Providing Integrative Decision Support to Physicians at the Point of Care: MET3 Clinical Decision Support System

Wojtek Michalowski
Szymon Wilk, Ken Farion, Dympna O’Sullivan

MET Research Group, University of Ottawa
in collaboration with
Telfer School of Management
School of Information Technology and Engineering
Departments of Pediatrics and Emergency Medicine
Outline

- Challenge
- MET research
- MET3 framework
- MET3-AE
- Next steps
Clinical decision support (CDS): *providing clinicians or patients with computer-generated clinical knowledge and patient-related information, intelligently filtered or presented at appropriate times, to enhance patient care*

There are technologies to create pervasive, mobile, and comprehensive CDS but.....

the main challenge is: **HOW TO CREATE A SYSTEM THAT CLINICIANS WILL USE?**
Requirements for Effective CDS

- Speed is everything
- Anticipate needs and deliver in real time
- Fit into user’s workflow
- Little things can make a big difference
- Make interactions easy
- Changing direction is easier than stopping
- Summarize patient data
- Create shareable CDS modules available across intra and extra nets

Bates et al., JAMIA, 2003
Sittig et al., JBI, 2008
Premise: Support All Stages of Physician Decision-making

Hypothetico-deductive approach: from a set of hypotheses to a treatment plan
**MET Research**

- **MET1**: provided support for MD’s ED triage on a mobile device (PDA)

- **MET2**: provided support for MD’s ED triage of a suite of acute pediatric conditions (abdominal pain, scrotal pain, hip pain) on a variety of computing devices (mobile and desktop)

- **MET3**: provides integrative support for all MD tasks according to the hypothetico-deductive model on a variety of computing devices integrating data coming from a variety of sources
MET2: Computer Implementation

- Client
- Sync Subsystem
- Model Repository
- Database
- Management Subsystem
- Integration Subsystem
- Audit Application
- Follow-up Application
- DataGate
- HIS

Trial-specific
**MET2-AP**: Human-computer Interactions
Integrative Clinical Decision Support at the Point of Care

- Intensive, but disjoint research on:
  - Hospital information systems (HIS), including electronic health record (EHR)
  - Clinical decision support (CDS)
  - Computerized clinical practice guidelines (CPG)
  - Repositories of clinical evidence

- **MET3** integrates clinical data, decision support and evidence at the point of care (POC)
MET3 Use Case:
Managing a Patient in the ED

1. Patient is registered. The ADT notifies the EHR and the MET3.
2. The MD uses the MET3 to record and retrieve patient data.
3. The MD asks for diagnostic support. The MET3 provides a diagnostic suggestion.
4. The MD orders a test and the MET3 passes this request to the LIS.
5. ...
6. Upon prescription of a treatment, the MET3 consults an embedded CPG.
7. The MD requests the evidence. The MET3 retrieves it from the evidence repository.
8. …
**MET3**: Design Framework

- System designed along multi-agent system architecture principles

- Structured translation of needs into functional requirements using O-MaSE methodology
  - Abstraction of object-oriented paradigm (agents are specialized objects)
  - Supports separation of ontology from processing and introduces creation of an domain ontology as important part of analysis
Maps requirements into goals and introduces relationships among them.
Domain Ontology

Used to derive abstract models required for achieving goals.
Agent Model

Shows types of agents needed to achieve goals and depicts all interactions (internal and external)
ED management of pediatric asthma patients
- Supports early management (around 1 hour after triage)
- Designed for MDs and nurses @ POC
- Integrates with HIS (ADT, EHR) to share patient data and with the *Cochrane Library* to retrieve evidence
- Uses decision model for predicting severity and integrates with the CPG for treatment options
- Uses indexing and retrieval model for identifying and providing patient-specific evidence

Encapsulates user-driven support
Diagnosis Suggestion: Predicting Severity of Exacerbation

- Tree-based model was developed from retrospective data using data mining techniques enhanced with:
  - Secondary clinical knowledge
  - Contextual normalization
- Model is customized for local settings, readable and interpretable
Diagnosis Suggester: Model Development 1

- Retrospective chart study with relevant records identified using ICD-10 code and data items transcribed by a trained abstractor
- Each record described by 42 + 1 attributes
- Significant number of missing values
Diagnosis Suggester: Model Development 2

- **Record filtering**: use of external data knowledge source (modified PRAM score) to remove questionable records;

- **Contextual normalization**: data-driven normalization of four age-dependent attributes using “mild neighbors” as a baseline.
Diagnosis Suggester: Model Development 3

**Learning data**

<table>
<thead>
<tr>
<th>Severity</th>
<th># of records</th>
<th>% of records</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td>98</td>
<td>41</td>
</tr>
<tr>
<td>Other</td>
<td>141</td>
<td>59</td>
</tr>
<tr>
<td>Total</td>
<td>239</td>
<td>100</td>
</tr>
</tbody>
</table>

**Validation data**

<table>
<thead>
<tr>
<th>Severity</th>
<th># of records</th>
<th>% of records</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td>65</td>
<td>53</td>
</tr>
<tr>
<td>Other</td>
<td>58</td>
<td>47</td>
</tr>
<tr>
<td>Total</td>
<td>123</td>
<td>100</td>
</tr>
</tbody>
</table>

**Validation results**

<table>
<thead>
<tr>
<th>Model</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tree-based with record filtering</td>
<td>76%</td>
<td>65%</td>
</tr>
<tr>
<td>Tree-based with record filtering and contextual normalization</td>
<td>84%</td>
<td>71%</td>
</tr>
<tr>
<td>Logistic regression</td>
<td>69%</td>
<td>68%</td>
</tr>
</tbody>
</table>
Treatment Suggester: Suggesting Treatment Option

- Rule-based model developed from the CAEP Pediatric Asthma CPG
- Links severity prediction or assessment with treatment options
- Easy to maintain and update
Evidence Provider: Identification of Core Concepts using the UMLS Metathesaurus

<table>
<thead>
<tr>
<th>CPG Diagnosis Index Terms</th>
<th>CPG Treatment Terms</th>
<th>Clinical Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild Asthma</td>
<td>Oxygen</td>
<td>Animal allergy</td>
</tr>
<tr>
<td>Moderate Asthma</td>
<td>Agonists</td>
<td>Environmental allergy</td>
</tr>
<tr>
<td>Severe Asthma</td>
<td>Corticosteroids</td>
<td>Food allergy</td>
</tr>
<tr>
<td></td>
<td>Anticholinergics</td>
<td>Allergen exposure</td>
</tr>
<tr>
<td></td>
<td>Magnesium sulfate</td>
<td>Inspiratory wheeze</td>
</tr>
<tr>
<td></td>
<td>Methylxanthines</td>
<td>Expiratory wheeze</td>
</tr>
</tbody>
</table>

An issue: How to retrieve patient-specific clinical evidence?
In order to expand coverage of the index terms, for each core concept, expanded concepts are identified using ISA (hyponyms), INVERSE_ISA (hypernyms), SAME_AS (synonyms) relations.
Evidence Provider: Indexing and Querying

Core and expanded concepts are identified in documents (reviews and studies) using the MetaMap system.
Documents are indexed with core concepts and indices are represented as weighted index vectors following the vector space model (VSM).
Upon request by MD, three concept-based queries are automatically formulated and executed, and their results are combined together into a final document list.
Evidence Provider: Presenting Retrieved Evidence

- Hierarchical presentation based on well defined structure of systematic reviews

**Combined inhaled anticholinergics and beta2 agonists for initial treatment of acute asthma in children**

**Background**
Several randomized controlled trials have examined, with conflicting results, the efficacy of the addition of anticholinergics to beta2 agonists in acute pediatric asthma. The pooling for a larger number of randomized controlled trials may provide not only greater power for detecting group differences and also provide better insight into the influence of patients’ characteristics and treatment modalities on efficacy.

**Objectives**
The aims of this study were to estimate the therapeutic and adverse effects attributable to the addition of inhaled anticholinergics to

**Beck 1985**

**Methods**
- RANDOMIZATION
  - Method: not described
- Means: number-coded solutions supplied by pharmacy
- BLINDING: double-blind; identical placebo
- WITHDRAWAL/DROPOUT: not described
- JADAD’s quality score=3

**Participants**
N = 25
- AGE: 6-17.5 years old
- BASELINE SEVERITY: <50% Pred FEV1
- COUNTRY: Canada
- OTHER: ability to perform spirometry consistently

**Interventions**
- PROTOCOL
**MET3-AE:** Computer Implementation

- **Encounter Assistant**
  - Model Repository
  - Model Manager
  - Evidence Provider
  - Treatment Suggester
  - Diagnosis Suggester
  - Data Manager
  - HIS Synchronizer
  - Mirth

- **Follow-up Assistant**
  - HIS

- **Trial-specific**
  - Audit Assistant

**System Components:**
- ***Evidence Repository***
- ***Data Repository***

**Network Connections:**
- Interconnections between various components for data synchronization and management.
**MET3-AE: Clinical Trial**

- Conducted in the ED at CHEO as a pilot study including the team of physicians, residents and nurses
- Planned for 6-8 months to enroll about 1200 patient-visits

- The major goal is to evaluate and compare predictive accuracy of physicians, PRAM score and MET3-AE
- The secondary goal is to verify the acceptance of clinicians for advanced CDS technology in the ED
**MET3-AE**: Encounter Assistant (PC)

### MET Asthma Module

**Patient**: Michael Brown (ID: 44) with complaint: ASTHMA

**Staff member**: Tomasz Buchert (ID: 1)

<table>
<thead>
<tr>
<th>History</th>
<th>7/14/11 1:02 PM</th>
<th>Assessment</th>
<th>7/14/11 1:05 PM</th>
</tr>
</thead>
</table>

**Medical History**

- **Primary care**: Family Doctor, Pediatrician, Walk-in/Other, None
- **Prev. chest HR**: Yes, No
- **Age of 1st asthma attack**: < 1 yr, 1-3 yrs, > 3 yrs
- **Current inhaled steroids**: < 1 wk, 1-4 wks, > 4 wks, None
- **Last exacerbation**: < 1 m ago, 1-3 m ago, 3-12 m ago, > 12 m ago
- **Last oral steroids**: < 1 m ago, 1-3 m ago, 3-12 m ago, > 12 m ago, Never
- **Prev. EID for asthma**: 1 visit, 2 visits, 3 visits, 4 or more visits, None
- **Prev. ad admission for asthma**: Floor, ICU, None
- **Smokers at home/daycare**: Yes, No
- **Carpets in bedroom**: Yes, No
- **Pet allergies**: Yes, No
- **Food allergies**: Yes, No
- **Environmental allergies**: Yes, No
- **Atopy/Eczema**: Yes, No
- **Family Hx asthma**: Yes, No

**Current Exacerbation**

- **Duration of SIT**: < 12 hrs, 12-48 hrs, > 48 hrs
- **LRTI SIT**: Yes, No
- **Fever**: Yes, No
- **Exposure to allergens**: Yes, No
- **Bronchodilators last 24 hrs**: 1-3, 4-6, > 6, None
- **Transport to ED**: Self, Ambulance

*Image of the MET Asthma module interface.*
**MET3-AE**: Follow-up Assistant
**MET3:** Next Steps

Development of “intelligent” clinical practice guideline:
- Customizable to local clinical practice
- Customizable to user’s level of expertise
- Applicable with incomplete patient data
- Integrated with a workflow
- Acting as a single point of entry for
  - Data capture/retrieval
  - Decision support
  - Integration with HIS/EHR
  - Access to clinical evidence
“Intelligent” CPG

- EHR/HIS
  - Data retrieval
  - Data capture
  - Incomplete patient data
  - Diagnostic evaluation
    - Treatment planning
    - Evidence retrieval
    - Clinical evidence

- Site-specific data model
- Site-specific diagnostic model
- Site-specific treatment model
- Site-specific evidence model

Customization

Single point of entry

Local clinical practice
How **MET3** Meets Requirements for Effective CDS

- Speed is everything: **All functions available instantaneously**
- Anticipate needs and deliver in real time: **Real time patient data, diagnostic support and evidence are delivered**
- Fit into user’s workflow: **System design comes from a decision-making model**
- Little things can make a big difference: **Clinical scores, evidence summaries are provided**
- Make interactions easy: **Point and click entry, familiar chart layout**
- Changing direction is easier than stopping: **Ability to move from one action to any other**
- Summarize patient data: **Patient and evidence summaries are available**
- Create shareable CDS modules available across intra and extra nets: **Decision models, ontology, solvers are shared and accessible from multiple entry points**
MET Research @ uOttawa

www.mobiledss.uottawa.ca