## Problem Statement

- Pediatric intensive care units (PICUs) care for critically ill and injured children
- Two types of PICUs: Level I and level II.
- Critically ill patients are frequently transferred from Level II to Level I PICUs.
- Decision to transfer is based on qualitative and broad guidelines.
- Transfer patients experience
  - worse clinical outcomes than patients initially admitted to Level I PICU
  - higher mortality the longer they spend in the Level II PICU before transferring.
- Most common example of transferred patients are children with respiratory failure; significant morbidity and mortality are associated with these patients.
- There is no objective criteria for if and when to transfer patients between levels.

### Goal:
Develop a systematic framework for making ICU transfer decisions for children with respiratory failure.

### Multi-step Approach

1. Identify factors associated with transfer using regression
2. Specify objective criteria for transferring patients
3. Testing threshold policies against actual transfer data

### Data:
646 patients (184 transferred, 462 non-transferred) from 6 Level II PICUs in MI and OH from January 1, 1997 to December 31, 2007.

## Identifying Important Factors

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days in PICU (10^4)</td>
<td>49.410</td>
<td>71.67</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Age (days, 30^4)</td>
<td>-0.620</td>
<td>0.578</td>
<td>0.16</td>
</tr>
<tr>
<td>Absolute change from initial PELOD score (10^4)</td>
<td>0.871</td>
<td>0.585</td>
<td>0.02</td>
</tr>
<tr>
<td>Minimum Heart Rate (10^4)</td>
<td>-0.481</td>
<td>0.322</td>
<td>0.14</td>
</tr>
<tr>
<td>Maximum Heart Rate (10^4)</td>
<td>0.643</td>
<td>0.272</td>
<td>0.03</td>
</tr>
<tr>
<td>Minimum Sysolic Blood Pressure (10^8)</td>
<td>-1.470</td>
<td>0.462</td>
<td>0.02</td>
</tr>
<tr>
<td>Maximum Sysolic Blood Pressure (10^8)</td>
<td>-0.205</td>
<td>0.321</td>
<td>0.52</td>
</tr>
<tr>
<td>Arterial Catheter</td>
<td>0.136</td>
<td>0.258</td>
<td>0.60</td>
</tr>
<tr>
<td>Central Venous Catheter</td>
<td>0.413</td>
<td>0.234</td>
<td>0.08</td>
</tr>
<tr>
<td>HFOV</td>
<td>1.567</td>
<td>0.491</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Nitric Oxide</td>
<td>1.444</td>
<td>0.740</td>
<td>0.05</td>
</tr>
<tr>
<td>Surfactant</td>
<td>1.278</td>
<td>0.883</td>
<td>0.06</td>
</tr>
<tr>
<td>Antibiotics</td>
<td>-0.944</td>
<td>0.527</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Sedative</td>
<td>-0.429</td>
<td>0.235</td>
<td>0.07</td>
</tr>
<tr>
<td>Blood Transfusion</td>
<td>0.587</td>
<td>0.348</td>
<td>0.01</td>
</tr>
</tbody>
</table>

### Left:
For each factor, regression was used to determine whether variable can explain variation in transfer status. Generalized estimating equations (GEE) and binary logistic regression (BLR) were used. Above: Multiple regression with backward elimination was used to determine important factors for explaining variation in transfer status. Important variables (p<0.05) are displayed. GEE and BLR were again used.

## Specify Objective Criteria

- Patients are transferred when estimated transfer probability (from regression) is above some threshold.
- Threshold is determined to minimize the weighted average of Type I and II error where
  - Type I error: transferring patient who did not need transfer
  - Type II error: not transferring a patient who needed transfer.

### Right:
Example of estimated transfer probability for a patient that is not transferred. For Right: Example of estimated transfer probability for a patient that is transferred.

## Testing Threshold Policies

### Left:
Optimal transfer thresholds (determined with training data) are displayed for various choices in importance between Type I and Type II error.

### Middle:
Average reduction in transfer delay is depicted using the optimal transfer thresholds.

### Right:
Demographics of patients in training and testing data.

## Next Steps

- Determine what happens in Level I PICUs after transfer
- Optimization model
- Incorporate operational components (e.g. number of beds.)

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