Clinical knowledge management at scale: fulfilling the promise of pervasive computerized clinical decision support for providers and consumers

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Objectives

1. Computerized Clinical Decision Support
   - Modalities of clinical decision support
   - Motivating factors and application results
2. Clinical Knowledge Management System
   - Typical knowledge engineering processes
   - System components and requirements
3. Challenges and opportunities
   - Implementation promises and pitfalls
   - Intra-institutional and inter-institutional

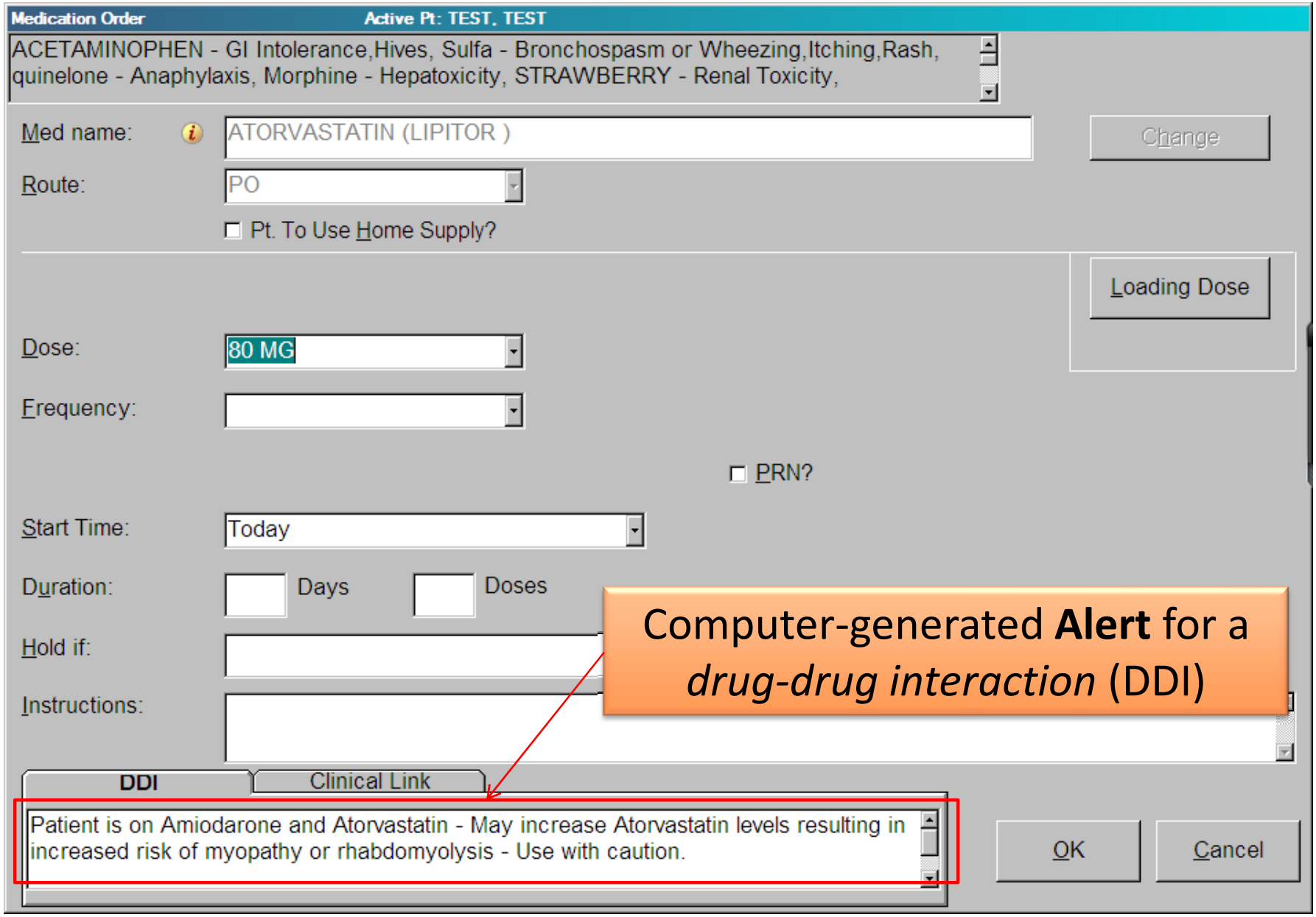
MITsdm system design and management

Computerized Clinical Decision Support

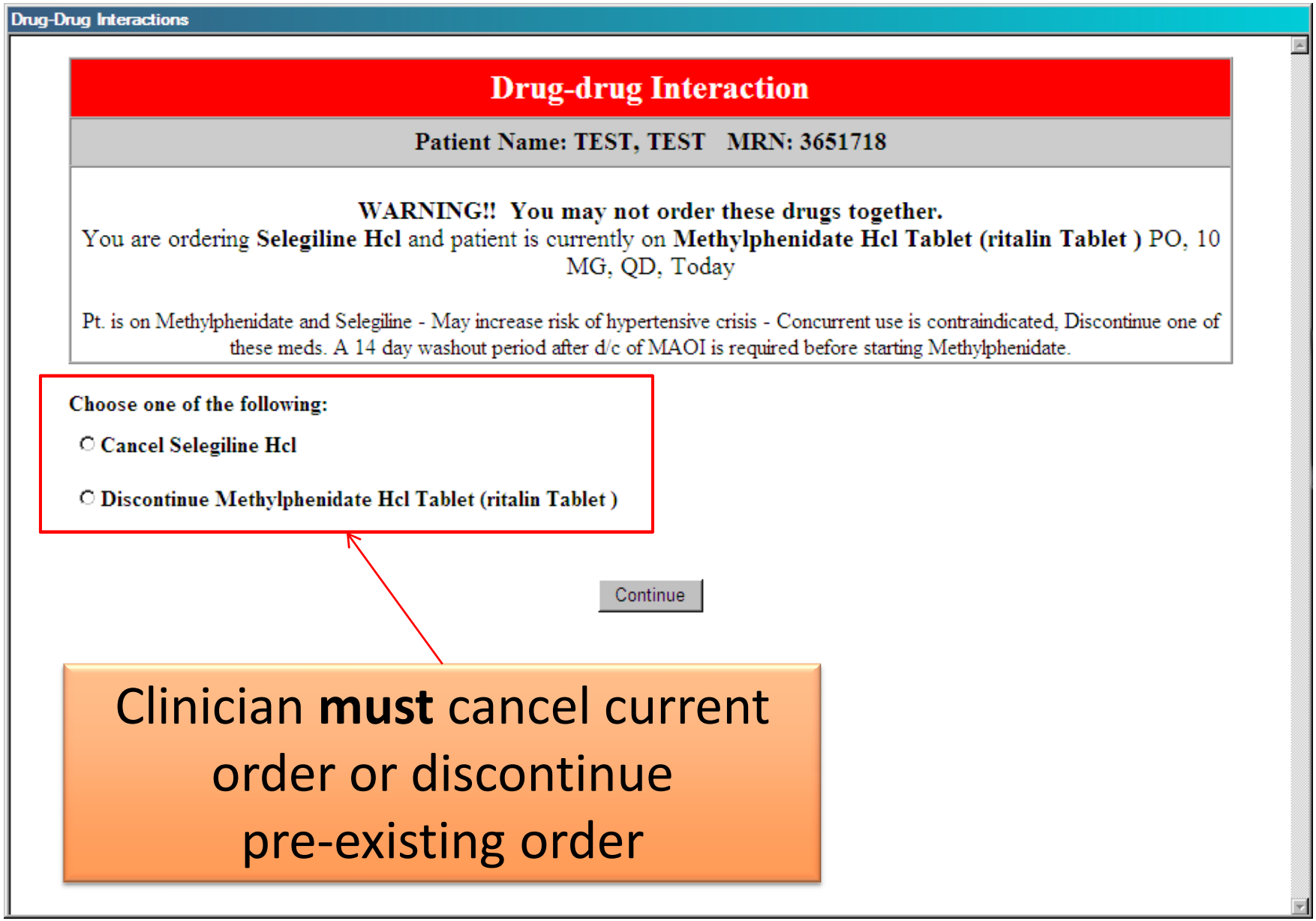
BRIGHAM AND WOMEN'S HOSPITAL HARVARD MEDICAL SCHOOL

PARTNERS HEALTHCARE CIRD Clinical Informatics Research & Development

Medication order CDS – example 1

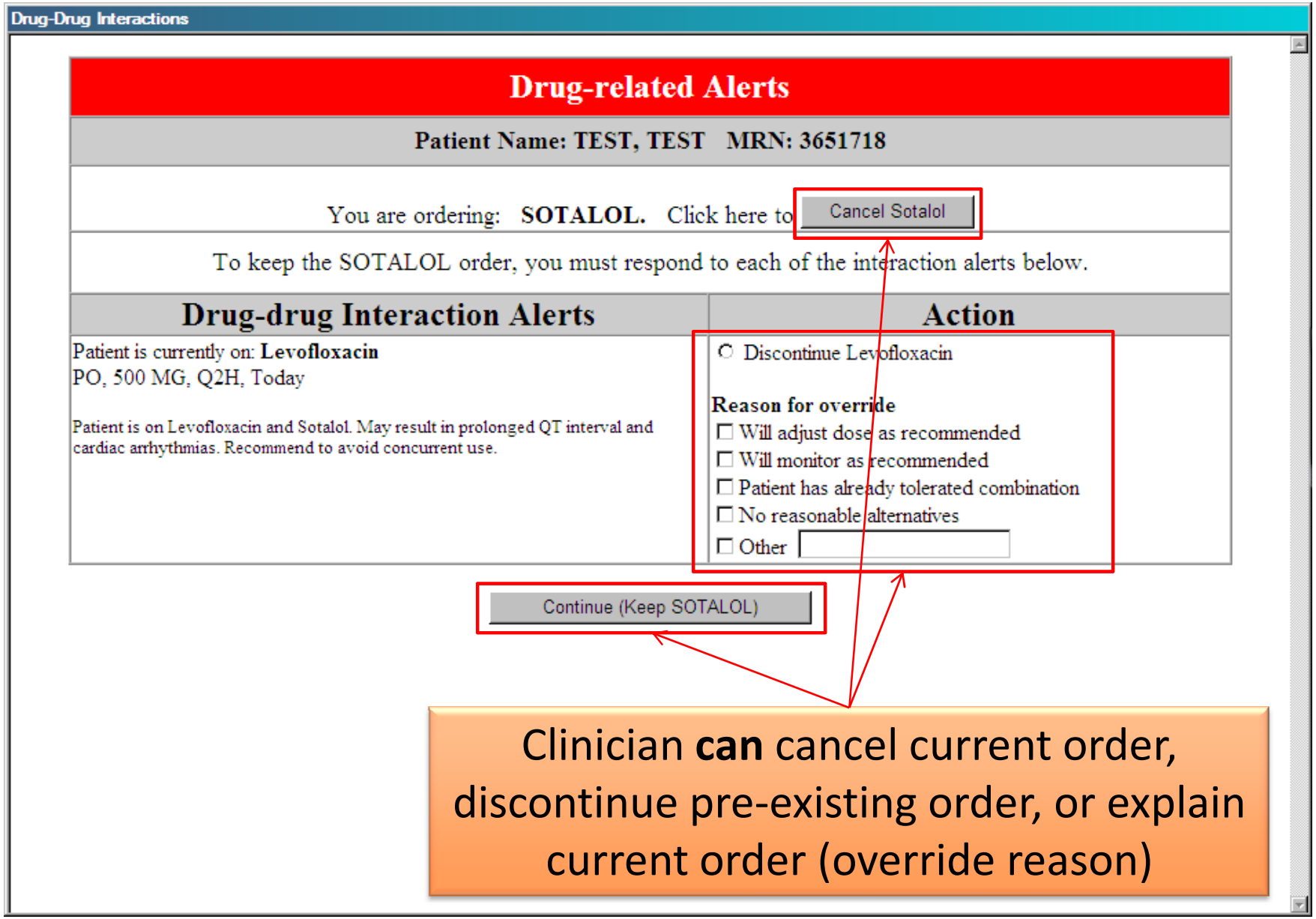


Interruptive Alert (force an action)

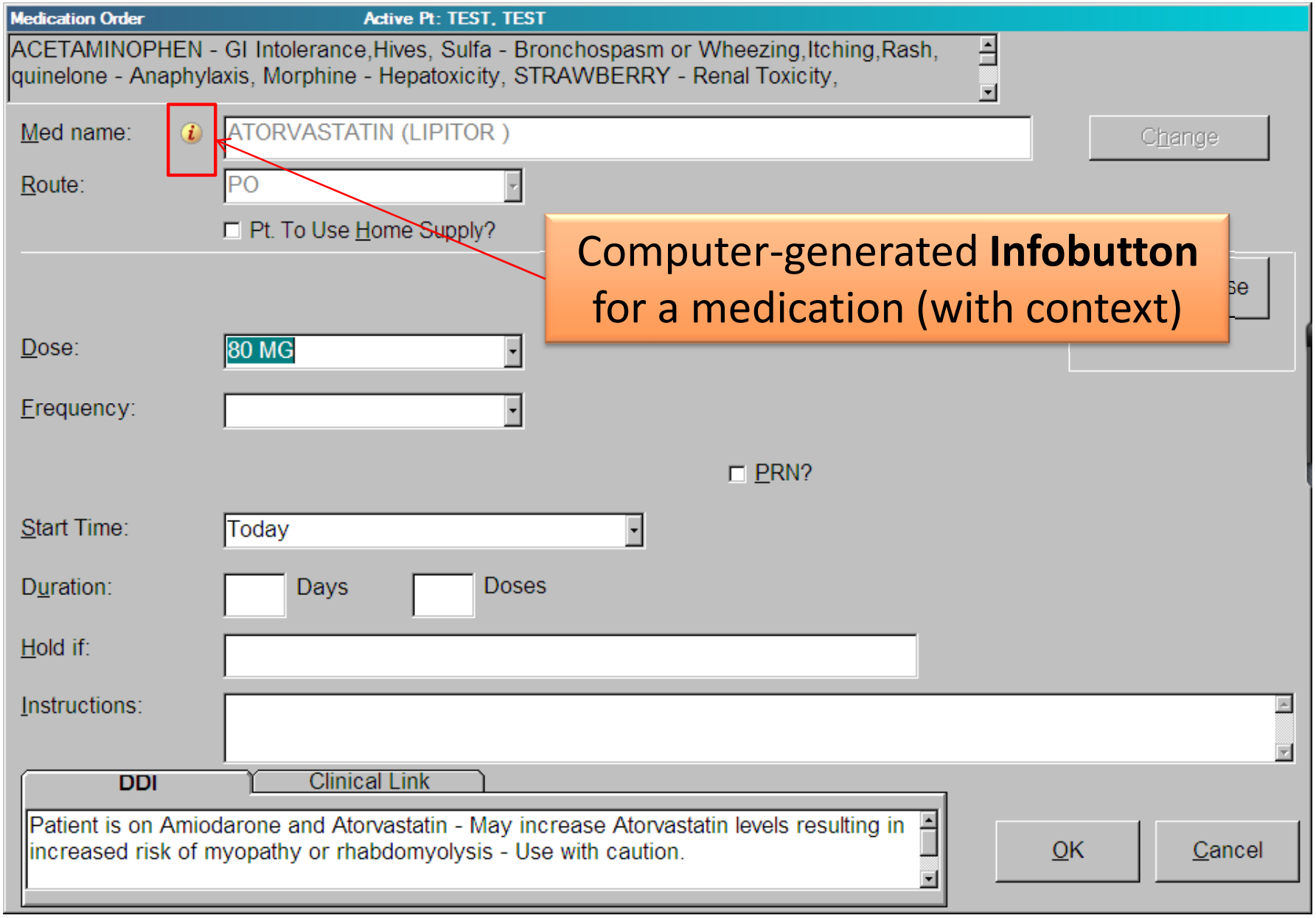


Clinician **must** cancel current order or discontinue pre-existing order

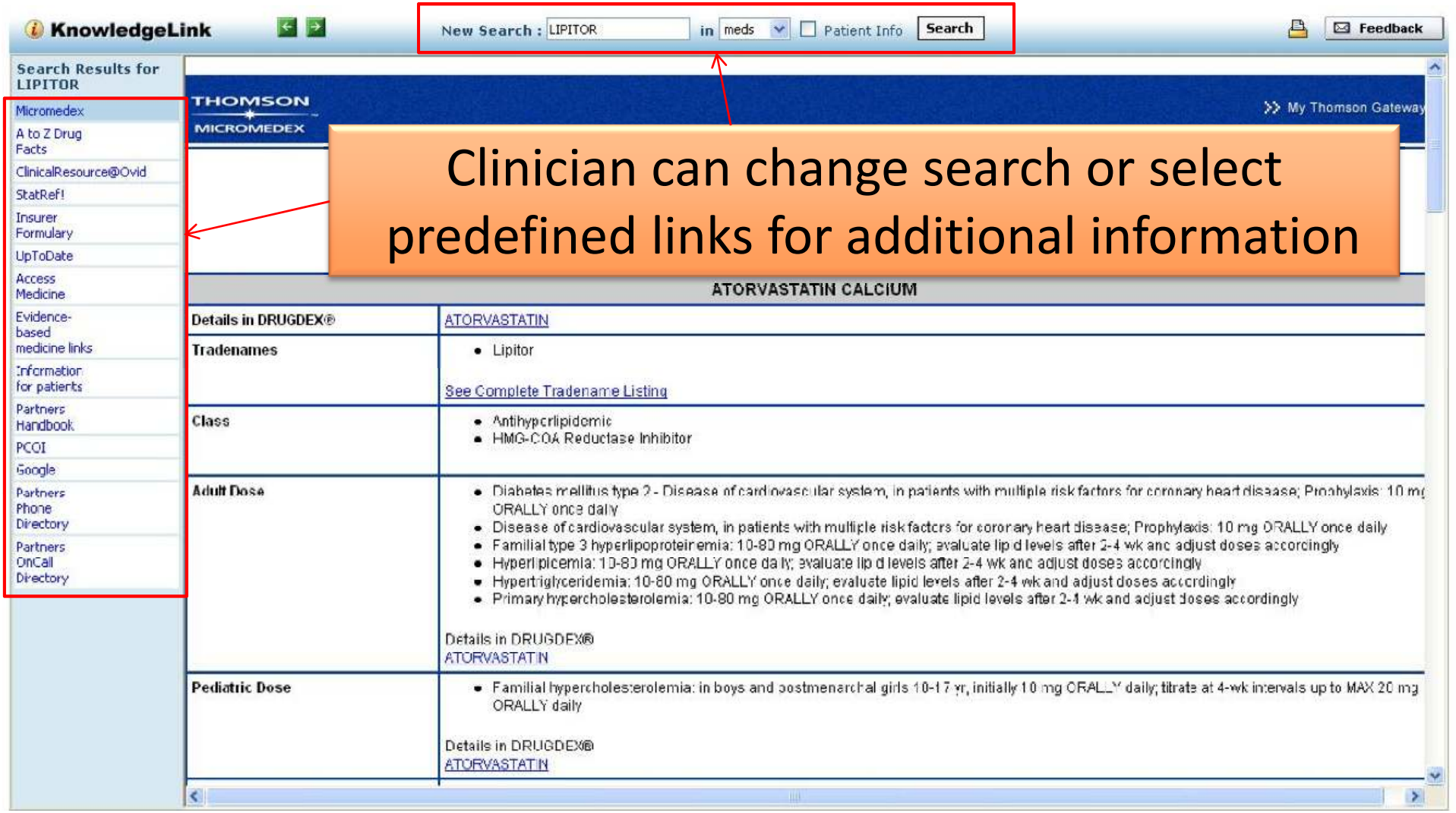
Interruptive Alert (suggest actions)



Medication order CDS – example 2



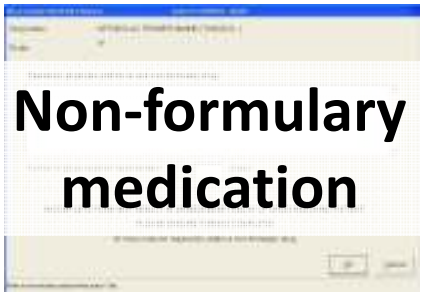
Context-enabled *"Infobuttons"*

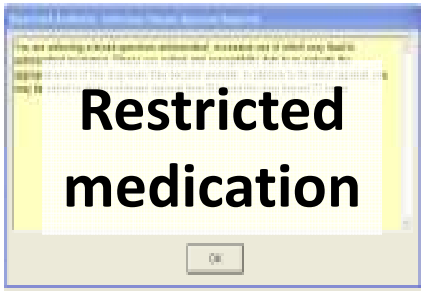


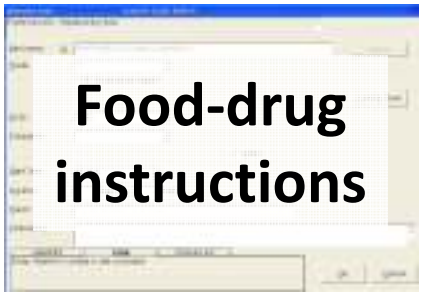
Modalities of CDS

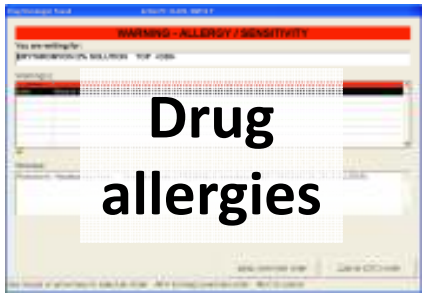
1. **Reference knowledge selection and retrieval**
   - e.g., **infobuttons**, crawlers (indexing)
2. **Information aggregation and presentation**
   - e.g., summaries, reports, dashboards
3. **Data entry assistance**
   - e.g., forcing functions, calculations, evidence-based templates for ordering and 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

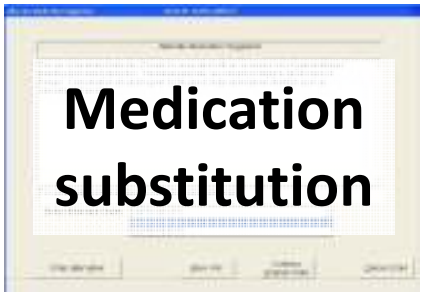
Other CDS for medication ordering: workflow

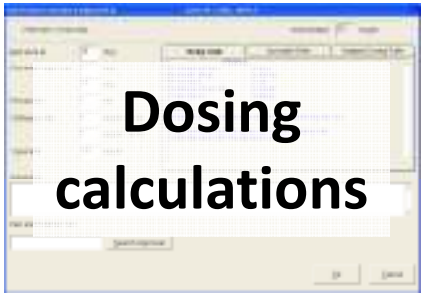


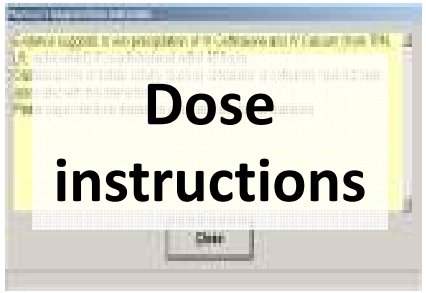












Evidence for CDS (knowledge-based)

- Systematic review of 70 studies (RCTs), up to 2003
  - Evaluating the ability of CDS to improve clinical practice
  - Focus on 15 CDS features (derived from literature)
- CDS improved practice in **68%** of trials
  - Key features (independent predictors)
    - CDS as part of clinician **workflow**
    - **Recommendations** rather than just assessments
    - CDS at the **time** and **location** of decision making
    - CDS **triggered** by computerized **data** analysis
- *(CDS without patient-specific guidance)*

Kawamoto K, Houlihan CA, Balas EA, Lobach DF. Improving clinical practice using clinical decision support systems: a systematic review of trials to identify features critical to success. *BMJ*. 2005;330(7494):765

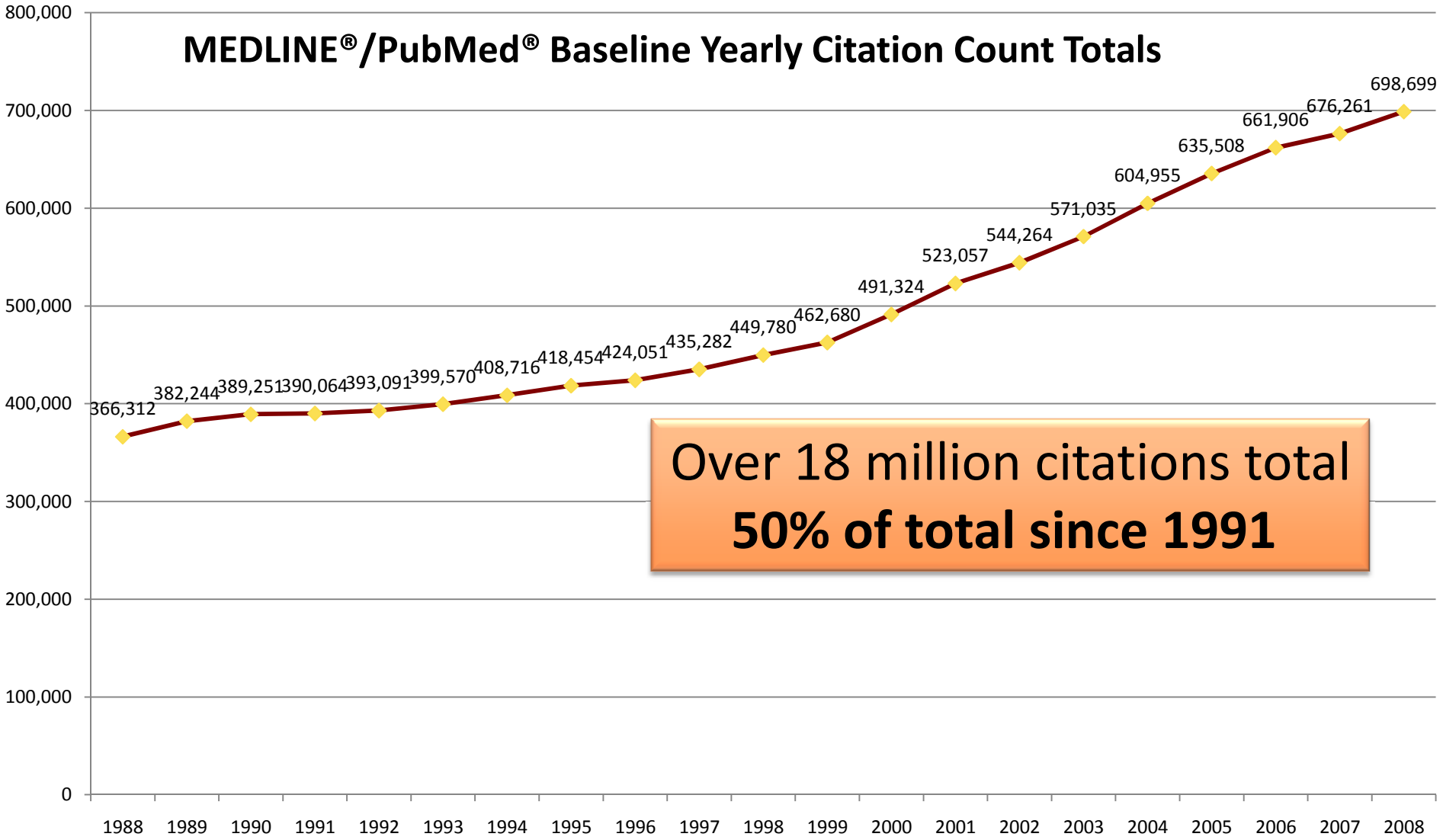
"Point-of-care" information needs

- Information needs
  - 47 physicians (self-reported)
    - 269 questions raised during 409 visits
      - » 2 questions for every 3 patients seen
    - Answers not pursued 70% of the time
- Frequent barriers
  - Pursued answers only 55%
    - Doubt that an answer existed – lack of usable information
  - Sources: colleague/peer (information consultation) and/or textbook (63%), electronic resource (16%)
    - Unable to find answer in 28%

Covell DG, Uman GC, Manning PR. Information needs in office practice: are they being met? *Ann Intern Med*. 1985 Oct;103(4):596-9.

Ely JW, Osheroff JA, Chambliss ML, Ebell MH, Rosenbaum ME. Answering physicians' clinical questions: obstacles and potential solutions. *J Am Med Inform Assoc*. 2005 Mar-Apr;12(2):217-24.

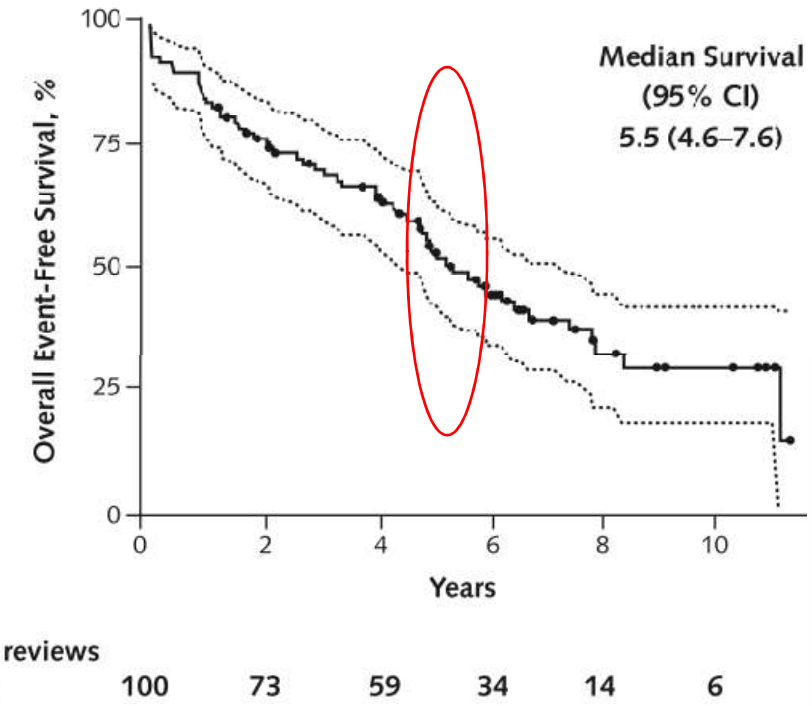
Scientific literature: knowledge explosion



Statistical Reports on MEDLINE®/PubMed® Baseline Data

"Survival" of clinically important evidence

Figure 2. **Overall survival time (95% CI) free of signals for updating.**



Shojania KG, Sampson M, Ansari MT, Ji J, Doucette S, Moher D. How quickly do systematic reviews go out of date? A survival analysis. *Ann Intern Med*. 2007 Aug 21;147(4):224-33.

Context

Clinicians rely on systematic reviews for current, evidence-based information.

Contribution

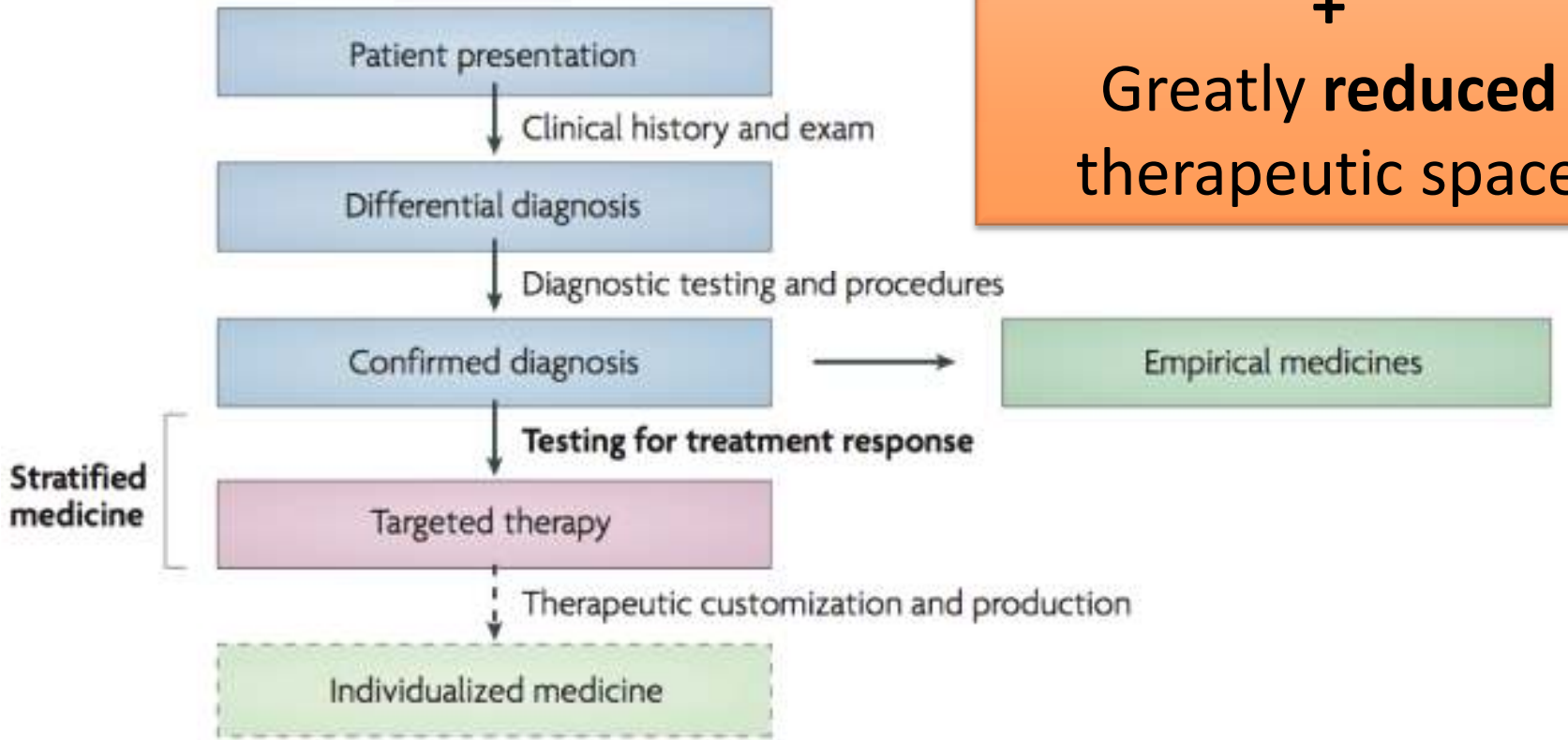
This survival analysis of 100 meta-analyses indexed in *ACP Journal Club* from 1995 to 2005 found that new evidence that substantively changed conclusions about the effectiveness or harms of therapies arose frequently and within relatively short time periods. The median survival time without substantive new evidence for the meta-analyses was 5.5 years. Significant new evidence was already available for 7% of the reviews at the time of publication and became available for 23% within 2 years.

Implication

Clinically important evidence that alters conclusions about the effectiveness and harms of treatments can accumulate rapidly.

Evolution towards "Stratified Medicine"

Greatly **expanded**
diagnostic space
+
Greatly **reduced**
therapeutic space



Trusheim MR, Berndt ER, Douglas FL. Stratified medicine: strategic and economic implications of combining drugs and clinical biomarkers. *Nat Rev Drug Discov*. 2007 Apr;6(4):287-93.

Routine testing for genetic differences

Government incentives for CDS

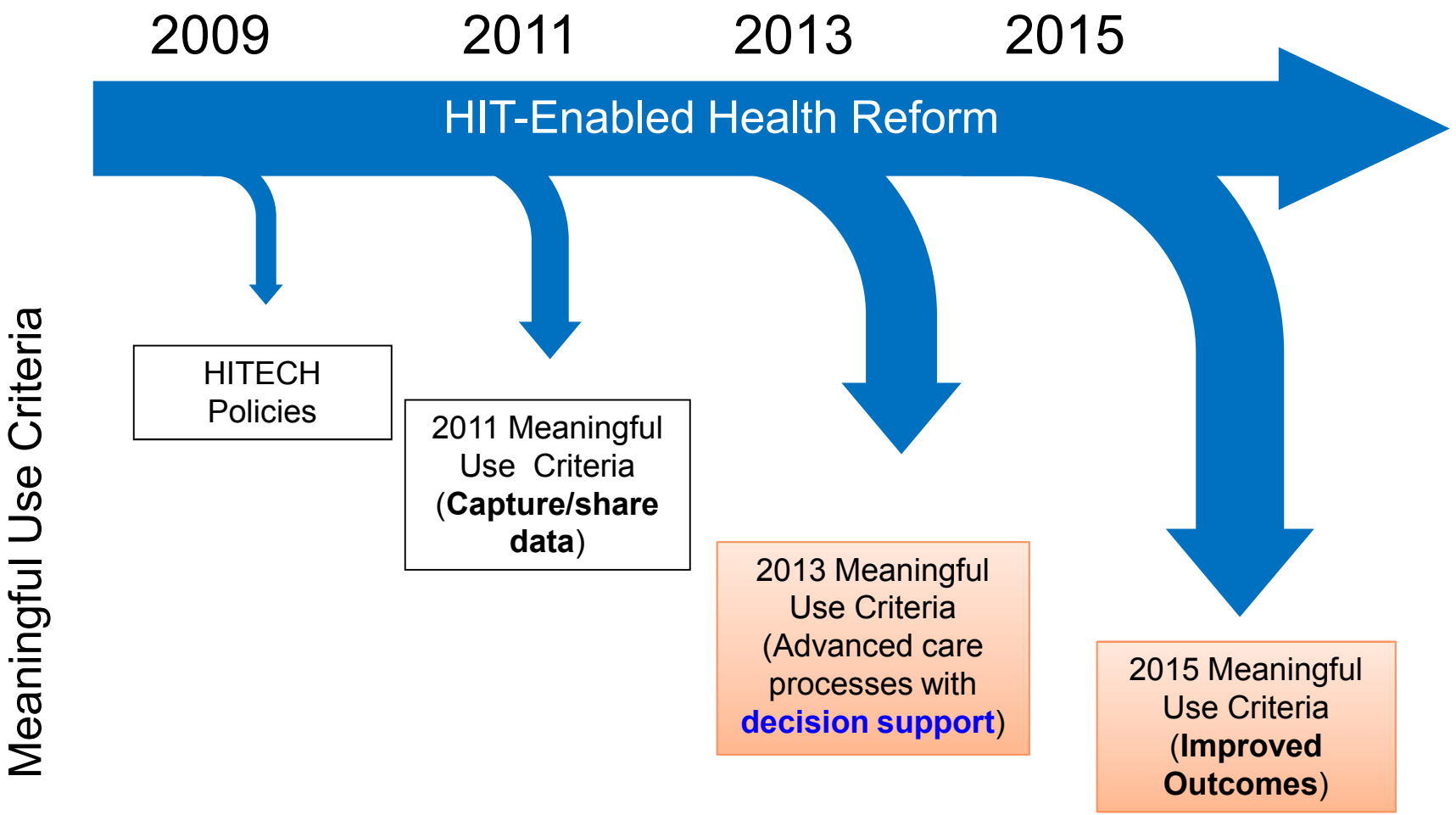
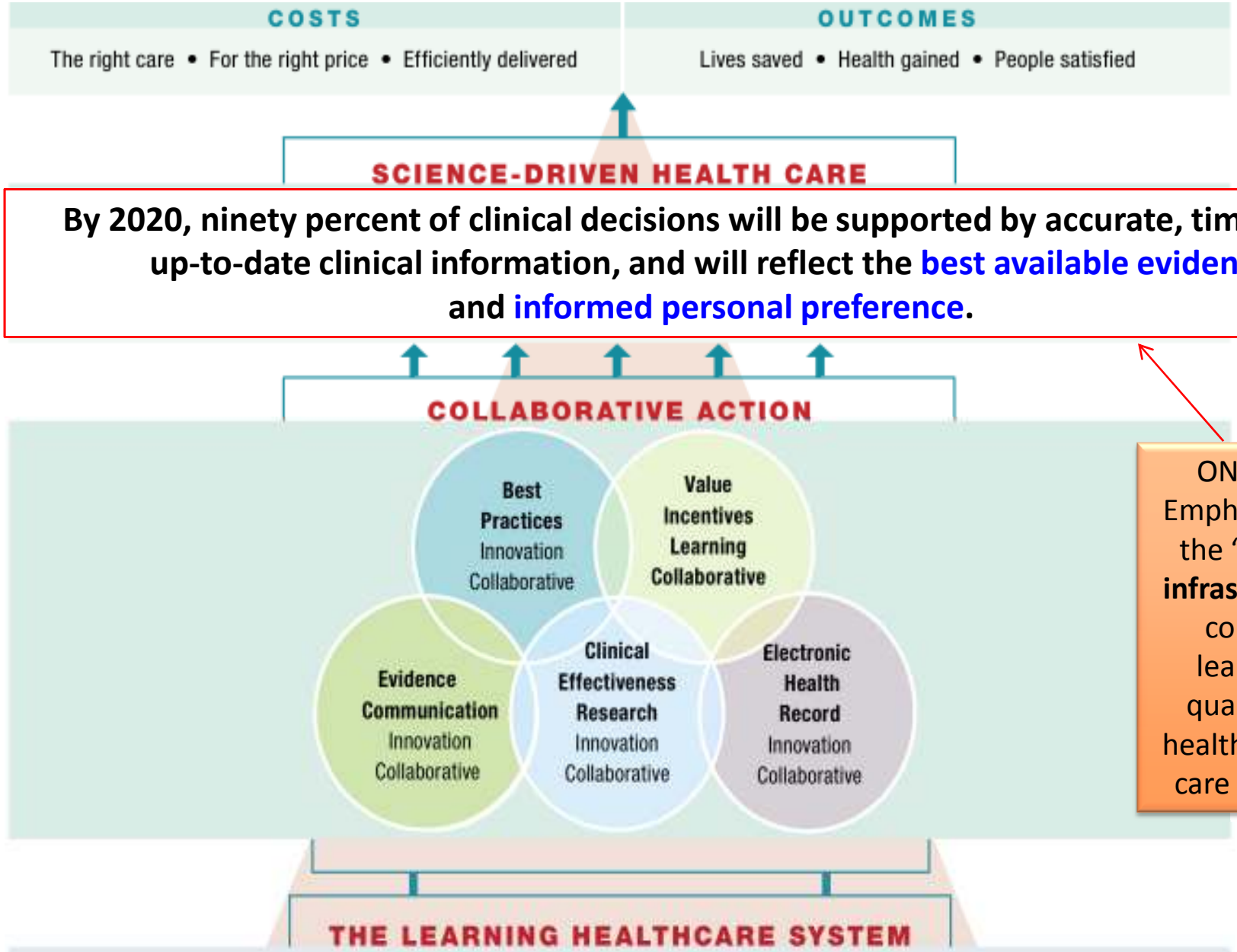


Diagram adapted from Tang & Mostashari (chairs) et al., Meaningful Use Workgroup Presentation. HIT Policy Committee, June 16, 2009.

Learning Healthcare System



ONC & IOM: Emphasis now on the "**Electronic infrastructure** for continuous learning and quality-driven health and health care programs."

MITsdm system design and management

Clinical Knowledge Management System

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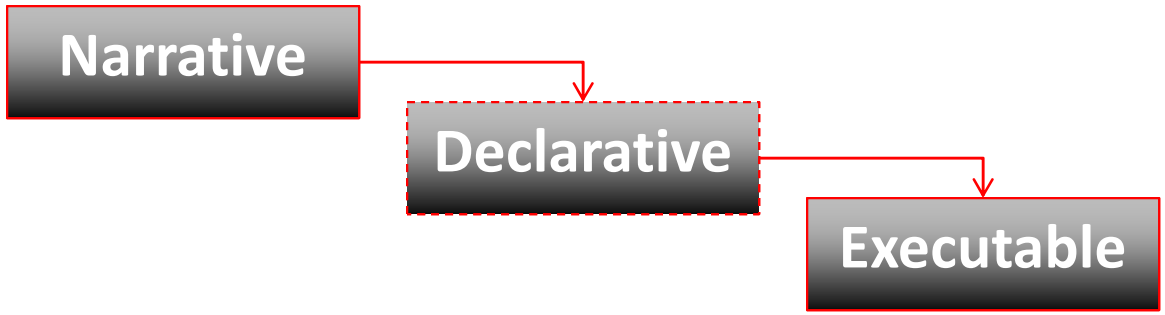
PARTNERS HEALTHCARE

CIRD Clinical Informatics Research & Development

Clinical Knowledge Management System

- **CKMS**: supports the implementation and management of computer-**accessible** and computer-**interpretable** clinical knowledge
  - Wide variety of knowledge assets
  - Overlapping knowledge asset lifecycles
  - Multiple deployment alternatives
    - ✓Clinical Decision Support (CDS) modalities
    - ✓Integrated with clinical care processes (“workflow”)



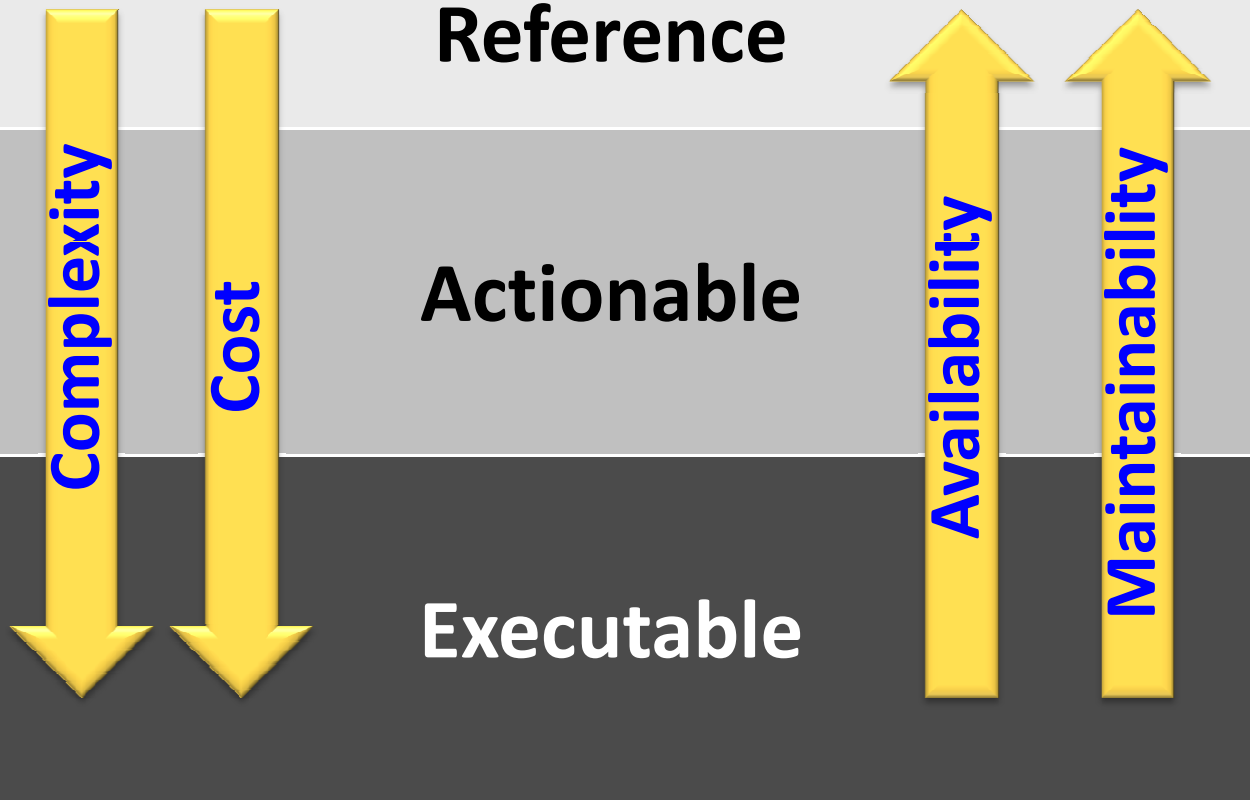
CDS implementation requirements

- ✓ Based on the **best evidence** available
- ✓ Covers problem in **detail** – problem solving, advice, explanations
- ✓ Readily **updatable** by clinician without unexpected effects
- ✓ Provides **links** to related local and Internet material
- ✓ System (knowledge) **performance** is validated against suitable gold standard
- ✓ Demonstrated practice or outcomes improvements in rigorous **study**
- ✓ **Clinician always in control**
  - Searching and browsing
  - Get help and explanations
  - Try out 'what-if' scenarios

Modified from Wyatt JC. Decision Support Systems. *J R Soc Med* 2000;93:629-633

Implementation of CDS modalities

CDS modality	Types of Knowledge Assets
1. Reference knowledge selection and retrieval	
2. Information aggregation and presentation	
3. Data entry assistance	
4. Event monitors	
5. Care workflow assistance	
6. Descriptive or predictive modeling	



Knowledge Lifecycle details

Medication rules and alerts

Generation

- New medications added to the enterprise dictionary (trigger)
- New requests from internal experts
- New information obtained from external reference sources

Acquisition

- Review of external reference sources (confirmation)
- Review of specialized literature (details)
- Validation with internal panel of experts (type of CDS alert)

Representation

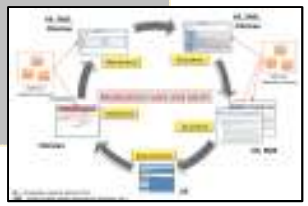
- Creation of new rules and alerts: specialized editor (software)
- Validation of new rules and alerts using test data

Deployment

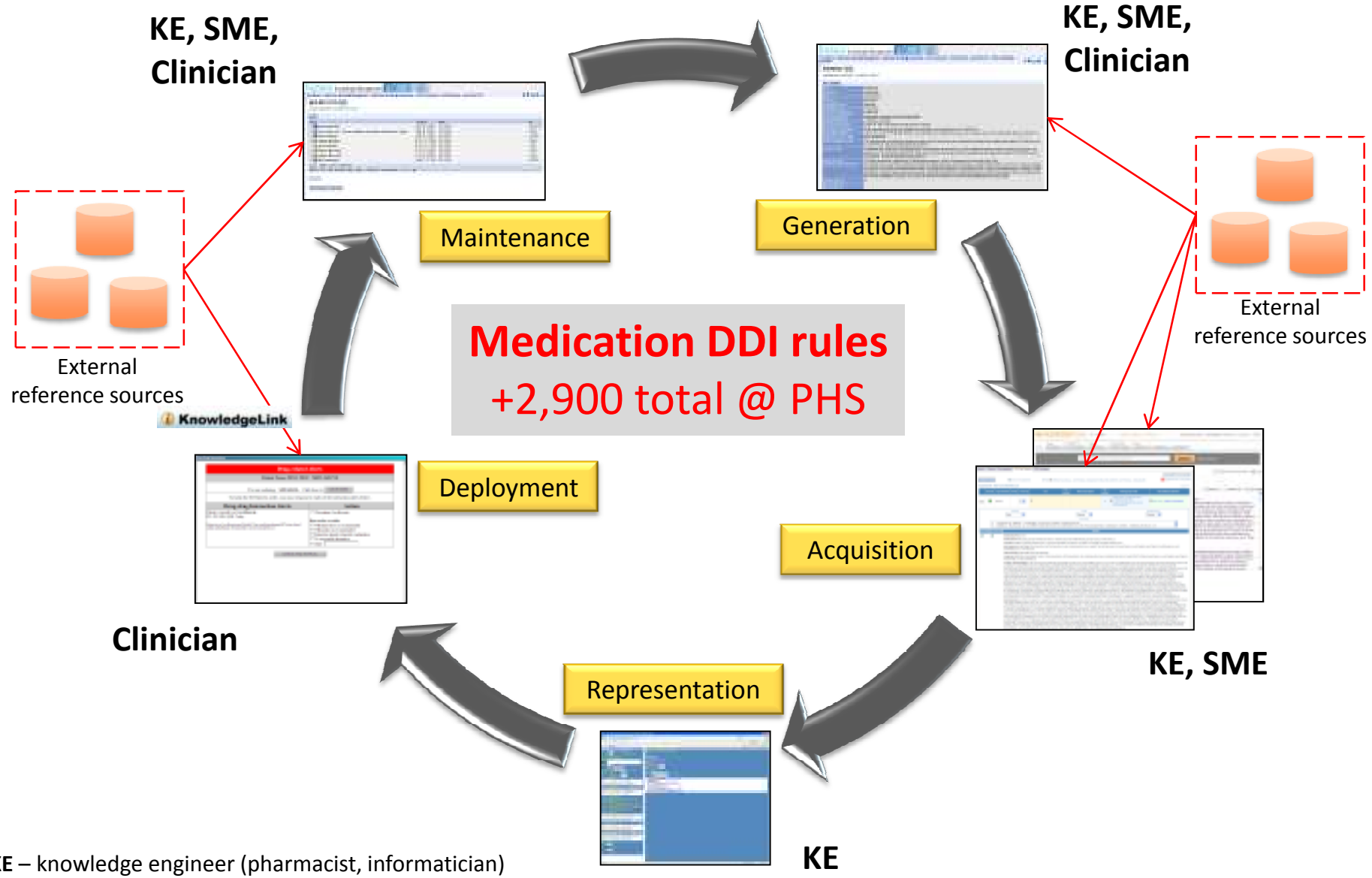
- Production release of new rules and alerts (software)
- Publication of the new rules (intranet portal)

Maintenance

- Comments received from users and internal experts
- Information obtained from external reference sources



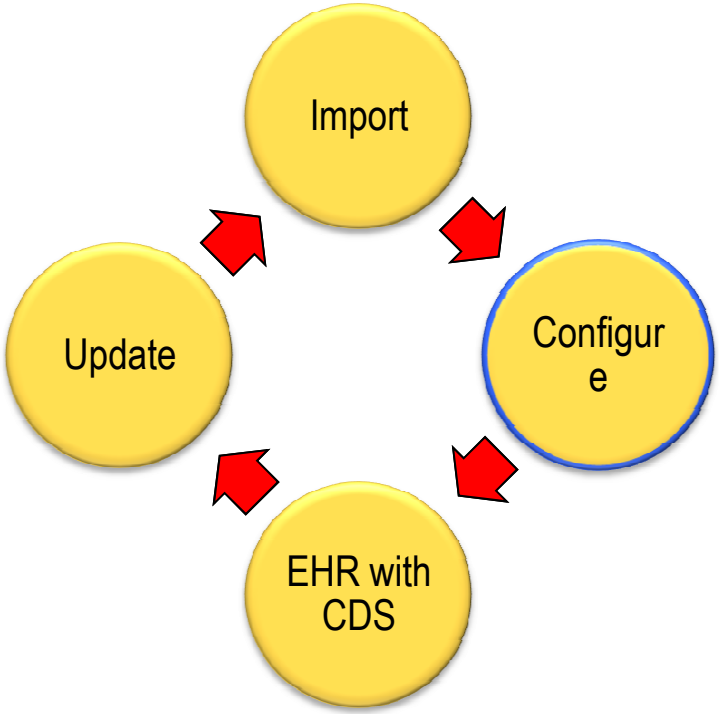
Typical knowledge management lifecycle



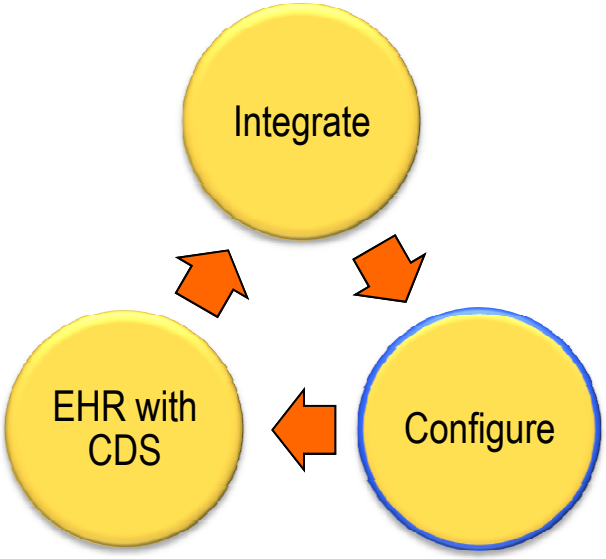
KE – knowledge engineer (pharmacist, informatician)
SME – subject matter expert (pharmacist, physician, etc.)

Lifecycle models with "outsourcing"

Knowledge
Content only

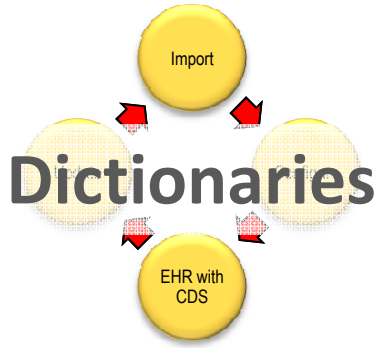


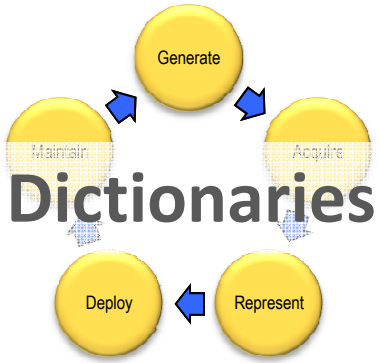
Knowledge
Services + Content

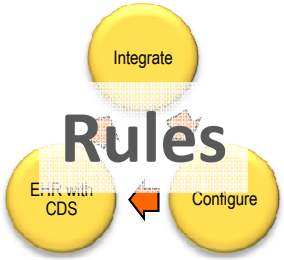


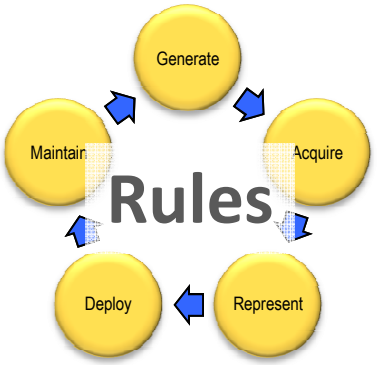
Both require content localization (configuration)

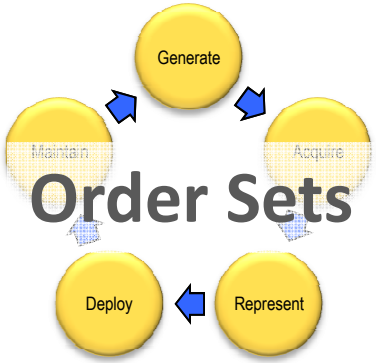
CKMS reality: concurrent lifecycles

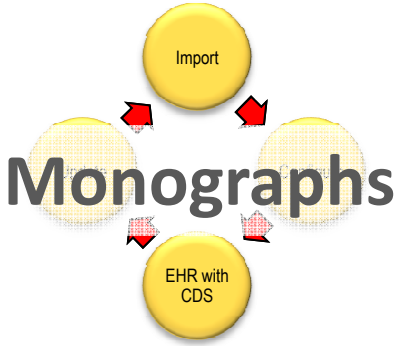


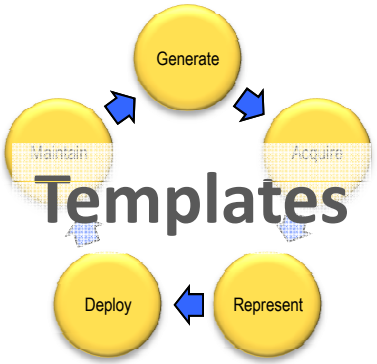


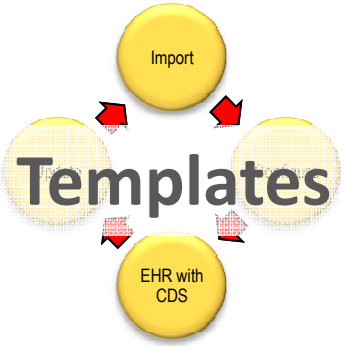


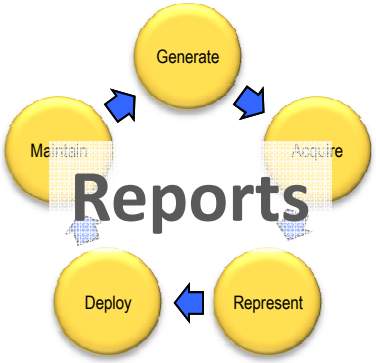


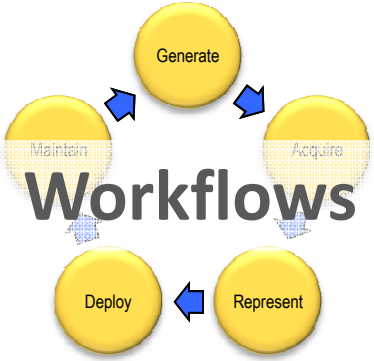


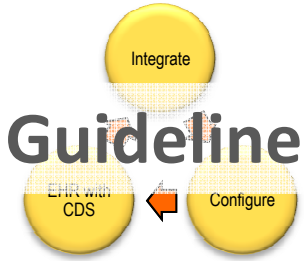


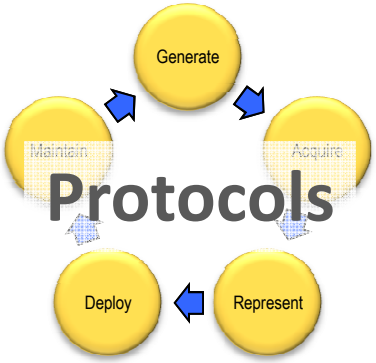




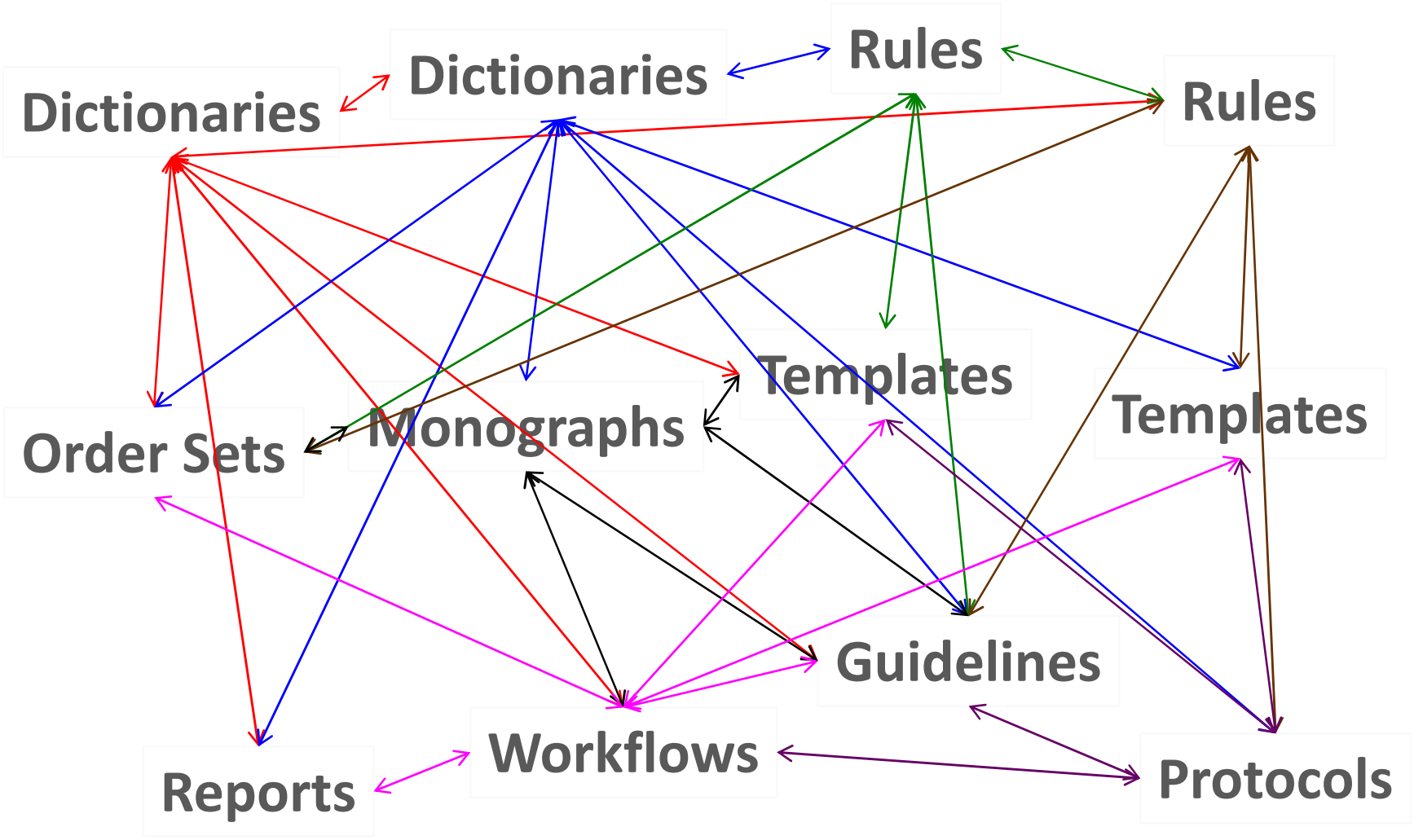








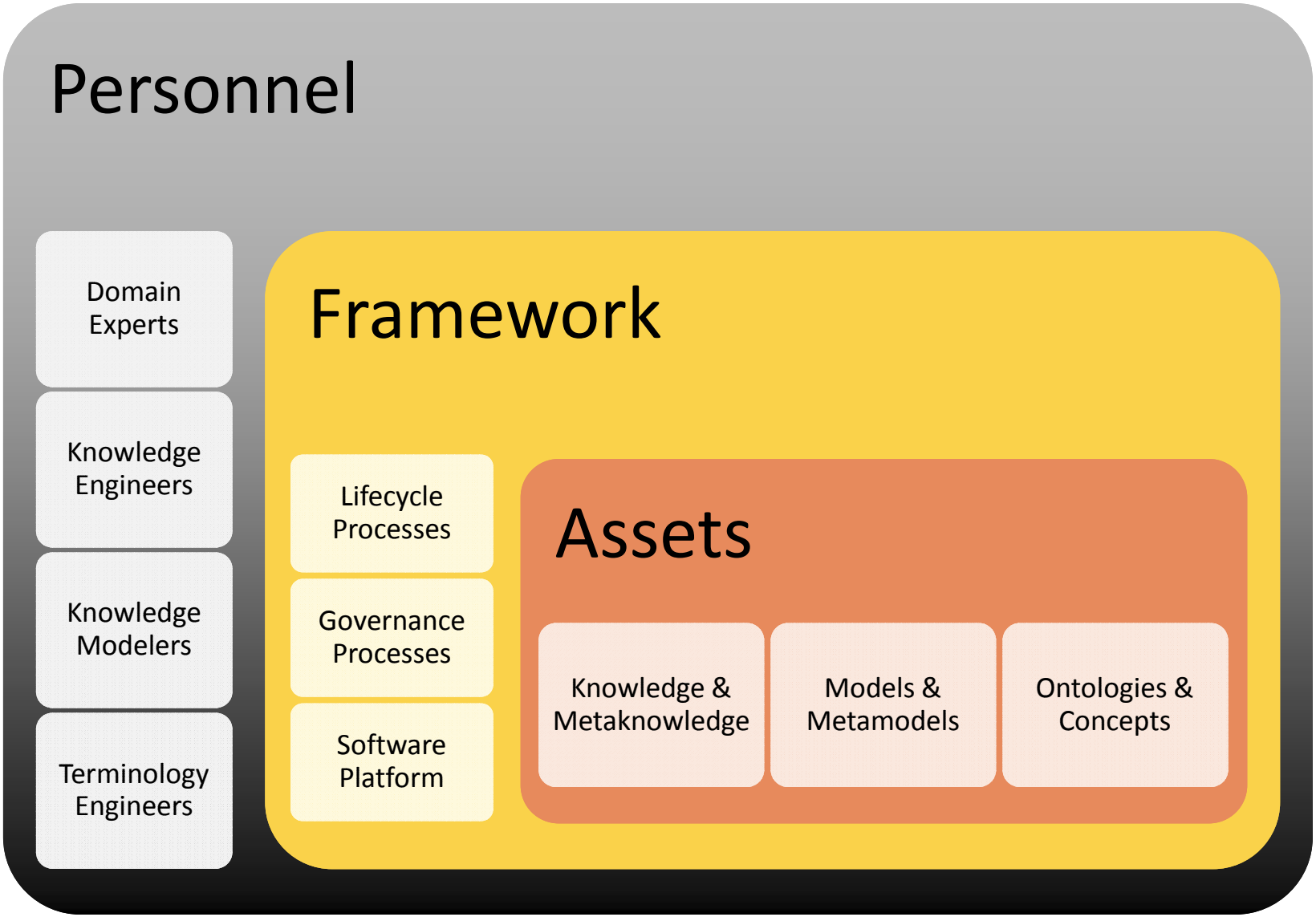
CKMS reality: content dependencies



CKMS @ Partners HealthCare

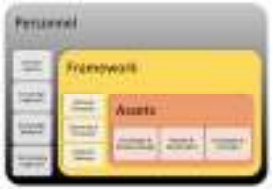
- Enable all knowledge content to be **accessible**, **updatable**, and **maintained** with an **audit trail**
- Reduce the **cost** and increase **efficiency** of both design and implementation **maintenance**
- Enable **stakeholder involvement** in the design process to support effective adoption and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

CKMS Components



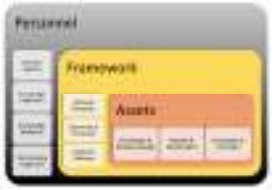
CKMS: Personnel requirements

- Dedicated **multidisciplinary team**
  - analysis, clinical, informatics, modeling, process analysis, project management, resource management, etc.
- Excellent analytical and communication **skills**
- Extensive initial **training** with an emphasis on **continuous learning** and (virtual) **collaboration**
- Process and artifact **specialization**
  - CDS modality, clinical domain, asset type, maintenance
- Career orientation towards specific **job families**
  - Knowledge engineer, modeler, domain expert, etc.
- Proactive **recruiting** and **retention** policies



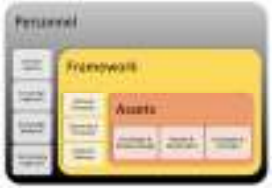
CKMS: Lifecycle requirements (1)

- **Integrated** support for all lifecycle phases
- Detailed **provenance** and consistent tracking of **dependencies**
- Configurable **process automation**
  - Reduce repetitive steps and improve content integrity
- Extensive **version**, **ownership**, and **access control**
  - Support for distributed curation
- Content **validation** services
  - Improve overall maintenance costs and consistency
- Analytical and user-initiated **feedback**
  - Continuously improve processes and content



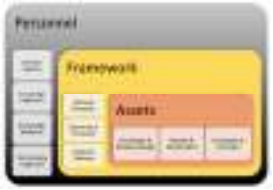
CKMS: Lifecycle requirements (2)

- **Distributed** and **collaborative** curation
  - Asynchronous and synchronous activities
  - Minimize the overhead of consensus building (evaluation-driven)
  - Expediency with transparency
- Curation processes **loosely coupled** to utilization
  - Optimized for integration and effective maintainability
  - Repurposing for multiple interventions and systems ("**localization**")
- **Active maintenance** (introspective)
  - Identify inconsistencies using structural and semantic inferences
  - Enable autonomous updates (propagation)
- Emphasis on projects with an **enterprise scope** (ROI)
  - Ability to host 'local' and 'niche' efforts (ensure maintainability)



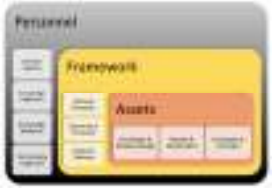
CKMS: Governance requirements

- Clinical **vision** and **leadership** helping the organization understand the need (alignment)
  - Business strategies, government incentives, relevant regulations
- Detailed **business case** illustrating the opportunity
  - Emphasis on CKM as an efficient model for *knowledge translation*
- Identify **opportunities** that rely on knowledge-driven interventions
  - Quality, safety, disease management, protocol-based care
- Detailed **roadmap** emphasizing continuous **evaluation**
  - Improvement supported by change management procedures
- Stakeholders directly involved with **planning** and **execution**
  - Clinical leaders that provide appropriate accountability
  - Availability of clinical domain experts
  - Incentives for active participation



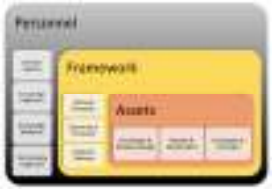
CKMS: Software platform requirements

- **Integration** – complete “workbench” that provides integrated content authoring, review, and publishing, while ensuring proper asset lifecycle management
- **Modularity** – component-based architecture that enables processes and content reuse, while ensuring proper management of dependencies
- **Configurability** – multiple concurrent lifecycle processes for authoring, reviewing, and publishing content, taking into account distinct content types and personnel roles
- **Extensibility** – new processes, tools, roles, metadada, and content can be added as needed without requiring platform changes
- **Compliance with standards** – content, processes, and models are represented (stored) using standard formats
- **Learning** – built-in utilization monitoring and analytical capabilities
- **Intelligence** – manage content with ‘meta-knowledge’



CKMS: Content (asset) requirements

- Authoritative **source** of clinical knowledge
  - Integrative view including ontologies, models, and knowledge (layers)
- Extensible **metadata**
  - Classification, lifecycle, and provenance processes
- Explicit representation **structural** and **semantic properties**
  - Using “meta-models” (logic-based) for multiple types of assets
- Explicit representation of **dependencies** and **associations**
  - Ensure integrity and enabling repurposing
- Ability to represent a growing number of unique (**individual**) combinations of **contextual characteristics**
  - Genes, proteins, cells, lifestyle, diet, environment, preferences, …
- Extensive **mappings** to external reference sources to ensure optimal interoperability



MITsdm system design and management

CKMS
Challenges & Opportunities

BWH BRIGHAM AND WOMEN'S HOSPITAL HARVARD MEDICAL SCHOOL

PARTNERS HEALTHCARE CIRD Clinical Informatics Research & Development

Expected benefits of a CKMS

- Improved **efficiency** and **reliability** of knowledge content creation and maintenance processes
  - Standardize and unify content authoring
  - Eliminate redundant content editing (manual)
  - Proper management of content dependencies
  - Appropriate use of reference content sources
  - Streamline communication: engineers, domain experts, and knowledge workers
  - Implementation of automated content validation processes
- Improve overall knowledge content **accuracy**, **completeness**, and **maintainability**
  - Reduce any potential risks to patients due to incorrect and/or outdated content

Overview of general KM trends

Creation	Specialists → Everyone, **collaborative** activity
Integration	At design time → **At use time** (ongoing)
Dissemination	Lecture, broadcasting, classroom → On demand, **integration** of learning and working, relevant to tasks, **personalized**
Learning paradigm	Knowledge transfer → Knowledge **construction**
Social structures	Individuals, top-down → **Communities of practice**, peer-to-peer
Work style	Standardize → ~~Improvise~~
Information spaces	Closed, static → Open, **dynamic**
Breakdowns	Errors to be avoided → Opportunities for innovation and learning
Tasks	System driven → User or task driven

Fischer G & Ostwald J. Knowledge Management: Problems, Promises, Realities, and Challenges. *IEEE Intelligent Systems*, January/February 2001, 60-72, 2001.

CKMS: implementation challenges

- Clinical **governance** and **stewardship** is poorly defined
  - Liability from outdated or incorrect knowledge not recognized
  - Cost of not having knowledge/CDS is not frequently considered
- **Projects** and **resources** defined in competition with activities
  - Clinical experts frequently unavailable (limited commitment)
  - Processes for creating & vetting knowledge not clearly defined
- **Maintenance** of knowledge assets is an afterthought
  - Knowledge once deployed for use is not easily accessible ('locked')
  - Software tools frequently ignore content dependencies and lifecycle
  - Long-term commitment to content maintenance is underestimated
- **Analytics** – impact on processes and outcomes not available

Availability of data

- Availability of **structured** and **coded** clinical data determines the feasibility of CDS interventions
  - Data is expensive to generate at the point-of-care (systematically)
  - Benefits frequently not tangible to data "producers" (extra incentives)
- **Dissemination** and **exchange** of knowledge assets depends on **data standardization** (structure & semantics)

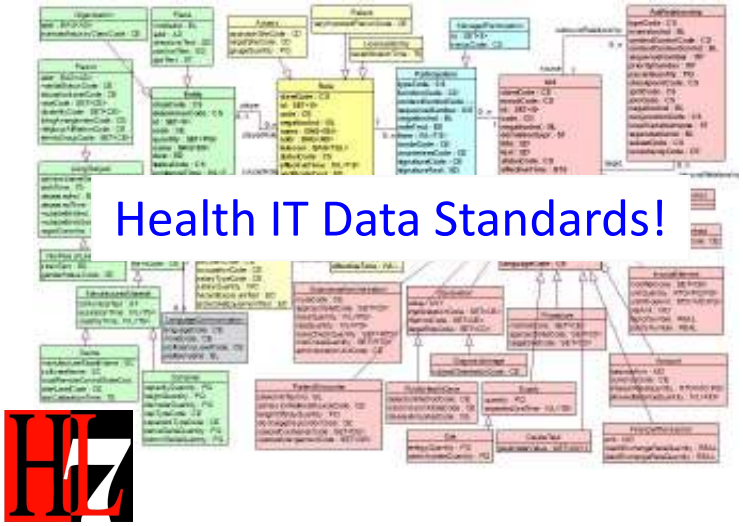
Natural language processing?

Voice recognition?

Mobile devices?

Knowledge-driven documentation?

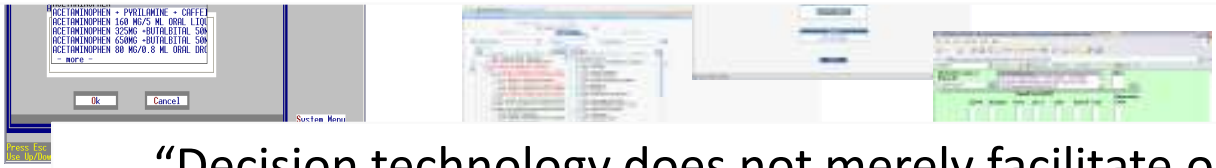
Semantic expressivity (adaptive)?



Cognitive aspects of CKMS/CDS tools

"Technologies mediate the decision-making process in distinct and often counterintuitive ways that can produce unintended consequences."[1]

Attention economy – "we have more information available than we have attention to understand and apply it. At the same time, finding information relevant to the task at hand is becoming increasingly critical."[2]



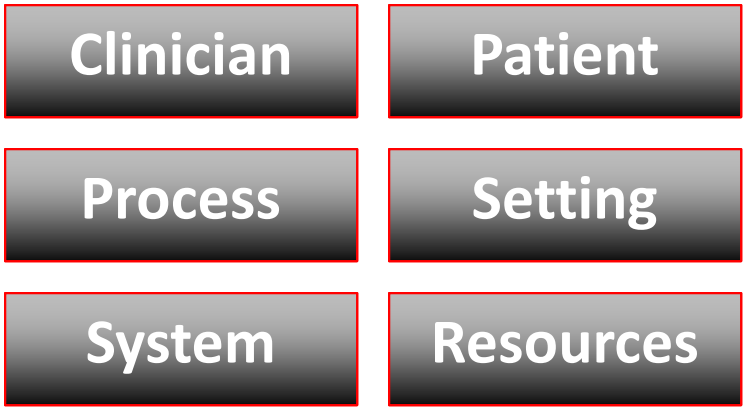
"Decision technology does not merely facilitate or augment decision-making rather it reorganizes decision-making practices."[1]

(1) Patel VL, Kaufman DR, Arocha JF. Emerging paradigms of cognition in medical decision-making. *J Biomed Inform*. 2002 Feb;35(1):52-75.

(2) Fischer G & Ostwald J. Knowledge Management: Problems, Promises, Realities, and Challenges. *IEEE Intelligent Systems*, January/February 2001, 60-72, 2001.

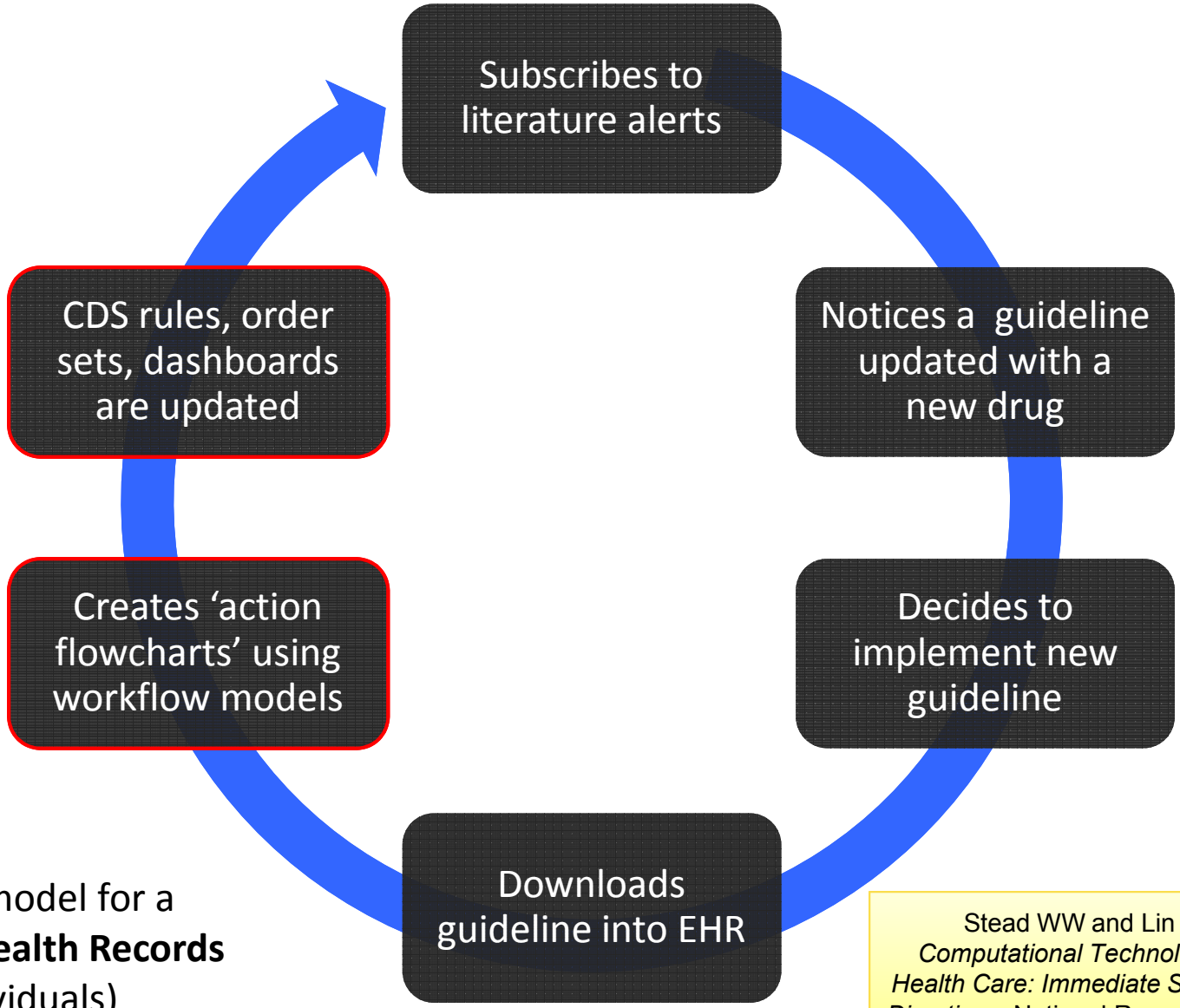
Context modeling

- "The real challenge is to "**say the right thing at the right time in the right way**." This is possible only with computational environments that take the **user's context** into account."
  - What the users are doing?
  - What they have done?
  - Where they are?
  - What they know?
  - …



Fischer G & Ostwald J. Knowledge Management: Problems, Promises, Realities, and Challenges. *IEEE Intelligent Systems*, January/February 2001, 60-72, 2001.

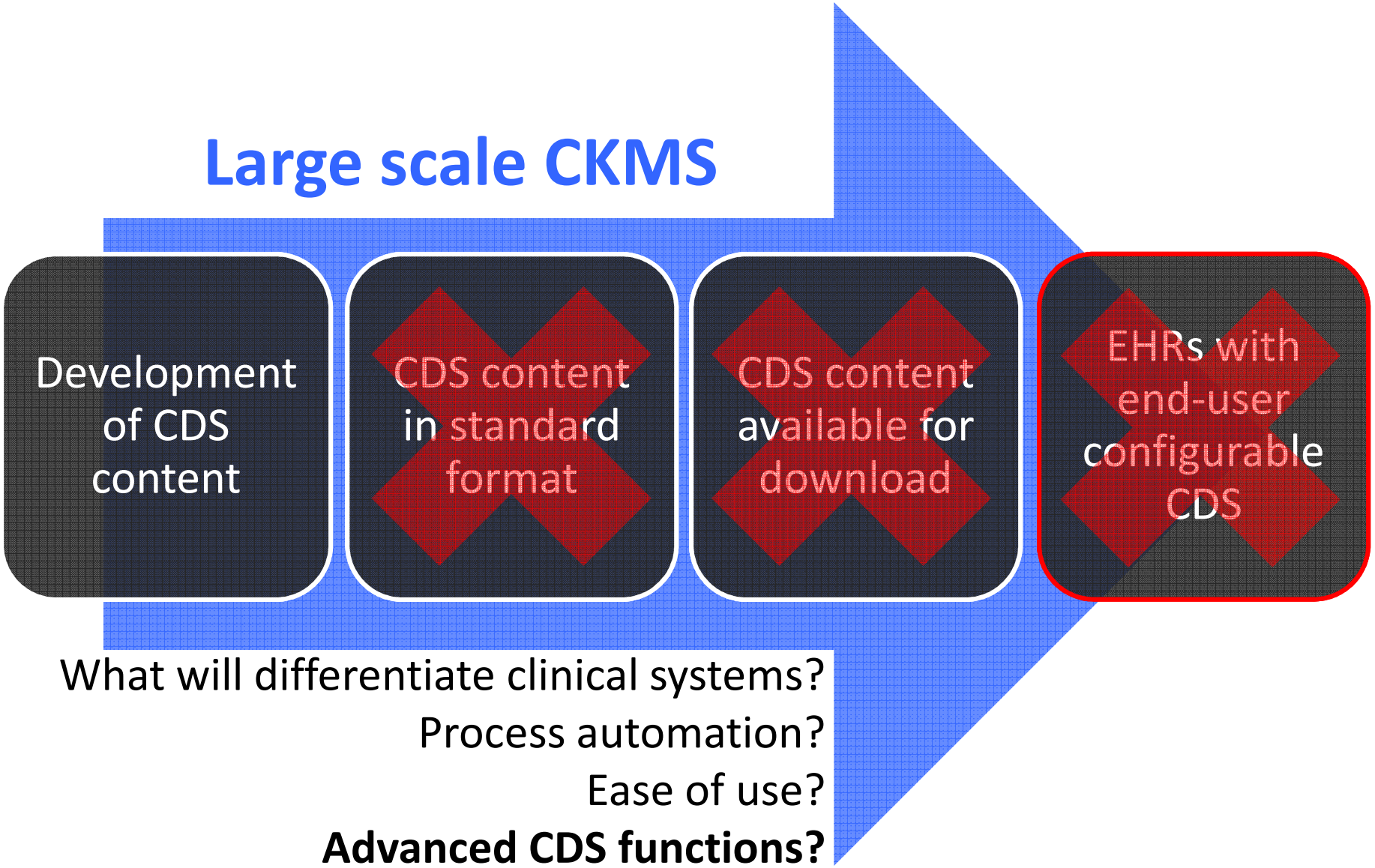
Efficient dissemination strategy



Similar model for a **Personal Health Records** (individuals)

Stead WW and Lin HS, editors. *Computational Technology for Effective Health Care: Immediate Steps and Strategic Directions*. National Research Council, 2009.

Current dissemination barriers



CDS consortium **Knowledge Management Portal** AHRQ

Home | About the Portal | About the Consortium | FAQ | Glossary | Terms of Use | Contact Us

Search Term :

diabetes [Search] [Clear Selection]

[Show Advanced Search]

[Collapse Results]

http://cdsportal.partners.org

Title: PHS Diabetes Guidelines 2009 L1

Specification Level	Contributing Entity	Content Type
Level 1 - Unstructured	Partners Healthcare Systems	Reference

Description: Clinical Guidelines for Treatment of Type 2 Diabetes in Non-Pregnant Adults, Feb 2009. Criteria for Diagnosis, Treatment Goals, Recommended Frequency of Diabetes Care Components, and Glycemia, LDL, & Hypertension Management for the Non-Pregnant Adult

Show Details..

Title: CDSC Diabetes L3

Open as XML

Specification Level	Contributing Entity	Content Type
Level 3 - Structured	Partners Healthcare Systems	Reminder

Description: Content contains 8 discrete reminders for screening, surveillance, and prevention of diabetic complications.

Show Details..

Title: PHS Classification Rules L3

Open as XML

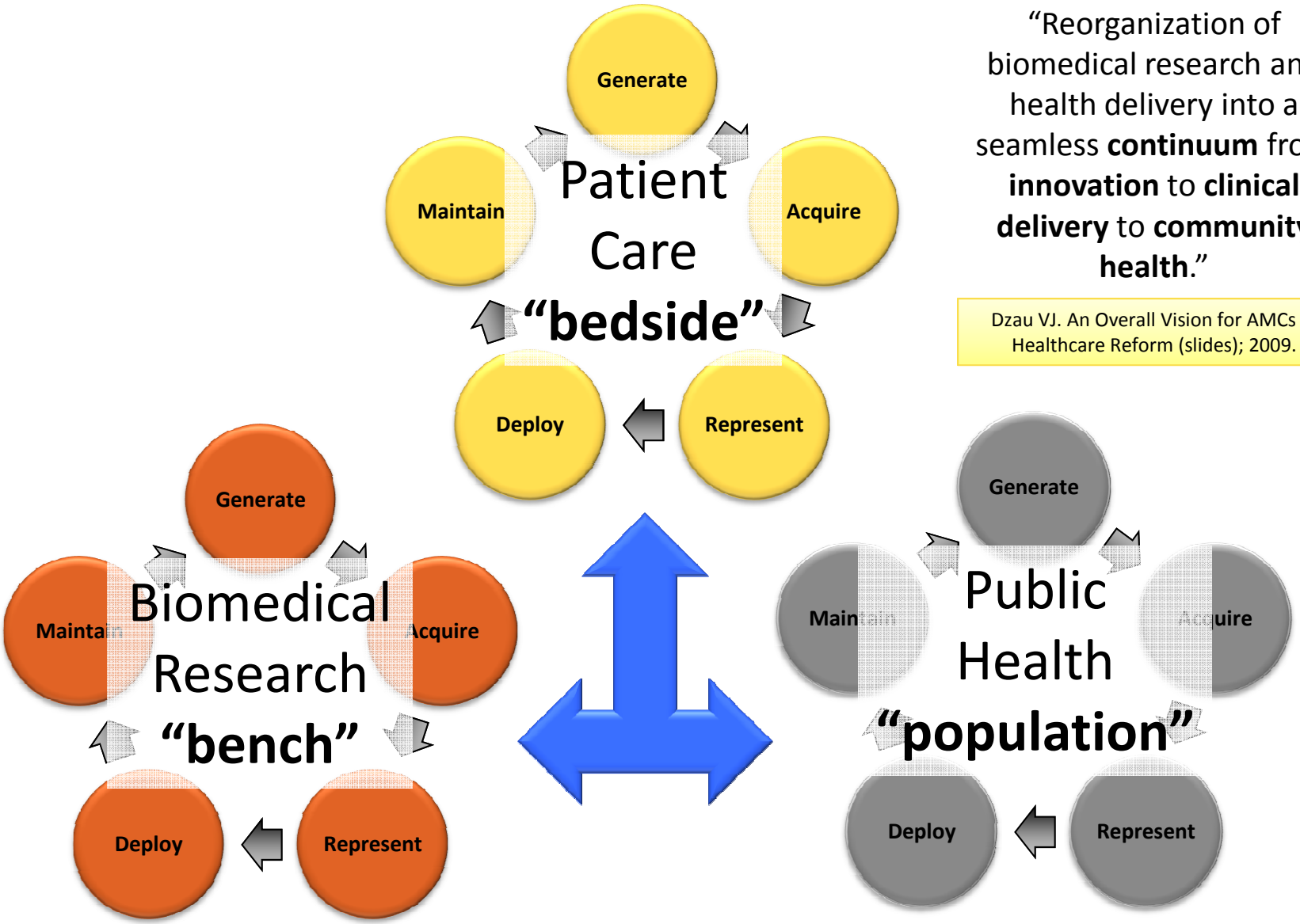
Specification Level	Contributing Entity	Content Type
Level 3 - Structured	Partners Healthcare Systems	Definition/Dictionaries

Description: Classification Rule Definitions design by Partners Health Care

Show Details..

Title: CDSC Diabetes L2

Integration of related KM systems



"Reorganization of biomedical research and health delivery into a seamless **continuum** from **innovation** to **clinical delivery** to **community health**."

Dzau VJ. An Overall Vision for AMCs in Healthcare Reform (slides); 2009.

Factors justifying a CKMS

- **Quantity of knowledge** (explosion)
  - Evolution towards stratified/personalized clinical practice
  - Complex decision making process demanding computerized support
- **Distributed care delivery processes** (fragmented)
  - Extensive knowledge is needed beyond organizational boundaries
  - Learning opportunities leading to optimal care and stewardship
- **Global trends towards knowledge socialization**
  - Consumers (patients) constantly seeking knowledge (empowerment)
  - Shared responsibility only possible with proper understanding
- **Knowledge content maintainability** (long-term)
  - Diversity and quantity makes traditional (manual) curation unrealistic
  - Increasing number (complexity) of dependencies across lifecycles and biomedical domains

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Fay Moy

Additional references

- Book "Clinical decision support: the road ahead"
  - Greenes RA, editor. Academic Press, 2006.
- Paper "Ten commandments for effective clinical decision support: making the practice of evidence-based medicine a reality."
  - Bates DW, Kuperman GJ, Wang S, Gandhi T, Kittler A, Volk L, Spurr C, Khorasani R, Tanasijevic M, Middleton B. J Am Med Inform Assoc. 2003 Nov-Dec;10(6):523-30. (PMID: 12925543)
- Paper "A roadmap for national action on clinical decision support."
  - Osheroff JA, Teich JM, Middleton B, Steen EB, Wright A, Detmer DE. J Am Med Inform Assoc. 2006 Jul-Aug;13(4):369-71. (PMID: 17213487)
- Paper "Just-in-time delivery comes to knowledge management."
  - Davenport TH, Glaser J. Harv Bus Rev. 2002 Jul;80(7):107-11, 126. (PMID: 12140850)
- Paper "Using commercial knowledge bases for clinical decision support: opportunities, hurdles, and recommendations."
  - Kuperman GJ, Reichley RM, Bailey TC. J Am Med Inform Assoc. 2007 Mar-Apr;14(2):141-5. (PMID: 16622160)
- Paper "Predictive data mining in clinical medicine: current issues and guidelines."
  - Bellazzi R, Zupan B. Int J Med Inform. 2008 Feb;77(2):81-97 (PMID: 17188928)

- Web site "**Open Clinical**" (UK): http://www.openclinical.org/

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Thank you!

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