Clinical Decision Support

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CTSI Biomedical Informatics Module
4 June 2015

http://jenders.bol.ucla.edu
Learning Objectives

• Understand key drivers of CDS, including availability of structured data for personalized medicine

• Learn the definition and scope of CDS
  – CDS = Applying knowledge to data

• Describe the details of standards and how they are used to implement CDS
Theme: Using Standards to Improve Knowledge Sharing in CDS

• CDS technology exists but is not being used optimally
  – Need to improve knowledge sharing (transfer, reuse, service-mediated access): Reduce the cost, improve the reliability of knowledge engineering, increase the likelihood of CDS use

• Approach: Standards
  – Standards: Not enough; too many!
    • Fill in current gaps + convergence
  – Make it easier
    • Better knowledge transfer
    • Better knowledge access: Standard interfaces instead of standard KR
    • Provide guidance on how to use CDS
Driver of CDS: Meeting Information Needs

- **Systematic review**: N = 72 studies of needs of physicians, medical residents, physician assistants, nurse practitioners, nurses, dentists and care managers

- **Frequency of clinician questions** (mean)
  - 0.57 questions/patient seen
  - Clinicians pursued 51%
  - Clinician need met in 78% of these

- **Domain of questions**
  - Drug tx: 34%
  - Cause of symptom, finding, test result: 24%

Need/Challenge for CDS: Changing Behavior

- **USA:** Only 54.9% of adults receive recommended care for typical conditions
  - community-acquired pneumonia: 39%
  - asthma: 53.5%
  - hypertension: 64.9%


- Delay in adoption: 10+ years for adoption of thrombolytic therapy

Challenge for CDS: Explosion in Data + Knowledge

A Rationale for Standardization: CDS

A Roadmap for National Action on Clinical Decision Support

June 13, 2006

Prepared by:
Jerome A. Osheroff, MD
Jonathan M. Teich, MD, PhD
Blackford F. Middleton, MD, MPH, MSc
Elaine B. Steen, MA
Adam Wright
Don E. Detmer, MD, MA

CDS National Roadmap: Three Pillars

- Enhanced health and health care through CDS
  - Best knowledge available when needed
  - High adoption & effective use
  - Continuous improvement of knowledge & CDS methods

Rationale: “Meaningful Use”

- Monetary incentive program created by ARRA HITECH (2009): Payments by CMS for participation
- **Key ingredients:** Use CEHRT “meaningfully” (eRx), health data exchange, reporting quality measures
- **Phases**
  - **Stage I (2011-2012):** Hospitals report 20/24 quality measures
  - **Stage II (2013):** Electronic data exchange (structured lab data, immunization registries), listing patients by condition, etc
  - **Stage III (2017+):** 2015 NPRM just closed for public comment (29 May)

CDS: Definitions

- **Foundational**: Key origin of field of Biomedical Informatics
  - AIM == Artificial Intelligence in Medicine
  - Computer-based diagnosis in the heyday of AI

- **Now**: Intelligent assistant
  - Support / assist human decision-makers, not supplant them

- **Core**: Applying knowledge to data

Improving Outcomes with Clinical Decision Support
An Implementer’s Guide

Second Edition

Jerome A. Osheroff, MD, FACP, FACMI
Jonathan M. Teich, MD, PhD, FACP, FHIMSS
Donald Levick, MD, MBA, FHIMSS
Luis Saldana, MD, MBA, FACEP
Ferdinand T. Velasco, MD
Dean F. Sittig, PhD, FACMI, FHIMSS
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Robert A. Jenders, MD, MS, FACP, FACMI

HIMSS
Improving Outcomes with Clinical Decision Support: An Implementer’s Guide


• Second edition (2012): Sponsored by AHRQ

• **Goal:** Provide practical advice to health care organizations
  – Choosing decision support goals
  – Choosing technology to advance those goals
  – Developing a deployment strategy

CDS Interventions

- **Computer-based** (though not necessary)
- **Typical examples**: Consulting a colleague, reading a text book, alert/reminder, data forms, order sets, clinical practice guidelines
- **Possible ingredients**: Trigger, logic, notification, data presentation, action items
- **Knowledge management**: Key program in leveraging CDS
  - Comprehensive process for acquiring, adapting and monitoring information for use in CDS
  - Keeps information up to date with clinical evidence, expert consensus and local conditions
CDS: What is it?

- **Definition**: “Clinical Decision Support is a process for enhancing health-related decisions and actions with pertinent, organized clinical knowledge and patient information to improve health and healthcare delivery.”
- **Recipients**: Patients, clinicians, administrators—anyone involved in care
- **Information**: General knowledge, intelligently processed patient data
- **Delivery formats**: Numerous = Data/order entry facilitators, filtered data displays, reference information, alerts, etc
CDS: Five Rights

- Framework for approaching & configuring CDS interventions
- “Rights”
  - Right information delivered to the
  - Right person in the
  - Right intervention format through the
  - Right channel at the
  - Right point in workflow
CDS: What (Else) Is It?

- **Computer-based CDS**: The use of information and communication technologies to bring relevant knowledge to bear on the health care and well-being of a patient.

- **Key aspects**
  - **Aim**: Make data apparent or easier to access or foster decision-making
  - **Provided to a user**: Clinician, patient, caregiver, technician
  - **Function**: Select or group knowledge
  - **Process**: Inferencing
  - **Result**: Take some action (includes information presentation) [open loop vs closed loop]

- **Core**: Applying information to data
Standards Pertinent to CDS

- **HL7**
  - v2.x, v3 messaging
  - CDA: Structured documents
  - SPL: Structured product labels
  - CCOW: Desktop interoperability
  - EHR Functional Model & Specification

- **Others**
  - Terminology: SNOMED, LOINC, ICD, etc
  - KR: Arden Syntax, others
The goal of the Newborn Screening Coding and Terminology Guide is to promote and facilitate the use of electronic health data standards in recording and transmitting newborn screening test results. The Web site includes standard codes and terminology for newborn tests and the conditions for which they screen, and links to other related sites. The codes and vocabulary standards are provided in a series of tables that you can view on the Web and/or download for your own use. These tables cover conditions recommended for screening by the Secretary’s Advisory Committee on Heritable Disorders in Newborns and Children (SACHDNC) or by a state within the U.S.

Use of these standards can speed the delivery of newborn screening reports, facilitate the care and follow-up of infants with positive test results, enable the use (and comparison) of data from different laboratories, and support the development of strategies for improving the newborn screening process.

This Web site also includes draft guidance for creating an HL7 version 2.x message using these codes with examples. If you would like us to notify you about updates to this guidance and other new content, please subscribe to the RSS feed for Updates, or join the NBS-Announcements e-mail list from the U.S. National Library of Medicine.

You can reach these various resources by picking a choice below.

**Views:** Generate customized Web views from the tables of conditions and analytes/measurements maintained by the U.S. National Library of Medicine (NLM®).
- **Conditions** — Conditions that are targeted by newborn screening
- **Analytes/Measurements** — Tests that are used as markers for newborn screening conditions
- **Tailored Views** — Specify subsets, or see relationships between conditions and analytes/measurements

**Downloads:** Download the tables of newborn screening conditions, of markers for these conditions and/or of mappings between conditions and their markers.

**Resources:** Find additional information about newborn screening and related codes and data standards, including the Newborn Screening Draft Detailed Use Case that was developed by the Office of the National Coordinator for Health Information Technology (ONC).

**Code and Terminology Standards:** View terms of use and other information about codes and terminologies listed and referenced on this Web site,
CDEs

• **Challenge:** Burgeoning electronic means for capturing data, but those data are not necessarily standardized
  – Example: REDCap

• **Goal:** Create standard libraries of instrument items and coded answer lists
  – Example: PROMIS (now coded in LOINC)

• **Multiple efforts underway**
  – NIH: ORDR, NINDS, NCI

• **Challenge:** Decentralized efforts not coordinated

# My Family Health History

**Create A New Family History**

Select "Create My History" to create your personal profile, enter your health information, and tell us how many people are in your immediate family. You can add other family members and enter their health histories later.

<table>
<thead>
<tr>
<th>Name</th>
<th>Relationship to Me</th>
<th>Add History</th>
<th>Update History</th>
<th>Remove Relative</th>
</tr>
</thead>
<tbody>
<tr>
<td>My Family</td>
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<tr>
<td>Self</td>
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</tbody>
</table>
Welcome to the NLM Personal Health Record (PHR)

With the NLM PHR you can

- Organize and keep track of your health information, including medical conditions, medications, vaccines, and test results
- Organize and keep track of your dependent’s information (e.g., children, elderly parents)
- Receive personalized health reminders about screening tests, vaccines, and other important issues
- Print medical summaries to share with your physicians or other family members

If you are having a medical emergency, you should dial 911, go to the nearest emergency room, or call your doctor.
# Urinalysis Panel

<table>
<thead>
<tr>
<th>When done</th>
<th>Where done</th>
<th>Comment</th>
<th>Next Due</th>
<th>Name</th>
<th>Value</th>
<th>Previous</th>
<th>Units</th>
<th>Range</th>
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<td>UA dipstick Panel</td>
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<td>Hemoglobin in Urine</td>
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<td>Urinalysis microscopic</td>
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<td>Other elements in Urine sediment</td>
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</tbody>
</table>

* indicates required information
### Medical Conditions

<table>
<thead>
<tr>
<th>Medical condition</th>
<th>Status</th>
<th>Started</th>
<th>Stopped</th>
<th>Description/Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asthma</td>
<td>Active</td>
<td>1982 May 01</td>
<td></td>
<td>Mild intermittent</td>
</tr>
<tr>
<td>Cholesterol - high</td>
<td>Active</td>
<td>2011 Jan 26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Common duct stone</td>
<td>Inactive</td>
<td>2011 Jan 03</td>
<td>2011 Jan 26</td>
<td></td>
</tr>
</tbody>
</table>

### Drugs

<table>
<thead>
<tr>
<th>Status</th>
<th>Drug</th>
<th>Instructions</th>
<th>Started</th>
<th>Stopped</th>
<th>Why stopped</th>
<th>Resupply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active</td>
<td>BACTRIM (Oral-pill) -- 800-160 mg Tabs</td>
<td>1 tab po bid</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Active</td>
<td>XOPENEX (Inhalant) -- 0.045 mg/puff MDI</td>
<td>2 puffs qid prn wheezing</td>
<td>2000 Oct 05</td>
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</tr>
</tbody>
</table>

### Questions to Ask Your Doctor

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<thead>
<tr>
<th>Category</th>
<th>Status</th>
<th>Question</th>
<th>Date entered</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medications</td>
<td>Not Asked</td>
<td>Can my inhaler give me palpitations?</td>
<td>2011 Jan 26</td>
<td></td>
</tr>
</tbody>
</table>
Further Data Aggregation: HIEs, Registries

- **Information Exchanges**
  - Locate and move data among partners
  - Clinical data: HIEs (e.g., Indiana)
  - Research data: PBRNs, other (RTRN)
  - Ultimate realization: NHIN
    - Promising mechanism for implementation: Direct Project

- **Registries**: Pool exchanged data
  - Cancer and immunization = most common
  - Ultimately connect via HIEs

Putting CDS Standards Together to Deliver Decision Support

- **Knowledge Transfer**
  - Procedural/Executable: Arden Syntax,
  - Declarative: HQMF, Order Set, CDS Knowledge Artifact Specification, (CQL)

- **Knowledge Access**
  - Infobutton, Decision Support Services

- **Infrastructure**
  - vMR, (QUICK)
“Outline”

HL7 HIMSS CCHIT Arden RIM HSSP
SOA DSS SNOMED ICD9 HCPCS NIC
NOC NDC RxNorm SQL GEM
ProFORMA ASTM CCR CDA CCD
EDIFACT LOINC CPT NANDA
BIRADS DICOM ICPC UMLS CEN
HITSP HISB ANSI ISO CTS AHIC
ONC CHI NCVHS HIPAA NDF-RT
HUGN CDISC ASC ICPC NCPDP IHE
ARRA HITECH ONC
SDO Process:
Health Level Seven International

- North America with 20+ international affiliates
  - JIC: Coordinate with other SDOs (e.g., CEN TC251)
- Subdivided into work groups that create/maintain different standards
- Mostly volunteer workers
- Heavily consensus-based, multilayer voting approval process
- Certification of adherence to process by external authority that charters SDOs (ANSI)
- Effect: Achieved through implementation/use
HL7 CDS Standards

• **Current** (or DSTU)
  – Arden Syntax
  – HQMF
  – Infobutton
  – DSS
  – Virtual Medical Record (vMR)

• **Implementation Guide**
  – CDS Knowledge Artifact Specification (= order sets + event-condition-action rules)
Arden Syntax for Medical Logic Modules

- Modular knowledge bases which are independent from one-another
- Share medical knowledge, not just reuse
- Procedural representation of medical knowledge
- Discrete units of knowledge = Medical Logic Module (MLM) = enough data + knowledge to make a single decision
- Explicit definitions for data elements
- HL7 / ANSI / ISO Standard
- Current version: 2.10 (final approval in progress)

Arden Syntax: Evolving with User Demand

• Moving away from relatively simple, clinician-friendly expressions to more powerful computability
• v2.7: Complex objects
• v2.8 (2011): Switch statement, complex list operators
• v2.9 (2012): Fuzzy logic
• v2.10 (2014): Complete XML representation format
• Active implementations
  – Fuzzy logic in infection control (U Vienna)
  – VA: Prototype implementation of health maintenance reminders via remote KB with GELLO to access data via “curly braces”
Healthcare Quality Measure Format (HQMF)

• Increasing mandates for clinical performance measurement

• Implementation of quality indicators (QIs) can be costly
  – Need to translate published QI to computable form
  – Need to collect digital data in structured format

• Solution: HQMF (2009) -> R2.1 (2014)

• **Active use:** eMeasures for CLABSI (CDC); retooling quality measures into HQMF (AHRQ); implementation guide.
Order Set Standard

- An order set is a functional grouping of orders in support of a protocol that is derived from evidence based best practice guidelines.
  - Document with possibly executable and conditional parts

- **Challenge:** All hospitals have them, but sharing and importation are difficult

- **Solution:** Standardized format (published 2012) that are interoperable: Shareable and importable in CPOE
Health eDecisions


- **Two key use cases**
  - CDS Guidance Service (send patient data, receive advice) = equivalent of HL7 DSS standard
  - Sharing knowledge artifacts (order sets, event-condition-action rules, document templates) = Replaces HL7 order set standard, possibly others

- **Focus**: Incorporate CDS standards into Meaningful Use regulation (NPRM 2015)
HeD -> Quality Improvement

- **US ONC Unified Clinical Quality Improvement Framework (aka CQF)**

- **Attempt to converge CDS and QI knowledge formalisms**

- **Artifacts under development**
  - **QUality Information and Clinical Knowledge (QUICK):** Data model that harmonizes NQF QDM + HL7 vMR
  - **Clinical Quality Language (CQL)**
Clinical significance

- NOT helpful for diagnosis in patients without anemia.
  - Red cell size distribution width should be used in conjunction with other diagnostic tests.
- Useful in the early classification of some anemias.
  - Red cell size distribution width often becomes abnormal earlier than other red cell parameters.
- More sensitive in microcytic conditions than microcytic.
- Most useful to distinguish early iron deficiency from:
  - anemia of chronic disease
  - thalassemia minor
- Useful to improve detection of early iron, vitamin B₁₂ or folate deficiency.
- Usually interpreted in conjunction with the mean cell volume (MCV).

<table>
<thead>
<tr>
<th>Indices</th>
<th>Red cell size distribution width elevated</th>
<th>Red cell size distribution width normal</th>
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<tbody>
<tr>
<td>MCV low</td>
<td>- Anemia of chronic disease (occasionally)</td>
<td>- Anemia of chronic disease (occasionally)</td>
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<table>
<thead>
<tr>
<th>Value</th>
<th>Reference Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>411 1000/UL</td>
<td>45-80 MUL/UL</td>
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<tr>
<td>42-53 %</td>
<td>14-18 G/DL</td>
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<td>27-33 PG</td>
<td>32-36 %</td>
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<td>11.5-14.5 %</td>
<td>15000-40000/UL</td>
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<tr>
<td>7.4-10.4 FL</td>
<td>1.8-8.0 1000/UL</td>
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</tbody>
</table>
Impact of Infobuttons

- Answers to over 85% of questions
- High positive impact in over 62% of infobutton sessions
  - Decision enhancement or learning
- Median session time: 35 seconds
- Usage uptake in medications and lab results

Cimino JJ. AMIA Ann Fall Symp. 2008.
Why did we need a standard?

Azithromycin
Female
75 years old
Medication order entry
Chronic kidney disease
User: MD
Setting: ED
Dose

Electronic Health Record

http://resource1.com/
search = “azithromycin”

http://resource2.com/
“azithromycin” [MeSH Terms] AND dose [All Fields]

http://resource3.com/
searchConcept = 3333 ^ azithromycin
filter = 11 ^ dosage
# Context Dimensions

<table>
<thead>
<tr>
<th><strong>Patient</strong></th>
<th><strong>User</strong></th>
</tr>
</thead>
</table>
| - Concept of interest  
- Gender / age  
- Vital signs / renal function  
- Problems / medications | - Patient vs. provider  
- Discipline / specialty |

<table>
<thead>
<tr>
<th><strong>EHR Task</strong></th>
<th><strong>Organization</strong></th>
</tr>
</thead>
</table>
| - E.g., order entry, problem list entry, lab results review | - Care setting  
- Service delivery location  
- Location of interest |
Standards-Based Approach

Aggregate Knowledge Response
Knowledge Response (Atom)
Knowledge Request (URL)

EHR
Infobutton Manager

HL7
Resource 1
Resource 2
Resource 3
For neonates requiring systemic treatment, prompt joint management with a pediatrician and ophthalmologist is recommended by the American Academy of Pediatrics and the American Society of Ophthalmology.

1. Commence pathogen-directed therapy according to results of diagnostic tests (see table below).

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Therapy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlamydial infection</td>
<td>Erythromycin oral</td>
</tr>
<tr>
<td>Gram-positive organisms</td>
<td>Erythromycin topical</td>
</tr>
<tr>
<td>Gram-negative organisms (other than suspected gonococcus)</td>
<td>Use either: Gentamicin topical OR Tobramycin topical</td>
</tr>
<tr>
<td>Gonococcal neonatal conjunctivitis</td>
<td>Ceftriaxone IV/IM</td>
</tr>
<tr>
<td>Gonococcal disseminated infection</td>
<td>Ceftriaxone IV</td>
</tr>
<tr>
<td>HSV conjunctivitis, blepharoconjunctivitis, or superficial keratoconjunctivitis</td>
<td>Acyclovir IV</td>
</tr>
</tbody>
</table>

The use of concomitant topical antivirals is controversial. The American Academy of Pediatrics recommends use of topical antivirals only. Considered unnecessary by other experts (because IV acyclovir levels in tears)
Interviews with HL7 Infobutton Implementers

**Strengths:**
- Simplicity
- Built over widely adopted standards

**Challenges:**
- Access to documentation & quick start guidance
- Competing priorities

**Benefits:**
- Adds business value
- Simple mechanism to support decision-making

**Adoption:**
- Knowledge publishers: High
- EHR vendors: Slow
- Meaningful Use to expedite

Meaningful Use Stage 2

- **Required CDS capability**
  - MAY use Infobutton Standard for provider reference information
  - MUST use Infobutton Standard for patient education

- Significant interest increase among EHRs vendors
Decision Support Service (DSS): Overview

- **Function:**
  - Evaluates patient data (**inputs**) and returns machine-interpretable conclusions (**outputs**)

- **Normative HL7/ANSI standard**
DSS: Architectural Overview

Patient data (e.g., care summary), modules to use

Conclusions about patient

Decision Support Service

Knowledge Modules

Client Decision Support Apps

Trigger

Queries for required pt data

Patient Data Sources

Institution A

Client Decision Support Apps

Queries for required pt data

Patient Data Sources

Institution B

Conclusions about patient

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Institution A

Client Decision Support Apps

Queries for required pt data

Patient Data Sources

Institution B
DSS – Primary Service Operations

1. Evaluate Patient
   Modules to use, required data

   Patient-specific evaluation results

2. Find Knowledge Modules
   Search criteria

   Modules meeting criteria

3. Get Data Requirements
   Module of interest

   Data requirements

4. Get Evaluation Result Semantics
   Modules of interest

   Output specification
HL7 DSS – Tools and Use

• Tools
  – OpenCDS: open-source reference implementation

• Known users of DSS standard (partial list)
  – Alabama Department of Public Health
  – CDS Consortium/Partners HealthCare
  – eClinicalWorks
  – HLN Consulting, LLC
  – HP Advanced Federal Healthcare Innovation Lab
  – New York City Department of Health & Mental Hygiene
  – University of Utah Health Care
  – VHA Knowledge Based Systems Office
Standard Data Models

• **Candidates**
  – vMR = Virtual Medical Record
  – RIM = HL7 Reference Information Model
  – FHIR = Fast Health Interoperable Resources
  – CDISC SDTM
  – OMOP CDM

• **Purpose:** Promote semantic interoperability
  – Data stored, retrieved, interpreted, displayed and analyzed with the same meaning as when first captured
  – “Big Data” -> Secondary use of clinical data
  – References to data (CDS, research studies, etc) can be shared regardless of vendor or implementation
Virtual Medical Record (vMR)

- **Goal:** Provide common information model upon which interoperable clinical decision support resources (e.g., rules) can be developed

- **Linked to the overall HL7 Reference Information Model (RIM)**
Project History

• Analysis of data required by 20 CDS systems from 4 countries (Kawamoto et al., AMIA 2010)

• Refinement of vMR via implementation within OpenCDS

• HL7 R1: 9/2011

• HL7 Logical Model R2: 1/2014
vMR Problem Model

DeniedProblem

Problem
+ ageAtOnset :PQ [0..1]
+ importance :CD [0..1]
+ problemStatus :CD [0..1]
+ severity :CD [0..1]
+ wasCauseOfDeath :BL [0..1]

ProblemBase
+ affectedBodySite :BodySite [0..*]
+ diagnosticEventTime :IVL_TS [0..1]
+ problemCode :CD
+ problemEffectiveTime :IVL_TS [0..1]

ClinicalStatement
+ dataSourceType :CD [0..1]
+ id :II
+ templateId :II [0..*]

BodySite
+ bodySiteCode :CD
+ laterality :CD [0..1]
HL7 vMR – Tools and Use

• Tools
  – OpenCDS: open-source reference implementation

• Known users of vMR standard (partial list)
  – Alabama Department of Public Health
  – eClinicalWorks
  – HLN Consulting, LLC
  – HP Advanced Federal Healthcare Innovation Lab
  – Intermountain Healthcare Homer Warner Center
  – Medical-Objects
  – New York City Department of Health & Mental Hygiene
  – University of Utah Health Care
  – VHA Knowledge Based Systems Office
OpenCDS

• Provides a reference implementation of the HL7 DSS and vMR standards

• 1.1 release freely available under Apache 2 open-source license

http://www.opencds.org
Featured Collaborators
**OpenCDS Knowledge Authoring - Rules**

**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 Outpatient encounter \(\leq 1\) or more times in the past \(\geq 2\) year(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 \(\text{with a laterality of Bilateral}\)
10. or 
11. Pt.Proc.Past.Count - Patient has had a Unilateral mastectomy \(\geq 2\) or more times in the past \(\leq 200\) year(s)
12. )

**THEN**
1. Assert that NQF 0031 denominator criteria met
# OpenCDS Knowledge Authoring – Decision Tables

<table>
<thead>
<tr>
<th>#</th>
<th>Desc</th>
<th>Vaccine</th>
<th>Gender</th>
<th>Dose #</th>
<th>Min Age</th>
<th>Units1</th>
<th>Max Age</th>
<th>Units2</th>
<th>Index Dose #</th>
<th>Min Interval</th>
<th>Units3</th>
<th>Rec Interval</th>
<th>Units4</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>HPV</td>
<td>Female</td>
<td>1</td>
<td>9 Yr</td>
<td>26</td>
<td>Yr</td>
<td>1</td>
<td>24</td>
<td>Day</td>
<td>61</td>
<td>Day</td>
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<td>5</td>
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<td></td>
<td>Male</td>
<td>1</td>
<td>11 Yr</td>
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Knowledge Authoring: Flow Diagrams
CDS: Ten Commandments

- Speed is everything
- Anticipate needs & deliver in real time
- Fit into user workflow
- Little things make a big difference (e.g., screen design)
- Recognize that MDs will resist stopping
- Changing direction is easier than stopping (e.g., dosing)
- Simple interventions work best
- Ask for information only if you really need it
- Monitor impact, get feedback and respond
- Manage & maintain your KBS

Summary

• Explosion in (structured) data plus regulatory & economic environment driving CDS

• Key to CDS: Delivering information to decision-makers under the Five Rights

• Standards = essential for disseminating knowledge using CDS, but universal agreement lacking

• Two key approaches
  – Knowledge transfer
  – Knowledge access
Thanks!

- Corey Arnold, PhD & William Hsu, PhD
- Gail Panatier
- NIMHD U54MD007598
- NCATS UL1TR000124

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