Adapting the Top Trading Cycle for Kidney Exchange
A Synthesis of Alvin E. Roth’s Work
Raina Ahuja, Asha Camper Singh, Rachel Keirouz, Steven Stone, Mohan Paturi

The Problem
- The kidney exchange process in the United States is inefficient and forces many people to wait long periods of time for a donated kidney.

The Process

<table>
<thead>
<tr>
<th>Goal</th>
<th>The Problem</th>
</tr>
</thead>
</table>
| INCREASE | - Mechanism: patients trade their live donor’s kidney for a better spot on the cadaver queue
| - Motivation: accommodate patients who have no compatible kidney match available
| - “Clean up” |

<table>
<thead>
<tr>
<th>Formula Score + Compatibility</th>
<th>Waiting List Position</th>
</tr>
</thead>
</table>
| Extremely complex | ABO Blood Type
| HLA Tissue Type
| Pre-transplant Crossmatch (Antibody Test) |

Top Trading Cycles Algorithm (TTC)
- House Allocation Problem
- Provides an algorithm to let people trade homes if they so choose, without getting a house worse than their own
- Graph with edges between people and homes

W-chain
- Mechanism: patients trade their live donor’s kidney for a better spot on the cadaver queue
- Motivation: accommodate patients who have no compatible kidney match available
- “Clean up”

W-Chain Selection Rules
1. Minimal w-chains
   a. Simplest, solves simultaneous exchange issue
2. Longest w-chains
   a. Benefits the largest number of people
3. Remove w-chain with starting with the highest priority pair
   a. Solve O-negative disadvantage by assigning O-negative pairs highest priority

The Formula Score

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Difficulties With Data
- Synthetic data
- Unsure of accuracy - difficult to get real data because of confidentiality issues
- Assumptions on percentage of those who want to waitlist

Existing Issues
- Altruism - ethical way to handle unpaired donor kidneys
- Morality of jumping the waitlist
- Dynamic graph
- Lack of nationwide participation

Current Direction
- Find incentives to encourage more hospitals to join and make kidney exchange happen on a larger scale
- Hospitals may keep the local good pairs for themselves - only enroll their hard-to-match pairs in the exchange system
- Causes loss of efficiency

Use integer programming (an optimization technique where all variables are restricted to be integers) to help find long chains:
- Chain selection rule: Longest w-chain
- An NP-hard problem to find the longest chain

Simulations

<table>
<thead>
<tr>
<th>Simulations</th>
<th>Waitlist 0% (no w-chains)</th>
<th>Exchange Method</th>
<th>O-Type % Waitlist</th>
<th>Total Trans. %</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td></td>
<td></td>
<td>27.6</td>
<td>53.92</td>
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<tr>
<td>TTC</td>
<td></td>
<td></td>
<td>9.6</td>
<td>91.05</td>
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<tr>
<td>Waitlist 40% (w-chains)</td>
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</tr>
<tr>
<td>TTCC (w-chains)</td>
<td>5.5</td>
<td></td>
<td></td>
<td>92.29</td>
</tr>
</tbody>
</table>

References and Acknowledgements

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