HIGHER RESOLUTION MEDICINE
PATIENT MONITORING, PROFILING, REAL TIME ANALYSIS

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Primer on AI for pharmaceutical scientists
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Disclosure

I have no relationships with commercial interests.

I hold a grant from the Réseau de recherche en santé respiratoire du Québec, a thematic network supported by the FRQS.
Research database

>3,000 patients
>1.2x10^9 data points

Data gathering process of the high resolution database (HRDB) in the Pediatric Intensive Care Unit (PICU) at CHU Sainte-Justine

Challenges of intensive care data

- Compartmentalization
  - Privacy
  - Integration
  - Harmonization

- Corruption
  - Erroneous Data
  - Missing Data
  - Imprecise Data

- Complexity
  - Multimodal Data
  - State Estimation
  - Events Prediction
# Validation process of HRDB

Quantitative validation

<table>
<thead>
<tr>
<th></th>
<th>Reference Median [min-max]</th>
<th>Database Median [min-max]</th>
<th>Mean difference</th>
<th>Agreement</th>
<th>R²</th>
<th>ICC (CI95%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Monitors' data</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heart rate (bpm)</td>
<td>117 [49-199]</td>
<td>117 [49-199]</td>
<td>−0.019</td>
<td>99.7%</td>
<td>1</td>
<td>1 (1–1)</td>
</tr>
<tr>
<td>Respiratory rate (bpm)</td>
<td>28 [11-89]</td>
<td>28 [11-89]</td>
<td>−0.001</td>
<td>99.9%</td>
<td>1</td>
<td>1 (1–1)</td>
</tr>
<tr>
<td>Pulse oximetry (%)</td>
<td>100 [74-100]</td>
<td>100 [74-100]</td>
<td>0</td>
<td>100.0%</td>
<td>1</td>
<td>1 (1–1)</td>
</tr>
<tr>
<td>Positive end expiratory pressure (cmH₂O)</td>
<td>7 [5-13]</td>
<td>7 [5-13]</td>
<td>0</td>
<td>100%</td>
<td>1</td>
<td>1 (1–1)</td>
</tr>
<tr>
<td>Positive inspiratory pressure (cmH₂O)</td>
<td>18 [8-35]</td>
<td>18 [8-35]</td>
<td>−0.022</td>
<td>95.5%</td>
<td>1</td>
<td>1 (1–1)</td>
</tr>
<tr>
<td>Respiratory rate (rpm)</td>
<td>34 [11-56]</td>
<td>34 [11-56]</td>
<td>0.008</td>
<td>94%</td>
<td>1</td>
<td>1 (1–1)</td>
</tr>
<tr>
<td>Infusion pumps</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate of infusion (ml/h)</td>
<td>1.3 [0-100]</td>
<td>1.3 [0-100]</td>
<td>0</td>
<td>100%</td>
<td>1</td>
<td>1 (1–1)</td>
</tr>
</tbody>
</table>

Validation process of HRDB

**Qualitative validation**

<table>
<thead>
<tr>
<th>Extent to which eligible population is representative of the country</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>No evidence or unlikely to be representative</td>
<td>Some evidence eligible population is representative</td>
<td>Good evidence eligible population is representative</td>
<td>Total population of country included</td>
<td></td>
</tr>
<tr>
<td>Few (&lt; 80%) or unknown</td>
<td>Some (80%-89%)</td>
<td>Most (90%-97%)</td>
<td>All or almost all (&gt; 97%)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Completeness of recruitment of eligible population</th>
<th>Identifier Admin info</th>
<th>Identifier Admin info</th>
<th>Identifier Admin info</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition or intervention</td>
<td>Condition or intervention</td>
<td>Condition or intervention Short or long-term outcome Major known confounders</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variables included in the database</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
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<td>Some (50%-79%)</td>
<td>Most (80%-97%)</td>
<td>All or almost all (&gt; 97%)</td>
<td></td>
</tr>
</tbody>
</table>

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<tr>
<th>Completeness of data (% variables at least 95% complete)</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
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Patient monitoring

Patient profiling

AI in the ICU

• Applications
  – Severity scoring
  – Prediction of sepsis
  – Decision support in mechanical ventilation

• Benefits
  – Rapid analysis of many physiological variables
  – Reduce inter-clinician variability

• Challenges
  – Fully electronic data (no paper!)
  – Data security and privacy

AI techniques

• Recurrent Neural Networks (and variants) for modeling real time data streams
  

• Automatized modeling and simulation: System Entity Structure approach to build virtual patients
  
Real time analysis

- In a HRDB, even data preprocessing steps can be time consuming
- Algorithm performance is critical
- Example
  - Synchronization (learning) of virtual patient with real patient
  - Might be needed at different times during an intervention
Thank you!