Proposal to Improve Organ Transplantation System and Reevaluate Policies for Liver Allocation

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Data 440 OR in DS

Introduction

Organ transplantation is a complex and intricate medical procedure that involves the transfer of organs from one individual to another, for the purpose of replacing a damaged or diseased organ. This process require a series of meticulous steps and careful considerations to ensure the success of the transplant. The organ transplantation system is a highly regulated and multi-faceted process that involves a team of medical professionals working together to identify suitable donors, assess donor-recipient compatibility, and perform the actual transplant surgery. This process can take months or even years, and involves a range of diagnostic tests, medical evaluations, and logistical planning. Additionally, the transplantation process is subjected to numerous ethical, legal, and social considerations. Including issues related to donor consent, organ allocation, and selecting a patient. These factors can further contribute to the overall complexity and duration of the transplantation process.

Relevancy to Operations Research

Operations research is a field of study that uses mathematical models and analytical methods to solve optimization problems related to the management of operations and resources. In the context of the organ transplantation system, operations research contributes to optimizing the allocation of organs to patients on the waiting list.

Specifically, operations research can be used to develop and evaluate allocation policies, such as the policies used by organizations like UNOS to determine how organs are allocated to patients. Operations research models can also be used to evaluate the performance of different allocation policies, considering factors such as waiting times, transplant success rates, and patient mortality rates.

Motivation / Purpose

UNOS operates the Organ Procurement and Transplantation Network (OPTN), a comprehensive system that coordinates the entire transplantation process, from the referral of patients to the identification of suitable donor organs and the matching of donors with recipients. The OPTN is responsible for maintaining the national organ transplant waiting list, which currently includes over 100,000 patients waiting for organs.

The aim of this analysis to identify critical variables using discrete event simulation to decrease the wait time and number of patients on the waitlist for life saving organs. Additionally, to investigate the results of prioritizing geographic proximity in comparison to UNOS's policy of prioritizing patients based on the severity of their illness and their potential for survival.

Problems

Two major issues to be analyzed:

1. Long wait times due to the complex system with variables such as organ shortage, slow referral time by physicians, medical eligibility, etc.
2. Policy for allocating liver: UNOS assigns organ for patients with urgent medical needs. This creates a great disparity in access to organs.

Methodology

Discrete Event Simulation 1 in R

1. Define the simulation environment: Set up the input variables for the simulation, such as the number of patients on the waitlist, the time interval for the simulation, and the distribution of wait times.
2. Create a trajectory: This represents the flow of patients through the system. In this case, it would involve patients joining the waitlist, waiting for a donor, and then receiving a transplant.
3. Define the resources: In this case, resources would be the availability of organs and spot on the waitlist.
4. Set up the arrival process: This defines how patients join the waitlist.
5. Alter variable values for the best result.

Discrete Event Simulation 2 in R

1. Assume the priority setting for organ allocation is set to the severity of the patient and the wait list is ordered by geographic proximity to the donor site.
2. Define the simulation environment.
3. Create a trajectory: This represents the flow of patients through the system. In this case, it would involve patients joining the waitlist, waiting for a donor, and then receiving a transplant.
4. Define the resources: availability of organs with preemption = True
5. Add generators: set up priority = 1 for allocating an organ is dependent on the severity of the patient.
6. Compare preemption = True / False.

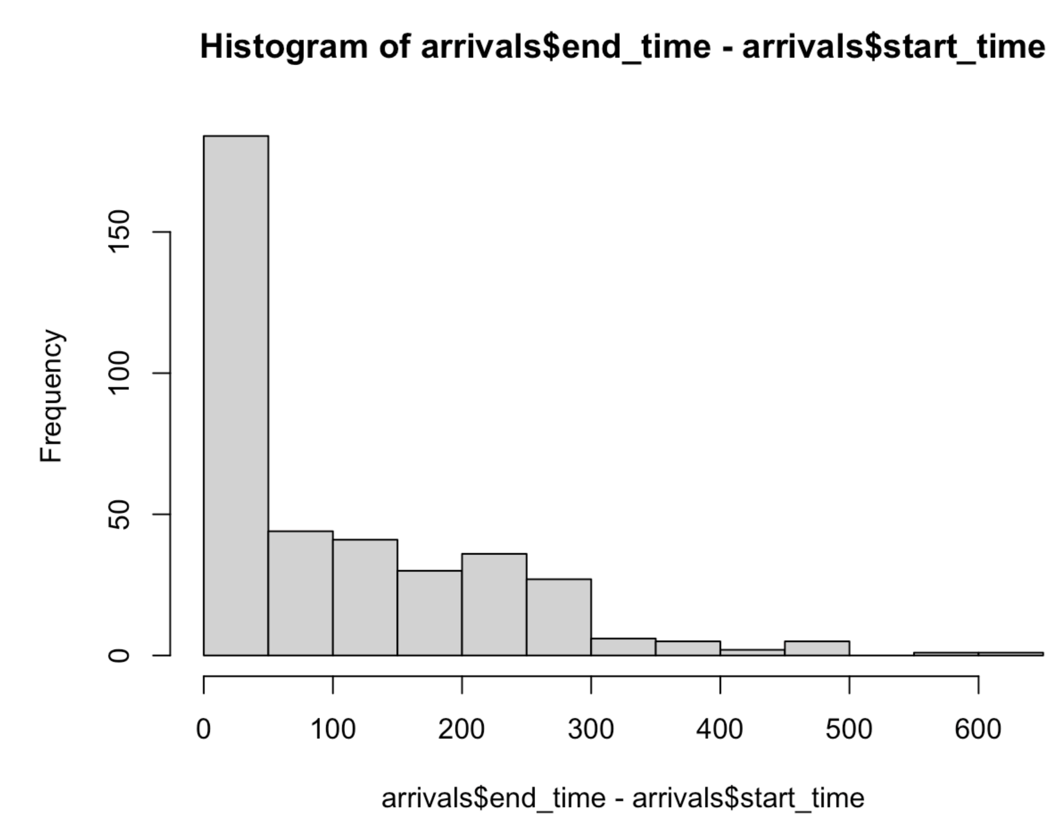
Discussion

Figure 2 displayed a significant decrease in wait time for patients on the organ wait list compared to Figure 1. Main contributing variable was speeding up the wait for a donor, meaning donor supply had to be increased. This simple simulation is limited in explaining the overall network of systems that are involved in the organ donation process. A much more accurate representation of the system would require multiple simulations working together.

Figure 3 presents two run throughs of the simulation that focused on changing the priority of liver allocation. There was a decrease in patients on the waitlist for liver when priority settings were not included, meaning that the liver match process will be dependent on proximity to transplantation site. A change to this policy could potentially improve patient outcomes and reduce wait times.

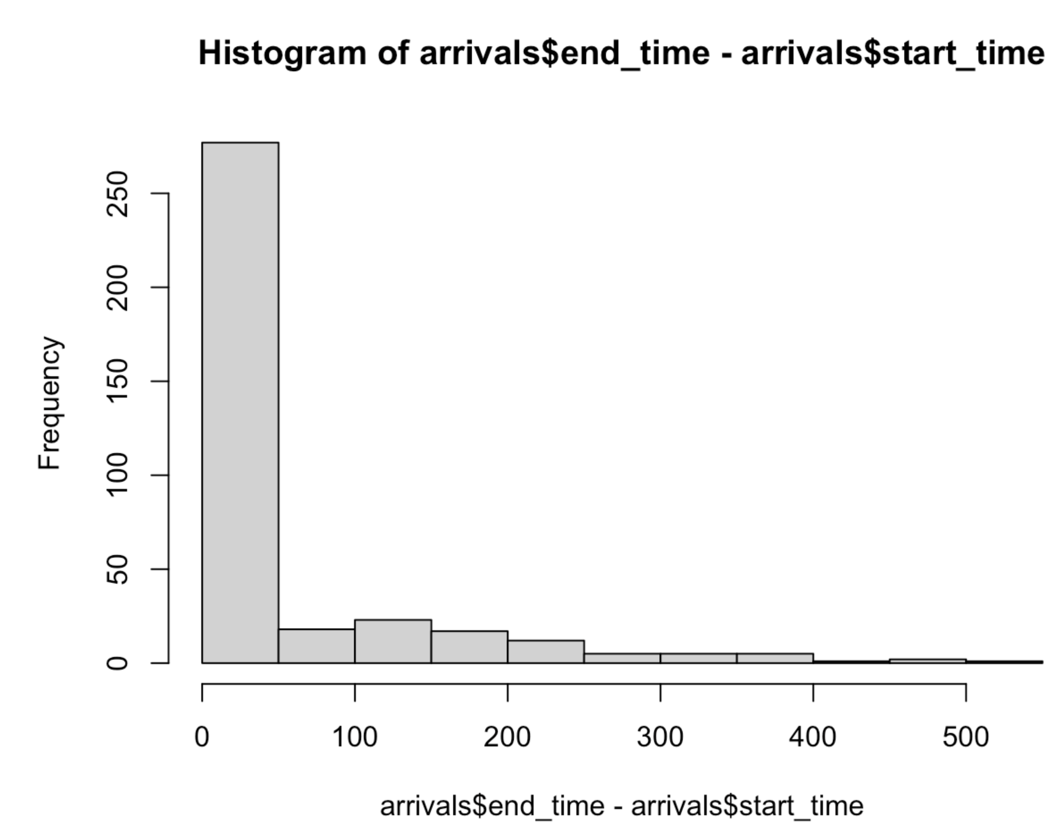
Visualization / Results

Figure 1.




```
> df_patients=arrivals[arrivals$resource=='spotonwaitlist',]
> mean(df_patients$activity_time)
[1] 155.0273
```

Figure 2.

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> mean(df_patients$activity_time)
[1] 16.62727
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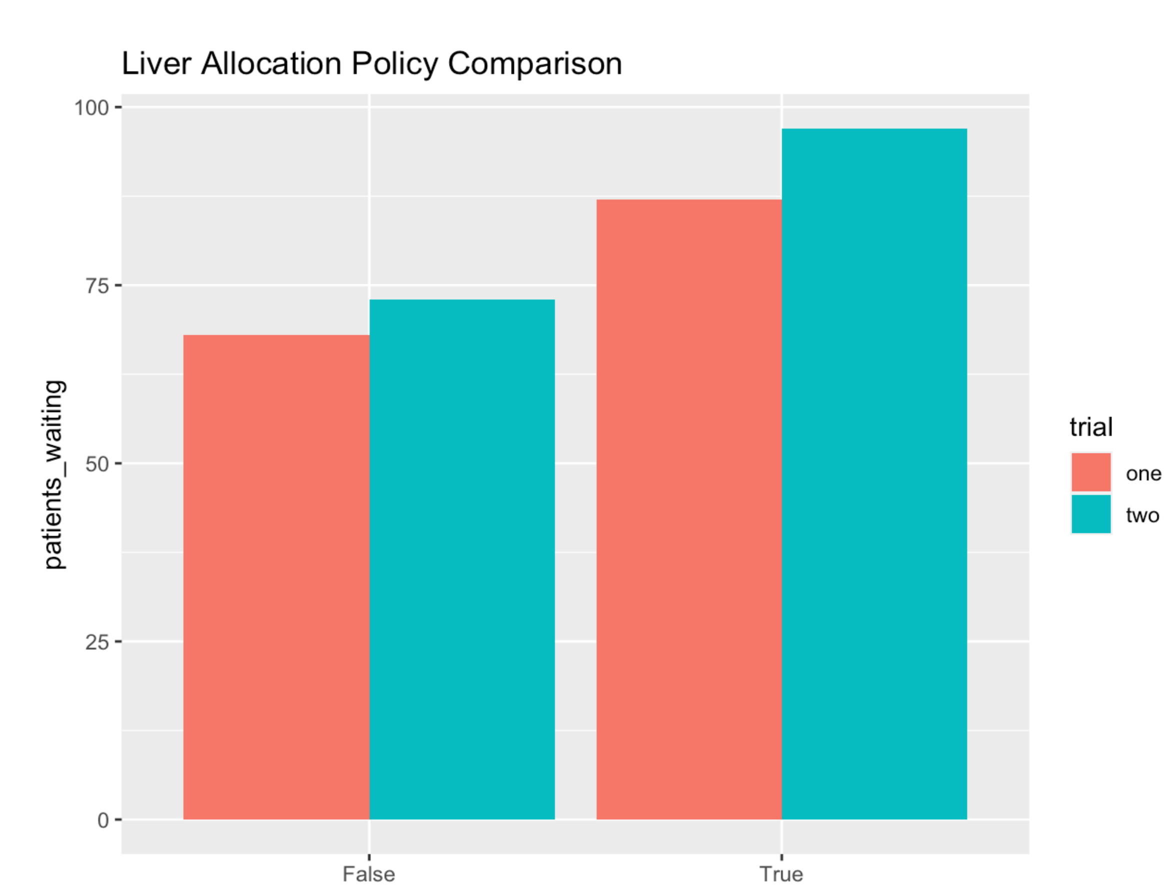
Figure 3.



Flow Chart

Simplified and brief overview of the system