Modeling Guidelines for Integration into Clinical Workflow

Samson W. Tu

Stanford Medical Informatics

Stanford University School of Medicine

Mark A. Musen, Ravi Shankar, James Campbell, Karen Hrabak, James McClay, Stanley M. Huff, Robert McClure, Craig Parker, Roberto Rocha, Robert Abarbanel, Nick Beard, Julie Glasgow, Guy Mansfield, Prabhu Ram, Qin Ye, Eric Mays, Tony Weida, Christopher G. Chute, Kevin McDonald, David Mohr, Mark A Nyman, Sidna Scheital, Harold Solbrig, David A Zill

Apelon, Inc., IDX Systems Corporation, Intermountain Health Care, Mayo Clinic, University of Nebraska Medical Center, Stanford Medical Informatics

Mary K Goldstein

VA Palo Alto Health Care System and Stanford University School of Medicine

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

Decision Support For Guideline Based Care

Begin or Continue Lifestyle Modifications

Not at Goal Blood Pressure (<140/90 mm Hg)

Lower goals for patients with diabetes or renal disease (see chapter 4)

Initial Drug Choices*

Uncomplicated Hypertension†	***Compelling Indications†***
Diuretics	Diabetes mellitus (type 1) with proteinuria
Beta-blockers	• ACE inhibitors
	Heart failure
Specific Indications for the Following Drugs (see table 9)	• ACE inhibitors
ACE inhibitors	• Diuretics
Angiotensin II receptor blockers	Isolated systolic hypertension (older persons)
Alpha-blockers	• Diuretics **preferred**
Alpha-beta-blockers	• Long-acting dihydropyridine calcium antagonists
Beta-blockers	Myocardial infarction
Calcium antagonists	• Beta-blockers (non-ISA)
Diuretics	• ACE inhibitors (with systolic dysfunction)

- Start with a low dose of a long-acting once-daily drug, and **titrate dose**.
- Low-dose combinations may be appropriate.

Not at Goal Blood Pressure

Patient Data

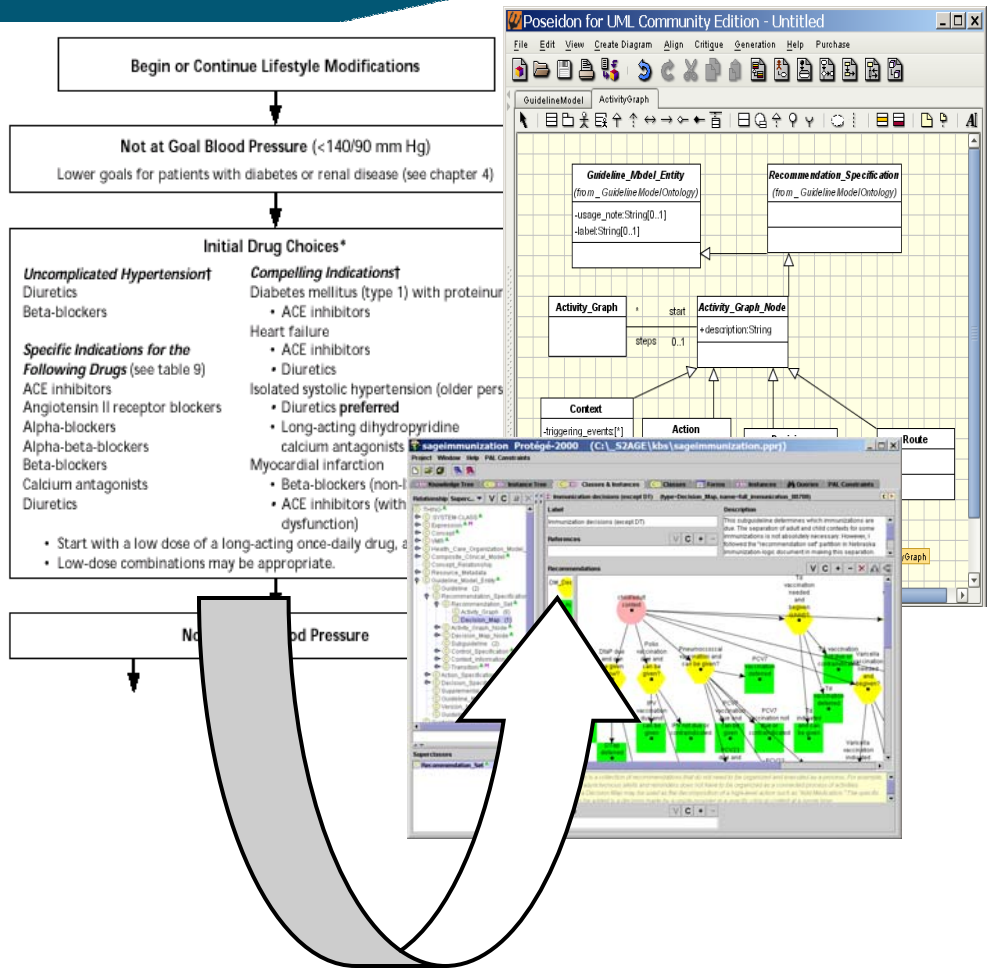
Guideline Decision-Support System

Consider adding an ACE Inhibitor because of a compelling indication (heart failure)

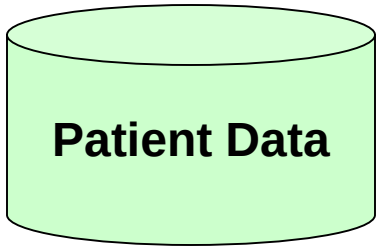
“Clinical decision support must be integrated with workflow”

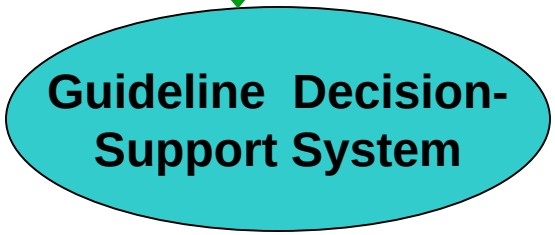
- Alert and reminders “must appear either at the appropriate time for consideration and action, or in a manner in which the user can determine if and when to evaluate and respond to it” (Krall, AMIA 2002)
- “…most valuable workflow support would come from automated documentation of interval assessment…Examination 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



Guideline Modeling Process

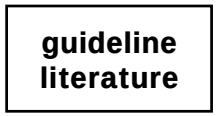




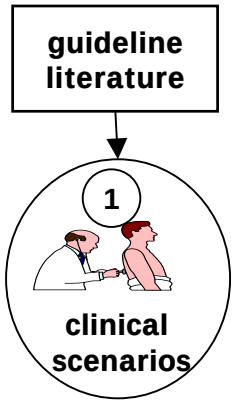
Consider adding an ACE Inhibitor because of a compelling indication (heart failure)

SAGE Approach: Deployment-driven Guideline Modeling

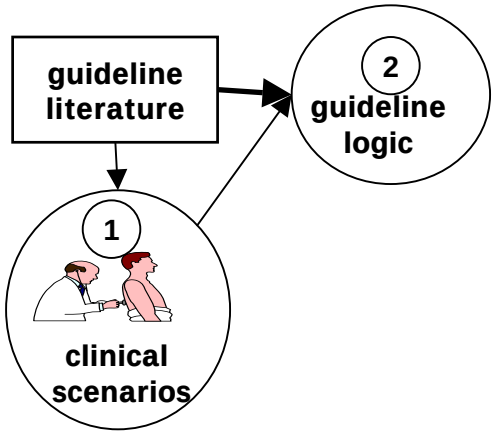
SAGE Approach: Deployment-driven Guideline Modeling



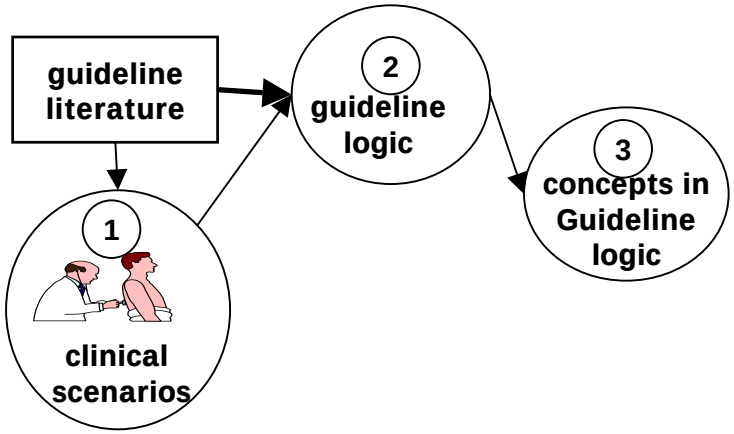
SAGE Approach: Deployment-driven Guideline Modeling



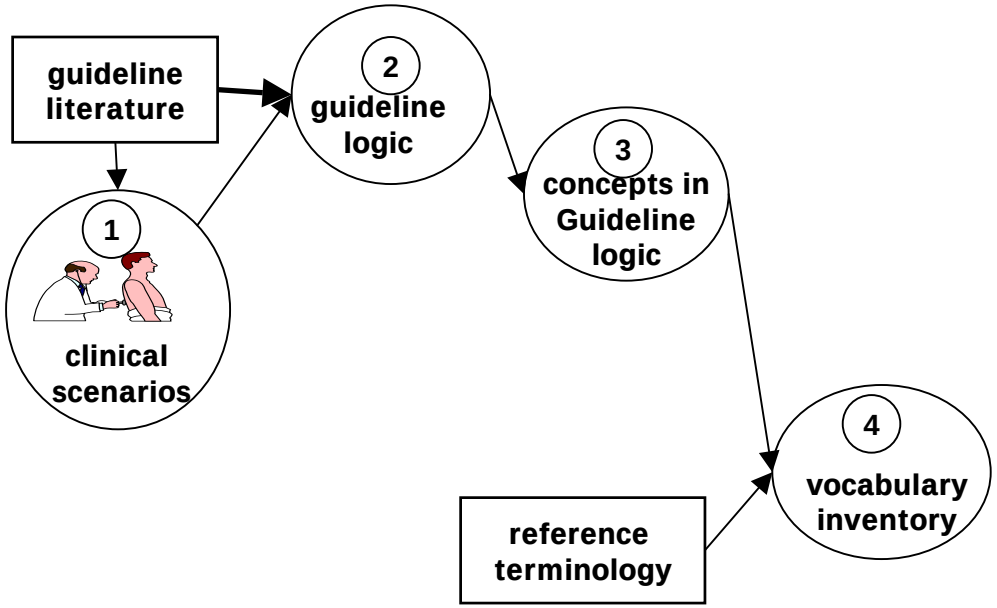
SAGE Approach: Deployment-driven Guideline Modeling



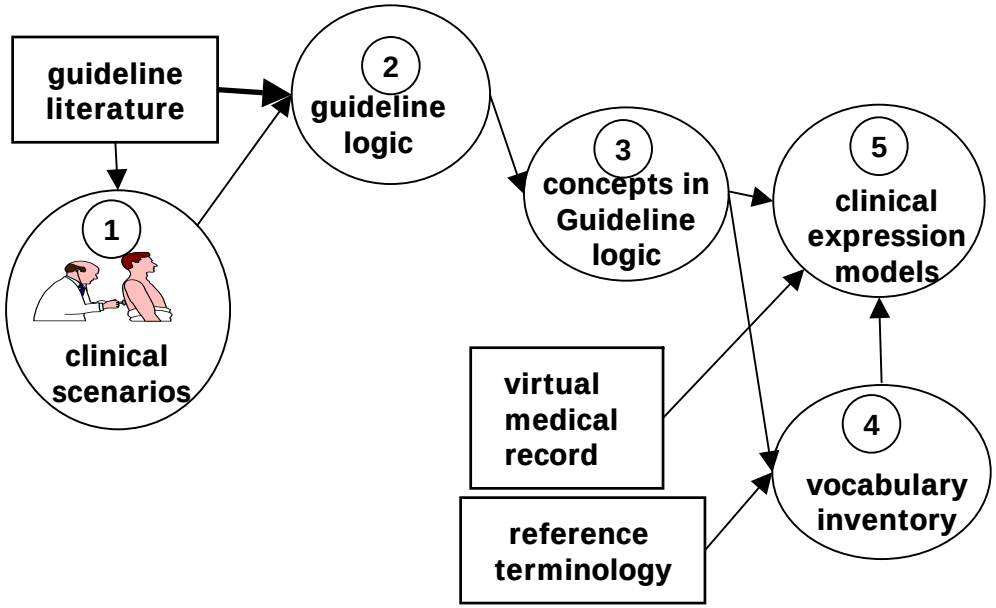
SAGE Approach: Deployment-driven Guideline Modeling



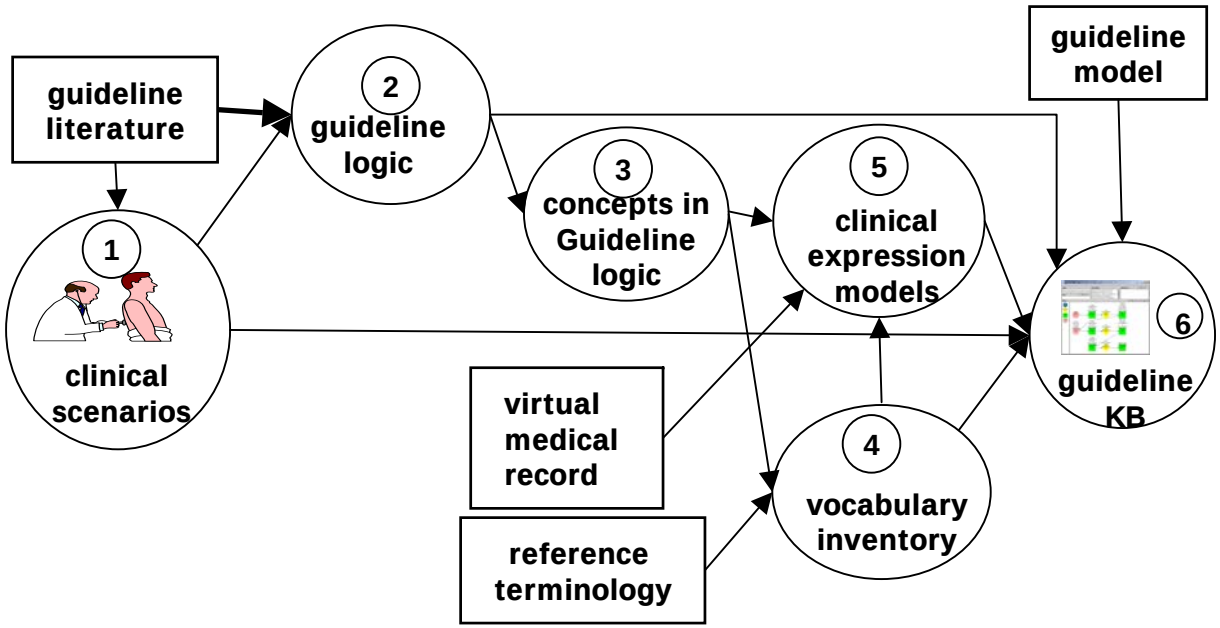
SAGE Approach: Deployment-driven Guideline Modeling



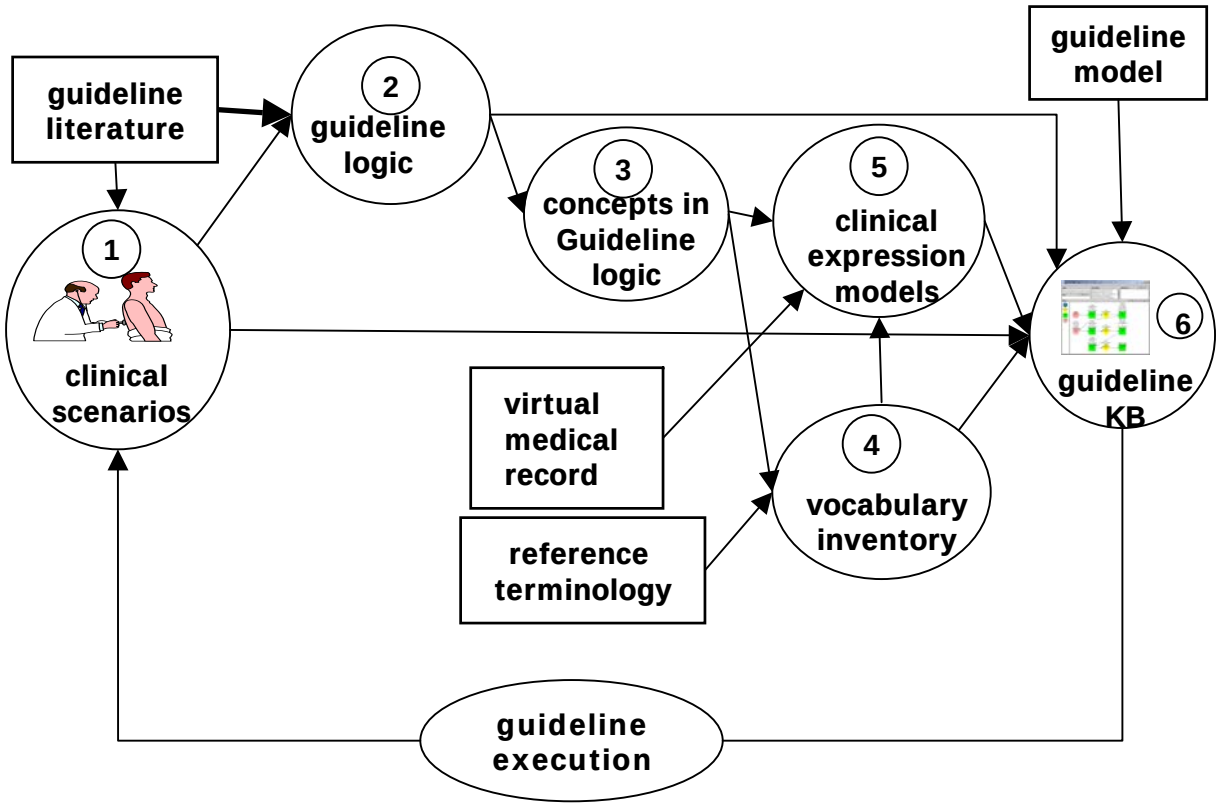
SAGE Approach: Deployment-driven Guideline Modeling



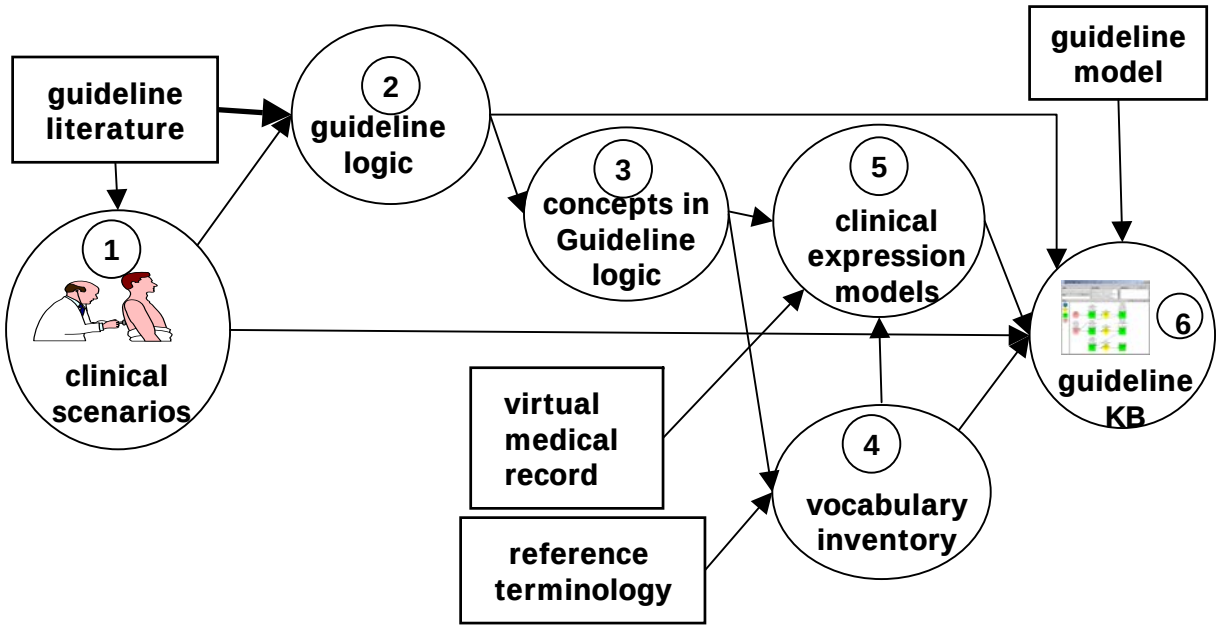
SAGE Approach: Deployment-driven Guideline Modeling

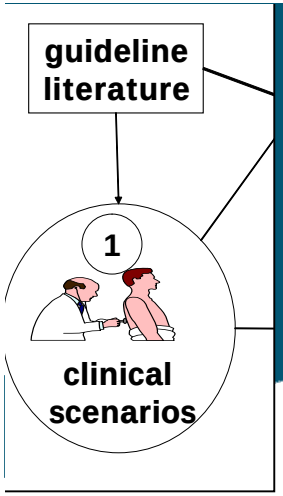


SAGE Approach: Deployment-driven Guideline Modeling



Today's Talk:


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



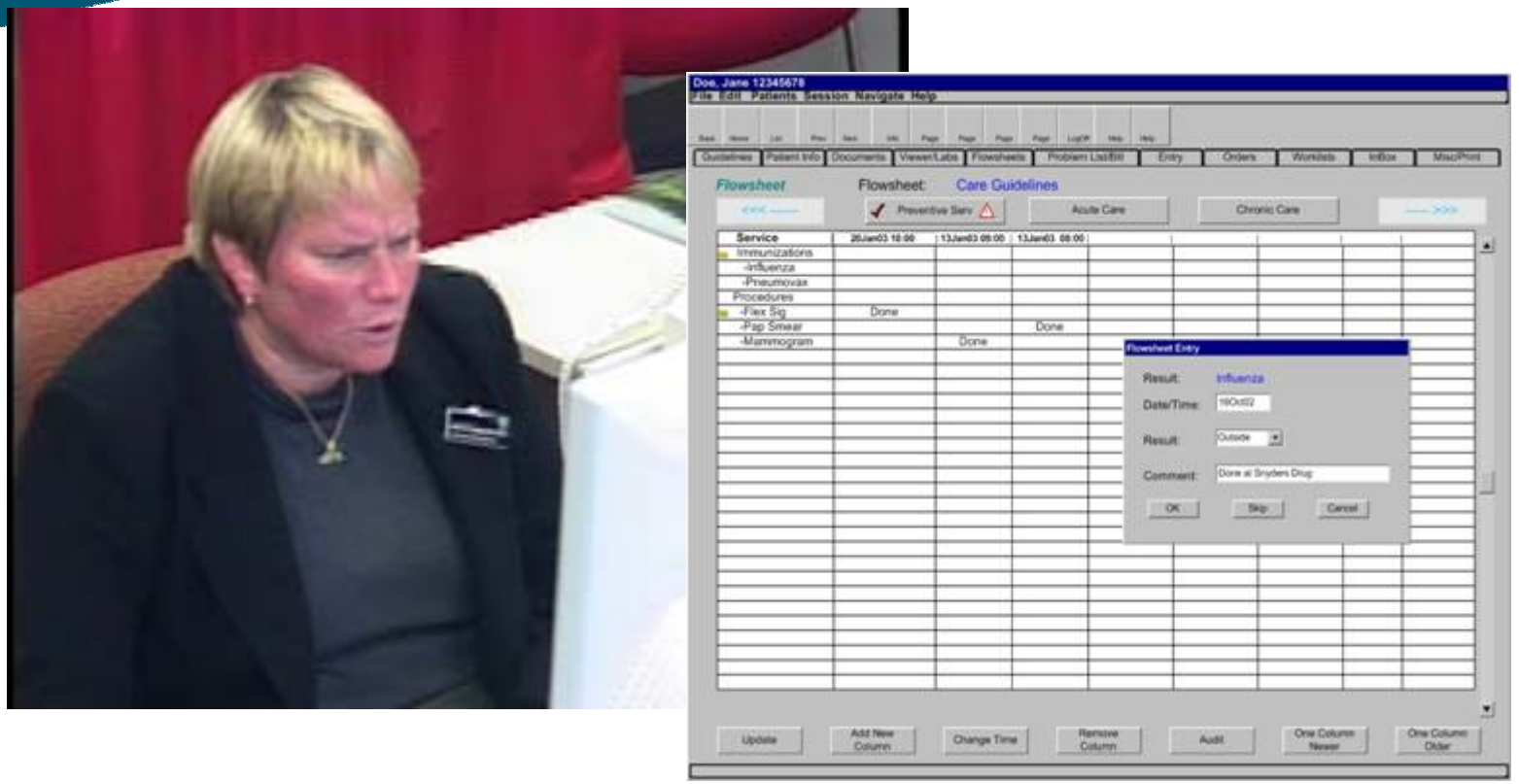
Deployment-Driven Guideline Modeling

- 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

Scenario Example

- 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

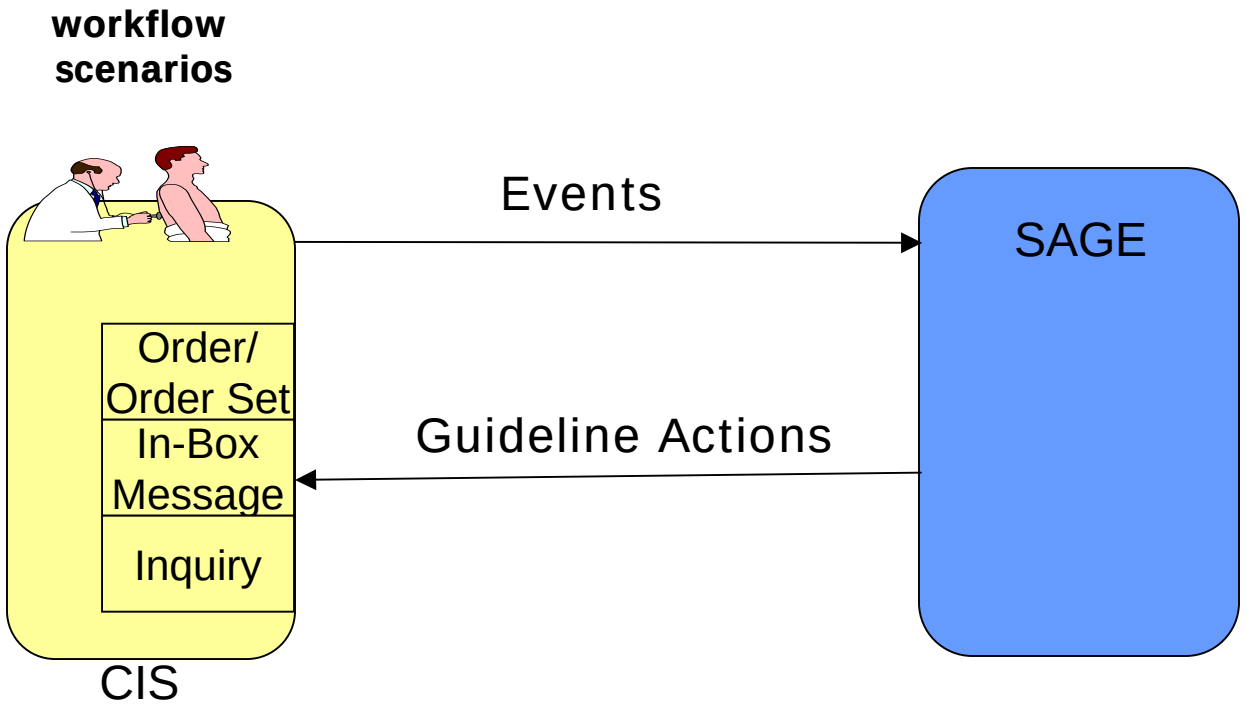
Usability Testing



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

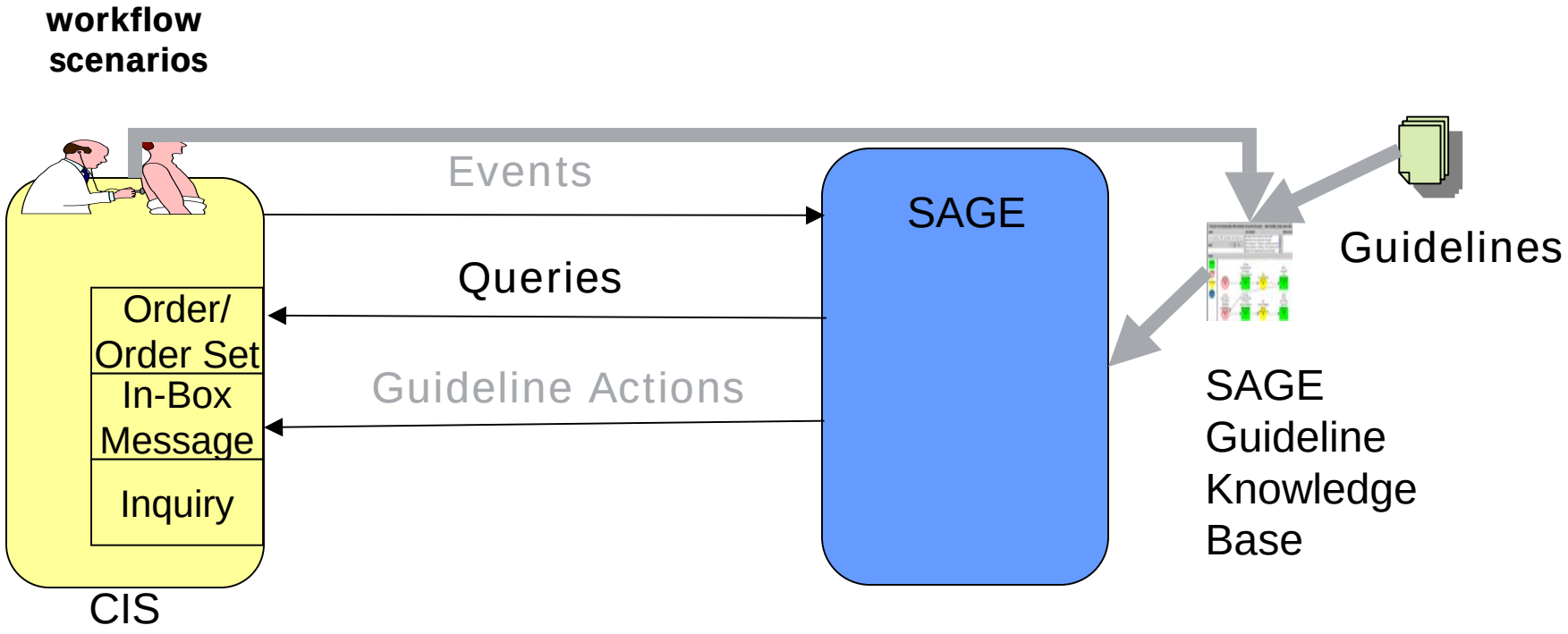
Results of Scenario Development

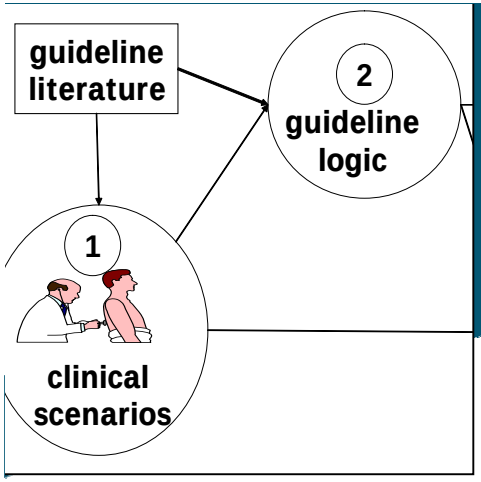
- Defines events that SAGE must respond to and guideline-based actions that SAGE should generate
- Defines timing, form, and content of decision-support services



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.



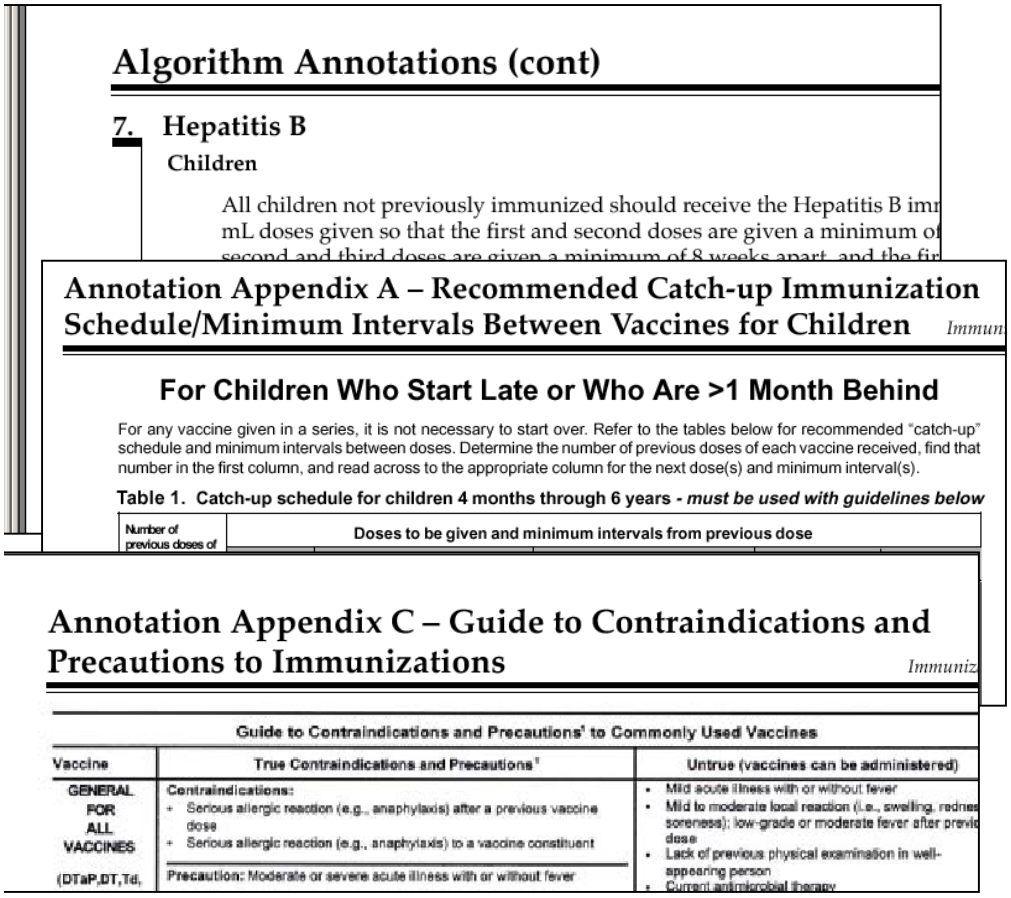


Distillation of Guideline Logic

"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



Algorithm Annotations (cont)

7. Hepatitis B

Children

All children not previously immunized should receive the Hepatitis B imm
mL doses given so that the first and second doses are given a minimum of
second and third doses are given a minimum of 8 weeks apart, and the fir

Annotation Appendix A – Recommended Catch-up Immunization Schedule/Minimum Intervals Between Vaccines for Children

Immun

For Children Who Start Late or Who Are >1 Month Behind

For any vaccine given in a series, it is not necessary to start over. Refer to the tables below for recommended "catch-up" schedule and minimum intervals between doses. Determine the number of previous doses of each vaccine received, find that number in the first column, and read across to the appropriate column for the next dose(s) and minimum interval(s).

Table 1. Catch-up schedule for children 4 months through 6 years - *must be used with guidelines below*

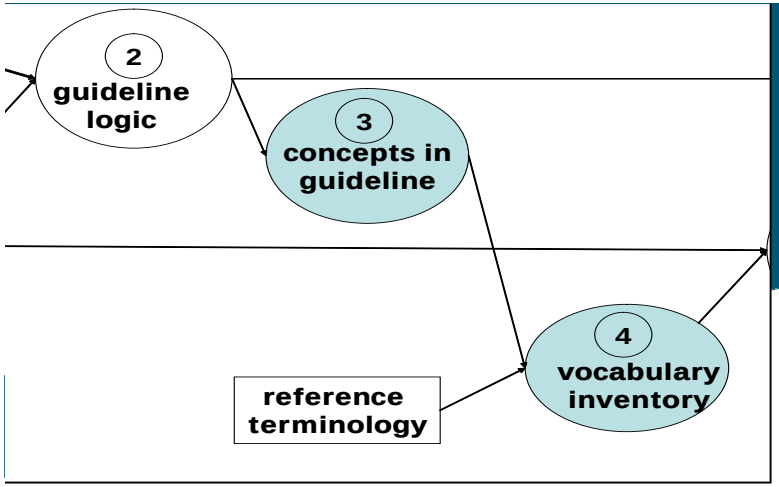
Number of previous doses of	Doses to be given and minimum intervals from previous dose

Annotation Appendix C – Guide to Contraindications and Precautions to Immunizations

Immuniz

Guide to Contraindications and Precautions[1] to Commonly Used Vaccines

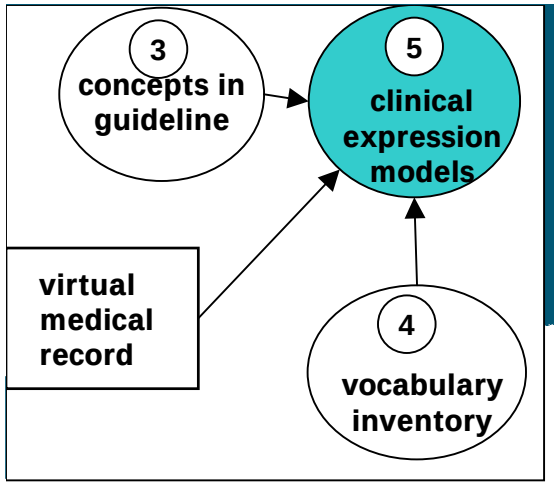
Vaccine	True Contraindications and Precautions[1]	Untrue (vaccines can be administered)
GENERAL FOR ALL VACCINES (DTaP,DT,Td,	Contraindications: + Serious allergic reaction (e.g., anaphylaxis) after a previous vaccine dose + Serious allergic reaction (e.g., anaphylaxis) to a vaccine constituent Precaution: Moderate or severe acute illness with or without fever	• Mild acute illness with or without fever • Mild to moderate local reaction (i.e., swelling, redne soreness); low-grade or moderate fever after previ dose • Lack of previous physical examination in well-appearing person • Current antimicrobial therapy



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

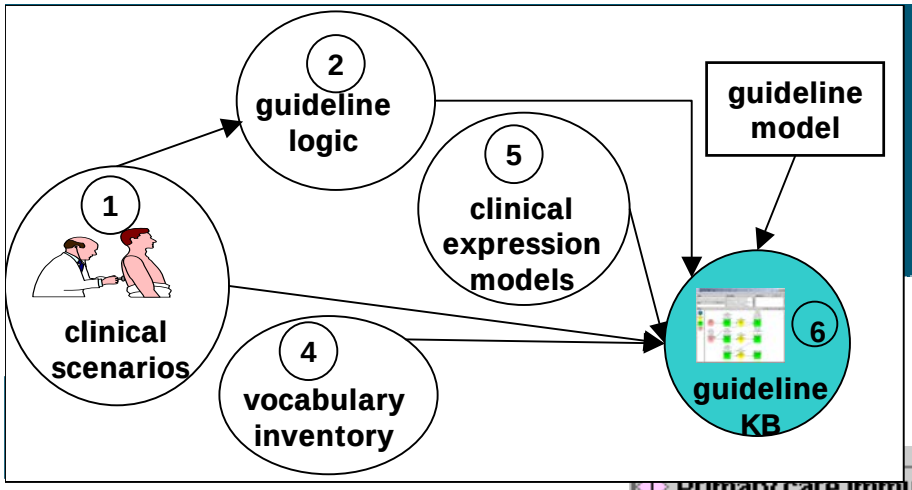
chronic pulmonary disease excluding asthma =
('Chronic respiratory disease: 17097001' AND 'Disease of lower respiratory system:128272009') AND NOT 'Asthma:195967001'



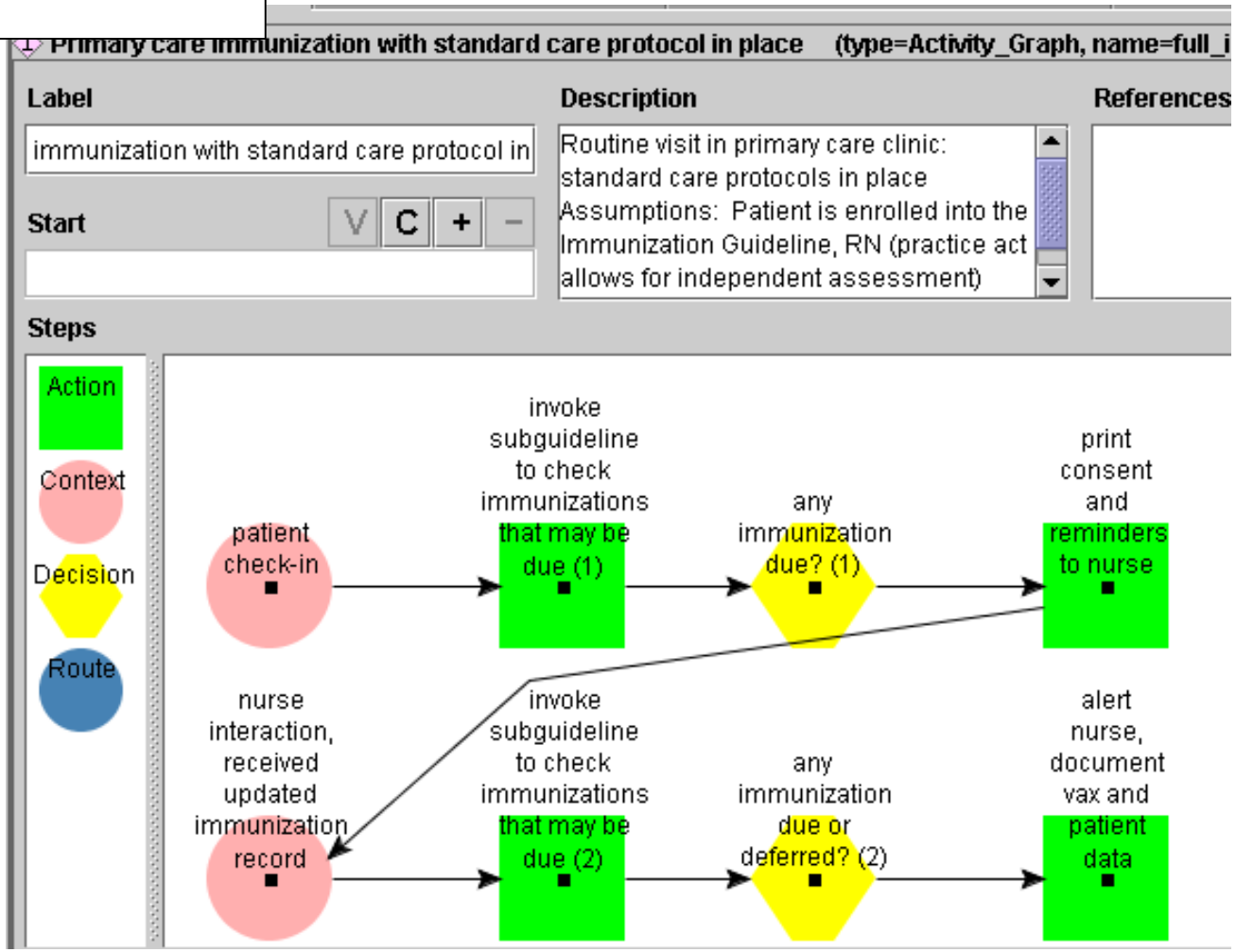
Define "Clinical Expression Models"

- 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)

Guideline Encoding: Top-Level Workflow-Aware Process



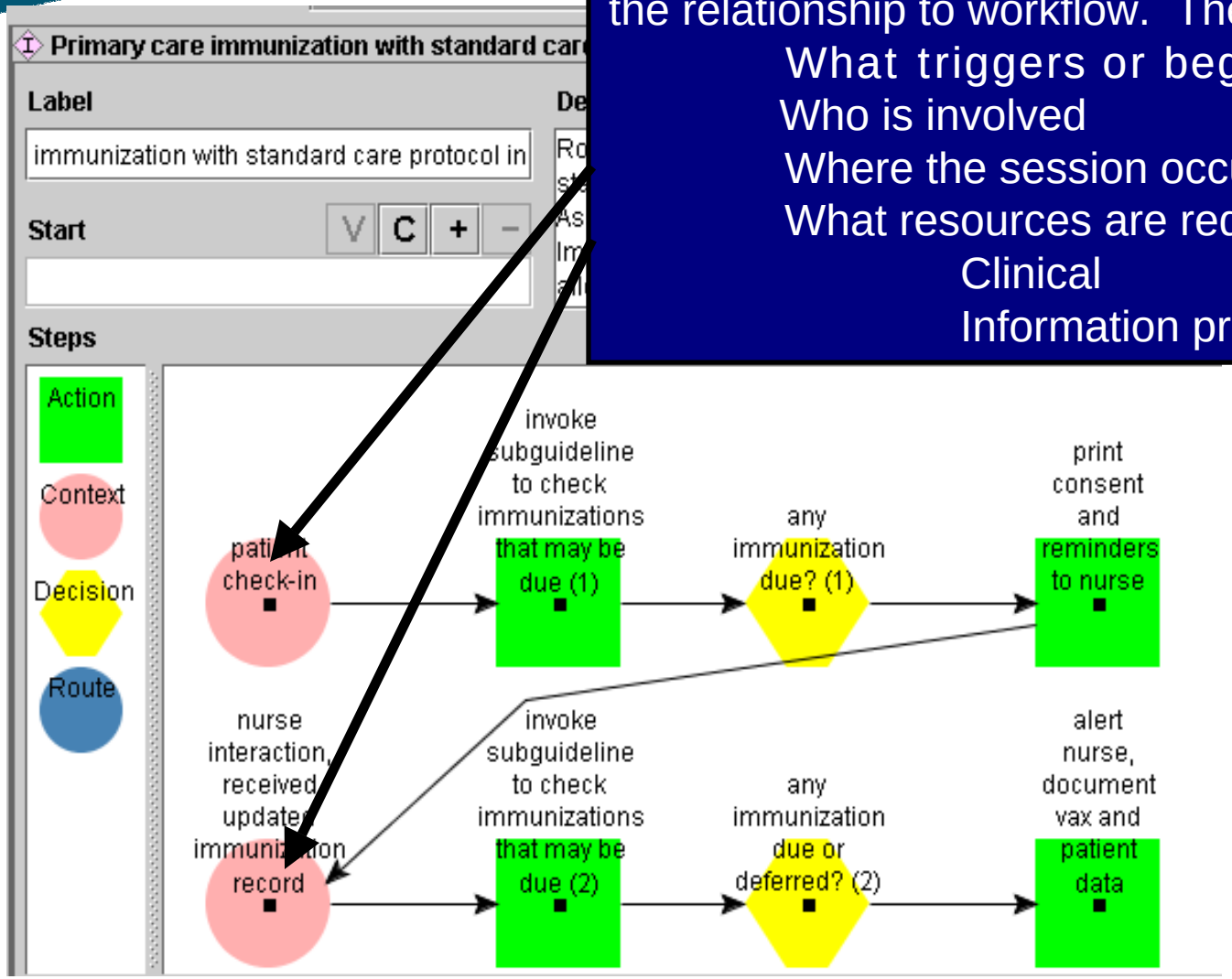
- Top-level process description in encoded guideline reflect expected reactions to events in clinical workflow



SAGE Context Model

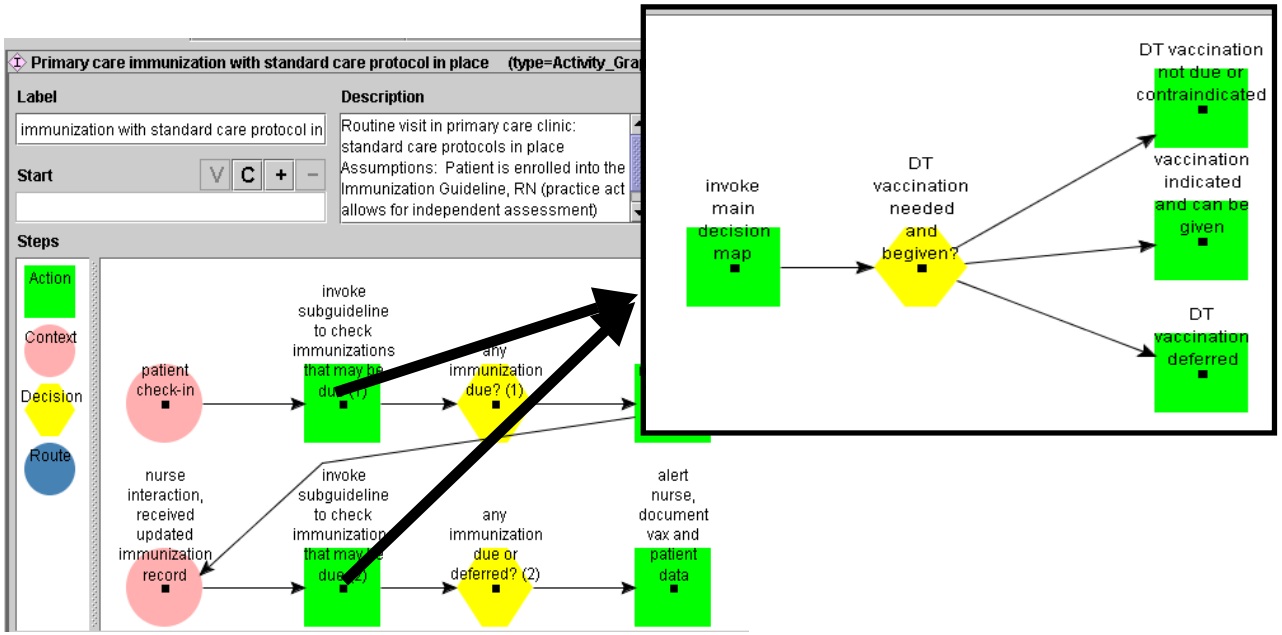
Context nodes organize and specify the relationship to workflow. They record:

- What triggers or begins sessio
- Who is involved
- Where the session occurs
- What resources are required
  - Clinical
  - Information processing



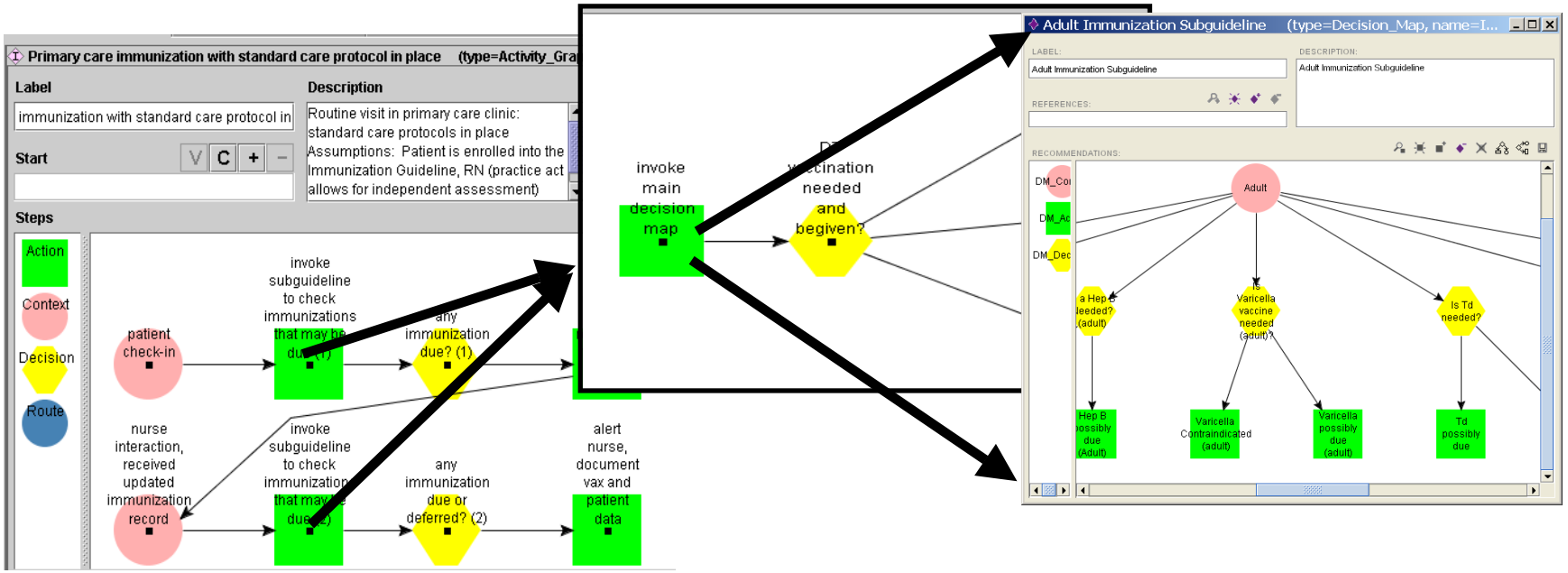
Decision Knowledge Encoded in Sub-guidelines

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



Decision Knowledge Encoded in Sub-guidelines

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



Results

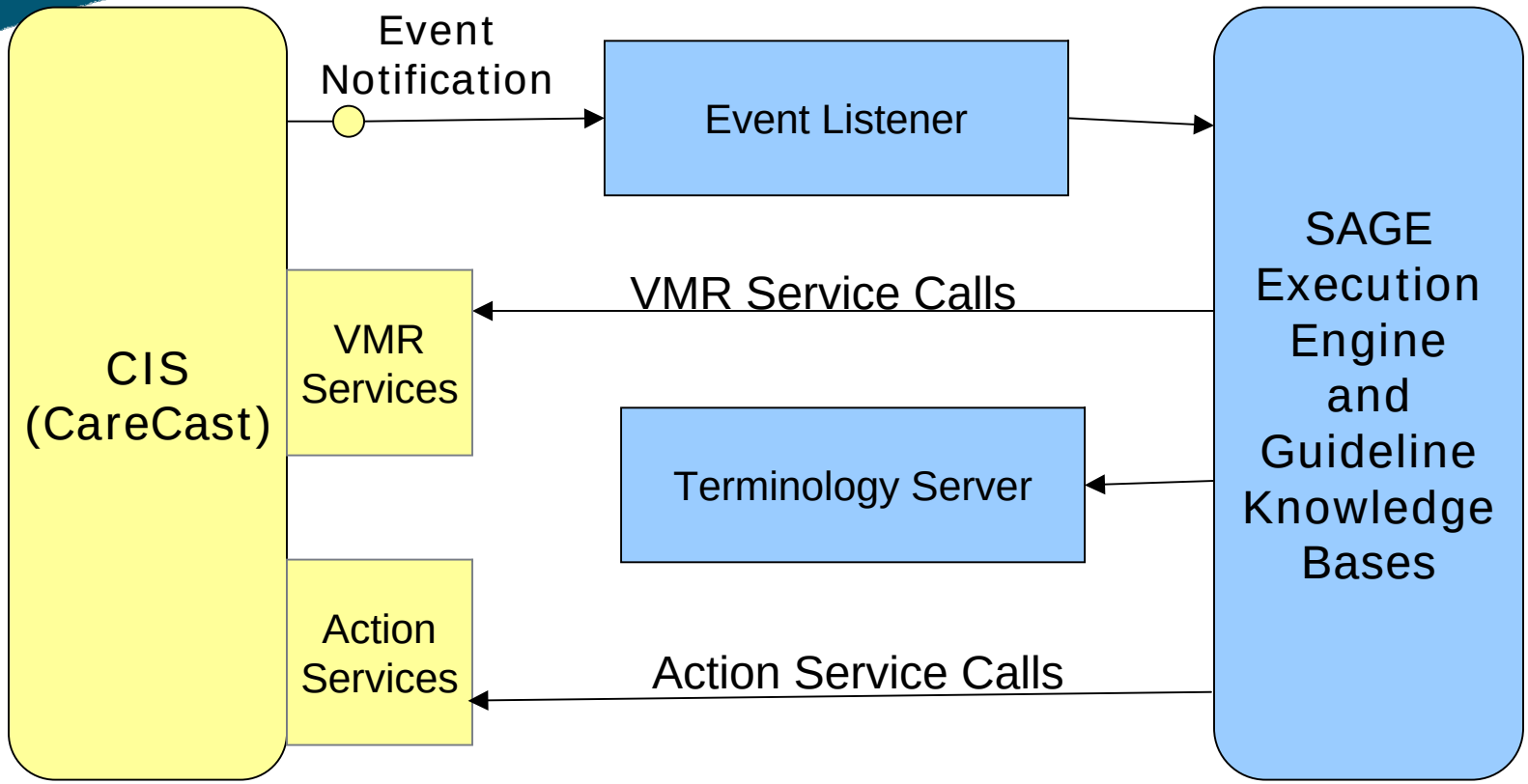
- Applied methodology (including execution stage) to exemplar guidelines:
  - Immunization, diabetes (completed)
  - Community-acquired pneumonia (in progress)
- Retrospectively verified that the deployment-driven methodology is consistent with the development process of the ATHENA hypertension DSS

Discussion

- "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



“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)