Multi-National, Multi-Institutional Analysis of Clinical Decision Support Data Needs to Inform Development of the HL7 Virtual Medical Record Standard

AMIA 2010 Fall Symposium
November 16, 2010

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(collaborators on next slides)

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Collaborators – 1 of 3

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Collaborators – 3 of 3

Collaborator	Institution
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Background

- **A "holy grail" of clinical informatics is scalable, interoperable clinical decision support (CDS)**
- **Key requirement for interoperable CDS and re-use of CDS knowledge resources = use of a common patient data model**
  - Referred to as a "Virtual Medical Record" or vMR (Johnson *et al.*, *AMIA Annu Symp Proc*, 2001)
- **Lack of a common vMR is a major barrier to sharing knowledge and scaling CDS**
  - Known as the "curly braces" problem in Arden Syntax

Example Challenge without VMR

Observation
- Code = BP
- Value = 120/80 mmHg

Blood Pressure
- Systolic = 120 mmHg
- Diastolic = 80 mmHg

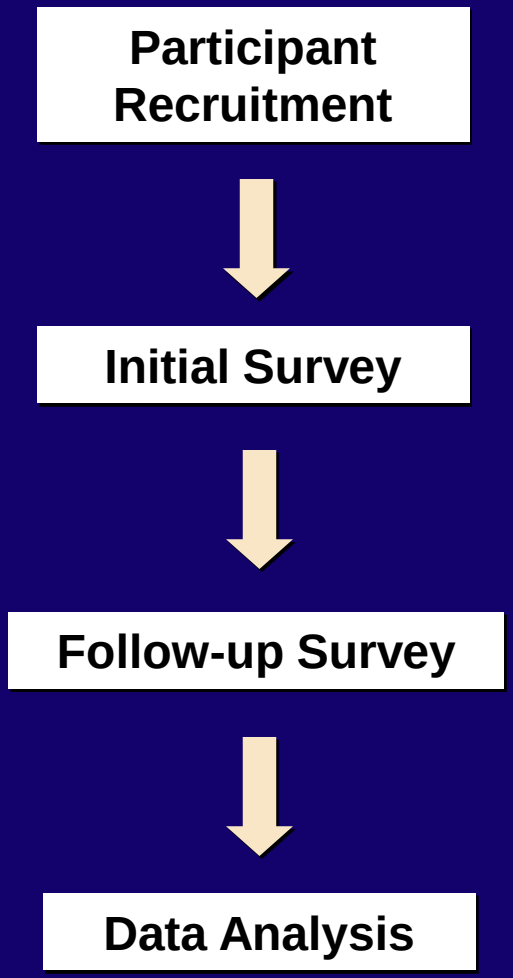
Observation
- Code = BP
  - Observation
    - Code = SBP
    - Value = 120 mmHg
  - Observation
    - Code = DBP
    - Value = 80 mmHg

Vital Sign
- Type = BP
- Value = 120/80
- Units = mmHg

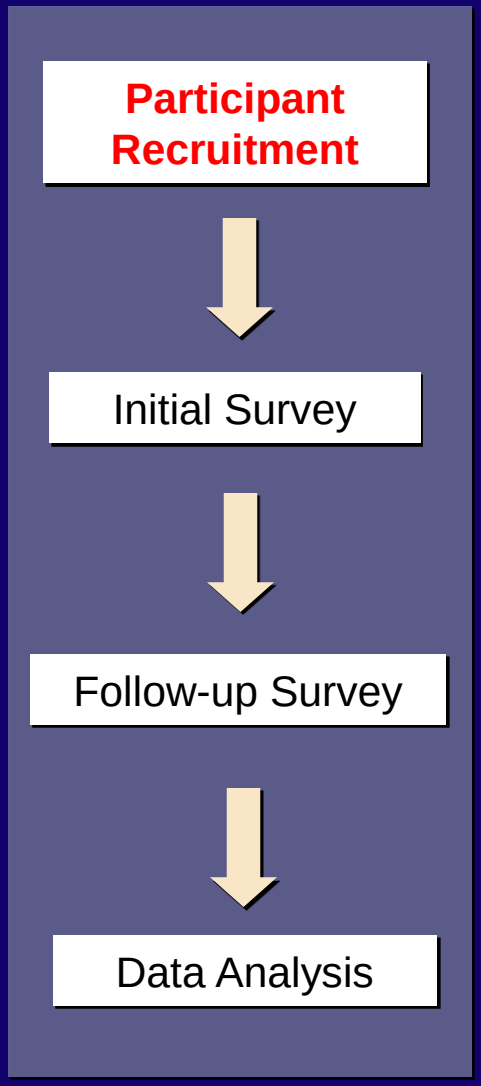
Study Objective

- To inform the specification of a standard HL7 vMR by identifying a representative set of data elements and associated terminologies used by current CDS systems

Study Overview

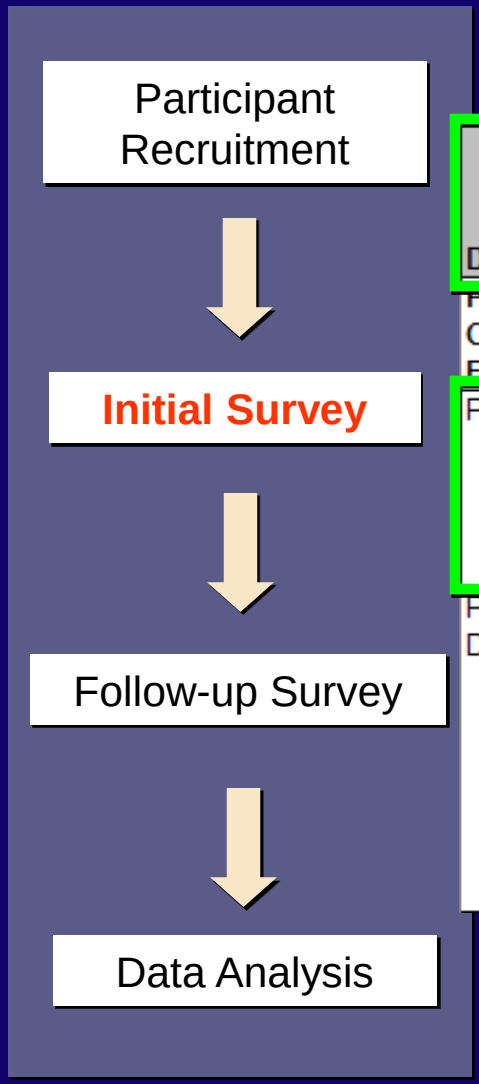


Participant Recruitment



- Open invitation on HL7 CDS Work Group list-serv for individuals with knowledge of CDS systems and their data needs
- Identification and recruitment of key experts

Initial Survey

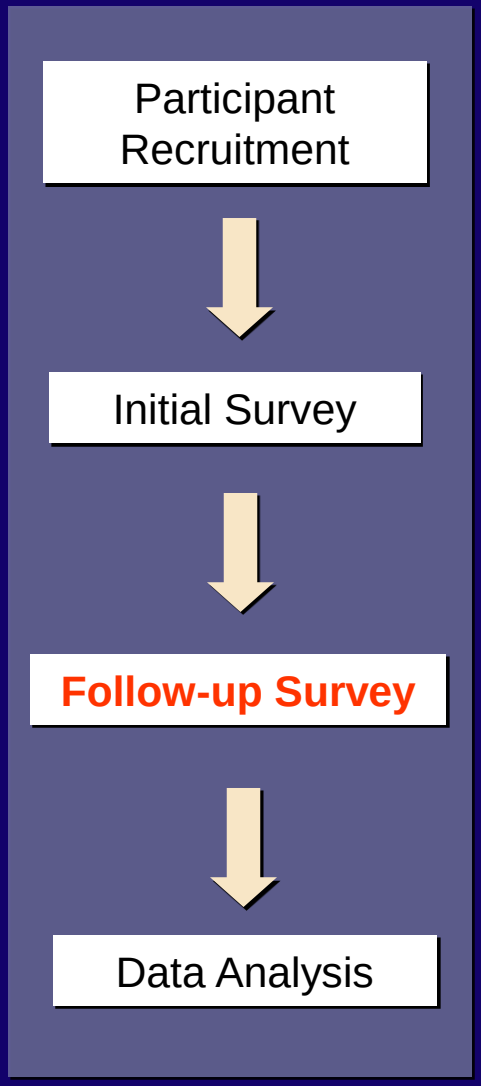


- Initial data elements from draft vMR

Data Element	Example(s)	Example Usage(s) for Making Patient-Specific Inferences	Used by CDS System to Make Patient-Specific Inferences?	Value Sets/Terminologies Used for Data Element
Problem Observation Data Elements				
Problem Code	ICD9CM 250.02; Type 2 diabetes mellitus, uncontrolled	To determine if a patient has a specific medical problem of interest, which has associated disease management needs.		
Problem Observation Date/Time	March 15, 2008 3:15 pm	To determine when a problem was observed relative to another piece of data that may over-ride this observation (e.g., a newer problem observation or a new laboratory finding).		

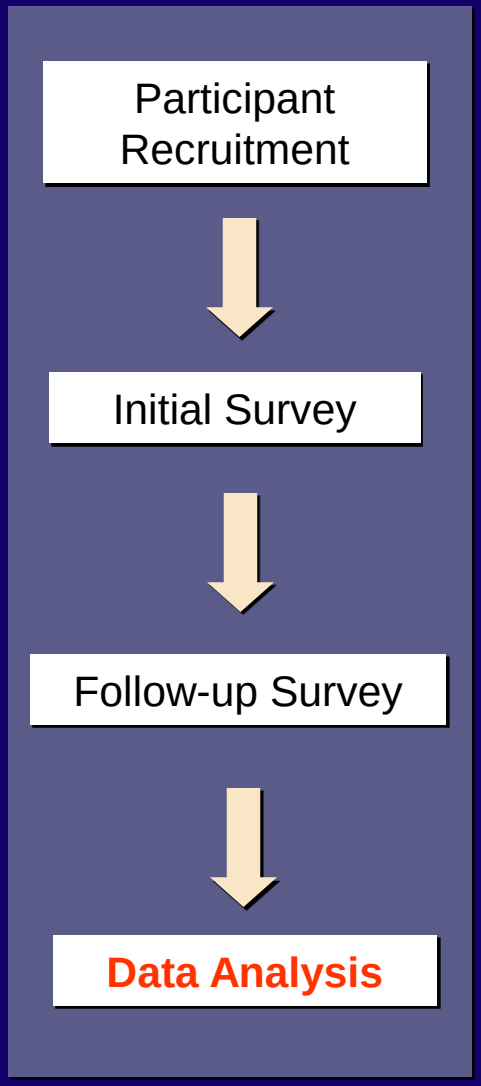
- Any data elements missing from survey instrument

Follow-up Survey



- **Use of expanded survey with newly identified data elements**

Data Analysis



- **Conceptually equivalent data elements merged**
  - Conducted in open, consensus-based process
- **Findings summarized in terms of:**
  - Data elements used
  - Associated terminologies and value sets
  - Frequency of use

Study Results

CDS Systems Included in Analysis

- **20 CDS systems from 4 countries**
- **Non-commercial CDS systems**
  - VHA VistA Clinical Reminders
  - Partners Enterprise Clinical Rules Service (ECRS)
  - Intermountain Foresight enterprise-wide decision support infrastructure
  - Duke chronic disease management system and enterprise care quality reporting system
  - DoD Distributed Decision Support & Knowledge Management Repository
  - HL7 Context-Aware Knowledge Retrieval (Infobutton) Standard

CDS Systems Included in Analysis

- **Non-commercial CDS systems (cont'd)**
  - Marshfield Clinic HealthFlow
  - Memorial Hermann Hospital Nutritionist's Assistant
  - NY Office of Mental Health Psychiatric Services Clinical Knowledge Enhancement System (PSYCKES)
  - Université Aix-Marseille Automatic Selection of Clinical Trials based on Eligibility Criteria (ASTEC) CDS
  - Univ. of Nebraska Medical Center Advanced Clinical Applications Program (ACAP)
  - Univ. of Victoria and BC Evidence-based Guideline and Decision Support System (EGADSS)

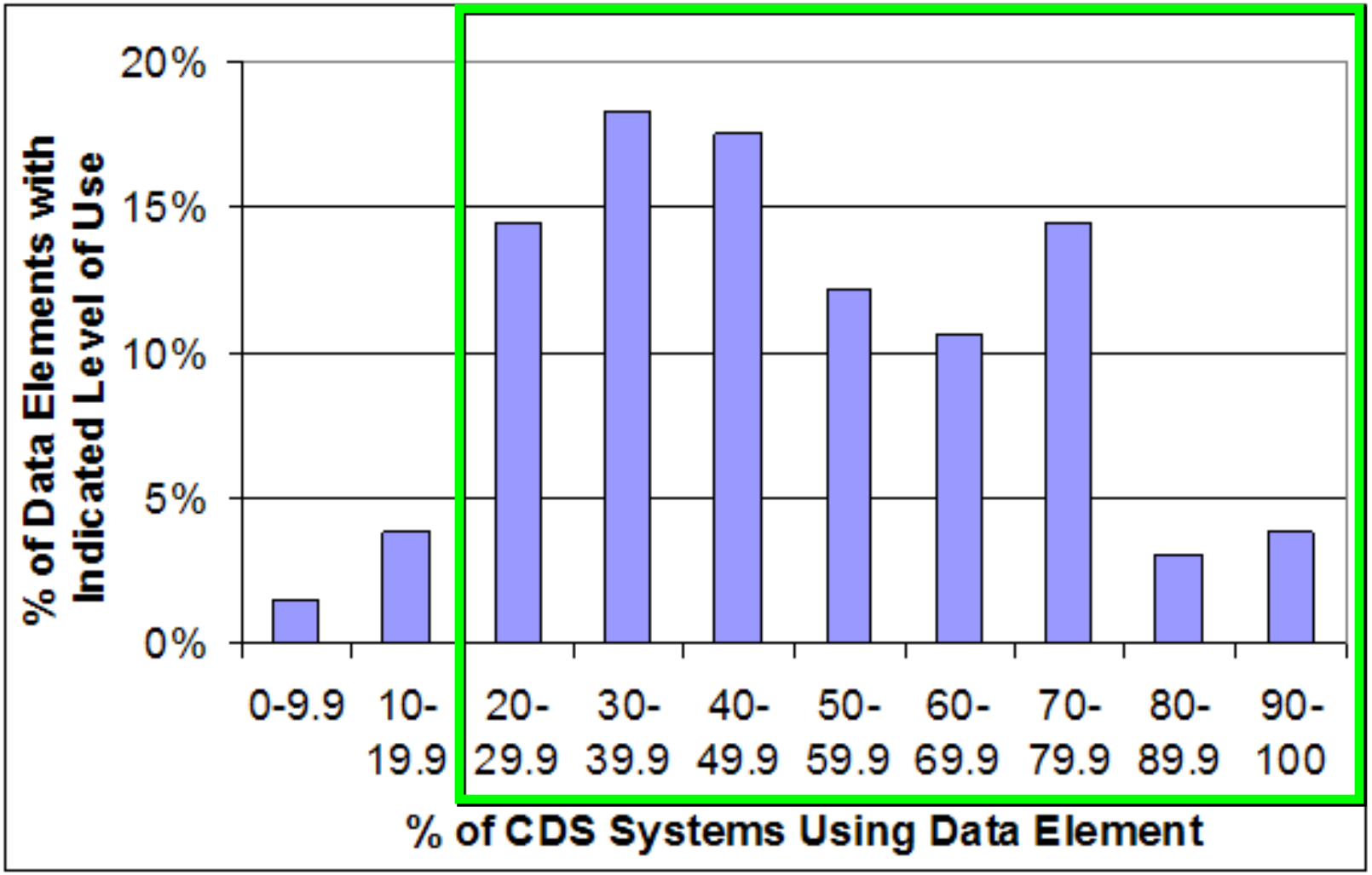
CDS Systems Included in Analysis

- **Commercial CDS systems**
  - Siemens Soarian® Clinical Information System and its Rules and Workflow Engines
  - Eclipsys Sunrise Clinical Information System
  - NIH Clinical Center Clinical Research Information System (CRIS) (Eclipsys Sunrise Clinical Manager)
  - Medi-Span
  - Wolters Kluwer Health - Infobutton APIs
  - Altos Solutions, Inc. OncoEMR
  - Medical-Objects GELLO enabled CDS System
  - Hughes riskApps

Multi-Institutional CDS Data Needs

- **131 data elements in use by 20 CDS systems**
  - 22 (17%) not in original data collection template
- **Primary data element groups**
  - Demographics
  - Healthcare Acts
    - *Problems, Encounters, Procedures, Medications, Adverse Reactions, Lab Results, Physical Findings, Goals, Observations*
  - Family History
  - CDS Context (e.g., system user type)

Data Element Usage Pattern



Problem Data Elements

Data Element	Example	% Using DE
Problem Identifier	EHR Problem ID 123	42%
Problem Type	Problem List Entry	65%
Problem Code	ICD9 code 250.40	95%
Problem Classification	Diabetes mellitus	26%
Problem Modifier	Negative/doesn't have	32%
Problem Status	Active, Resolved	65%
Status Time Interval	1995 to present	55%
Date/Time Noted	2010-06-15	75%
Observer Type	Physician	20%
Observation Method	Histological confirmation	5%
Associated Enc. ID	Encounter ID ABCD	35%

Terminologies and Value Sets

- **Variety of standard and non-standard terminologies and value sets in use**
  - E.g., SNOMED CT, LOINC, ICD9, ICD10, CPT, MeSH, NDC, RxNorm, HL7-defined value sets (e.g., for gender)
- **Many non-standard terminologies and value sets in use could be, or have been, mapped to standard terminologies of similar granularity**

Further Details

- **More information in AMIA paper**
- **Full data set and analyses available on HL7 vMR project wiki**
  - http://wiki.hl7.org/index.php?title=Image:HL7vMR_Cross_Institutional_CDS_Data_Needs_Analysis_vFinal.zip

Summary of Findings

- **20 CDS systems from 4 countries analyzed to identify representative set of data elements used by CDS systems**
- **131 data elements identified**
  - All but two used across multiple systems
- **Non-standard terminologies noted to be generally mappable to standard terminologies**

Study Strengths

- **Diverse study sample**
  - Minimizes chances of false negative findings (i.e., the overlooking of important data elements)
- **Based on actual CDS systems**
  - Minimizes chances of false positive findings (i.e., the inclusion of data elements not truly useful for CDS)
- **Data element set relatively compact and suitable for standardization and adoption**
- **Addresses well-recognized problem and has potential to facilitate significant advances in CDS scalability and impact**

Study Limitations

- **Study participants self-selected based on interest and primarily from one country (U.S.)**
  - However, largest and most diverse sample to date
- **Use of initial data entry template may have biased responses**
  - However, close to 20% of identified data elements not included in original data entry template
  - Indicates individual contributors actively pursued inclusion of data elements regardless of status in original data entry template

Why Not Just Use the CCD as the vMR?

- **CCD does not include all needed information**
  - E.g., Family history model suitable for CDS
- **CCD is not sufficiently intuitive for direct use by CDS knowledge authors**

Problem Model – CCD vs. VMR

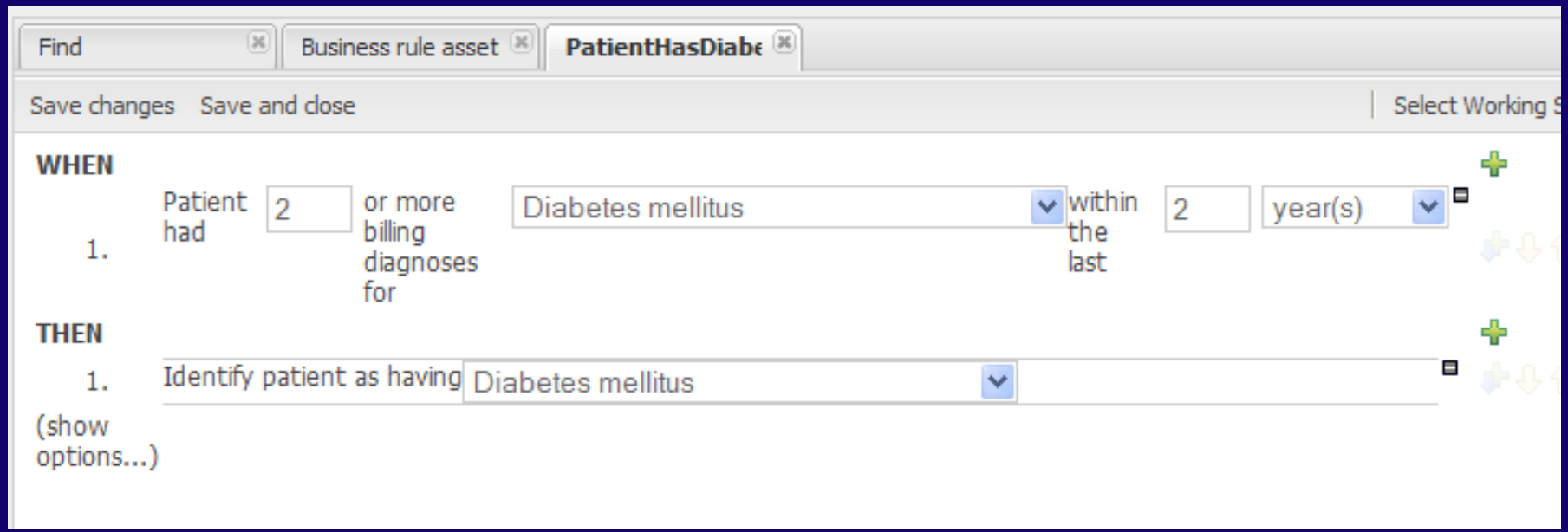
```
<entry typeCode="DRIV">
  <act classCode="ACT" moodCode="EVN">
    <templateId root="2.16.840.1.113883.10.20.1.27"/>
    <!-- Problem act template -->
    <id root="6a2fa88d-4174-4909-aece-db44b60a3abb"/>
    <code nullFlavor="NA"/>
    <entryRe
      <obse
        <te
        <!--
        <id
        <co
        <st
        <eff
          <low value="1950"/>
        </effectiveTime>
        <value xsi:type="CD" code="195967001" codeSystem="2.16.840.1.113883.6.96" displayName="Asthma"/>
        <entryRelationship typeCode="REFR">
          <observation classCode="OBS" moodCode="EVN">
            <templateId root="2.16.840.1.113883.10.20.1.50"/>
            <!-- Problem status observation template -->
            <code code="33999-4" codeSystem="2.16.840.1.113883.6.1" displayName="Status"/>
            <statusCode code="completed"/>
            <value xsi:type="CE" code="55561003" codeSystem="2.16.840.1.113883.6.96" displayName="Active"/>
          </observation>
        </entryRelationship>
      </observation>
    </entryRelationship>
  </act>
</entry>
```

```
<problem>
  <id root="6a2fa88d-4174-4909-aece-db44b60a3abb"/>
  <clinicalStatementType code="problem"/>
  <problemCode codeSystem="2.16.840.1.113883.6.96" code="195967001"  displayName="Asthma"/>
  <problemEffectiveTime start="1950"/>
  <problemStatus code="Active"/>
</problem>
```

Current HL7 vMR Project Status

- **Initial ballot May 2010 based on current study**
- **Significant, ongoing work**
  - Over two dozen participants in vMR discussions at October 2010 HL7 meeting
  - All work products posted on project wiki at http://wiki.hl7.org/index.php?title=Virtual_Medical_Record_(vMR)
- **Next ballot anticipated May 2011**
- **Prototype vMR being evaluated in OpenCDS**
  - Open-source reference implementation of HL7/OMG Decision Support Service standard using JBoss Drools rules engine and vMR data model
  - Wed 8:30-10:00am panel on open-source CDS

OpenCDS – Clinician Authoring Web Interface



Authoring – vMR-Based Underlying Details

Viewing source for: PatientHasDiabetesMellitusPerEncounterDiagnoses

```
1. |rule "PatientHasDiabetesMellitusPerEncounterDiagnoses"
2. |    no-loop true
3. |    salience 50
4. |    dialect "java"
5. |    when
          EvalTime($evalTimeValue_Diabetes_Mellitus : evalTimeValue) and
   $problemConceptsWithConcept_Diabetes_Mellitus : java.util.List( size >= 2 ) from collect ( ProblemConcept(
   problemConcept == "Diabetes_Mellitus" ) ) and
   $encDxProblemsWithSelectedConceptAndTimeFrame_Diabetes_Mellitus : java.util.List( size >= 2 ) from collect (
6. |Problem( dataSourceType == "submittedAdmin", id memberOf
   (LogicHelperUtility.getInstance().getProblemIds($problemConceptsWithConcept_Diabetes_Mellitus)),
   problemStatementTimeStart <= $evalTimeValue_Diabetes_Mellitus &&
   eval(org.opencds.utilities.DateUtility.getInstance().getAbsoluteTimeDifference($evalTimeValue_Diabetes_Mellitus,
   problemStatementTimeStart, 1).getTimeDifferenceForUnit(1) <= 2))) and $vmr : VMR()
7. |    then
          String problemId = java.util.UUID.randomUUID().toString(); String problemConcept = "Diabetes_Mellitus";
   ProblemConceptSearched problemConceptSearched = new ProblemConceptSearched();
   problemConceptSearched.setProblemId ( problemId ); problemConceptSearched.setConceptSearched ( true ); insert
8. |( problemConceptSearched ); Problem problem = new Problem(); problem.setId( problemId );
   problem.setProblemCodeSystem( "OpenCDS" ); problem.setProblemCode( problemConcept );
   problem.setDataSourceType("inferred"); problem.setProblemStatus("Active"); insert(problem);
   $vmr.getNamedObjects().put("InferredActiveProblem_Diabetes_Mellitus", problem); update($vmr);
9. |end
```

OpenCDS – Clinician Authoring via Web Table

Find | Business rule asset | PatientHasDiabetes | DiabetesMellitus

Save changes | Save and close

Decision table

Modify

Row Num	Description	Has Diabetes	A1c on Record	Age >=	Age <=	Last A1c Value	>= X Mo Since Last	< X Mo Since Last	A1c Need
1	No DM, Not due	N							Not_Due
2	DM, No A1c, Due	Y	N						Due
3	DM, A1c, 0-5yo, < 8.5, Not due	Y	Y	0	5	< 8.5	0	5	Not_Due
4	DM, A1c, 0-5yo, < 8.5, Almost due	Y	Y	0	5	< 8.5	5	6	Almost_Due
5	DM, A1c, 0-5yo, < 8.5, Due	Y	Y	0	5	< 8.5	6		Due
6	DM, A1c, 0-5yo, >= 8.5, Not due	Y	Y	0	5	>= 8.5	0	2	Not_Due
7	DM, A1c, 0-5yo, >= 8.5, Almost due	Y	Y	0	5	>= 8.5	2	3	Almost_Due
8	DM, A1c, 0-5yo, >= 8.5, Due	Y	Y	0	5	>= 8.5	3		Due
9	DM, A1c, 6-12yo, < 8, Not due	Y	Y	6	12	< 8	0	5	Not_Due
10	DM, A1c, 6-12yo, < 8, Almost due	Y	Y	6	12	< 8	5	6	Almost_Due
11	DM, A1c, 6-12yo, < 8, Due	Y	Y	6	12	< 8	6		Due
12	DM, A1c, 6-12yo, >= 8, Not due	Y	Y	6	12	>= 8	0	2	Not_Due
13	DM, A1c, 6-12yo, >= 8, Almost due	Y	Y	6	12	>= 8	2	3	Almost_Due
14	DM, A1c, 6-12yo, >= 8, Due	Y	Y	6	12	>= 8	3		Due
15	DM, A1c, 13-19yo, < 7.5, Not due	Y	Y	13	19	< 7.5	0	5	Not_Due
16	DM, A1c, 13-19yo, < 7.5, Almost due	Y	Y	13	19	< 7.5	5	6	Almost_Due
17	DM, A1c, 13-19yo, < 7.5, Due	Y	Y	13	19	< 7.5	6		Due

Authoring – vMR-Based Underlying Details

Viewing source for: DiabetesMellitusNeedForHemoglobinA1cTestRule

Viewing source for: DiabetesMellitusNeedForHemoglobinA1cTestRule

```
188. | #from row number: 10
189. | rule "Row 10 DiabetesMellitusNeedForHemoglobinA1cTestRule"
190. |    salience 10
191. |    no-loop true
192. |    dialect "java"
193. |    when
          $vmr : VMR( this != ( null ) , eval( org.opencds.utilities.LogicHelperUtility.vmrContainsNamedObject($vmr,
       "InferredActiveProblem_Diabetes_Mellitus") == org.opencds.utilities.StringUtility.convertYorNToBoolean("Y") ), eval(
194. | org.opencds.utilities.LogicHelperUtility.vmrContainsNamedObject($vmr, "MostRecentObservationFor_Hemoglobin_A1c_Test") ==
       org.opencds.utilities.StringUtility.convertYorNToBoolean("Y") ), eval( ((Observation)
       $vmr.getNamedObjects().get("MostRecentObservationFor_Hemoglobin_A1c_Test")).getPhysicalQuantityValue() < 8 ))
195. |       $patient : Patient( ageInYearsInt >= "6" , ageInYearsInt <= ( 12 ) )
          $evalTime : EvalTime( evalTimeValue != ( null ) , eval( ((org.opencds.common.structures.AbsoluteTimeDifference)
       org.opencds.utilities.DateUtility.getInstance().getAbsoluteTimeDifference(((Observation)
       $vmr.getNamedObjects().get("MostRecentObservationFor_Hemoglobin_A1c_Test")).getObservationTimeStart(),
       $evalTime.getEvalTimeValue(), java.util.Calendar.MONTH)).getMonthDifference() >= 5 ), eval(
196. | ((org.opencds.common.structures.AbsoluteTimeDifference)
       org.opencds.utilities.DateUtility.getInstance().getAbsoluteTimeDifference(((Observation)
       $vmr.getNamedObjects().get("MostRecentObservationFor_Hemoglobin_A1c_Test")).getObservationTimeStart(),
       $evalTime.getEvalTimeValue(),java.util.Calendar.MONTH)).getMonthDifference() < 6 ))
197. |    then
198. |       Observation $observation = new Observation();
199. |       $observation.setClinicalStatementType( "interventionNeedObservation" );
200. |       $observation.setDataSourceType( "inferred" );
201. |       $observation.setObservationCodeSystem( "OpenCDS" );
202. |       $observation.setObservationCode( "Hemoglobin_A1c_Test" );
203. |       $observation.setCodedValueCodeSystem( "OpenCDS" );
204. |       $observation.setCodedValueCode( "Almost_Due" );
```

Acknowledgements

- **Research support**
  - NHGRI K01 HG004645 (PI: K. Kawamoto)
- **Study collaborators and wider community of contributors to HL7 vMR effort**

www.opencds.org

OpenCDS

Search this site

Home | Collaborators | Architecture | Key Components | Screenshots | Join the Community

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 Intermountain Healthcare, the Veterans Health Administration, the University of North Carolina at Chapel Hill, and Apelon, Inc.

Breaking News

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 3 hours ago by Kensaku Kawamoto

Intermountain Healthcare joins as OpenCDS collaborator The OpenCDS team is delighted to announce that Intermountain Healthcare, which is world-renowned for its cutting-edge clinical decision support and knowledge management capabilities, has joined OpenCDS as an ...

Posted 5 hours ago by Kensaku Kawamoto

Veterans Health Administration joins as OpenCDS collaborator

The OpenCDS team is excited to announce its newest collaborator: the Veterans Health Administration (VHA), which is the largest healthcare provider network in