Modeling Guidelines for Integration into Clinical Workflow

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SAGE: Standards-Based Active Guideline Environment

- 3-year US NIST Advanced Technology Program grant
- IDX leads R&D consortium that includes as partners:
  - Apelon, Inc.
  - Intermountain Healthcare (IHC)
  - Mayo Clinic
  - University of Nebraska Medical Center (UNMC)
  - Stanford Medical Informatics (SMI)
- Ultimate goal: An infrastructure that will allow execution of standards-based clinical practice guidelines across heterogeneous clinical information systems (CIS)
- Focus is on the goal of deployment of guideline knowledge within the workflow of clinical information systems
Consider adding an ACE Inhibitor because of a compelling indication (heart failure)
“Clinical decision support must be integrated with workflow”

- Alert and reminders “must appear either at the appropriate time for consideration and action, or in a manner in which the user can determine if and when to evaluate and respond to it” (Krall, AMIA 2002)
- “…most valuable workflow support would come from automated documentation of interval assessment...Examination of action boxes suggests additional areas for workflow support...” (Shiffman, SCAMC 1994)
- “…a workflow management system (WFMS) could be a suitable tool to fully implement a GL and to control both its execution and outcome” (Quaglini, AIM 2000)
Problem: How to Create Computer-Interpretable Guideline Knowledge Base so that the DSS Supports Clinical Workflow

Initial Drug Choices

- Uncomplicated Hypertension
- Diabetes
- Beta blockers

Specific Indications for the Following Drugs (see table 9)
- ACE inhibitors
- Angiotensin II receptor blockers
- Alpha-blockers
- Calcium antagonists

Guideline Modeling Process

Patient Data

Guideline Decision-Support System

Consider adding an ACE Inhibitor because of a compelling indication (heart failure)
SAGE Approach: Deployment-driven Guideline Modeling
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guideline literature
SAGE Approach: Deployment-driven Guideline Modeling
SAGE Approach: Deployment-driven Guideline Modeling

1. Clinical scenarios
   - Guideline literature

2. Guideline logic
SAGE Approach: Deployment-driven Guideline Modeling
SAGE Approach: Deployment-driven Guideline Modeling

1. Clinical Scenarios
2. Guideline Logic
3. Concepts in Guideline Logic
4. Vocabulary Inventory

- Guideline Literature
- Reference Terminology
SAGE Approach: Deployment-driven Guideline Modeling

1. Clinical scenarios
2. Guideline logic
3. Concepts in Guideline logic
4. Virtual medical record
   - Reference terminology
5. Clinical expression models

- Guideline literature
- Clinical scenarios
SAGE Approach: Deployment-driven Guideline Modeling

1. Clinical scenarios
2. Guideline logic
3. Concepts in Guideline logic
4. Virtual medical record
5. Clinical expression models
6. Vocabulary inventory

The diagram illustrates the process of guideline modeling, starting with clinical scenarios and literature, leading to guideline logic and eventually forming a guideline model.
SAGE Approach: Deployment-driven Guideline Modeling

1. clinical scenarios → guideline literature
2. guideline logic
3. concepts in Guideline logic
4. virtual medical record reference terminology
5. clinical expression models vocabulary inventory
6. guideline KB

guideline model

execution
Today’s Talk:

1. Clinical scenarios
2. Guideline logic
3. Concepts in Guideline logic
4. Virtual medical record
5. Reference terminology
6. Vocabulary inventory
7. Guideline KB
8. Guideline model
Deployment-Driven Guideline Modeling

- Assumption: Guideline DSS is reactive
  - Not in control of clinical workflow
  - Respond to external events (including passage of time)
- Methodology
  - Empirically define points in care processes where guideline DSS may provide services
  - Discover characteristics of human-computer interactions that enhances prospect of acceptance
- Method used in SAGE
  - Create scenarios that walk through steps of care process
  - Create prototype GUI for validation in usability lab
• Patient arrives for visit with primary physician. At check-in, SAGE checks for immunizations that are due, alerts nurse, prints consents and information sheets. Nurse then reviews any other shots received, updates the record, and SAGE pre-order immunizations to be given that day.
Usability Testing

- Develop mock-up forms with simulated decision-support interactions
- Prototypes tested by clinicians in Mayo usability lab
Results of Scenario Development

- Defines **events** that SAGE must respond to and **guideline-based actions** that SAGE should generate
- Defines **timing, form, and content** of decision-support services

![Diagram showing workflow scenarios with events, guidelines, and SAGE interaction]
Results of Scenario Development

- Defines events and actions that SAGE must respond to and generate
- Defines form and content of decision-support services
- Define what guideline knowledge must be encoded and what data must be queried.
Distillation of Guideline Logic

“checks for immunizations that are due”

IF AGE < 19 YEARS and no contraindication to Hep B AND No reason for deferral AND Number Hep B VACCINE DOSES = 3 AND 1ST DOSE GIVEN WITHIN 7 DAYS OF BIRTH AND 3RD DOSE GIVEN BEFORE 6 MONTHS AGE AND TIME FROM LAST DOSE IS >= 8 WEEKS THEN ADVISE HEP B VACCINE DUE
Develop Vocabulary Inventory

- Guideline concepts must be extracted from guideline logic
- Guideline concepts need to be operationalized in terms of reference terminologies
  - Contextualization
  - De-abstraction
  - Disambiguation
- Reference terminologies need to be extended
  - Post-coordination
  - Concept expressions

**chronic pulmonary disease excluding asthma** =

(`'Chronic respiratory disease: 17097001' AND 'Disease of lower respiratory system:128272009') AND NOT 'Asthma:195967001'
Define “Clinical Expression Models”

- How are statements about patient represented in a clinical information system (CIS)?
  - “Anaphylactic reaction to vaccine”
  - Virtual medical record (VMR): Simplified view of patient data used by the DSS
  - VMR class ‘Allergy’ class that has attributes such as ‘code,’ ‘allergen,’ ‘reaction,’ and ‘effective time’
  - Clinical expression model
    Allergy where
    - code is ‘vaccines allergy’ (or its subconcepts)
    - allergen is ‘vaccine’ (or its subconcepts)
    - reaction is ‘anaphylaxis’ (or its subconcepts)
Top-level process description in encoded guideline reflect expected reactions to events in clinical workflow.
SAGE Context Model

Context nodes organize and specify the relationship to workflow. They record:
- What triggers or begins session
- Who is involved
- Where the session occurs
- What resources are required
- Clinical Information processing
Decision Knowledge Encoded in Sub-guidelines

Can be thought of as reusable subsets of guideline logic for repeated use within a recommendation set
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Can be thought of as reusable subsets of guideline logic for repeated use within a recommendation set.
Results

• Applied methodology (including execution stage) to exemplar guidelines:
  • Immunization, diabetes (completed)
  • Community-acquired pneumonia (in progress)

• Retrospectively verified that the deployment-driven methodology is consistent with the development process of the ATHENA hypertension DSS
• “Deployment-driven” guideline modeling versus “document-driven” guideline modeling
  • Encoding of narrative guideline for decision-support use cases is a highly selective process
  • Necessary medical knowledge is synthesized from different parts of a guideline and from multiple sources
• Top-level process descriptions in executable guideline are highly dependent on workflow
  • Contrast: GLIF modeling assume successive refinement from high-level conceptual flowchart to computable formalism and finally to implementation
Thank you
Integration of SAGE Decision-Support System with Clinical Information System

CIS (CareCast)

- VMR Services
- Action Services

Event Notification

- Event Listener

VMR Service Calls

Terminology Server

Action Service Calls

SAGE Execution Engine and Guideline Knowledge Bases
Alert and reminders “must appear either at the appropriate time for consideration and action, or in a manner in which the user can determine if and when to evaluate and respond to it” (Krall, AMIA 2002)

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