Scheduling Fellows to Achieve Adequate Training on Procedures with Random Occurrences

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Transplant Surgery at UMHS

- 2-year Fellowship in Section of Thoracic Surgery
- 2 junior + 2 senior fellows each year
- Q4 call schedule
- UNOS Certification Requirements:
  - 20 heart transplants
  - 15 lung transplants
If a program has **4 fellows** on a Q4 call schedule and expects **40 transplants** per year, the probability that each fellow participates in at least **10 transplants** within a year (to be on track for 20 in 2 years) is...

~5%. 
Motivation

• 3 of 10 deaths due to cardiovascular disease or COPD in the United States
• Medicare population expected to double by 2030
• Aging cardiothoracic (CT) surgeons
  – Mean age: 55 years old
  – 65% (lung) and 70% (heart) are 51+ years old
• Decreasing number of CT surgeons nationally
  – 2004-08: 26% decline in CT fellows
  – 2010: fewer applicants than positions (93/116)
**Graduate Medical Education**

**Residency/Fellowship**: graduate medical training required for certification to practice independently

- **Medical School**: 4 years
- **Residency**: 3 – 7 years
- **Fellowship**: 2 – 3 years
- **Independent Practice**

**Call Schedule**: schedule of residents/fellows responsible for covering emergency operations

<table>
<thead>
<tr>
<th>Sun</th>
<th>Mon</th>
<th>Tue</th>
<th>Wed</th>
<th>Thu</th>
<th>Fri</th>
<th>Sat</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Chen</td>
<td>2</td>
<td>Jones</td>
<td>3</td>
<td>Smith</td>
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<tr>
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<td>29</td>
<td>Chen</td>
<td>30</td>
<td>Jones</td>
<td>31</td>
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</tbody>
</table>

(Medical School) 4 years

(Medical School) 4 years

Call Schedule: schedule of residents/fellows responsible for covering emergency operations
Our Approach

• Analyze historical data (Jan. 2009 – May 2011)

  \[ IAT(\text{transplants}) \sim \text{Exponential}(\lambda=0.10) \]

  \[ \downarrow \]

  \[ \text{Transplants/year} \sim \text{Poisson}(\lambda=40) \]

• Simulate occurrences of transplants
• Match occurrences to call schedule
• Assess performance and generate graphical reports for medical personnel to inform decision-making
Simulator: User Inputs

- Number of fellows (4)
- Expected number of transplants per year (40)
- UNOS certification requirement (10)
- Duration of fellowship in days (365)
- Rotation method (Q4 call schedule)
- Number of repetitions (1 – 100,000)
- Advanced settings

(default, canonical settings)
Graphical Outputs: One Repetition

**Bar Graph: Day of Year**

- **Fellow 1**: 13 transplants
- **Fellow 2**: 10 transplants
- **Fellow 3**: 7 transplants
- **Fellow 4**: 10 transplants
- **Unassigned**: 2 transplants

**Pie Chart: Transplant Distribution**

- **Fellow 1**: 31%
- **Fellow 2**: 24%
- **Fellow 3**: 16%
- **Fellow 4**: 24%
- **Unassigned**: 5%
Another Try

<table>
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<tr>
<th>Fellow</th>
<th>Transplants</th>
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<tbody>
<tr>
<td>Fellow 1</td>
<td>8</td>
</tr>
<tr>
<td>Fellow 2</td>
<td>8</td>
</tr>
<tr>
<td>Fellow 3</td>
<td>8</td>
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<tr>
<td>Fellow 4</td>
<td>14</td>
</tr>
<tr>
<td>Unassigned</td>
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</table>
Graphical Outputs: 100,000 Repetitions

Mean Number of Fellows Certified = 1.91

Percentage of Repetitions

Number of Fellows Certified

- 0%: 7.3%
- 10%: 27.4%
- 20%: 37.4%
- 30%: 22.6%
- 40%: 5.3%
Implications: Potential System Changes

• Change certification policies
  – Surgical simulator certification
  – Proficiency-based certification
• Try alternative scheduling paradigms
  – On call until procedure
  – On call until certified
Mean Number of Fellows Certified = 1.94

- 41.6% of repetitions result in 0 certified fellows.
- 6.4% result in 1 certified fellow.
- 6.8% result in 2 certified fellows.
- 6.6% result in 3 certified fellows.
- 38.5% result in 4 certified fellows.
Mean Number of Fellows Certified = 3.32

Number of Fellows Certified

<table>
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<th>Percentage</th>
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</thead>
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<tr>
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<tr>
<td>3</td>
<td>53.9%</td>
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<tr>
<td>4</td>
<td>38.9%</td>
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Conclusions

• We can use simulation to assess program performance
• Alternative scheduling paradigms may increase the rate of certification for cardiothoracic transplants at UMHS, but feasibility is a concern
• UMHS should not expect to adequately train all fellows for cardiothoracic transplants in most years
Current Efforts and Future Work

• Redesign the simulator to incorporate:
  – Other procedure types (scheduled and unscheduled)
  – Other distributions to describe procedure arrivals
  – ACGME work-hour restrictions
  – Fellow characteristics (junior vs. senior, etc.)
  – More fellow-to-procedure matching paradigms
• Assess other residency/fellowship programs at UMHS and partner institutions
• Build optimization models
Collaborators

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- Asher Perlmutter¹

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Questions / Comments

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The simulator can be found at: transplantsimulator.herobo.com.

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