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Network-Based Kidney Allocation Simulation: Evaluating Organ Matching Strategies in Variable Hospital Networks

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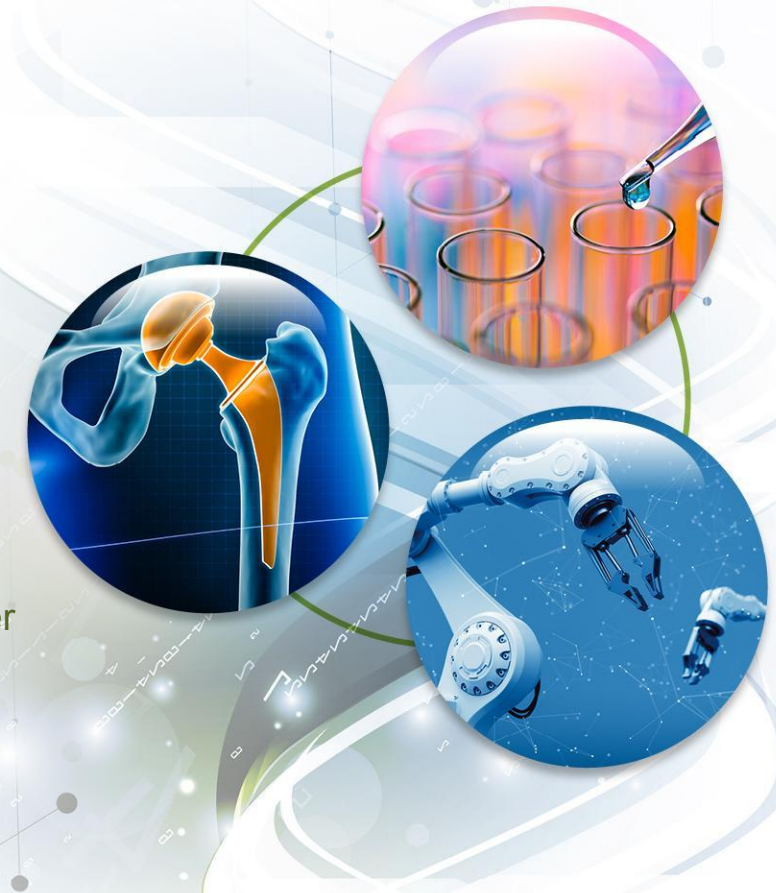

Relevant Disclosures – Aniruth

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- **Consulting / Employment / Other Financial Interests:** Co-founder, KidneyChain
- **Professional / Other:** National Kidney Foundation (NKF) Kidney Advocacy Committee

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Relevant Disclosures – Benjamin

No relevant disclosures.

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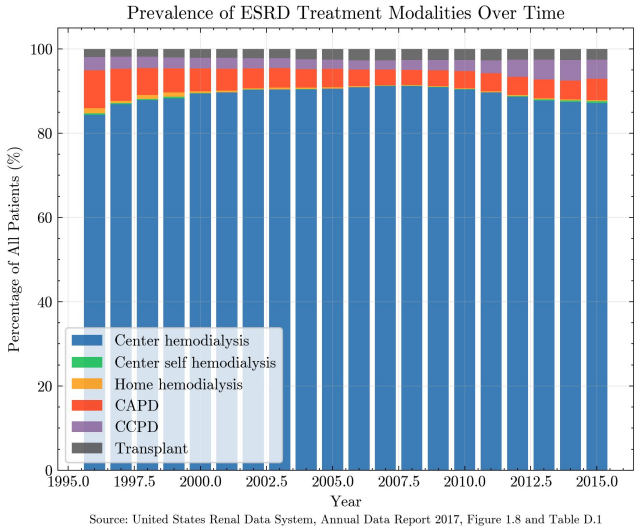
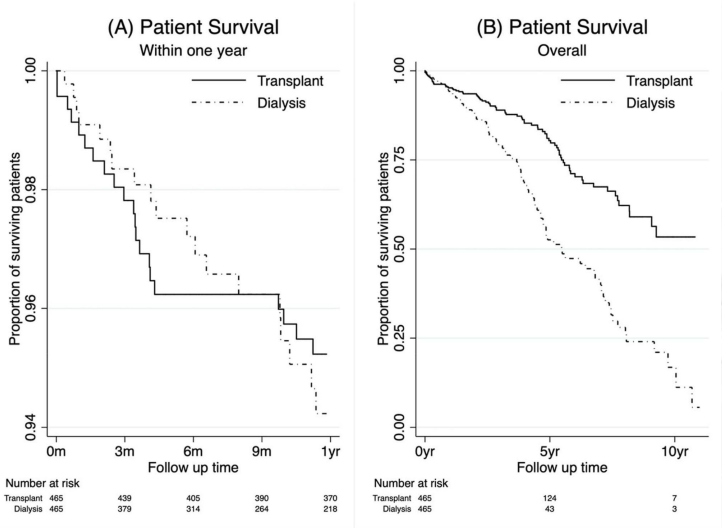
Background – Kidney Transplants

- Kidney transplants are the best treatment for end-stage renal disease (ESRD)





(Shi et al., *American Journal of Transplantation*)

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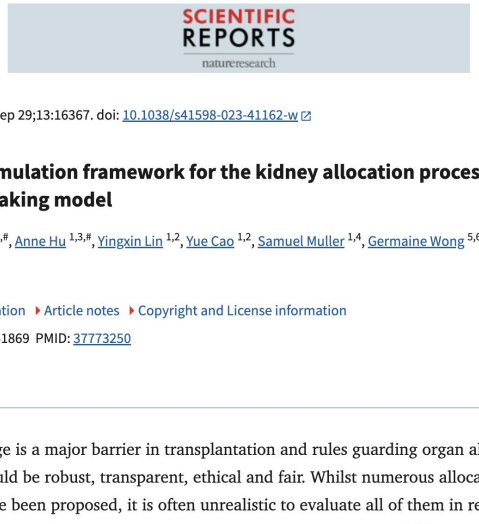
Background – Existing Simulations

- Existing allocation simulations often ignore hospital-network effects



SCIENTIFIC REPORTS
nature research

Sci Rep. 2023 Sep 29;13:16367. doi: 10.1038/s41598-023-41162-w

simKAP: simulation framework for the kidney allocation process with decision making model

Yunwei Zhang [1,2,#], Anne Hu [1,3,#], Yingxin Lin [1,2], Yue Cao [1,2], Samuel Muller [1,4], Germaine Wong [5,6,7], Jean Yee Hwa Yang [1,2,✉]

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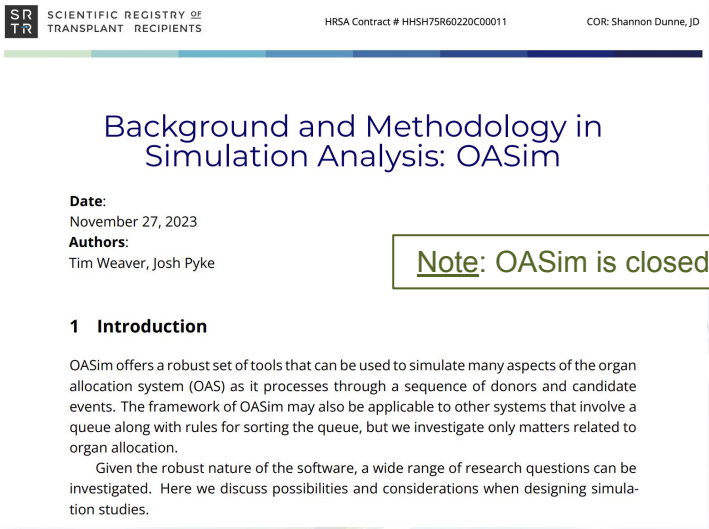
Abstract

Organ shortage is a major barrier in transplantation and rules guarding organ allocation decisions should be robust, transparent, ethical and fair. Whilst numerous allocation strategies have been proposed, it is often unrealistic to evaluate all of them in real-life



SRTR SCIENTIFIC REGISTRY OF TRANSPLANT RECIPIENTS

HRSA Contract # HHSH75R60220C00011 COR: Shannon Dunne, JD

Background and Methodology in Simulation Analysis: OASim

Date:
November 27, 2023
Authors:
Tim Weaver, Josh Pyke

Note: OASim is closed source

1 Introduction

OASim offers a robust set of tools that can be used to simulate many aspects of the organ allocation system (OAS) as it processes through a sequence of donors and candidate events. The framework of OASim may also be applicable to other systems that involve a queue along with rules for sorting the queue, but we investigate only matters related to organ allocation.

Given the robust nature of the software, a wide range of research questions can be investigated. Here we discuss possibilities and considerations when designing simulation studies.

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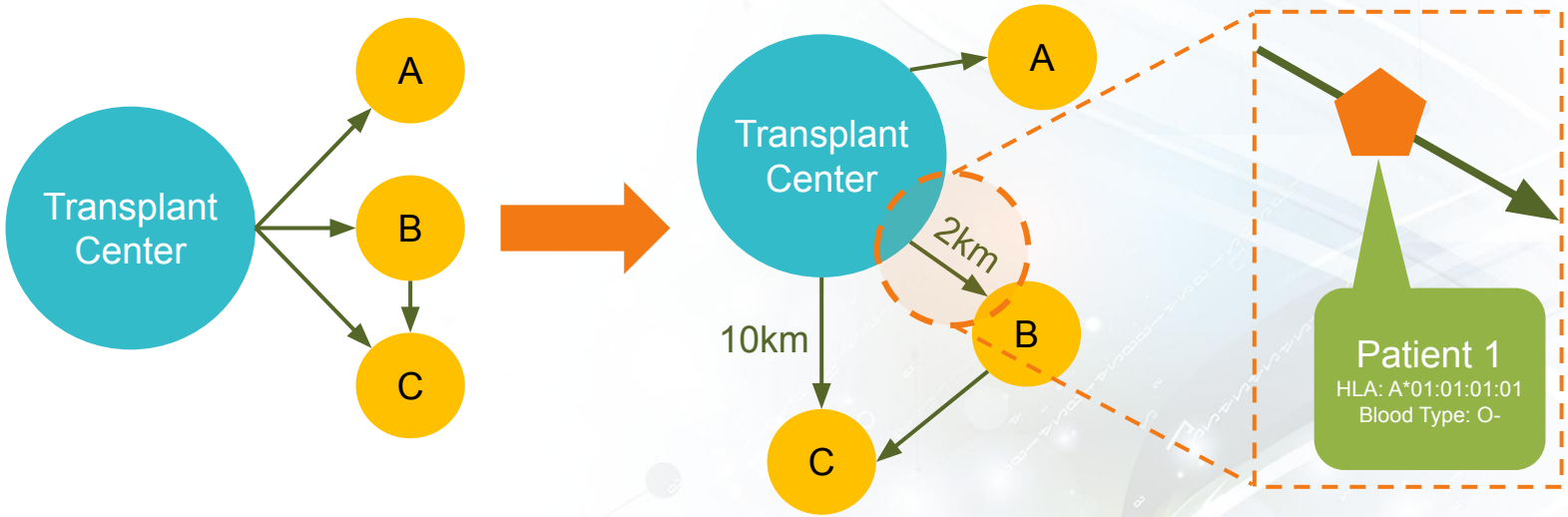
Methods – Overview

- **Patients** travel along **edges** in a graph composed of **transplant centers** and **hospitals**



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Methods – Allocation Policies

- **Default (“Comprehensive”) Strategy:** Uses the built-in compatibility score (see supplemental slides)
- **Wait Time Emphasis:** Adds bonus points for patients waiting longer, improving their chances.
- **Urgency Emphasis:** Gives higher scores to patients with greater medical urgency so critical cases are prioritized.
- **HLA Emphasis:** Increases weight on HLA matching while still considering size and organ quality to boost long-term success.

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Case Study –Allocation Policy Comparison

- Evaluates all four matching policies under identical network compositions and conditions
- Varies key environmental parameters: organ arrival probability, patient arrival probability, and network size
- Measures policy effectiveness through successful transplant rates and patient outcomes across multiple runs
- **Goal:** Understand how different strategies perform and how environmental changes affect policy effectiveness

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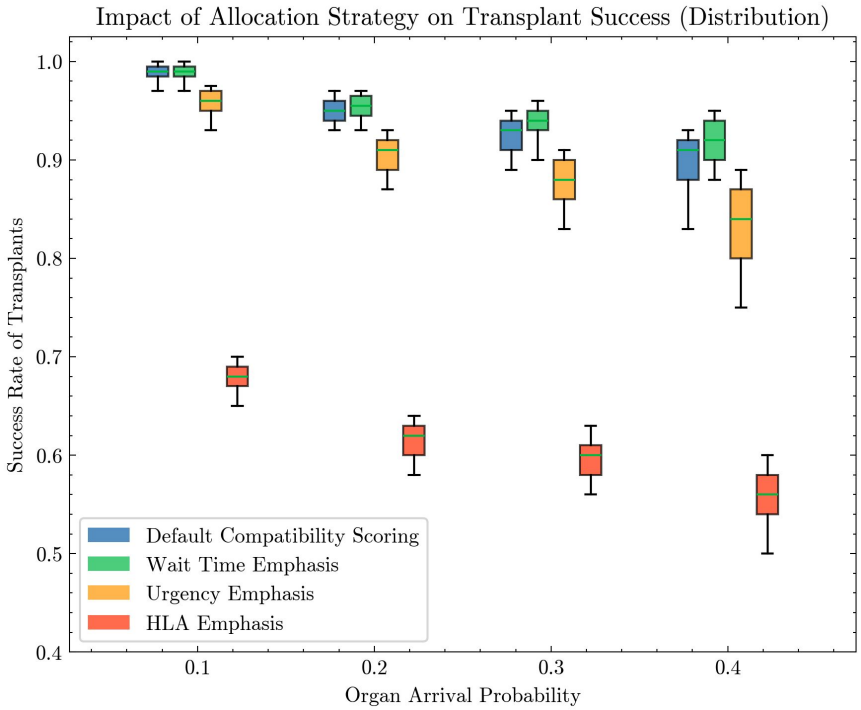
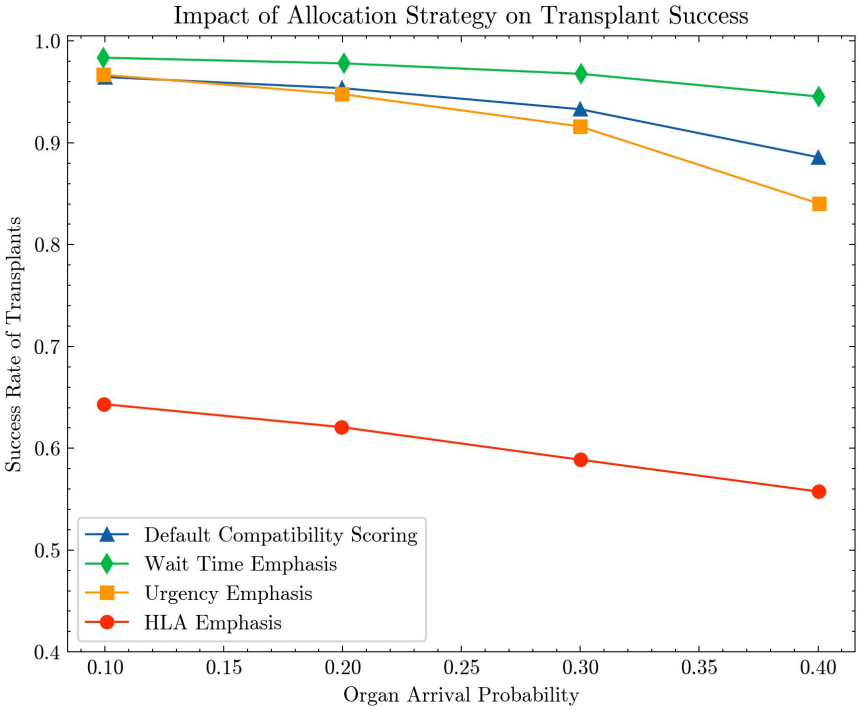
Results – Allocation Policy Comparison





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Case Study – Effects of Network Composition

- Examines how hospital network structure (transplant center-to-hospital ratio) impacts matching outcomes
- Maintains constant total organ arrival rate (0.19/“day”) across configurations to isolate network composition effects
- Measures effectiveness through successful transplant rates and average patient wait times
- **Goal:** Understand whether certain policies perform better under centralized vs. decentralized network structures

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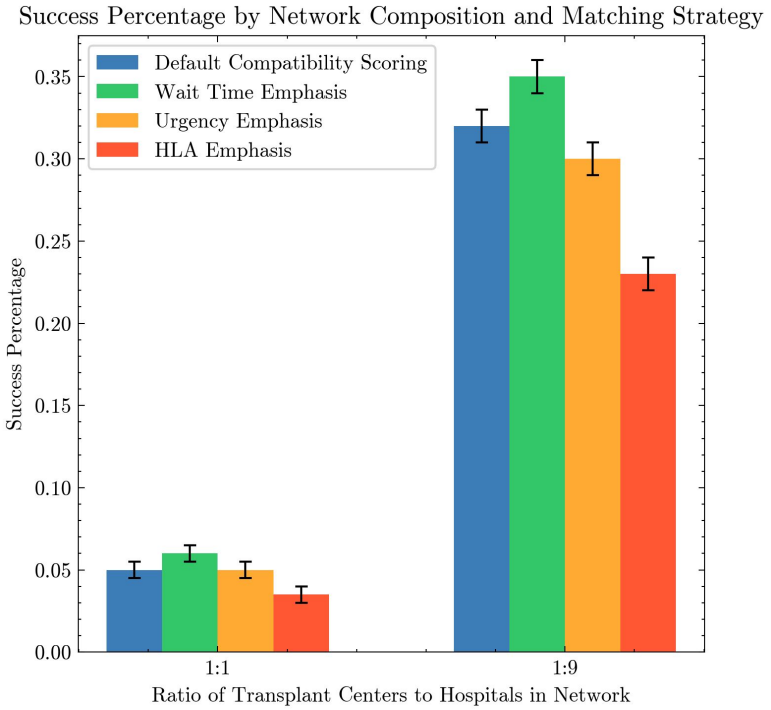
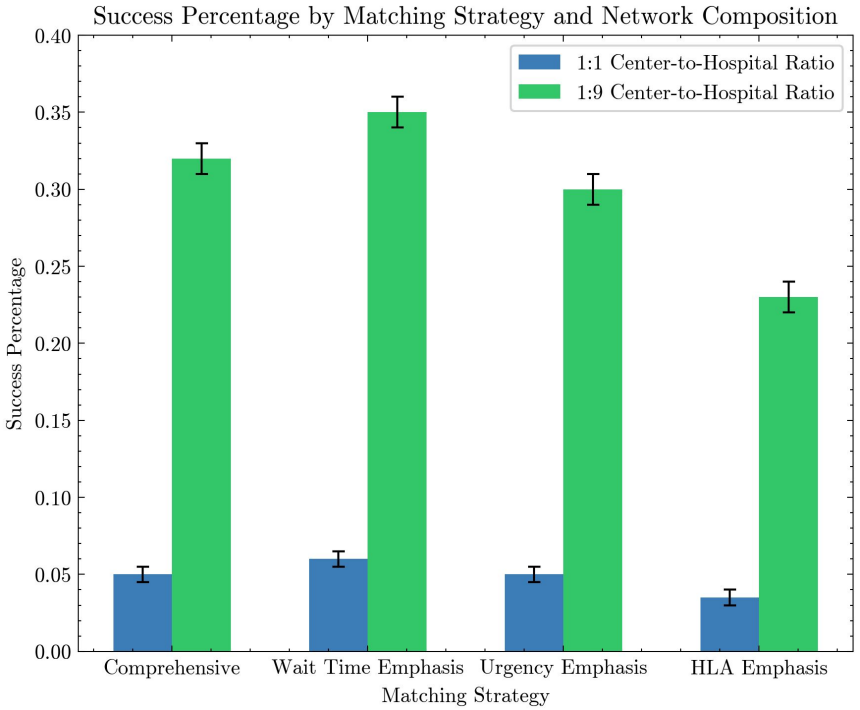
Results – Effects of Network Composition





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Key Takeaways

- Urgency and wait-time matching give best outcomes
- Strict HLA focus increases waits and lowers success
- More organs slightly reduce match quality
- Centralized, high-volume centers improve efficiency and results

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Future Work

- These results are just the beginning
- In the future we plan to:
  - Analyze even more allocation strategies
  - More effectively stratify organ donations in the model by deceased vs. living
  - Utilize the simulation to train reinforcement learning algorithms

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  - Alexander Sha
  - Sudeep Senivarapu
  - Anishsairam Murari
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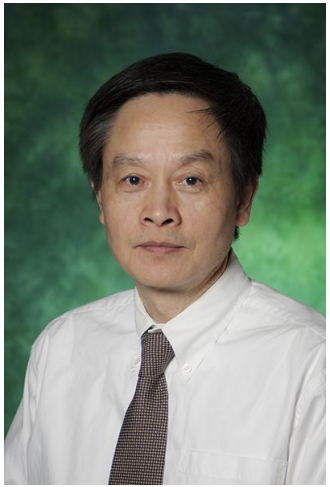

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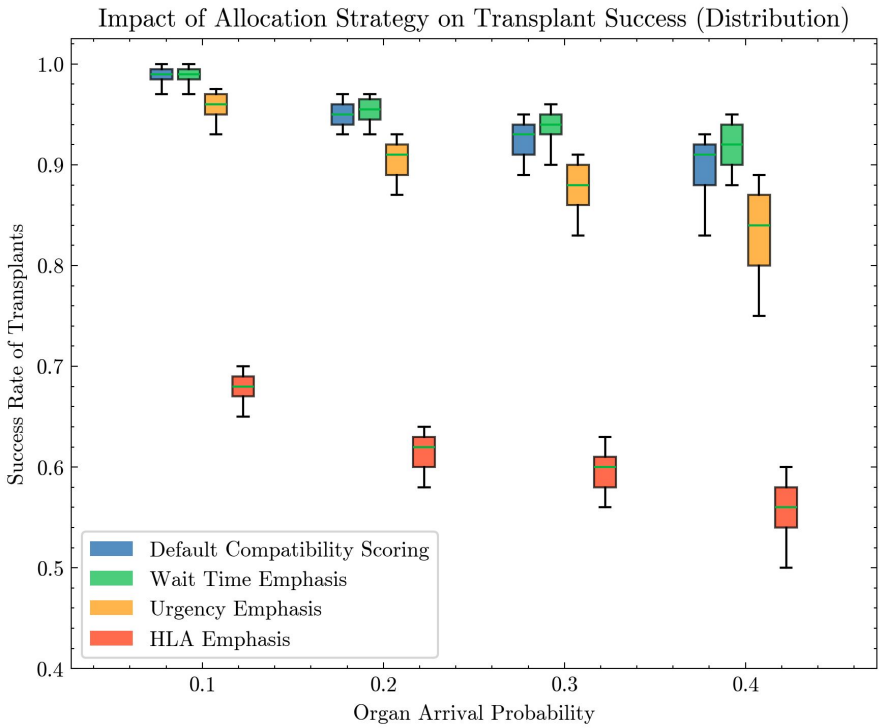
Supplemental slides: Figures, equations, etc.

Supplemental Slides – F1



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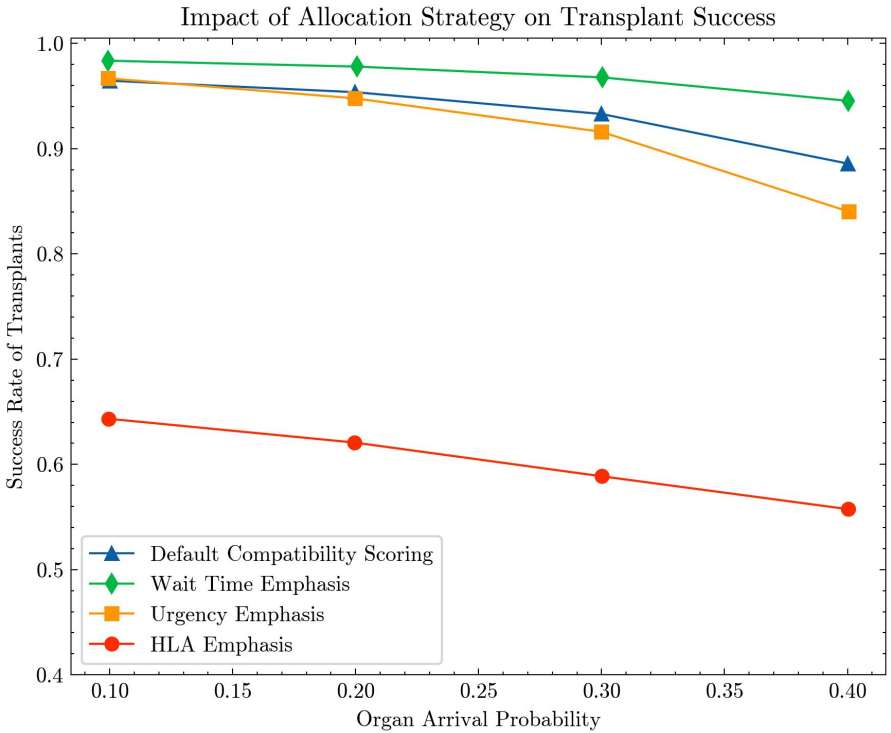
Supplemental Slides – F2



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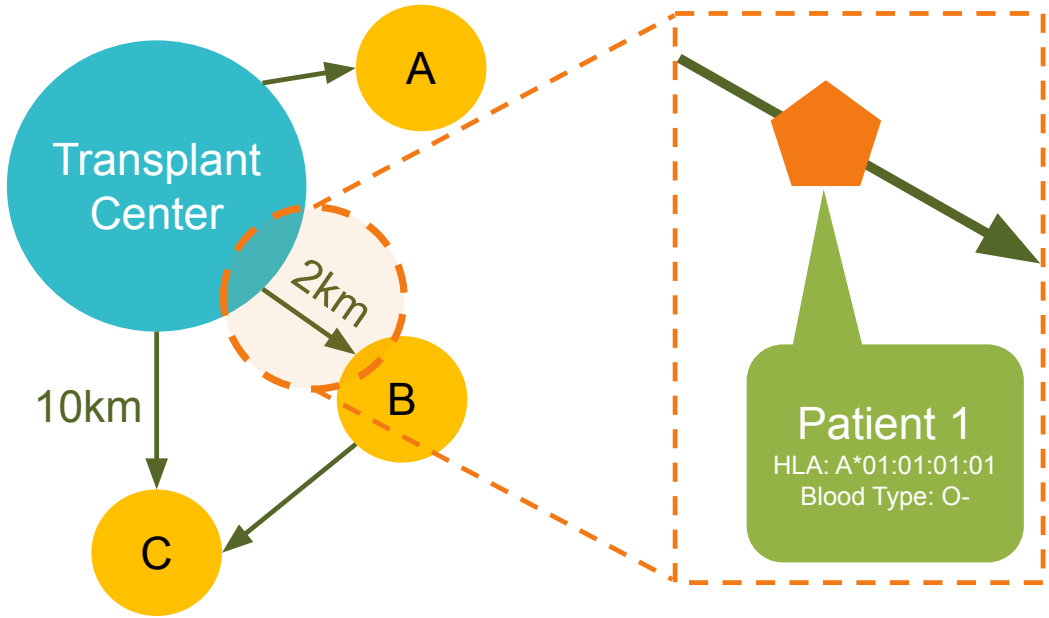
Supplemental Slides – F3



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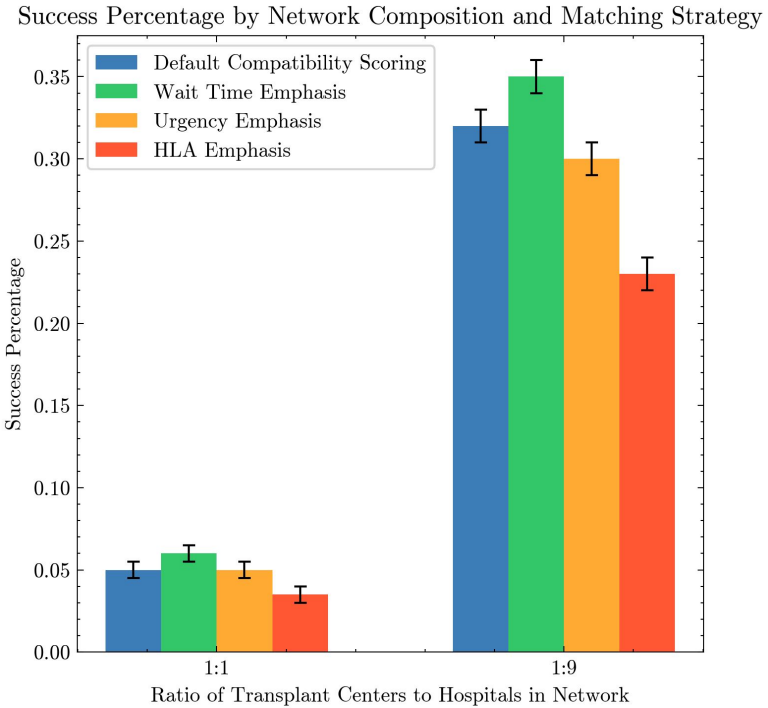
Supplemental Slides – F4



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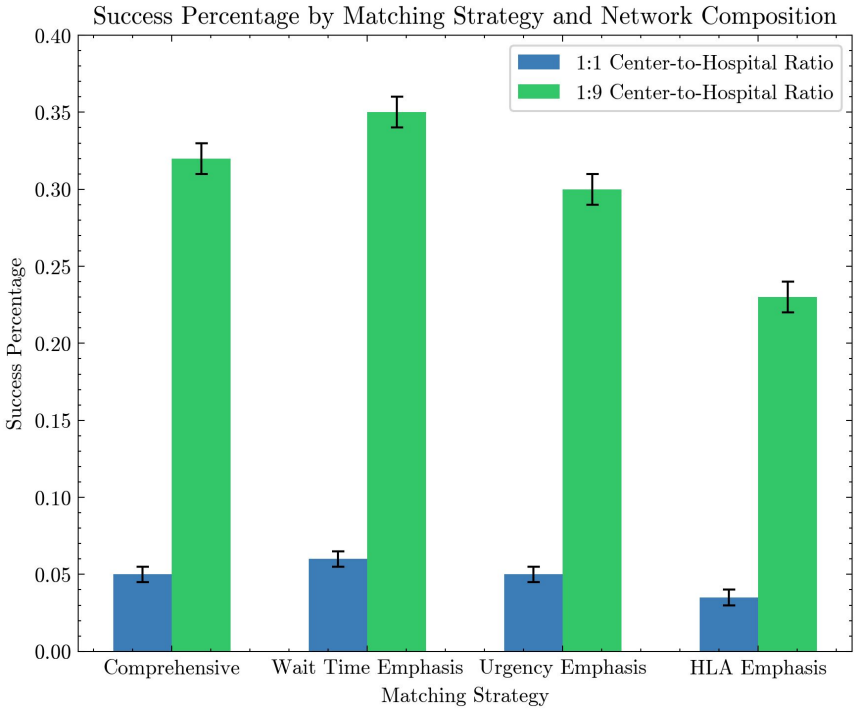
Supplemental Slides – F5



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