

## Background and Objectives

The ability to perform heart and lung transplantation is within the unique expertise of cardiothoracic (CT) surgeons who have met the caseload certification requirements of the United Network for Organ Sharing (UNOS). These requirements must be met while maintaining compliance with Accreditation Council for Graduate Medical Education (ACGME) work hour rules (80 hours/week limit and minimum 1 day off/week). Transplant events occur unpredictably, often creating conflict between the need for adherence to ACGME rules and the need for operative transplant experience. This study investigates the occurrence of transplant opportunities in relation to an ACGME compliant standard surgical call schedule, and the consequent ability to train UNOS-certified

## Methods

The challenges inherent to building a compliant schedule that would adequately train surgeons were identified as: stochastic nature of transplantation opportunities and procedure times, restrictions in the resident work schedule, and requirements for certification (Figure 1).

### Challenges to obtaining adequate training for UNOS

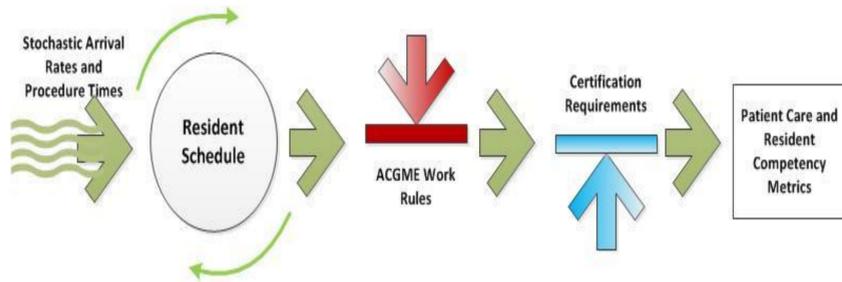


Figure 1

## Methods

To address these issues a Pro-Model based simulation model was built to monitor the system performance. We obtained operative logs and transport times of all adult cardiothoracic transplants taking place at the University of Michigan from July 2009 to July 2011. We also collected resident work hour logs. A detailed process flowchart of events involved in procurement and transplantation was generated (Figure 2).

### Process Flowchart of Events in Cardiothoracic Transplantation

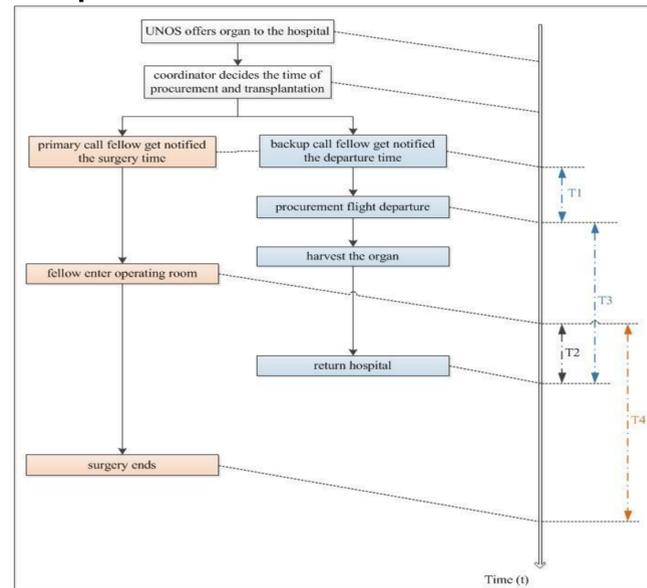


Figure 2

We developed probabilistic distributions for the time duration between critical events during each procedure (Figure 3). We used these variables as input to our simulation, running 50 year long replications (January 3 2011 to December 31 2011) to obtain key metrics with statistical significance

## Results

### Probabilistic Distributions for Time Duration Between Critical Events

	Arrival Rate	Resident Contact to Procurement Departure (T1)	OR Entry to Procurement Return (T2)	Total Procurement Time (T3)	Total OR Time (T4)
<b>Heart (minutes)</b>	Exponential $\lambda=16346.6$	Weibull $\alpha=3.065$ $\beta=896.645$	Beta $\alpha=9.3$ $\beta=18.5$ min=0 max=848	Lognormal $\alpha=5.84$ $\beta=0.3385$ max=720	Normal mean=609 $\sigma=111.6$ max=1080
<b>Lung (minutes)</b>	Exponential $\lambda=16346.2$	Lognormal $\alpha=6.392$ $\beta=0.615$	Beta $\alpha=7.52$ $\beta=6.69$ min=0 max=468	Weibull $\alpha=4.19$ $\beta=395.883$ max=720	Normal mean=689 $\sigma=155.508$ max=1080

Figure 3

Through simulation, we monitor three key metrics: the number of days off per month for each resident, the number of violations in 80 hour duty hour limits per week for each resident, and the total number of procurement and transplant surgeries performed per year for each resident.

### Maximum and Minimum Working Hours per Resident

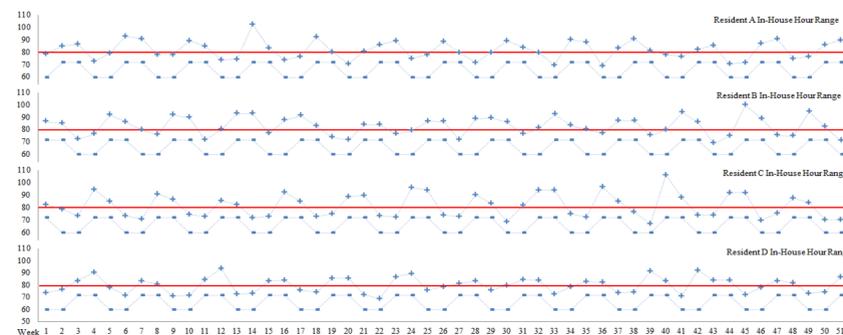


Figure 4

## Results

### 80-Hour Rule

The amount of overtime work beyond the required maximum of 80 hours/week is obtained and 631 violations happened in the 10400 weeks for the 50 replications of a 363-day long period of simulation time. The rate of violation is 6.07% with a 95% confidence interval of 5.62% to 6.52%. Actual 80 hour violations from our historical dataset were higher (36%,  $p<0.001$ ), likely due to emergency operations and consultations not accounted for in this model.

### Day-off Rule

Our calculations shows that on average, 22.50% of the working months for a resident will have a day-off violation, and that in 6.04% of the weeks will a scheduled day-off be occupied by work.

### Certification Rate

Despite having a high volume of cardiothoracic transplants, the likelihood of obtaining certification in our current training paradigm is low.

	Probability	95% CI
Certified Both	10%	2.60%
Certified Heart Surgery	21%	5.51%
Certified Lung Surgery	53%	9.89%
Fail	36%	15.81%

Figure 5

## Conclusions

- The stochastic nature of CT transplantation events will predictably lead to work hour violations within the setting of rigid call schedules and ACGME regulations.
- Despite being a high volume center in cardiac (#13/140) and lung (#19/69) transplantation, our ability to graduate UNOS-certified surgeons is limited.
- Unpredictable schedule demands in specialties such as CT transplant surgery are incompatible with increasingly rigid ACGME work hour rules.
- There is a need for educated dialogue amongst all relevant constituencies to find viable alternatives to maintain patient safety and manage physician fatigue.