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

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8/11 - Director, Knowledge Management & Mobilization, Univ. of Utah
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

### Diabetes

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

Example Care Quality Reporting

<table>
<thead>
<tr>
<th>Patient Name</th>
<th>&lt;7</th>
<th>&gt;9</th>
<th>Done</th>
<th>Done 2X</th>
<th>Aspirin Therapy</th>
<th>BP</th>
<th>Eye Exam</th>
<th>Flu Vaccine</th>
<th>Foot Monofilament Exam</th>
<th>LDL</th>
<th>LDL &lt; 100</th>
<th>Done</th>
<th>Done</th>
<th>BMI &lt; 25</th>
<th>Done</th>
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</tr>
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<tbody>
<tr>
<td>XXXXXXXX, XXXXXX</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
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</tbody>
</table>

Source: Duke University Health System.
Example Care Manager Alert

COACH Alerts for Ms. Jenny Rawlings

Document ID: 24
06/08/05 (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. [Name] (COACH link). 23 yr. old Caucasian female, DOB [DOB]/82. Medicaid #: [ID] Duke MRN: [ID] [Home #: 919-####]

   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.

   Priority: 23.0

2. [Name] (COACH link). 8 mo. old Caucasian male, DOB [DOB]/04. Medicaid #: [ID] Duke MRN: [ID] [Home #: 919-####]

   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 visits.

   Priority: 19.5

Example Patient Reminder Letter

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

Example Medication Management Report

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

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

<table>
<thead>
<tr>
<th>Drug Description</th>
<th>% Days Covered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anti-hypertensive agent</td>
<td>!! 25%</td>
</tr>
<tr>
<td>lisinopril oral tablet 20 mg</td>
<td>25%</td>
</tr>
<tr>
<td>insulin, metformin, oral hypoglycemic, or thiazolidinedione (TZD)</td>
<td>! 59%</td>
</tr>
<tr>
<td>insulin glargine, human recombinant analog subcutaneous insulin pen 300 unit/3 ml</td>
<td>44%</td>
</tr>
<tr>
<td>insulin lispro subcutaneous insulin pen 100 unit/ml</td>
<td>5%</td>
</tr>
<tr>
<td>insulin lispro subcutaneous vial (sdv,mdv or additive) 100 unit/ml</td>
<td>18%</td>
</tr>
<tr>
<td>metformin hcl oral tablet 850 mg</td>
<td>16%</td>
</tr>
</tbody>
</table>

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 between 18 and 40
   • diabetes mellitus
   • hyperlipidemia

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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- **Problem**
  - Need for scalable CDS

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  - Standards-based, open-source CDS services

- **OpenCDS**

- **Discussion**
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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- Discussion
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

**Decision Support Service**

**Knowledge Modules**

Institution A

- Client Decision Support Apps
- Patient Data Sources
- Queries for required pt data

Institution B

- Client Decision Support Apps
- Patient Data Sources
- Queries for required pt data

Conclusions about patient:

Patient data, knowledge modules to use

Standard Interface:
HL7/OMG Decision Support Service Standard
(http://hssp-dss.wikispaces.com)

Standard Data Models:
HL7 Virtual Medical Record (vMR) Standard
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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
- Duke University
- 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

Online Triage
Get care advice online before your visit!

Step 1:
Enter information about your problem online

Step 2:
The nurse reviews your case and emails you her response

- Save Time and Money
- Safety Check
- Secure and Private
- Personal Response

Frequently Asked Questions

Secure Webpage

Sign In
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

- **DSS “wrappers” for other CDS engines**
OpenCDS – Sample Topologies

DSS Client

OpenCDS DSS Interface

OpenCDS Adapter X

CDS Engine/Service X (e.g., SEBASTIAN, KMR-DDSS, CDSC)

Apelon Distributed Terminology System (DTS)

OpenCDS Drools Adapter

OpenCDS Drools Engine

OpenCDS Drools Knowledge Authoring Platform
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
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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
Acknowledgements

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

- Numerous OpenCDS collaborators
  - In particular, David Shields, University of Utah
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 9:31 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
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"
        - AND:
          - 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.

**WHEN**

1. Initialize - Note that all criteria below must be met for the rule to fire.
2. Pt.Age.Low - Patient age is greater than or equal to 42 years
3. Pt.Age.High - Patient age is less than or equal to 69 years
4. Pt.Gender - Patient gender is Female
5. Pt.Enc.Past.Count - Patient has had a 1 or more times in the past 2 years(s)
6. not ( )
7. Pt.Proc.Past - Patient has had a Bilateral mastectomy
8. or
9. Pt.Proc.Past.Lat - Patient has had a Mastectomy with a laterality of Bilateral
10. or
11. Pt.Proc.Past.Count - Patient has had a Unilateral mastectomy 2 or more times in the past 200 years(s)
12. )

**THEN**

1. Assert that NQF 0031 denominator criteria met

(show options...)
OpenCDS Implementation – Numerator

**WHEN**
1. Initialize - Note that all criteria below must be met for the rule to fire.
2. Pt.Proc.Past - Patient has had a **Breast cancer screening**
   - in the past **2** year(s)

**THEN**
1. Assert that **NQF 0031 numerator criteria met**
   (show options...)

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OpenCDS Implement. – Underlying Details
# Batch Regression Testing

**Scenarios for package: NQF_0031_v1_v1_0_0**

**Run all scenarios**

Overall result: **SUCCESS**

- Results: 
  - 100%
  - 0 failures out of 38 expectations.

- Rules covered: 
  - 75%
  - 75% of the rules were tested.

- Uncovered rules: Post_CreateOutput

## Scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>001. Test_Pre_RequireConceptDeterminationMethod_NQF</td>
<td>Open</td>
</tr>
<tr>
<td>002. Test_NQF_42yoF</td>
<td>Open</td>
</tr>
<tr>
<td>003. Test_NQF_42yoF_OutptEnc_12_31_2009</td>
<td>Open</td>
</tr>
<tr>
<td>004. Test_NQF_42yoF_OutptEnc_12_30_2009</td>
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</tr>
<tr>
<td>005. Test_NQF_42yoF_OutptEnc_01_01_2012</td>
<td>Open</td>
</tr>
<tr>
<td>006. Test_3_Plus_Bilateral_Mastectomy_2011_01_01</td>
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<td>007. Test_3_Plus_Mastectomy_with_Bilateral_Laterality_2011_01_01</td>
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<td>008. Test_3_Plus_1_Unilateral_Mastectomy_2011_01_01</td>
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<tr>
<td>009. Test_3_Plus_2_Unilateral_Mastectomy_2011_01_01_and_2011_01_01</td>
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<tr>
<td>010. Test_3_Plus_2_Unilateral_Mastectomy_2011_01_01_and_2011_03_01</td>
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<tr>
<td>011. Test_NQF_Breast_Cancer_Screening_12_31_2009</td>
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<tr>
<td>012. Test_NQF_Breast_Cancer_Screening_12_30_2009</td>
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<tr>
<td>013. Test_NQF_Breast_Cancer_Screening_01_01_2012</td>
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</tr>
</tbody>
</table>

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<?xml version="1.0" encoding="UTF-8"?>
  <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>
          <drId itemId="payload001"/>
          <containingEntityId scopingEntityId="edu.utah" businessId="123.456.7.8.2.1" version="1.0.0"/>
        </dataRequirementItemData>
        <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>
<soap:Envelope xmlns:soap="http://www.w3.org/2003/05/soap-envelope">
    <soap:Body>
            <evaluationResponse>
                <finalKMEvaluationResponse>
                    <kmId scopingEntityId="org.opencds" businessId="NQF_0031_v1" version="1.0.0"/>
                    <kmEvaluationResultData>
                        <evaluationResultId itemld="PrimaryEvaluationResult"/>
                        <data>
                            <informationModelISSId scopingEntityId="org.opencds.vmr"
                                businessId="KMEvaluationResult" version="1.0.0"/>
                            <base64EncodedPayload>[Payload]</base64EncodedPayload>
                        </data>
                    </kmEvaluationResultData>
                </finalKMEvaluationResponse>
            </evaluationResponse>
        </ns2:evaluateAtSpecifiedTimeResponse>
    </soap:Body>
</soap:Envelope>
<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">
        <name value="Denominator criteria met"/>
      </code>
    </clinicalStatement>
  </relatedClinicalStatement>
  <relatedClinicalStatement>
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      <displayName value="Contains"/>
    </sourceRelationshipToTarget>
    <clinicalStatement xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:type="ObservationEvent">
      <id root="D8c3c0a5-06d8-4adb-aab6-6ef9ad8b53b5" extension=""/>
      <code code="C55" codeSystem="2.16.840.1.113883.3.795.12.1" codeSystemName="OpenCDS">
        <name value="Numerator criteria met"/>
      </code>
    </clinicalStatement>
  </relatedClinicalStatement>
</observationEvent>