Evolution of the Knowledge Management Program at Partners HealthCare (PHS)

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Learning Health System (LHS) Seminar
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Overview

• History
  – Goals, types of assets, initial challenges, tactics

• Current state
  – Program, principles, types of assets
  – New challenges, revised tactics

• Implementation framework
  – Levels of support, areas of focus

• Future directions

• Conclusions
HISTORY
Knowledge Management

• Established in **2003** as a formal function within the Clinical Informatics R&D group – clinical team within Information Systems

• Responsibility for designing, developing, and supporting **processes, tools, and assets** – e.g. governance, lifecycle, authoring, deployment

• **Enterprise** content areas – e.g. terminologies, catalogues, rules, reference sources, etc.
Original Strategic Goals

- Reduce the **cost** and increase the **speed** of knowledge acquisition and maintenance for decision support
- Speed **translation** of clinical innovation and evidence into clinical practice
- **Proactive, anticipatory** decision support architecture to set foundation for personalized medicine – avoid “interruptive” decision support
- Improve Partners’ **organizational effectiveness** as a learning organization through organizational alignment and data-driven performance improvement
- **Align** knowledge assets with business, regulatory, safety and quality requirements
- Only **build** what we cannot **buy**
- Partners has created some of the best decision support in production in the world, the goal here is to keep the knowledge **up to date**
Content Examples at PHS

- **Medication** Data Dictionary with default doses, **weight-based** doses, dose strings, and **drug-drug** interaction checking – multiple applications and populations via Common Medication Services
- Gerios and Nephros for proactive dosing for *elderly* and/or *renal insufficient*
- **Drug-lab** monitoring, **duplicate drug** checking, **drug-group** checking, **drug-disease** checking, **drug-pregnancy** checking
- Primary and secondary preventive health **reminders**
- Results Manager (**abnormal test results**)  

- Inpatient and outpatient **order sets**
- Inpatient **interactive rules** (application specific, hard-coded)
- Concept **dictionary** and problem list
- Patient **monographs**
- **Radiology ordering** decision support
- Outpatient **documentation templates**

*Slide created by Tonya Hongsermeier, MD, MBA (Mar 2006)*
Content Life-Cycle Challenges

- Prioritization mechanism not always clear
- Stewardship processes not always clear
- Lack of coordination

- Unclear mechanism for subject matter expert participation...
  Who says so? Friend of Researcher?
- No budgetary model to reimburse experts...
- No tools to support efficient collaboration – 3000 row tables
- Little or no audit trail of decisions made

- Project competition with other engineering projects, prioritization processes unclear
- Knowledge editors typically do not enable content auditing, knowledge editors siloized, no support of inheritance or propagation
- Little or no documentation about content in production
- MS Office doesn’t help maintain data about content

- Little analytic data available on decision support content or impact on clinical outcomes impact to direct updating
- Tendency to rely on query of transaction systems
- No content management tools to support process and ensure timeliness
Deployed Tactics (2008)

- **Transparency and Governance** (2004)
  - Document library portal of decision support knowledge specifications in production
    - 600 documents representing 10s of 1000s of rules
  - New governance and subject matter expert panels

- **Collaboration and Content Life-cycle Tools** (2005)
  - Collaboration Portals aligned with governance and business goals of Partners
    - 60 spaces to date, Documentum’s eRoom
  - Content Management infrastructure for sharing, versioning, auditing, scheduling, tracking
    - Documentum’s Content Management Services

- **Content Editing Re-architecture** (2006)
  - Once decision is made for knowledge to change, change will be implemented rapidly at all touch-points
  - Primary focus of KM development going forward
KM software tools

10-15 loosely connected tools used just to maintain Meds
CURRENT STATE
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

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
## 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</td>
<td>Template</td>
<td>Local</td>
<td>Vendor</td>
</tr>
<tr>
<td></td>
<td>11,800 data elements</td>
<td></td>
<td></td>
<td></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).

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CKM Lifecycle @ PHS

Request (new or update)

Evaluate

Authorize & Prioritize

Monitor

Design

Test & Deploy

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.

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**BY THE NUMBERS**

<table>
<thead>
<tr>
<th>Count</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>70,000+</td>
<td>Clinicians and Staff</td>
</tr>
<tr>
<td>Over 3,000</td>
<td>Experts</td>
</tr>
<tr>
<td>3.3 Million</td>
<td>Active Patients</td>
</tr>
</tbody>
</table>

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**By the Numbers Details**

- **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.
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)
  - Replace isolated tools with integrated infrastructure
  - Expose assets and processes to users and stakeholders
  - Expand monitoring process (KM lifecycle & CDS evaluation)
- Engage and collaborate with other organizations
# CDS Monitoring Portal

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 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>Alerteed 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 “How did the alert intensity change for a given BPA over time based on alerted patients?”</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 “How did the alert intensity change for a given BPA over time based on alerted physicians?”</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 “How did users interact with the shown BPA?”</td>
</tr>
</tbody>
</table>
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 software platform (CKMS)

- **Integration**
  - Complete lifecycle: authoring, collaboration, and publication
  - (Replace and consolidate legacy editors and repositories)

- **Extensibility**
  - Core set of knowledge types and lifecycles with rich metadata
  - Configurable extensions to support local and reference assets

- **Integrity**
  - Versioning and dependency management across knowledge types
  - Configurable validation patterns and rules (global or type-specific)

- **Interoperability**
  - Extensive set of web services
  - Import & Export assets and type definitions (simple XML format)

- **Semantic “intelligence”**
  - Decision support for knowledge curators
  - Prevent errors and suggest options: sustainable long-term maintenance
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.)
IMPLEMENTATION FRAMEWORK
Levels of support

• Reactive Support
  – Troubleshooting and maintenance of existing assets
  – Preservation of original scope: quantity and coverage

• Periodic Improvement
  – Sporadic improvements beyond identified problems
  – Limited expansion of original scope

• Continuous Improvement
  – Anticipatory identification of problems and needs
  – Expanded (dynamic) scope, including new data types
  – Scalable and cost-effective processes and interventions
Why Continuous Improvement?

- 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.
Complexity challenge

Interdependencies vs. Number of Assets

Assuming that a given asset is typically connected to 3 other assets
CDS framework

- **Clinical Decision Support (CDS)**
  - **Activities**: analysis, design, specification, build, testing, monitoring, and troubleshooting; evaluate and report the effectiveness of interventions; integration with user workflows and reporting; dependencies management
  - **Assets**: alerts, reminders, med warnings, duplication warnings, therapeutic alternatives, infobuttons, order sets, smart lists, etc. – multiple applications
  - Support enterprise, site-specific, and research/innovation efforts

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**Reactive Support**
- Alerts, reminders, and Infobuttons
- +800 interventions for Enterprise needs

**Periodic Improvement**
- Alerts, reminders, Infobuttons, **warnings**
- +1,200 interventions for Enterprise and Site-specific needs

**Continuous improvement**
- **All CDS**, including patients and devices
- +2,000 interventions for Enterprise, Site-specific, **Research & Innovation** needs
Why Clinical Decision Support?

• Opportunity
  – Complete CDS interventions – advanced protocols, risk stratification, management of comorbid conditions
  – Extend to patients and allied healthcare professionals
  – Devices, genomic, patient generated data, preferences
  – Performance data to continuously improve interventions

• Challenges
  – Numerous interventions – some stakeholders not represented
  – Optimal implementation – limited EHR features, maintenance
  – Poor design rejected by users – negative perception about EHR reliability and utility
  – Interdependencies – isolated tools, resource intensive process, fragmentation, inconsistencies
Data Definitions framework

- **Data Definitions**
  - **Activities**: selection, analysis, mapping; management of local extensions; definition of reference models for high priority clinical topics; integration with user workflows, CDS, and reporting; dependencies management
  - **Assets**: data elements, local extensions, and standard reference models
  - Support enterprise, site-specific, and research/innovation efforts

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Reactive Support

- Data definitions, local extensions, and reference models
- +20 clinical topics for Enterprise needs

Periodic Improvement

- Data definitions, local extensions, and reference models
- +40 clinical topics for Enterprise and Site-specific needs

Continuous improvement

- Data definitions, local extensions, and reference models
- +100 clinical topics for Enterprise, Site-specific, Research & Innovation needs
Why Data Definitions?

• Opportunity
  – Data defined with standard reference models – consistency, completeness, and interoperability
  – Sustainable process – new domains, single electronic record for all settings and disciplines

• Challenges
  – Data definitions not shared across EHR modules or settings – similar data stored and encoded differently
  – Large libraries of definitions – promote inconsistency, distinctions not documented, overlapping domains/topics
  – Manual verification – constantly evolving data collection tools (e.g. forms, flowsheets, templates, macros, etc.)
  – Poor data quality – affecting CDS, reports, registries, etc.
Additional frameworks

- Data classification
- Terminologies (dictionaries)
- Software infrastructure
- Process analytics
FUTURE DIRECTIONS
KM opportunities (1/2)

• **Individualized** interventions
  – Integration and effective use of "new" data sources
  – e.g. devices, genomic, patient entered, preferences

• Minimize **fatigue** and maximize **utility**
  – Detailed representation of context and state
  – e.g. intervention targeting and continuous learning

• Prevent **malfunctions**
  – Decision support to assist knowledge engineers
  – e.g. automate configuration, customize validation rules
KM opportunities (2/2)

• Proactive **maintenance**
  – Automated detection of malfunctions
    – e.g. continuously monitor active interventions, detection algorithms

• **Localized** knowledge **translations**
  – Automated detection of new evidence (from data)
    – e.g. evidence augmented by patterns of use, concurrent interventions with prospective evaluations

• **Mitigate** **complexity**
  – Adopt new decision support methods and tools
    – e.g. combine inference methods, “dynamic” knowledge assets
CONCLUSIONS
Challenges – implementation

- **Data** availability and quality
  - e.g. data not coded, coded inconsistently, not enough detail (codes)
- **Rudimentary tools** (editing, versioning, linking)
  - e.g. incorrect logic, missing values, related elements, automated validation; content management tools are not a solution
- **Labor intensive testing**
  - e.g. positive and negative tests, regression testing, automated testing; creation and maintenance of useful test data/patients
- **Proliferation of CDS vendors**
  - e.g. single vendor will not fulfill all your needs, overlapping interventions (reconciliation) not identified as a significant problem
- **Internal (EHR) versus external service**
  - e.g. immature standards, complex configuration, peculiar features
Challenges – large scale

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

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