Multi-Agent Support Framework for Managing Children with Asthma Exacerbations in the Emergency Department

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Outline

- Asthma in children and its management
- Issues and challenges
- Multi-agent systems
- A³Support
- Future research
Asthma in Children

- Asthma is a respiratory disease in which the airways constrict in response to some triggers (e.g., viruses, animal dander, dust)
- Asthma is the most common chronic disease in children (10% of Canadian population)
- Asthma exacerbations are the most common reasons for visits to the emergency department (ED)
- Asthma is expensive – children with asthma use 3 times more prescriptions, and require 2 times as many ambulatory care and ED visits as other pediatric patients
Management Workflow of Asthma Exacerbations

- Underestimation of the severity results in premature discharge and a possible return visit
- Overestimation of the severity results in patients unnecessarily occupying beds and clinical resources

<table>
<thead>
<tr>
<th>Severity</th>
<th>Duration</th>
</tr>
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<tbody>
<tr>
<td>Mild</td>
<td>≤ 4 hours</td>
</tr>
<tr>
<td>Moderate</td>
<td>4 – 12 hours</td>
</tr>
<tr>
<td>Severe</td>
<td>12 – 16 hours</td>
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</tbody>
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Current Management Tools (1)

- Paper-based tools and forms
- No direct support for evidence-based decision making
Current Management Tools (2)
Future Management Tools

- Paper charts and forms replaced by hospital information systems (HIS) including
  - Electronic health record (EHR)
  - Laboratory information system (LIS)
  - Computer physician order entry (CPOE)
  - Admission-discharge-transfer (ADT)

- Availability of the wireless network throughout the ED

- An opportunity to introduce a clinical decision support system (CDSS) for managing asthma exacerbations
Issues and Challenges

- Different users complete diversified tasks from the management workflow using different information systems
- Interactions with multiple systems
- No support for evidence-based decision making
- Lack of uniform security and privacy solutions
Security and Privacy Issues

- Legal framework provided by PHIPA – Personal Health Information Protection Act

- The "circle of care"
  - Defines members of the health care team who are involved in providing care or treatment to a particular patient
  - Members of a "circle of care" can collect and use the patient’s personal health information for that care, unless they know that the patient has expressly withheld or withdrawn consent

- "Lock boxes"
  - Patient has right to have his/her health information withheld from the members of a circle of care
Multi-Agent Architecture

- Multi-agent system is composed of several software agents, collectively capable of solving problems.

- Proposed approach is inspired by RETSINA (Reusable Environment for Task-Structured Intelligent Networked Agents) developed at Carnegie-Mellon University.

- RETSINA has three levels of architecture:
  - Infrastructure architecture
  - Functional architecture
  - Agent architecture

- RETSINA does not rely on a "coordinator" and uses capability-based coordination to coordinate the agents.
A³Support System Architecture

- A³Support: providing support Anytime And Anywhere

- Structure of the system reflects the management workflow
  - Each user group has corresponding interface agent
  - Each patient management task has corresponding task agent
  - Each hospital system has corresponding information agent

- Additional components
  - Clinical evidence repository (CER) with information agent
  - "Circle of care" – access of authorized users with task agent
  - "Lock boxes" – access to authorized information with task agent
**A³Support Infrastructure Architecture**

**Security**
- Communication security for preventing losses of information
- Infrastructure integrity for preventing inappropriate manipulation of the infrastructure components

**Agent Communication Language (ACL)**
- Syntax of exchanged messages
- Shared ontology of terms used in exchanged messages
- Conversational protocols that drive message exchange

**Communication**
- Direct channel for transferring messages between agents and agents and the infrastructure

**Agent directory**
- Lookup mapping the name of the agent to its physical location (*white book*)

**Operating environment**
- Physical networks, computers, operating systems etc.
A³Support Functional Architecture

**Interface agents**
- Interact with users, receive user input, and display results

**Task agents**
- Help users perform tasks, formulate problem-solving plans and execute these plans

**Information agents**
- Provide access to a heterogeneous information sources

- **Interface agents**
  - Triage task interface agent
  - Registration clerk interface agent
  - Nurse interface agent
  - EP interface agent

- **Task agents**
  - Registration task agent
  - Triage task agent
  - Treatment task agent
  - Assessment task agent
  - Disposition task agent
  - Evaluation task agent
  - Pathway monitoring task agent

- **Information agents**
  - ADT information agent
  - "Lock-box" task agent
  - EHR information agent
  - LIS information agent
  - CPOE information agent
  - CER information agent
  - Admission-Discharge-Transfer (ADT)
  - Electronic health record (EHR)
  - Laboratory information system (LIS)
  - Computer physician order entry (CPOE)
  - Clinical evidence repository (CER)
A³Support Agent Architecture

**Communicator**
exchanges and interprets messages from other agents, identifies objectives

**Planner**
selects appropriate plan template from the plan library and creates a plan

**Executor**
executes and monitors scheduled tasks, handles failures

- **Objectives**
- **Plan**
- **Current actions**
- **Working memory**

**Plan library**
- If goal = treatment/medication then search Cochrane Library for pediatric asthma trials
- If goal = evaluation, then search Medline for evaluation of pediatric asthma exacerbations

**Communicator exchanges and interprets messages from other agents, identifies objectives**

**Planner selects appropriate plan template from the plan library and creates a plan**

**Executor executes and monitors scheduled tasks, handles failures**

**Working memory**

**Search Cochrane Library for pediatric asthma trials**

http://www.update-software.com/search/search.asp?zoom_query=asthma+asthma+pediatric&Login=Search
Future Research

- ACL and shared ontologies
- Computer implementation of A³Support
- Integration with existing hospital systems and data exchange methods
- Provision of meaningful evidence for decision support
- Prospective evaluation of clinical performance
Thank You

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