Translating Knowledge into Practice for Continuous Improvement - Knowledge Management

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Leadership Strategies for Information Technology in Health Care
- May, 2016 -
Overview

• Background
  – Motivation for CDS, continuity of care, problems

• Clinical Knowledge Management Program
  – Definition, challenges, opportunities

• Program at Partners HealthCare
  – CDS transfer to Epic, lifecycle, monitoring

• Program Scenarios
  – Portal, information retrieval, production rules

• Conclusions
Healthcare Industry

• Very complex processes with high degree of fragmentation
• Mandatory evolution toward integrated and streamlined processes
• Growing adoption of information technology (interoperability)
• Reliance on decision practices guided by a constantly evolving body of knowledge
• Clinical decisions supported by evidence – influenced by available local resources and preferences
Computerized Decision Support

- CDS known to improve care
  - Better with more complex CDS
  - But has to follow the patient
- EHR MU incentives require CDS use
  - Dependency on available structured data
  - High data quality and consistency is essential
  - Alignment with quality & safety measures
- Knowledge is constantly growing
  - Existing knowledge assets quickly obsolete
  - Must evolve toward individualized decisions
  - Must combine evidence & personal preferences
CDS has to follow the patient

- Clinical systems might have very **similar CDS features**, but are frequently **not** configured the same way
  - CDS triggered in one setting may **not** be confirmed or re-enacted in subsequent settings
- Without continuity and consistency across settings and institutions, interventions have **decreased effectiveness** for disseminating evidence and reducing unwarranted variability
Knowledge Exchange?

- Home
- Rehabilitation Phase
- Shared Repository? External Services?
- Hospital Procedure
- Ambulatory Visit

CDS?
CDS malfunctions

- Widespread and persist for long periods
- The failure to fire is difficult to detect
- Better methods needed to detect and prevent

- *Incidence of malfunctions is relatively low*
- *Scalability of proposed solutions is essential*
- *Emphasis on prevention, not simply detection*

CLINICAL KNOWLEDGE MANAGEMENT (CKM) PROGRAM
CKM Program

- **Systematic** and **sustainable** acquisition, adaptation (localization), and management of knowledge assets for different “modalities” of CDS
- Includes the **adaptation** of “reference” knowledge to reflect local and institutional requirements, resources, and priorities
- Follows a well-defined **lifecycle**, including specific stages for documentation, testing, and monitoring – supported by integrated set of tools and resources

Modalities of CDS

1. Reference knowledge selection and retrieval
   – e.g., infobuttons, crawlers

2. Information aggregation and presentation
   – e.g., summaries, reports, dashboards

3. Data entry assistance
   – e.g., forcing functions, calculations, evidence-based templates for ordering and documentation

4. Event monitors
   – e.g., alerts, reminders, alarms

5. Care workflow assistance
   – e.g., protocols, care pathways, practice guidelines

6. Descriptive or predictive modeling
   – e.g., diagnosis, prognosis, treatment planning, treatment outcomes
## Implementation of CDS modalities

<table>
<thead>
<tr>
<th>CDS modality</th>
<th>Types of Knowledge Assets</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Information selection and retrieval</td>
<td>Reference</td>
</tr>
<tr>
<td>2. Information aggregation and presentation</td>
<td>Actionable</td>
</tr>
<tr>
<td>3. Data entry assistance</td>
<td>Executable</td>
</tr>
<tr>
<td>4. Event monitors</td>
<td></td>
</tr>
<tr>
<td>5. Care workflow assistance</td>
<td></td>
</tr>
<tr>
<td>6. Descriptive or predictive modeling</td>
<td></td>
</tr>
</tbody>
</table>

- **Complexity**
- **Cost**
- **Availability**
- **Maintainability**
Knowledge Engineering challenges

- Labor-intensive **acquisition** process (SMEs)
- Inability to achieve proper **domain coverage**
- Rudimentary **tools** & **resources**
- **Costly** and **inefficient** maintenance

- Well-trained personnel equipped with efficient tools and processes
- Distributed and **collaborative activities** – i.e. cooperation across teams and institutions
  - Common tools, processes, and standards
Implementation challenges

- **Data availability**
  - Data not coded, coded inconsistently, not enough detail (codes)
- **Large number of dependencies** (frequency of changes)
  - Data definitions, classifications, EHR configuration, new evidence
- **Rudimentary tools** (editing)
  - Incorrect logic, missing values, related rules, automated validation
- **Labor intensive testing**
  - Positive and negative tests, regression testing, automated testing
- **EHR system** or integrated CDS engine
  - Limited integration options, complex configuration, peculiar features
CKM PROGRAM @ PARTNERS HEALTHCARE (PHS)
Program guiding principles @ PHS

- Objectively improves safety, quality, and efficiency
- Supported by evidence, clinical best practices, and sound clinical thinking
- Aligns with and promotes clinical and business goals
- Acceptable to practicing end users (workflow integration)
- Adheres to informatics and knowledge management best practices
- Best utilizes talent, resources, and capital of Partners
- Supports research and teaching missions of Partners
Scope (knowledge content) @ PHS

**Infrastructure**

**Process:** Collaboration, Lifecycle, Metadata, Namespaces

**Technology:** Editors, Browsers, Portals, Repositories, Software
## Inventory of Knowledge Assets Managed Centrally at Partners (1/2)

<table>
<thead>
<tr>
<th>Knowledge Asset Collection</th>
<th>Collection Size¹</th>
<th>Asset Type</th>
<th>Asset Source²</th>
<th>Asset Editor³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemotherapy Prescribing Dictionary: includes investigational agents</td>
<td>2,800 concepts</td>
<td>Dictionary</td>
<td>Local</td>
<td>Local</td>
</tr>
<tr>
<td>Drug Classification Subsets</td>
<td>2,500 classes</td>
<td>Dictionary</td>
<td>Custom</td>
<td>Local</td>
</tr>
<tr>
<td>Immunization Dictionary: includes reference mappings</td>
<td>620 concepts</td>
<td>Dictionary</td>
<td>Local</td>
<td>Vendor</td>
</tr>
<tr>
<td>Master Drug Dictionary (MDD): includes non-commercially available medications</td>
<td>11,000 concepts</td>
<td>Dictionary</td>
<td>Local</td>
<td>Local</td>
</tr>
<tr>
<td>Medication Concept Mappings</td>
<td>15,700 mappings</td>
<td>Dictionary</td>
<td>Local</td>
<td>Local</td>
</tr>
<tr>
<td>Oral Investigational Chemotherapy Dictionary</td>
<td>600 concepts</td>
<td>Dictionary</td>
<td>Local</td>
<td>Local</td>
</tr>
<tr>
<td>Outpatient neonatal dosing dictionary</td>
<td>60 concepts</td>
<td>Dictionary</td>
<td>Local</td>
<td>Local</td>
</tr>
<tr>
<td>Problem List Classification Subsets</td>
<td>530 classes</td>
<td>Dictionary</td>
<td>Local</td>
<td>Local</td>
</tr>
<tr>
<td>Problem List Dictionary</td>
<td>5,000 concepts</td>
<td>Dictionary</td>
<td>Custom</td>
<td>Local</td>
</tr>
<tr>
<td>Partners KnowledgeLink (infobutton manager)</td>
<td>650 resource profiles</td>
<td>Reference</td>
<td>Local</td>
<td>Local</td>
</tr>
<tr>
<td>Partners Handbook: portal of electronic clinical reference resources</td>
<td>600 external and 900 internal links</td>
<td>Reference</td>
<td>Local</td>
<td>Local</td>
</tr>
<tr>
<td>Critical Laboratory Alerts</td>
<td>175 rules</td>
<td>Rule</td>
<td>Local</td>
<td>Vendor</td>
</tr>
<tr>
<td>Disease Management and Preventive Care Reminders</td>
<td>340 rules</td>
<td>Rule</td>
<td>Local</td>
<td>Local</td>
</tr>
<tr>
<td>Drug Dosing in Elderly</td>
<td>320 dosing rules</td>
<td>Rule</td>
<td>Local</td>
<td>Local</td>
</tr>
<tr>
<td>Drug Dosing in Renal Insufficiency</td>
<td>400 dosing rules</td>
<td>Rule</td>
<td>Local</td>
<td>Local</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Knowledge Asset Collection</th>
<th>Collection Size¹</th>
<th>Asset Type</th>
<th>Asset Source²</th>
<th>Asset Editor³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drug-Disease Alerts</td>
<td>510 rules</td>
<td>Rule</td>
<td>Custom</td>
<td>Local</td>
</tr>
<tr>
<td>Drug-Drug Interaction Alerts</td>
<td>10,000 rules</td>
<td>Rule</td>
<td>Local</td>
<td>Local</td>
</tr>
<tr>
<td>Drug-Laboratory Alerts</td>
<td>440 rules</td>
<td>Rule</td>
<td>Custom</td>
<td>Local</td>
</tr>
<tr>
<td>Drug-Pregnancy Alerts</td>
<td>690 rules</td>
<td>Rule</td>
<td>Custom</td>
<td>Local</td>
</tr>
<tr>
<td>Drug-Utilization Alerts</td>
<td>15 rules</td>
<td>Rule</td>
<td>Local</td>
<td>Local</td>
</tr>
<tr>
<td>Duplicate Therapy Alerts</td>
<td>25 category rules</td>
<td>Rule</td>
<td>Custom</td>
<td>Local</td>
</tr>
<tr>
<td>Family History Reminders</td>
<td>25 algorithms</td>
<td>Rule</td>
<td>Local</td>
<td>N/A</td>
</tr>
<tr>
<td>Food-Drug Interaction Alerts</td>
<td>130 rules</td>
<td>Rule</td>
<td>Custom</td>
<td>Local</td>
</tr>
<tr>
<td>Health Monitoring</td>
<td>70 rules</td>
<td>Rule</td>
<td>Local</td>
<td>Local</td>
</tr>
<tr>
<td>Immunization Schedule Reminders</td>
<td>370 rules</td>
<td>Rule</td>
<td>Local</td>
<td>Vendor</td>
</tr>
<tr>
<td>Problem-list Reminders</td>
<td>80 rules</td>
<td>Rule</td>
<td>Local</td>
<td>Local</td>
</tr>
<tr>
<td>Relevant Laboratory Results for Order Entry</td>
<td>600 rules</td>
<td>Rule</td>
<td>Local</td>
<td>Local</td>
</tr>
<tr>
<td>Documentation Calculated Functions (inpatient)</td>
<td>500 functions</td>
<td>Template</td>
<td>Local</td>
<td>Vendor</td>
</tr>
<tr>
<td>Documentation Forms (inpatient)</td>
<td>500 templates and 11,800 data elements</td>
<td>Template</td>
<td>Local</td>
<td>Vendor</td>
</tr>
<tr>
<td>Documentation Flowsheets (outpatient)</td>
<td>5 templates</td>
<td>Template</td>
<td>Local</td>
<td>Local</td>
</tr>
</tbody>
</table>

¹Collection Size: not exact numbers given constantly changing nature of most collections, with assets periodically added and retired.
²Asset Source: “Local” represents assets not available in 3rd-party knowledge sources (i.e., proprietary Partners assets); “Custom” represents assets obtained from 3rd-party knowledge sources, but subsequently curated and modified by Partners for internal use.
³Asset Editor: “Local” represents an editor (authoring tool) developed internally by Partners; “Vendor” represents editors obtained from 3rd-party vendors, including generic XML-editing tools; “N/A” represents assets implemented as source code (no editor).
CKM Lifecycle @ PHS

Request (new or update)

Evaluate

Authorize & Prioritize

Monitor

Test & Deploy

Design

Implement
Ongoing activities @ PHS

• Transition!
  – **Partners eCare**: implementation of Epic
    ▪ System is live at BWH, MGH, NWH, MEEI, and PCPO
  – Migration (and preservation) of *legacy assets*
  – Evolving understanding of what Epic can/cannot do

• Implementing analytics platform for Clinical KM
  – **Monitoring** and evaluation of CDS interventions
  – Optimization of KM activities

• Completed new KM software platform (**CKMS**)
  – Repository + Portal + Authoring + SME Collaboration
  – System live since February 2015
**Partners eCare**

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**What is Partners eCare?**

Partners eCare is a Partners-wide initiative to implement the Epic electronic health record and administrative system by 2017.

---

**BY THE NUMBERS**

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>70,000+ Clinicians and Staff</td>
<td>Partners eCare will be implemented at each Partners hospital, outpatient center, physician practice, and post-acute service, as well as at Dana-Farber Cancer Institute and Massachusetts Eye and Ear.</td>
</tr>
<tr>
<td>Over 3,000 Experts</td>
<td>Clinical and administrative representatives from across Partners are lending their expertise to ensure the system serves our patients, caregivers and institutions.</td>
</tr>
<tr>
<td>3.3 Million Active Patients</td>
<td>Clinicians and staff will have access to one system for all patient records from anywhere within the Partners network.</td>
</tr>
</tbody>
</table>
Recognized challenges @ PHS

- New EHR system includes a **significantly larger collection of data & knowledge assets**, estimated at 4 to 5 times the number of assets previously managed/curated.

- Level of integration of the new EHR system greatly increases the **number & complexity of interdependencies** between assets, aggravated by important limitations of “internal” configuration tools.

- Sites are demanding **site-specific customization & filtering** of assets, given disparate needs, target patient populations, resources, and processes.

- Need for **targeted & continuous CDS interventions** increases as more emphasis is made to manage high-risk populations and episodes, taking into account **different payer contracts** and **unique patient characteristics**.

- Need for **consistent data definitions** aligned with **standards** is even more critical given increased demand for Interoperability, CDS, and Analytics.
Program milestones @ PHS

✓ Establish governance structure with clear guiding principles
✓ Define priorities considering ongoing programs & initiatives
✓ Catalog features & content available in legacy systems
✓ Assimilate features & content available in new EHR system
✓ Resolve or mitigate identified gaps (features & content)
✓ Define work plan aligned with EHR implementation timeline
✓ Implement KM lifecycle (available tools)
✓ Implement monitoring process (CDS interventions)
  o Replace isolated tools with integrated infrastructure
  o Expose assets and processes to users and stakeholders
  o Expand monitoring process (KM lifecycle & CDS evaluation)
  o Engage and collaborate with other organizations
Clinical Decision Support Monitoring Reports

This page shows monitoring reports on the Clinical Decision Support (CDS) interventions built for the Partners' Epic implementation. The data underlying the reports come from the "CDS Universe," a business representation of selected Epic Clarity tables, as well as a CDS tracking system used by the Knowledge Engineering team.

If this is your first time accessing the site, we recommend that you read the Frequently Asked Questions (FAQ) page.

_all CDS Interventions_

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDS Interventions by Status (Details)</td>
<td>Table</td>
<td>Lists all CDS interventions by release and firing status</td>
</tr>
<tr>
<td>CDS Interventions by Status (Count)</td>
<td>Stacked histogram</td>
<td>Shows the count of CDS interventions by release and firing status</td>
</tr>
<tr>
<td>CDS Interventions by Status (Percent)</td>
<td>Stacked histogram</td>
<td>Shows the percentages of CDS interventions by release and firing status</td>
</tr>
</tbody>
</table>

_best Practice Advisories_

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alert Data</td>
<td>Table</td>
<td>Shows the &quot;raw&quot; alerting data for Best Practice Advisories (BPAs)</td>
</tr>
<tr>
<td>Daily Alerted Patient Count</td>
<td>Line graph</td>
<td>Plots the number of patients who received one or more alerts per BPA(s) per day</td>
</tr>
<tr>
<td>Alerted Patients per CDS</td>
<td>Bar chart</td>
<td>Shows the total count of alerted patients per CDS</td>
</tr>
<tr>
<td>Volume of Alerted Patients</td>
<td>Area plot</td>
<td>Shows the total count of alerted patients per day</td>
</tr>
<tr>
<td>Patient Alert Volume per Day</td>
<td>Clustered histogram</td>
<td>Shows the number of alerted patients per alert volume for a given BPA. Answers the question &quot;How did the alert intensity change for a given BPA over time based on alerted patients?&quot;</td>
</tr>
<tr>
<td>Provider-Patient Alert Volume per Day</td>
<td>Clustered histogram</td>
<td>Shows the number of unique patient-provider combinations per alert volume for a given BPA. Answers the question &quot;How did the alert intensity change for a given BPA over time based on alerted physicians?&quot;</td>
</tr>
<tr>
<td>User BPA Follow-Up Action Count</td>
<td>Stacked histogram</td>
<td>Shows the number of user follow-up actions following a BPA. Answers the question &quot;How did users interact with the shown BPA?&quot;</td>
</tr>
</tbody>
</table>
CDS Monitoring: Example

Reminder to document a principal problem
09/15/15 - Released silent for monitoring; firing was excessive
11/17/15 - Revised to fire only on admitted patients (exclude ED patients)
12/22/15 - Activated; ~200 patient-alerts/day
CKM PROGRAM:
APPLICATION SCENARIOS
Scenario 1: CKM Portal

- Web-base portal (intranet/Internet)
- **Open access** to a complete inventory of knowledge assets created and/or used (multiple types)
- Asset **metadata**, including identification, provenance, lifecycle, designations (labels and names), and classifications
- Essential **documentation** (detailed specifications)
- Enables process **transparency** and effective **collaboration** (including reuse)
## Portal Overview

![CKMS Clinical Knowledge Management System](Image)

**Results 1-25 of 3,053,473**

- **Category**:
  - Knowledge (3053473)

- **Authority**:
  - nlm.nih.gov (2936304)
  - loinc.org (79527)
  - partners.org (37298)
  - semedy.com (344)

- **Namespace**:
  - SNOMEDCT.USA (2935567)
  - LOINC (79527)
  - PHS.Rollup (34843)
  - PHS (2455)
  - UML.SemanticNetwork (548)
  - KMS (311)

- **More**

- **Entity Type**:
  - SNOMED CT association (2509697)
  - SNOMED CT concept (423789)
  - LOINC concept (78959)
  - Rollup (34843)
  - User concept (817)
  - Resource with file (728)

- **More**

- **State**:
  - Published (3053473)

- **Created**
- **Modified**
- **Last Appraised**

### Table

<table>
<thead>
<tr>
<th>Entity Name</th>
<th>ID</th>
<th>Entity Type</th>
<th>Published</th>
<th>Created</th>
<th>Modified</th>
<th>Last Appraised</th>
</tr>
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<tbody>
<tr>
<td>General Health survey</td>
<td>LOINC:...B46C3:1</td>
<td>User concept</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Angle</td>
<td>PHS:...B904A:2</td>
<td>Kind of quanti...</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blood pressure timed molecular</td>
<td>LOINC:...E0E3C:1</td>
<td>User concept</td>
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<tr>
<td>Decimal Substance Fraction</td>
<td>LOINC:...D985E:1</td>
<td>User concept</td>
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<tr>
<td>H&amp;P.SURG PROC</td>
<td>LOINC:...C8F89:1</td>
<td>User concept</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Diagnosis list entry task context</td>
<td>PHS:...29610:1</td>
<td>User concept</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proton pump inhibitors duplicate therapy alert</td>
<td>PHS:...D236F:2</td>
<td>External resource</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obstetrical order set</td>
<td>LOINC:...36E05:1</td>
<td>User concept</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Practice registered nurse (clinical discipline)</td>
<td>PHS:...E98A6:1</td>
<td>User concept</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Medication management (condition management)</td>
<td>PHS:...F4281:1</td>
<td>User concept</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drug dose (for transmitting doses for pharmacokinetics)</td>
<td>LOINC:...94A9E:1</td>
<td>User concept</td>
<td></td>
<td></td>
<td></td>
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<td>Mass Content</td>
<td>LOINC:...66847:1</td>
<td>User concept</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
Asset Metadata

Description of LMR Reminder # 146 - Adult Seasonal Influenza

**Type**: Resource with file

**Lifecycle state**: Published

**Creator**: Sharon Boi

**Date created**: October 8, 2015 4:05:52 PM

**Curator**: Sharon Boi

**Date last modified**: October 8, 2015 4:31:26 PM

**Date last appraised**: October 8, 2015 4:24:36 PM

**Lifecycle transition**: October 8, 2015 4:05:52 PM, Work in progress
October 8, 2015 4:14:39 PM, Under review
October 8, 2015 4:24:36 PM, Approved
October 8, 2015 4:31:26 PM, Published

**Source**

**Designations**

**Long name**: Description of LMR Reminder # 146 - Adult Seasonal Influenza (preferred, active, human readable)

**Programmatic name**

**Schema name**

**Short name**: Adult Seasonal Influenza (LMR Reminder # 146) (active, human readable)
Asset Identifier (revisions)
Asset Designations (labels)

Long name
Programmatic name
Schema name
Short name

Description of LMR Reminder # 146 - Adult Seasonal Influenza (preferred, active, human readable)

Short name
Flu (active, human readable)
Grippe (active, human readable)
Influenza (active, human readable)
Influenza, NOS (inactive, human readable)

SNOMED CT concept ID
6142004 (active, human readable)

SNOMED CT description ID
Flu (11205017) (active, human readable)
Grippe (11206016) (active, human readable)
Influenza (11203012) (active, human readable)
Influenza (disorder) (800481016) (active, human readable)
Influenza, NOS (11204018) (inactive, human readable)

Designations
Long name
Programmatic name
Schema name
Short name

Resource with file (external resource type) (active, human readable)
typeExternalResourceWithFile (active, human readable)

Resource with file (preferred, active, human readable)
Asset Classification (tagging)

| Resource subject                  | Adult
|                                  | Ambulatory care setting
|                                  | Family medicine (clinical discipline)
|                                  | Health maintenance (disease management)
|                                  | Partners Healthcare System (PHS) Longitudinal medical record (LMR) clinical information system
| Resource title                   | LMR Reminder # 146 - Adult Seasonal Influenza@eng
| Resource type                    | Care reminder to provider

**Health maintenance (disease management)**

- **Identifier**
  - **Authority**: Partners
  - **Namespace**: PHS
  - **Id fragment**: 2E2DA1A9-6E79-4C3D-8249-53C5BF9A66D
  - **Entity revision**: 1

**Health Care Activity**

- **Identifier**
  - **Authority**: nlm.nih.gov
  - **Namespace**: UMLS Semantic Type
  - **Id fragment**: T058
  - **Entity revision**: 1
Asset Classification ("Health Maintenance")

<table>
<thead>
<tr>
<th>Designations</th>
<th>ID</th>
<th>Entity Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description of LMR Reminder # 117 - Lead Screening at 1 yr of age</td>
<td>PHS:...C4B59:2</td>
<td>Resource with file</td>
</tr>
<tr>
<td>Description of LMR Reminder # 213 - Chlamydia Screening: Females 18-24</td>
<td>PHS:...8ABDD:1</td>
<td>Resource with file</td>
</tr>
<tr>
<td>Description of LMR Reminder # 189 - Non-DM, non-CHD &amp; equiv, Pos Risk Factors (HTN), almost due for total cholesterol - NOW</td>
<td>PHS:...2E231:1</td>
<td>Resource with file</td>
</tr>
<tr>
<td>Description of LMR Reminder # 187 - Non-DM, non-CHD &amp; equiv, Pos Risk Factors (HTN), overdue for total cholesterol</td>
<td>PHS:...0C21B:1</td>
<td>Resource with file</td>
</tr>
<tr>
<td>Description of LMR Reminder # 198 - Almost due for CRC screening (Pers Hx risk CRC)</td>
<td>PHS:...D382E:2</td>
<td>Resource with file</td>
</tr>
<tr>
<td>Description of LMR Reminder # 362 - Almost due for Pap smear (ages &gt;=21 and &lt;30)</td>
<td>PHS:...BEBB9:2</td>
<td>Resource with file</td>
</tr>
<tr>
<td>Description of LMR Reminder # 213 - Chlamydia screening in females 18-24</td>
<td>PHS:...8ABDD:2</td>
<td>Resource with file</td>
</tr>
<tr>
<td>Description of LMR Reminder # 186 - Non-DM, non-CHD &amp; equiv, Moderate Fx for CAD, overdue for total cholesterol</td>
<td>PHS:...6F3D4:3</td>
<td>Resource with file</td>
</tr>
<tr>
<td>Description of LMR Reminder # 199 - Overdue for CRC screening (Pers High Risk -IBD)</td>
<td>PHS:...B7F11:3</td>
<td>Resource with file</td>
</tr>
<tr>
<td>Description of LMR Reminder # 146 - Adult Seasonal Influenza</td>
<td>PHS:...F26FD:3</td>
<td>Resource with file</td>
</tr>
</tbody>
</table>
Asset Types (properties)

**Identifier**
- **Identifier**: urn:lsid:partners.org:PHS:ADF48D6D-F5D5-40CB-A999-DF72042EC088:1
- **Authority**: Partners
- **Namespace**: PHS
- **Id fragment**: ADF48D6D-F5D5-40CB-A999-DF72042EC088
- **Entity revision**: 1

**Properties**
- **Age range**: Age >= 0 years and < 19 years
- **Available for historic use**: false
- **Definition**: A child/person between birth and 19 years of age
- **Legacy LSID**: 
- **Precoordinated**: true
- **Primitive**: false
- **Semantic group**: Age Group
Asset Types (properties)

Brigham and Woman's Hospital (BWH) adult drug administration guideline (DAG): Caffeine and sodium benzoate injection

Identifier
- **Identifier**: urn:lsid:partners.org:PHS:6F47240C-A839-4292-BDF5-73092A1EB0AC:1
- **Authority**: Partners
- **Namespace**: PHS
- **Id fragment**: 6F47240C-A839-4292-BDF5-73092A1EB0AC
- **Entity revision**: 1

Resource source: BWH DAG Committee (adult)
Resource state: Published
Resource subject: CAFFEINE AND SODIUM BENZOATE
Resource title: Caffeine and sodium benzoate injection@eng
Resource type: Drug administration guideline
Resource URL: [http://www.bwhpikenotes.org/policies/Pharmacy/Drug_Administration/DAG/CaffeineNaBenzoateDAG.htm](http://www.bwhpikenotes.org/policies/Pharmacy/Drug_Administration/DAG/CaffeineNaBenzoateDAG.htm)
Scenario 2: Infobuttons

- **Context-aware** information retrieval
- Simple mechanism to enable access to **knowledge** at the point-of-decision (reference or actionable)
- Can be used to retrieve **metadata**, relevant **citations**, and other related **assets**
- Requires asset **classification** (tagging) and mechanisms to select asset **type** and user **context**
- Relatively easy to implement and supported by most EHR systems (HL7 **standard**)
- Sophisticated implementations can also display available **semantic associations**
### Problem List infobuttons

<table>
<thead>
<tr>
<th>Problem Description</th>
<th>Additional Details</th>
</tr>
</thead>
</table>
| **Depression**      | Type: Acute Severity: Major Condition: Worse
|                     | Comments: no changes pt still depressed... |
|                     | Comments: Inoperable |
| **Brain cancer**    | Onset: 04/04/2011 Comments: must reduce their stress an... |
| **Diabetes mellitus** | Type: Chronic Onset: 11/30/2007 |
| **Hypertension**    | Type: Acute Onset: 09/11/2001 Comments: updating a problem that was... |
| **R/O Depression**  | Type: Acute Severity: Minor Onset: 02/16/2011 Resolution: 05/09/2011 |
|                     | Location: Right Onset: 03/02/2011 Comments: hurts |
| **Asthma**          | Type: Chronic Severity: Minor Onset: 02/16/2011 Resolution: 05/09/2011 |
|                     | Location: Right Onset: 03/02/2011 Comments: hurts |
| **PR Foot pain**    | Onset: 07/07/2010 |
| **Appendectomy**    | Onset: 04/05/2011 |
| **F/H Dyspnea**     | Onset: 06/15/2011 |
| **H/O Bulimia nervosa** | Type: Chronic Onset: 02/16/2011 Resolution: 05/09/2011 |
| **H/O Verruca plantaris** | Location: Right Onset: 03/02/2011 Comments: hurts |
| **Glaucoma**        | Type: Chronic Severity: Minor Onset: 02/16/2011 Resolution: 05/09/2011 |
| **RSK Melanocytic nevus of skin** | Location: Right Onset: 03/02/2011 Comments: hurts |
| **RSK Arteriosclerotic vascular disease** | Type: Chronic Severity: Minor Onset: 02/16/2011 Resolution: 05/09/2011 |

Information about "Depression"
Asset Metadata Retrieval

Care reminder to provider

<table>
<thead>
<tr>
<th>Resource Name:</th>
<th>Description of LMR Reminder # 144 - Needs Pneumococcal (high risk medical condition)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resource ID:</td>
<td>urn:lsid:partners.org:PHS:6718621A-054C-4F70-9487-527AFB822867:1</td>
</tr>
<tr>
<td>Revision Number:</td>
<td>1</td>
</tr>
<tr>
<td>Approving Body:</td>
<td>PHS Ambulatory CIT</td>
</tr>
<tr>
<td>Developer of Intervention:</td>
<td>PHS KM</td>
</tr>
<tr>
<td>First Created:</td>
<td>2007-04-05</td>
</tr>
<tr>
<td>Last Revised:</td>
<td>2007-05-09</td>
</tr>
<tr>
<td>Last Appraised:</td>
<td>2007-05-09</td>
</tr>
</tbody>
</table>

Reference Citation:

- CDC
- USPSTF
- Infectious Disease Society of America
- American College of Preventive Medicine


Funding Source:

Partners HealthCare System, Inc. (PHS)
Scenario 3: Rule Specifications

- Specification and management of rules (if... then ...)
- Overcome knowledge engineering challenges related to maintainability and extensibility
- Adopt same lifecycle and framework defined for other types of knowledge assets
- Proactive management of dependencies, starting with data definitions
- Configurable validation scripts to confirm semantic compatibility of rule components
- Ability to export rule specifications using different representation formats (standards)
Production Rule

[IF] Caffeine > 30 mcg/mL [THEN] Alert level 2
Expression, Data Element, and Value

[IF] Caffeine > 30 mcg/mL [THEN] Alert level 2

Caffeine > 30 mcg/mL

Caffeine lab test result

Caffeine [Mass/volume] in Serum or Plasma

<table>
<thead>
<tr>
<th>Identifier</th>
<th>urn:lsid:loinc.org:LOINC:3422-3:2</th>
</tr>
</thead>
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<tr>
<td>Authority</td>
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<td>LOINC</td>
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<tr>
<td>Id fragment</td>
<td>3422-3</td>
</tr>
<tr>
<td>Entity revision</td>
<td>2</td>
</tr>
</tbody>
</table>
Graphical view
Content Consumers
(e.g., Clinical applications and services, EHR systems, etc.)

CKMS

EXPORT
(same XML format used for Import)

Publication
Review & Vetting
Authoring
Validation
Linking

IMPORT
(XML format compatible with available standards – e.g., CTS2)

Content Sources
(e.g., EHR content, Open source content, Licensed content, etc.)
CONCLUSIONS
Strategic Goals @ Partners

- Enable all knowledge content to be **accessible, updatable, and maintained** with an audit trail
- Reduce the **cost** and increase **efficiency** of both design and implementation maintenance
- Enable **stakeholder** involvement in the design process to support effective adoption and use
- Ensure alignment with **quality, safety, and operating** business drivers (Risk Contracts, CQI, ACO, etc.)
- Avoid potential **liability** of making incorrect or incomplete recommendations due to lack of **coverage or update**
Advanced CDS → KM opportunities

• Multiple CDS **options** available
  – Different modalities from simple to complex
  – But knowledge is constantly changing
  – And local **adaptations** are frequently needed

• “**Stateful**” CDS assistance is very attractive
  – Implementation of complete pathways/protocols
  – But **very few** EHRs support required features
  – And knowledge “**evergreen**” is very expensive

• Needed **standards** are still evolving
  – Progress: terminologies, data models, and knowledge
  – Inability to implement **at scale** (no cost-sharing)
Successful CKM Program

• Enables health care institutions to effectively utilize knowledge-driven computer systems
  – Improve care safety and quality
  – Keep pace with frequent scientific advances
  – Embrace new care delivery models
  – Promote continuous learning

• Overcome knowledge engineering and implementation challenges
Additional references (1/3)

- Book “Clinical Decision Support - The Road to Broad Adoption (2nd edition)”
  - Chapter 28 - A Clinical Knowledge Management Program

- Paper “Ten commandments for effective clinical decision support: making the practice of evidence-based medicine a reality.”

- Paper “Just-in-time delivery comes to knowledge management.”

- Paper “Using commercial knowledge bases for clinical decision support: opportunities, hurdles, and recommendations.”
Additional references (2/3)


Additional references (3/3)


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Beatriz Rocha

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Tonya Hongsermeier
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