Bayesian Belief Network Model of a Clinical Caremap: Implementation of the Radical Prostatectomy Caremap in MET Support Environment

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Outline

☐ Clinical Caremap
☐ Bayesian Belief Network (BBN)
☐ Radical Prostatectomy Caremap (RPC)
☐ BBN Model for RPC
☐ MET Decision Support Environment
☐ Mobile Caremap Monitor (MCM) – Implementation Using Ontological Engineering
☐ Discussion
Clinical Caremap

- Represents sequencing and timing of interventions for a particular clinical presentation
- Designed to minimize delays and resource utilizations and to maximize the quality of care
- Used to monitor and control patient’s progress measured according to standard process and clinical outcomes, e.g., length of stay (LOS)

Radical prostatectomy caremap (RPC) describes patient’s management from a post-op to a fourth day of stay in the hospital
Bayesian Belief Network (BBN)

- Models a stochastic process composed of the events with associated conditional probabilities and relationships between these events.
- Generates an answer to conditional-type queries, e.g., considering the patient’s health status on a given day, what impact would X have on meeting the expected day of discharge
BBN Model for the RPC – Variables

- **Independent variables describing the patient’s state on a specific post-op day**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
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<tbody>
<tr>
<td>Psychological condition</td>
<td>✓</td>
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<td></td>
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<tr>
<td>Vital signs</td>
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<td>✓</td>
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<tr>
<td>Temperature</td>
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<td>✓</td>
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<td>Activity with the RPC</td>
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<td>✓</td>
<td>✓</td>
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<tr>
<td>Nutrition with the RPC</td>
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<td>✓</td>
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<td>Pain at rest</td>
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<td>Respiratory function</td>
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<td>JP output</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
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<td>Evidence of hematuria</td>
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<td>✓</td>
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<tr>
<td>Pain with mobility</td>
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<td>✓</td>
<td>✓</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

- **Dependent variable describing clinical outcome**
  - LOS (*met* if 4 days or shorter, *delayed* otherwise)
BBN Model for the RPC – Knowledge Discovery

☐ Learning data set
- 75 patients managed by various clinical teams between 2002 and 2003 at the Ottawa Hospital – Civic Campus
- Data transcribed from patient’s files and evaluated by urology specialists for consistency and correctness

☐ Learning method
- K2 algorithm (implemented in Bayesware Discoverer) used to build the BBN structure and calculate the conditional probabilities
BBN Model for the RPC – Structure
BBN Model for the RPC – Verification

- Testing data set
  - 50 patients managed by various clinical teams between 2002 and 2003 at the Ottawa Hospital – Civic Campus
  - Independent from the learning set
  - Data reviewed according to the same regimen as learning data set

- Test results:
  - Overall accuracy: 82%
  - Accuracy for predicting LOS \textit{met}: 90%
  - Accuracy for predicting LOS \textit{delayed}: 65%
Decision support environment for applications supporting various clinical decision problems

- Triage of acute pain (abdomen, scrotum, hip)
- Triage of asthma exacerbations

- Easily adaptable to support any other clinical decision problem

- Accessible on a variety of computing platforms when and where required – ubiquitous support

- Designed according to the anytime & anywhere architecture (A³)
A³ Architecture

- Relies on logical models of domain, support and system components and models of access platforms
- Specific applications (for a given decision problem and access platform) are rendered on demand from these logical models
- Logical models are represented as ontologies divided into several areas (referring to specific models)
  - Domain (patients, episodes, presentations)
  - Support (decision models and solvers)
  - System (user interface and application modules)
Mobile Caremap Monitor (MCM)

- New application within the MET environment
- Allows estimating variances from the RPC
- Easily expandable to support caremaps for other clinical presentations

- Ontological model for the MCM is built from the MET generic ontology and specialized for the RPC
Ontological Model of the MCM – Structure
Ontological Model of MCM – Description

☐ Domain
  ■ A single patient can have several episodes (e.g., visits in the ED or hospitalizations)
  ■ Each episode is bound to a single clinical presentation

☐ Support
  ■ Decision model contains the knowledge necessary to support a clinical presentation
  ■ Solver instantiates model using actual data to arrive at a solution
  ■ Attribute mappers pre-process values of attributes according to the requirements of decision models
Ontological Model of MCM – Description (2)

- System
  - Editing modules manage user interface for presenting and modifying patient’s data
  - Support modules provide support functionality for clinical presentations
  - User interface renderers lay-out and manage logical screens
  - Logical screens group and manage several attribute editors
  - Attribute editors bind specific widgets (editing tools) to specific attributes
MCM in Action - Desktop computer

All attributes can be presented at once and „inlined” owing to a large display.
MCM in Action – Handheld Device

Tabs and pop-up dialogs are used to fit the interface on a small display.
Discussion

- BBN adequately models the RPC and very well describes probabilistic inferences, as verified on testing data set
- MET decision support environment is rich enough to include the MCM
- Ontological engineering provides necessary high level abstract models to capture intertwined nature of clinical domain description and clinical domain support
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Thank You

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