Scheduling Fellows to Achieve Adequate Training on Procedures with Random Occurrences

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**BACKGROUND**

**Claim**
Projected shortage of cardiothoracic (CT) transplant surgeons over the next 10 years

**Evidence**
Heart and lung surgeons constitute the oldest group of surgeons (average age of 55)

**Motivation**
Certification for CT transplant surgery is experience-based

**Problem**
Transplant opportunities are not scheduled but occur randomly in time

**Approach**
Collaboration between engineering and medicine has led to the development of simulation software that illuminates the effects of randomness in transplant opportunities on a fellowship program’s ability to train transplant surgeons

**KEY QUESTION**
If a program has 4 fellows (rotating call daily) and receives an average of 40 transplants per year, what is the likelihood that each fellow receives 10 within 1 year?

<table>
<thead>
<tr>
<th>0% – 20%</th>
<th>21% – 40%</th>
<th>41% – 60%</th>
<th>61% – 80%</th>
<th>81% – 100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.01</td>
<td>0.05</td>
<td>0.35</td>
<td>0.60</td>
<td>0.04</td>
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</tbody>
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**SIMULATOR OUTPUTS**

**Development Principles**
- Coded an easy-to-use tool to simulate transplant arrivals and fellow assignment in the Visual Basic programming language using the Visual Studio environment
- Quickly generates results for single repetition, multiple repetition, and sensitivity analyses

**LINKING CASE VOLUME TO OUTCOMES**

The sensitivity analysis tool illustrates the minimum average number of procedures per year required to enable certification of a certain percentage of the fellows.

For example, an average of at least 50 transplants per year is needed to provide confidence that 3 of the 4 fellows in a program will be certified in a typical year if each is required to achieve at least 10 transplants.

**CONCLUSIONS**

Due to randomness in occurrence, a large number of transplant opportunities are needed to ensure that all fellows can be certified when using a fixed rotating schedule. In the example above, the probability is only ~5% even though the average number of transplants appears to be sufficient.

This could be addressed by reducing the size of the residency program, increasing the program’s duration to allow extra time, or increasing the case volume. All of these are problematic, however.

In the long term, changes in UNOS certification requirements, as well as the development of surgical simulators to supplement live training experiences, might facilitate timely training of transplant surgeons.

But new scheduling paradigms (possibly in conjunction with supporting changes in ACGME work hour rules) may be the best way in the short term to ensure greater success in allowing fellows to achieve certification within the confines of the current program structure. Engineering techniques can be used to develop, simulate, and analyze these new approaches to scheduling fellows.

**FUTURE WORK**
- Identify and implement more call schedule paradigms into simulator
- Incorporate 80-hour work week regulations into simulator
- Work with UMHS program directors to assess their residency/fellowship structures
- Evaluate other CT transplant programs across the country to compare to UMHS

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