Scheduling Residents to Achieve Adequate Training on Procedures with Random Occurrences

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INFORMS Annual Meeting 2013

October 9, 2013

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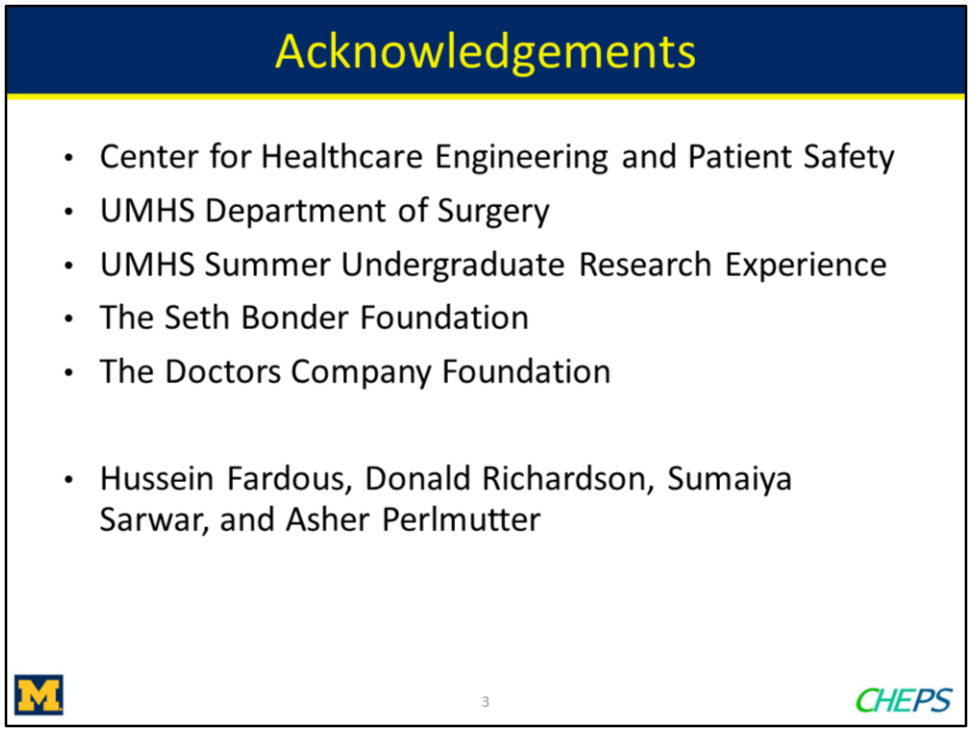
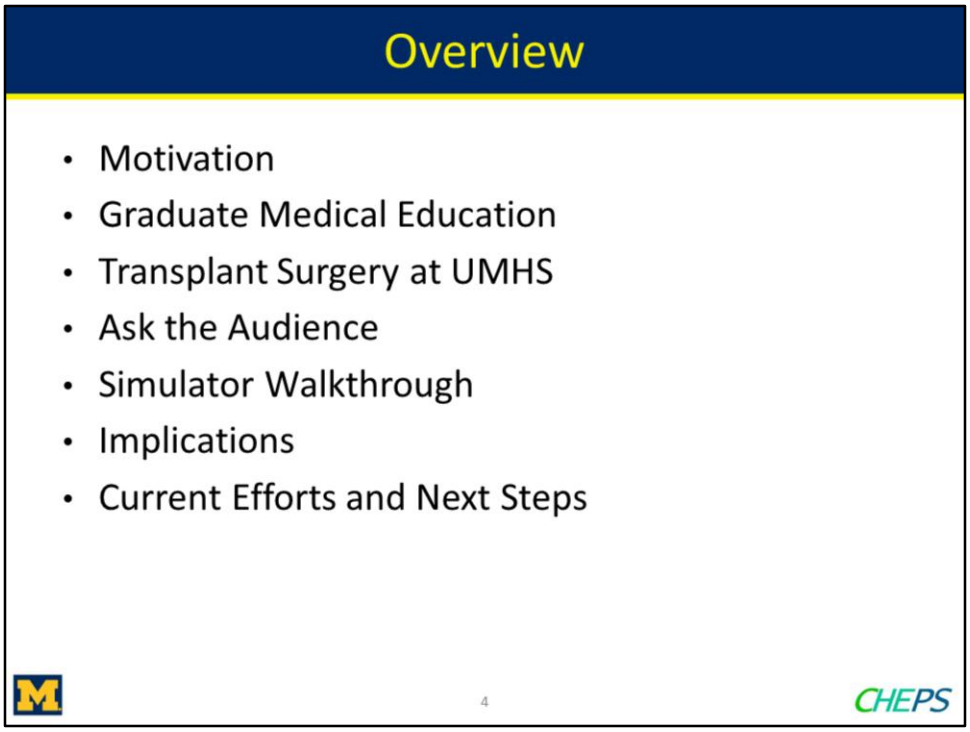
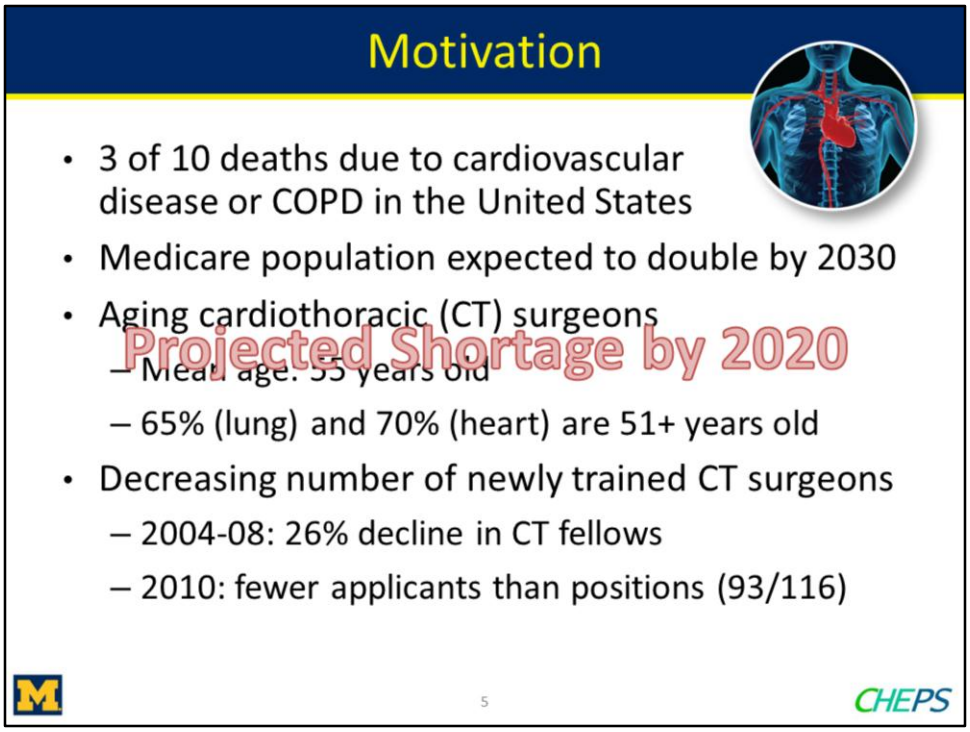


thanks to the organizations funding this research as well as the students that worked on it this summer



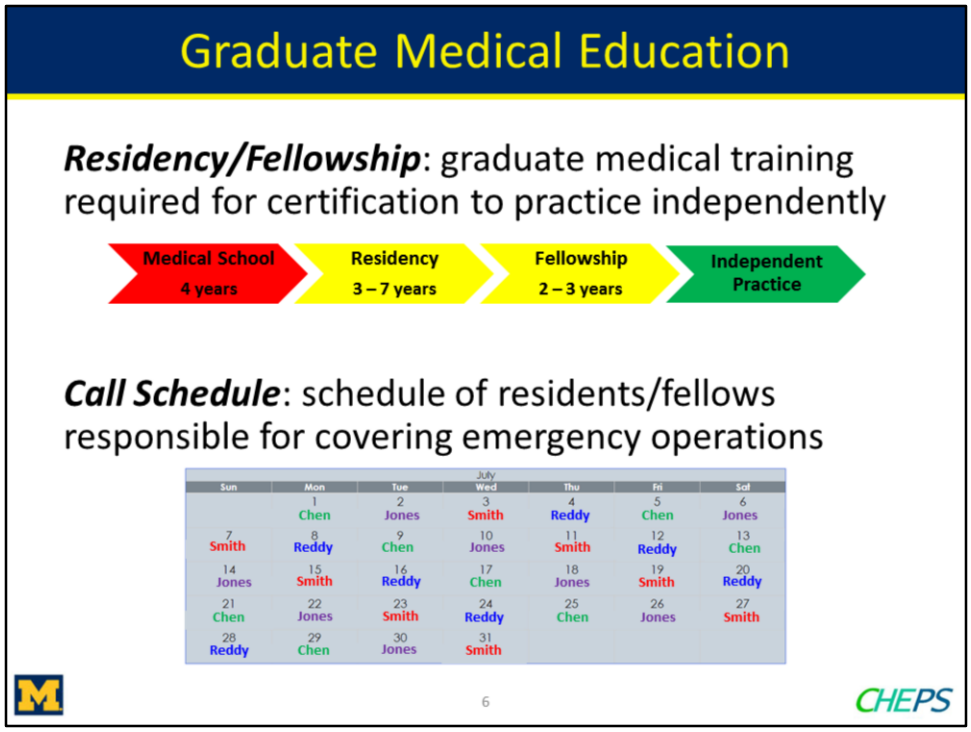
I'll start today's presentation by briefly discussing the motivation for this work and provide some background for you regarding graduate medical education, particularly transplant surgery at the University of Michigan Health System. Just a head's up, I've got a question for you all about halfway through. Don't worry though, as we'll show you how we got to the answer using simulation. Finally, I'll cover the implications of our findings and talk about where our research can go from here.



The CDC reports that cardiovascular disease (more simply, heart disease) and chronic obstructive pulmonary disease (more simply, lung disease) are the first and third leading killers of Americans, accounting for nearly 30 percent of all deaths each year. Moreover, these disease categories especially afflict the elderly, a population that is expected to double in the next 15 years.

So how do we treat heart and lung disease? Well, for end-stage disease, heart or lung transplantation performed by a cardiothoracic surgeon may be necessary. But these physicians are also aging. Well more than half of all CT surgeons are nearing retirement age. Furthermore, we're training fewer of them. In the past decade, we've seen a sharp decline in the number of cardiothoracic surgery fellows, culminating in filling only about 80% of all available fellowship positions across the country in 2010.

All of these factors contribute to a 2010 finding by the Society of Thoracic Surgery – there will be a projected shortage of CT surgeons by year 2020.



Before I go too far, I want to make sure everyone here is familiar with the terms residency and fellowship. Say you want to become a surgeon: you go through 4 years of medical school and graduate. Are you ready to go perform surgeries? Not really. Instead, you spend several years training at a hospital under more experienced physicians. During that time, you've got many program requirements, operational requirements, and clinical obligations, all subject to work-hour restrictions. That's called **residency**.

Now, if you want to do something really cool like cardiothoracic surgery, you have to spend even more time training in that subspecialty. That's called **fellowship**.

Finally, there also must be some way to assess whether these **residents** and **fellows** are capable of going off to practice independently. In most cases, this is done through **experience-based certification**. Basically, if you participate in enough operations during your residency or fellowship, you're considered prepared.

Another key aspect of the domain is a call schedule. **Call schedules** are commonly used to assign the responsibility of handling emergency or unplanned operations. These are usually fixed in advance, like in the one shown here. As you can see, there's a pattern by which each of the 4 individuals is **on call** every 4th day. This rotation is what is known as a **Q4 call schedule**.

Transplant Surgery at UMHS

- 2-year Fellowship in Section of Thoracic Surgery
- High-volume training program
- 2 junior + 2 senior fellows each year
- Q4 call schedule
- Beyond scope of core program requirements
- UNOS Certification Requirements:
  - 20 heart transplants
  - 15 lung transplants

7

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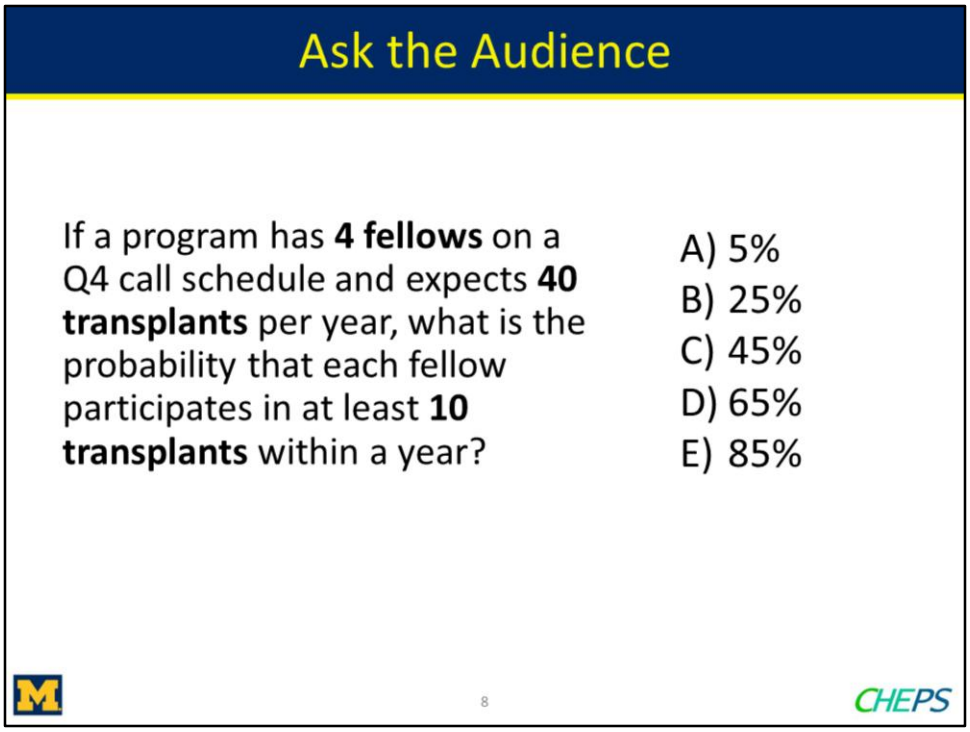
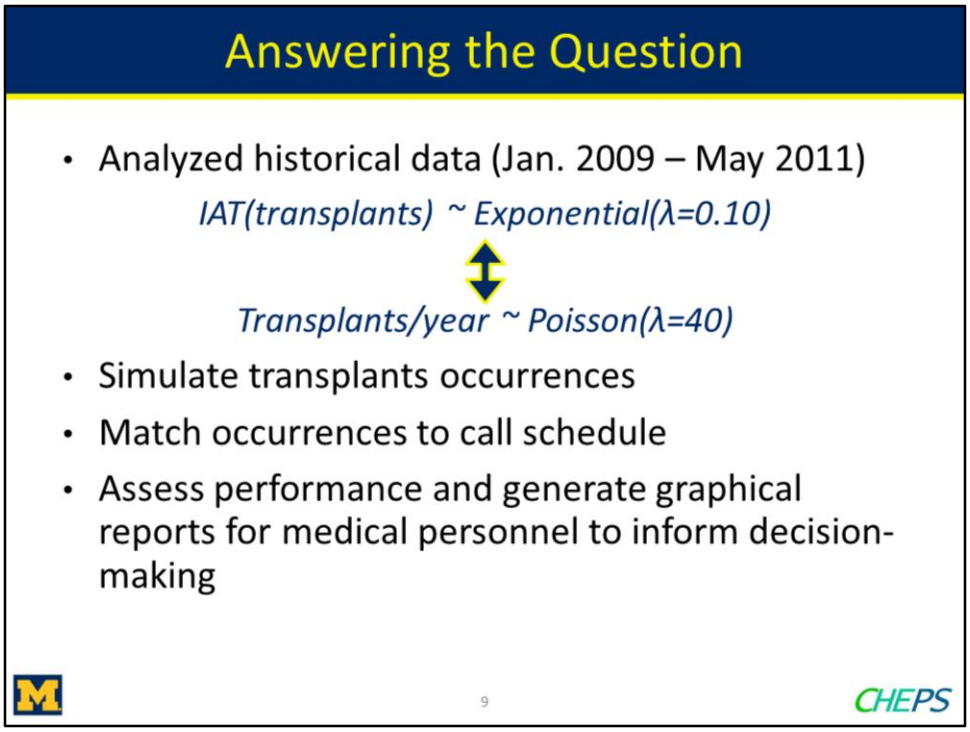
At U of M, the Section of Thoracic Surgery trains 4 fellows (2 of them first-years and 2 of them second-years) at any given time in a 2 year fellowship. Each fellow is given the opportunity to simultaneously train for certification to perform heart and/or lung transplants, which are surgical experiences **not** required for program completion and certification as a cardiothoracic surgeon. In order to receive that transplant certification, they must participate in at least 20 hearts or 15 lung transplants for certification in each, respectively.

Of course, transplants are emergent, unplanned operations with little advanced warning, so they fall under the responsibility of the on call fellow. At UMHS, they follow the Q4 call schedule I depicted on the last slide.



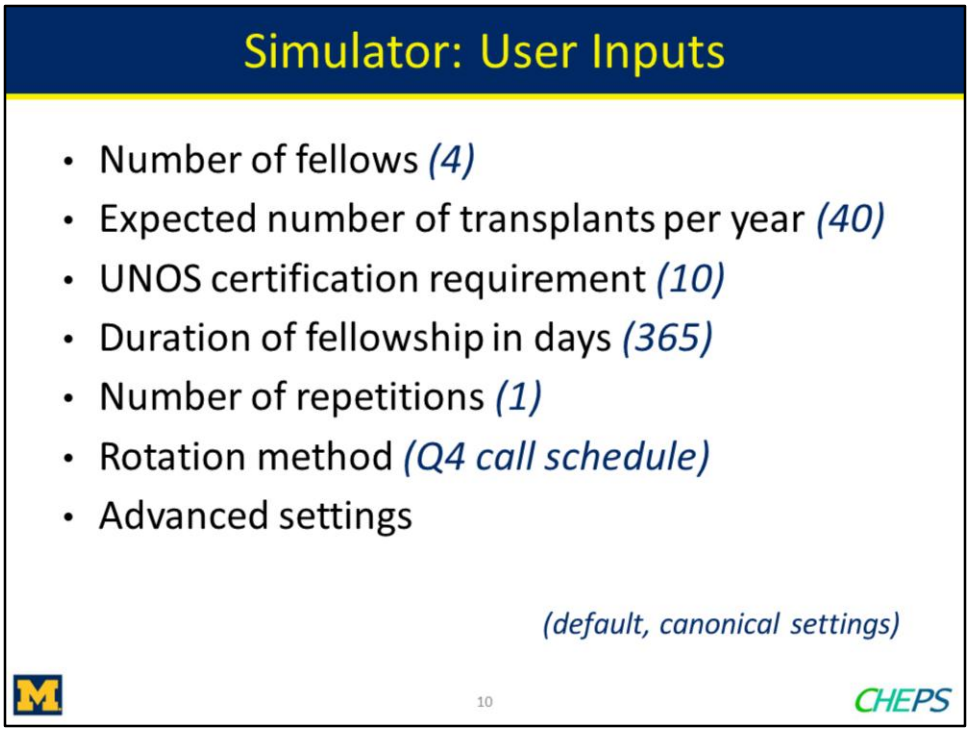
Here's the question we wanted to answer: how well does the fellowship perform in getting its graduates certified as transplant surgeons?

To frame our canonical example, let's make a simplification and assumption. First. we'll consider just training on heart transplants. Remember, you needed to get at least 20 heart transplants over a 2 year fellowship. For ease we want to consider just a single year, so you only need 10. Assume that your hospital expects to get 40 of these transplants each year. What is the likelihood that everyone is sufficiently trained?



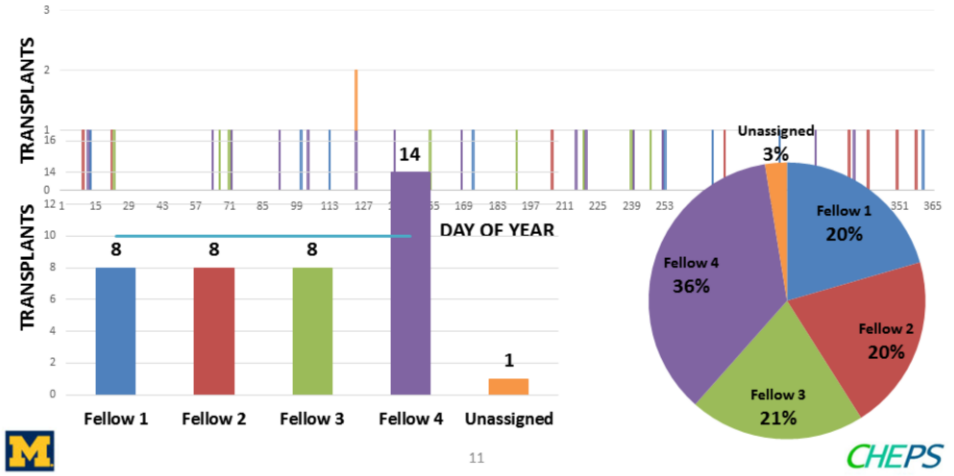
To figure out the answer to that question, we evaluated the case data from 2009 into May of 2011. Fitting the data showed that the interarrival time of transplants was reasonably described by the exponential distribution. Intuitively, that makes sense. Organs for transplants can be offered to any of a couple thousand people on the waiting list at a given time based on how well the recipient matches the donor, so it wouldn't be a stretch to say that transplant occurrences at UMHS are independently and evenly distributed and fit all the nice characteristics of the exponential distribution. We found that the average interarrival time was roughly 9 days, which equates to a Poisson distribution of about 40 transplants per year.

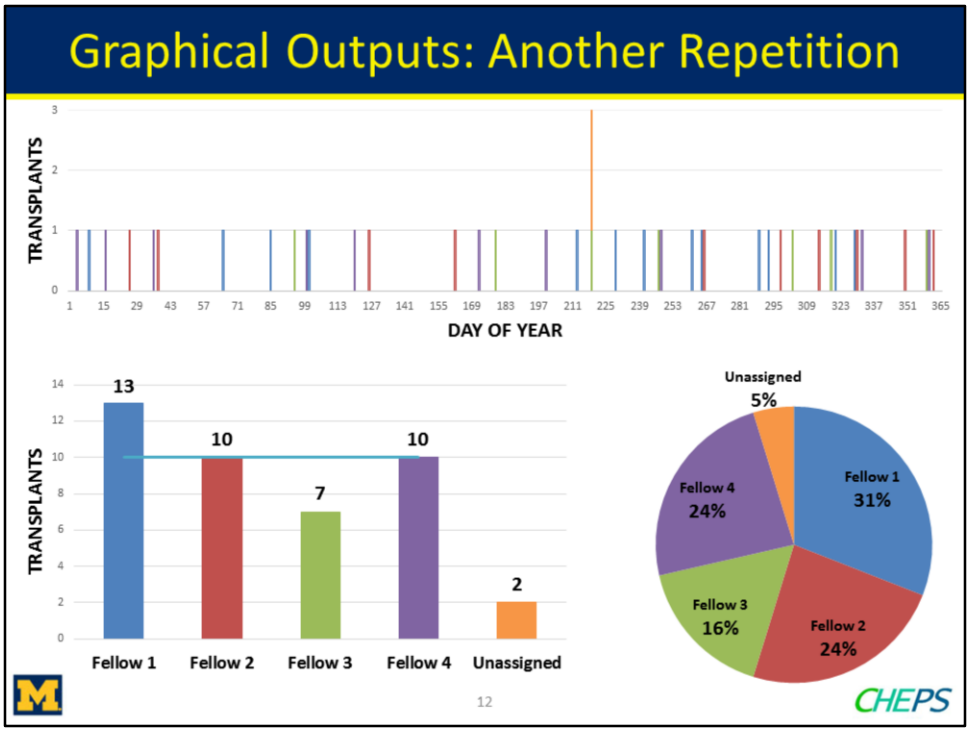
We then built a tool to simulate the occurrence of transplants, match them to the on call fellow, and produce reports for assessing the program performance.



The simulator is very easy to use, requiring only a few basic inputs listed here with their canonical defaults. We also built some advanced functionality into the simulator, including the ability to incorporate seasonality, how to handle multiple procedures, and more, but we won't get into those today. This really all boils down to statistics and probability, so let's 'roll the dice' so to speak on a single repetition…

Graphical Outputs: A Single Repetition

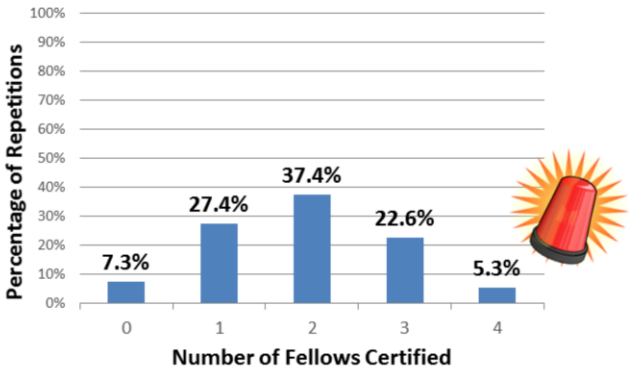




Got really close this time. And if you inspect the timeline, the 2 that are unassigned were on Fellow 3's day. It was even closer to certifying everyone than it looks like and that was with just 42 cases! Maybe it's not so bad after all….

Graphical Outputs: 100,000 Repetitions

Rotation method: *Q4 call schedule*



Mean Number of Fellows Certified = 1.91

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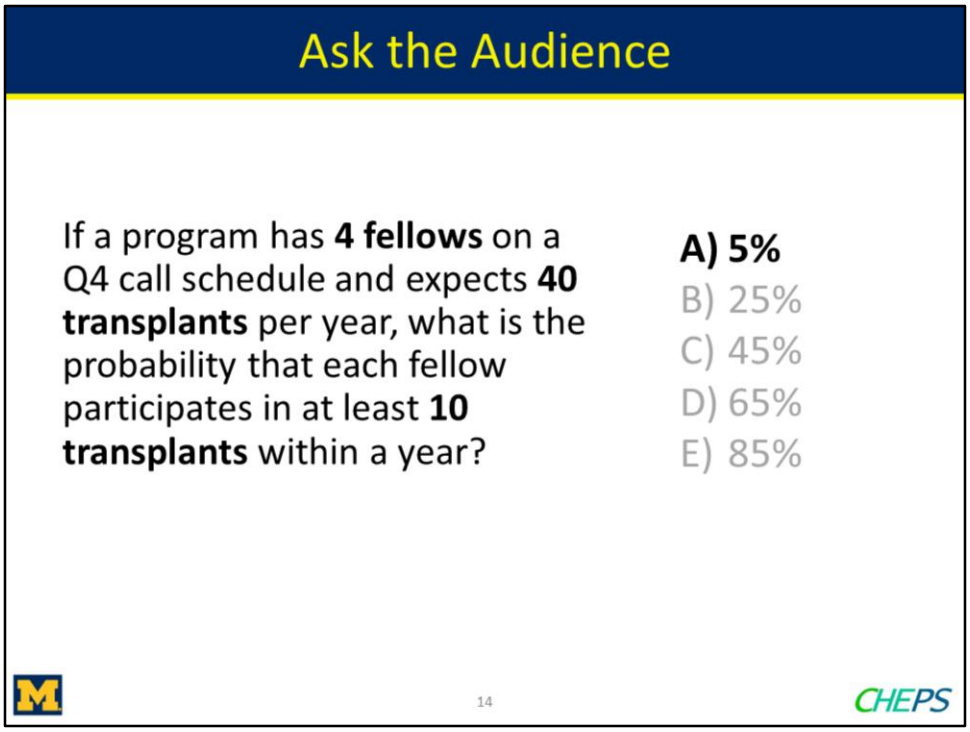

The simulator gives us the answer.

Implications: Potential System Changes

- ✗ Reduce program size
- ✗ Increase program case volume
- ✓ Change policy regarding certification
  - Surgical simulator certification
  - Proficiency-based certification
- ✓ Try alternative scheduling paradigms

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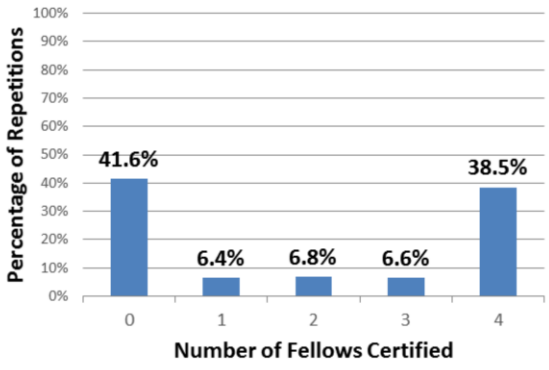
100,00 Repetitions: Alternative Paradigm #1

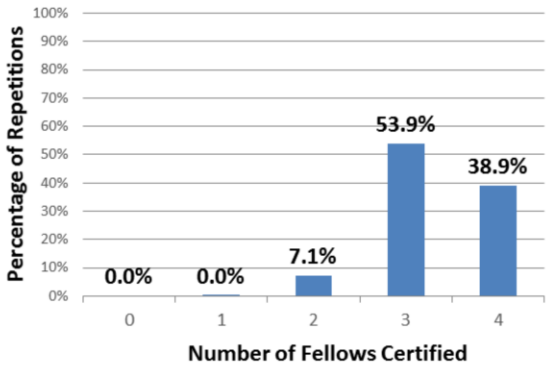
Rotation method: *on call until procedure*



Mean Number of Fellows Certified = 1.94

100,00 Repetitions: Alternative Paradigm #2

Rotation method: *on call until certified*



Mean Number of Fellows Certified = 3.32

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acknowledge these aren't really possible.

Current Efforts and Future Work

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

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Questions / Comments

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

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