2015 Healthcare Engineering and Patient Safety Symposium

CENTER FOR HEALTHCARE ENGINEERING & PATIENT SAFETY
UNIVERSITY OF MICHIGAN

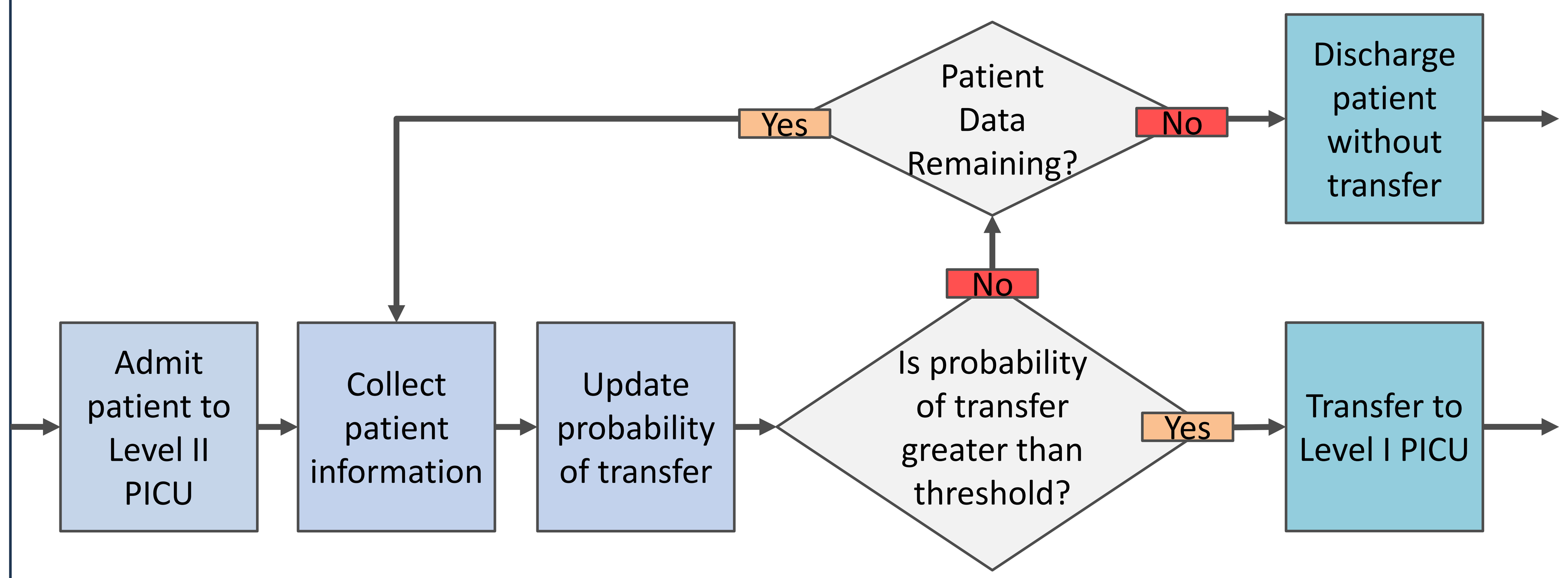
An Innovative Framework to Improve Efficiency of Interhospital Transfers

Luke Bruski, Mariel Lavieri, Fola Odetola, and Gabriel Zayas-Caban

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.

<u>Goal</u>: 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.

1 Identifying Important Factors

Covariate	Coefficient	Standard Error	P-Value
Days in PICU (10^4)	49.410	16.67	< 0.01
Age (days, 10^4)	-0.820	0.578	0.16
Absolute change from initial PELOD score (10^4)	0.871	0.385	0.02
Minimum Heart Rate (10^4)	-0.481	0.322	0.14
Maximum Heart Rate (10^4)	-0.443	0.272	0.10
Minimum Systolic Blood Pressure (10^4)	-1.070	0.462	0.02
Maximum Systolic Blood Pressure (10^4)	-0.205	0.321	0.52
Arterial Catheter	0.136	0.258	0.60
Central Venous Catheter	0.413	0.234	0.08
HFOV	1.567	0.491	< 0.01
Nitric Oxide	1.444	0.740	0.05
Surfactant	1.278	0.683	0.06
Antibiotics	-0.944	0.327	< 0.01
Steroids	-0.429	0.233	0.07
Blood Transfusion	0.587	0.240	0.01

Characteristic	Coefficient (β)	Standard Error	P-Value
Intercept	-0.209	0.307	0.50
Absolute difference from initial PELOD score (10^4)	0.961	0.319	<0.01
HFVO	1.33	0.534	0.01
Antibiotics	-1.24	0.349	<0.01
Blood Transfusion	0.676	0.287	0.02

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.

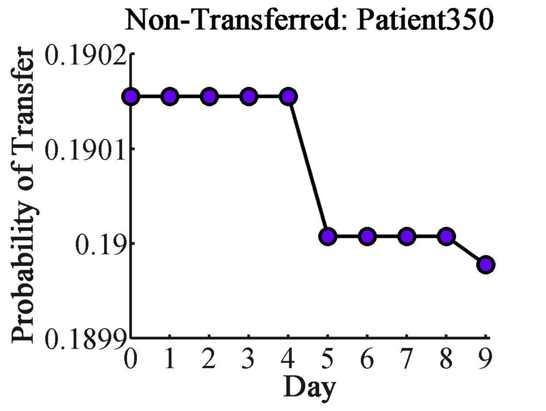
Above: Multiple regression with backward elimination was used to determine important factors for explaining variation in transfer status. Important variables ($p<0.05$) are displayed. GEE and BLR were again used.

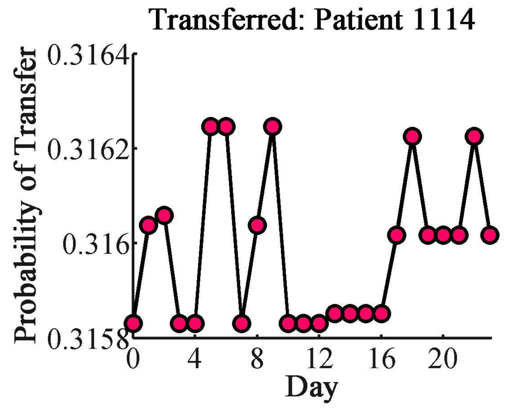
2 Specify Objective Criteria

- 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.

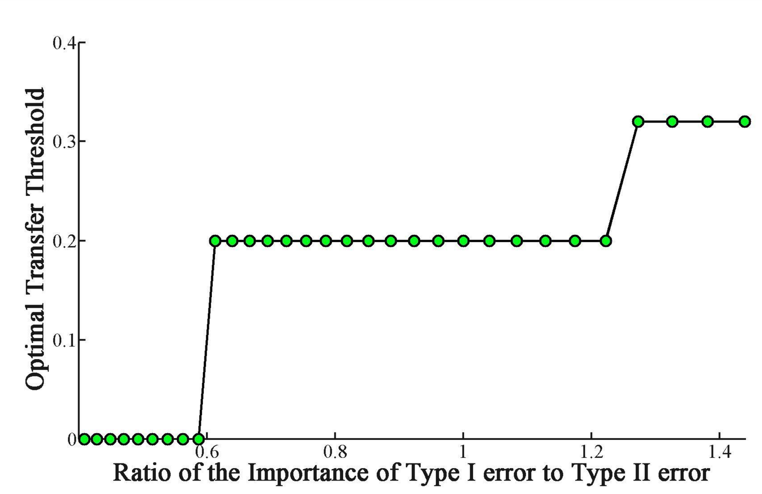
Right: Example of estimated transfer probability for a patient that is not transferred.

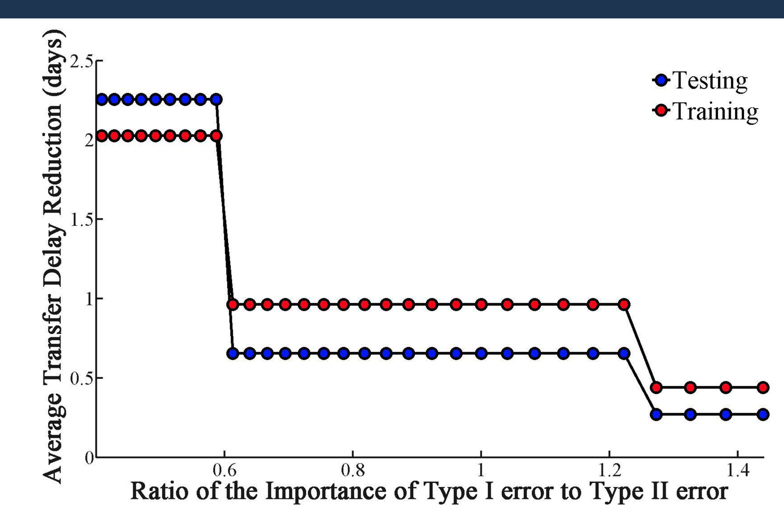
Far Right: Example of estimated transfer probability for a patient that is transferred.





3 Testing Threshold Policies





	Training data		Testing data		
Characteristic	n	Proportion	n	Proportion	P-Value
Mean Age in months (SD)	53.0 (66.2)		42.5 (64.5)		0.08
Central Venous Catheter	140	0.38	134	0.36	0.61
HFVO	19	0.05	18	0.05	0.85
Nitric Oxide	8	0.02	5	0.01	0.40
Surfactant	9	0.02	7	0.02	0.61
Antibiotics	328	0.88	325	0.87	0.60
Steroids	175	0.47	148	0.40	0.04
Blood Transfusion	118	0.32	113	0.30	0.66
Sepsis	13	0.04	6	0.02	0.13
Mean PICU stay in days (SD)	9.5 (11.7)		9.5 (15.8)		0.92
Mean maximum change from initial PELOD score (SD)	11.0 (8.7)		10.2 (7.9)		0.15
Mean minimum Heart Rate (SD)	110.7 (26.3)		112.7 (25.6)		0.28
Mean maximum Heart Rate (SD)	153.4 (27.0)		155.5 (26.8)		0.28
Mean minimum Systolic Blood Pressure (SD)	87.9 (18.7)		86.0 (17.6)		0.16
Mean maximum Blood Pressure (SD)	119.5 (22.2)		117.8 (21.0)		0.28

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.)

Acknowledgements

The authors would like to thank the following organizations for their support:

- Center for Healthcare Engineering and Patient Safety
- Seth Bonder Foundation
- Institute for Healthcare Policy and Innovation
- President's Postdoctoral Fellowship