Patient–Specific Clinical Decision Support for Physicians, and other Health Care Team Members, Using Electronic Health Record Data

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Views expressed are those of speaker and not necessarily those of Department of Veterans Affairs
Outline

- Challenges in keeping up with the evidence for managing common chronic diseases
  - Multimorbidity, evidence in clinical medicine, clinical practice guidelines
- Developing Evidence-Based Clinical decision support (CDS)
  - Making clinical knowledge computable, linking CDS systems to patients’ clinical data, implementing in actual clinical settings, evaluating clinician response
- Presenting recommendations to clinicians
  - Clinical workflow, user interface
Refined research-implementation pipeline: 
*Implementation research and clinical research*

Slide courtesy of Brian Mittman, PhD
Evidence Base in Clinical Medicine

- How evidence is developed to guide clinical practice decisions
  - Randomized clinical trials
    - Small short trials, often with process measures
    - Large multisite trials with outcome measures
  - Other forms of evidence

- Challenges for physicians to keep up with the clinical trials and other evidence base
  - Impossible to read all the papers or even summaries of them
  - Remembering, comparing/contrasting/deciding when the evidence is sufficient to call for a change in clinical practice
Clinical Practice Guidelines

- Synthesize and summarize evidence
- Recommend best practices
- Produced by multiple sources
- Even once the most authoritative guideline is selected:
  - Challenge to memorize it or have it available at the time it is needed
  - Time it takes to search the guideline for the information relevant to the particular patient
Making it Patient–Specific

- Ideally would have the guideline information that is specific to the patient being seen pulled out and presented to the physician at the time of seeing the patient (Point of Contact)
  - That is, Patient–Specific information presented at Point of Contact
From Evidence to Patient Care:

• Coordinated across the patient’s conditions
• Designed for either doctor-patient dyad or for team care
A Note re Clinical Reminders built into Electronic Health Records

- Consensus on some tests and treatments as indicated under certain circumstances
  - Simple rules to invoke
    - Example: preventive health care measures, monitoring of common chronic diseases such as hypertension and diabetes
- Electronic health record (EHR) systems
  - Alerts and reminders
- Works well when patient has only simple problems or the rules are very simple
Challenges presented by Multimorbidity

- More than 50% of older adults have 3+ chronic conditions

- Patients are complex
  - Many diagnoses
  - Many medications

- Medical literature is huge

- Almost all existing guidelines have a single disease focus
  - Each individual recommendation may have good evidence-base, but much less is known about the effect of multiple potentially interacting medications and diseases; effects on functional status
Decision Support for Clinicians for Managing Complex Patients

- CDS multimorbidity goal:
  - Take account of patients’ other conditions when making recommendations regarding the target condition
  - Must go well beyond alerts and reminders

- Achieve coordination of guidelines and prioritization of recommendations
  - Link information technology with clinical care
    - Information highly tailored to the patient being seen
    - Presented quickly to the clinician within the workflow
Guidelines for Patients with Multimorbidity: Linked Guidelines

- Lipids
  - Hypertension
  - Other

- Index Comorbidity: Diabetes
Vision for Clinical Decision Support Integrated with EHR

- Automatically identify patients for whom recommendations should be displayed

- Display advisory to provider/clinician when patients’ record accessed or at other appropriate trigger (e.g. order entry)

- Provide detailed clinical recommendations
  - Use all the clinical data available
  - Go well beyond simple clinical reminders
  - Provide links to additional clinical info

- Build a library of encoded guidelines in multiple clinical domains
ATHENA–CDS Goals

To improve patient care by:

- Developing a CDS system capable of representing complex clinical knowledge
  - Encode medical knowledge
    - Level of detail includes clinical nuances
  - Integrate with patient data
    - Use all relevant patient data

- Implementing the CDS in the electronic health record (EHR) in a clinical setting
Making Clinical Knowledge Computable

- Encode clinical knowledge into computer-interpretable “knowledge base”

- ATHENA-HTN Knowledge Base 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/](http://protege.stanford.edu/overview/)

Goldstein et al Proc AMIA Symp. 2000;300–4
Goldstein et al Proc AMIA Symp. 2001;214–8
Assessment and Treatment of Hypertension: Evidence-based Automation – Clinical Decision Support: ATHENA–CDS

- Started with hypertension
  - Designed as a model with plan from the start for extension to other clinical domains
  - Built ATHENA–Hypertension (HTN)
  - VA collaboration with Stanford University

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

Knowledge Acquisition Program: Protege

Protégé, developed at Stanford Biomedical Informatics Research (BMIR)

• Free, open-source, java-based
• National resource for biomedical knowledge bases
  • Supported by National Library of Medicine
  • A core component of the National Center for Biomedical Ontology (NCBO)
• Strong community of developers and users
  • Academic, government, and corporate
Clinical Scenarios/Action Choices

**hypertension management diagram (Management Diagram)**

- **First Step**
  - SBP\(\geq 180\) or DBP\(\geq 110\)
  - Subcategory: 
    - Not on drug therapy
    - No-drug-therapy-choices

- **Last Step**
  - SBP\(=220\) or DBP\(=115\), extremely <more>
  - Not on drug therapy, consider adding drug
  - Blood pressure not adequately controlled, intensity <more>
  - Evaluate new drug to pressure
  - Substituting clopindide
  - ACEI secondary prevention

- **Steps**
  - On one anti-hypertensive drug
  - One-drug-therapy-choices
  - Continue with one-drug regimen
  - On one drug, consider substituting drug
  - Alpha blocker monotherapy, add drug
  - Step up choices

- **Choices**
  - Followed by
  - Selection

- **Action Choice**
  - Scenario

- **Case Step**
  - Case Selection
Patient specific guideline-based recommendations for opioid therapy, alerts if patient is high risk for misuse and more!

Cautions:
- COPD
- Current or past drug-induced mental disorder
- Depression
- Age >= 65 years

Patient data:
- Patient name, SSN, and date of birth

Checklist:
- Conducted Pain Assessment
- Ordered a Urine Drug Screen
- Educated Patient to Call Ahead for Refills (7-10 days before running out)
- Had Patient Sign Pain Management Agreement
- Documented Pain Assessment, UDS, Patient Education, Pain Management Agreement

Tools as drop down menus:
Template for Drug Classes
Encoding Clinical Knowledge into Computable Form: ATHENA HTN Knowledge Base
Execution Engine

- The Knowledge Base (KB) encodes the clinical knowledge in computable formats.
- To generate recommendations, one needs an execution engine (aka Guideline Interpreter) to process clinical data with the KB.
  - Samson Tu at BMIR has developed this.
- Can do offline testing of the system by providing clinical data and running the execution engine.
Once the system is deemed ready for wider use, can link to patient data from electronic record system to process large numbers of cases daily
ATHENA-CDS Architecture

- VISTA hierarchical Database in MCPRS/EHR
- Data Mediator
- SQL Server: Relational database
- ATHENA HTN Guideline Knowledge Base
- Treatment Recommendation
- Guideline Interpreter
- Dashboard
Presenting Recommendations to Clinicians

- Alternate channels of communication
  - Within electronic health record cover sheet as used for one patient at a time
  - Within clinical dashboard for population management by care teams

- Considerations of clinical workflow
  - Which care team member accesses which channel and at what times/settings within workflow
Receptivity to IT Task Support

- Rapid adoption of technology people find easy to use and helpful to what they want to do
  - e.g., smartphones
- When people must perform tedious tasks and they are offered an IT tool that simplifies the task they must do anyway...
- Problem when the IT is clumsy
  - or forces choices the health professional doesn’t accept
  - or is too far ahead of what they consider to be part of their job
ATHENA Hypertension Advisory

Recommendations

Blood Pressure apparently not under control:
Based on last measurement of 145/92 taken 87 days ago on mm/dd/yyyy
23% High

*Estimated 10 Year cardiovascular risk factor for this patient

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 therefore benefit from this drug therapy

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

Therapeutic Possibilities

- Discontinue atenolol

AND start one of the following drugs
- ACE Inhibitors (lisinopril)
- (non-DHP) Calcium Channel Blocker (diltiazem)

Add one or more of the following drugs
- ACE Inhibitors (lisinopril)
- (non-DHP) Calcium Channel Blocker (diltiazem)

Increase dosage of hydrochlorothiazide

Indications

- Heart Failure
- CKD

Contraindications

- Brochospastic disease
- Heart Failure

Blood Pressure and Prescription History

Blood Pressure:
142/90

Prescription:
- Lisinopril 80 MG
- Med 2 5 MG
- Med 3 100 MG
- Med 4 80 MG
- Med 5 80 MG
- Med 6 5 MG
- Med 7 100 MG

Showing 7 of 10 drugs. See All

References Sources

Patient Summary

Thank you!

Do you have feedback for the Research team?

Exit

Don't forget you know the patient better than we do.
message utpat lorem ipsum dolor sit amet, consectetur adipiscing
142/90 on MM-DD-YYYY

- **Terazosin**: 2 mg
- **Hydrochlorothiazide**: 12.5 mg
- **Metoprolol**: 100 mg
- **Felodipine**: 2.5 mg
- **Lisinopril**: 10 mg

Showing most recent 7 of 10 drugs. See All
Getting CDS for Complex Patients into Clinical Workflow

- Complexity of current CDS needs exceed capabilities of most EHR systems
  - require external CDS systems for flexibility
- Yet, health professionals work in the EHR in their primary workflow for patient care
- It is time-consuming to launch a separate application to access CDS
  - might slow things down, might not be done
- Optimally, health professionals (clinicians) will be able to see advisories from an external CDS without leaving the EHR
ATHENA-HTN Multi-Site Studies that Displayed Recommendations within EHR

VISN 1 Study:
2008–2009
50+ Providers
7,000+ Patients
11,000+ Clinic visits

Three-Site Study:
2002–2003
50+ Providers
5,000+ Patients
Almost 10,000 Clinic visits

VISN 1 sites:
Bedford, MA
Boston, MA
Manchester, NH
Providence, RI
West Haven, CT

San Francisco VA
Palo Alto VA
Durham VAMC, North Carolina
Goldstein MK et al JAMIA 2004
Once decision support is implemented technologically, will clinicians use it?

Many clinical decision support systems are used only a tiny percent of time available

- For example, physicians viewed a hyperlipidemia guideline only 20 of 2610 visit opportunities (0.8%)
  - note that even infrequent use may still be beneficial, at very low cost for reaching large number of clinicians
Clinician Use: Time Trend BP Updates

Percentage of ATHENA Hypertension Advisories with a Blood Pressure Update

- Percent of Advisories Displayed that had a BP Update
- Month

- Month 1: 15%
- Month 2: 35%
- Month 3: 25%
- Month 4: 15%
- Month 5: 20%
- Month 6: 18%
- Month 7: 22%
- Month 8: 30%
- Month 9: 33%
- Month 10: 28%
- Month 11: 25%
- Month 12: 22%
- Month 13: 20%
- Month 14: 18%
- Month 15: 15%
Interpreting Feedback from Clinicians

Clinicanc-reported barriers

- **Data factors**: 5%
- **Monitoring or lifestyle counseling**: 9%
- **Lack of agreement with specific recommendations**: 11%
- **Patient nonadherence**: 19%
- **Not a clinical priority**: 23%
- **Other patient factors**: 49%

Lin N et al AMIA Proc 2006

% of all visits with barriers-related feedback (n=368)
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 in a Network Collaborative (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

- Veterans Integrated Service Network (VISN) 1, New England Healthcare Network
Issues: Prioritizing Recommendations

- Incorporate patient preferences
  - For health outcomes
  - For specific treatments
  - For treatment of specific diseases
  - Other

- Compare expected improvement in health/well-being of different treatments

- Consider how well each guideline applies to this patient
Potential Use in Team Care
Patient–Centered Medical Home (PCMH)/Patient–Aligned Care Team (PACT)

PCMH/PACT Panel of Patients

VISN Data Warehouse
Performance on Quality Indicators

Dashboard monitored by PCMH/PACT nursing staff

ATHENA-CDS generates recommendations with nurse or pharmacist

Recommendation/draft orders, if needed,
Discussed with doctor
Moving to Dashboard Display

- Performance measures for common chronic diseases
  - For example, Blood Pressure meeting target, HbA1c meeting target
- Existing dashboard displaying performance on the performance measures
- Goal: add recommendations about what to do next if patient’s data are not meeting the target
Organizes EHR (VistA) data for
- Panel management
- Visit view of patients coming in today
- Communication within PACT team

Primarily triggered by performance measures
- Displays meeting or not meeting measure (aggregate or drill-down to patient-level)

Our Task: Add clinical decision support for PACT team
- Funded by VA HSR&D Investigator–Initiated Research project
Structured vs Unstructured Data in Electronic Health Records

- Data elements such as laboratory values and vital signs are typically in structured data fields and have associated metadata
  - Often follow standardized formats used across different health care systems

- Much of the information content in electronic health records is in unstructured (free text fields)
What is Natural Language Processing (NLP)?

“Automated technique that converts narrative documents into a coded form that is appropriate for computer–based analysis”

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.hsrdrresearch.va.gov/for_researchers/vinci/chir.cfm
Finding Lines/Devices in CXR Reports

CXR Device Extractor review system (Dan Wang, PhD).
Ejection Fraction (EF) in Echocardiography Reports

- Regular expressions–based CUIMANDREef
  - Garvin J et al *JAMIA* 2012
- J Garvin and S Meystre new method, CHIEF

**Extraction of left ventricular ejection fraction information from various types of clinical reports.**
Kim Y, Garvin JH, Goldstein MK, Hwang TS, Redd A, Bolton D, Heidenreich PA, Meystre SM.

**Classification of Contextual Use of Left Ventricular Ejection Fraction Assessments.**
Kim Y, Garvin J, Goldstein MK, Meystre SM.

**Automated extraction of ejection fraction for quality measurement using regular expressions in Unstructured Information Management Architecture (UIMA) for heart failure.**
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[Explain]

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

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- Add one or more of the following drugs
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- Increase dosage of hydrochlorothiazide

**Indications**
- Heart Failure
- CKD

**Contraindications**
- Brochosporic disease
- Heart Failure

**Blood Pressure and Prescription History**

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142/90 on [blank]
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- Lisinopril: 80 mg
- Med 2: 5 mg
- Med 3: 10 mg
- Med 4: 50 mg
- Med 5: 80 mg
- Med 6: 5 mg
- Med 7: 100 mg

- Showing 7 of 10 drugs. See All

**Do you have feedback for the Research team? Thank you!**
Considerations in User Interface

- Attention is a scarce and valuable resource
  - Health information technology influences where attention is directed
  - Must consider how to design the GUI to direct attention correctly and not detract attention from other important clinical activities
  - Example of an issue in GUI:
    - Balance of how much information to display on top level so no additional clicks are required to view it
      - Vs
  - Decluttered appearance of top level
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See additional slides for additional acknowledgements
Thank you!

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Additional Slides
ATHENA-Opioid Therapy was supported by:

- TRX 04-402: Decision Support for the Management of Opioid Therapy in Chronic Pain, from VA Health Service Research and Development Service (HSR&D)
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