Overview of Clinical Decision Support and Knowledge Management

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Overview

• Background
  – Clinical Decision Support (CDS) modalities
  – Examples from Partners HealthCare

• Knowledge Management (KM)
  – KM program, challenges, opportunities
  – Assets and tools used at Partners HealthCare

• Conclusions
  – Successful program, care workflow, sharing
Modalities of CDS

- Reference knowledge **selection** and **retrieval**
  - e.g., infobuttons, crawlers (indexing)
- Information **aggregation** and **presentation**
  - e.g., summaries, reports, dashboards
- Data **entry assistance**
  - e.g., forcing functions, calculations, evidence-based templates for ordering and documentation
- **Event monitors**
  - e.g., alerts, reminders, alarms
- Care **workflow assistance**
  - e.g., protocols, care pathways, practice guidelines
- **Descriptive** or **predictive** analytics
  - e.g., diagnosis, prognosis, treatment planning, treatment outcomes
CDS: infobuttons

Information about "Depression"
CDS: alerts for medication ordering

Drug - Allergy Intervention

Alert Message
The patient has a probable allergy: AMOXICILLIN. Reaction(s): Hives, itching.

Reasons for override:
- Patient does not have this allergy, will D/C pre-existing allergy
- Patient has taken previously without allergic reaction
- Low risk cross sensivity, will monitor
- No reasonable alternatives

Drug - Drug Interaction

Alert Message
Patient is currently on: Methotrexate (ORAL) 5 MG (2.5 MG TABLET Take 2) PO QWEEK
Patient is on Methotrexate and Penicillin G Benzathine - May result in methotrexate toxicity - Recommend to avoid concurrent use.

Reasons for override:
- Will D/C pre-existing drug
- Will adjust dose as recommended
- Will monitor as recommended
- Patient has already tolerated combination
- No reasonable alternatives
- Other
CDS: interruptive alert with action

Clinician **must** cancel current order or discontinue pre-existing order.
CDS: geriatric medication dosing

Geriatric Dosing - appropriate doses and frequencies for geriatric population: doses - 0.5 TAB, 1 TAB; frequencies - Q6H, 1 Tablet + 5mg Hydrocodone & 500mg Acetaminophen. Do not exceed 6 tablets/day (Jgm of Acetaminophen). For constipation, often worsened by an opioid, add a stool softener and a stimulant.
CDS: preventive care reminders

**Reminders**

- No known documented smoking status. Click to enter status.
- Patient due for repeat pneumococcal.
- Recommend bone densitometry and appropriate treatment for patients at high risk for osteoporosis.
- Patient has CAD-equivalent on problem list and aspirin is not on the med list. Recommend aspirin.
- Patient with DM overdue for urine microalbumin/creatinine ratio (rec: q1 year).
- Patient with DM overdue for HbA1C (rec: q4 months).
- Patient with DM overdue for ophthalmology exam (rec: q1 year).
- Patient has CHD-equivalent, overdue for lipid assessment (rec: q1 year).

**Problems**

- Diabetes mellitus
- Coronary artherosclerosis

**Health Maintenance**

<table>
<thead>
<tr>
<th>Problem</th>
<th>Date of Last</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diabetes</td>
<td>03/24/2008</td>
</tr>
<tr>
<td>Coronary Artherosclerosis</td>
<td></td>
</tr>
</tbody>
</table>

**Flowsheets**

<table>
<thead>
<tr>
<th>Item Name</th>
<th>Date of Last</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood Pressure</td>
<td>04/25/2008</td>
</tr>
<tr>
<td>Temperature</td>
<td>04/25/2008</td>
</tr>
<tr>
<td>Pulse</td>
<td>04/25/2008</td>
</tr>
<tr>
<td>Respiration Rate</td>
<td>04/25/2008</td>
</tr>
<tr>
<td>CO2 Sat</td>
<td>04/25/2008</td>
</tr>
<tr>
<td>Height</td>
<td>04/25/2008</td>
</tr>
<tr>
<td>Weight</td>
<td>04/25/2008</td>
</tr>
<tr>
<td>BMI</td>
<td>04/25/2008</td>
</tr>
<tr>
<td>Pain Level</td>
<td>04/25/2008</td>
</tr>
</tbody>
</table>

**Allergies**

- Add New

**Family History**

- Add New

**Last Known Values**

- Test Description | Last Known Date
|------------------|----------------|

**Advance Directives**

- Other

**Order Bone Density Scan**

- Done elsewhere
- Patient refuses bone density test
- Patient refuses medication
- Patient does not tolerate meds
- Bone Density scheduled today
- Medication started today
- Provider deferred

**Clinical Informatics**
CDS key challenges

• Reliable change management
  – Revisions with preservation of dependencies
  – Efficient propagation of changes
  – Preservation of meaning (intent)

• High scalability
  – Ability to handle multiple clinical conditions with reasonable development and maintenance costs
  – Adoption of distributed and collaborative curation framework (easy to create and deploy)
  – Maximize reusability and maintainability
KNOWLEDGE MANAGEMENT (KM)
KM 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

# 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>

- **Reference**
  - Complexity
  - Cost
- **Actionable**
  - Availability
  - Maintainability
- **Executable**

*Clinical Informatics*
Scope (assets) @ Partners

- **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

*Clinical Informatics*
### 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).

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

Basic KM scenario: 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
CONCLUSIONS
CDS: Care workflow assistance

(Registration)  

(Triage)  
knowledge retrieval, data entry assistance, event monitors

(Clinician preference)  
Pneumonia protocol

(Initial Assessment)  
data entry assistance, knowledge retrieval, order entry assistance, event monitors

(Protocol eligibility)  
Protocol stratification

(Complete Assessment)  
information presentation, data entry assistance, knowledge retrieval, event monitors

(Patient preferences)  
2nd Episode

(Analysis & Plan)  
knowledge retrieval, order entry assistance, information aggregation, data entry assistance, event monitors

(Appropriate Abx)  
Co-morbidities

Clinical Informatics
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 is vital
CDS overview

- CDS known to improve care
  - Better with more complex CDS
  - But has to follow the patient

- US EHR 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
Successful KM 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
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