Designing Clinical Decision Support System for the Point of Care Emergency Department Patient Management

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OUTLINE

• Clinical Decision Support Systems
  • Patient-specific systems
  • Helping clinicians, helping learners
  • MET Research Overview

• Discussion
  • Data
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  • Clinical validation and evaluation
Clinical Decision Support System

- Any program designed to help health care professionals make clinical decisions
  - Very broad definition
  - Misses how important and influential CDSS can be
  - CDSS may help non-clinicians with clinical decisions
    - Patients
    - Other health care providers
Clinical Decision Support System

- Emergency Medicine Information Technology Consensus Conference (SAEM – Orlando 2004):
  - Identified several recommendations related to the need for ED decision support systems to improve patient care
  - “The most exciting promise of computers is the potential for computers to add value by providing decision support to clinicians.”

Clinical Decision Support System

- Good evidence for existence of specific features that positively correlate with successful clinical implementation:
  - Automatic decision support as part of existing clinical workflow
  - Delivery of decision support at time/location of decision making
  - Provision of actionable recommendations, not just assessments
  - Computer-based generation of decision support

CDSS – Patient-specific systems

- Multiple opportunities throughout the ED visit
- Many stand-alone or niche systems in place
  - Drug and reference manuals
  - Patient/procedure trackers for individual clinicians
  - Computerized versions of existing clinical decision rules
- Need to move towards a comprehensive system integrated with EHR and CPOE
Triage

• ED triage assessment and categorization extremely important
• Systematically applying the correct CTAS score ensures
  • Prompt recognition of seriously ill patients
    • Key complaints
    • Abnormal vital signs
  • True representation of acuity/workload
    • Staffing, resource utilization
    • Future funding – MD remuneration, ED funding
Computer-assisted Triage

“Emergency triage: Comparing a novel computer triage program with standard triage”

Dong et al. Acad Emerg Med 2005

- Compared memory-based nurse triage and computer-assisted nurse triage to a expert panel consensus standard
  - Computer-assisted had higher agreement with standard
  - Memory-based nurse triage yielded significant down-triaging of patients
Investigation & Treatment

- Emergency medicine in Canada is the leader in developing high quality, highly accurate clinical decision rules

  - Ankle/foot x-ray
  - Knee x-ray
  - C-spine
  - CT head for head injury
  - CT head for pediatric head injury
  - CT/LP for suspected SAH
  - Chest pain evaluation
  - Severe outcomes in bronchiolitis

- All can be easily computerized as stand-alone systems
- Need to be incorporated into a larger suite of CDSS tools operating in the background of the EHR, CPOE
Decision Support within CPOE

- Many opportunities to help MDs make better treatment/investigation decisions
  - Safety (drug interactions, allergy)
  - Cost-effectiveness (cheaper medication)
  - Adherence to practice guidelines (asthma order sets which prompt for systemic steroids early)
  - Other efficiencies (CXR in addition to hip x-ray for elderly fall)
CDSS – Improved MD performance

Systematic review of trials assessing the effects of CDSS, compared to care without CDSS

• 64% of 97 studies showed improved MD performance
  • 40% of diagnostic systems
  • 76% of reminder systems
  • 62% of disease management systems
  • 65% of drug-dosing/prescribing systems

• Limited effect on patient outcome
  • only 13% showed improvement

Mobile Emergency Triage
MET Research Group

- TRUE Collaborative Multi-Disciplinary Research

- Management
- Decision Science
- Systems Science

- Medicine
- Biostats

- Comp Sci.
- Comp Eng.
The goal of ED care is to efficiently “triage” patients to the most appropriate disposition path

- Discharge home
- Observe/investigate for possible pathology
- Refer to another specialist for definitive assessment/management of probable pathology

“Triage” extends beyond the initial assessment and categorization performed by the triage nurse and involves MD evaluation
MET for MD Evaluation

• Developed with the following goals:
  • Improved data collection
    • Ensure that the MD is considering all important patient attributes in an organized fashion
      • Especially important for the learner
    • Data entry and decision support at the point of care
  • Assist MD decision making
  • Promote earlier, more accurate triage/disposition decisions
    • get the patient on the right path from the start
  • NOT a diagnostic test
    • focus on “What’s the next step?”, not “What’s the problem?”

W. Michalowski et al. “Design and development of a mobile system for supporting emergency triage”, M of Inf in Med. 2005
Helper NOT Enforcer

- Provide a weighted recommendation for all possible outcomes
- Allow MD to combine recommendations with their own clinical judgments

MET Pediatric Clinical Modules

• Abdominal pain (MET-AP)

• Hip pain/limp (MET-HP)

• Scrotal pain (MET-SP)

• Asthma (MET-A³Support - Asthma)
The issue: To facilitate ED triage of acute childhood conditions at the point of care

Canadian Triage Acuity Scale (CTAS)
CTAS1 - Immediate
CTAS2 - ≤ 15 min.
CTAS3 - ≤ 30 min.
CTAS4 - ≤ 1 hour
CTAS5 - ≤ 2 hours

Prioritization
(Triage nurse)

Priority categories

Medical assessment and disposition
(MD)

Discharge
Observation/ further investigation
Consult
• Retrospective database of about 600 cases
• All documented attributes initially captured
• Cases categorized into 1 of 3 triage outcomes
  • Discharge
  • Consult surgery for appendicitis
  • Observe/investigate for other pathology– intra-abd or extra-abd
• Analysis and data mining using rough sets theory
• 13 attributes selected
  • Most discriminating
  • Most commonly documented on chart
• Pilot tested on hold-out sample
  • Overall accuracy 82%; consult sensitivity 92%/specificity 89%
MET-AP Clinical Validation Trial

- Prospective validation trial (July 2003 – Feb 2004)
  - Patients 1-16 years old
  - Acute abdominal pain <10 days duration
  - Assessed in the usual fashion
  - MD and/or residents recorded data on a PDA and entered their prediction
  - Chart and telephone follow-up to determine the patient’s final outcome (gold standard)
## Results

<table>
<thead>
<tr>
<th></th>
<th>MD Assessments (n=457)</th>
<th>Resident Assessments (n=339)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MET-AP Triage Accuracy</td>
<td>72.2%</td>
<td>69.3%</td>
</tr>
<tr>
<td>MD Prediction Accuracy</td>
<td>70.2%</td>
<td>62.8%</td>
</tr>
</tbody>
</table>

MET: Current Research

- Create methodological and applied health informatics solutions that allow Emergency MD to take full advantage of the wealth of information that will be accessible when Electronic Health Records become widely available in Canada.

- Look beyond the Electronic Health Record and provide the means and methodologies for using this repository of information for evidence-based, patient-specific decision-making.
MET-A$^3$Support - Asthma
Management Workflow of Asthma Exacerbations

- Underestimation of the exacerbation severity results in premature discharge and a possible return visit.
- Overestimation of the exacerbation severity results in patient unnecessarily occupying bed and clinical resources.

<table>
<thead>
<tr>
<th>Severity</th>
<th>ED LOS</th>
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<tbody>
<tr>
<td>Mild</td>
<td>$\leq 4$ hours</td>
</tr>
<tr>
<td>Moderate</td>
<td>4 – 12 hours</td>
</tr>
<tr>
<td>Severe</td>
<td>12 – 16 hours</td>
</tr>
</tbody>
</table>

Severity

ED LOS

Mild

Moderate

Severe

Triage

Triage assessment

Registration

Treatment

Evaluation

Repeated assessment

Disposition

Discharge

Admit
Current Management Tools

- Paper-based tools and forms
- No direct support for evidence-based decision making
Scenario

1. ADT sends registration record to the CDSS.
2. The MD uses the CDSS to record data and asks for diagnostic support.
3. The CDSS provides diagnostic suggestion.
4. The MD orders some tests and the CDSS passes this request to CPOE.
5. Subsequent management process follows.
6. Upon prescription of a treatment, the CDSS consults an embedded CPG.
7. The MD requests the evidence and the CDSS retrieves it from the Cochrane Library.
8. Patient management is continued.
Issues and Challenges

- Information and knowledge are distributed
- Provision of integrated support involves several decision points/problems
- Solving some problems may require advanced models (OR, AI)
- Supporting patient management may require using "services" provided by a hospital
- All information and decisions have to be shared for continuity and coordination of care
A³ Support Architecture

- A³Support: providing integrated decision support anytime and anywhere in the ED
- Intended for MDs and nurses
- Multi-agent system composed of several "logical" agents, collectively capable of solving problems
- Users have full control over the agents – they define goals for the agents and activate them
- Some agents are implemented as services (hybrid multi-agent and service-oriented architecture)
- Engineered using the O-MaSE (Organization-based Multi-agent System Engineering) methodology
Goal Model for $A^3$ Support
A³Support Functional Architecture

Security Manager -> Evaluation Suggester -> Treatment Suggester -> Evidence Provider -> Evidence Repository

Encounter Manager -> Encounter Supporter

Data Manager

HIS Synchronizer -> HIS
Evaluation Suggester

- Provides evaluation of asthma severity for a specific patient based on current patient state (mild vs. other exacerbations)

- Employs prediction model developed from retrospective and prospective asthma data using data mining techniques enhanced with
  - Secondary clinical knowledge
  - Contextual normalization
Evaluation Suggester

- Tree-based model proved to be the most appropriate (AUC) in a series of computational experiments
- It is better for readability and comprehension
Evidence Provider

- Retrieves medical evidence from online medical repository (the Cochrane Library) to support evidence-based decision making
- Enhanced indexing to create fine-grained descriptions of systematic reviews and referenced articles
- A search model that automatically formulates a query using information from a current patient-physician encounter
- Presentation model that ranks retrieved results and abstracts retrieved evidence
Evidence Provider

• Complex ontological model of concepts was created for indexing entries in Systematic Reviews section of the Cochrane Library
• Weights to compute the ranks established on the basis of expert opinions and simulation experiments
Discussion

"Nurse, get on the internet, go to SURGERY.COM, scroll down and click on the 'Are you totally lost?' icon."
Clinical Data

• Deficiency in data
  • Paucity of centers with EHR
  • Few comprehensive clinical data repositories
• Standards/protocols for data sharing/pooling
  • MeSH, LOINC not used/enforced
  • Can HL7 be considered a standard?
  • Interoperability
• Privacy and security
  • How much of the total picture to reveal?
Models

- Expert versus knowledge-based
  - How to capture the tacit knowledge of experts?
  - What source of existing knowledge?
    - Does retrospective data work?
    - Can we overcome data issues between sources?
- Clinical decision rules versus “other” models
  - How good a decision model should be?
  - What’s best when multiple rules/models need to interact?
Clinical Validation and Evaluation

• What outcomes need to be measured?
  • Patient care
  • MD performance
  • Health system performance
• What level of accuracy is clinically acceptable? medico legally defensible?
• By what methods to evaluate?
  • Do we need RCT evidence? At what level of randomization?
    • Patient
    • Clinician
    • System
• What about system usability, reliability?
Thank you

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