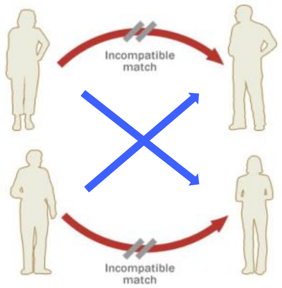
Unpaired Kidney Exchange: Overcoming the double coincidence of wants without a medium of exchange

M. Akbarpour (Stanford GSB), J. Combe (CREST – Ecole Polytechnique), Y. He (Rice U), V. Hiller (U Paris II), R. Shimer (U of Chicago), O. Tercieux (CNRS & PSE)

Standard technologies for Kidney Exchange:

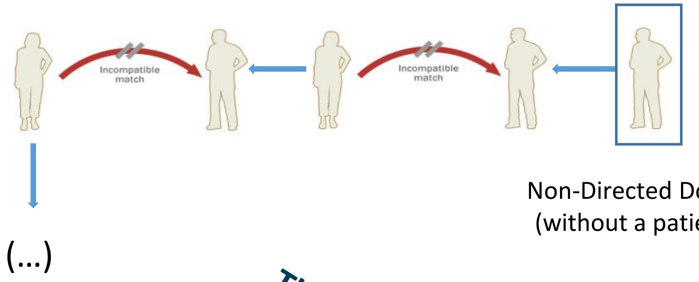
Pairwise exchanges

- ✓ Donor gives while patient receives
- ✓ No renege risks of donors
- × Double coincidence of wants



Chains

- ✓ Donor gives **after** patient receives
- × Renege risks of donors



Non-Directed Donor (without a patient)

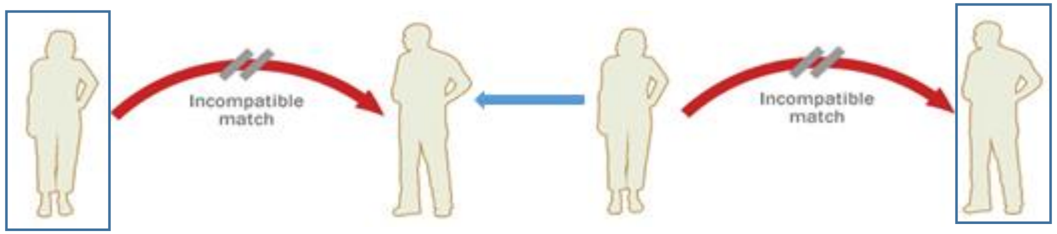
Theory + Empirical simulations

Unpaired performs better

Proposition of this paper: Realize transplantations as soon as they are possible

Unpaired Kidney Exchange

- ✓ Donor gives **before** the patient receives
- × Renege risk for donors
- ✓ Donor gives **after** the patient receives
- × Waiting time of patients in P
- ✓ No needs of altruistic donors



Donor gives **after** patient receives
Waiting List D

Donor gives **before** patient receives
Waiting List P

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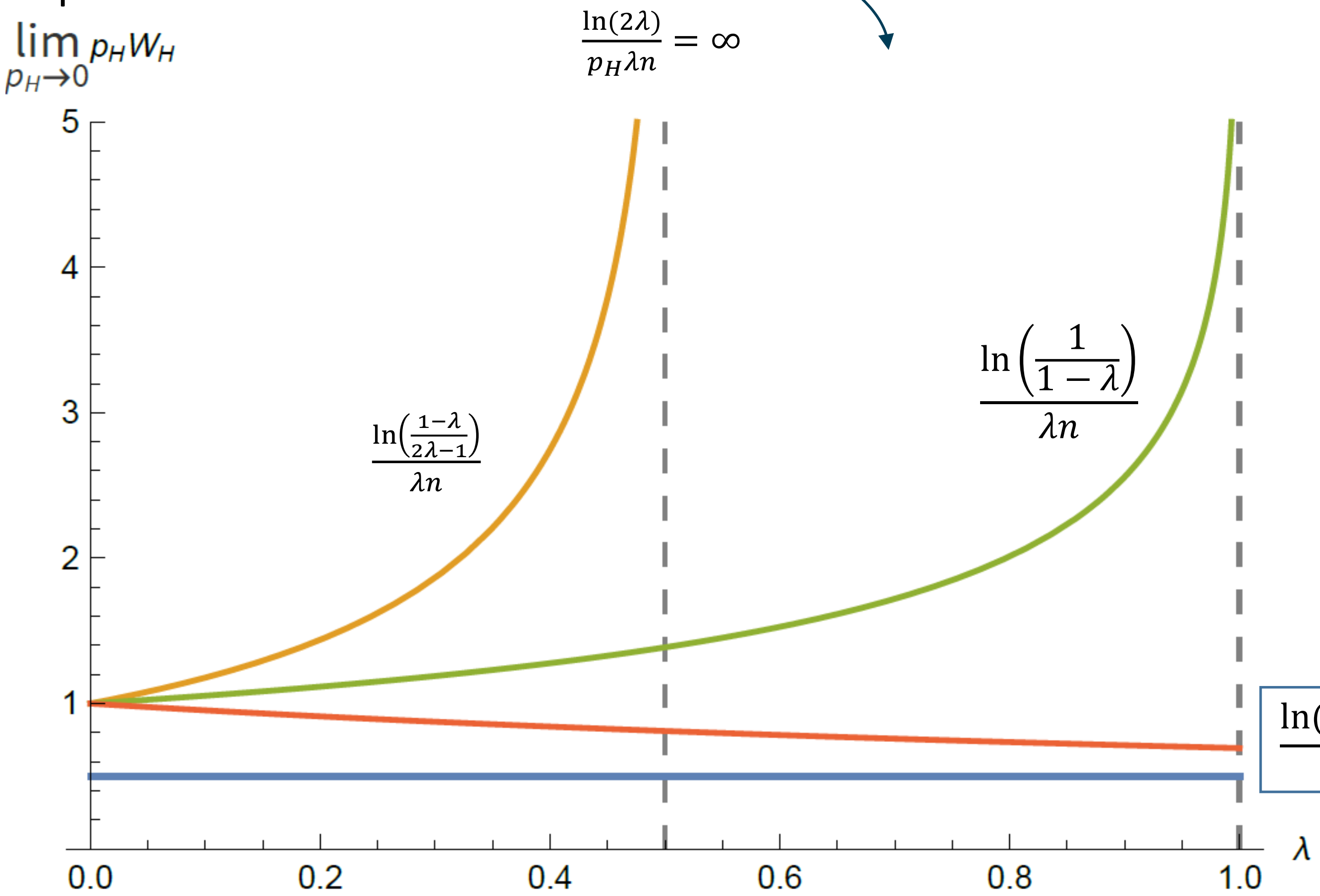
We focus on the limit of the average waiting time at steady-state when $p_H \to 0$

$$\lim_{p_H \to 0} \left(\lambda W_H(ALG) + (1-\lambda) W_E(ALG)\right)$$

We can show that for the algorithms we study $p_H W_E(ALG) \to 0$ as $p_H \to 0$

$\Rightarrow$ **Need to study the limit of $p_H W_H(ALG)$**

H patients



$\frac{\ln(1+\lambda)}{\lambda n}$ → Our main result

Model

- Continuous time
- Pairs of patient-donor arrive at Poisson rate n
- Proportion λ of **hard to match** patients

$\Rightarrow$ Prob. p_H to be compatible with a donor (iid)

- Proportion $1-\lambda$ of **easy to match patients**

$\Rightarrow$ Prob. $p_E = 1$ to be compatible with a donor (iid)

- Patients and donors leave the market once matched

W (Optimal) ≈ W (Unpaired) < W (Chain) < W (Pairwise)

- Lower bound
- Pairwise
- Chains
- Unpaired

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We perform counterfactual simulations by drawing arrival dates consistent with the real participation of each pair + no exit

Data

- French KEP+DDL from Dec 2013 – Feb 2018

⇒ Only pairwise exchanges + centralized at national level

- Small market: 78 pairs participated
- Data on 540 pairs who did "desensitization"

	Pairwise	Chain (+ Pairwise)	Unpaired	Omniscient (best ex post)
Nb. of grafts	22.74	23.14	44.47	45.23
% of grafts	29.2%	29.7%	57%	58%
Waiting time (days)	706.32	674.65	424.17	410.35
Waiting time in P (days)	0	0	392.19	598

Match rate of unpaired greedy similar to omniscient but…

… the waiting time in P is a real issue so far.

- Small market issue?

⇒ We simulate large markets (FR, APKD, NKR)

- Can propose good kidneys from deceased donors to patients in P

⇒ We simulate this using data on the French Deceased Donor List (DDL)

Significantly weaken the issue

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Large market simulations

	French KEP + Desensit pairs			NKR		
	Pairwise	**Unpaired**	**Omn.**	**Pairwise**	**Unpaired**	**Omn.**
Size	586	586	586	2390	2390	2390
% grafts	44%	67%	69%	56%	73%	74%
Waiting Time	471	270	254	392	237	222
Waiting time in P	0	265	424	0	102	431

Unpaired still close to Omniscient + waiting time in P is low (even for HS patients)

Use of the DDL

	Pairwise	Chain (+ Pairwise)	Unpaired
Size	78	78	78
Nb. of grafts	22.74	23.14	65.5 (+21)
Nb of grafts from living	22.74	22.14	39.94 (-5)
Waiting Time	706.32	674.65	171.47 (-238)
Waiting time in P	0	0	77.1 (-315)

80% of grafts + median waiting time in P at 4 days!