Building Clinical Decision Support and Automated Performance Measures for Heart Failure

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QUERI CHF Network Meeting
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Views expressed are those of the speaker and not necessarily those of the Dept of Veterans Affairs
Systems we have developed or studied presented in this talk are non-commercial

Overview

1. ***Clinical Decision Support: ATHENA-HF***
2. ***Ejection Fraction from free text in VistA***

   CHIR TUCP EF Natural Language Processing
3. ***Combining ATHENA-HF and EF from VistA for automated performance measures and clinical decision support***

ATHENA-HF Co-Investigators

- *Paul Heidenreich, MD, MS*
- *Susana B. Martins, MD*
- *Samson W. Tu, MS*
- *Dan Wang, PhD*
- *Barry Massie, MD*
- *Elaine Furmaga, PharmD*

Clinical Decision Support started with hypertension extended to other clinical domains, including HF

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Perspectives on JAMIA Informatics

White Paper ■

A Roadmap for National Action on Clinical Decision Support

JEROME A. OSHEROFF, MD, JONATHAN M. TEICH, MD, PHD, BLACKFORD MIDDLETON, MD, MPH, MSC, ELAINE B. STEEN, MA, ADAM WRIGHT, DON E. DETMER, MD, MA

Abstract This document comprises an AMIA Board of Directors approved White Paper that presents a roadmap for national action on clinical decision support. It is published in JAMIA for archival and dissemination purposes. The full text of this material has been previously published on the AMIA Web site (www.amia.org/inside/initiatives/cds). AMIA is the copyright holder.

■ **J Am Med Inform Assoc.** 2007;14:141–145. DOI 10.1197/jamia.M2334.

"Clinical decision support (CDS) provides clinicians, staff, patients, or other individuals with knowledge and person-specific information, intelligently filtered or presented at appropriate times, to enhance health and health care."

Medicine (Emergency Medicine) Harvard University (JMT), Boston, MA; Clinical Informatics R&D, Partners Healthcare System, and Brigham & Women's Hospital, Harvard Medical School (BM), Boston, MA; Editorial and Research Consultant, American Medical

Clinical decision support (CDS) provides clinicians, staff, patients, or other individuals with knowledge and person-specific information, intelligently filtered or presented at appro-

From Evidence to Patient Care: Decision Support with Actionable Guidelines

ATHENA Clinical Decision Support (CDS) System

- **A**ssessment and **T**reatment of **H**ypertension: **E**vide**n**ce-based **A**utomation (ATHENA): Patient-specific information & recommendations
- Automated clinical decision support (CDS) system
  - VA HSR&D group collaboration with Stanford informatics research group
  - EON technology for guideline-based decision support, developed at Stanford BioMedical Informatics Research (BMIR)
  - Built with Protégé
    - open-source Java tool for creation of customized knowledge-based applications developed Stanford Biomedical Informatics Research (BMIR)

http://protege.stanford.edu/overview/

Goldstein et al Proc AMIA Symp. 2000;:300-4
Shankar et al Medinfo. 2001;10:538-42
Goldstein et al Proc AMIA Symp. 2001;:214-8

Athena in Greek mythology is a symbol of good counsel, prudent restraint, and practical insight

WINDOW FRAME

ATHENA Hypertension Advisory

References Sources

Patient Name XXXX-XX-XXXX View Patient Summary

Recommendations | Lifestyle | Adherence | Assumptions | Patient Summary

Blood Pressure apparently not under control:
Based on last measurement of **145/92** taken 87 days ago on mm/dd/yyyy

CARDIO RISK FACTOR* **23% High**

*Estimated 10 Year cardiovascular risk factor for this patient Explain

Enter a new BP: Update

Date: MM/DD/YR Write back to Vista

Recommendations

Other Patient Information and Alerts

- Consider intensifying drug treatment: **BP Elevated** based on most recent available BP
- There appears to be a **Strong Contraindication** to a currently prescribed drug, evaluate clinical significance
- Bronchospasm is a **Strong Contraindication** or use of beta adrenergic receptor antagonists, although many patients tolerate and teherefore benefit from this drug therapy

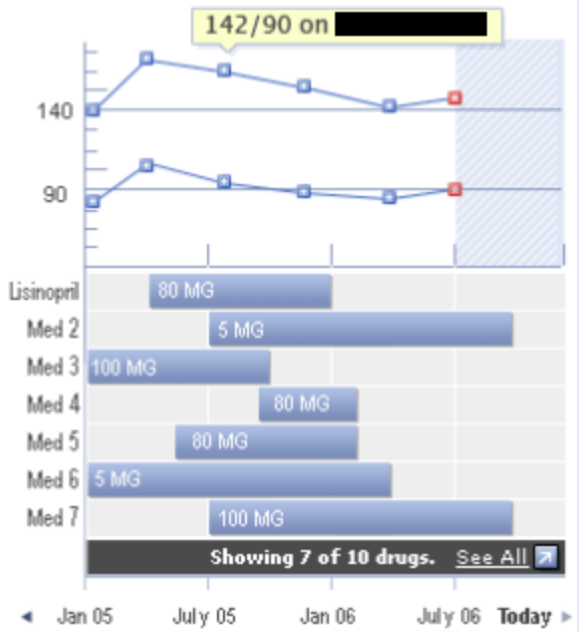
Review lifestyle modifications with the patient. See the Lifestyle page.

Therapeutic Possibilities (CLICK FOR IMPORTANT PRESCRIPTION INFORMATION)	Indications	Contraindications
Discontinue atenolol	Heart Failure EVIDENCE CKD	Brochospastic disease
AND start one of the following drugs		
ACE Inhibitors (lisinporil)	Heart Failure EVIDENCE CKD EVIDENCE	
(non-DHP) Calcium Channel Blocker (diltiazem)	CKD	Heart Failure
Add one or more of the following drugs		
ACE Inhibitors (lisinporil)	Heart Failure EVIDENCE CKD EVIDENCE	
(non-DHP) Calcium Channel Blocker (diltiazem)	CKD	Heart Failure
Increase dosage of hydroclorothiazide		

Compelling Indication Relative Indication Relative Contraindication Strong Contraindication Adverse Effects

Don't forget you know the patient better than we do message utpat lorem ipsum dolor sit amet, consecteteur adipiscing

Blood Pressure and Prescription History

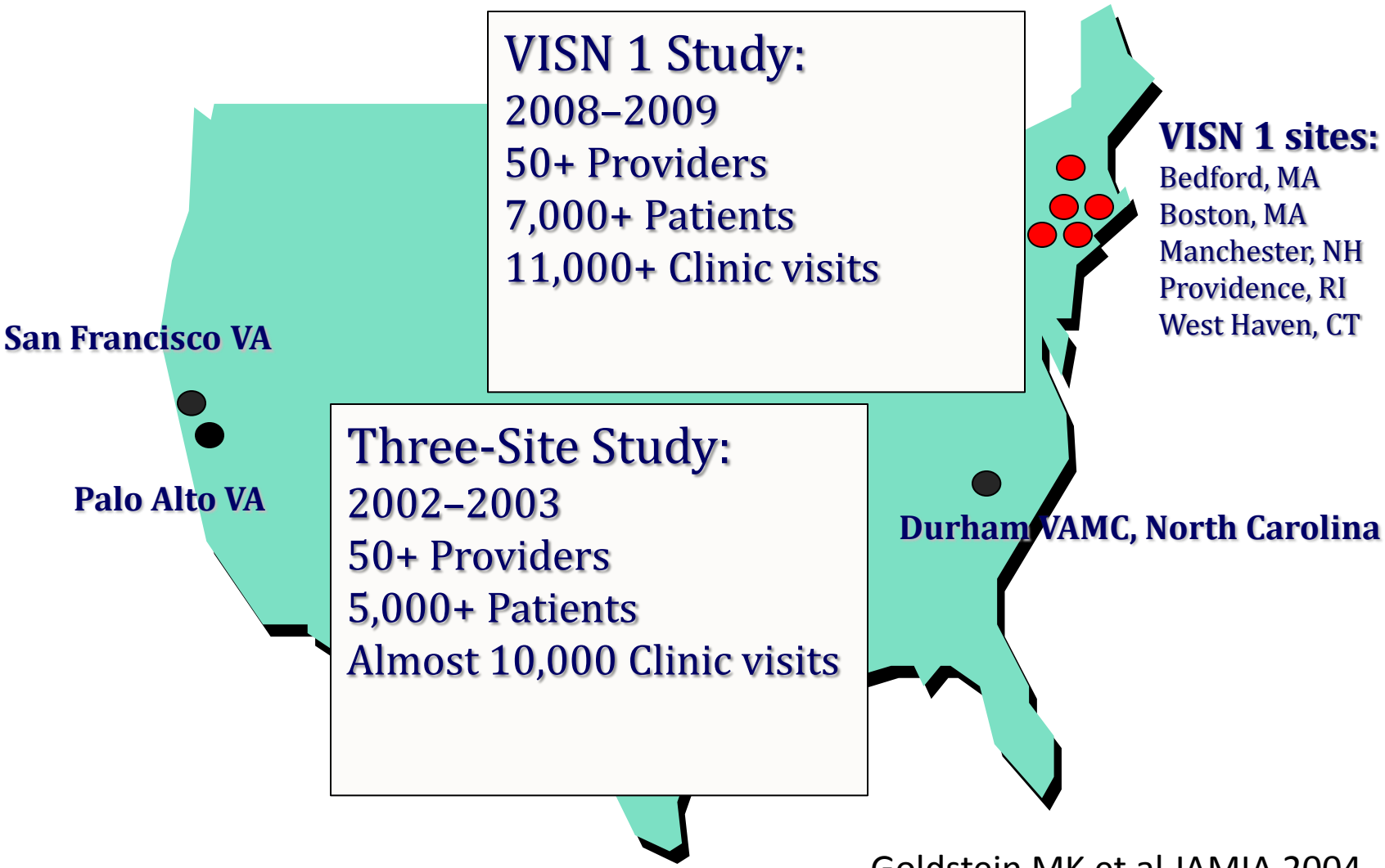


Do you have feedback for the Research team? Thank you!

Do not display advisory for this clinic visit again Exit

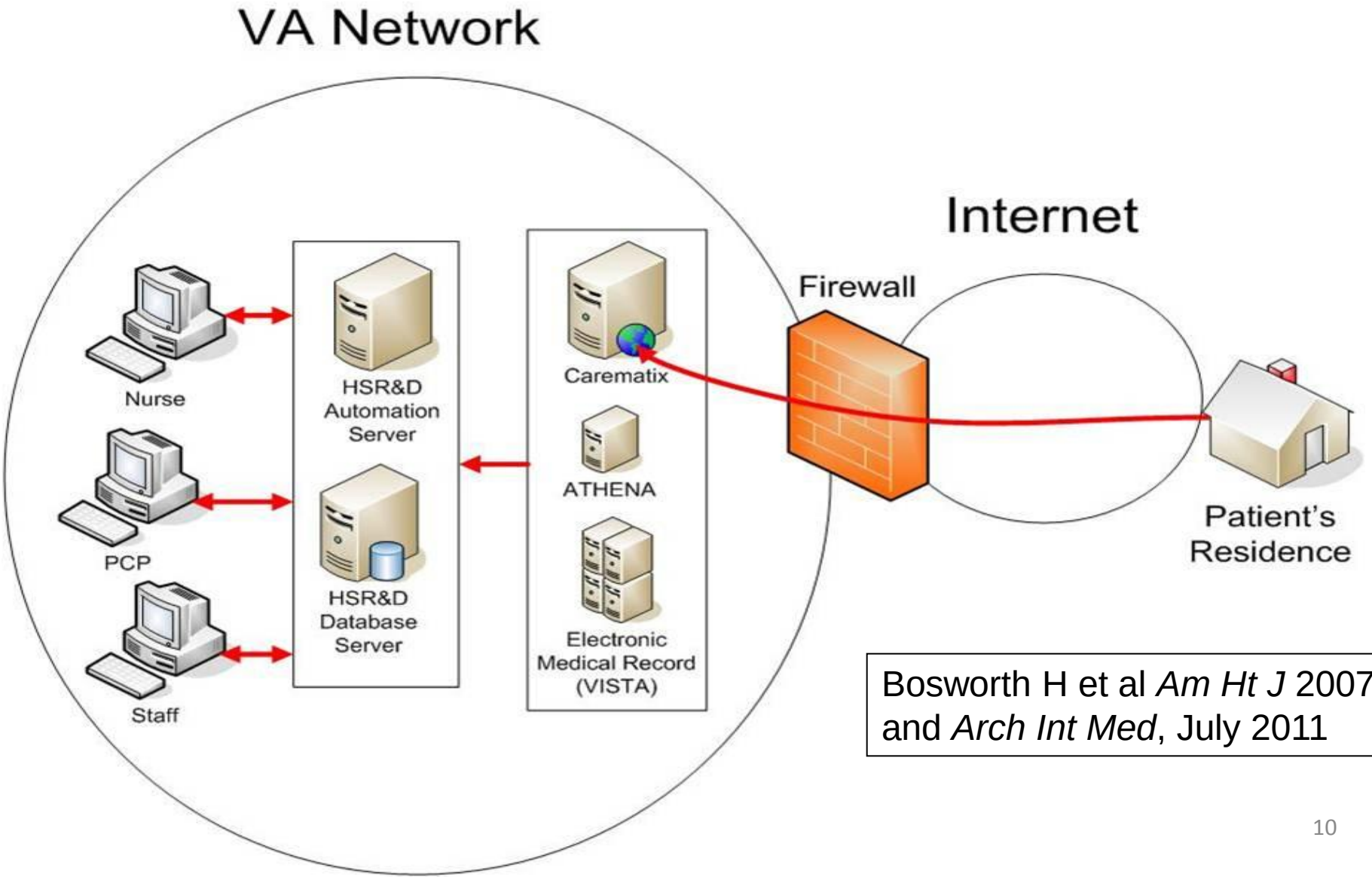
SYNTHETIC PATIENT DATA

ATHENA-HTN Evaluation Studies



Goldstein MK et al JAMIA 2004

HINTS Study: Telemedicine



Bosworth H et al *Am Ht J* 2007 and *Arch Int Med*, July 2011

ATHENA-HF Research Objectives

- **Create an automated knowledge base (KB) of Heart Failure (HF) management recommendations based on evidence-based clinical practice guidelines (CPGs) that can be processed with patient data from the electronic health record for use in clinical decision support (CDS) or quality assessment for care of older adults with HF.**

- **Develop a method to co-process additional guidelines to provide individualized patient-centric rather than disease-centric recommendations for patients with multiple comorbid chronic conditions.**

Steps in Developing

- **VA Quality Enhancement Research Initiative (QUERI) HF experts selected the ACC/AHA Guidelines as the guideline to encode.**
- **We encoded the recommendations into computable formats using the open-source knowledge acquisition system Protégé with the EON model designed for CPGs.**
- **Clinical concepts were extracted from each recommendation, and the source for patient data in the electronic health record (EHR) identified.**
- **Subject matter experts clarified sections of the guideline to operationalize the recommendations.**
- **We used a guideline execution engine developed in previous work with ATHENA-CDS system to process the encoded clinical knowledge with patient data.**
- **Accuracy was evaluated using the testing environment in Protégé**

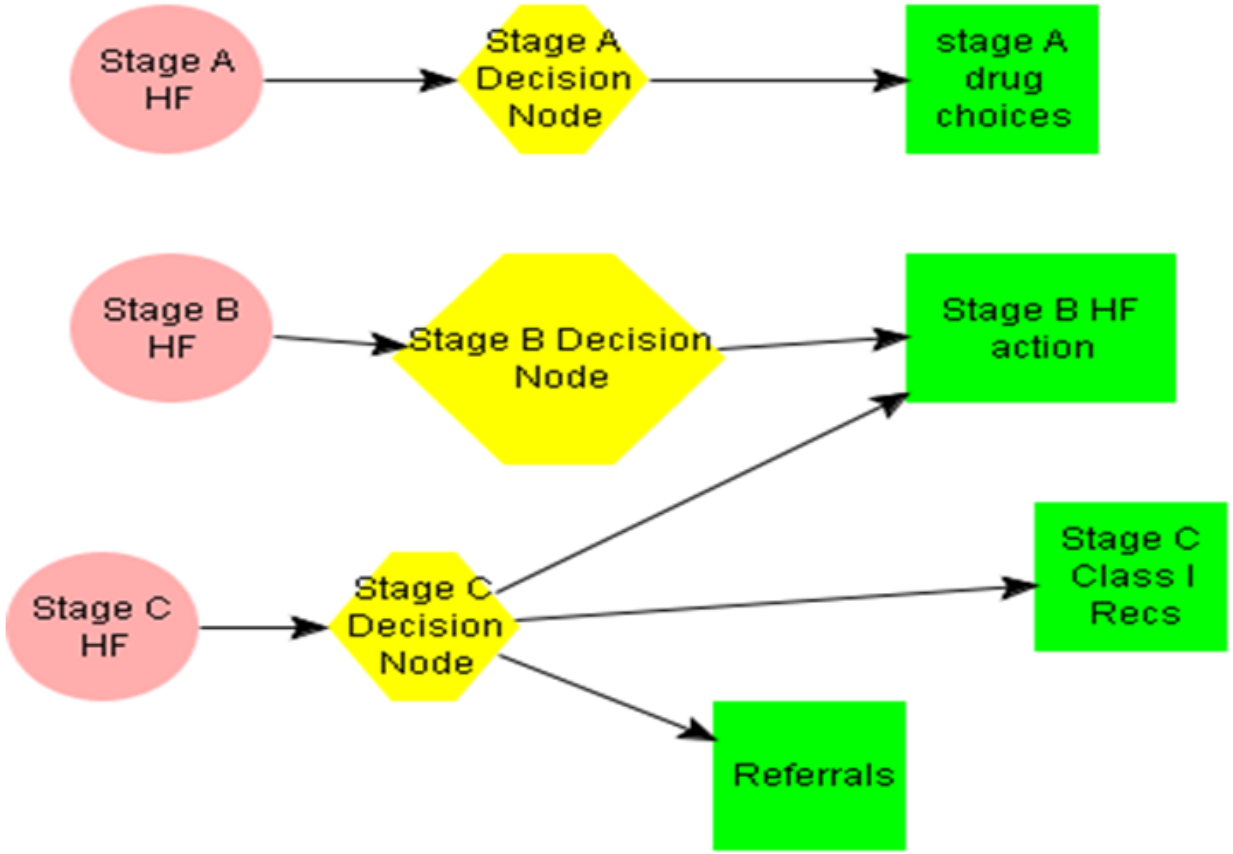


Figure 3. Heart Failure Management Diagram

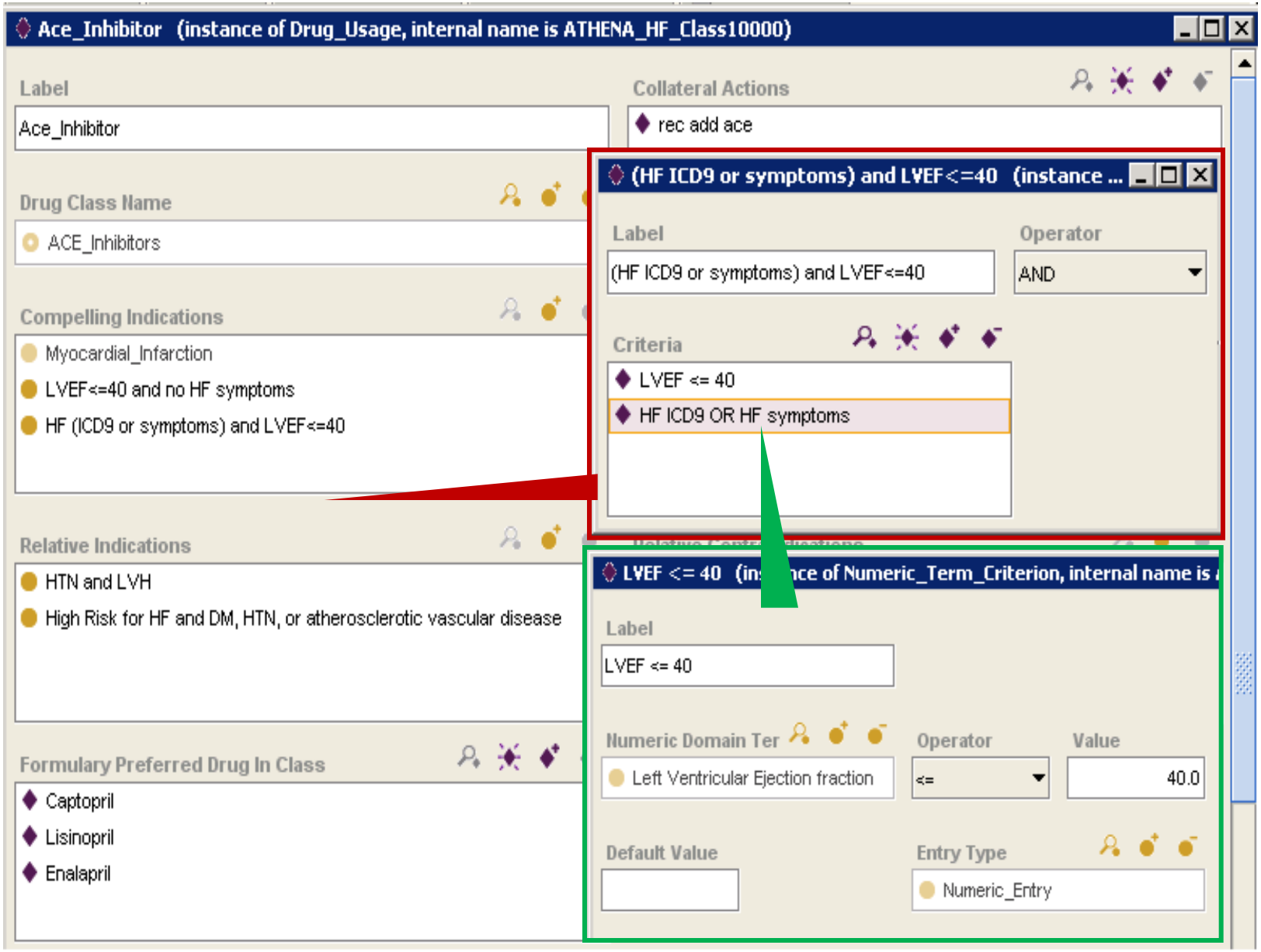


Figure 1. Drug knowledge acquisition template

4.2 Patients With Cardiac Structural Abnormalities or Remodeling Who Have Not Developed Heart Failure Symptoms (Stage B)

Recommendations

Class I

1. **All Class I recommendations for Stage A should apply to patients with cardiac structural abnormalities who have not developed HF. (Levels of Evidence: A, B, and C as appropriate)**
2. **Beta blockers and ACEIs should be used in all patients with a recent or remote history of MI regardless of EF or presence of HF (see Table 3). (Level of Evidence: A)**
3. **Beta blockers are indicated in all patients without a history of MI who have a reduced LVEF with no HF symptoms (see Table 3 and text). (Level of Evidence: C)**

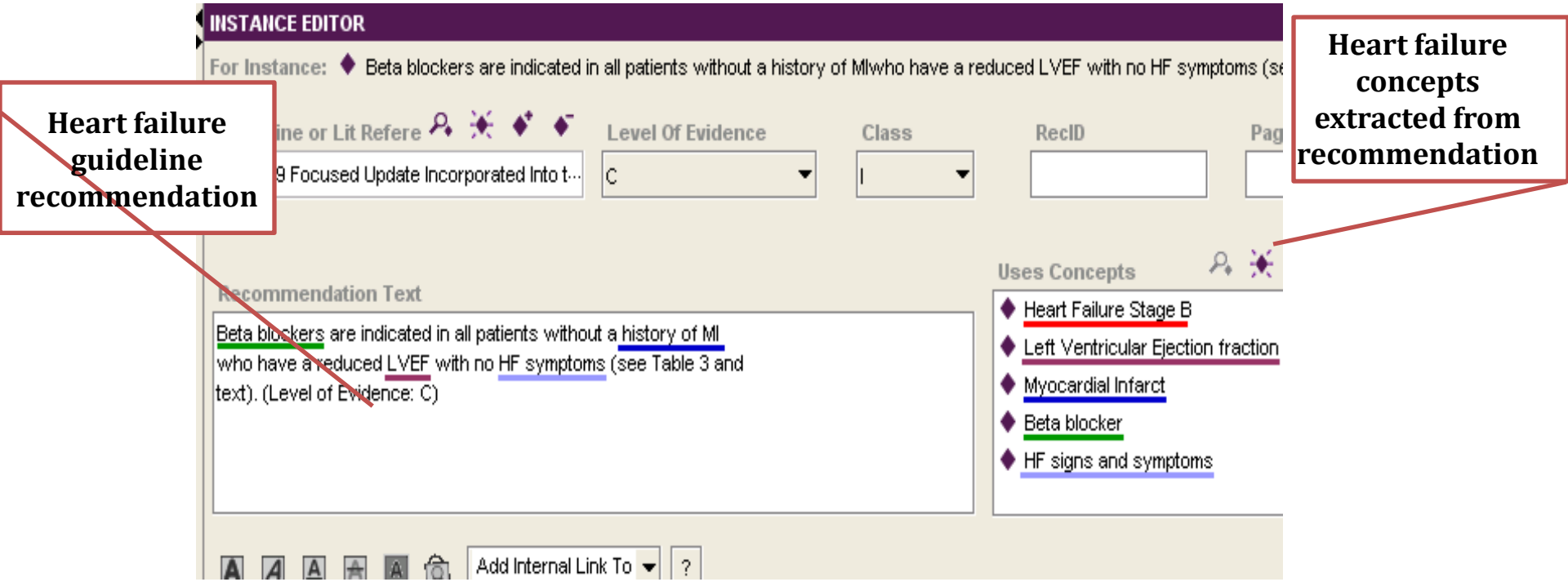


Figure 2. Defining recommendation concepts

Status and Insights

- **We encoded 53 recommendations for HF Stages A, B and C. 123 concepts were required to encode these recommendations.**
- **The data required for the majority of concepts are available in structured data elements in the EHR, while a few concepts require natural language processing (NLP) of free-text data, or user input at the time of the patient visit.**
- **Preliminary results of testing with 28 test cases confirmed that the system generated all relevant recommendations.**
- **We successfully loaded and ran additional guidelines providing recommendations across multiple conditions for patients with these comorbidities: diabetes, hypertension, chronic kidney disease, and hyperlipidemia.**

Once guidelines are encoded this way, what next?

- **We successfully encoded and validated evidence-based recommendations for Stages A, B and C HF into an ATHENA-HF KB.**
- **The majority of the patient data is accessible in the EHR; yet, some crucial data will require interaction with the end-user and/or NLP (natural language processing) of free-text.**

Information Extraction from Free Text in Electronic Record

VA HSR&D Consortium for Healthcare Informatics Research (CHIR)

The Consortium for Healthcare Informatics Research (CHIR) develops methods in natural language processing and makes information available that is currently stored as free-text in the VA electronic health record (EHR). The research conducted by CHIR and supported by VINCI will unleash the information content of EHRs to advance knowledge that improves the care of Veterans.

Mission of CHIR

CHIR advances the effective use of unstructured text and other types of clinical data in the EHR to improve the health of Veterans.

http://www.hsrd.research.va.gov/for_researchers/vinci/chir.cfm

VA HS&RD Consortium for Healthcare Informatics Research (CHIR)

Translational Use Case Projects (TUCP)

Ejection Fraction (EF) from Echocardiography reports in VA:

CHIR TUCP EF Round 1: completed (next slide)
Next round: about to start

CUIMANDREef (Capture with UIMA of Needed Data using Regular Expressions for EF)

Lead: Jennifer Garvin, VA SLC
-Developed and tested extraction of EF from echocardiography reports at 7 VAMCS
- Excellent performance characteristics
- Manuscript under review
-VA HSR&D Cyber Seminar (available from archive)

Guidelines to Performance Measures: Automating Quality Review for Heart Failure (HF RRP 2011)

Anticipating start in January

Aim

• To develop methods to process computable guidelines encoded in ATHENA-HF with patient data from the VA electronic health record (EHR) to generate quality measurement outputs.

Methods

- VA Quality Enhancement Research Initiative (QUERI) HF experts have identified the 4 most important recommendations from the ACC/AHA guidelines.
  - One of these, the recommendation regarding aldosterone antagonists, illustrates the complex criteria: in addition to specific triggers for the recommendation based on cardiac ejection fraction (EF), recent diagnoses (e.g., myocardial infarction), and other medications, there are complex precautions for monitoring serum potassium.
- Develop methods to apply these guideline recommendations to VA EHR data for patients with HF on VA's secure computing environment VINCI, to generate data tables that display the patient's eligibility for each recommendation, and, for eligible cases, the guideline adherence or non-adherence of current management.
  - Determination of eligibility for the target recommendations is based on the patient's EF, which is not available as a structured data element in the EHR at present.
- Incorporate natural language processing (NLP) software developed in the VA HSR&D CHIR project to extract the EF from free text of echocardiography reports to serve as input data to our system.
- Work with QUERI-HF and with the Performance Measurement group in the VA Office of Informatics and Analytics as stakeholders who will inform the design of the system.

Specific Aims

1. ***To refine the encoding of 4 ACC/AHA HF guideline recommendations in ATHENA-HF knowledge base***
2. ***To define and apply the necessary patient data inputs to process the guideline recommendations:***
    a. To link the output of the NLP EF software to become input to the HF guidelines system
    b. To identify other patient data necessary for input and assemble sample data on VINCI
3. ***To extend the existing execution engine, developed for processing one case at a time, to process these recommendations with test data for multiple cases;***
    a. To establish a system on VINCI to process multiple VA records for patients with HF to generate a database recording applicability of the guidelines and adherence where applicable
4. ***To test the accuracy of the conclusions generated from the recommendations with test data***

Acknowledgements

- ATHENA-CDS: Stanford BMIR (Mark Musen, Samson Tu, et al), VA Palo Alto OI&T, VA VISN 1, Brian Hoffman, Robert Coleman, Susana Martins, Hayden Bosworth, Gene Oddone, et al
- CHIR: Dan Wang, Daniel Rubin, et al
- VA Palo Alto GRECC: Dallas Chambers, Sylvia Leung, Tammy Hwang, Tim Keng, et al
- Funding sources: VA HSR&D, NIH/NLM

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VA QUERI RRP-11-428

VA HSR&D IMV 04-062-1, RRP 09-119, HIR 09-007

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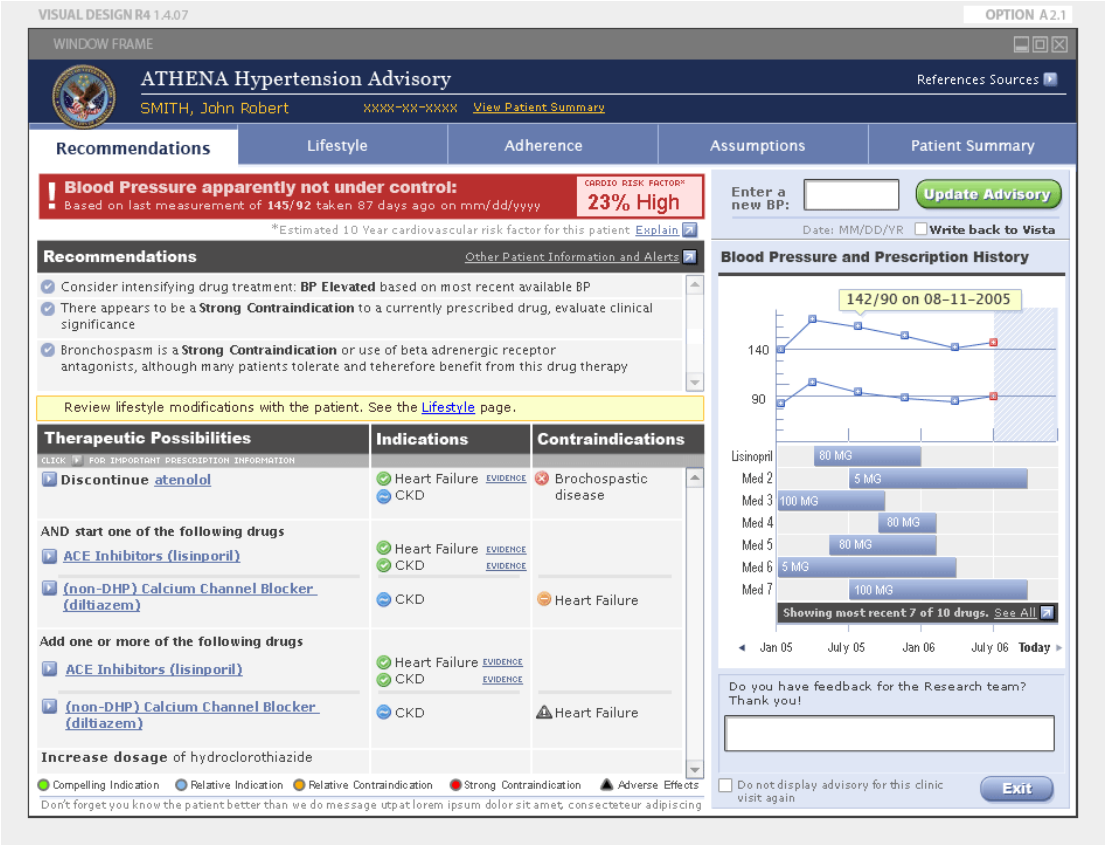


Stanford University
School of Medicine

VA PAHCS
Veterans Affairs
Palo Alto Health Care System

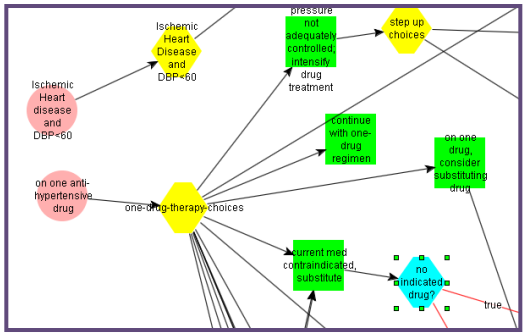
Extra slides

Challenges for GLs and CDS: Integrated Guidelines

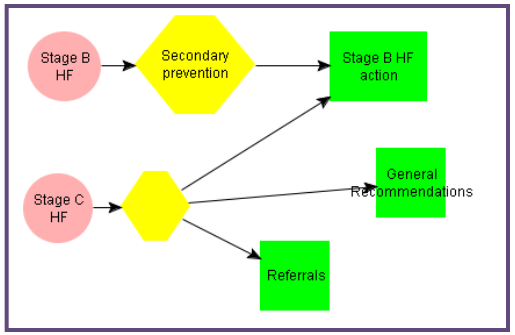
- Patients often have multiple co-existing problems
- While each individual recommendation may have good evidence-base
  - Much less is known about the effect of large number of potentially interacting medications
  - Limits of feasibility of how much can be done at one time
- Need both coordination of guidelines and prioritization of recommendations
- Further research needed

Encoded Guidelines

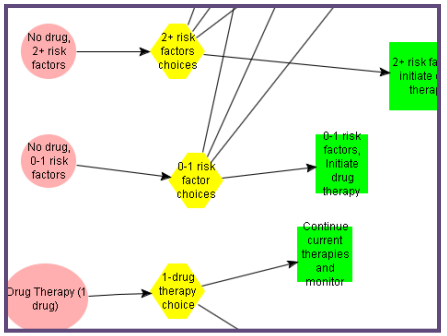
ATHENA Hypertension



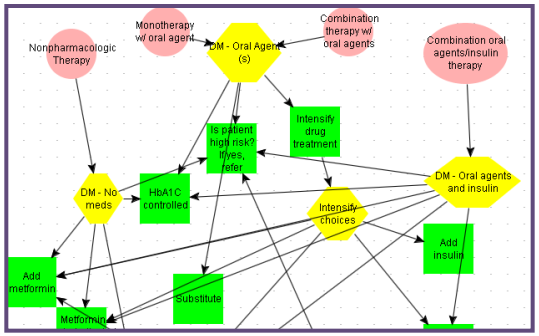
ATHENA Heart Failure



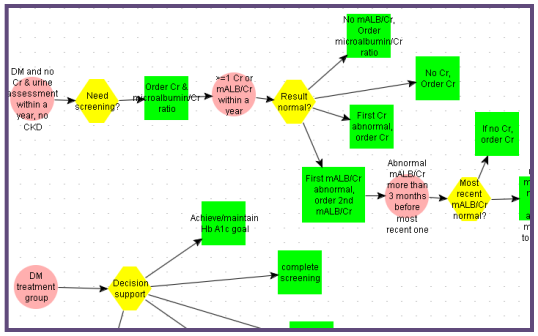
ATHENA Hyperlipidemia



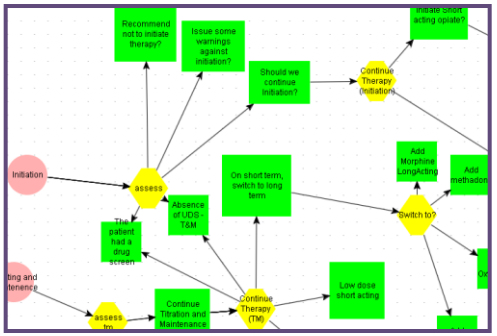
ATHENA Diabetes



ATHENA Kidney Disease



ATHENA Opioid Therapy



Relevance to Clinical Practice: Multiple guidelines

- **The ability to process multiple guidelines together for the same patient is an important step in developing tools for quality improvement for patient-centric care of individuals with multiple comorbidities.**
- **These knowledge bases of computable clinical knowledge, with an execution engine to process with electronic health record patient data, may be used for real-time CDS or for retrospective quality review.**
- **The complexity of clinical knowledge that can be encoded allows for nuanced CDS and potentially for more sophisticated performance measures.**

GLINDA Project: Automated Reasoning for Application of Clinical Guidelines

http://www.stanford.edu/~hyunggu/glinda.html

- Computational methods for reasoning about evidence-based practice
- Mechanisms for dealing with the fuzziness of clinical situations
  - Application of multiple clinical-practice guidelines
  - Adjustments for patient co-morbidities
  - Adjustments for interactions among interventions

Team

Mark Musen, M.D., Ph.D.[2]
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Susana Martins, M.D., M.Sc.[1]
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Pamela Kum, M.A.[1]

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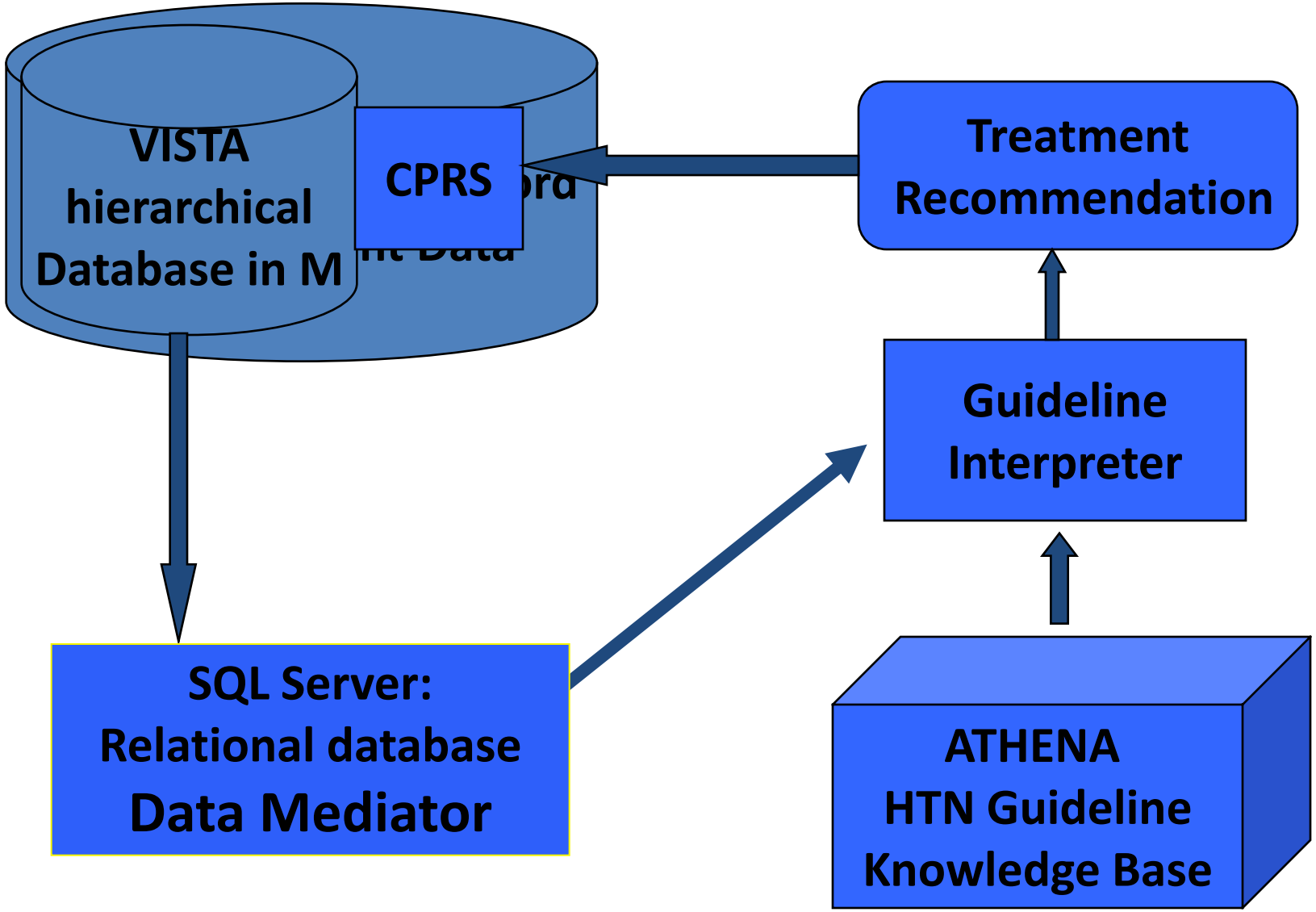
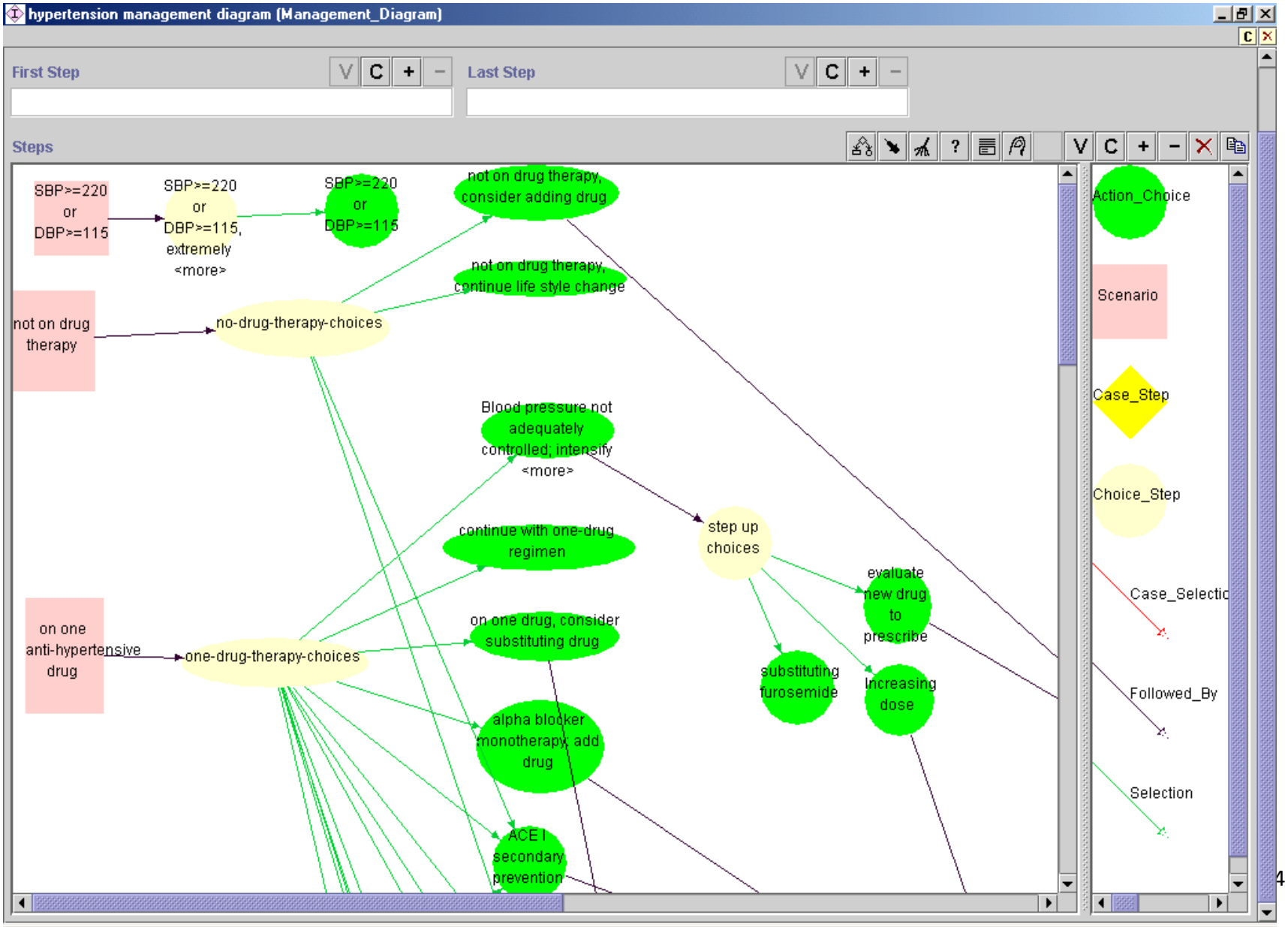
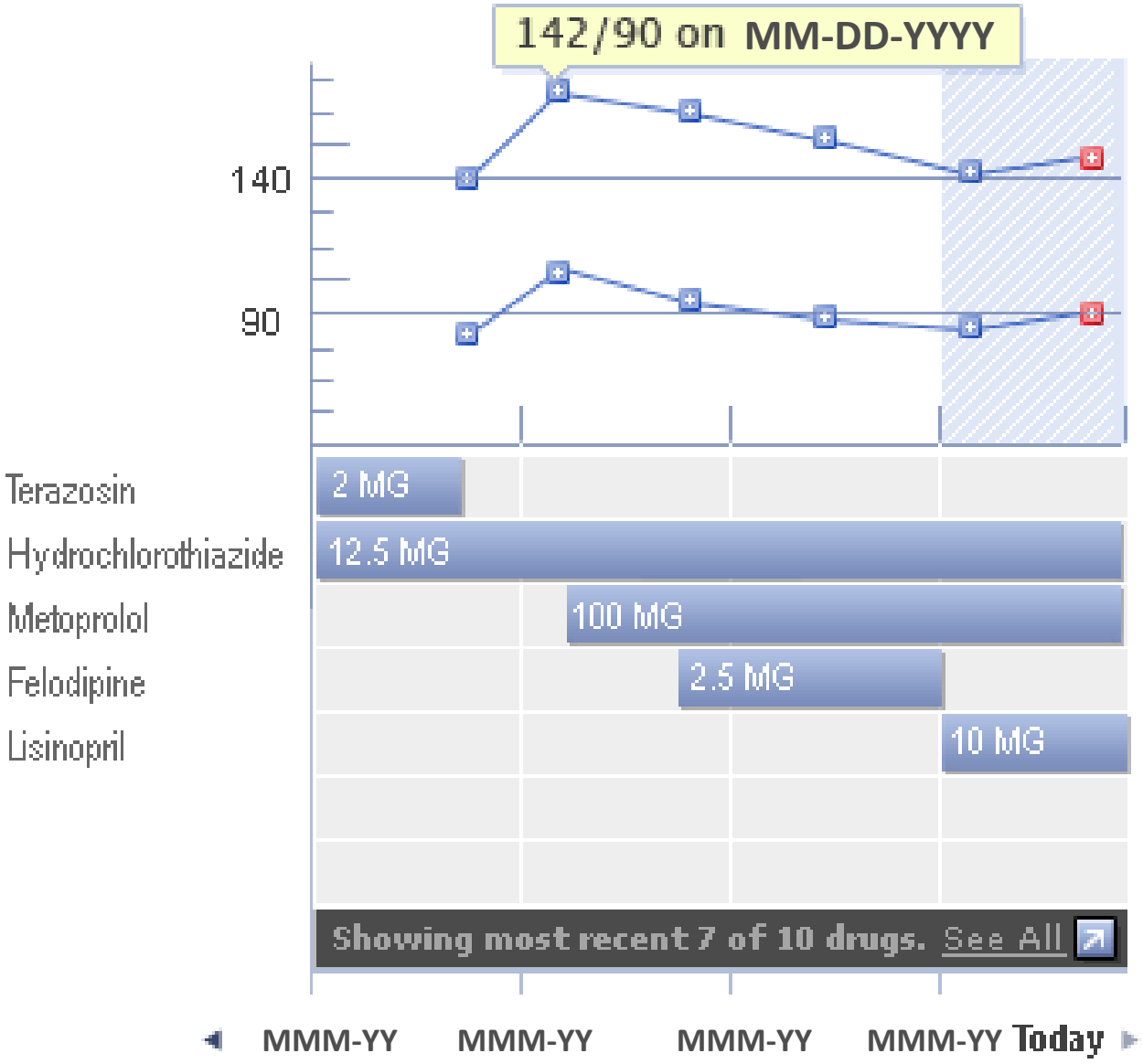
ATHENA Architecture



Clinical Scenarios/Action Choices




142/90 on MM-DD-YYYY
140
90
Terazosin
Hydrochlorothiazide
Metoprolol
Felodipine
Lisinopril
2 MG
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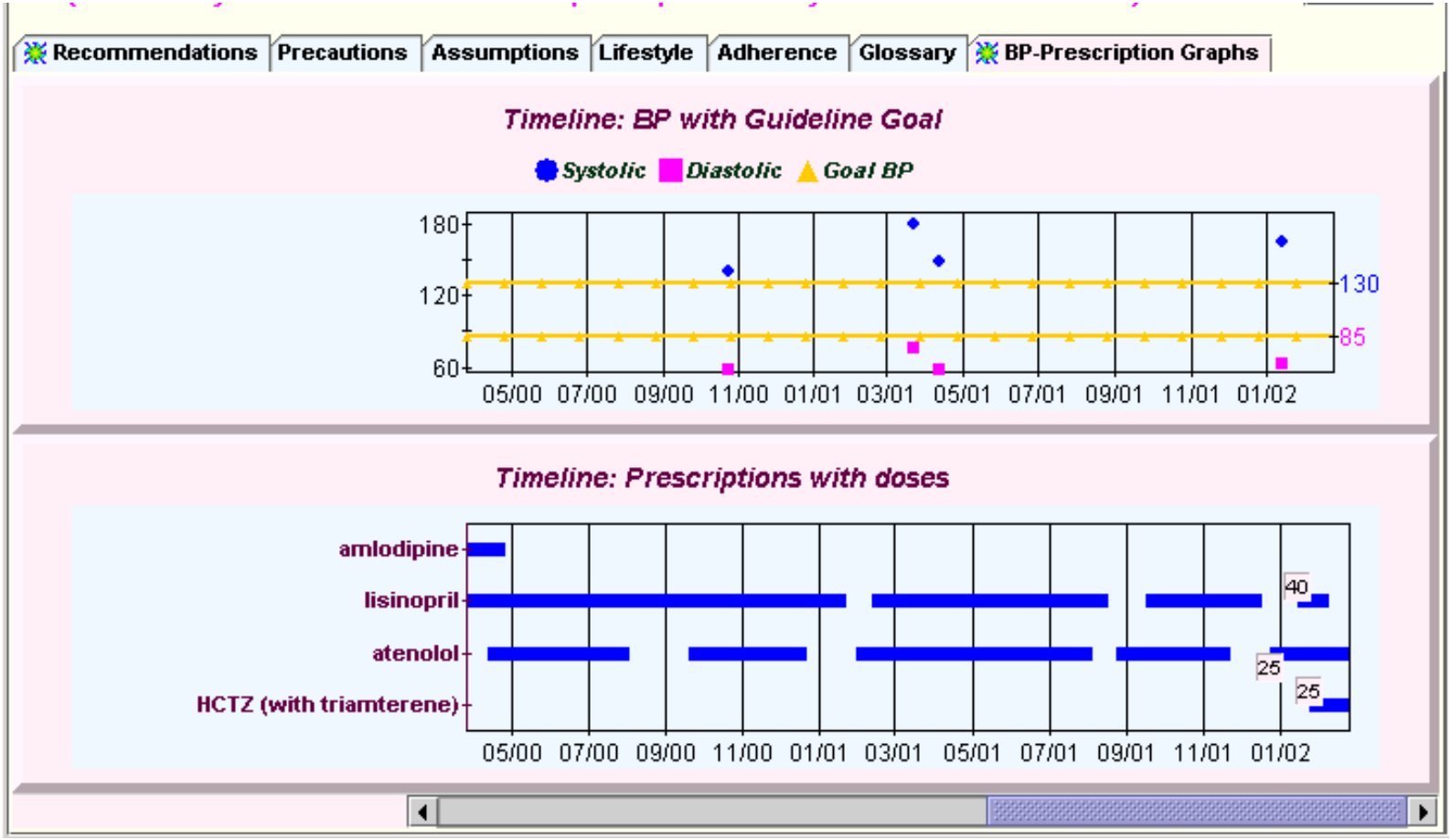
Today

ATHENA Hypertension Advisory:
BP- Prescription Graphs



Goldstein, M. K. and B. B. Hoffman (2003). Graphical Displays to Improve Guideline-Based Therapy of Hypertension. Hypertension Primer. J. L. Izzo, Jr and H. R. Black. Baltimore, Williams & Wilkins.

CDS for alternative care delivery systems: Nurse Management HTN

- Durham VAMC using ATHENA-HTN in study of nurse-management for hypertension
  - Home blood pressures (BPs) uploaded by telephone and sent to VA database
  - Program on VA server monitors for elevated home BPs and alert nurses
  - Medication Management (ATHENA-HTN) Phone Intervention
  - Medication management implemented by study MD/RN

- HINTS project, PI Bosworth

Background

- In TUCP Round 1, the CHIR TUCP-Ejection Fraction (EF) project has built a natural language processing (NLP) tool (CUIMANDREef) which uses free-text echocardiogram reports to extract heart failure-related concepts and values used for performance measurement.
- The Automated Data Acquisition for Heart Failure: Performance Measures and Treatment (ADAHF) project (PI: Jennifer Garvin) created a machine learning version of CUIMANDREef to create a new NLP tool called the Congestive Heart Failure Information Extraction Framework (CHIEF).

Objectives & Aims

- Objective: To expand the application of a natural language processing (NLP) tool built in TUCP-EF Round 1 and ADAHF project to other Veteran Affairs Medical Centers.
- Specific aims to accomplish this objective include:
  - (1) identify and extract VistA location of echocardiogram reports,
  - (2) apply, train and assess NLP tool to echocardiogram reports to a reference standard and
  - (3) modify NLP tool until the system achieves desired target accuracy.

Methods

- Identify the location of the echocardiogram reports, project staff will coordinate with VA QUERI Coronary Heart Failure and VA O&IT representatives.
- Work with VINCI to extract echocardiogram reports of all VA Medical Centers from the Corporate Data Warehouse (CDW) to VINCI secured servers.
- Use the VINCI dashboard to select a sample for more detailed evaluation.
- Examine the echocardiogram records for any additional template-types that were not present in the echocardiogram records reviewed in TUCP-EF Round 1.
- Draw a random sample of echocardiogram reports from a random sample of VA Medical Centers.
- Annotate and adjudicate sample of echocardiogram reports at a document level to create a final reference standard.
- The final reference standard will serve to test and evaluate the performance of the automated information extraction.
- Analyze the applied NLP tool for any inter-facility variation among VA Medical Centers and the system performance effect from report format.

Implications

This project will create a system which VINCI may implement and re-test on all free-text echocardiogram reports at all VA Medical Centers nationwide.

Clinician Reaction to HTN CDS in 3-site Trial

- Clinicians used the system extensively
  - Data logged by system
  - Speaks to usability and usefulness
- Clinicians reported ATHENA-HTN affected their prescribing decisions
- Questionnaire data solicited input for improving next version
- Identify barriers to following the guidelines

Lin ND et al AMIA 2006

Goldstein et al JAMIA 2004

Survey Results ATHENA-HTN VISN 1

- 89% response rate from primary care providers randomly allocated to the intervention (CDS) group
- 34/41 (83%) reported system useful or very useful reminder to intensify treatment when patient's BP was above target
- 29/40 (73%) reported the information was often or very often useful

Patient-Centered Care