Kidney Exchange Program

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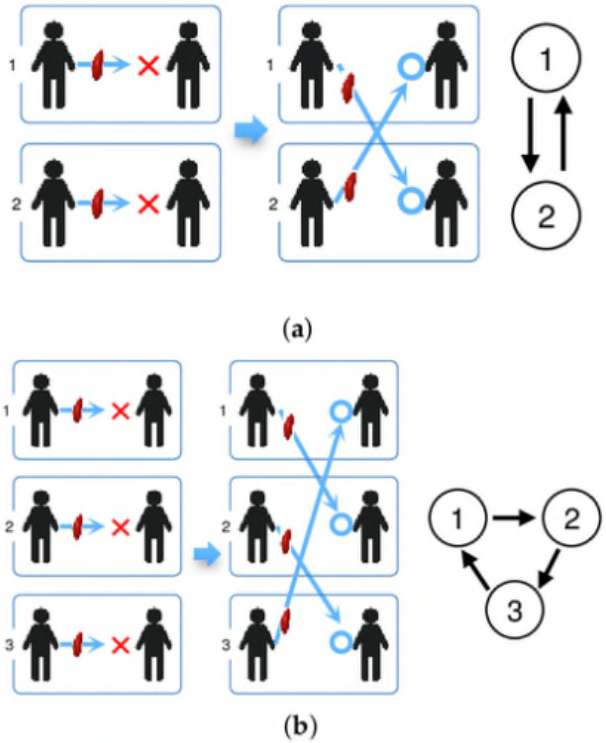
Kidney Exchange Program: Concept

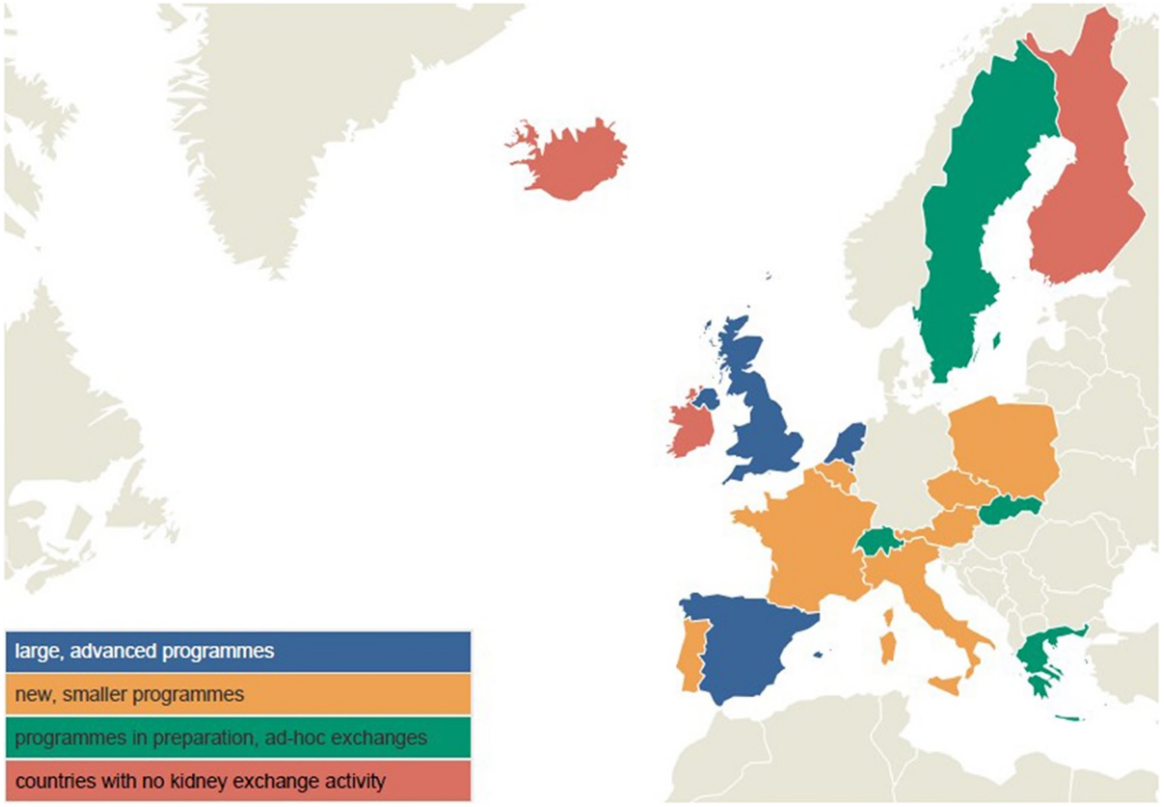
- A person in need of kidney transplant might have multiple persons willing to donate them a kidney.
- No donor from that pool might be compatible.
- People are much more likely to donate kidney to a friend or relative then a total stranger.
- **Solution:** Create a pool of people in need of kidney transplant and along with the people willing to donate them a kidney.
- Form kidney chains.



Kidney Exchange Program: History

- First implemented in New England 2004 – 2005.
- Alvin E. Roth – 2012 Nobel Memorial Prize in Economic Sciences.
- Has been implemented all over the world.
- 3-way exchange kidney chains considered optimal.
- Longest kidney chain ever: 6-way exchange.

Kidney Exchange Programs: Europe



Kidney Exchange Program: Compatibility

- Object: Minimize the likelihood of kidney being rejected by kidney transplant recipient.
- Blood type: 'A', 'B', 'AB', 'O'
  - 'O' can receive kidney from 'O'
  - 'A' can receive kidney from 'A' or 'O'
  - 'B' can receive kidney from 'B' or 'O'
  - 'AB' can receive kidney from 'AB', 'A', 'B' or 'O'
  - Rhesus (+/-), not important
- Donor‘s Physical Condition: Age, BMI, eGFR, SBP, History of Smoking

Kidney Exchange Program: Compatibility

- HLA Antigen Matches
  - HLA-A
  - HLA-B
  - HLA-C
  - HLA-DR
- Transplants performed even though several HLA mismatches exist

Kidney Exchange Program: Dataset

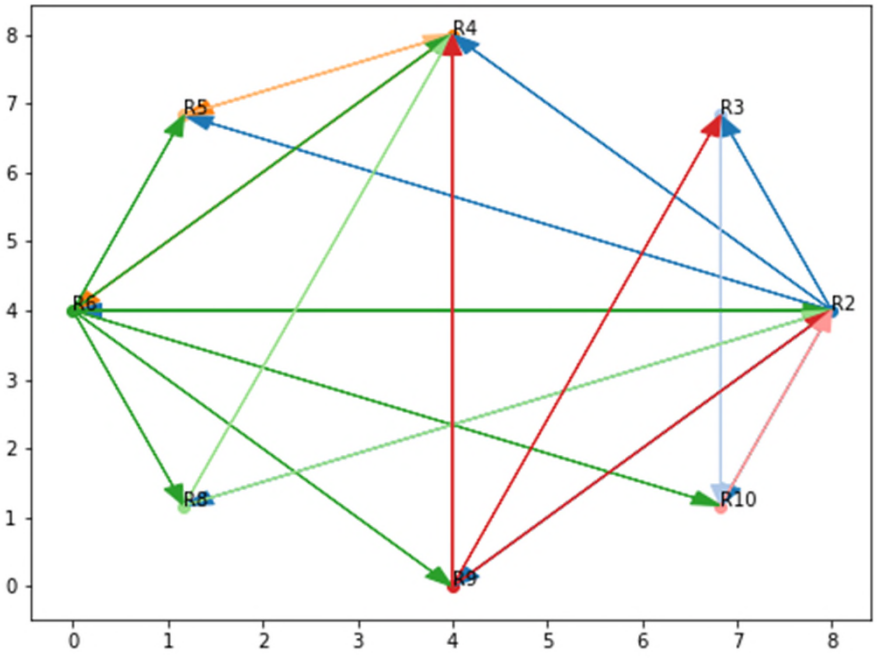
- Complete:
  - Bloodtype Distribution - Vísindavefur
  - BMI Distribution – Landlæknir
  - History of Smoking Distribution – Landlæknir
- Incomplete:
  - Systolic Blood Pressure Distribution – Hjartavernd
  - Heritage – Hagstofan
  - eGFR – Dutch study
- Missing:
  - HLA distribution amongs the Icelandic population – deCode

Kidney Exchange Program: Method

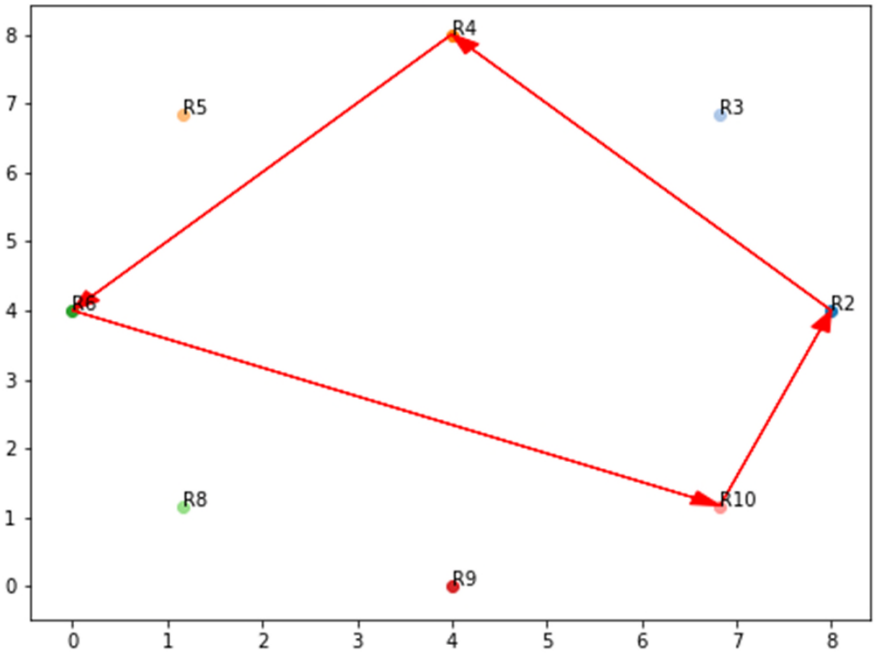
- Preprocessing
- Genetic Algorithm
- Sequence with Permutations
- Objective Functions:
  - Longest possible kidney chain
    - Higher risk of kidney rejection
    - Logistical problems
  - Maximum kidney distribution
    - Higher risk of kidney rejection
  - Lowest risk kidney chain
    - Lowest risk of kidney rejection
    - Will favor a slightly lower risk 2-way exchange over a 3-way exchange
  - **Constrained kidney chain size – Lowest risk kidney chain of that size selected**
    - Accounts for logistics, f. ex. amount of kidney transplants possible at the same time

Kidney Exchange Program: Results

Possible Kidney Exchanges



Best 4-way Exchange Kidney Chain

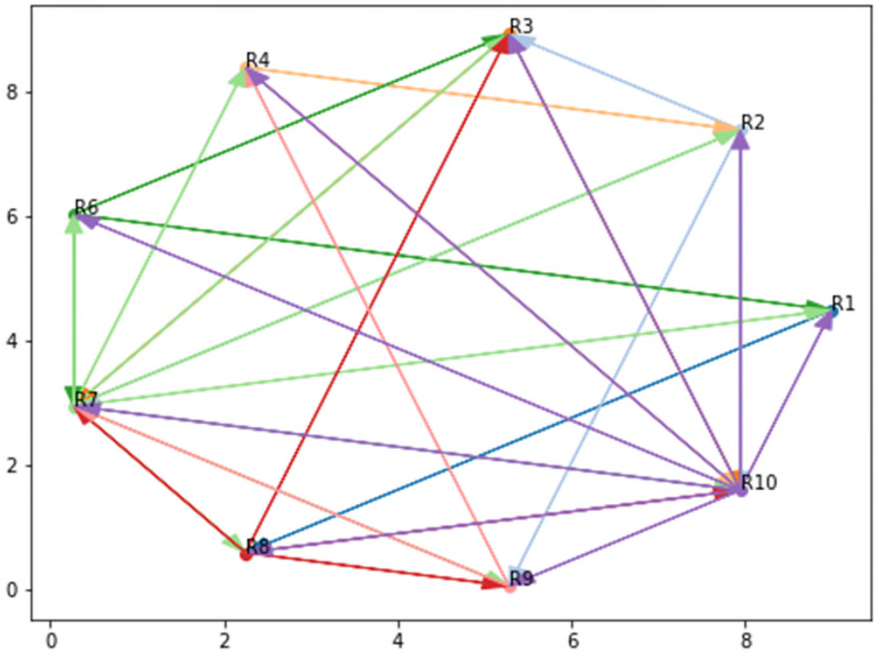


Kidney Exchange Program: Results

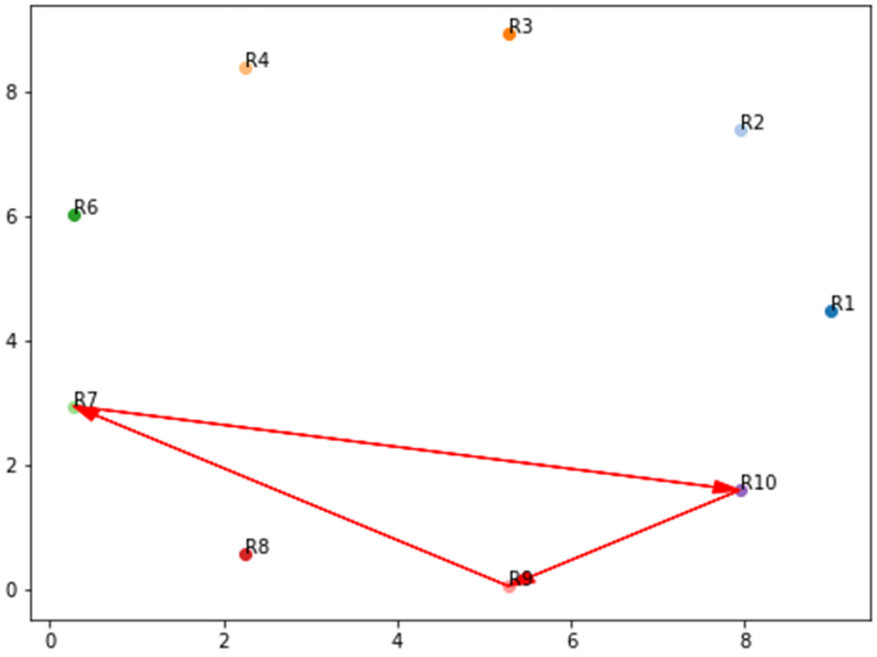
Donor #1	Recipient #1	Donor #2	Recipient #2
Bloodtype: 'O' History of Smoking: 0.0 Age: 34 eGFR: 108.85 BMI: 18.0 African Heritage: 0 SBP: 122.0 Gender: 0	Bloodtype: 'B' History of Smoking: 1.0 Age: 55 eGFR: 60.42 BMI: 19.0 African Heritage: 0 SBP: 120.0 Gender: 1	Bloodtype: 'O' History of Smoking: 0.0 Age: 51 eGFR: 62.18 BMI: 21.0 African Heritage: 0 SBP: 120.0 Gender: 1	Bloodtype: 'O' History of Smoking: 0.0 Age: 29 eGFR: 97.76 BMI: 30.0 African Heritage: 0 SBP: 108.0 Gender: 1
Unrelated: 1.0 HLA-B Mismatches: 2.0 HLA-DR Mismatches: 1.0		Unrelated: 1.0 HLA-B Mismatches: 0.0 HLA-DR Mismatches: 1.0	
Donor #3	**Recipient #3**	**Donor #4**	**Recipient #4**
Bloodtype: 'O' History of Smoking: 0.0 Age: 19 eGFR: 104.52 BMI: 24.0 African Heritage: 0 SBP: 122.0 Gender: 0	Bloodtype: 'A' History of Smoking: 1.0 Age: 44 eGFR: 88.55 BMI: 18.0 African Heritage: 0 SBP: 122.0 Gender: 0	Bloodtype: 'O' History of Smoking: 0.0 Age: 36 eGFR: 86.52 BMI: 20.0 African Heritage: 0 SBP: 122.0 Gender: 0	Bloodtype: 'A' History of Smoking: 0.0 Age: 27 eGFR: 81.81 BMI: 27.0 African Heritage: 0 SBP: 108.0 Gender: 1
Unrelated: 1.0 HLA-B Mismatches: 1.0 HLA-DR Mismatches: 0.0		Unrelated: 1.0 HLA-B Mismatches: 1.0 HLA-DR Mismatches: 1.0	

Kidney Exchange Program: Results

Possible Kidney Exchanges



Best 3-way Exchange Kidney Chain



Kidney Exchange Program: Results

Donor #1	Recipient #1	Donor #2	Recipient #2	Donor #3	Recipient #3
Bloodtype: 'O' History of Smoking: 0.0 Age: 21 eGFR: 85.84 BMI: 21.0 African Heritage: 0 SBP: 108.0 Gender: 1	Bloodtype: 'A' History of Smoking: 0.0 Age: 28 eGFR: 84.94 BMI: 35.0 African Heritage: 0 SBP: 108.0 Gender: 1	Bloodtype: 'O' History of Smoking: 0.0 Age: 18 eGFR: 107.16 BMI: 23.0 African Heritage: 0 SBP: 108.0 Gender: 1	Bloodtype: 'O' History of Smoking: 0.0 Age: 39 eGFR: 82.03 BMI: 24.0 African Heritage: 0 SBP: 108.0 Gender: 1	Bloodtype: 'O' History of Smoking: 0.0 Age: 18 eGFR: 114.72 BMI: 27.0 African Heritage: 0 SBP: 122.0 Gender: 0	Bloodtype: 'AB' History of Smoking: 1.0 Age: 38 eGFR: 76.77 BMI: 22.0 African Heritage: 0 SBP: 108.0 Gender: 1
Unrelated: 1.0 HLA-B Mismatches: 0.0 HLA-DR Mismatches: 1.0		Unrelated: 1.0 HLA-B Mismatches: 1.0 HLA-DR Mismatches: 2.0		Unrelated: 1.0 HLA-B Mismatches: 1.0 HLA-DR Mismatches: 1.0	

Kidney Exchange Program: Further work

- Obtain the minimum criteria used by the Icelandic Health Care System to evaluate Donor/Recipient compatibility
- Obtain the incomplete and missing datasets in order to properly represent the Icelandic population
- Estimate if a Kidney Exchange Program could be economically beneficial for the Icelandic Health Care System