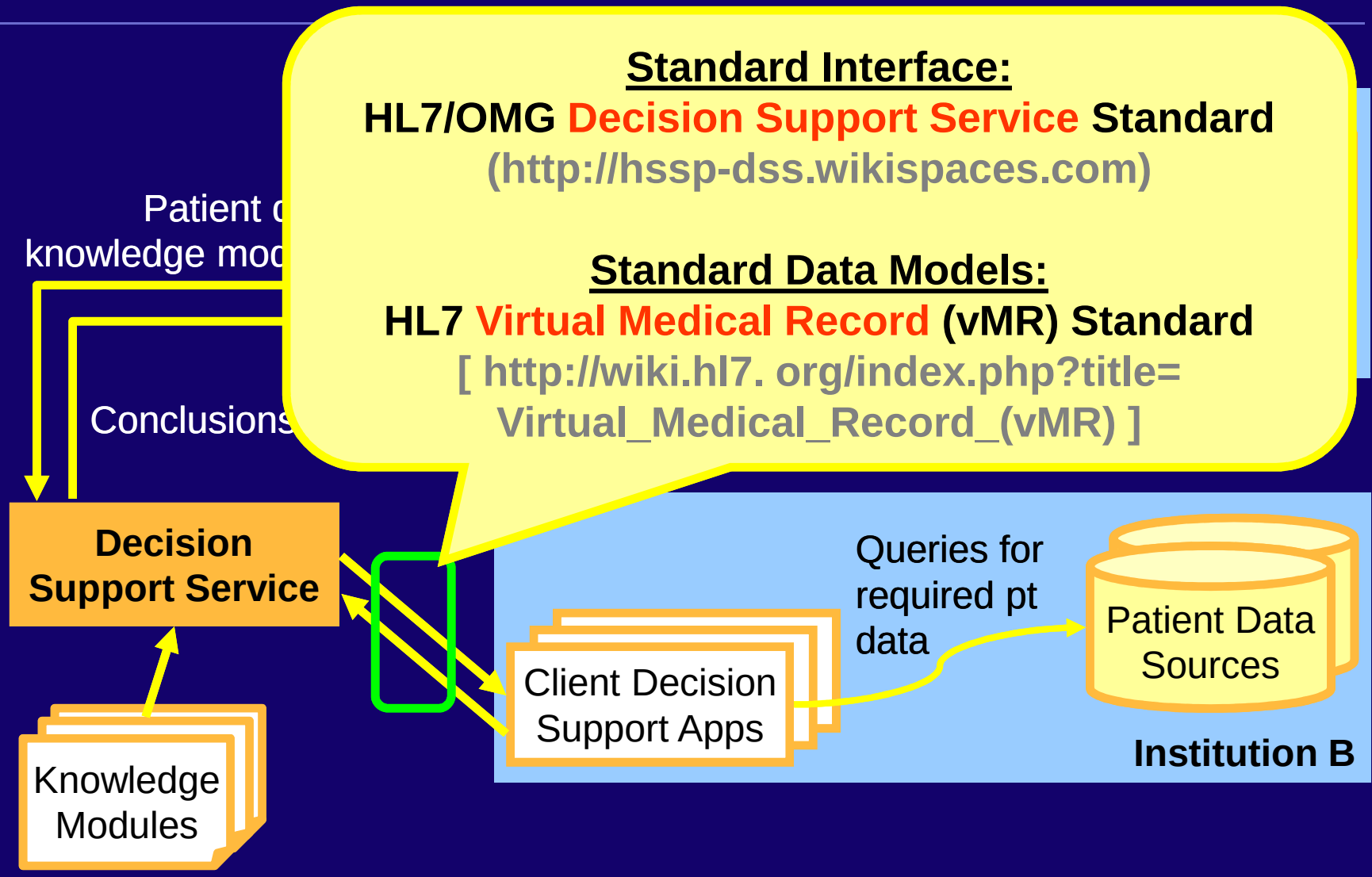
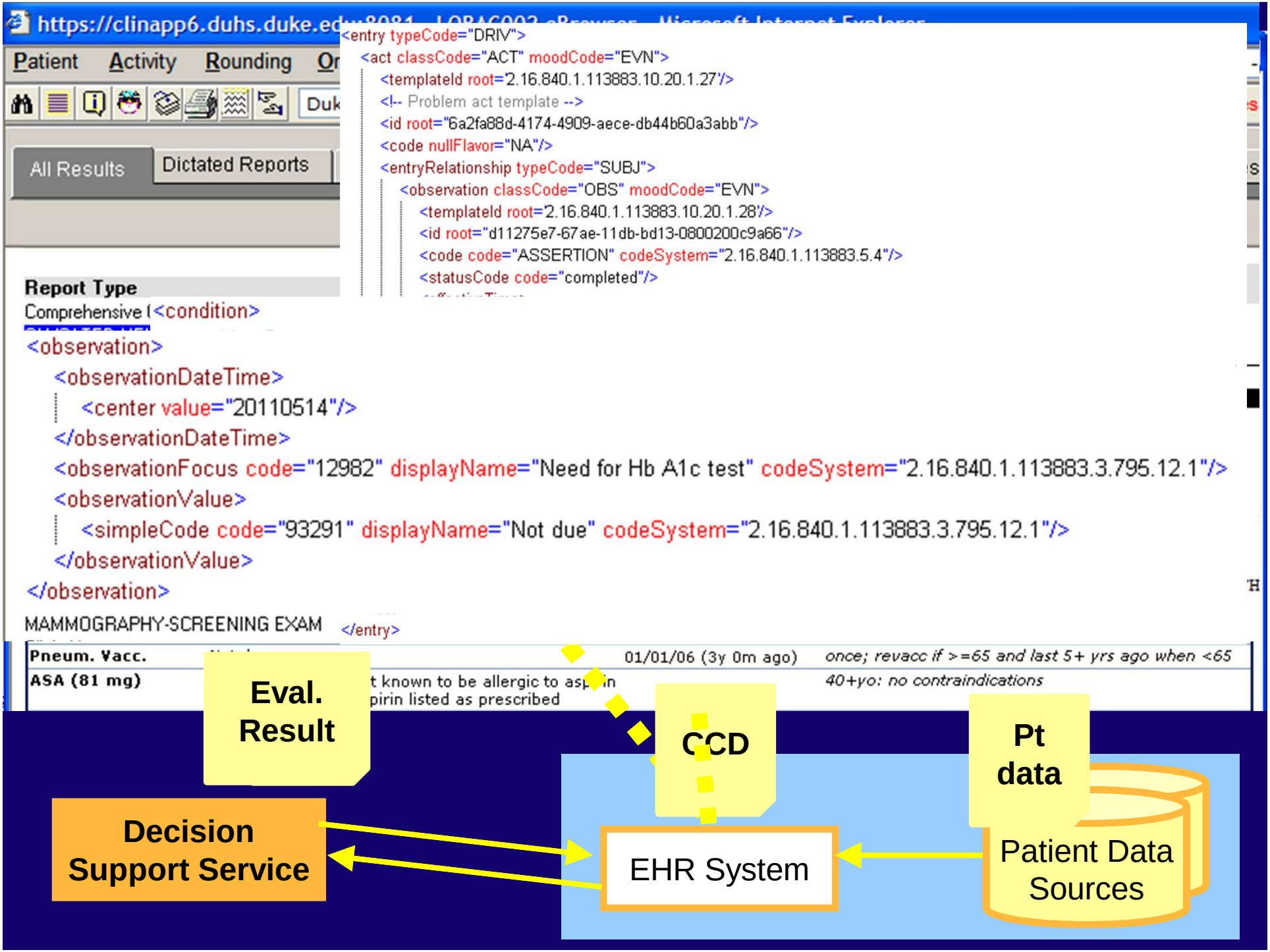
Rationale for Open, Standards-Based CDS Services

- **Why CDS services?**
  - Encapsulates knowledge in highly reusable components
  - Supports multiple knowledge representation approaches
  - Validated by several groups
    - *SEBASTIAN*
    - *DOD DDSS-KMR*
    - *Partners ECRS / CDS Consortium*
- **Why standards-based?**
  - To enable interoperability and scalability
- **Why open source?**
  - To foster adoption and collaboration

CDS Services – Architectural Overview




https://clinapp6.duhs.duke.edu
Patient
Activity
Rounding
All Results
Dictated Reports
Report Type
Comprehensive
<entry typeCode="DRIV">
<act classCode="ACT" moodCode="EVN">
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<!-- Problem act template -->
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<code nullFlavor="NA"/>
<entryRelationship typeCode="SUBJ">
<observation classCode="OBS" moodCode="EVN">
<templateId root='2.16.840.1.113883.10.20.1.28'/>
<id root="d11275e7-67ae-11db-bd13-0800200c9a66"/>
<code code="ASSERTION" codeSystem="2.16.840.1.113883.5.4"/>
<statusCode code="completed"/>
<condition>
<observation>
<observationDateTime>

</observationDateTime>
<observationFocus code="12982" displayName="Need for Hb A1c test" codeSystem="2.16.840.1.113883.3.795.12.1"/>
<observationValue>
<simpleCode code="93291" displayName="Not due" codeSystem="2.16.840.1.113883.3.795.12.1"/>
</observationValue>
</observation>
MAMMOGRAPHY-SCREENING EXAM
</entry>
Pneum. Vacc.
01/01/06 (3y 0m ago)
once; revacc if >=65 and last 5+ yrs ago when <65
ASA (81 mg)
40+yo: no contraindications
Eval. Result
CCD
Pt data
Decision Support Service
EHR System
Patient Data Sources

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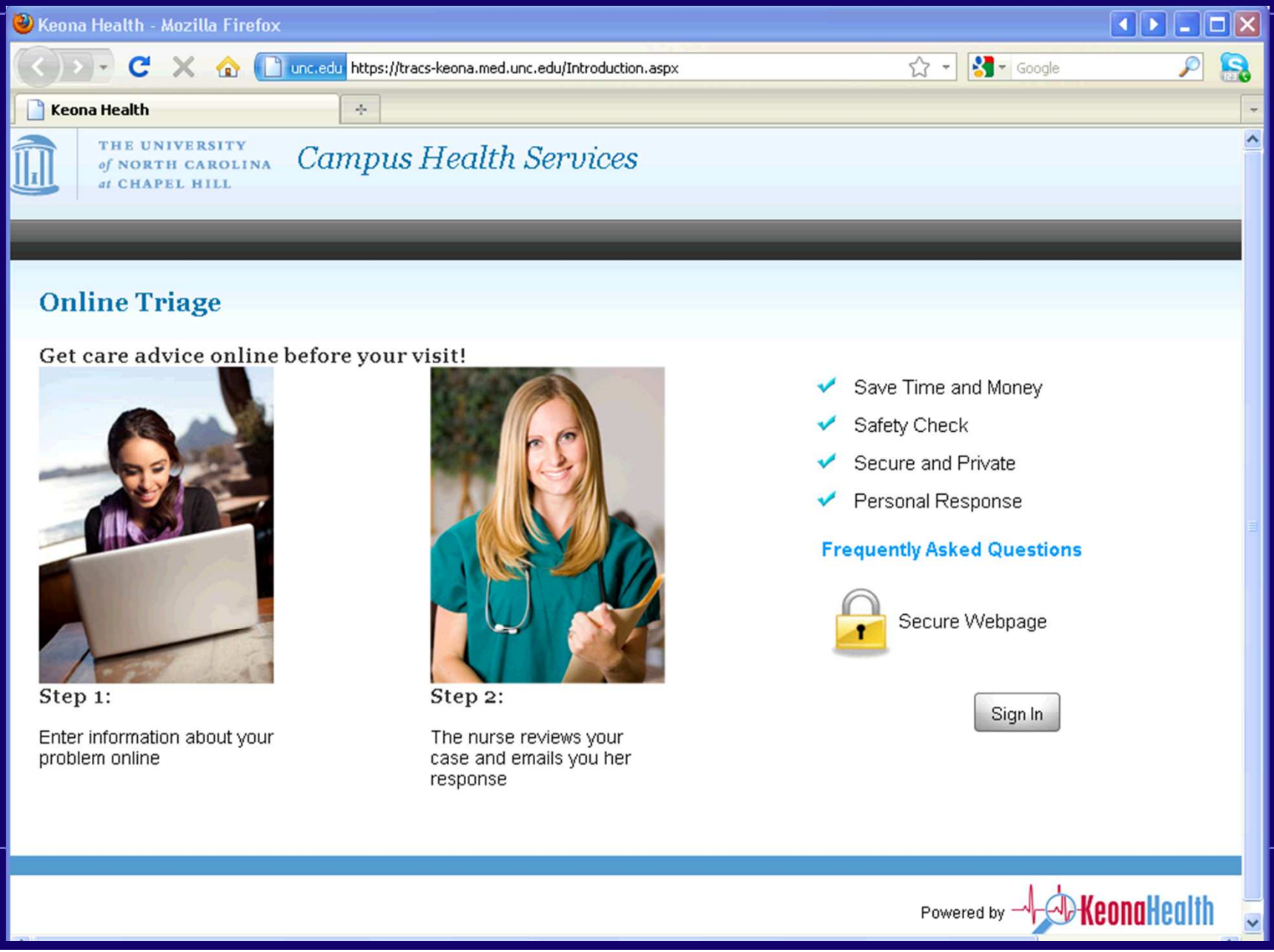
OpenCDS

- **Goal**
  - Facilitate widespread availability of advanced CDS capabilities through open-source, collaborative development of standards-based DSS infrastructure, tooling, and high-value services
- **Methods**
  - Contribute through Open Health Tools
  - Leverage open-source JBoss Drools rules engine
  - Use modular architecture, enable iterative refinement, support multiple knowledge represent. approaches
  - Develop all components required to author, test, and operationally support standards-compliant DSSs

Current OpenCDS Collaborators

- University of Utah
- HLN Consulting
- Veterans Health Admin.
- Intermountain Healthcare
- Univ. of NC at Chapel Hill
- Main Line Health
- Apelon, Inc.
- Keona Health
- Mass. General Hospital
- EBSCO
- Religent, Inc.
- IsoDynamic, Inc.
- Hospital Universitario Virgen del Rocío, Spain
- MaRS Innovation, Canada
- SmartCare, Africa
- Emetra AS, Norway
- Visumpoint, LLC
- Genesys, LLC
- Df8health
- Under active discussions with several other organizations and individuals

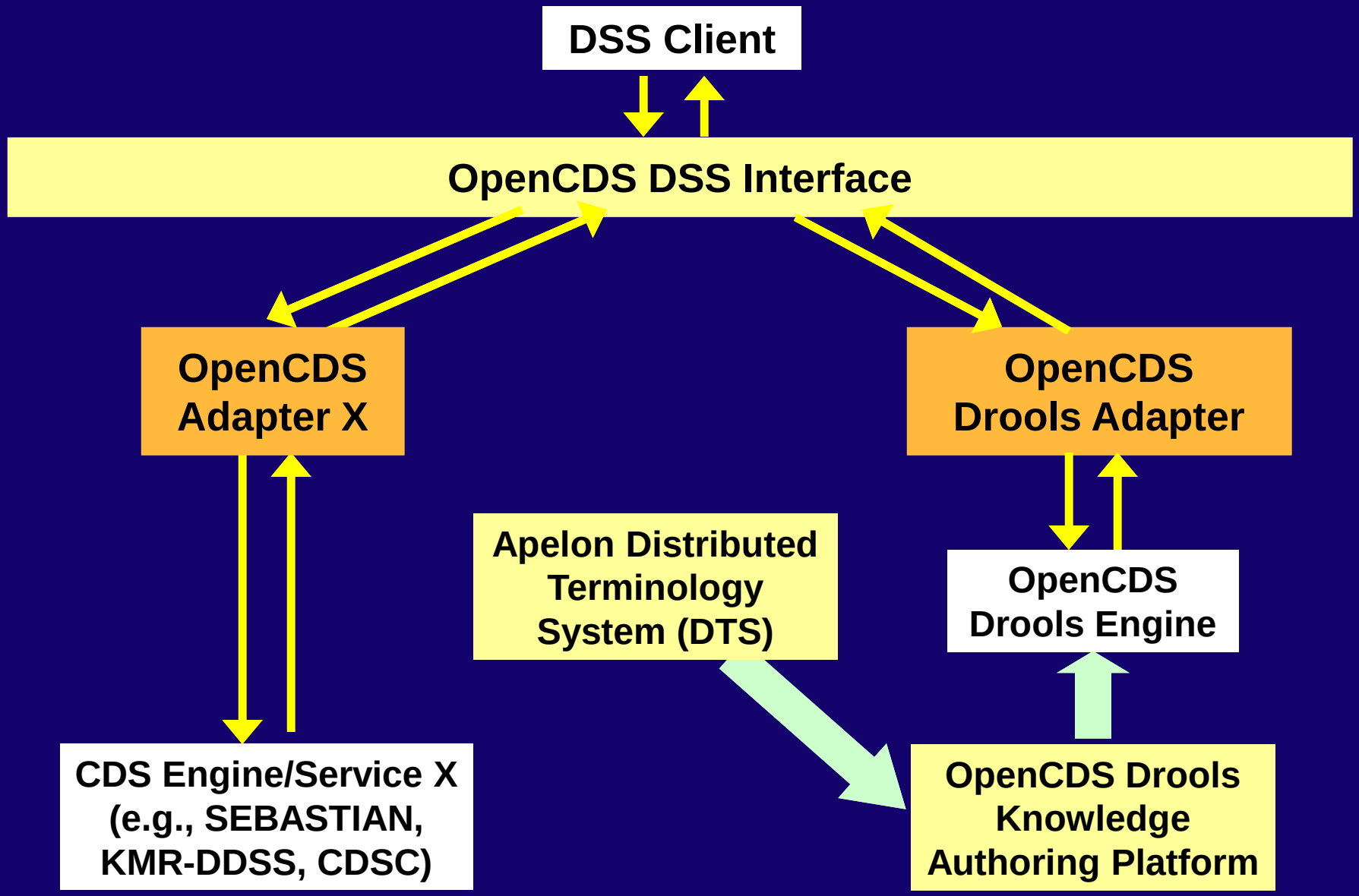
Operational Deployment – Online Triage



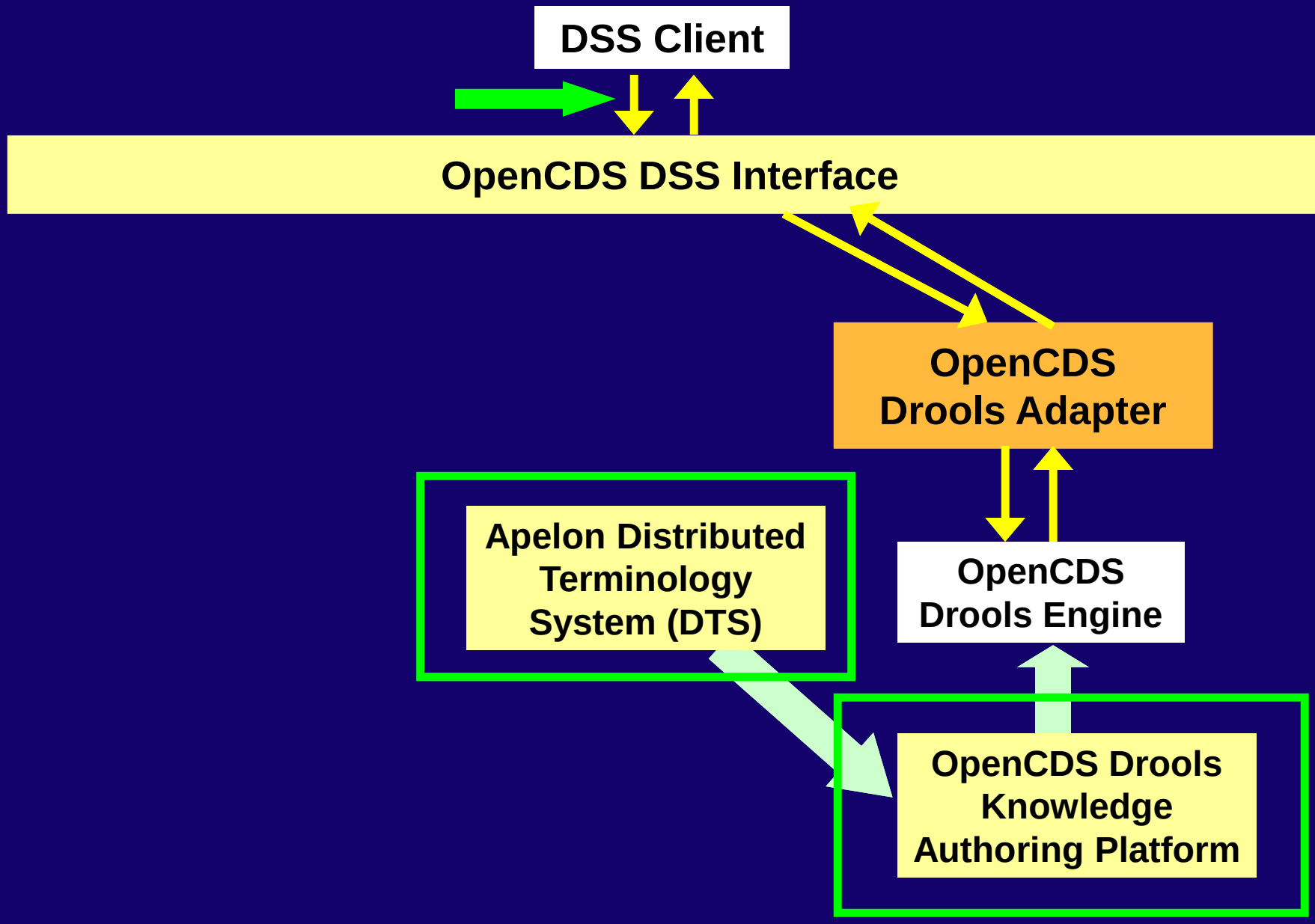
Key Components

- **Standard interfaces and data models**
  - Reference implementation of HL7/OMG DSS interface
  - vMR data model
  - Data mappers (e.g., for CCD → vMR)
- **Reference DSS knowledge management framework**
  - JBoss Drools and associated authoring/knowledge management tools
  - Full-featured terminology support
  - A “domain specific language” for intuitive knowledge authoring
  - Knowledge repository and knowledge sharing service
- **DSS “wrappers” for other CDS engines**

OpenCDS – Sample Topologies



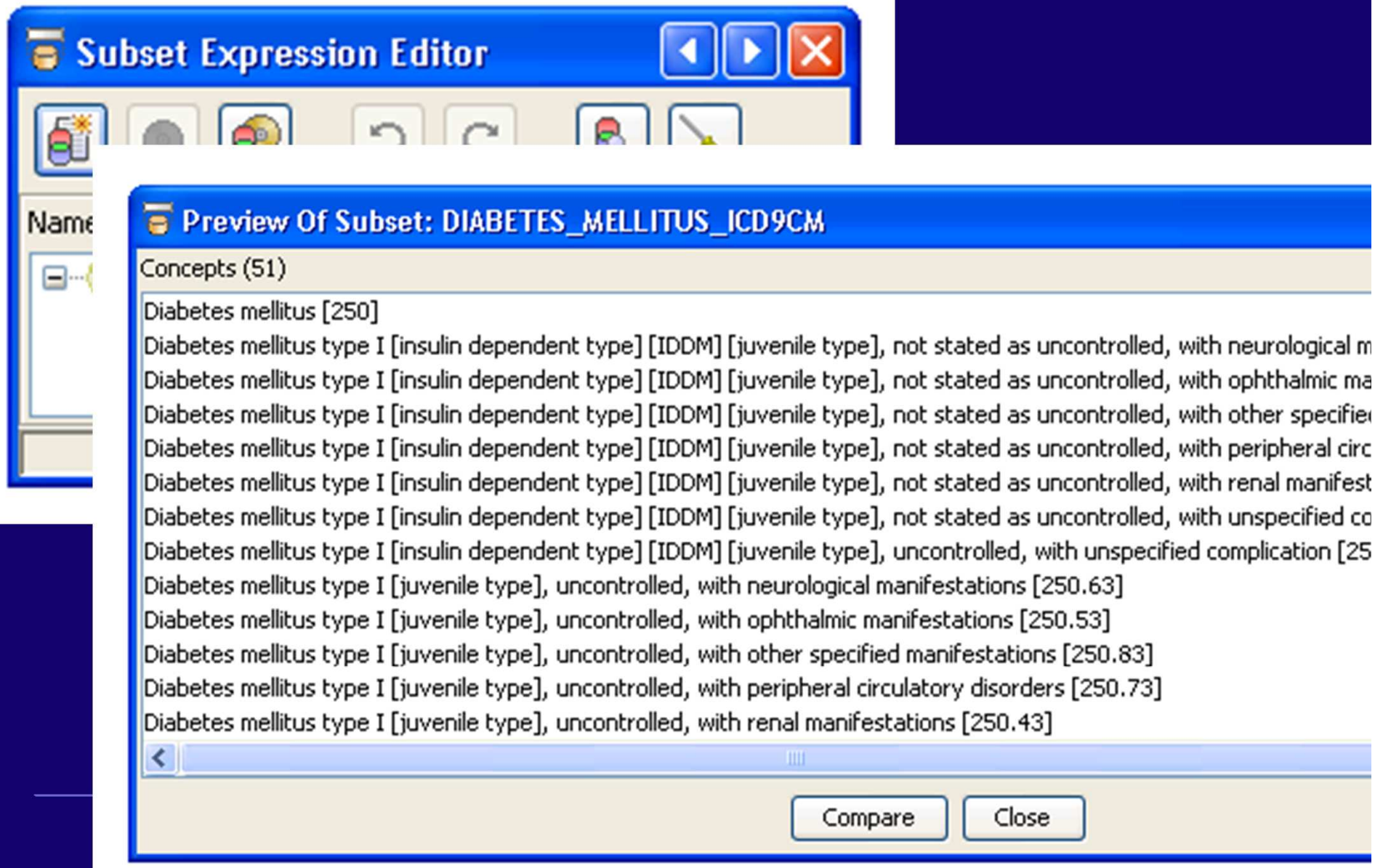
OpenCDS – Tour and Demo



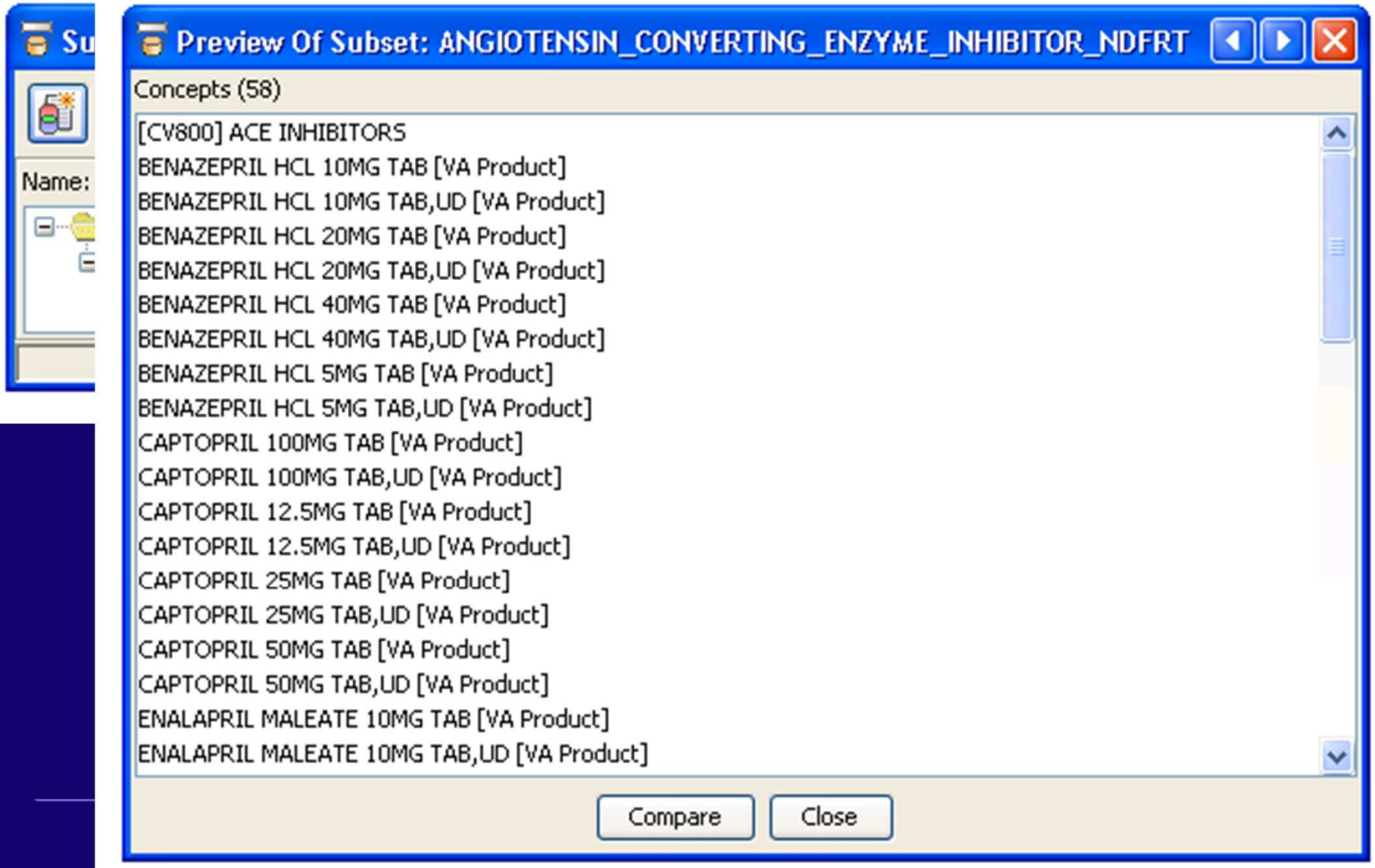
Terminology Management

- **External codes converted into internal OpenCDS concept(s) using terminology service**
  - E.g., ICD9CM 250.42 →
    - *Diabetes mellitus with renal manifestations*
    - *Diabetes mellitus*
    - *Endocrine disease*
- **Separates terminology management from logic engineering**
- **Uses Apelon DTS, but architecture supports use of other terminology services**

OpenCDS – Terminology Mgmt. with Apelon



OpenCDS – Terminology Mgmt. with Apelon



Live Demo

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Key Benefits of Approach

- **Builds on robust open-source community and resources**
- **Provides standard architectural framework for integrating various CDS knowledge resources**
- **Supports full life cycle of knowledge authoring, testing, maintenance, and execution**
- **Provides an open-source framework for collaboration and innovation in CDS**
  - Freely available under Apache 2.0 license

Key Challenges and Potential Solutions

Challenge	Potential solutions
Increased effort required to develop and support knowledge resources for use in multiple contexts	▪ Balance generalizability with resource realities ▪ Spread knowledge development cost over multiple deployment settings
Limited content availability	▪ Provide federal funding for content development ▪ Create an interoperable, standards-based market for such knowledge

- **Bottom line assessment: benefits >> challenges**

Acknowledgements

- **Research support**
  - NHGRI K01 HG004645 (PI: K. Kawamoto)
  - University of Utah Dept. of Biomedical Informatics
- **Numerous OpenCDS collaborators**

www.opencds.org

OpenCDS

Search this site

Home | Collaborators | Architecture | Key Components | Screenshots | References | Acknowledgments | Alpha Release | Join OpenCDS

Home

What is OpenCDS?

OpenCDS is a **multi-institutional, collaborative effort** to develop **open-source, standards-based clinical decision support (CDS) tools and resources** that can be widely adopted to enable CDS at scale.

Who is Involved?

OpenCDS was founded by Dr. Kensaku Kawamoto, MD, PhD, who is a faculty member at the Duke Center for Health Informatics and a co-chair of the HL7 CDS Work Group. OpenCDS collaborators include the University of Utah, Intermountain Healthcare, the Veterans Health Administration, the University of North Carolina at Chapel Hill, and Apelon, Inc.

Breaking News

OpenCDS Alpha Release Available An alpha release of OpenCDS is now available to collaborators. Please see the Alpha Release tab for more information.
Posted Apr 26, 2011 9:51 AM by Kensaku Kawamoto

EBSCO Joins as OpenCDS Collaborator The OpenCDS team is very excited to announce that EBSCO, one of the leading knowledge content providers in healthcare, has joined OpenCDS as a collaborator. The OpenCDS team will be ...
Posted Apr 26, 2011 9:51 AM by Kensaku Kawamoto

OpenCDS at AMIA 2010 OpenCDS collaborators will be discussing OpenCDS and/or its component technologies at the following sessions of the 2010 American Medical Informatics Association (AMIA) Fall Symposium, which will be held in ...
Posted Apr 26, 2011 9:50 AM by Kensaku Kawamoto

Thank You!

- **Kensaku Kawamoto, MD, PhD**

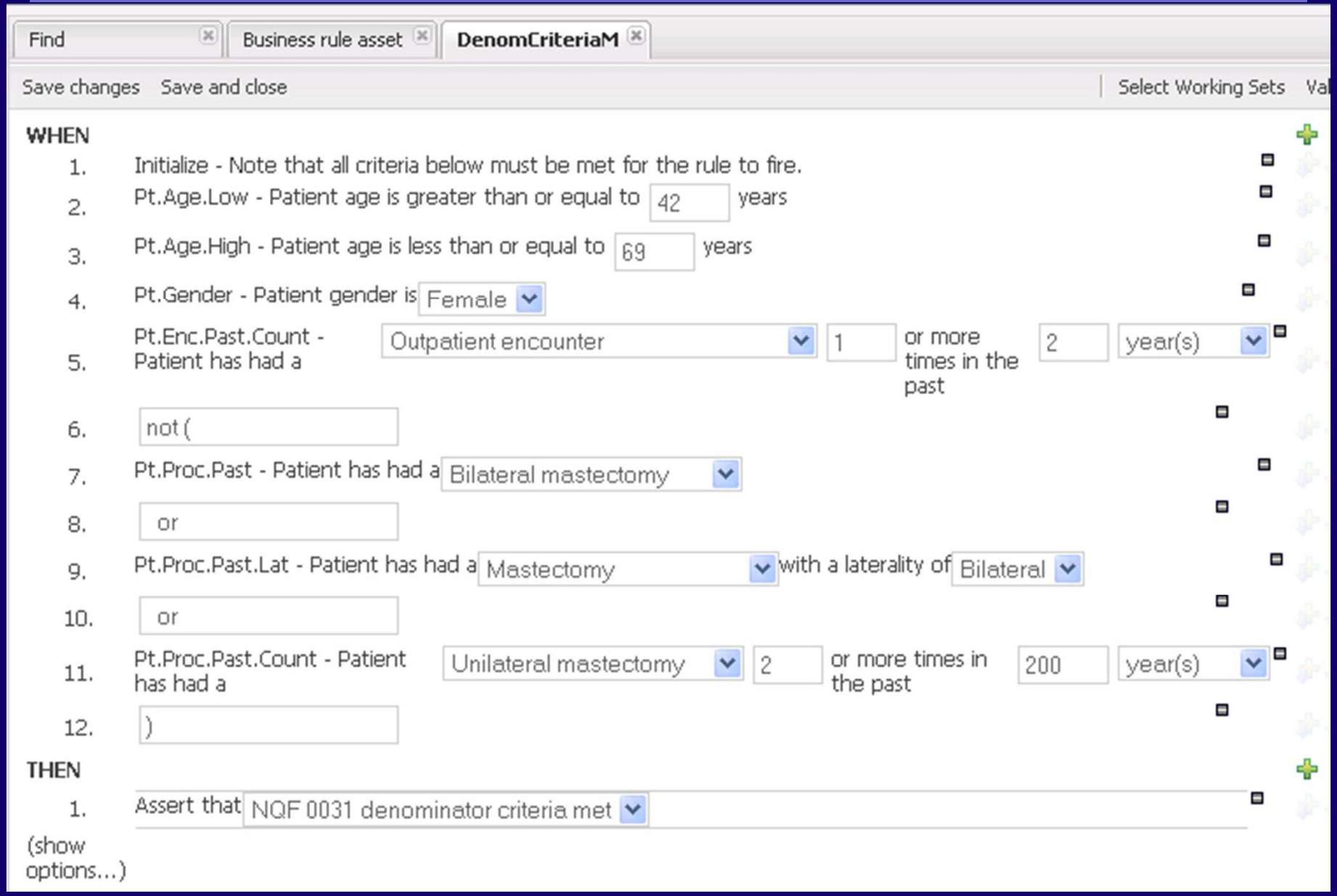
  kensaku.kawamoto@opencds.org

Backup Slides

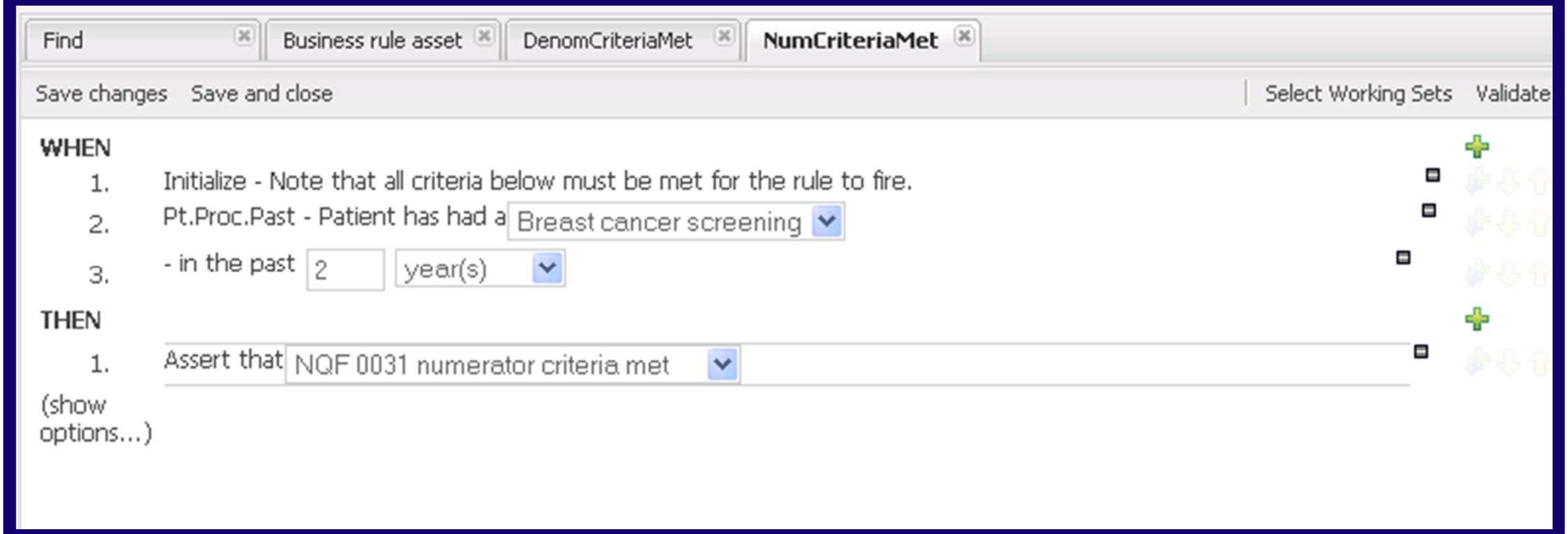
NQF Measure 31 for Meaningful Use

- **Initial Patient Population** =
  - AND: "Patient characteristic: birth date" >= 41 year(s) and <= 68 year(s) starts before start of "Measurement period"
  - AND: "Patient characteristic: Gender Female"
- **Denominator**=
  - AND: "Initial Patient Population"
  - AND: "Encounter: encounter outpatient" <= 2 year(s) starts before or during "Measurement end date"
  - AND NOT:
    - AND:
      - OR: "Procedure performed: bilateral mastectomy"
      - OR:
        - AND: "Procedure performed: unilateral mastectomy CPT"
        - AND: "Procedure performed: bilateral mastectomy modifier"
      - OR:
        - AND: > 1 count(s) of
          - AND: "Procedure performed: unilateral mastectomy"
        - AND:
          - AND NOT: FIRST:"Procedure performed: unilateral mastectomy" concurrent with SECOND :"Procedure performed: unilateral mastectomy"
      - starts before or during "Measurement end date"
- **Numerator** =
  - AND: "Diagnostic study performed: breast cancer screening" <= 2 year(s) starts before or during "Measurement end date"
- **Exclusions** =
  - None

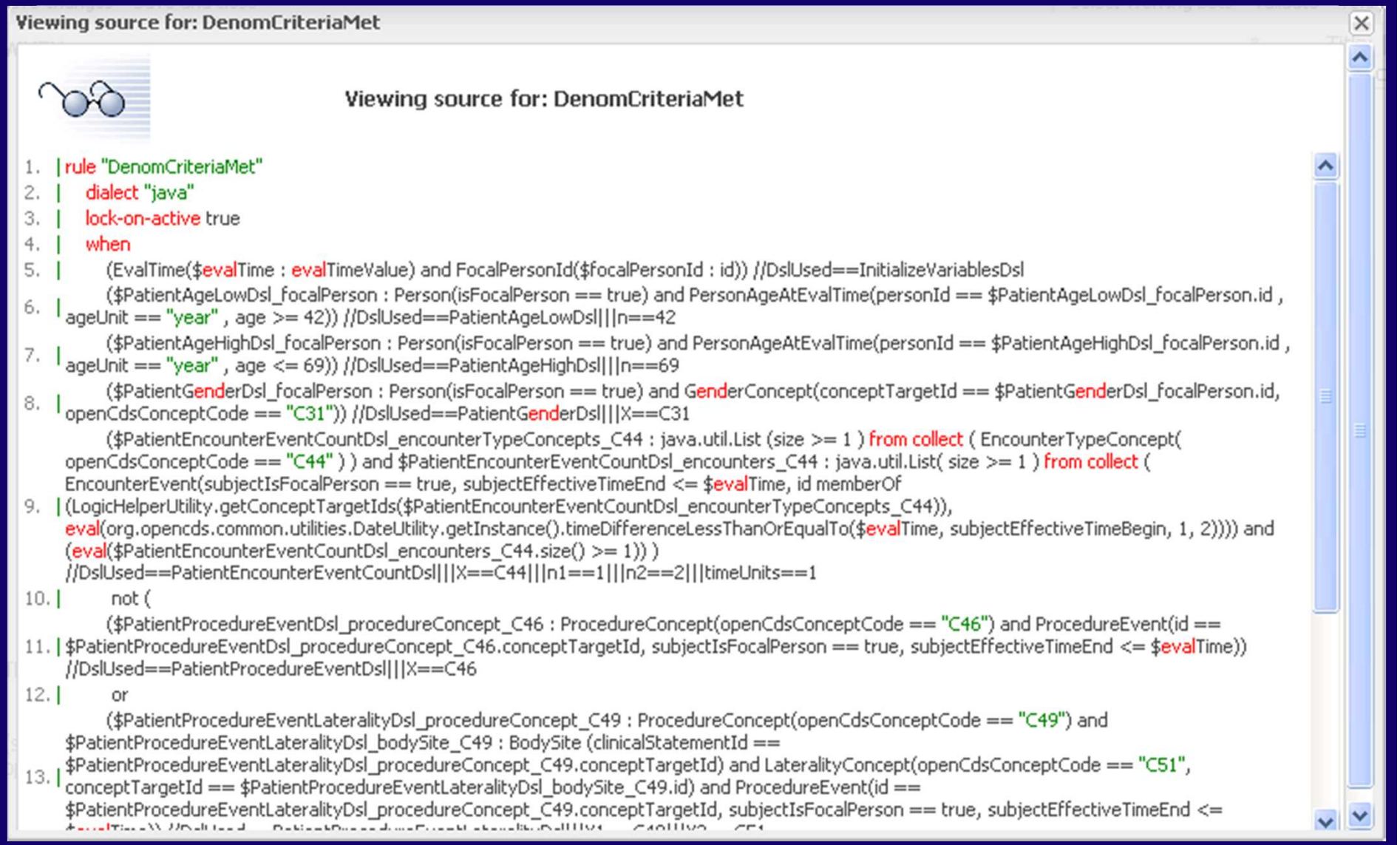
OpenCDS Implementation – Denom.



OpenCDS Implementation – Numerator

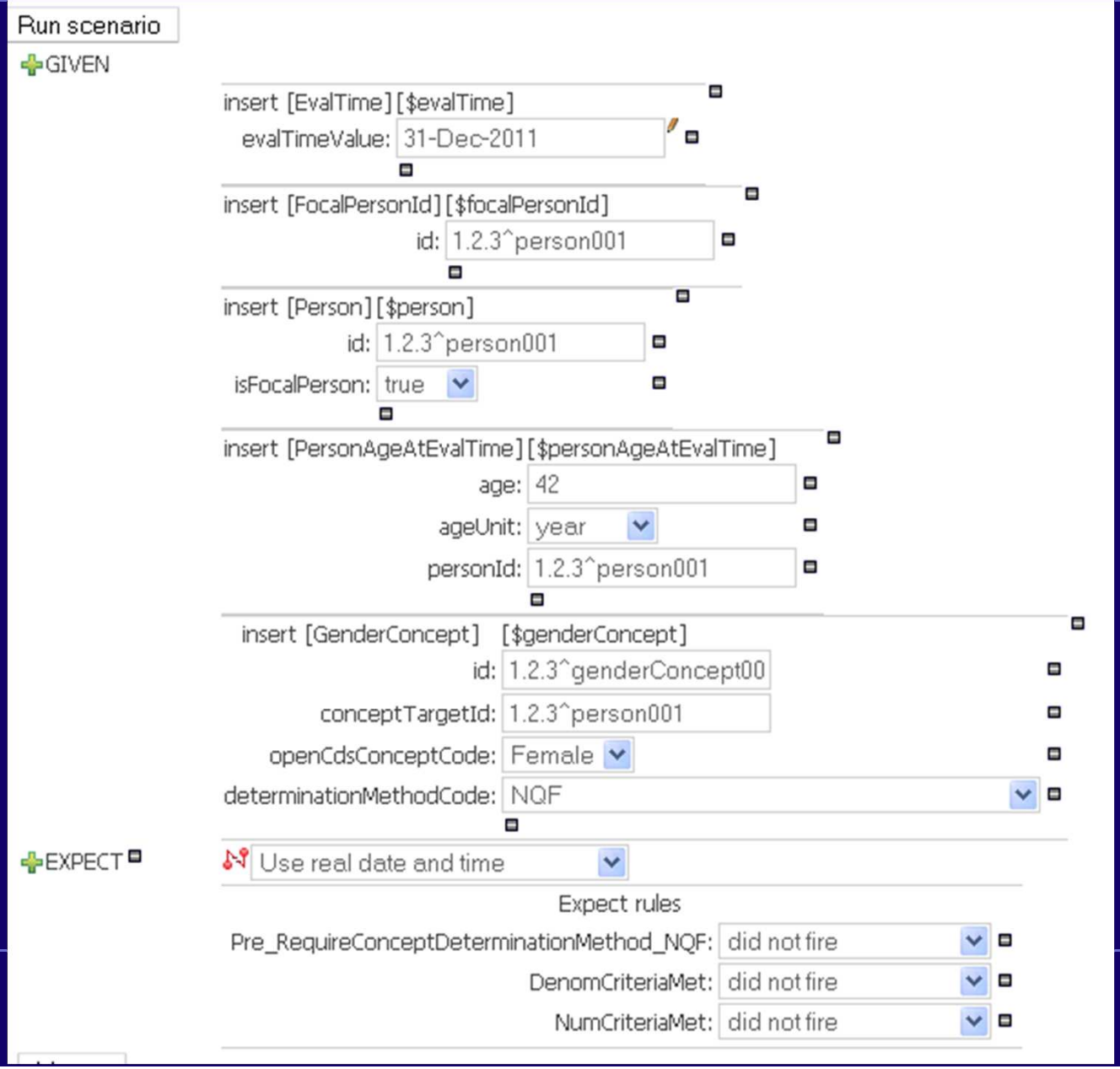


OpenCDS Implement. – Underlying Details

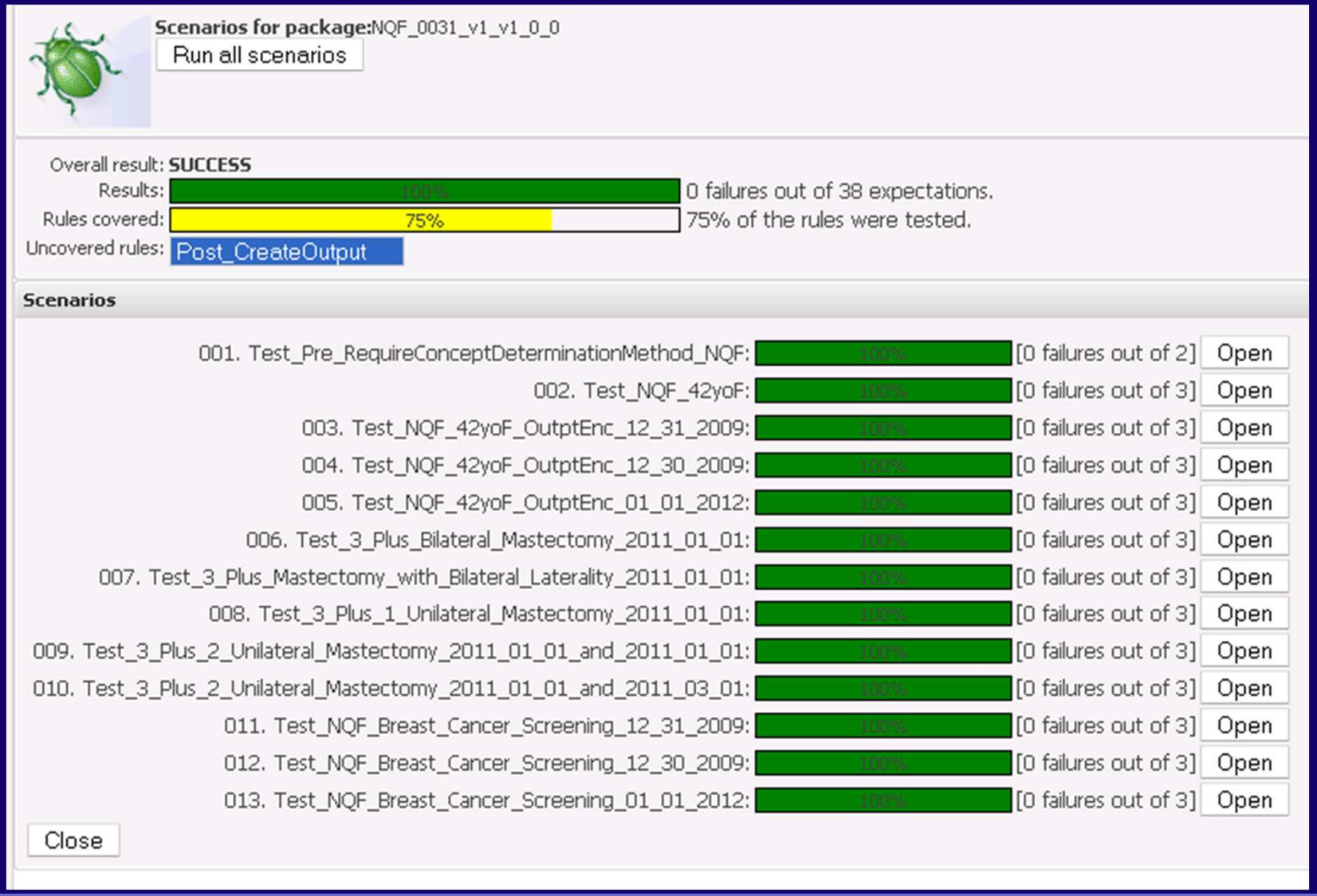



```
1.  rule "DenomCriteriaMet"
2.      dialect "java"
3.      lock-on-active true
4.      when
5.          (EvalTime($evalTime : evalTimeValue) and FocalPersonId($focalPersonId : id)) //DslUsed==InitializeVariablesDsl
6.          ($PatientAgeLowDsl_focalPerson : Person(isFocalPerson == true) and PersonAgeAtEvalTime(personId == $PatientAgeLowDsl_focalPerson.id ,
    ageUnit == "year" , age >= 42)) //DslUsed==PatientAgeLowDsl|||n==42
7.          ($PatientAgeHighDsl_focalPerson : Person(isFocalPerson == true) and PersonAgeAtEvalTime(personId == $PatientAgeHighDsl_focalPerson.id ,
    ageUnit == "year" , age <= 69)) //DslUsed==PatientAgeHighDsl|||n==69
8.          ($PatientGenderDsl_focalPerson : Person(isFocalPerson == true) and GenderConcept(conceptTargetId == $PatientGenderDsl_focalPerson.id,
    openCdsConceptCode == "C31")) //DslUsed==PatientGenderDsl|||X==C31
9.          ($PatientEncounterEventCountDsl_encounterTypeConcepts_C44 : java.util.List (size >= 1 ) from collect ( EncounterTypeConcept(
    openCdsConceptCode == "C44" ) ) and $PatientEncounterEventCountDsl_encounters_C44 : java.util.List( size >= 1 ) from collect (
    EncounterEvent(subjectIsFocalPerson == true, subjectEffectiveTimeEnd <= $evalTime, id memberOf
    (LogicHelperUtility.getConceptTargetIds($PatientEncounterEventCountDsl_encounterTypeConcepts_C44)),
    eval(org.opencds.common.utilities.DateUtility.getInstance().timeDifferenceLessThanOrEqualTo($evalTime, subjectEffectiveTimeBegin, 1, 2)))) and
    (eval($PatientEncounterEventCountDsl_encounters_C44.size() >= 1)) )
    //DslUsed==PatientEncounterEventCountDsl|||X==C44|||n1==1|||n2==2|||timeUnits==1
10.         not (
11.         ($PatientProcedureEventDsl_procedureConcept_C46 : ProcedureConcept(openCdsConceptCode == "C46") and ProcedureEvent(id ==
    $PatientProcedureEventDsl_procedureConcept_C46.conceptTargetId, subjectIsFocalPerson == true, subjectEffectiveTimeEnd <= $evalTime))
    //DslUsed==PatientProcedureEventDsl|||X==C46
12.         or
13.         ($PatientProcedureEventLateralityDsl_procedureConcept_C49 : ProcedureConcept(openCdsConceptCode == "C49") and
    $PatientProcedureEventLateralityDsl_bodySite_C49 : BodySite (clinicalStatementId ==
    $PatientProcedureEventLateralityDsl_procedureConcept_C49.conceptTargetId) and LateralityConcept(openCdsConceptCode == "C51",
    conceptTargetId == $PatientProcedureEventLateralityDsl_bodySite_C49.id) and ProcedureEvent(id ==
    $PatientProcedureEventLateralityDsl_procedureConcept_C49.conceptTargetId, subjectIsFocalPerson == true, subjectEffectiveTimeEnd <=
```

Testing Environment



Batch Regression Testing



DSS Invocation - Wrapper

```
<?xml version="1.0" encoding="UTF-8"?>
<SOAP-ENV:Envelope xmlns:SOAP-ENV="http://www.w3.org/2003/05/soap-envelope"
xmlns:dss="http://www.omg.org/spec/CDSS/201012/dss">
  <SOAP-ENV:Header/>
  <SOAP-ENV:Body>
    <dss:evaluateAtSpecifiedTime>
      <interactionId scopingEntityId="edu.utah" interactionId="123456" submissionTime="2011-12-31T00:00:00.000"/>
      <specifiedTime>2011-12-31</specifiedTime>
      <evaluationRequest>
        <kmEvaluationRequest>
          <kmId scopingEntityId="org.opencds" businessId="NQF_0031_v1" version="1.0.0"/>
        </kmEvaluationRequest>
        <dataRequirementItemData>
          <driId itemId="payload001">
            <containingEntityId scopingEntityId="edu.utah" businessId="123.456.7.8.2.1" version="1.0.0"/>
          </driId>
          <data>
            <informationModelSSId scopingEntityId="org.opencds.vmr" businessId="VMR" version="1.0.0"/>
            <base64EncodedPayload>[Payload]</base64EncodedPayload>
          </data>
        </dataRequirementItemData>
      </evaluationRequest>
    </dss:evaluateAtSpecifiedTime>
  </SOAP-ENV:Body>
</SOAP-ENV:Envelope>
```

DSS Invocation - Payload

```
<vMR xsi:schemaLocation="urn:org.opencds.vmr.schema.vmr.xsd" xmlns="urn:org.opencds.vmr.schema" xmlns:xsi="http://www.w3.org
  <id root="1.2.3" extension="vmr001"/>
  <vMRType code="alpha" codeSystem="2.16.840.1.113883.3.795.12.1"/>
  <templateId root="2.16.840.1.113883.3.795.11.1.1"/>
  <focalPersonId root="1.2.3" extension="Pat001"/>
  <person>
    <id root="1.2.3" extension="Pat001"/>
    <templateId root="2.16.840.1.113883.3.795.11.2.1"/>
    <entityType code="PRSN" codeSystem="HL7oid"><displayName value="person"/></entityType>
    <demographicData>
      <gender code="10174" codeSystem="2.16.840.1.113883.5"><displayName value="Female"/></gender>
      <birthTime value="19690628"/> <!-- 42.5 yo at 12/31/2011 -->
    </demographicData>
    <clinicalStatements>
      <encounterEvents>
        <encounterEvent>
          <clinicalStatementType code="EncounterEvent" codeSystem="OpenCDSoidForClinicalStatementType"/>
          <id root="1.2.3" extension="Enc001"/>
          <templateId root="2.16.840.1.113883.3.795"/>
          <code code="99201" codeSystem="2.16.840.1.113883.6.12"><displayName value="Outpatient encounter"/></code>
          <subjectEffectiveTime><low value="20110101"/><high value="20110101"/></subjectEffectiveTime>
          <dataSourceType code="Clinical" codeSystem="2.16.840.1.113883.3.795"/>
          <status code="completed" codeSystem="HL7oid"/>
        </encounterEvent>
      </encounterEvents>
      <procedureEvents>
        <procedureEvent>
          <clinicalStatementType code="ProcedureEvent" codeSystem="OpenCDSoidForClinicalStatementType"/>
          <id root="1.2.3" extension="Proc001"/>
          <templateId root="2.16.840.1.113883.3.795"/>
          <code code="77056" codeSystem="2.16.840.1.113883.6.12"><displayName value="Mammography; bilateral"/></code>
          <subjectEffectiveTime><low value="20100601"/><high value="20100601"/></subjectEffectiveTime>
          <dataSourceType code="Clinical" codeSystem="2.16.840.1.113883.3.795"/>
          <status code="completed" codeSystem="HL7oid"/>
        </procedureEvent>
      </procedureEvents>
    </clinicalStatements>
    <clinicalStatementRelationships/>
    <entities/>
    <clinicalStatementEntityRelationships/>
  </person>
</vMR>
```

DSS Response - Wrapper

```
<soap:Envelope xmlns:soap="http://www.w3.org/2003/05/soap-envelope">
  <soap:Body>
    <ns2:evaluateAtSpecifiedTimeResponse xmlns:ns2="http://www.omg.org/spec/CDSS/201012/dss">
      <evaluationResponse>
        <finalKMEvaluationResponse>
          <kmId scopingEntityId="org.opencds" businessId="NQF_0031_v1" version="1.0.0"/>
          <kmEvaluationResultData>
            <evaluationResultId itemId="PrimaryEvaluationResult"/>
            <data>
              <informationModelSSId scopingEntityId="org.opencds.vmr"
                businessId="KMEvaluationResult" version="1.0.0"/>
              <base64EncodedPayload>[Payload]</base64EncodedPayload>
            </data>
          </kmEvaluationResultData>
        </finalKMEvaluationResponse>
      </evaluationResponse>
    </ns2:evaluateAtSpecifiedTimeResponse>
  </soap:Body>
</soap:Envelope>
```

DSS Response - Payload

```
<observationEvent>
  <id root="a3dd2db8-32e0-4601-8d04-77070e335725" extension=""/>
  <code code="C53" codeSystem="2.16.840.1.113883.3.795.12.1" codeSystemName="OpenCDS">
    <displayName value="Quality measure"/>
  </code>
  <relatedClinicalStatement>
    <sourceRelationshipToTarget code="C57" codeSystem="2.16.840.1.113883.3.795.12.1" codeSystemName="OpenCDS">
      <displayName value="Contains"/>
    </sourceRelationshipToTarget>
    <clinicalStatement xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:type="ObservationEvent">
      <id root="fb047b96-51a5-4d1b-961a-710e3fe7c5ca" extension=""/>
      <code code="C54" codeSystem="2.16.840.1.113883.3.795.12.1" codeSystemName="OpenCDS">
ame value="Denominator criteria met"/>
      </code>
      <value xsi:type="BL" value="true"/>
    </clinicalStatement>
  </relatedClinicalStatement>
  <relatedClinicalStatement>
    <sourceRelationshipToTarget code="C57" codeSystem="2.16.840.1.113883.3.795.12.1" codeSystemName="OpenCDS">
      <displayName value="Contains"/>
    </sourceRelationshipToTarget>
    <clinicalStatement xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:type="ObservationEvent">
      <id root="08c3c0a5-06d8-4adb-aab6-6ef9ad8b53b5" extension=""/>
      <code code="C55" codeSystem="2.16.840.1.113883.3.795.12.1" codeSystemName="OpenCDS">
ame value="Numerator criteria met"/>
      </code>
      <value xsi:type="BL" value="true"/>
    </clinicalStatement>
  </relatedClinicalStatement>
```