

# Matching Algorithms and Organ Distribution

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Embedded EthiCS module for CS 1200: Introduction to Algorithms and their Limitations

*Modified module and slides originally from Entwistle (2022).*

# Agenda

- Intro
- Background on kidney donation and motivation
- Warmup
- Two different ethical approaches
  - Maximization (outcomes-based)
  - Maximin (needs-based)
- Class Activity
- Prioritarianism

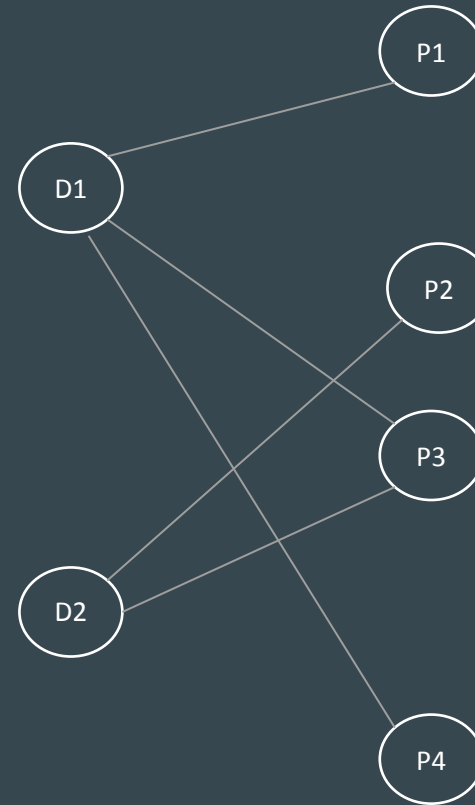
# Background on Organ Donation

- Approximately 103,485 people are currently waiting for an organ transplant.
  - In 2023, about 46,000 organ transplants were performed.
- With respect to kidneys transplants specifically:
  - over 90,000 waiting for a kidney
  - roughly 28,000 kidney transplants completed in 2023
  - approximately 13 people die each day waiting for a kidney transplant
- Motivating Question: how should we arrange matches under conditions of scarcity?

*Source: United Network for Organ Sharing website*

# Donor matching under scarcity

- Last week you studied algorithms to maximize the number of patients that receive organs based on compatibility constraints.
- Today's focus:
  - is maximizing the *number* of matches the right objective?
  - if there are multiple ways to maximize matches, how choose which patients to prioritize?



# Motivation:

- Mapping technical solutions onto social problems:
  - Benefits:
    - given a well-defined problem & metric, CS can provide tools for how to optimize for that metric
  - Limits:
    - can't tell us what metric to optimize for, or how to evaluate whether that metric is the right one
- Implementing technical solutions:
  - Where is the data coming from?
  - Does the data contain bias?
- Ethical reasoning can help us think through these concerns.

# Warmup

- By yourself:
  - think about what factors should be considered when deciding which patients to prioritize for kidney donation? Write 2-3 down. (1 min)
- With the person or few people next to you:
  - share the factors you wrote down and discuss why those factors might be relevant. (2 min)

# Kidney Donations:

Factors listed as relevant by the United Network on Organ Sharing (UNOS) website.



## Kidney

- Waiting time
- Donor/recipient immune system compatibility ([CPRA score](#))
- Prior living donor
- Distance from donor hospital
- Survival benefit
- Pediatric status

# Outcomes-based Approach

- Utilitarianism: an ethical theory which says (roughly speaking) that the right action is always the one that maximizes the greatest total welfare.
- Kidney donation:
  - Match in a way that maximizes the greatest total welfare.

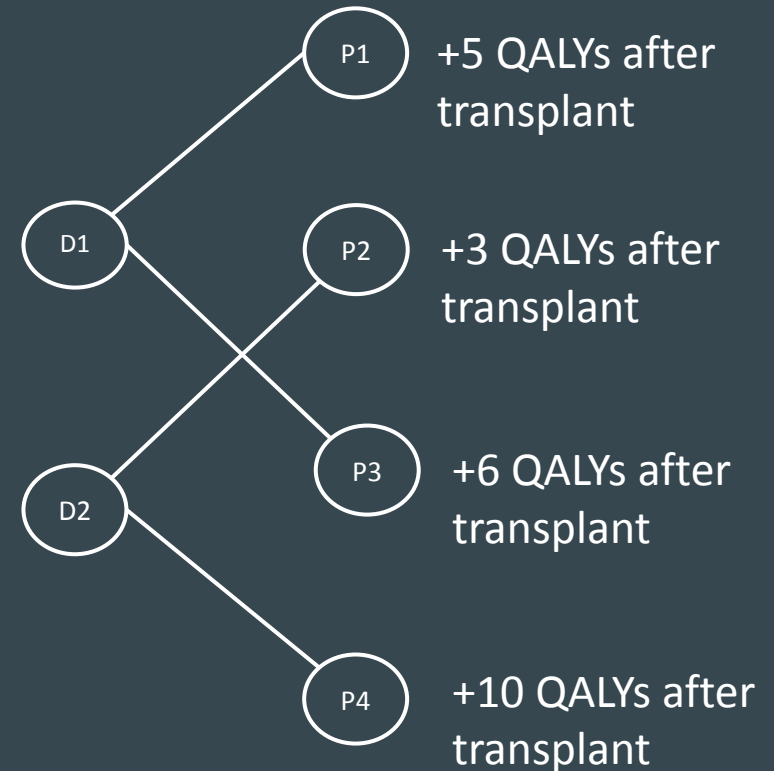


# Maximizing welfare?

- What is the greatest total welfare in the kidney case?
  - One option: life years gained
- Another way of doing this is through quality-adjusted life years (QALYs).
  - One year lived in perfect health = 1 QALY
- Maximizing total welfare = maximizing total QALYs gained

# Maximization

- (2 min) With the person next to you, discuss which pairs we should choose to match according to the maximization principle?
- The maximization principle dictates that we choose **P3 and P4** because doing so would maximize total QALYS gained.



# Problems with Maximization

- In this scenario, P1 and P2 don't end up receiving kidneys because the total number of QALYs they are expected to gain is not as high as the total number of QALYs that P3 and P4 are expected to gain.
- With a partner: why might it be *unfair* that P1 and P2 are passed over in favor of patients with better expected outcomes? What are some possible reasons that P1 and P2 have lower expected outcomes? (3 min).

# Problems with Maximization (cont.)

- Why might P1 and P2 have lower expected outcomes in the first place?
  - Age
  - More severe disease
  - Time on transplant list
  - Socioeconomic and racial inequality in healthcare
- Other considerations:
  - data concerns: general socioeconomic and racial inequality in society
  - QALYs as a metric

# Needs-based Approach

- Needs-based theory: scarce medical resources should go to those that need them the most.
- Maximin principle: pick the donor-recipient pair that help the least well-off people.

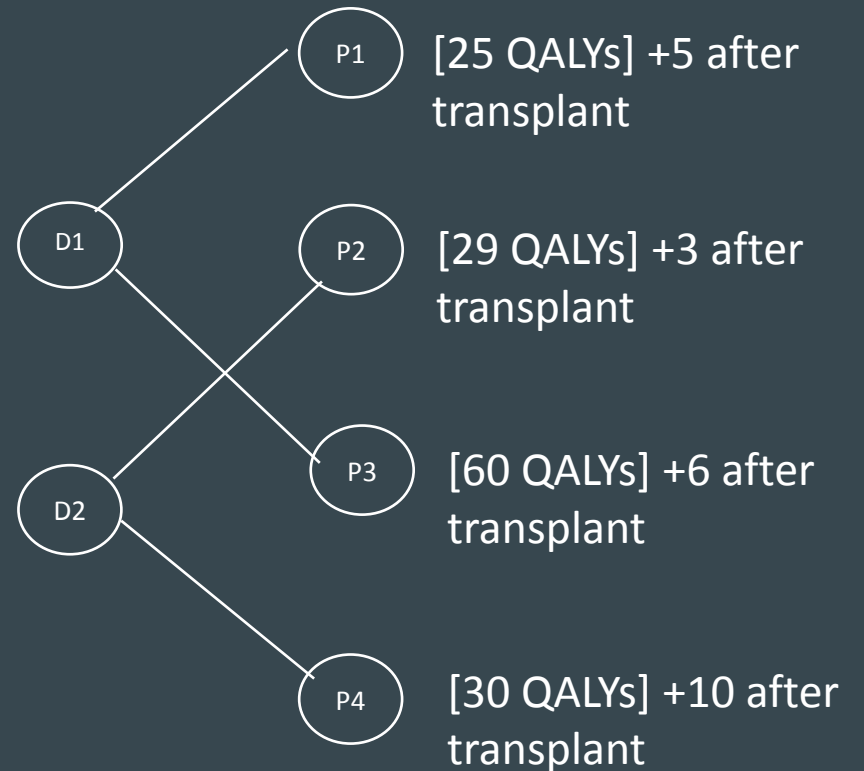
# Least well-off?

- How do we determine who is the least well-off?
  - Someone who has had fewer QALYs is worse-off than someone who has had more QALYs.
- Maximin: pair donors with patients who have the fewest QALYs to start.

# Maximin Applied

(1 min) With the person next to you, discuss which of the compatible patients we should prioritize, according to the maximin principle:

According to the maximin principle, we should choose **P1 and P2**, because in doing so we help the least well-off patients, where the “least well-off” means they’ve had the fewest QALYs



# Problems with Maximin?

- In this scenario, P3 and P4 do not end up receiving a kidney because they have had a greater number of QALYs than P1 and P2.
- With a partner: why might it be *unfair* that P3 and P4 do not receive a kidney in this case? (3 min).



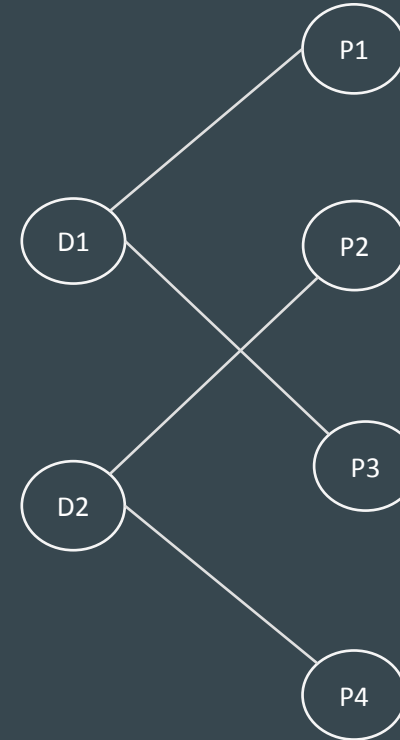
# Problems with Maximin (cont.)

- Problems with a needs-based approach

- Will prioritize giving the kidney to the least well-off even in cases where it doesn't seem intuitive, for example if:
  - the benefits to the least well-off are very small and the benefits to a different compatible pair might be large;
  - or the difference between the least well-off and slightly less well-off are not large.
- Use of QALYs to determine “least well-off” is flawed.
  - People with disabilities not well represented by the metric
  - Data concerns

# Activity (5 min)

- Your side of the room will be assigned to argue for Maximin (needs-based) or Maximization (utilitarian).
- With your partners: come up with reasons in favor of your assigned position. Be ready to report back to the larger class.



# Maximization vs. Maximin?



# Class Vote

## Outcomes-based Approach

- Maximization: maximize the greatest total welfare (greatest number of QALYs gained)
- Moral intuition: do the most good with the resources you have.
  - sensitive to scale
  - not sensitive to starting point

## Needs-based Approach

- Maximin: help the least well-off patients (lowest starting number of QALYs).
- Moral intuition: help those who need it most.
  - sensitive to starting point
  - not sensitive to scale.

Which of the two principles do you think should be used to decide how to allocate kidneys to patients?



Maximization (utilitarian approach)

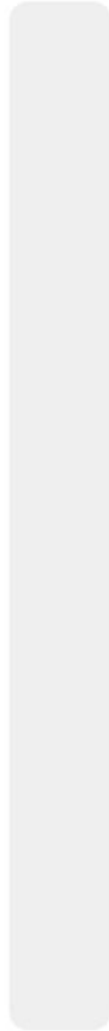
Maximin (needs-based approach)



Which of the two principles do you think should be used to decide how to allocate kidneys to patients?

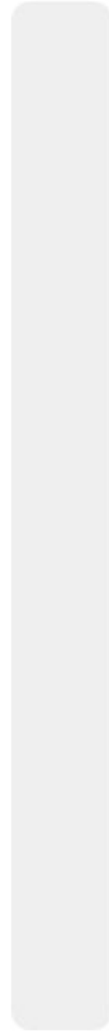


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Maximization (utilitarian approach)

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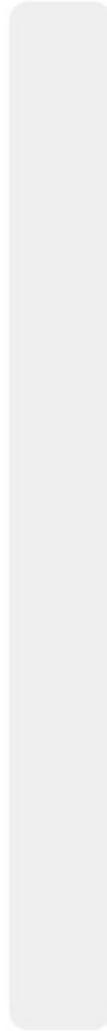
Maximin (needs-based approach)



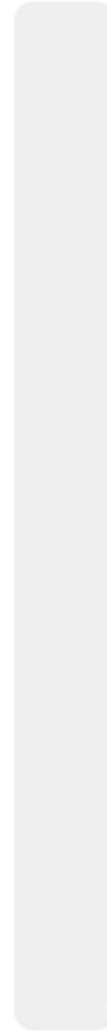
Which of the two principles do you think should be used to decide how to allocate kidneys to patients?



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Maximization (utilitarian approach)

Maximin (needs-based approach)



# Another option:

- Prioritarianism:

- (1) the lower an individual person's level of well-being over the course of their life, the greater the moral value of a benefit to that individual.
- (2) we should act so as to maximize moral value.

- Principle: prioritize getting benefits to those whose well-being is lower, but all benefits are taken into account (they will just be weighted differently).

- (3 min) With a partner: how would this work in the organ donation case?



# Reflections?

- If prioritarianism had been an option in the poll, would it have changed your answer? Why or why not?
- What difficulties remain when it comes to mapping this kind of technical solution (e.g. matching algorithms) onto social problems (e.g. kidney donation)?

Thank you!

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