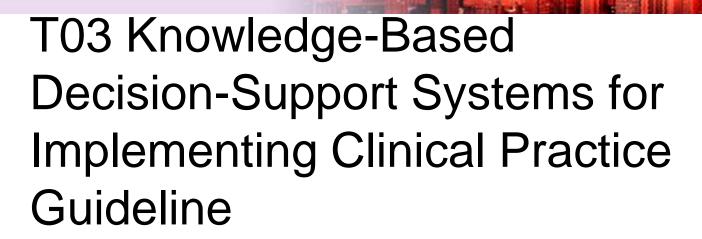
November 3-7, Chicago AMIA 2012 Annual Symposium

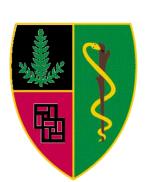
Informatics: Transforming Health and Healthcare



AMIA Annual Symposium Tutorial Saturday, November 3, 2012







• • Course Faculty

- Mary K. Goldstein, MD, MS
 - Director, GRECC, VA Palo Alto Health Care System; and Professor of Medicine (PCOR & HRP), Stanford University
- Susana B. Martins, MD, MS
 - Health Science Research Scientist, VA Palo Alto Health Care System
- Mor Peleg, PhD
 - Associate Professor of Information Systems, Haifa University, Haifa, Israel

Course Coordinator

- Samson W. Tu, MS
 - Senior Research Scientist, Center for Biomedical Informatics Research, Stanford University

• • Acknowledgement: Collaborators

- The presentation uses slides created by Dr. Kawamoto with his permission
- InferMed, UK
- Jeff Garber (Harvard)
- John Fox, Vivek Patkar, and Ioannis Chronakis (Oxford)

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- ATHENA Project
 - PIs: Mary Goldstein, MD, Brian Hoffman, MD
 - Funded in part by VA Palo Alto Health Care System and Department of Veterans Affairs Health Services Research and Development (HSR&D)
- Stanford Biomedical Informatics Research EON and GLINDA Projects
 - PI: Mark Musen
 - Funded by National Library of Medicine

Opinions expressed are those of the speakers and not of the Department of Veteran Affairs and other funding agencies

• • Objectives

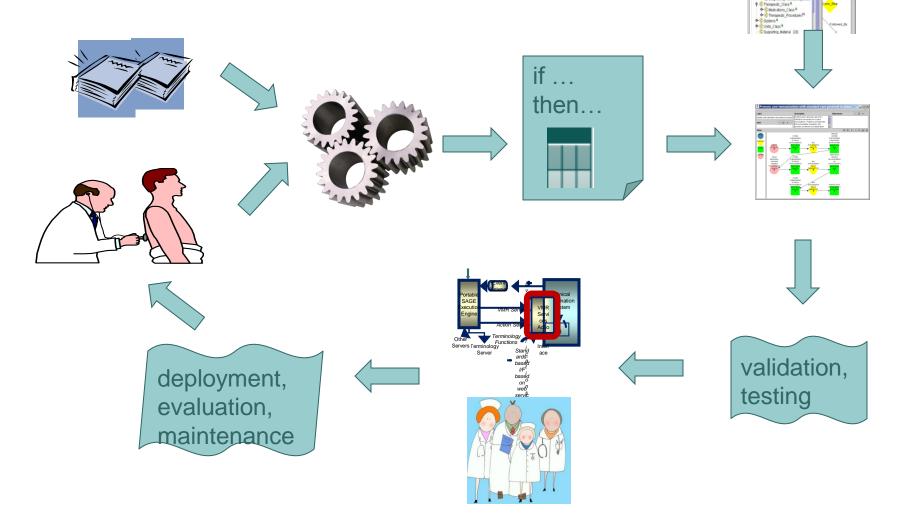
- Introduce the concept of knowledge-based clinical decision support systems (CDSS) for guideline-based care
- Understand the steps and issues involved in encoding guideline knowledge
- Describe alternative methods for representing computable clinical practice guidelines (CPGs)
- Outline the issues involved in deploying and integrating CDSS for guideline-based care

References to existing and emerging standards in CDS

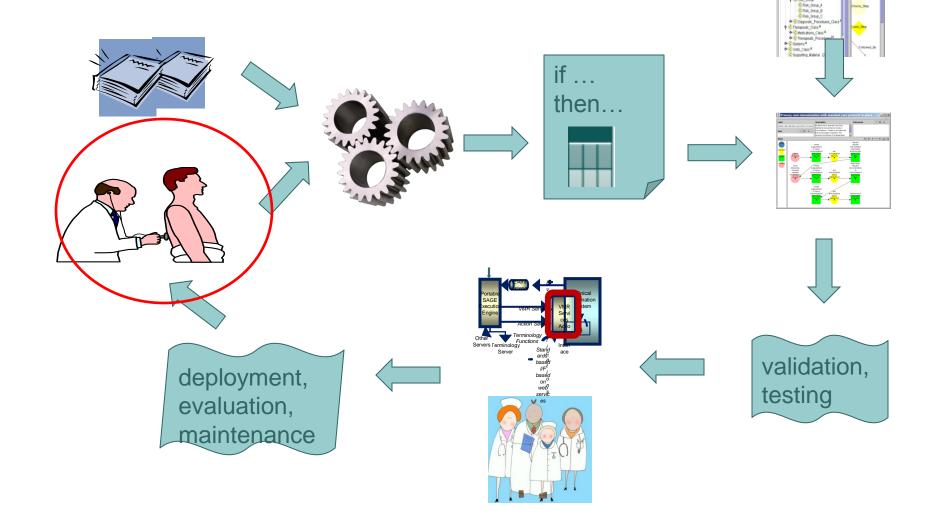
• • Course Outline

- Introduction to clinical decision support
- 2. Clinical practice guidelines
- Operationalization of guideline recommendations
- 4. Guideline modeling formalisms
- 5. Application of encoded guideline to patient
- 6. Implementation exercise
- 7. Socio-technical issues
- 8. Standards

Big Picture: Steps in Developing CDSS



Clinical Decision Support

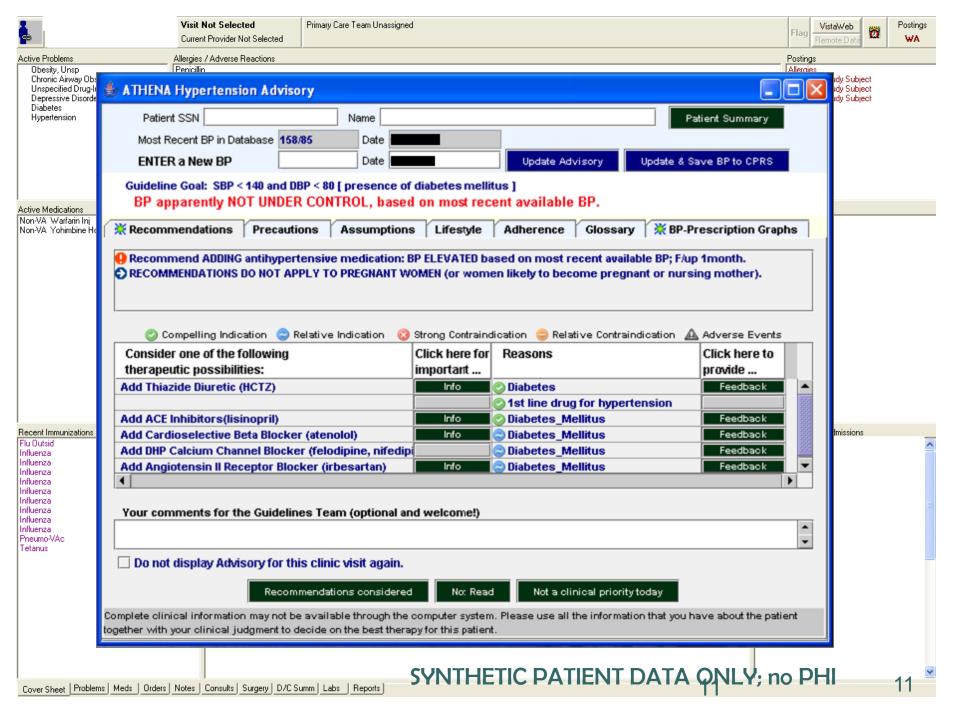


Clinical Decision-SupportSystem

- Definition
 - "Any computer program designed to help health professionals make clinical decisions" (Musen 2006)
- Three types of CDSS
 - Tools for information management
 - Tools to focus attention
 - Check-list effect (Gawande 2009)
 - Tools to provide patient-specific recommendations

• Example: ATHENA HTN CDS

- Collaboration between Stanford and Veteran Affairs Palo Alto Health Care System
- Application of EON guideline model and technology (Tu, 2001a) to various clinical domains at VA (Goldstein 2000, Michel 2008)
- ATHENA-HTN deployed at multiple VA sites in California, North Carolina, & New England
- High level of physician usage



Example Disease Management Reminders

a https://clinapp6.d	uhs.duke.edu:80	081 - Patient Summary for	- Microsoft Internet Explorer			
Allergies/ADE [Problems Med	lications Medications Vitals	Cautions Disease	Mgmt. Print Send Clos	;e	
All Health Maintenance Diabetes* Hypertension*						
Re-Evaluate	Input Observat	ions Last evaluated Mon Jan	12 21:09:31 EST 2009			
▼ Diabetes				Remove from Diabetes List		
Focus	Status	Relevant Data	Last Done	Guidelines		
Height	Not Due	Height: 154.9cm (61.0in)	12/15/08(age 61y 3m)	21+yo: once after age 21		
Weight/BMI	DUE NOW	Weight: 77.1kg (170.0lb) BMI: 32.1	01/08/09 (0m 4d ago)	21+yo: q visit. Goal: BMI <25		
B.P.	DUE NOW	BP: 120/69 mm Hg Patient has diabetes or GFR <60	01/08/09 (0m 4d ago)	18+yo: annual; if diabetic or HTN q visit. Goal <140/90, 130/80 if diabetic or GFR <60.		
Alcohol Screen	Not Due	Abstains	01/08/09 (0m 4d ago)	10+yo: check alcohol use yearly (excessive: males >2/d, females >1/d)		
Visual Foot Exam	DUE NOW		01/08/09 (0m 4d ago)	q visit		
Foot Monofilament	Not Due		01/08/09 (0m 4d ago)	annual		
HgbA1C	Not Due	HgbA1C: 6.2%	01/08/09 (0m 4d ago)	21+yo: q6mo if <7%, q3mo if >= 7%. Goal: <7%.		
Urine Micro alb/cr	Not Due	alb/cr ratio: * mg/g	10/08/08 (3m 4d ago)	10+yo: annual		
Total Chol.	Not Due	Total-C: 151 mg/dL	12/15/08 (0m 28d ago)	annual, goal <200		
LDL Chol.	Not Due	LDL-C: 94 mg/dL	12/15/08 (0m 28d ago)	annual, goal <100		
Eye Exam	DUE NOW	Intervention considered but not de Reason: Scheduled	livered on 01/08/09.	10+yo: annual		
Flu Yacc.	CONSIDER		>2y ago	annual, unless egg allergic		
Pneum. Yacc.	Not due		01/01/06 (3y 0m ago)	once; revacc if >=65 and last 5+ yrs ago when <6	5	
ASA (81 mg)	Not Due	Not known to be allergic to aspirin Aspirin listed as prescribed		40+yo: no contraindications		
Education	Not Due	Completed	01/08/09 (0m 4d ago)	once; repeat annually if HgbA1C >=7%		

Source: Duke University Health System. Lobach DF, Kawamoto K, et al. Medinfo. 2007;861-5. Used with permission

How do Different Types of CDS Technologies Compare

Alert and Reminders

- Use few data
- Relatively simple knowledge

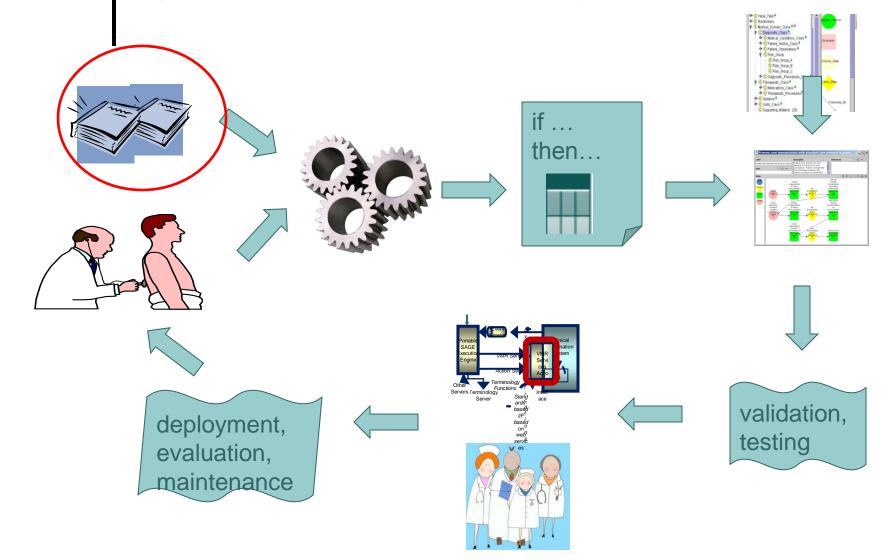
Guideline-Based CDS

- Based on consensus knowledge
- Complex data,knowledge, andCDS output

Prediction-Based CDS

- Uses mathematical models
- Data intensive
- CDS based prediction of future states (& value)

Clinical Practice Guidelines



• • The "Quality Chasm"

- Institute of Medicine (IOM) report on Crossing the Quality Chasm*
- > Health care system must improve in
 - Patient safety, evidence-based practice
- Improvability gaps between best practices and actual practice
- Information technology (IT) can support quality improvement
 - But IT is underutilized in clinical setting

^{*} Crossing the Quality Chasm: A new health system for the 21st century. National Academy Press, 2001

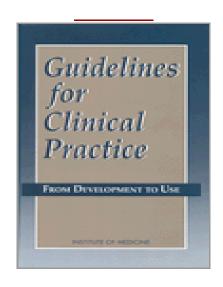
Quality Measurement and Improvement in Healthcare

- National Quality Forum (NQF) assembles healthcare experts to refine and endorse standards and measures. Link: www.qualityforum.org
- Linking quality indicators to health information technology systems
- Using quality indicators/performance measures as part of quality improvement

Literature Synthesis: Clinical Practice Guidelines

Intended to improve clinical practice

- summarize evidence
- recommend best practice
- reduce small area variation that is due to custom rather than to evidence-based differences in practice due to patient characteristics
- Newer forms of evidence syntheses



•Field, M. J., K. N. Lohr, et al., Eds. (1992). <u>Guidelines for Clinical Practice:</u> <u>From Development to Use</u>. Institute of Medicine. Washington, D.C., National Academy Press.

Home

Guidelines

Browse

- By Topic

- By Organization
- Guidelines in Progress
- Guideline Index
- Guideline Archive
- Related NQMC Measures

Expert Commentaries

Guideline Syntheses

Guideline Resources

Annotated Bibliographies

Compare Guidelines

FAQ

Submit Guidelines

About

My NGC

Guidelines by Topic

Browse topics to find guidelines represented in NGC that are linked to a particular term derived from the U.S. National Library of Medicine's (NLM) Medical Subject Headings (MeSH) (MeSH) (Medical vocabulary for disease/condition, treatment/intervention, and health services administration. MeSH is one of the controlled vocabularies included within the Unified Medical Language System (UMLS) (what's this?)

MeSH terms are arranged hierarchically ranging from broad headings to more narrow concepts. For example, the general concept "Nervous System Diseases" can be followed through the MeSH hierarchy down to the concept "Myasthenia Gravis, Neonatal;" the broad concept "Diagnostic Techniques, Digestive System" can be followed through "Endoscopy, Gastrointestinal" to the narrow concept "Sigmoidoscopy."

Create Topic E-mail Alerts

Disease/Condition

- Anatomy (12)
- Organisms (39)
- **▶ Diseases** (2445)
- Chemicals and Drugs (6)
- Analytical, Diagnostic and Therapeutic Techniques and Equipment (124)
- Psychiatry and Psychology (450)
- Phenomena and Processes (535)
- Disciplines and Occupations (3)
- Anthropology, Education, Sociology and Social Phenomena (74)
- Humanities (1)
- ► Information Science (8)
- Named Groups (104)
- ► Health Care (245)

5000+ GLs!!

Treatment/Intervention

- ▶ Anatomy (65)
- Drganisms (46)
- Diseases (185)
- ▶ Chemicals and Drugs (1733)
- Analytical, Diagnostic and Therapeutic Techniques and Equipment (2432)
- Psychiatry and Psychology (895)
- ► Phenomena and Processes (920)
- Disciplines and Occupations (455)
- Anthropology, Education, Sociology and Social Phenomena (896)
- ➤ Technology, Industry, Agriculture (273)
- ► Humanities (58)
- ► Information Science (306)
- Named Groups (30)
- ► **Health Care** (1779)
- ► Publication Characteristics (9)

Health Services Administration

- ▶ Chemicals and Drugs (2)
- Analytical, Diagnostic and Therapeutic Techniques and Equipment (70)
- Psychiatry and Psychology (54)
- Phenomena and Processes (17)
- Disciplines and Occupations (34)
- Anthropology, Education, Sociology and Social Phenomena (122)
- Technology, Industry, Agriculture (9)
- ► Humanities (7)
- ► Information Science (102)
- Named Groups (12)
- ► Health Care (211)
- ► Geographicals (5)

http://www.guidelines.gov/

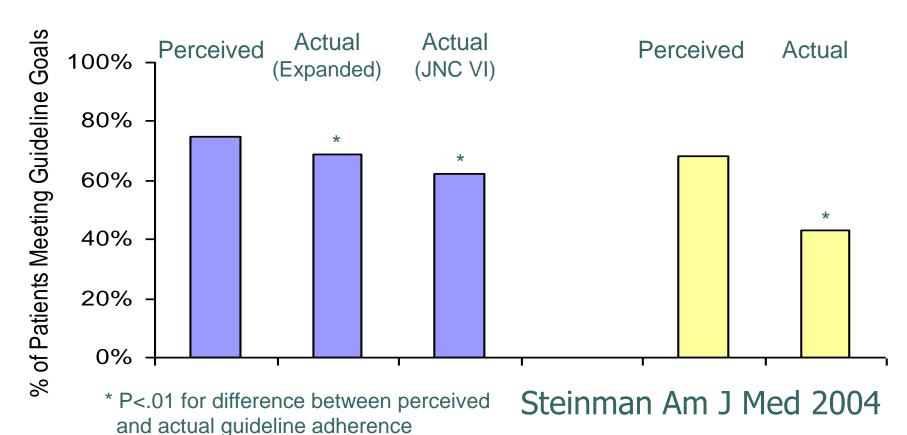
Are Clinicians Aware of Their Own Performance?

- Clinicians not aware of their own rate of guideline adherence
 - From baseline data for ATHENA project
 - Steinman, M.A., M.A. Fischer, M.G. Shlipak, H.B. Bosworth, E.Z.
 Oddone, B.B. Hoffman, and M.K. Goldstein, *Clinician awareness of adherence to hypertension guidelines*. Am J Med, 2004. **117**(10): p. 747-54.

Perceived vs. Actual Guideline Adherence



Adherence to Blood Pressure <140/90



What Does It Take To Change Practice?

- Changing physician practice requires more active steps than simply making guideline available
 - Lomas, J., G.M. Anderson, K. Domnick-Pierre, E. Vayda, M.W. Enkin, and W.J. Hannah, Do Practice Guidelines Guide Practice? The effect of a consensus statement on the practice of physicians. NEJM, 1989. 321:1306-1311.
- Field of implementation research
 - Handbooks
 - Department of Veterans Affairs (VA) Health Services Research and Development (HSR&D)Implementation Guide:
 www.queri.research.va.gov/implementation
 - Journals
 - Implementation Science

Theoretical Model of the Path to Guideline Adherence

"Awareness to Adherence" model, in which the clinician must

- Become Aware of guideline
- Accept it
- Adopt it
- Adhere to it

Pathman, D. E., T. R. Konard, et al. (1996). "The Awareness-to-Adherence Model of the Steps to Clinical Guideline Compliance."

<u>Medical Care</u> 34:873-889.

Many other conceptual models for influencing clinician behavior

Linking Informatics Support for Clinical Practice Guidelines to Theoretical Model

Step	Facilitators	Informatics Support
Aware	Priming Activities such as profiling of baseline performance	Profiling from pharmacy and diagnosis database
Accept	Active education such as Academic Detailing; Clinical Opinion Leaders	Present evidence relevant to patient; allow opinion leaders to browse knowledge
Adopt	Enabling strategies such as incorporation into clinic workflow	Integration with existing EMR
Adhere	Reinforcing Strategies such as reminders	Point-of-care patient- specific advisories

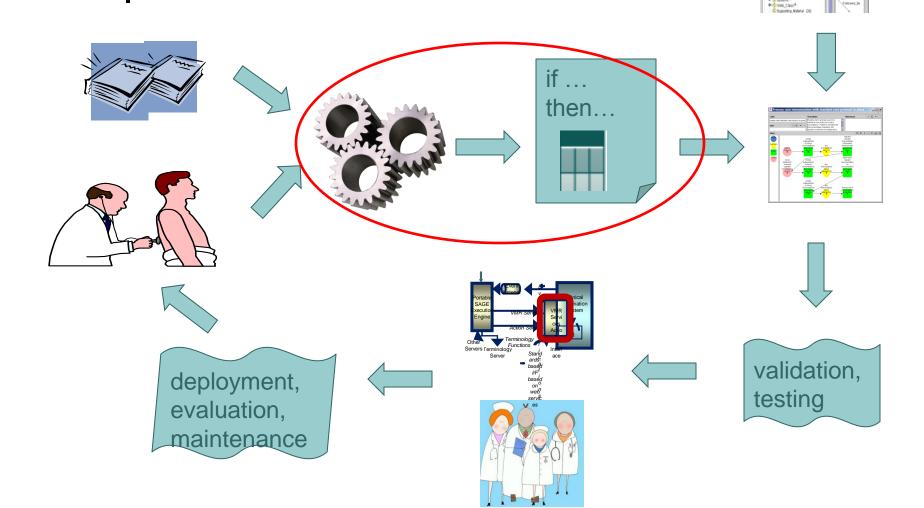
CDSS Only One of Many Steps to Improve Quality of Care!

- Address the barrier of "forgetfulness" and human limits of information processing
 - McDonald, C. J. (1976). "Protocol-Based Computer Reminders, the Quality of Care and the Non-Perfectability of Man." <u>New England Journal of</u> <u>Medicine</u> 295: 1351-1355.
- Early Understanding of when CDS is most effective:
 - patient-specific
 - delivered at point-of-care, that is arrive at the time of clinical decision making, rather than delayed
 - Tierney, W. M., S. L. Hui, et al. (1986). "Delayed Feedback of Physician Performance versus Immediate Reminders to Perform Preventive Care." <u>Medical</u> Care 24: 659-666.
 - require a response
 - Litzelman, D. K., R. S. Dittus, et al. (1993). "Requiring Physicians to Respond to Computerized Reminders Improves their Compliance with Preventive Care Protocols." Journal of General Internal Medicine 8: 311-317.

Recent Evidence Syntheses: Effect of Clinical Decision Support Systems

- CDS systems are effective at improving health care process measures across diverse settings, though evidence for efficiency outcomes remains sparse¹
- On-screen point of care clinical reminders achieve improvements in provider behavior²
- CDS can improve care processes and patient health in chronic disease management and acute medical care^{3,4}
 - 1. Bright *Ann Intern Med* 2012
 - 2. Shojania Impl Sci 2011
 - 3. Roshanov Impl Sci 2011
 - 4. Sahota Impl Sci 2011

Operationalization



Encoding a Clinical Practice Guideline

Therefore, chest radiographs should be ordered before any therapy is prescribed in nearly all patients with chronic cough (Grade II-2). Chest radiographs do not have to be routinely obtained before beginning treatment for presumed PNDS in young nonsmokers, in pregnant women, or before observing the result of discontinuation of an ACEI.

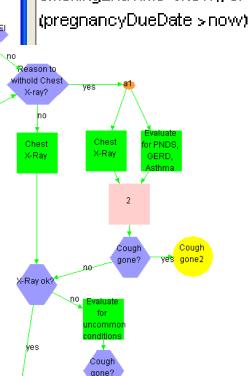
knowledge gap

Knowledge gap

(PNDSCertainty > 6) and (Age > 18 year) and smokingEndTime < now)) or the fore ion of an ion of

Shiffman RN, Michel G, Essaihi A, Thornquist E. Bridging the Guideline Implementation Gap: A Systematic, Document-Centered Approach to Guideline Implementation. J Am Med Inform Assoc 2004;11(5):418-26.

Tu, S. W., Musen, M. A., et al (2004). Modeling Guidelines for Integration into Clinical Workflow. Medinfo 2004, San Francisco, CA, USA, 174-178.



Selection of Guideline Recommendations

- High impact
 - Recent clinical findings & evidence
 - Gap between best and usual practice
- Easily implementable
 - Available data
 - Clear criteria
 - Relative advantage of computer
 - e.g., calculating risk of CV event
 - e.g., visualization

Operationalize Recommendations

- > Transform recommendations into computable format
 - Make implicit knowledge explicit
 - Make decision criteria evaluable against available data
- > Examples
 - Beta blockers are indicated in all patients without a history of MI who have a reduced LVEF with no HF symptoms.
 - The combination of hydralazine and nitrates is recommended to improve outcomes for patients selfdescribed as African-Americans, with moderate-severe symptoms of heart failure on optimal therapy with ACEIs, beta blockers, and diuretics.

2009 Focused Update: ACCF/AHA Guidelines for the Diagnosis and Management of Heart Failure in Adults, Circulation 2009;119:1977-2016.

Recommendations to Encode

Which BB?

Absence of contraindications?

Standard vocabulary? ICD9?

How to define? Below normal? Lower?

Beta blockers are indicated in all patients without a history of MI who have a reduced LVEF with no HF symptoms

Where in patient data? Standard vocabulary?

The combination of hydralazine and nitrates is recommended to improve outcomes for patients self-described as African-Americans, with moderate-severe symptoms of heart failure on optimal therapy with ACEIs, beta blockers, and diuretics.

How to define?

How to define?

Drug dose

ranges?

Method to Create Encodable Knowledge

- Selection of guideline recommendations
- Augmentation
- Qualification
- > Formalization of concepts
- De-abstraction
- Disambiguation
- Creating formal statements

• • • Augmentation

Add missing details

Guideline text: "Beta blockers are indicated in all patients without a history of MI who have a reduced LVEF with no HF symptoms."

Added knowledge: Which of the beta blockers (e.g., atenolol, metoprolol, pindolol, etc.) is the formulary preferred drug?

• • • Qualification

Make assumptions explicit

Text: "Beta blockers are indicated in all patients without a history of MI who have a reduced LVEF with no HF symptoms."

Implicit knowledge: absence of major Adverse Drug Event (ADE), contraindications

Explicit: In the absence of major ADE or contraindications, beta blockers are indicated...

• • • Formalization of concepts

Add vocabulary codes, refine scope of terminology, add temporal constraints

Text: "heart failure"

<u>Vocabulary codes</u>: Diagnostic codes (ICD 9) or Medication codes

Refine scope: "... except diastolic heart failure"

Add temporal constraints: In the last 12 months

• • • De-abstraction

Make abstract terms concrete for computation

Text: "reduced LVEF"

De-abstraction: LVEF <=40

• • Disambiguation

Clarify concepts with multiple interpretations and define mutually-exclusive values that can be measured

Text: "optimal therapy with ACEIs, beta blockers, and diuretics"

Disambiguation:

- Active prescriptions for *all* or *any* of ACE Inhibitor, beta blockers and diuretics?
- What is "optimal"? Need clarification from expert

Building Formal Statement

Translate narrative text into encodable statements

Text: "Beta blockers are indicated in all patients without a history of MI who have a reduced LVEF with no HF symptoms"

Formal: IF (absence of myocardial infarction) AND (LVEF <40) AND (absence of heart failure) AND (absence contraindications to beta blocker)

THEN recommend Beta blocker (atenolol)

• • Exercise!

ATP III content:

"For most patients with coronary heart disease and a baseline LDL cholesterol>=130mg/dL, an LDL lowering drug will be required to achieve an LDL cholesterol<100mg/dL."

Start by identifying the clinical concepts and applying the steps discussed earlier

• • Example

ATP III content:

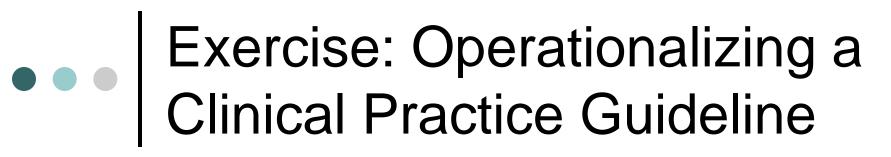
"For most patients with coronary heart disease and a baseline LDL cholesterol>=130mg/dL, an LDL lowering drug will be required to achieve an LDL cholesterol<100mg/dL."

• • Formal statement

ATP III content:

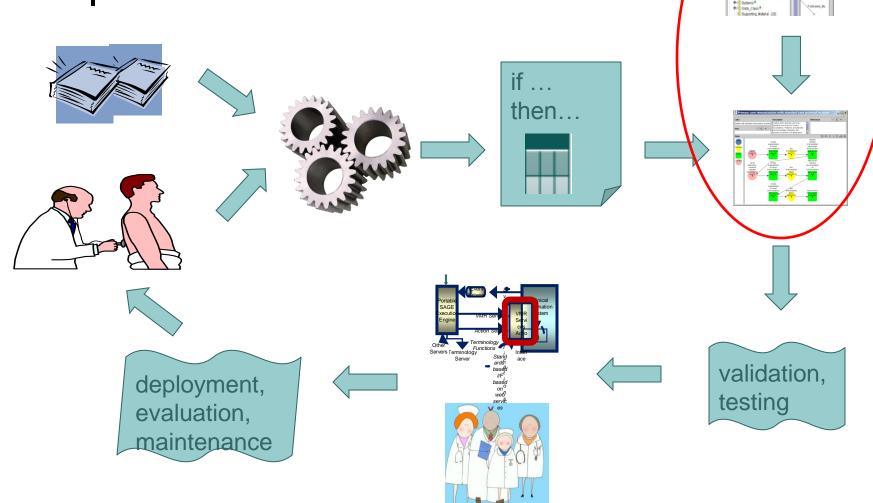
"For most patients with coronary heart disease and a baseline LDL cholesterol>=130mg/dL, an LDL lowering drug will be required to achieve an LDL cholesterol<100mg/dL."

IF (Not taking LDL-lowering drug) AND (LDL cholesterol (LOINC code)>=130) AND (presence of CHD(ICD9 codes)) AND (absence of contraindications to statin) THEN recommend (Statin)





Guideline Modeling Formalism



• • Course Outline

- 1. Introduction to clinical decision support
- 2. Clinical practice guidelines
- Operationalization of guideline recommendations
- 4. Guideline modeling formalisms
 - Arden Syntax and Medical Logic Module
 - Knowledge model approach
- 5. Application of encoded guideline to patient
- 6. Implementation exercise
- 7. Socio-technical issues
- 8. Standards

Dimensions of Guideline Modeling Formalisms

- How is the CDS invoked?
- How are the data acquired and structured?
- What are the modeling primitives?
- > How are decision criteria written?
- What interaction styles does it support?

Arden Syntax and Medical Logic Module

- An industry standard maintained by Health Level 7
- Organize decision knowledge as a collection of procedural rules (MLMs), written in Arden Syntax
- Each MLM designed to model knowledge required to make a single medical decision such as:
 - Contraindication alerts, management suggestions, data interpretations, treatment protocols, and diagnosis scores
- Can represent guidelines as a collection of MLMs (Starren, 1994), but management of related MLMs a problem

Knowledge Slots: Execution Logic of MLM

```
How is CDS invoked?
<Knowledge>
                                              - Data-driven trigger
   <Type>data-driven</Type>
   <Evoke>gentamicin_order;</Evoke>
   <Priority>50</Priority>
    <Data> creatinine_clearance := read last {creatinine_clearance } .... 
    <Logic> if creatinine_clearance < 30 then
      calc_daily_dose := 3 * (0.05 + creatinine_clearance / 100);
      ordered_daily_dose := periodic_dose * periodic_interval/(1 day);
     if (abs(ordered_daily_dose - calc_daily_dose)/calc_daily_dose > 0.2) then
       conclude true; endif; endif; </Logic>
   <Action>
    write "Due to renal insufficiency, the dose of gentamicin"
         "should be adjusted. A single dose of " ||
         calc_daily_dose || " mg should be given, ]]>
   </Action>
   <Urgency>50</Urgency>
  </Knowledge>
```

Knowledge Slots: Execution Logic of MLM

```
<Knowledge>
     <Type>data-driven</Type>
     <Evoke>gentamicin_order;</Evoke>
```

How are data acquired &structured?
- Assignment to variables using
"curly-braces" query into EHR

```
<Priority>50</Priority>
 <Data> creatinine_clearance := read last {creatinine_clearance } .... 
 <Logic> if creatinine_clearance < 30 then
   calc_daily_dose := 3 * (0.05 + creatinine_clearance / 100);
   ordered_daily_dose := periodic_dose * periodic_interval/(1 day);
   if (abs(ordered_daily_dose - calc_daily_dose)/calc_daily_dose > 0.2) then
    conclude true; endif; endif; </Logic>
 <Action>
  write "Due to renal insufficiency, the dose of gentamicin"
      "should be adjusted. A single dose of " ||
      calc daily dose | | " mg should be given, ]|>
 </Action>
 <Urgency>50</Urgency>
</Knowledge>
```

Knowledge Slots: Execution Logic of MLM What are the modeling primitives? -Procedural statements

```
<Knowledge>
                                             -Computer program-like expressions
   <Type>data-driven</Type>
                                             How are decision criteria written?
   <Evoke>gentamicin_order;</Evol
                                             - String syntax or XML
   <Priority>50</Priority>
    <Data> creatinine_clearance /:= read last {creatinine_clearance } .... 
    <Logic> if creatinine_clearance < 30 then</p>
      calc_daily_dose := 3 * (0.05 + creatinine_clearance / 100);
      ordered_daily_dose := periodic_dose * periodic_interval/(1 day);
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  </Knowledge>
```

Knowledge Slots: ExecutionLogic of MLM

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<Knowledge>
   <Type>data-driven</Type>
   <Evoke>gentamicin_order;</Evoke>
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       conclude true; endif; endif; </Logic>
   <Action>
    write "Due to renal insufficiency, the dose of gentamicin " ||
         "should be adjusted. A single dose of " ||
         calc_daily_dose || " mg should be given, ]]>
   </Action>
                                                  What interaction style does
   <Urgency>50</Urgency>
                                                  it support?
  </Knowledge>
                                                  - Push messages to user
```

Knowledge Model Approach to Encoding Guidelines

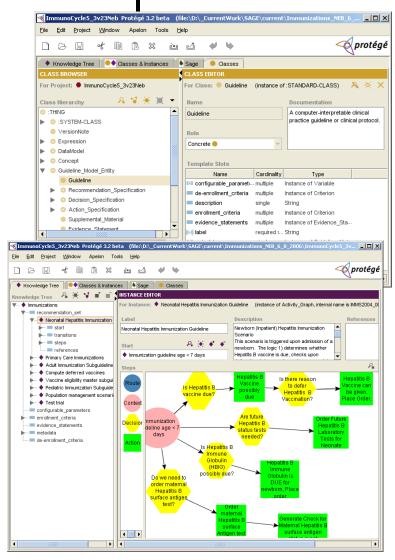
- Guideline Model
 - Computable representation of guideline recommendations
 - e.g. goals, risk categories, tasks (decisions, actions)
 - Often uses graphical networks to represent flow of guideline tasks
- Numerous modeling formalisms for representing guidelines
 - e.g., EON, PROforma, PRODIGY, GLIF, Asbru, GUIDE (Peleg 2003)
 - Make different design choice for representing guidelines
- Recurrent issue: Standardization

Two Example Formalisms: EON & PROforma

> EON

- National Library of Medicine funded project at Stanford
- Uses Protégé knowledge-engineering environment to facilitate encoding of guidelines and protocols
- The guideline modeling & execution technology used in ATHENA
- > PROforma: to be introduced later

EON Guideline Model and Modeling Environment

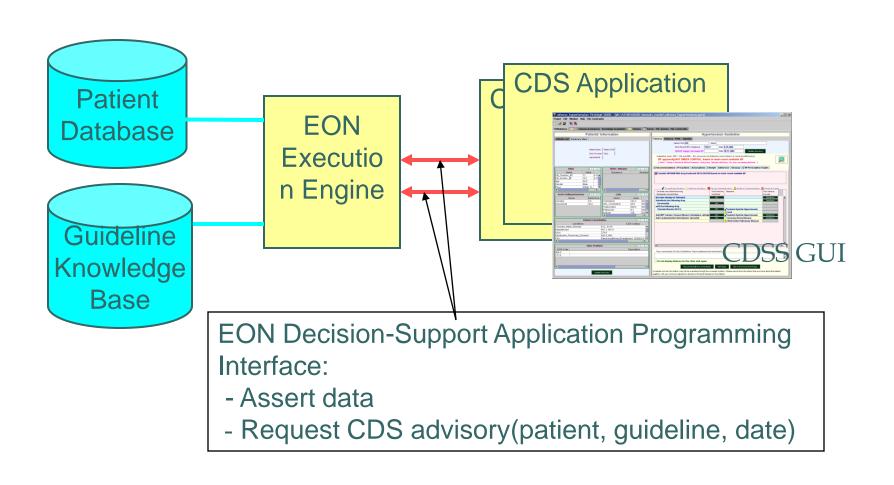


- Guideline model and instances created in Protégé
- Guideline model represented as a collection of classes and relationships among them
- Encoding a guideline (e.g. immunization guideline) means creating instances of these classes
- Protégé provides tool to specify guideline recommendations as directed graphs

Dimensions of Guideline Modeling Formalisms

- How is the CDS invoked?
- How are the data acquired and structured?
- How are decision criteria written?
- What are the modeling primitives?
- What interaction styles does it support?

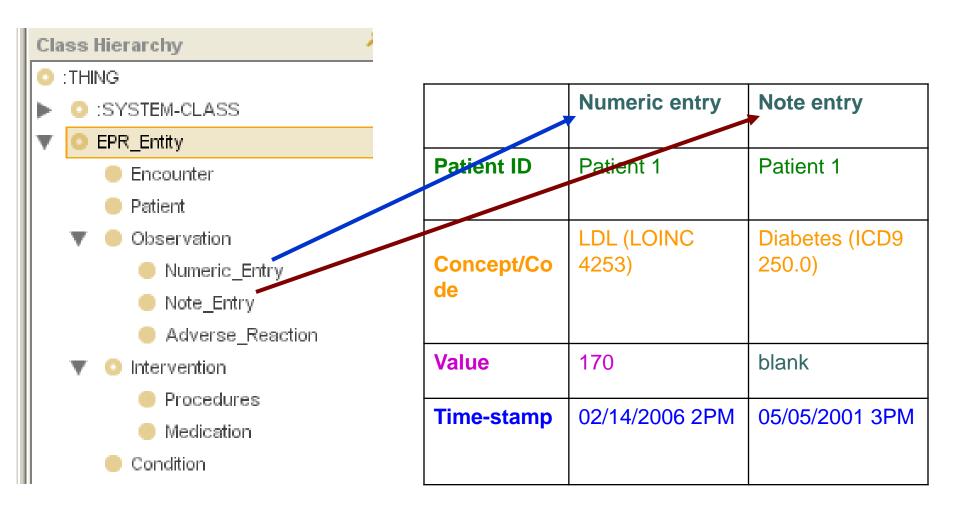
How is the CDS Invoked?



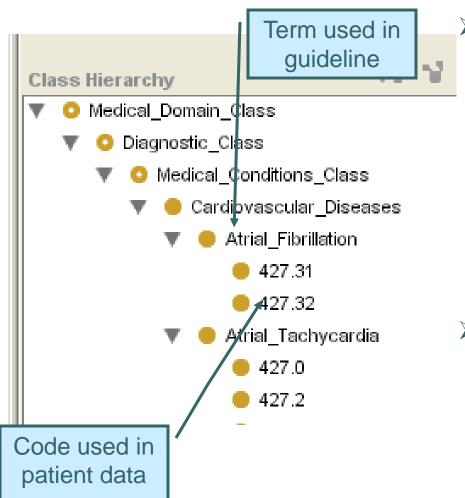
• • Structuring Patient Data

- Clinical statements about patient
 - "Patient 1 has diabetes"
 - "Patient 1's LDL cholesterol was 170mg/dl on 02/14/2006"
 - "Patient 1 is taking lisinopril 20 mg/day"
- Some high-level components:
 - Patient ID
 - Structured data element
 - Value
 - Drug name
 - Drug dose
 - Time-stamp

Patient Data Model



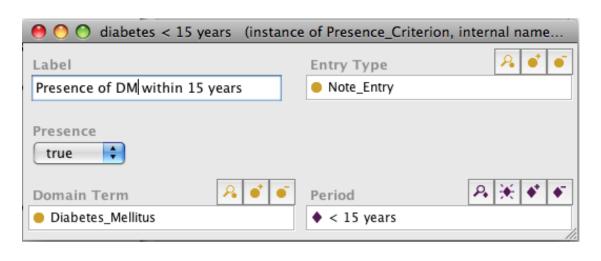
How Are Concepts Defined?



- Taxonomic hierarchy
 - Defines concepts used in guidelines
 - Maps guideline concepts to codes used in data
- Other CDS systems may use external terminologies

How are Decision Criteria Written?

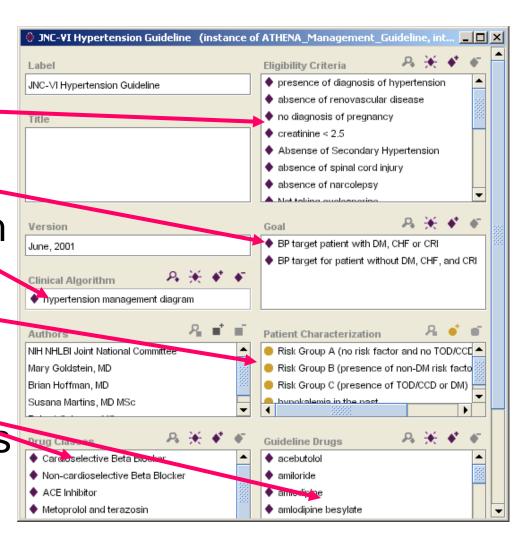
- Fill-in-blank templates to encode relatively simple expressions
- Other expression languages for complex criteria



Presence of DM within the last 15 years

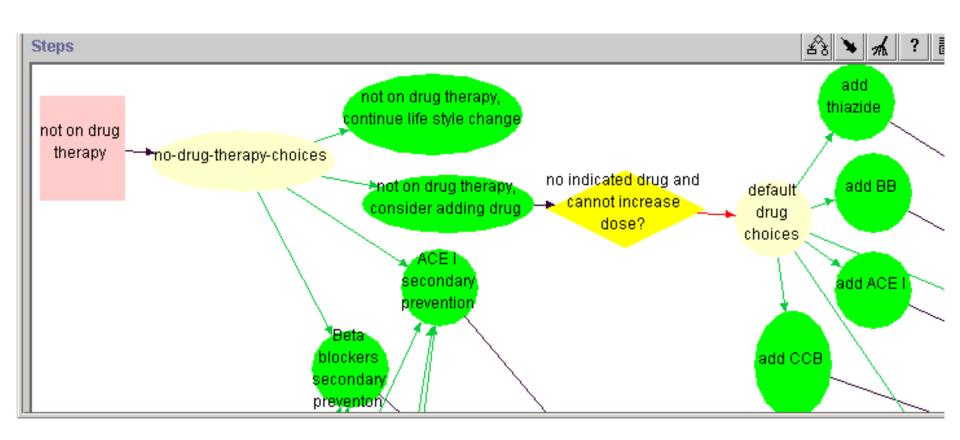
What Modeling Primitives are Available?

- Eligibility
- Goals
- Clinical algorithm
- Abstractions about patient
- Properties of treatment options

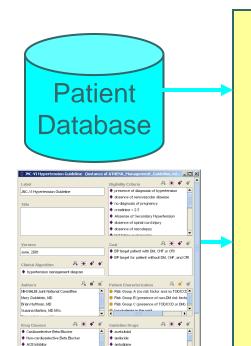


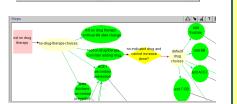
ATHENA HTN: Clinical Algorithm

scenario, decisions, action choices



What Interaction Styles Does EON Support?





EON Execution Engine

Patient satisfy eligibility criteria?

- Patient satisfy goal?
- Compute patient abstractions
- Evaluate clinical algorithm
 - * Which scenario fits the patient?
 - * What decisions need to be made?
 - * Evaluate alternatives
 - * Choose preferred alternatives
 - * Continue to traverse algorithm
- Return results as advisory

Request Guideline-based Advisory

CDS Application

Section Proposed Control of All Annual Control of Annual Control of

Return
Guideline-based
Advisory



• • PRO*forma* Guideline Model

- Developed by Advanced Computation Laboratory, Cancer Research UK, J. Fox
- Tools (authoring & execution): Arezzo, Tallis
- Grounded in a logical model of decision making and plan enactment
- Use: CDSS routinely used in domains including HIV, cancer care and postoperative pain management Sutton&Fox 2003; Fox &Das 2000

• • The PROforma GL model

- Main idea: a deliberately minimal set of modeling constructs (soundness, teaching)
- Tasks:



- All tasks share attributes describing goals, control flow (scheduling), preconditions, and post-conditions
- In the next slides, preconditions of tasks are displayed in blue on incoming arcs



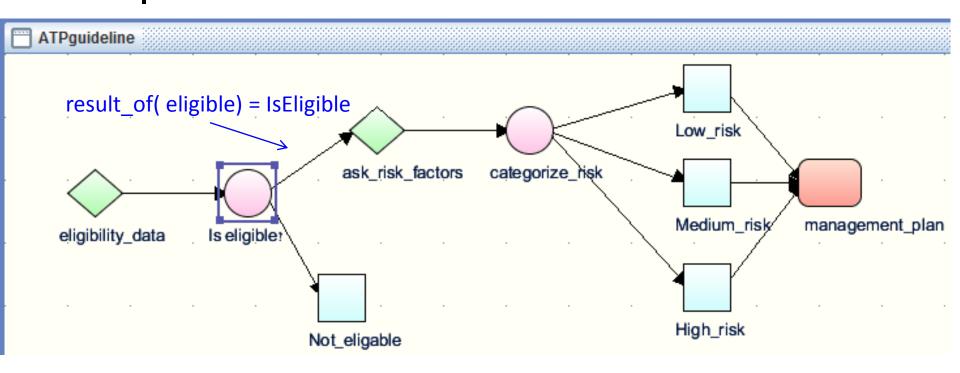
PROforma Decision

- Candidates: NotEligible, IsEligible
- > Arguments: (for, against, confirm, exclude)

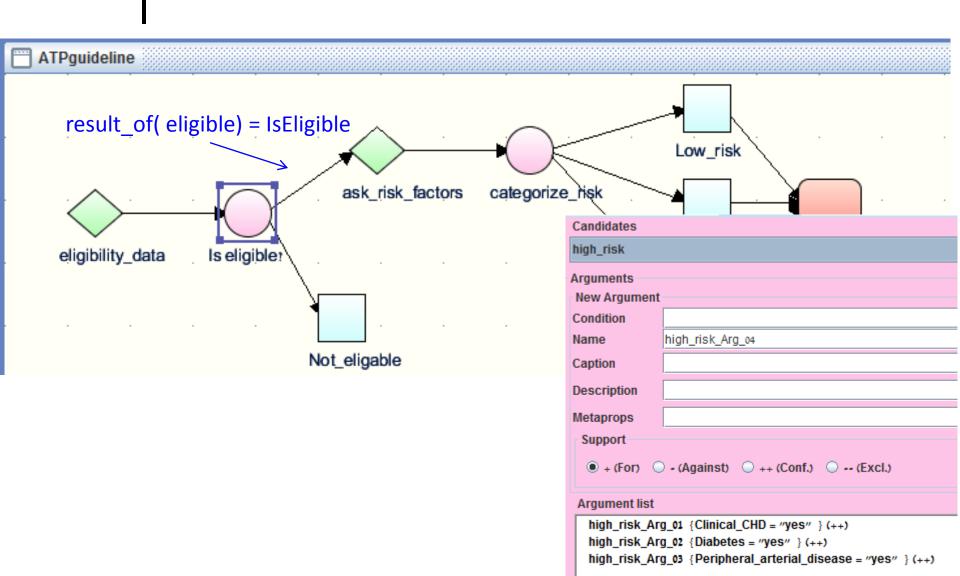
Candidate	Support	Condition
Eligible	For	Age>=18
Eligible	For	pregnancy= "no"
Candidate	Support	Condition
Not Eligible	Confirm	Age<18
Not Eligible	Confirm	pregnancy= "yes"

- Rules for recommending arguments
 - IsEligible: Netsupport >= 2
 - NotEligible: Netsupport >= 1

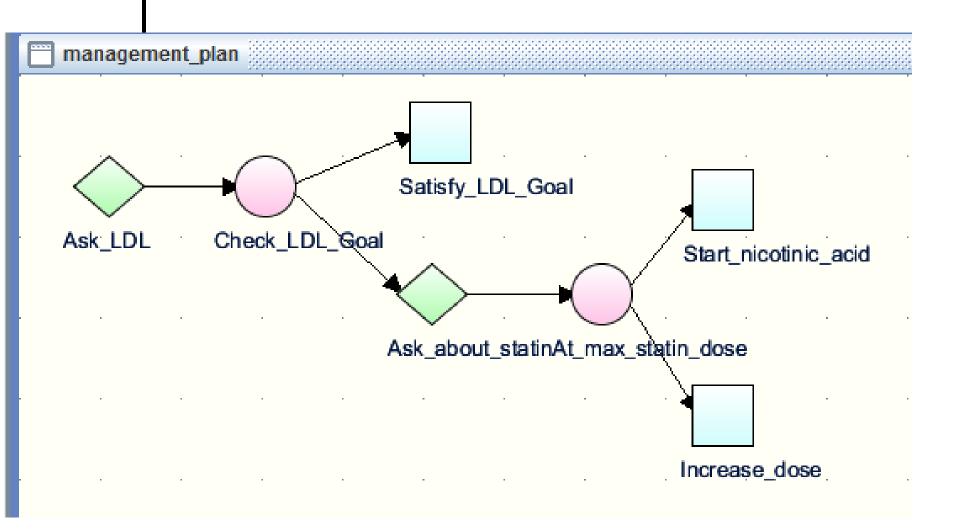
PROforma Modeling: Tallis



PROforma Modeling: Tallis



In-zooming of Management Plan



Tallis tool (web-based)

Many thanks to Prof. John Fox and Dr. Vivek Patkar from Oxford University





IRC in Coginitve Science & Systems Engineering



Tallis Web Enactment

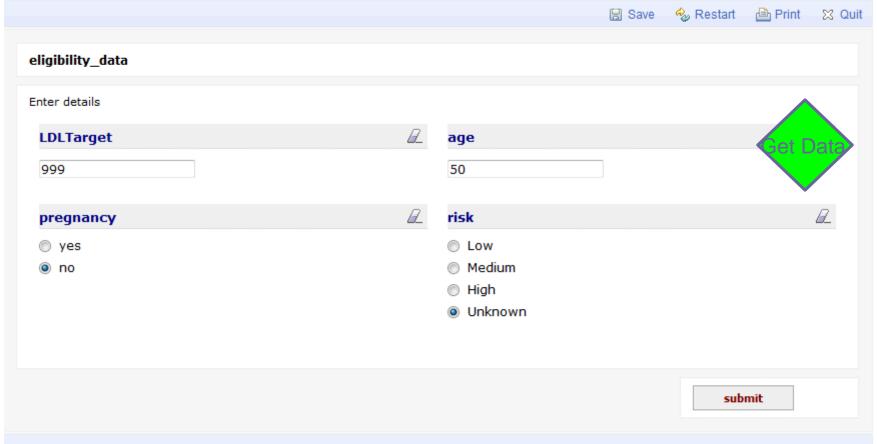


untitled				Save	🍫 Restart	📤 Print	⊠ Quit
Active tasks	eligibility_data						
▶ eligibility_data	chgibinty_data						
Triggerable tasks	Enter details						
No triggers available	LDLTarget		age				
Information							
Guideline summary	999						
Inspect engine state		7	atat.				0
Engine Data view	pregnancy	2	risk				
PROforma workflow	⊚ yes		○ Low				
PROforma task tree	⊚ no		Medium				
Actions			⊚ High				
Refresh engine			Unknown				
					sub	mit	
	Tallis suite - Web Enactme	nt © 2002 - 2011 cossac.org	& openclinical.net				

Tallis Technology | Discusion Forum | Feedback/Contact







Tallis suite - Web Enactment © 2002 - 2011 cossac.org & openclinical.net

Tallis Web Enactment









23 Quit

Is eligible?

Decision: Select the relevant intervention to link to arguments for and against

Candidates

- - ⊕ Age > 18
 - Not pregnant

There are no applicable arguments for that candidate.

Decision

commit

Tallis suite - Web Enactment @ 2002 - 2011

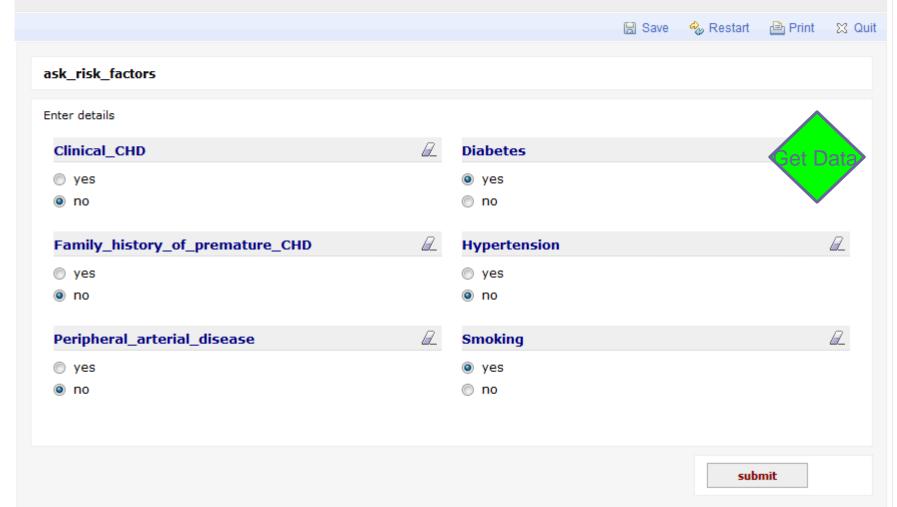
Tallis Technology | Discusion For

Clinician may decide to choose the other alternative

13.

















categorize_risk

Decision: Select the relevant intervention to link to arguments for and against

Candidates

- - Diabetes
- X ⊚ low_risk ⊞
 - ⊕ Age > 45
 - Smoker
 - Diabetes = yes
- X ⊚ medium_risk ⊞
 - Smoking
 - Diabetes
 - ⊕ Age > 45



commit













High_risk

Conclude high risk and LDLTarget < 100



confirm

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23 Quit

Check_LDL_Goal

Decision: Select the relevant intervention to link to arguments for and against

Candidates

- - UDL > = LDL target
 - Satisfy_LDL_Goal

 ⊕

There are no applicable arguments for that candidate.



commit

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12











X Quit

At_max_statin_dose

Decision: Select the relevant intervention to link to arguments for and against

Candidates

- √

 ⑤ Start_nicotinic_acid

 ⊞
 - At_maximum_statin_dose = "yes"
 - Taking_statin = "yes"

 - Taking_statin = "yes"



commit

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12





LEGEND

The protocol has completed

Tasks completed during enactment

- High_risk
- ◆ ask_risk_factors ⊞
- ♦ eligibility_data ⊞
- Start_nicotinic_acid
- At_max_statin_dose ⊞
- ◆ Ask_about_statin ⊞
- Ocheck_LDL_Goal ⊞
- ◆ Ask_LDL ⊞

Tasks discarded during enactment 🖽







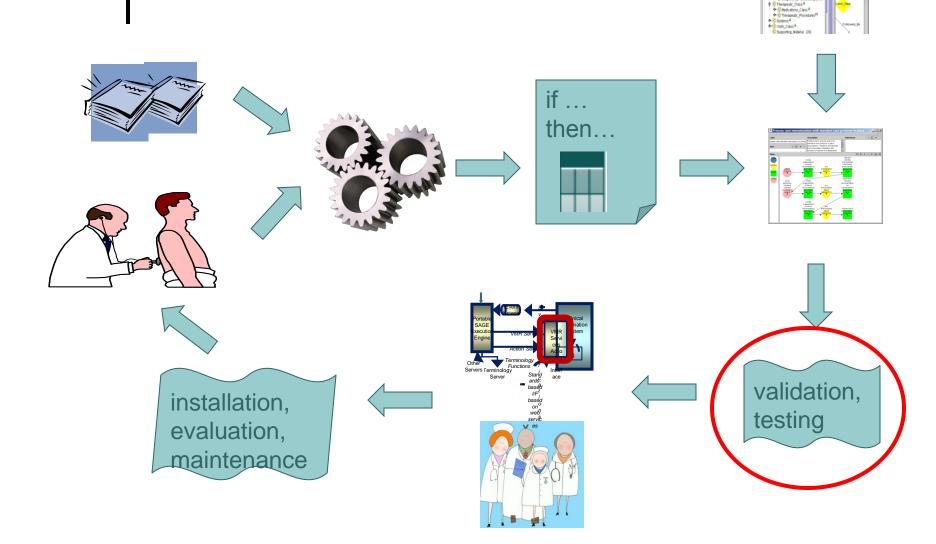
Discussion of differences between EON and PROforma

- Ease of learning
 - How easy is it to learn the model semantics?
- Semantic elements
 - Can you answer the question: what are the eligibility criteria?
- Domain-specificity
 - Can you encode a guideline in a non-medical domain?

More information about guideline models and tools

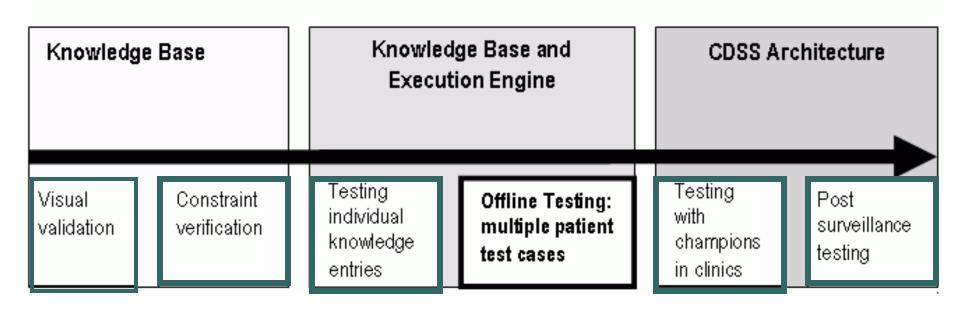
...could be found at openclinical.org

Validation and Testing



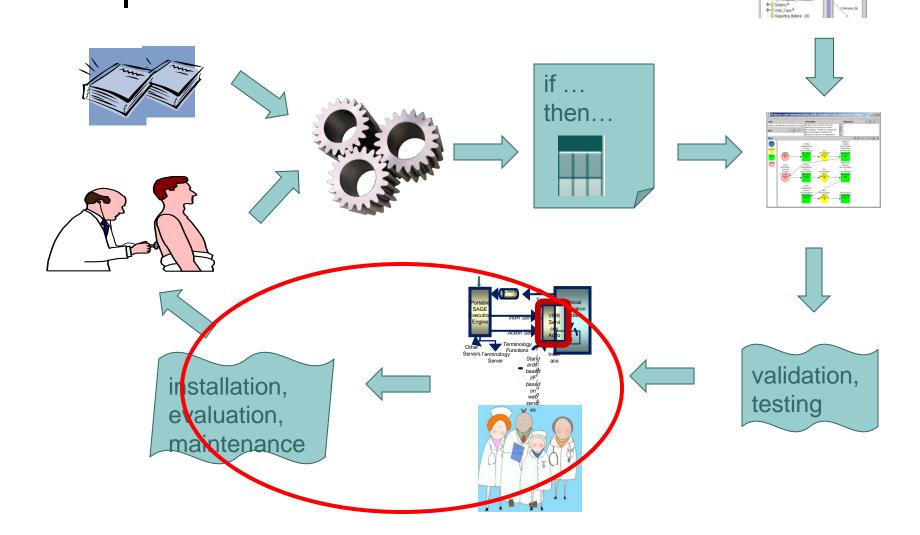
• • Step by Step Testing

Testing phases in the development of a CDSS



Martins, SB, Lai, S, Tu, S, Shankar, R, Hastings, SN, Hoffman, BB, et al. Offline testing of the ATHENA Hypertension decision support system knowledge base to improve the accuracy of recommendations. AMIA Annu Symp Proc 2006:539-43.

Implementation Issues



• • Implementation Exercise

Small group discussion (see next page for instruction)

Group discussion of the exercise





• • Course Outline

- 1. Introduction to clinical decision support
- 2. Clinical practice guidelines
- Operationalization of guideline recommendations
- 4. Guideline modeling formalisms
- 5. Application of encoded guideline to patient
- 6. Implementation exercise
- 7. Socio-technical issues
- 8. Standards

Knowing and Doing

"If to do were as easy as to know what were good to do, chapels had been churches and poor men's cottages princes' palaces."

Portia, Act I, Merchant of Venice, Shakespeare

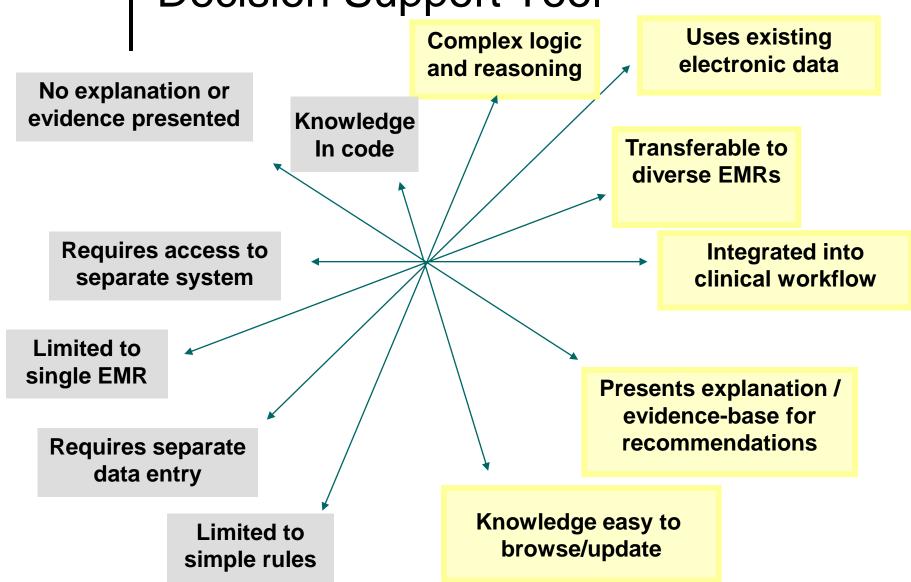
"Knowing is not enough; we must apply. Willing is not enough; we must do."

Goethe

From Evidence
to Patient
Care: Decision
Support with
Actionable
Guidelines



Additional Dimensions of Decision Support Tool



Decision Support for Common Chronic Diseases

The physician often seen as wondering about a clinical question and then seeking out decision support:



The "Field of Dreams" approach to medical informatics implementations:

If you build it, they will come

• • Effects of CDSS - Earlier

"Many CDSSs improve practitioner performance. To date, the effects on patient outcomes remain understudied and, when studied, inconsistent."

Systematic review, Garg et al, JAMA, 2005

- "..a leading CPOE system often facilitated medication error risks...must attend to errors that these systems cause in addition to errors that they prevent..."
 - Koppel et al, JAMA, 2005

Recent Evidence Syntheses: Effect of Clinical Decision Support Systems

- CDS systems are effective at improving health care process measures across diverse settings, though evidence for efficiency outcomes remains sparse¹
- On-screen point of care clinical reminders achieve improvements in provider behavior²
- CDS can improve care processes and patient health in chronic disease management and acute medical care^{3,4}
 - 1. Bright Ann Intern Med 2012
 - 2. Shojania *Impl Sci* 2011
 - 3. Roshanov Impl Sci 2011
 - 4. Sahota Impl Sci 2011

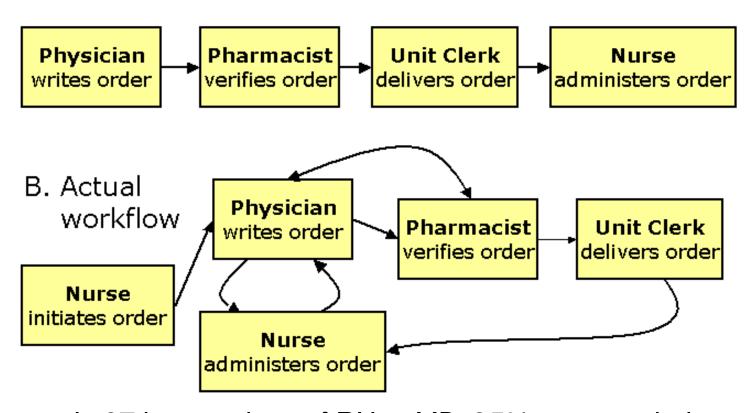
Addressing Human Factors Issues: Cognitive Tasks Analyses

- Observation of the initial use of CPOE in an intensive care unit
 - Actual workflow does not follow computer model
 - In 97 interruptions of RN to MD, 25% were reminders to enter computer orders

The effects of CPOE on ICU workflow. CH Cheng, et al. AMIA Annu Symp Proc. 2003

Entering and interpreting orders

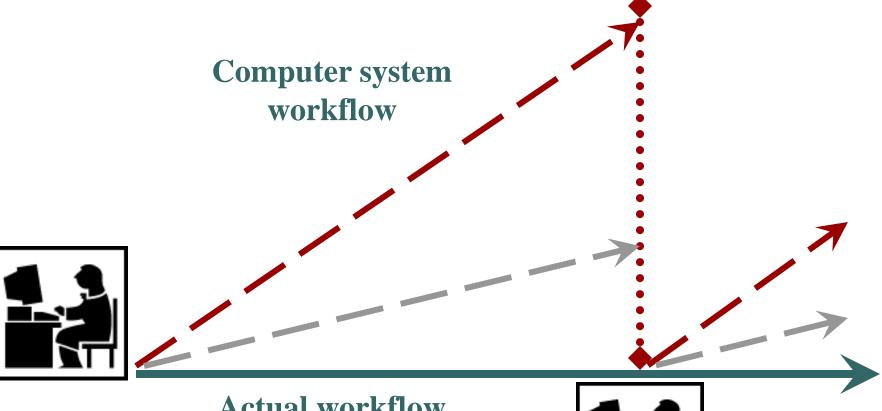
A. CPOE conceptualization of workflow



In 97 interruptions of RN to MD, 25% were reminders

The effects of CPOE on ICU workflow. CH Cheng, et al. AMIA Annu Symp Proc. 2003

CPOE workflow should resemble actual workflow

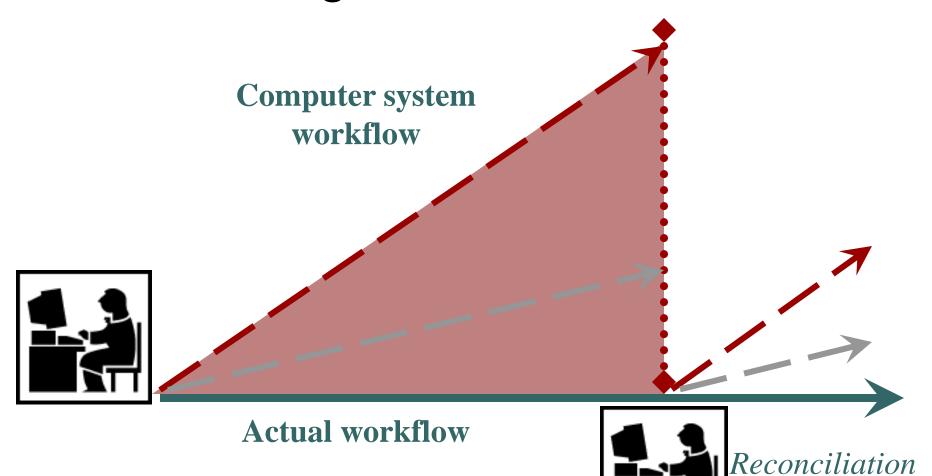


Actual workflow

Slide courtesy of Carol Cheng Cain



Computer system workflow diverges from actual workflow



Slide courtesy of Carol Cheng Cain

The Modern Problem of TMI

- "Too much information"
 - "...the Devil of Information Overload and his impish underlings the computer virus, the busy signal, the dead link..." (Gleick, The Information)
 - Reminder fatigue
 - Replicating chart notes
 - How to find the new info? How to review them all?
 - Displays with too many items to monitor, too many false alarms
 - Space shuttle, aviation

Designing for Safety

Computer systems can affect human problem solving and lead to errors/ unintended consequences

- Data overload
- "automation surprises"
- Unobservable automated actions
- Missing data
- Inaccuracies in program inputs or logic
- Rearranging clinician priorities
- Generating false expectations
 - Goldstein, M.K., B.B. Hoffman, R.W. Coleman, S.W. Tu, R.D. Shankar, M. O'Connor, S. Martins, A. Advani, and M.A. Musen, *Patient safety in guideline-based decision support for hypertension management: ATHENA DSS. JAMIA*, 2002. 9(6 Suppl): S11-6.
 - full text available through pubmedcentral

Designing for People

Example design consideration:

When is that right time in the workflow to provide information?

Automatic vs deliberative modes of work

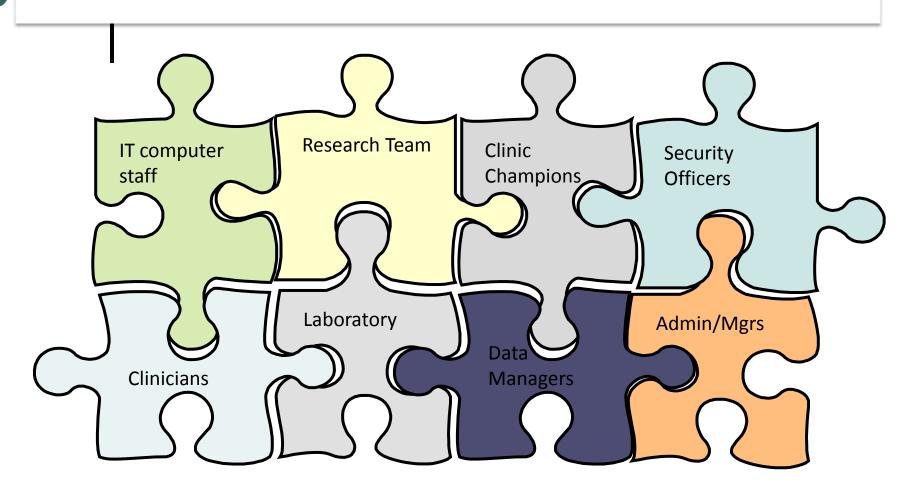
• • Goal for Developers

- Computers to do the things that computers do well
 - For example, search, retrieve, compare, count, compute logical algorithms
- To assist people, to free time for people to do what people do well
 - For example, interact with other people, detect emotional cues, weigh alternatives, communicate, make judgments about what to do

• • Socio-Technical

- Berg, M., Rationalizing Medical Work: Decision-Support Techniques and Medical Practices. Inside Technology, ed. W.E. Bijker, W.B. Carlson, and T. Pinch. 1997, Cambridge, Massachusetts: The MIT Press.
- Berg, M., Patient care information systems and health care work: a sociotechnical approach. Int J Med Inf, 1999. 55(2): p. 87-101.

Working with Stakeholders: "SocioTechnical" Aspect

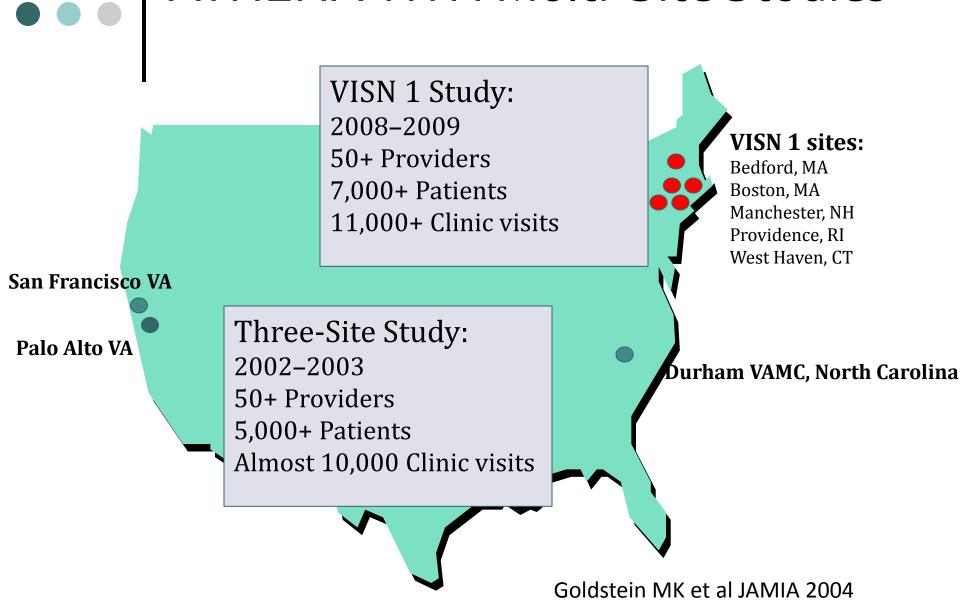


Berg, M. Rationalizing Medical Work. MIT Press 1997

Berg, M. Pt care info systems and health care work: a sociotechnical approach.

Int J Med Inform 1999

ATHENA-HTN Multi-Site Studies



• • Recommendations

- Use a conceptual model to guide the implementation
 - Include stakeholders
- Design for Safety
- Test for usability
 - Include real-world settings
- Monitor after deployment

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• • Why Standards?

Allows plug-and-play of components

Need for Standardizing Data Model

Observation

Code = BP

Value = 120/80 mmHg

Blood Pressure

Systolic = 120 mmHg

Diastolic = 80 mmHg

Observation

Code = BP

Observation

Code = SBP

Value = 120 mmHg

Observation

Code = DBP

Value = 80 mmHg

Vital Sign

Type = BP

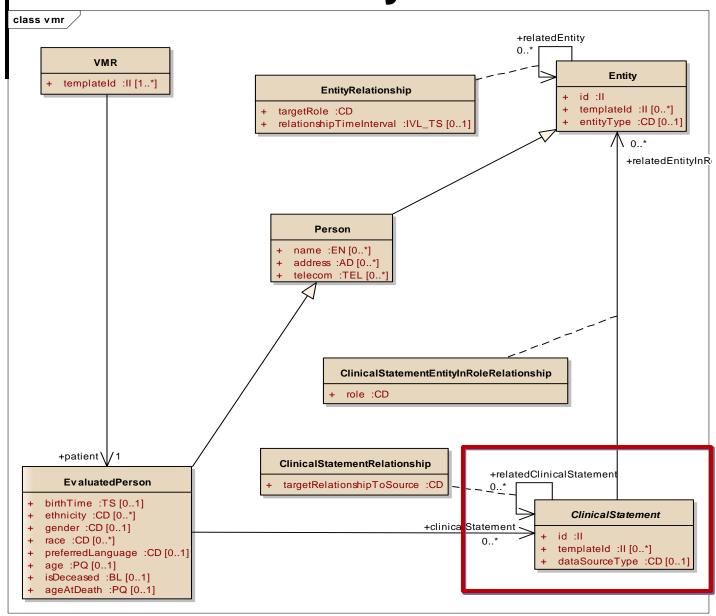
Value = 120/80

Units = mmHg

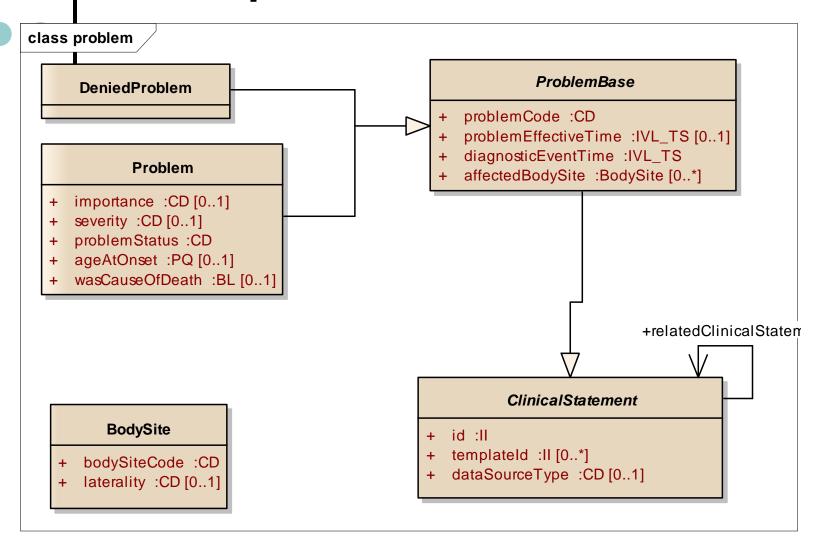
Health Level 7 Virtual Medical Record

- Virtual Medical Record (vMR)
 - Standardized information model for CDSS (Johnson, 2001)
 - Allows CDSS decision criteria to be formulated in terms standard queries
- Health Level 7 International
 - Standard developing organization
 - V3 Reference Information Model specifies the "grammar" of HL7 messages, including data type definitions
- Standard vMR being developed in HL7

HL7 vMR Balloted as a Domain Analysis Model



Example Clinical Statement



• • Standardization: GELLO

- Health Level 7 Standard expression language for decision support
- Expressive but complex
- No available standard implementation

Presence of Diabetes Mellitus within the last 3 months

Let diabetes: CodedValue = Factory.CodedValue ("SNOMED-CT", "73211009")

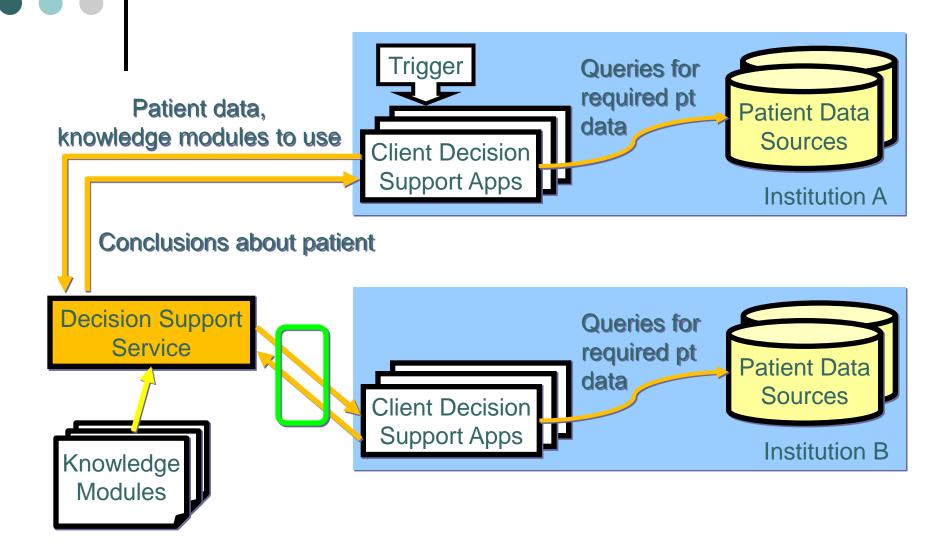
. .

Observation → exists(code.equal(finding) and value.implies(diabetes) and effective_time.intersect(ThreeMonthsAgo, PointInTime.NOW()))

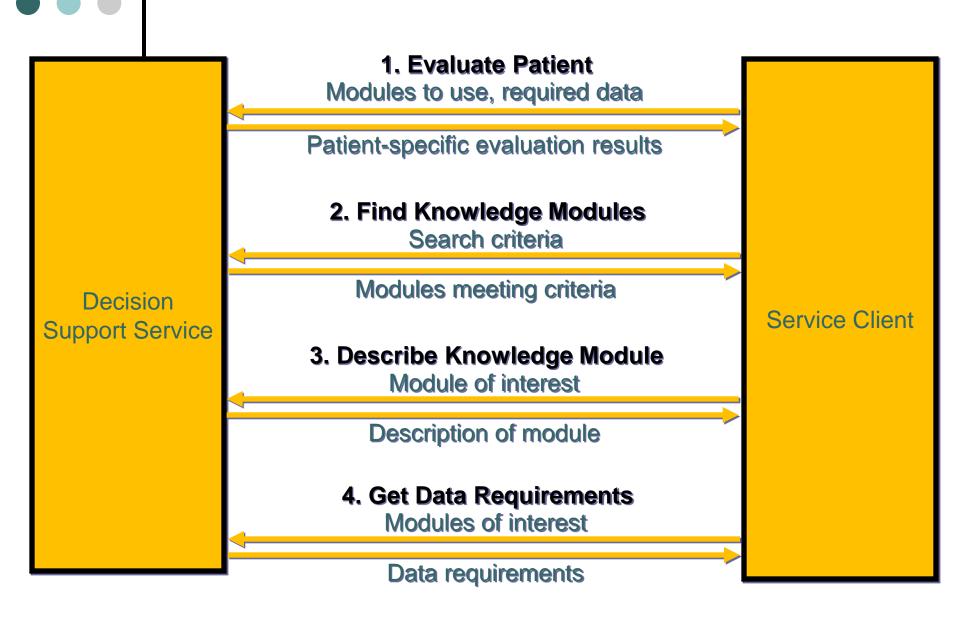
Standardization of Decision Support Service (DSS)

- Business purpose:
 - To facilitate implementation and maintenance of clinical decision support (CDS) applications
- Approach:
 - Evaluates patient data (inputs) using knowledge modules and returns machineinterpretable conclusions (outputs)
- Normative HL7/ANSI standard developed in collaboration with Object Management Group (OMG)

DSS – Architectural Overview



DSS – Primary Service Operations



Standard-Based CDS Deployment: OpenCDS

- Standard interfaces and data models
 - Reference implementation of HL7/OMG DSS interface
 - vMR data model
 - Data mappers (e.g., for CCD → vMR)
- Reference DSS knowledge management framework
 - JBoss Drools and associated authoring/knowledge management tools
 - Full-featured terminology support
 - Knowledge repository and knowledge sharing service
- DSS "wrappers" for other CDS engines

OpenCDS: http://www.opencds.org

• • Course Outline

- Introduction to clinical decision support
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- 5. Application of encoded guideline to patient
- Deployment of CDS
- 7. Socio-technical issues
- 8. Standards