Translating Knowledge into Practice for Continuous Improvement: Knowledge Management

Roberto A. Rocha, MD, PhD, FACMI
Clinical Informatics Director
Partners eCare, Partners Healthcare System
Assistant Professor of Medicine
Division of General Internal Medicine and Primary Care
Brigham and Women’s Hospital, Harvard Medical School

Leadership Strategies for Information Technology in Health Care: May, 2017
Overview

• Background
  – Partners eCare, informatics, challenges

• Clinical Knowledge Management Program
  – Definition, challenges, opportunities

• Program at Partners HealthCare
  – Knowledge transference, lifecycle, monitoring

• Program Scenarios
  – Portal, infobuttons, dependencies, validation

• Conclusions
Partners eCare (PeC)

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

70,000+ Clinicians and Staff

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.

Over 3,000 Experts

Clinical and administrative representatives from across Partners are lending their expertise to ensure the system serves our patients, caregivers and institutions.

3.3 Million Active Patients

Clinicians and staff will have access to one system for all patient records from anywhere within the Partners network.
Clinical Informatics @ PHS (1/2)

- **Multiple** groups and teams involved with Informatics
  - Becoming very popular, particularly among clinicians
- **Enterprise** team dedicated to EHR activities
  - **Operational** *(applied)* role with emphasis on knowledge management, clinical decision support (CDS), data management, ontology management, interoperability, and standards

- Complex operational problems require **formal** approach
  - Analysis + experimentation + evaluation
  - Apply informatics expertise to define, plan, and carry out projects
- Involved with research and **innovation**
  - Explore research and innovation-oriented opportunities, including academic and industry collaborations
Operational challenges (informatics perspective)

- 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

- The level of integration of the new EHR system greatly increases the number and complexity of interdependencies between assets, aggravated by important limitations of internal configuration tools

- The deployment of the system at PHS sites requires site-specific customization & filtering of assets, taking into account disparate needs, target patient populations, and resources

- The need for targeted & continuous knowledge-driven interventions increases with the need to manage high-risk populations, taking into account different payer contracts and unique patient characteristics

- The need for consistent data definitions aligned with existing standards is critical for increasing demand for Interoperability, CDS, and Analytics
CLINICAL KNOWLEDGE MANAGEMENT PROGRAM
"Software is clearly simpler to update or extend than hardware, and we all want to believe that, with sufficient care, software can be just as reliable. There are many reminders that justifying this might require more evidence than is often assumed. Building robust software really does require a different approach."

"For both hardware and software design, not using the right tools is just not cool"

Clinical Knowledge Management (CKM)

- **Systematic** and **sustainable** acquisition, adaptation (*localization*), and management of knowledge assets
  - Assets → CDS, population management, analytics, etc.

- 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

Scope of CKM activities

- **CDS (Clinical Decision Support)**
  - alerts, reminders, medication warnings, duplication warnings, therapeutic alternatives, infobuttons, etc.

- **Data Classification**
  - forms, flowsheets, documentation templates, data fields, calculators, etc.

- **Data Definitions**
  - data elements, value sets, and data models for problems, medications, procedures, etc.

- **Terminology & Ontology Management**
  - master files, dictionaries, translation tables, and reference ontologies (e.g. SNOMED CT, ICD-10-CM, LOINC)

- **Software Infrastructure**
  - editors, portals, repositories, virtual collaboration tools, knowledge retrieval services, rule execution engines
Utilization of knowledge assets

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
CKM Program challenges

• **Governance** and **stewardship** are difficult to implement
  – Domain experts (SMEs) frequently have limited commitment
  – Cost of not having knowledge is frequently overlooked
  – Lack of a systemic view promotes overlapping efforts (*variation*)

• **Processes** and **tools** to curate assets are inadequate
  – Knowledge once deployed for use is **not** easily accessible (*locked*)
  – Maintenance of knowledge assets is an afterthought
  – Processes for configuring and vetting assets not explicitly defined

• **Liability** from outdated or incorrect assets not recognized

• **Analytics** regarding impact on clinical processes and outcomes is generally **not** available
CKM governance options – multiple sites

**Centralized (top-down)**
- Corporate sanctioned groups
- Dedicated central resources
- Assets pre-approved & pre-prioritized
- Enterprise implementation

**Grassroots (bottom-up)**
- Front-line clinicians
- Shared central resources
- Central asset approval & prioritization
- Enterprise implementation

**Distributed (decentralized)**
- Local sanctioned groups
- Shared central resources
- Local approval & prioritization
- Enterprise or Local implementation

**Independent (autonomous)**
- Local resources & governance
- Dedicated local resources
- Local approval & prioritization
- Local implementation

**Outsourced (menu based)**
- 3rd party assets
- Dedicated central resources
- Central or local approval & prioritization
- Enterprise implementation
Optimal governance?

- Alignment with business **needs** and overall clinical **strategy** – expected **differentiation** and **competitive advantage**
- Appropriate decision **autonomy** and **communication** – streamlined approval and prioritization (**transparency**)
- **Empowerment** of frontline clinicians (**knowledge workers**) – **tangible benefits** to stakeholders and end-users
- Reasonable implementation **costs** (**customization**) – **consistency** and long-term **maintainability**

- Single process will likely **not** support **expectations**
  - Optimal allocation of **resources** to each governance process
  - Resolution of potential **conflicts** between processes
Assets: implementation challenges

- Limited number of skilled **resources** using defined **processes**
  - Infrequent cooperation across teams and institutions
- Rudimentary **tools** (*editing*)
  - Incorrect logic, missing values, related rules, automated validation
- Large number of **dependencies** (*frequent changes*)
  - Data definitions, classifications, EHR configuration, new evidence
- Labor intensive **testing** and ongoing **maintenance**
  - Positive and negative tests, regression testing, error detection
- **EHR system** (+ *integrated engines*)
  - Limited integration options, complex configuration, peculiar features
- **Data** availability (*CDS & analytics*)
  - Data not coded, coded inconsistently, not enough detail (*codes*)
Assets: implementation strategy

- Forms & flowsheets
- Order Sets
- Registries
- Dashboards
- Alerts
- Reminders
- Protocols
- Infobuttons (reference)

- Moderate Cost & Complexity
- High Cost & Complexity
- Low Cost & Moderate Complexity
- Low Cost & Complexity
CKM PROGRAM @ PHS
Clinical Informatics @ PHS (2/2)

• Transition!
  – Epic system is live at major sites
  – Ongoing migration (and preservation) of legacy assets
  – Evolving knowledge of what Epic can/cannot do

• Implementing analytics platform for KM
  – Monitoring and evaluation of KM activities
  – Process optimization and improvement

• Completed new KM software platform (CKMS)
  – Repository + Portal + Authoring + SME Collaboration
  – New platform live since February 2015
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 & business goals
- Acceptable to end users (workflow integration)
- Adheres to informatics and KM best practices
- Best utilizes talent, resources, and capital
- Supports research and teaching missions
KM Scope @ PHS

**Dictionaries**
- Terminologies
- Coding Systems
- Ontologies
- Classifications

**Templates**
- Documentation
- Orders
- Reports
- (Models)

**Rules**
- Alerts
- Reminders
- Workflows
- Protocols

**Reference**
- Manuals
- Books
- Guides
- (Evidence)

**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>

### Inventory of Knowledge Assets Managed Centrally at Partners (2/2)

<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>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>

¹ **Collection Size**: not exact numbers given constantly changing nature of most collections, with assets periodically added and retired.

² **Asset 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.

³ **Asset 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
- Grassroots (bottom-up)
  - Front-line clinicians
  - Shared central resources
  - Central asset approval & prioritization
  - Enterprise implementation
- Design
- Monitor
- Test & Deploy
- Implement
Program milestones @ PHS

✓ Establish **governance** structure with clear guiding principles (*grassroots*)
✓ Define **priorities** considering ongoing clinical 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 & dashboard (*CDS interventions*)

- Replace isolated tools with **integrated infrastructure** (CKMS)
- Improve stakeholder **access** to processes and assets (*transparency*)
- **Expand** monitoring – e.g. *data definitions, uncoded data, CDS evaluation*
- 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 “raw” alerting data for Best Practice Advisories (BPAs)</td>
</tr>
<tr>
<td>Daily Alotted 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 Alotted Patients</td>
<td>Area chart</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
Able to maintain rate of 1 new CDS release per day, but taking into account increasing rate of CDS revisions.
**Business Days to Activation**
Measured from start of design (or build)

- **Avg 172 days**
- **Avg 74 days**
- **Avg 64 days**
- **Avg 20 days**

**Year in which CDS was begun**
- 2013
- 2014
- 2015
- 2016
- 2017
- 2018

Becoming more **proficient** and **efficient** at developing CDS
CKM PROGRAM: APPLICATION SCENARIOS
Clinical Knowledge Management System

- CKMS is a **suite of applications** and **services** for collaborative authoring and curation of assets, including search, display, and dissemination of asset collections
  - Assets: data definitions, models, dictionaries, ontologies, rules, etc.
  - Complete asset curation lifecycle, including ability to export for subsequent use by EHRs, as well as other clinical and research applications
  - Configurable metadata for assets managed by applications and repositories
  - CKMS was co-developed by **PHS** and **Semedy AG**
Asset Sources
(e.g., EHR content, Open source content, Licensed content, etc.)

ETL

CKMS

EXPORT
(same XML format used for Import)

Publication

Review & Vetting

Authoring

Validation

Linking & Tagging

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

ETL

Asset Consumers
(e.g., Clinical applications and services, EHR systems, etc.)
Scenario 1: Asset Portal

- Web-base **portal** (*intranet/Internet*)
- Open access to a **complete inventory** of 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: search & facets

#### CKMS

**Clinical Knowledge Management System**

**Knowledge Portal**

---

**Results 1-25 of 3,321**

- **Category**
  - Knowledge (3321)
- **Authority**
  - nlm.nih.gov (2253)
  - partners.org (531)
  - loinc.org (474)
  - cdc.gov (63)
- **Namespace**
  - SNOMED.CT.USA (2253)
  - LOINC (474)
  - PHS.Rolup (21)
  - ICD9CM.dia (12)
- **Entity Type**
  - SNOMED CT association (2025)
  - LOINC concept (474)
  - EDG record (471)
  - SNOMED CT concept (228)
  - ICD-10-CM diagnosis (45)
  - Resource with file (37)
  - Rollup (21)

---

**Filter by name**

<table>
<thead>
<tr>
<th>Entity Name</th>
<th>ID</th>
<th>Entity Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anesthesia for pneumocentesis (procedure)</td>
<td>SNOMED.CT.USA:...79001:3</td>
<td>SNOMED CT concept</td>
</tr>
<tr>
<td>Pneumocystis jiroveci Ag [Presence] in Blood</td>
<td>LOINC:...932-7:3</td>
<td>LOINC concept</td>
</tr>
<tr>
<td>Pneumocystis due to talc dust</td>
<td>ICD10CM.dia:...62.0:0:2</td>
<td>ICD-10-CM diagnosis</td>
</tr>
<tr>
<td>Pneumocystis jiroveci Ag [Presence] in Throat</td>
<td>LOINC:...941-8:3</td>
<td>LOINC concept</td>
</tr>
<tr>
<td>Pneumocystis jiroveci Ag [Presence] in Nose</td>
<td>LOINC:...936-8:3</td>
<td>LOINC concept</td>
</tr>
<tr>
<td>Pneumocystis jiroveci DNA [#/volume] in Serum or Plasma by Probe and target amplification method</td>
<td>LOINC:...440-1:3</td>
<td>LOINC concept</td>
</tr>
<tr>
<td>Antimony pneumocystis (disorder)</td>
<td>SNOMED.CT.USA:...91003:3</td>
<td>SNOMED CT concept</td>
</tr>
<tr>
<td>Pneumocystis sp identified in Lung tissue</td>
<td>LOINC:...712-8:3</td>
<td>LOINC concept</td>
</tr>
</tbody>
</table>

---

Welcome, rar40 | May 17, 2017
### Asset Metadata

**Description of LMR Reminder # 142 - Needs Pneumococcal**

* (age > 65 and no Pneumococcal ever) %

<table>
<thead>
<tr>
<th>Identifier</th>
<th>urn:lsid:partners.org:PHS:B8670C0E-B494-4DE6-9E5D-603C01B9F8F1:5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Authority</td>
<td>Partners</td>
</tr>
<tr>
<td>Namespace</td>
<td>PHS</td>
</tr>
<tr>
<td>Id fragment</td>
<td>B8670C0E-B494-4DE6-9E5D-603C01B9F8F1</td>
</tr>
<tr>
<td>Entity revision</td>
<td>5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type</th>
<th>Resource with file</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lifecycle state</td>
<td>Published</td>
</tr>
<tr>
<td>Creator</td>
<td></td>
</tr>
<tr>
<td>Date created</td>
<td>October 8, 2015 4:05:52 PM</td>
</tr>
<tr>
<td>Curator</td>
<td></td>
</tr>
<tr>
<td>Date last modified</td>
<td>October 8, 2015 4:31:26 PM</td>
</tr>
<tr>
<td>Date last appraised</td>
<td>October 8, 2015 4:24:36 PM</td>
</tr>
<tr>
<td>Lifecycle transition</td>
<td>October 8, 2015 4:05:52 PM, Work in progress</td>
</tr>
<tr>
<td></td>
<td>October 8, 2015 4:14:59 PM, Under review</td>
</tr>
<tr>
<td></td>
<td>October 8, 2015 4:24:36 PM, Approved</td>
</tr>
<tr>
<td></td>
<td>October 8, 2015 4:31:26 PM, Published</td>
</tr>
</tbody>
</table>
Asset Identifier: namespace + revision

**Identifier**

<table>
<thead>
<tr>
<th>Identifier</th>
<th>urn:lsid:partners.org:PHS:B8670C0E-B494-4DE6-9E5D-603C01B9F8F1:5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Authority</td>
<td>Partners</td>
</tr>
<tr>
<td>Namespace</td>
<td>PHS</td>
</tr>
<tr>
<td>Id fragment</td>
<td>B8670C0E-B494-4DE6-9E5D-603C01B9F8F1</td>
</tr>
<tr>
<td>Entity revision</td>
<td>5</td>
</tr>
</tbody>
</table>

**Identifier**

<table>
<thead>
<tr>
<th>Identifier</th>
<th>urn:lsid:cdc.gov:ICD10CM.diagnosis:G00.1:3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Authority</td>
<td>cdc.gov</td>
</tr>
<tr>
<td>Namespace</td>
<td>ICD-10-CM diagnosis</td>
</tr>
<tr>
<td>Id fragment</td>
<td>G00.1</td>
</tr>
<tr>
<td>Entity revision</td>
<td>3</td>
</tr>
</tbody>
</table>

**Identifier**

<table>
<thead>
<tr>
<th>Identifier</th>
<th>urn:lsid:partners.org:PHS.PeC.TST.EDG:617495:2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Authority</td>
<td>Partners</td>
</tr>
<tr>
<td>Namespace</td>
<td>PHS.PeC.TST.EDG</td>
</tr>
<tr>
<td>Id fragment</td>
<td>617495</td>
</tr>
<tr>
<td>Entity revision</td>
<td>2</td>
</tr>
</tbody>
</table>
## Asset Designation: labels + types

### Designations

<table>
<thead>
<tr>
<th>ICD code</th>
<th>G00.1 (active, human readable)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inclusion term</td>
<td>Meningitis due to Streptococcal pneumoniae (active, human readable)</td>
</tr>
<tr>
<td>Short name</td>
<td>Pneumococcal meningitis (preferred, active, human readable)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Generic med ID</th>
<th>523</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generic name</td>
<td>PNEUMOCOCCAL VAC. POLYVALENT (active, human readable)</td>
</tr>
<tr>
<td>Misspelling</td>
<td>PNEUMOCOCCAL VACCINE POLYVALENT [1279] (active, human readable)</td>
</tr>
<tr>
<td>Rollup ID</td>
<td>618</td>
</tr>
<tr>
<td>Short name</td>
<td>PNEUMOCOCCAL VAC. POLYVALENT (preferred, active, human readable)</td>
</tr>
<tr>
<td>Synonym</td>
<td>PNEUMOVAX 231 [1280] (active, human readable)</td>
</tr>
</tbody>
</table>
Asset tagging: classification + retrieval

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
### Asset Types: extensible properties

#### Pediatric

<table>
<thead>
<tr>
<th>Action</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Create Revision</td>
<td>To Retired</td>
</tr>
<tr>
<td>Change Curator</td>
<td>Validate</td>
</tr>
<tr>
<td>Clone</td>
<td>Refresh</td>
</tr>
<tr>
<td>Show Graph</td>
<td>Contact Curator</td>
</tr>
</tbody>
</table>

#### Identifier

<table>
<thead>
<tr>
<th>Identifier</th>
<th>urn:lsid:partners.org:PHS:ADF48D6D-F5D5-40CB-A999-DF72042EC088:1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Authority</td>
<td>Partners</td>
</tr>
<tr>
<td>Namespace</td>
<td>PHS</td>
</tr>
<tr>
<td>Id fragment</td>
<td>ADF48D6D-F5D5-40CB-A999-DF72042EC088</td>
</tr>
<tr>
<td>Entity revision</td>
<td>1</td>
</tr>
</tbody>
</table>

#### Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age range</td>
<td>Age &gt;= 0 years and &lt; 19 years</td>
</tr>
<tr>
<td>Available for historic use</td>
<td>false</td>
</tr>
<tr>
<td>Definition</td>
<td>A child/person between birth and 19 years of age</td>
</tr>
<tr>
<td>Legacy LSID</td>
<td></td>
</tr>
<tr>
<td>Precoordinated</td>
<td>true</td>
</tr>
<tr>
<td>Primitive</td>
<td>false</td>
</tr>
<tr>
<td>Semantic group</td>
<td>Age Group</td>
</tr>
</tbody>
</table>
Asset Types (properties)

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

- **Create Revision**
- **To Retired**
- **Change Curator**
- **Validate**
- **Clone**
- **Refresh**
- **Show Graph**
- **Contact Curator**

**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)
- Can also display available semantic associations
Care reminder to provider

Resource Name:
Description of LMR Reminder # 144 - Needs Pneumococcal (high risk medical condition)


Revision Number: 1

Approving Body:
PHS Ambulatory CIT

Developer of Intervention:
PHS KM

First Created: 2007-04-05
Last Revised: 2007-05-09
Last Appraised: 2007-05-09

Reference Citation:


Funding Source:
Partners Healthcare System, Inc. (PHS)
Scenario 3: structural integrity

- Updates to important **building blocks** not well documented or communicated – e.g. dictionaries, classification sets, data elements, triggering conditions, etc.
  - Updates are frequently **not** traceable (*no change history*)

- Updates do **not** always trigger **revisions** of dependent items until attempts are made to move assets to a testing environment or production use (*broken dependencies*)

- Relevant dictionaries systematically uploaded to CKMS
  - Generate automated change **notifications**
  - Detect **broken dependencies** before assets are moved to production
Dictionary update $\rightarrow$ CDS rule errors

Prompt provider to add hyperlipidemia to problem list if patient meets criteria

Change to ICD-10-CM code mapped to problem list term(s) caused CDS rule to fire incorrectly (false positives)

Incident confirmed the need to remediate CDS rules with direct dependencies on problem list terms

Incident also confirmed the need to refactor similar CDS rules to avoid direct dependencies on terms
Scenario 4: semantic validation

- Opportunity to proactively evaluate when a source should be updated and if remediation or exceptions are needed
- Validate **semantic** dependencies
  - Example: notify the knowledge engineer if a value threshold is not compatible with laboratory test being referenced (e.g. *if caffeine > 30 mg/mL then ...*),
  - query reference ontology to confirm analyte (*caffeine - serum*),
  - value range (*8 to 20*), but different unit of measure (*mcg/mL*)
CKMS Integration with eCare

• CKMS has been successfully integrated with Epic
  – Semi-automated ETL process enables import of Epic master files
  – Automated process is under development

• Proactive management and tracking of assets created/curated outside CKMS
  – Visualization via domain specific presentation templates
  – Robust metadata related to changes between asset revisions
  – Identifying and anticipating broken dependencies
  – Validation of expected changes when reference sources are updated
CONCLUSIONS
CKM Program: core activities

• Establish **governance** for essential asset types
• Define and optimize curation **processes** (*lifecycle*)
• Implement software **platform** integrated with knowledge **sources** and **consumers**
• **Monitor & evaluate** processes and interventions
• Seek alignment with **standards**, maximizing interoperability and external collaborations
• **Collaborate** with other institutions to help amortize operational **costs** and promote **innovation**
• 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*)
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
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
  – Enable collaboration among institutions

• Overcome (mitigate) knowledge engineering and implementation challenges
Useful References

• 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 available upon request
Acknowledgements

Saverio Maviglia
Charles Lagor
Eileen Yoshida
Priyaranjan (Raj) Tokachichu
Christopher Vitale
Margarita Sordo

Other members of the Clinical Informatics Team at Partners

Blackford Middleton
Tonya Hongsermeier
Beatriz Rocha
Thank you!

Roberto A. Rocha, MD, PhD
rarocha@bwh.harvard.edu
http://scholar.harvard.edu/rarocha

This work by Roberto A. Rocha is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License