Endogenous Priority in Centralized Matching Markets: The Design of the Heart Transplant Waitlist

Kurt R. Sweat

Carey Business School
Johns Hopkins University
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The data reported here have been supplied by the United Network for Organ Sharing as the contractor for the Organ Procurement and Transplantation Network. The interpretation and reporting of these data are the responsibility of the author and in no way should be seen as an official policy or interpretation by the OPTN or the US Government. Based on data as of June 26, 2023.

Centralized matching markets and endogenous priority

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- Prioritization often interacts with other **decisions**
  - **Transplantation**: treatments for end-stage organ failure
- Participants *change* decisions due to priority: **decisions** $\iff$ *priority*

Transplantation

Transplantation

THE WALL STREET JOURNAL.

Trump Signs Executive Order on Kidney Disease

President's move encourages kidney transplants, less expensive at-home dialysis treatments

By Rebecca Ballhaus
July 10, 2019 1:04 pm ET

The New York Times

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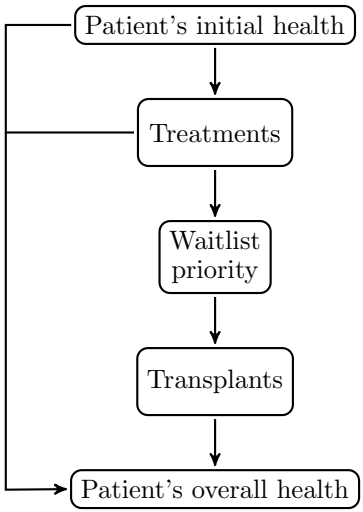
Setting for today: Heart transplant waitlist for adult patients

Priority and incentives in heart transplantation



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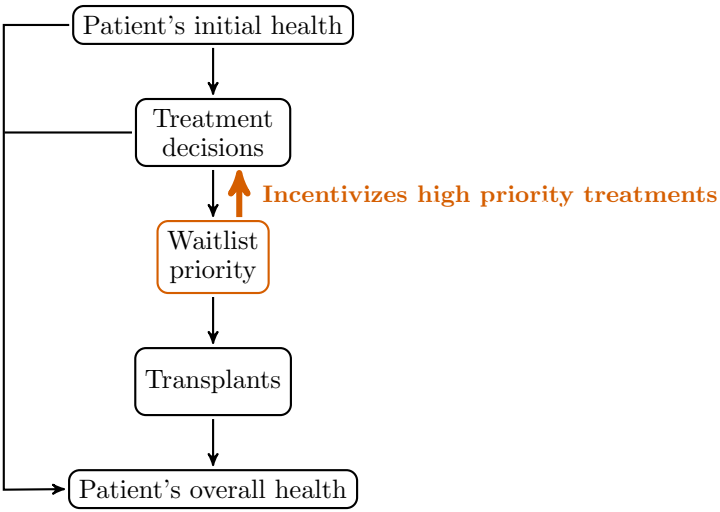

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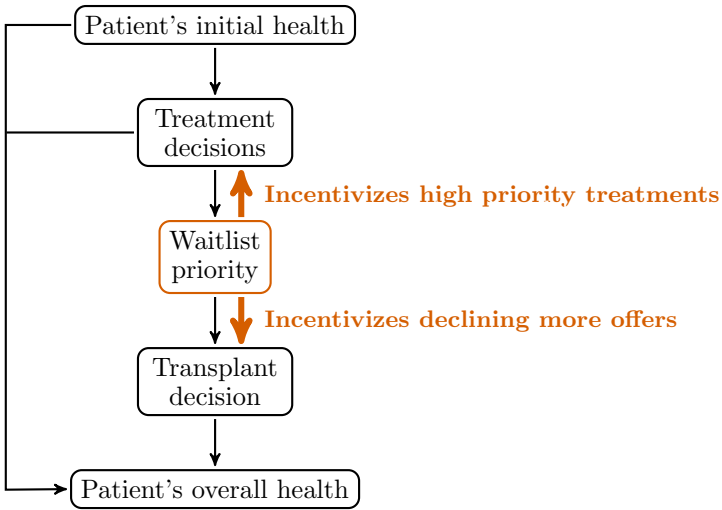

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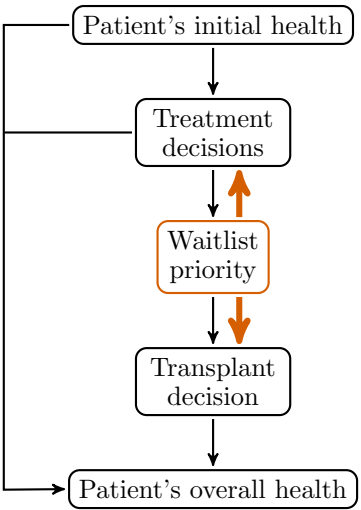


This paper: Employs a *structural model* of the doctors' treatment and transplant decisions and leverages a recent *change to the waitlist design* to **disentangle** how these two channels affect patients' health outcomes.

Outline of talk

Setting and Data

Descriptive Evidence

Model and Results

Conclusion

Heart failure in the United States

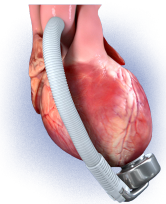
- Heart failure affects millions in the United States and is deadly
  - 6.7 million adults from 2017-2020 had heart failure (Tsao et al., 2023)
  - ≈80,000 deaths per year (Tsao et al., 2023)
  - End-stage patients: 50% 1-year survival *without* a transplant (Friedrich and Böhm, 2007)

- **Heart transplants** are the best 'cure' for end-stage heart failure
  - 90% 1-year survival *after a transplant* (Khush et al., 2021)
  - 50% 12-year survival *after a transplant* (Khush et al., 2021)

- Large percentage of donor hearts go untransplanted
  - ≈3,000-4,000 patients join the waitlist each year
  - ≈3,500-5,000 donor hearts offered each year
  - Donor hearts cannot be offered to all feasible patients: ≈40% untransplanted

Treatments for end-stage heart failure

- Patients on the waitlist receive two relevant types of treatments:
  - **Durable treatments**:
    Implanted for months-years
    Able to return home



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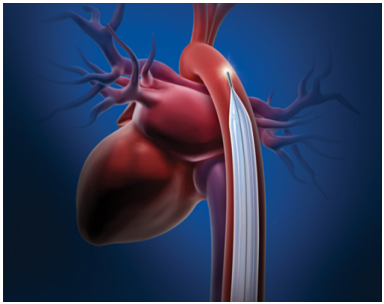

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  - **Durable treatments**:
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  - **Temporary treatments**:
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    Must remain in the hospital
- Treatments are often given in sequence and can be given simultaneously
- Difference in waitlist mortality by treatment (2015-2017)
  - **Durable treatment**: 20%
  - **Temporary treatment**: 30%
- Similar 5-year post-transplant survival (≈80%)

Treatments and the waitlist design

- **Heart transplant waitlist design**:
  First-come-first-served with *priority groups*
- **1999-2018 priority groups**:
  Temporary treatment $\sim$ Durable treatment $\succ$ No treatment

[The Committee] proposes modifications to the adult heart allocation system to better stratify the most medically urgent heart transplant candidates . . .
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- **Oct. 2018-present priority groups**:
  Temporary treatment $\succ$ Durable treatment $\succ$ No treatment
- **Potential benefits of redesign**:
  1. Target patients expected to die sooner.
  2. Increase number of transplants.

Key facts about the data and sample

- Data provided by the administrator of the waitlist (UNOS/OPTN) that includes information on all patients on the heart transplant waitlist and deceased organ donors

- **Patient data**: 14,658 adult patients that entered the waitlist from 2015-2019
  - Patient characteristics related to health, treatment suitability, donor suitability
  - Treatment choices on each day

- **Donor data**: 21,828 deceased donors offered to patients in the sample
  - Donor characteristics relevant for quality and suitability
  - ≈430,000 offers for heart transplants with choice to accept/decline offer

- **Post-transplant data**: 10,100 patients transplanted from 2010-2014
  - Same characteristics as patient and donor data, longer follow-up time

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Descriptive evidence on offers and declines

	Previous design		Current design	
	Dur.	Temp.	Dur.	Temp.
Treatment usage				
Within first week	34%	10%	21%	32%
Any time on waitlist	45%	18%	25%	48%
Priority and declines				
Offers per day	0.21	0.28	0.45	0.81
Declines per day	0.19	0.25	0.41	0.71
Patient outcomes				
Received transplant	80%	72%	86%	92%
3-year post-transplant survival	86%	86%	81%	86%

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2. *Priority and declines*: Consistent with expected effect of policy and additional declines of offers
3. *Outcomes*: More transplants, potentially due to overall increase in offers

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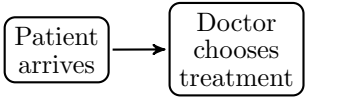

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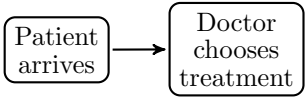

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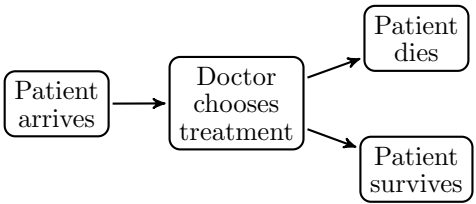

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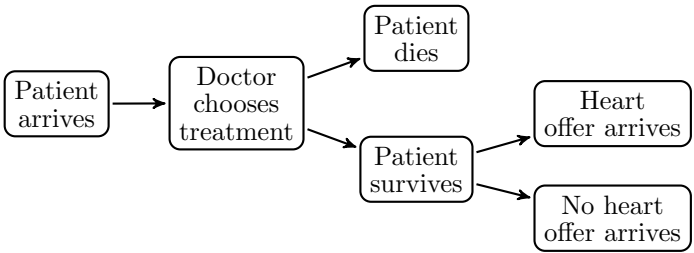

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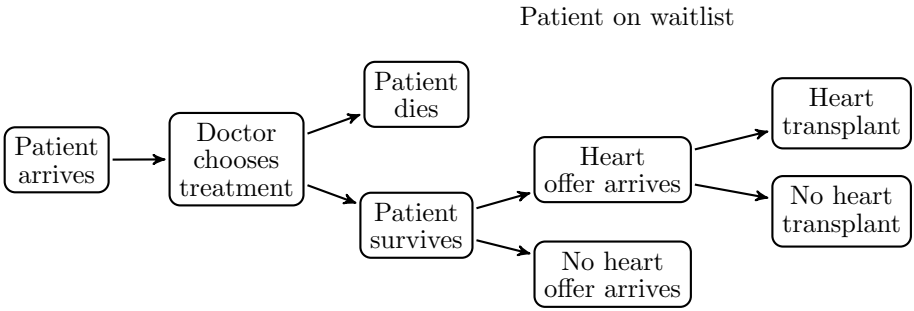

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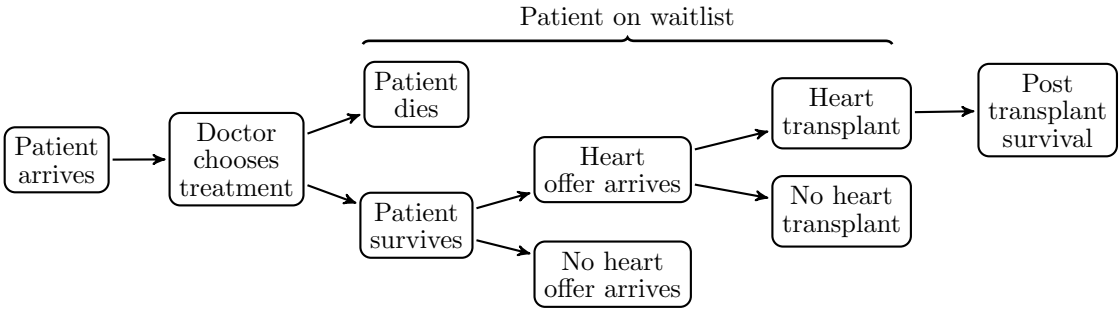

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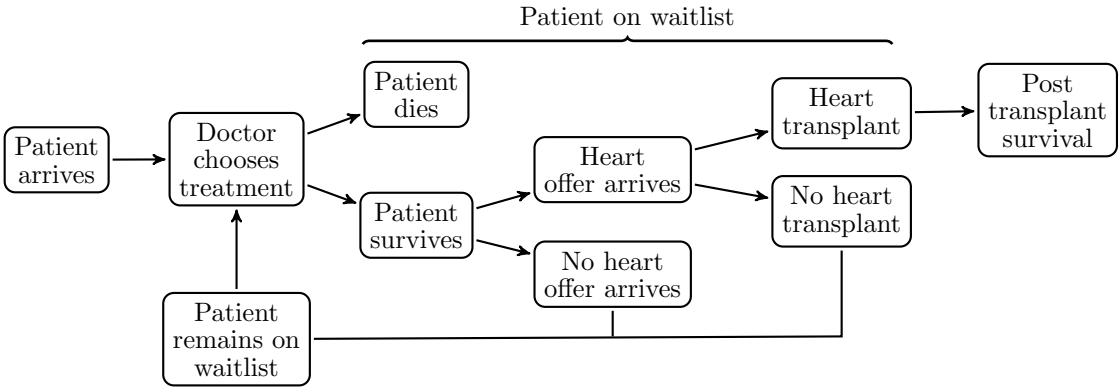

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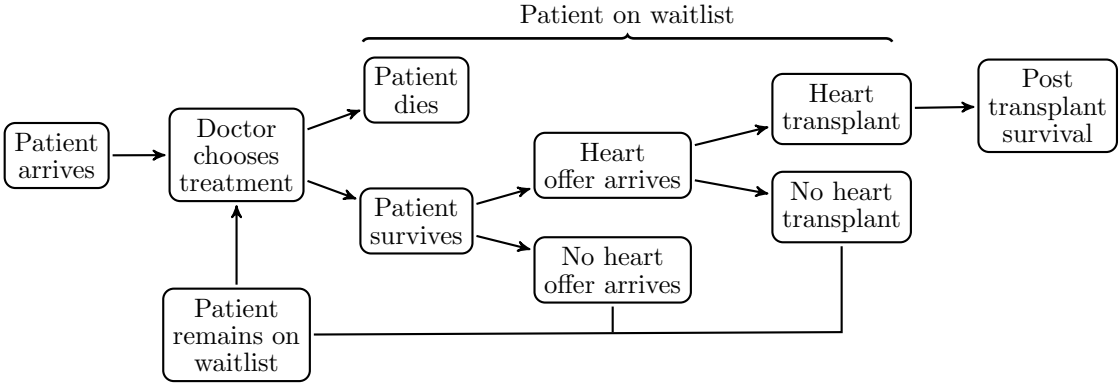

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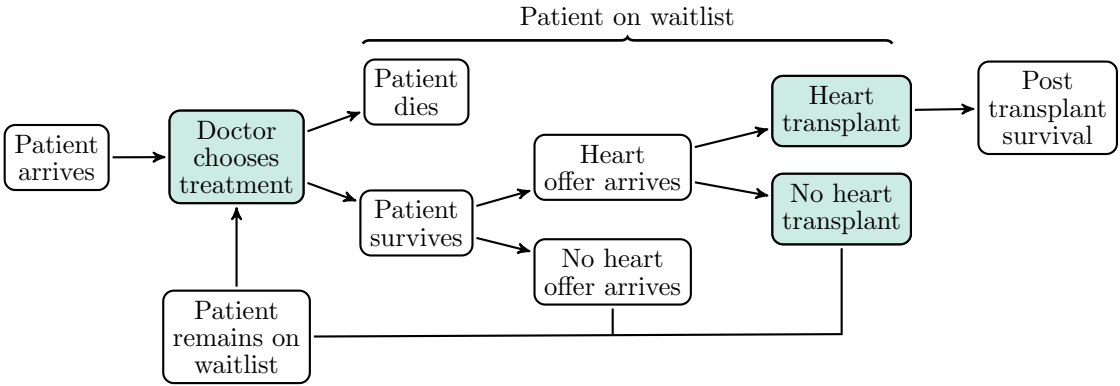

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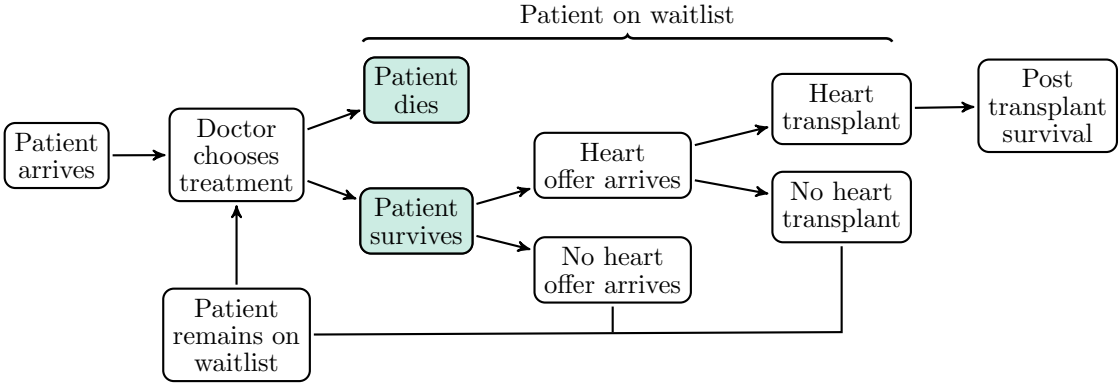

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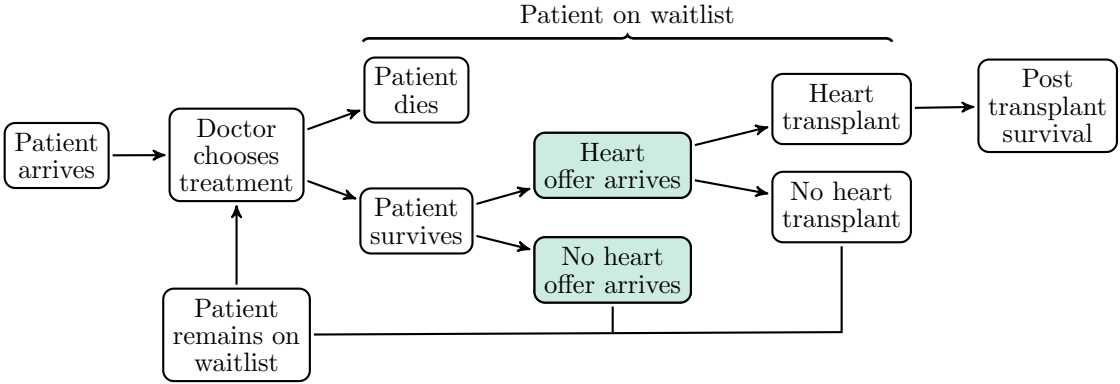

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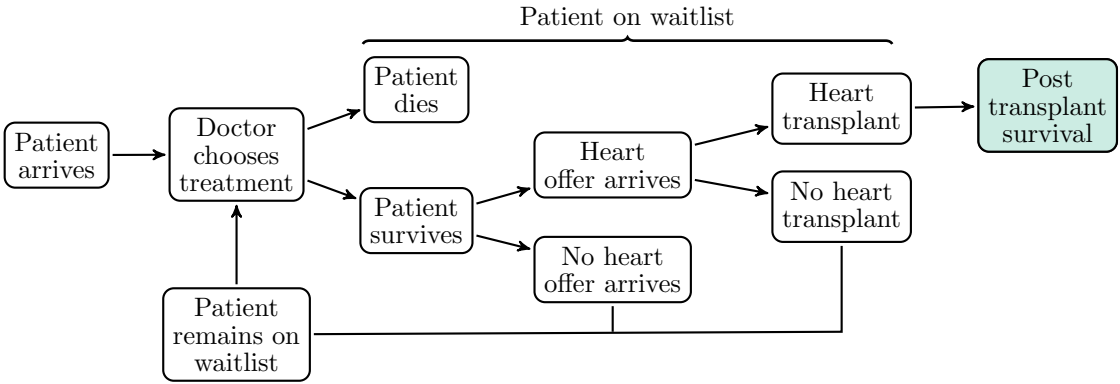

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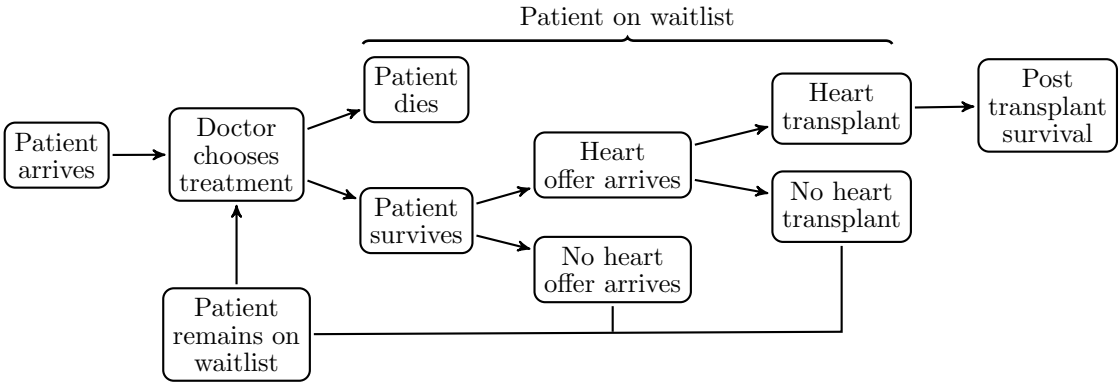

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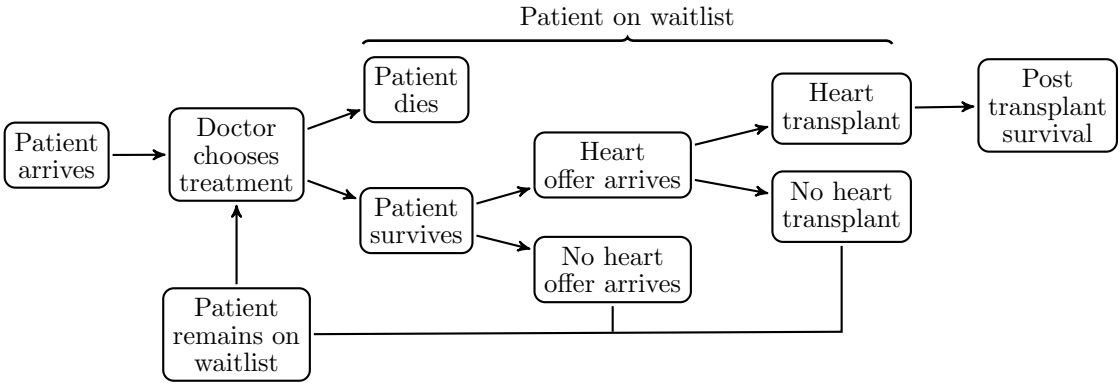

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Estimation: Parameters estimated on ≈15k patients for ≈2.5mil patient-days with ≈21k donors offered and ≈430k offers made.

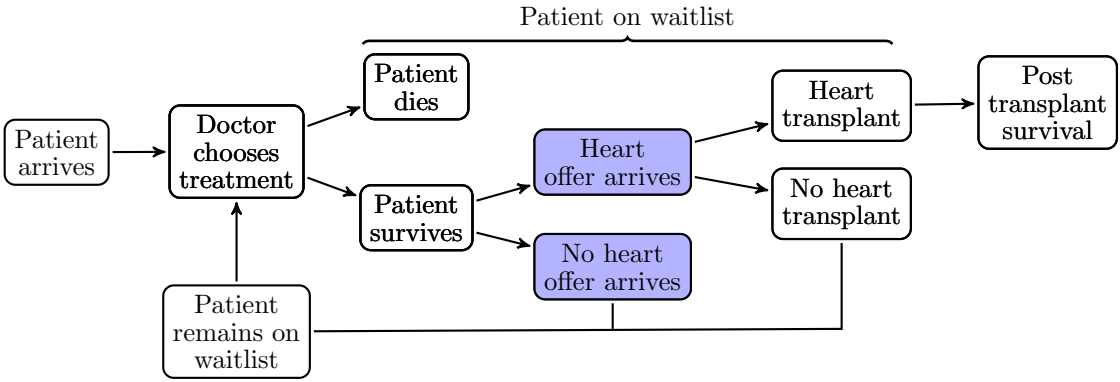
Overview of results

1. **Redistribution:** Estimate decisions and consequent expected life-years under both designs for each patient

2. **Targeting:** Estimate untransplanted survival for each patient

3. **Channels:** Disentangle effect of treatment decisions vs. transplant decisions

Estimating counterfactual outcomes for a particular patient



Preference parameters
Survival parameters
Heart offer arrival under the previous waitlist design

$\Longrightarrow$

Distribution of treatment decisions, transplant decisions, and survival under the **previous design**

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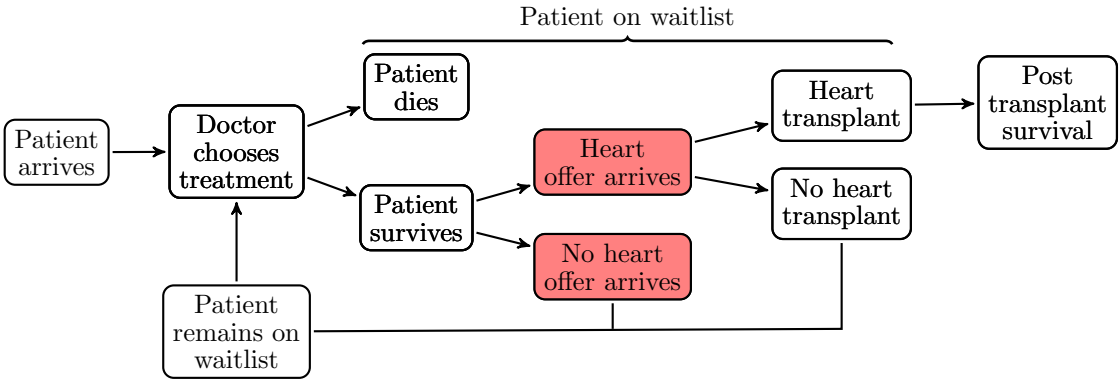

Preference parameters
Survival parameters
Heart offer arrival under the current waitlist design

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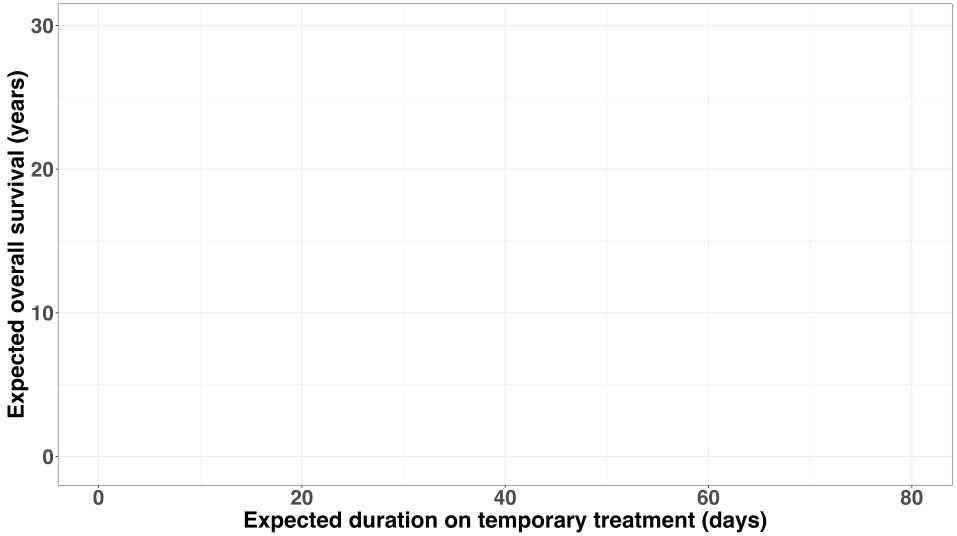
Estimating counterfactuals for an exemplary patient



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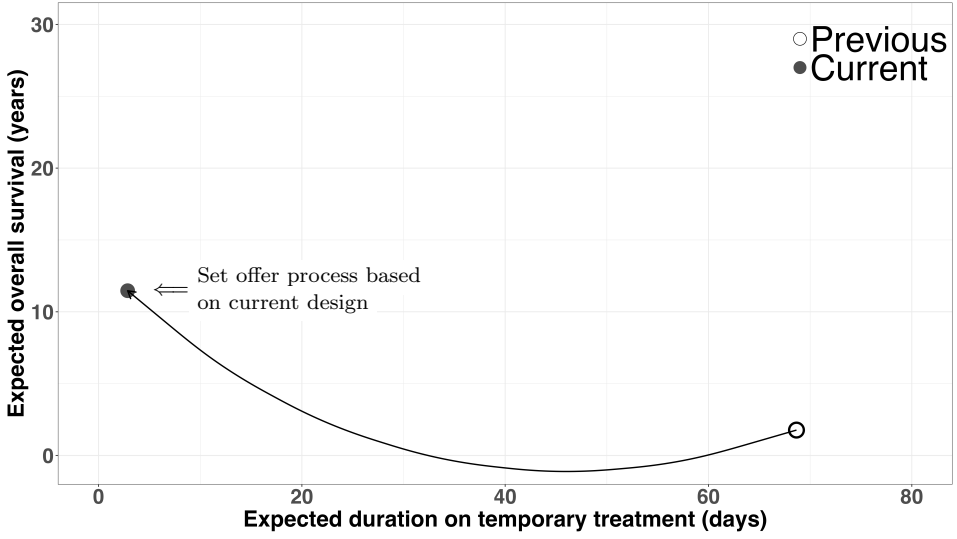
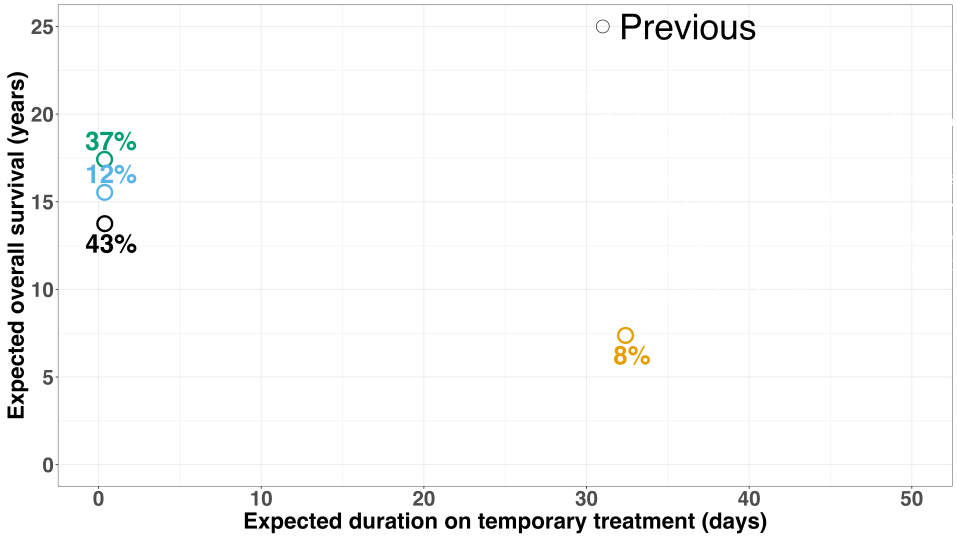


Clustering by outcomes to understand redistribution

- The counterfactuals under the previous and current design can be estimated for all $\approx 15,000$ patients
- To demonstrate key effects of interest, construct four clusters of patients on four expected quantities of interest:
  1. Expected survival under the previous design
  2. Expected survival under the current design
  3. Expected temporary treatment duration under the previous design
  4. Expected temporary treatment duration under the current design
- Follow the median expected survival and expected temporary treatment duration under the previous and current design for each cluster

Redistribution caused by the waitlist design change



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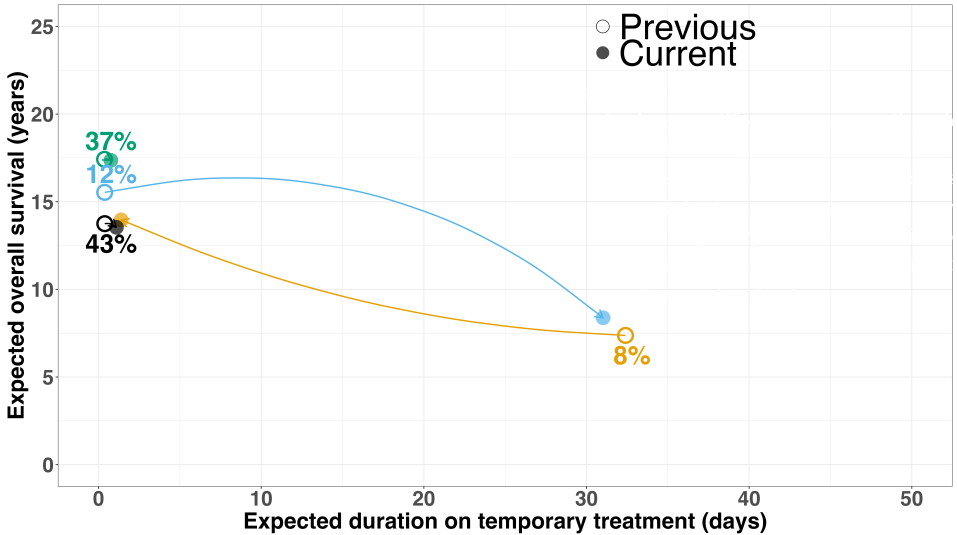

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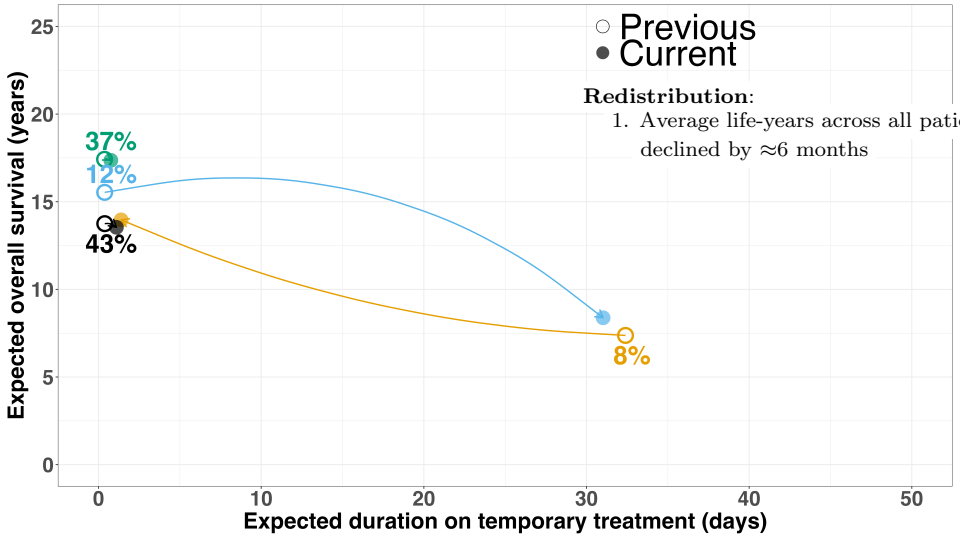

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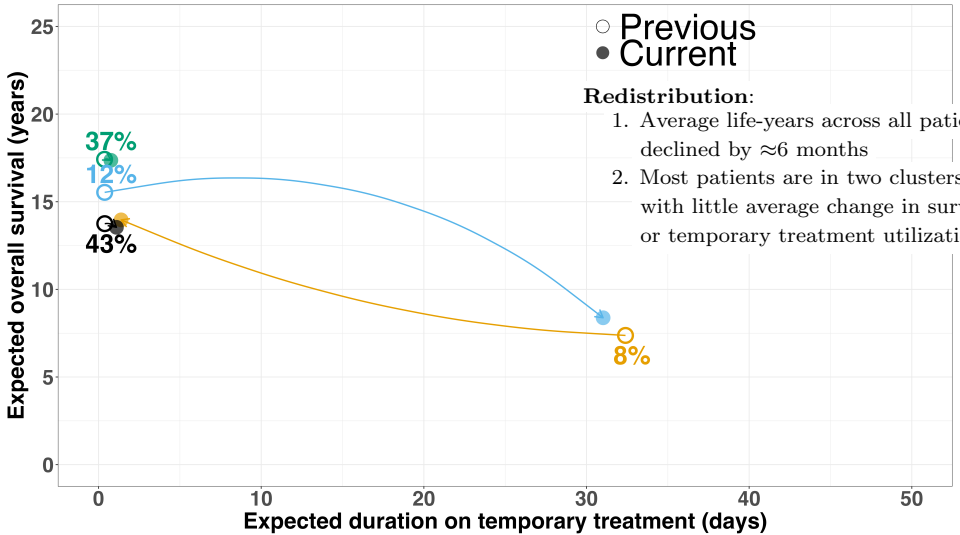

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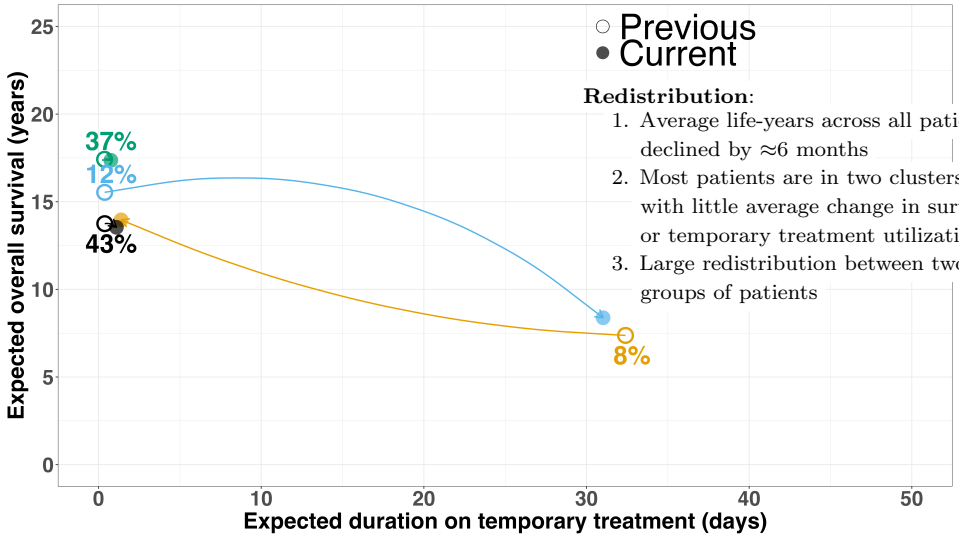

Redistribution:

1. Average life-years across all patients declined by ≈6 months
2. Most patients are in two clusters with little average change in survival or temporary treatment utilization
3. Large redistribution between two smaller groups of patients

Overview of results

1. **Redistribution:** Estimate decisions and consequent expected life-years under both designs for each patient

   Change resulted in redistribution rather than aggregate survival gains

2. **Targeting:** Estimate untransplanted survival for each patient

3. **Channels:** Disentangle effect of treatment decisions vs. transplant decisions

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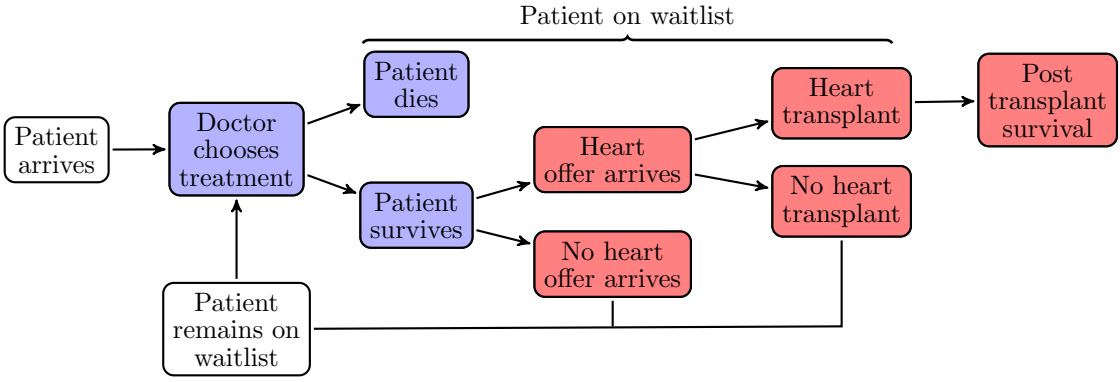
Estimating counterfactual to disentangle treatments vs. transplants



Treatment choice and waitlist survival under the **previous** design

Heart offer arrival under the **current** waitlist design

$\Longrightarrow$

Effect of receiving a transplant under the **current** design and treatments under the **previous** design

Change in median survival due to treatments vs. transplants

	Beneficiaries	Disadvantaged	Other patients
Previous design	7.4 years	15.5 years	15.3 years
Current design	14.0 years	8.4 years	15.1 years
Previous treatments and current transplant	13.3 years	9.6 years	15.1 years
Percent of patients	8%	12%	80%

- Additional time spent on treatments is only responsible for 17% of reduction in survival for disadvantaged patients
- Disadvantaged patients are expected to reject more offers
  - Beneficiaries: 76% of offers $\rightarrow$ 15% of offers
  - Disadvantaged: 14% of offers $\rightarrow$ 65% of offers

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   Patients who are made worse off, are primarily made worse off due to doctors declining offers rather than receiving treatments that negatively affect their health

Conclusion and policy implications

- Design results in redistribution towards sicker patients who receive temporary treatments under either design
- Healthier patients receive more temporary treatments and worse outcomes, primarily due to changes in **transplant** decisions
- **Policy implication**: Redesign should focus on disincentivizing rejecting offers
- **Future work**:
  - Evaluate counterfactual waitlist designs that penalize rejecting offers

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- **Policy implication**: Redesign should focus on disincentivizing rejecting offers
- **Future work**:
  - Evaluate counterfactual waitlist designs that penalize rejecting offers
  - How do health policy, market design, and competition interact to create incentives that distort health outcomes?
  - How can we use data to improve allocational efficiency of medical resources while accounting for incentives?

References

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