OPTUMHealth™
Education

Transplant trends: Current data and statistics

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Department of Mathematics, USNA and Department of Surgery, Johns Hopkins University

Disclosure Information

- I have no conflicts of interest to disclose.
- My research is funded by the National Institutes of Health. I am also an investigator with the Scientific Registry of Transplant Recipients, funded by the Health Resources Services Administration.

Making sense of transplant data

- Transplantation is one of the most data-rich areas of medicine
  - Organ Procurement and Transplantation Network (OPTN) maintains a national transplant registry: waiting lists, recipients, organ offers, outcomes
  - Records relating to care for end-stage organ failure
  - Insurance claims
  - Pharmacy claims
- Find insights and make recommendations
  - Policy for allocating scarce resources
  - Innovation and excellence in patient care
  - Insurance coverage

Data analytics to help providers, payers, policymakers do the right thing

- Explore current utilization, innovation and donation trends in transplant
- Identify strategies to increase utilization and improve access to organ transplant
- Explain how national data is used to develop strategies to drive improvement and address inequities in transplant

- We use data analytics to
  - **increase utilization** by urging physicians to use more organs in the right recipients,
  - **help caregivers** offer the best treatments for each individual patient
  - recommend policies that **allocate organs more equitably**

Kidney discards and delays in placing organs

- Kidney discard rate is approximately **50% for KDPI > 85** and approximately **20% overall**
  (Bae et al. 2017)

- Long delays can cause usable organs of marginal quality to be eventually discarded (Massie et al. 2010)

Organ offers: sequential or simultaneous

- Current policy : **sequential expiration of offers**
  - After a center becomes primary, when all higher-priority candidates have declined, then a 1 hour / 30 minute time limit starts for that center to answer
  - Shorter time limits implemented last year, but still offers expire sequentially

- We propose to make **simultaneously expiring kidney offers in batches** to multiple centers
  - for post-recovery kidneys at regional and national allocation level

ORIGINAL ARTICLE

AJT

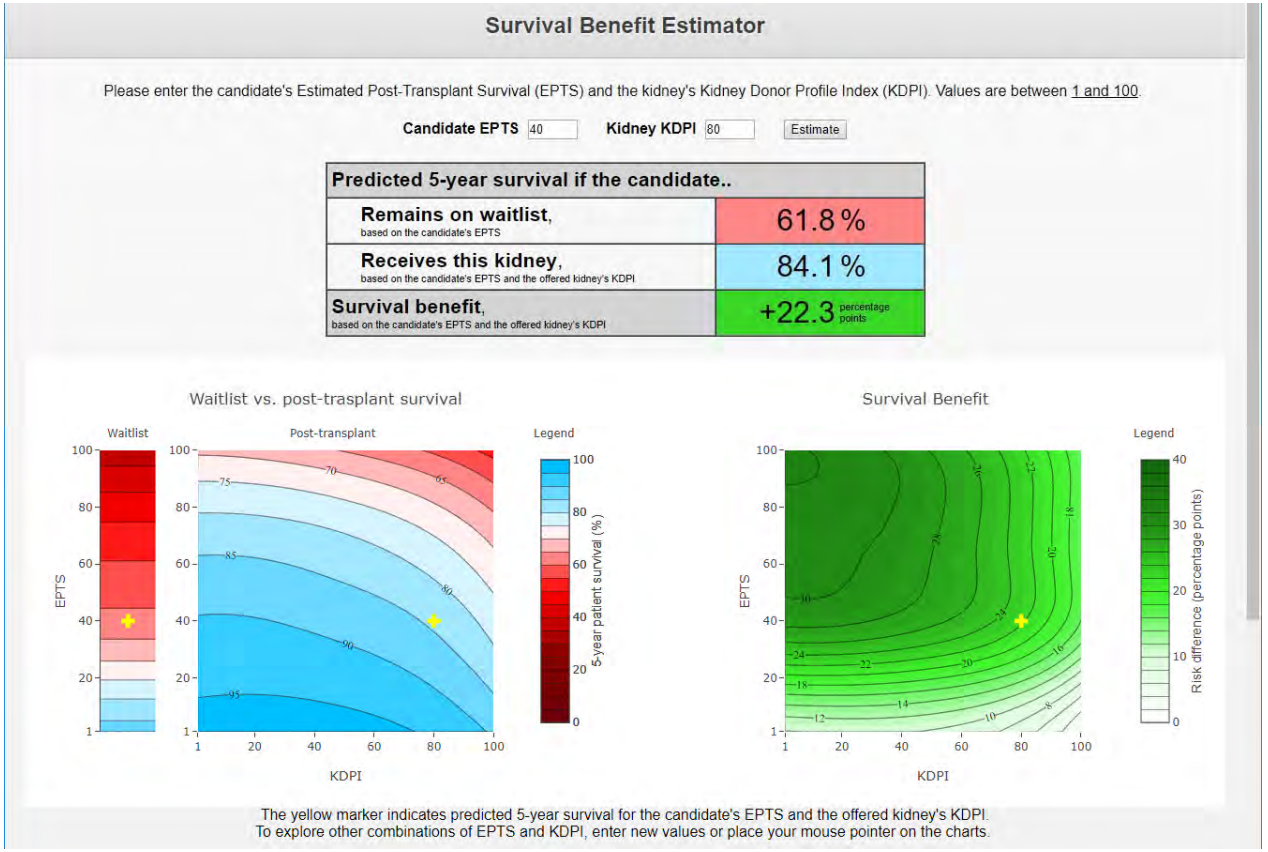
Accelerating kidney allocation: Simultaneously expiring offers

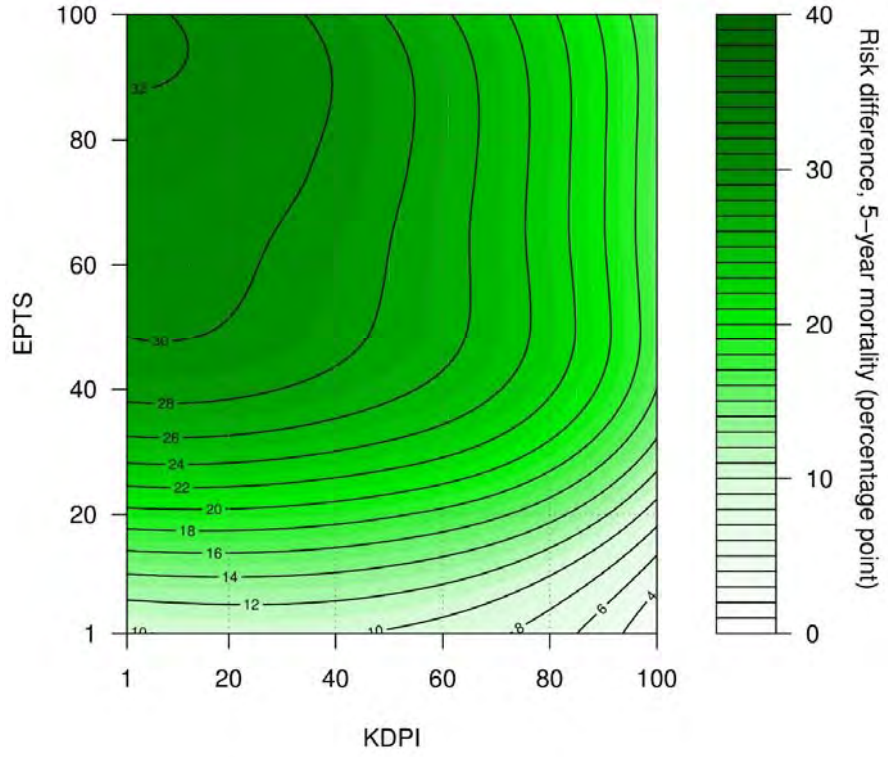
Michal A. Mankowski[1] | Martin Kosztowski[2,3] | Subramanian Raghavan[4] | Jacqueline M. Garonzik-Wang[2] | David Axelrod[3] | Dorry L. Segev[2,5,6] | Sommer E. Gentry[2,6,7]

TABLE 2 Number of kidneys accepted and cumulative acceptance percentage as kidneys progress from local to regional to national offers

	Low KDPI (≤85%)		High KDPI (>85%)	
		National		National
Small batch		10 085 (92%)		1257 (65%)
Medium-size batch		10 665 (97%)		1646 (85%)
Large batch		10 802 (98%)		1737 (89%)

Non-ideal kidneys (with higher KDPI) still give survival benefit




EPTS
KDPI
Risk difference, 5–year mortality (percentage point)
100
80
60
40
20
1
1
20
40
60
80
100
40
30
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0
32
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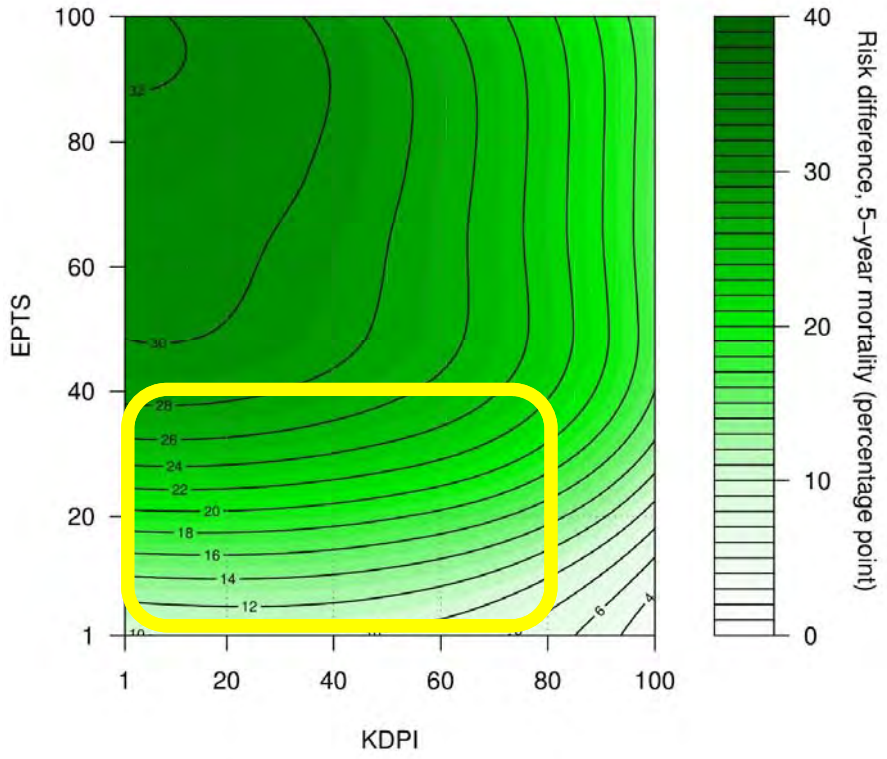
EPTS
KDPI
Risk difference, 5–year mortality (percentage point)
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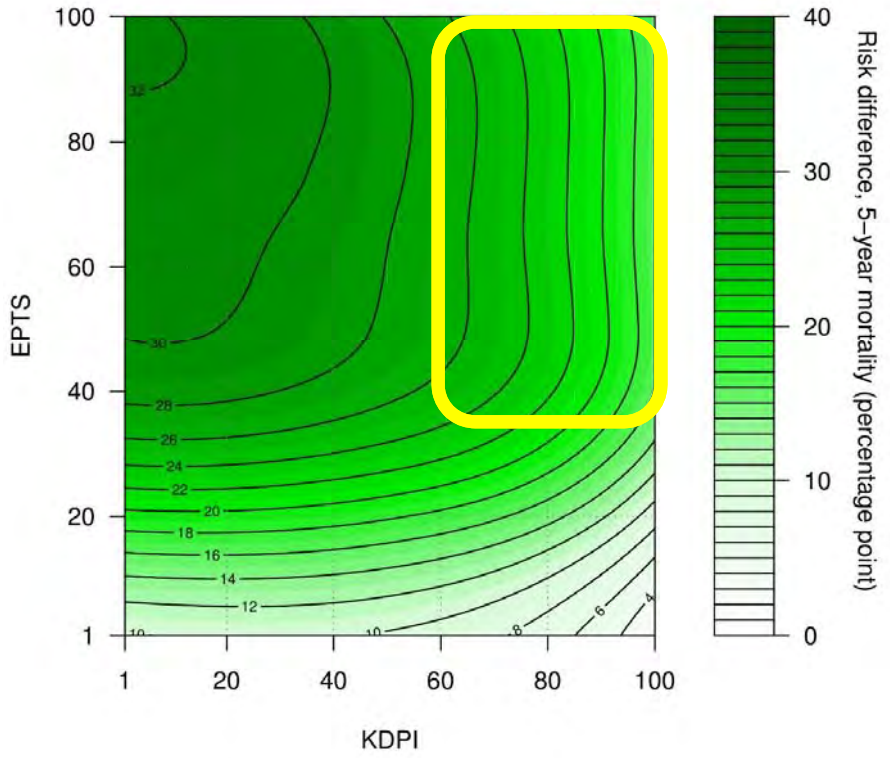
EPTS
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Risk difference, 5–year mortality (percentage point)
100
80
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20
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80
100
40
30
20
10
0
32
30
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26
24
22
20
18
16
14
12
10
8
6
4

Infectious-Risk Donors

- US Opioid epidemic: almost 30% of donors are IRD
- Discard rates 2x higher for IRDs than non-IRD counterparts
- Seems wasteful to discard these: there should be *someone* on the list who would benefit

ORIGINAL ARTICLE

AJT

Turn down for what? Patient outcomes associated with declining increased infectious risk kidneys

Mary G. Bowring[1] | Courtenay M. Holscher[1] | Sheng Zhou[1] | Allan B. Massie[1,2] | Jacqueline Garonzik-Wang[1] | Lauren M. Kucirka[1] | Sommer E. Gentry[1,3] | Dorry L. Segev[1,2,4]

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[2]Department of Epidemiology, Johns Hopkins School of Public Health, Baltimore, MD, USA

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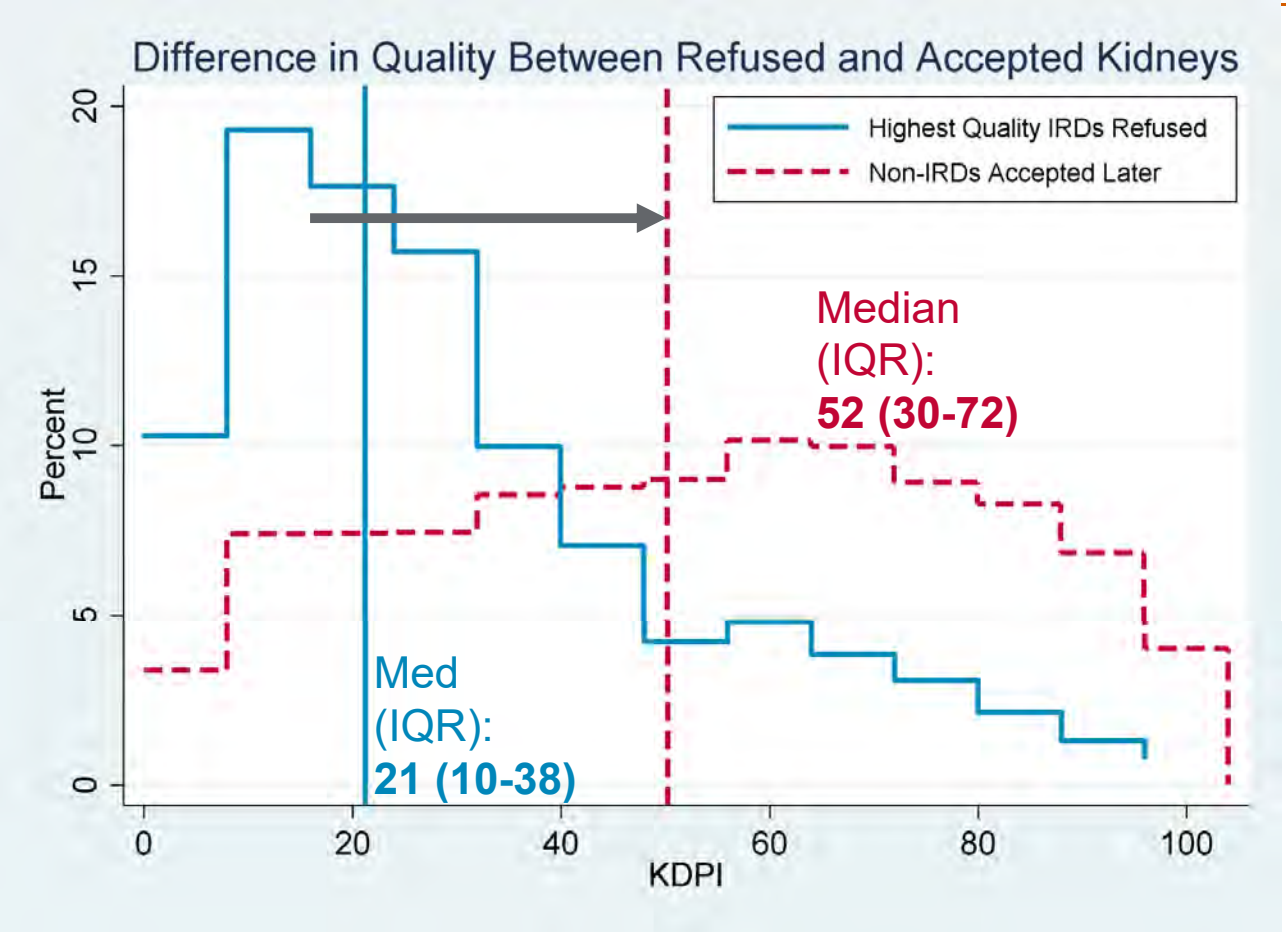
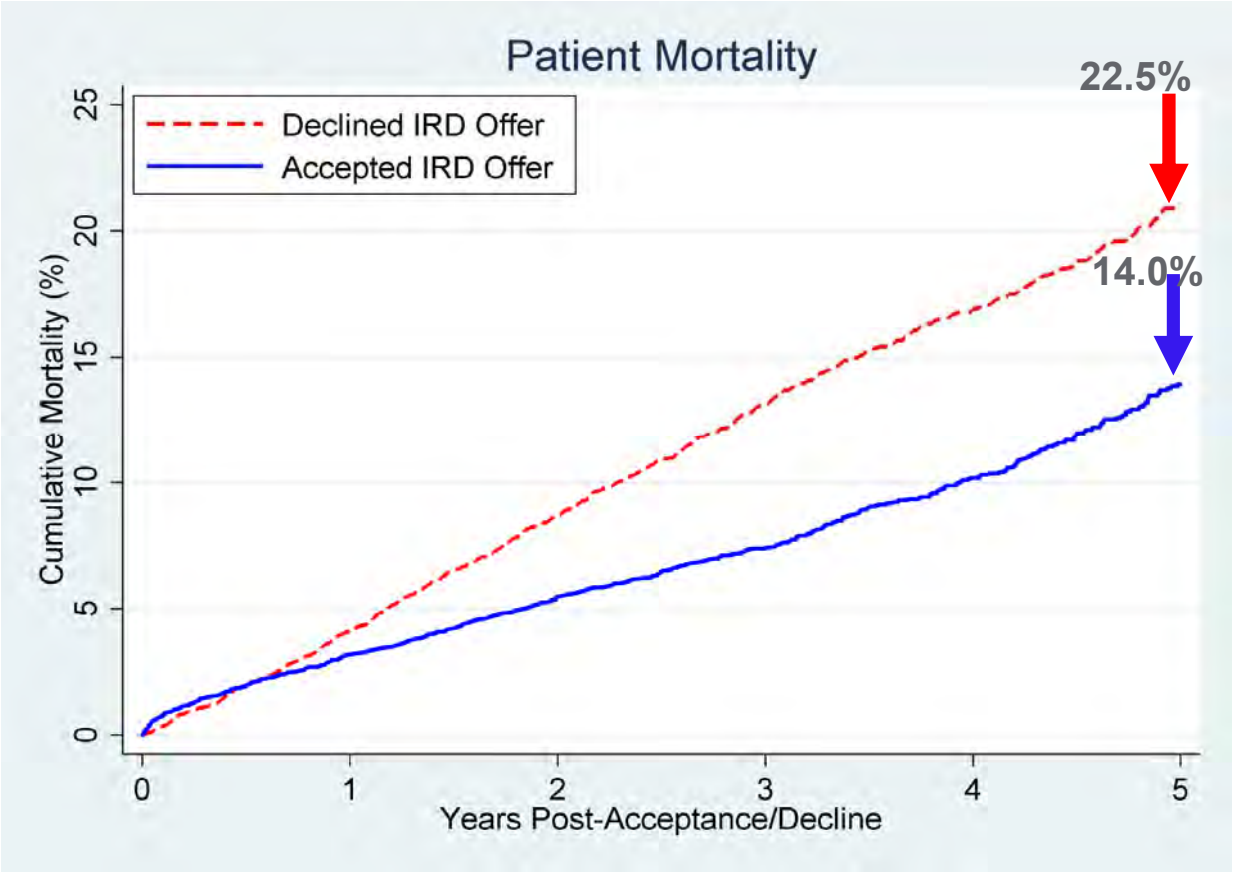
Funding information
National Institute of Diabetes and Digestive and Kidney Diseases, Grant/Award Number: K24DK101828, F30DK095545, K01DK101677 and F32DK109662; American College of Surgeons Resident Research Scholarship

Infectious risk donors are higher-quality (lower KDPI)



Patients accepting infectious risk donors were less likely to die in 5 years



American Journal of Transplantation 2013; 13: 1227–1234
Wiley Periodicals Inc.

doi: 10.1002/ajt.12206

Identifying Appropriate Recipients for CDC Infectious Risk Donor Kidneys

E. K. H. Chow[1,†], A. B. Massie[1,2,†], A. D. Muzaale[1,2], A. L. Singer[1], L. M. Kucirka[1], R. A. Montgomery[1], H. P. Lehmann[3] and D. L. Segev[1,2,*]

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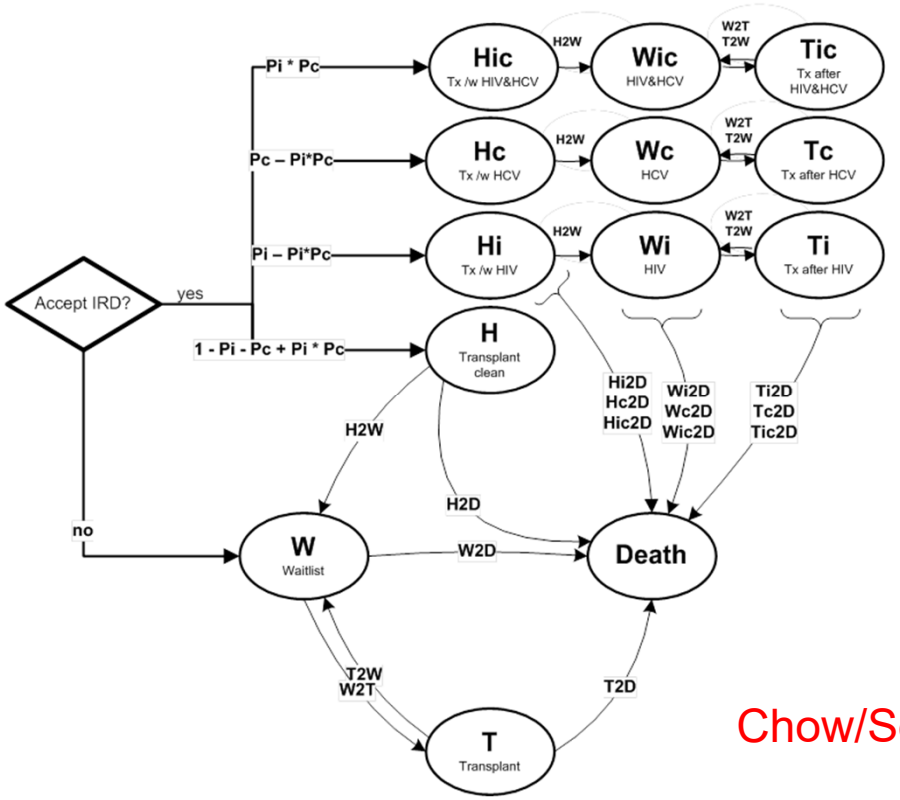
[2]Department of Epidemiology, Johns Hopkins School of Public Health, Baltimore, MD
[3]Division of Health Sciences Informatics, Johns Hopkins University School of Medicine, Baltimore, MD
**Corresponding author: Dorry Segev, dorry@jhmi.edu*
[†]Both authors contributed equally.

donors; NAT, nucleic acid testing; OPTN, Organ Procurement and Transplantation Network; PHS, Public Health Service; PRA, panel reactive antibody; SRTR, Scientific Registry of Program Recipients; T2D, time to death after transplantation with a non-IRD kidney; W2D, time to death from the waitlist; W2T, time to transplant from the waitlist

Received 19 September 2012, revised 23 October 2012 and accepted 19 November 2012

Background

Should candidate accept an IRD kidney? Markov Decision Process Model



Chow/Segev AJT 2013

transplantmodels.com

The Epidemiology Research Group for Organ Transplantation is a research group focused on organ transplantation at the Johns Hopkins School of Medicine. Below are some of the decision models we have developed.

For more information, please visit our website, www.transplantepi.org

Living Kidney Donor Risk Index (LKDPI)

This model predicts recipient risk of graft loss after living donor kidney transplantation based on donor characteristics, on the same scale as the KDPI ...

Massie AB, Leanza J, Fahmy LM, Chow EK et al. A Risk Index for Living Donor Kidney Transplantation. AJT 2016 (epub ahead of print)

Continue to model »

ESRD Risk Tool for Kidney Donor Candidates

This model is intended for low-risk adults considering living kidney donation in the United States. It provides an estimate of 15-year and lifetime incidence of end-stage renal disease...

Grams ME, Sang Y, Levey AS, Matsushita K, Ballew S, Chang AR et al. Kidney-Failure Risk Projection for the Living Kidney-Donor Candidate. NEJM 2015 (epub ahead of print)

Continue to model »

Infectious Risk Donors

When a patient with end stage renal disease (ESRD) on the waitlist for a kidney is offered an Infectious Risk Donor (IRD) kidney, they need to decide whether they will accept the IRD kidney and the associated infectious risk, or if they will decline it and continue to wait for the next available infectious-risk free kidney ...

Chow, E. K. H., Massie, A. B., Muzaale, A. D., Singer, A. L., Kucirka, L. M., Montgomery, R. A., ... & Segev, D. L. (2013). Identifying appropriate recipients for CDC infectious risk donor kidneys. American Journal of Transplantation, 13(5), 1227-1234.

Continue to model »

Transplant Candidacy for Patients 65+

This prediction model is intended for adults with ESRD on dialysis aged 65 and above; it provides the predicted probability of 3-year survival after kidney transplantation (KT). Patients with predicted 3-year post-KT survival in the top quintile are deemed "excellent" candidates ...

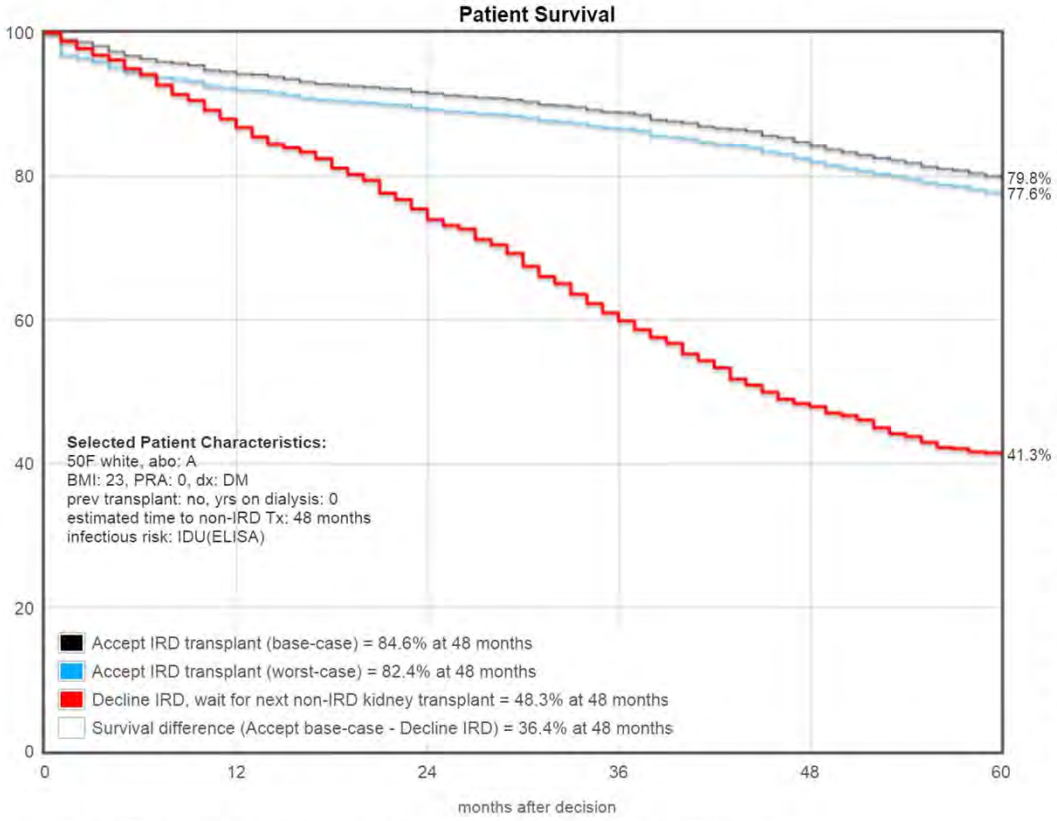
Grams, M. E., Kucirka, L. M., Hanrahan, C. F., Montgomery, R. A., Massie,

Pediatric Transplant: Living or deceased donor first?

Most pediatric kidney transplant recipients live long enough to require retransplantation. The most beneficial timing for living donor transplantation in candidates with one living donor is not clear...

Van Arendonk, K. J., Chow, E. K., James, N. T., Orandi, B. J., Ellison, T. A.,

Johns Hopkins IRD Kidney Transplant Calculator



base-case estimate: mortality risk (if seroconverted) increased by 4.12% HIV, 3.42% HCV per year
worst-case estimate: mortality risk (if seroconverted) equivalent to immediate (100% chance) death

Recipient Characteristics:

Age: (20-75)	50
Gender:	female
ABO:	Type A
Ethnicity:	White
BMI: (19-39)	23
PRA: (0-100)	0
Renal failure diagnosis:	diabetes mellitus
Previous transplant:	no
Years on waitlist:	0
Estimated time remaining until non-IRD transplant *:	48 months

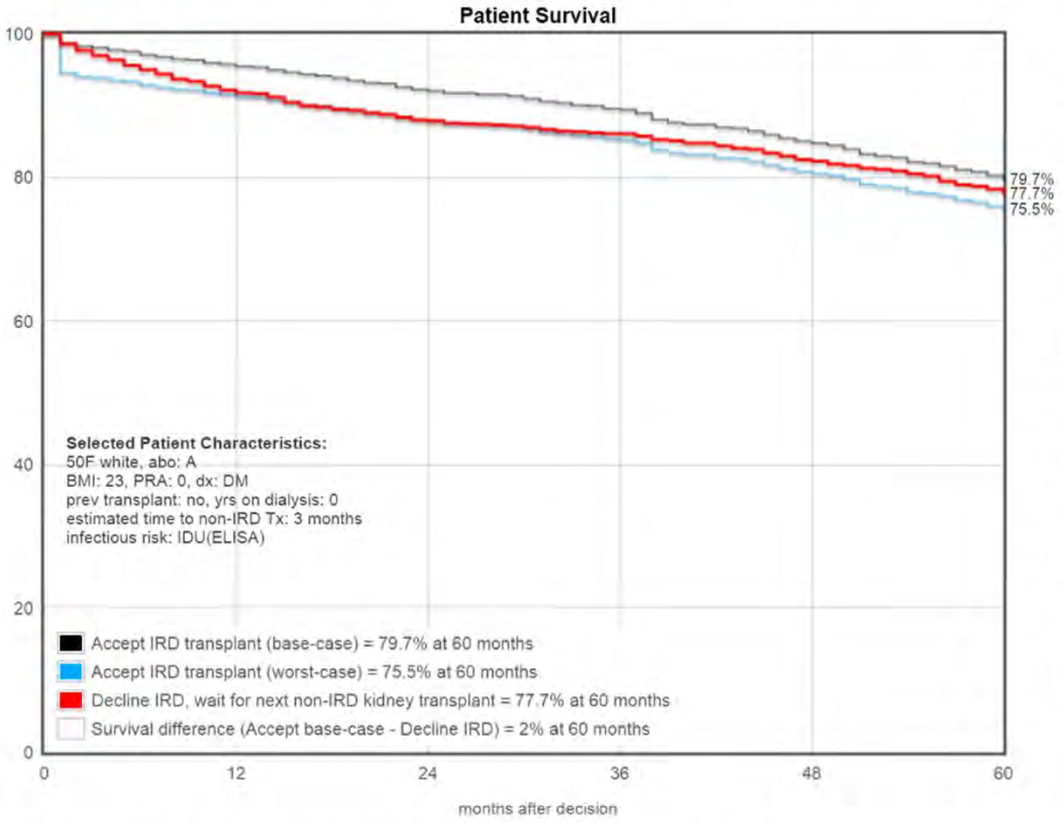
* This is time in addition to the time the patient may have already waited. eg: if a patient has spent 1 year on the waitlist, and the estimated time remaining until a non-IRD transplant is 18 months, the patient is expected to have waited 30 months since listing, before a non-IRD transplant.

Donor Characteristics:

Infectious Risk Behavior:	Intravenous drug users
Serology Testing Used:	ELISA

www.TransplantModels.com/IRD

Johns Hopkins IRD Kidney Transplant Calculator



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ABO:	Type A
Ethnicity:	White
BMI: (19-39)	23
PRA: (0-100)	0
Renal failure diagnosis:	diabetes mellitus
Previous transplant:	no
Years on waitlist:	0
Estimated time remaining until non-IRD transplant *:	3 months

* This is time in addition to the time the patient may have already waited. eg: if a patient has spent 1 year on the waitlist, and the estimated time remaining until a non-IRD transplant is 18 months, the patient is expected to have waited 30 months since listing, before a non-IRD transplant.

Donor Characteristics:

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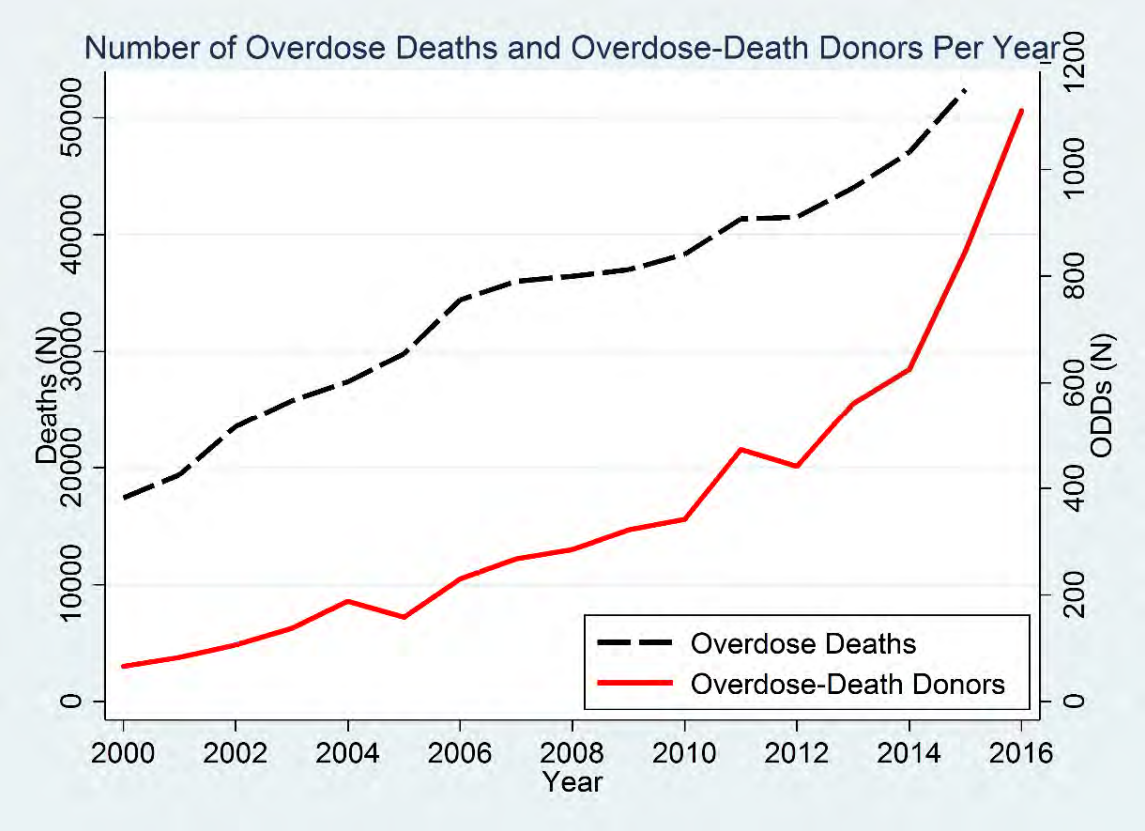
Serology Testing Used:	ELISA

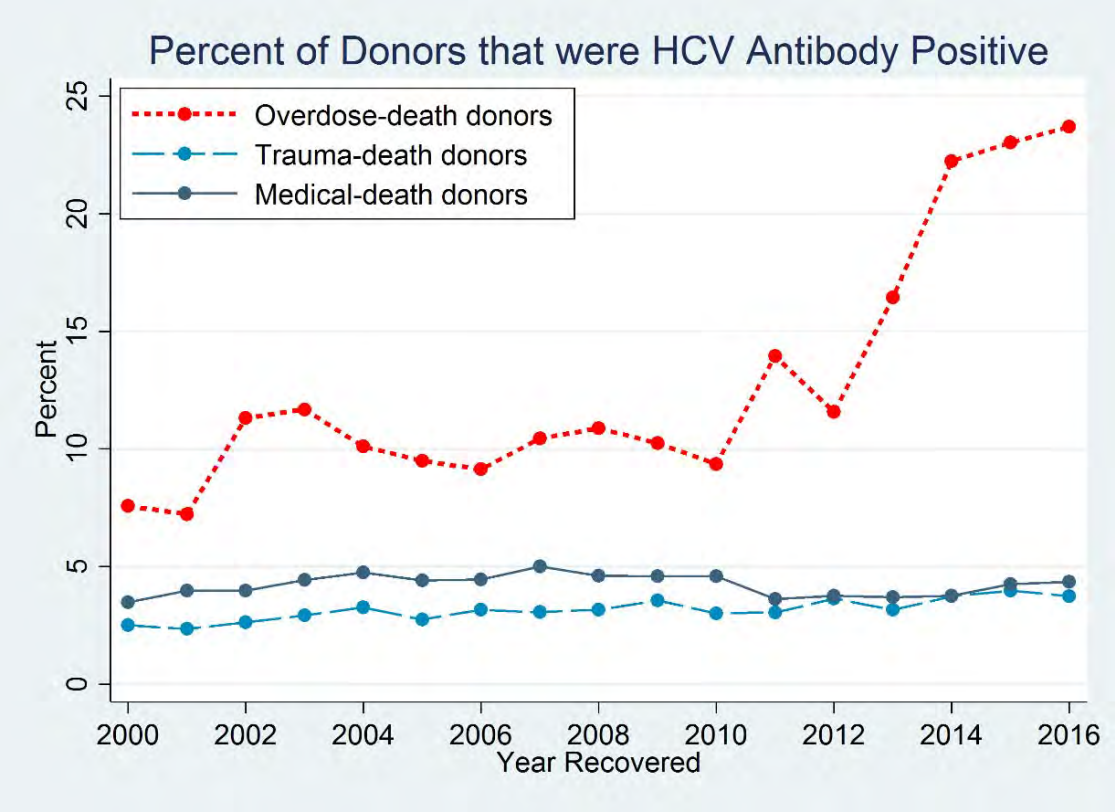
www.TransplantModels.com/IRD

Opioid overdose death donors



Durand/Segev, Annals Internal Medicine, 2018

Overdose death donors: 25% HCV+



Durand/Segev, Annals Internal Medicine, 2018

HCV Treatment in Transplantation

- Direct acting antivirals (DAAs) cure HCV in 95-100% of patients
- Effective and tolerated with minimal drug interactions in transplant recipients

HCV+ Donors

- Number of HCV+ donor kidneys exceeds number of HCV+ kidney transplant candidates
  - > 40% of recovered HCV+ kidneys discarded
  - 4X discard rate compared to HCV-
- Potential pool of HCV+ kidneys may be larger since not all HCV+ kidneys are recovered

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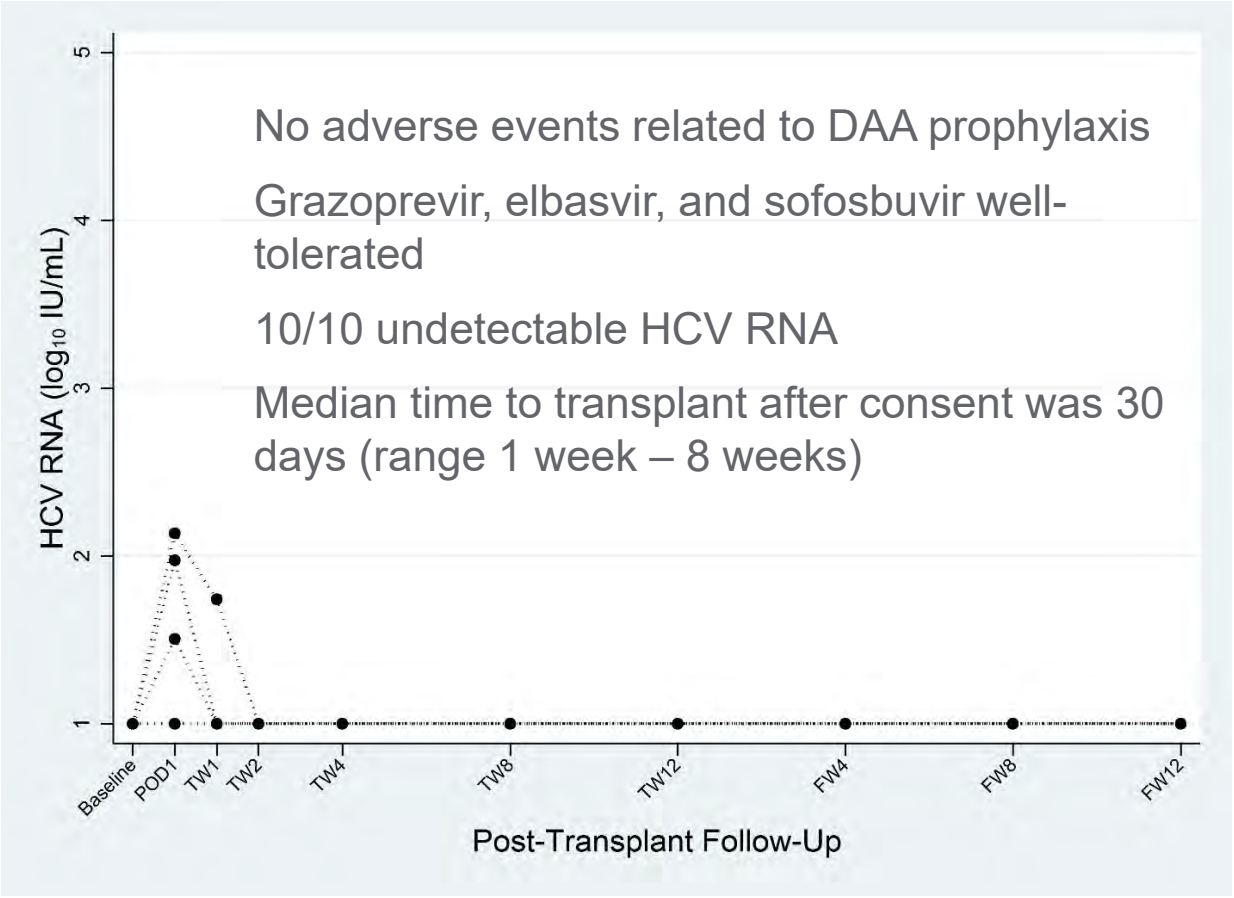
EPIDEMIOLOGY
RESEARCH GROUP IN
ORGAN TRANSPLANTATION

EXPANDER: Exploring Transplants Using Hepatitis-C Infected Donor Kidneys for HCV-Negative Recipients

Durand et al, Annals of Internal Medicine, 2018

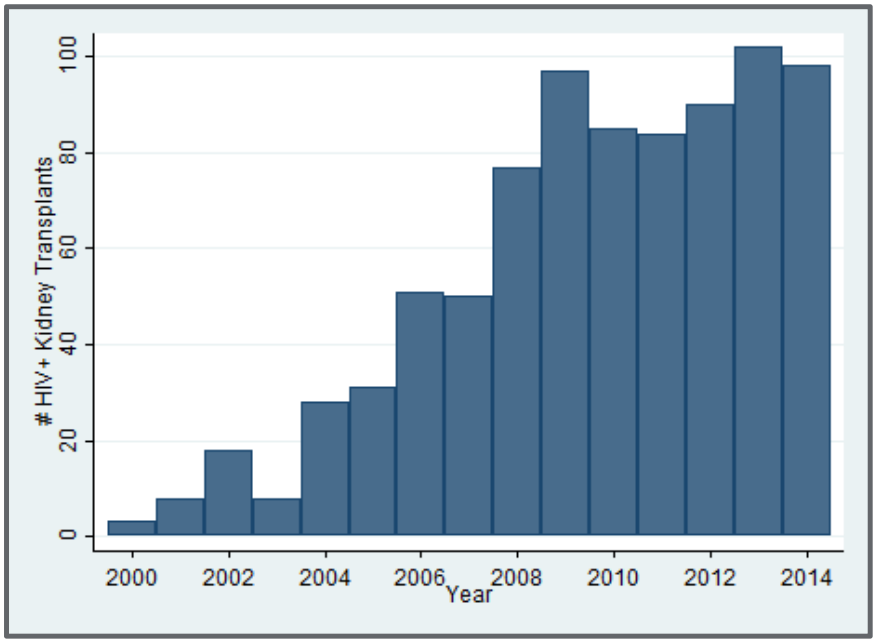
HCV- patients transplanted with HCV+ kidneys and DAA prophylaxis

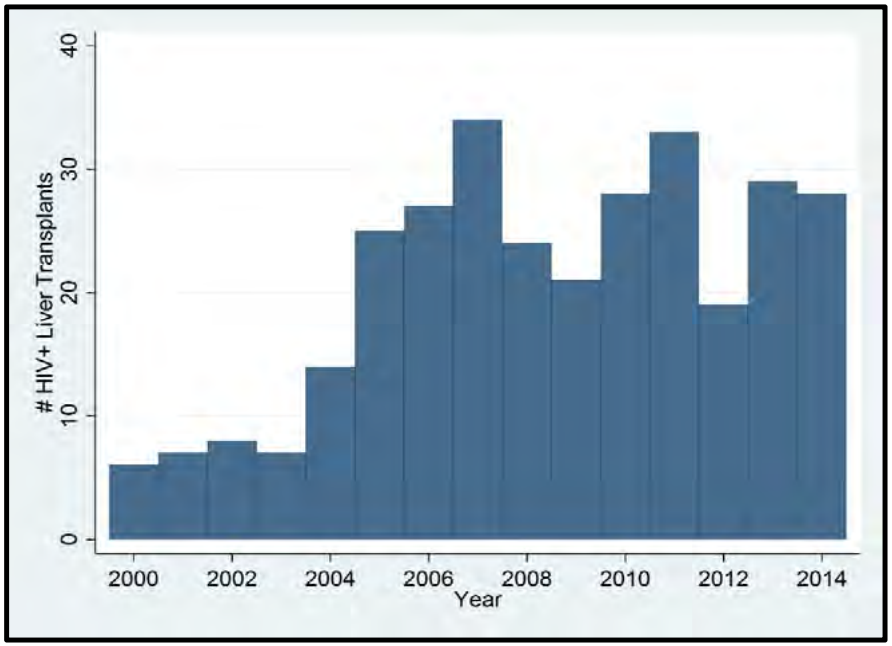


Challenges of HCV+ kidneys to HCV- recipients

- Cost-effectiveness (metabolic, renal advantages)
- Insurance coverage for DAAs
  - Pre-approval for prophylactic treatment
  - Pre-approval without delay for post-tx treatment
  - Approval without requirements for fibrosis
- Larger cooperative trials, longer-term outcomes
- Increased utilization (discard rate still very high)

Kidney and liver transplants for HIV+ recipients increasing





- HIV+ KT, > 12 fold increase
- > 100 transplants per year

- HIV+ LT, > 4 fold increase
- > 30 transplants per year

American Journal of Transplantation 2011; 11: 1209–1217
Wiley Periodicals Inc.

doi: 10.1111/j.1600-6143.2011.03506.x

Estimating the Potential Pool of HIV-Infected Deceased Organ Donors in the United States

B. J. Boyarsky[a], E. C. Hall[a,b], A. L. Singer[a], R. A. Montgomery[a], K. A. Gebo[c,d,e] and D. L. Segev[a,d,*]

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[b] *Department of Surgery, Georgetown University School of Medicine, Washington, DC*
[c] *Department of Medicine, Johns Hopkins University School of Medicine, Baltimore, MD*
[d] *Department of Epidemiology, Johns Hopkins School of Public Health, Baltimore, MD*
[e] *HIV Research Network, Baltimore, MD*
* *Corresponding author: Dorry L. Segev, dorry@jhmi.edu*

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[c] *Department of Medicine, Johns Hopkins University School of Medicine, Baltimore, MD*
[d] *Department of Epidemiology, Johns Hopkins School of Public Health, Baltimore, MD*
[e] *HIV Research Network, Baltimore, MD*
[*] *Corresponding author: Dorry L. Segev, dorry@jhmi.edu*

- How many people are we talking about?
- How many lives would be saved?
- How much money would Medicare save?

Received 03 December 2010, revised 24 January 2011 and accepted for publication 09 February 2011

"All the News That's Fit to Print"

The New York Times

Washington Edition
Today, summerlike, clouds then sun, breezy, high 85. **Tonight**, mostly cloudy, showers, a thunderstorm late, low 59. **Tomorrow**, more rain, high 65. Weather map, Page D8.

VOL. CLX . . . . No. 55,372 MONDAY, APRIL 11, 2011 $2.00

A Push to Let H.I.V. Patients Accept Organs That Are Infected

By PAM BELLUCK

David Aldridge of Los Angeles had a kidney transplant in 2006, but he will soon need another. Like many people living with H.I.V., he suffers from kidney damage, either from the virus or from the life-saving medications that keep it at bay.

Until recently, such patients did not receive transplants at all because doctors worried that their health was too compromised. Now they can get transplants, but organ-donor waiting lists are long. And for Mr. Aldridge, 45, and other H.I.V. patients, a potential source of kidneys and livers is off limits, because it is illegal to transplant organs from donors who test positive for H.I.V.

But now, Mr. Aldridge and other experts are calling for repeal of the provision that bans such transplants, a 23-year-old amendment to the National Organ Transplant Act.

"The clock is ticking more quickly for those who are H.I.V.-positive," said Dr. Dorry Segev, transplant surgery director of clinical research at Johns Hopkins and a co-author of a new study indicating that 500 to 600 H.I.V.-infected livers and kidneys would become available each year if the law were changed. "We have a huge organ shortage. Every H.I.V.-infected one we use is a new organ that takes one more person off the list."

The ban on transplanting or-

Quotation of the Day

"The clock is ticking more quickly for those who are H.I.V.-positive."
DR. DORRY SEGEV, a co-author of a study indicating that 500 to 600 H.I.V.-infected livers and kidneys would become available each year if the law were changed to allow their use in some patients.

From Bench to Bill: How a Transplant Nuance Became One of Only 57 Laws Passed in 2013

Brian J. Boyarsky, BA, and Dorry L. Segev, MD, PhD*†*

"I'm just a bill, yes I'm only a bill,
and I'm sitting here on Capitol Hill.
Well it's a long, long journey in capital city,
It's a long, long wait while I'm sitting in committee,
But I know I'll be a law someday…
At least I hope and pray that I will,
but today I am still just a bill."

(Schoolhouse Rock)

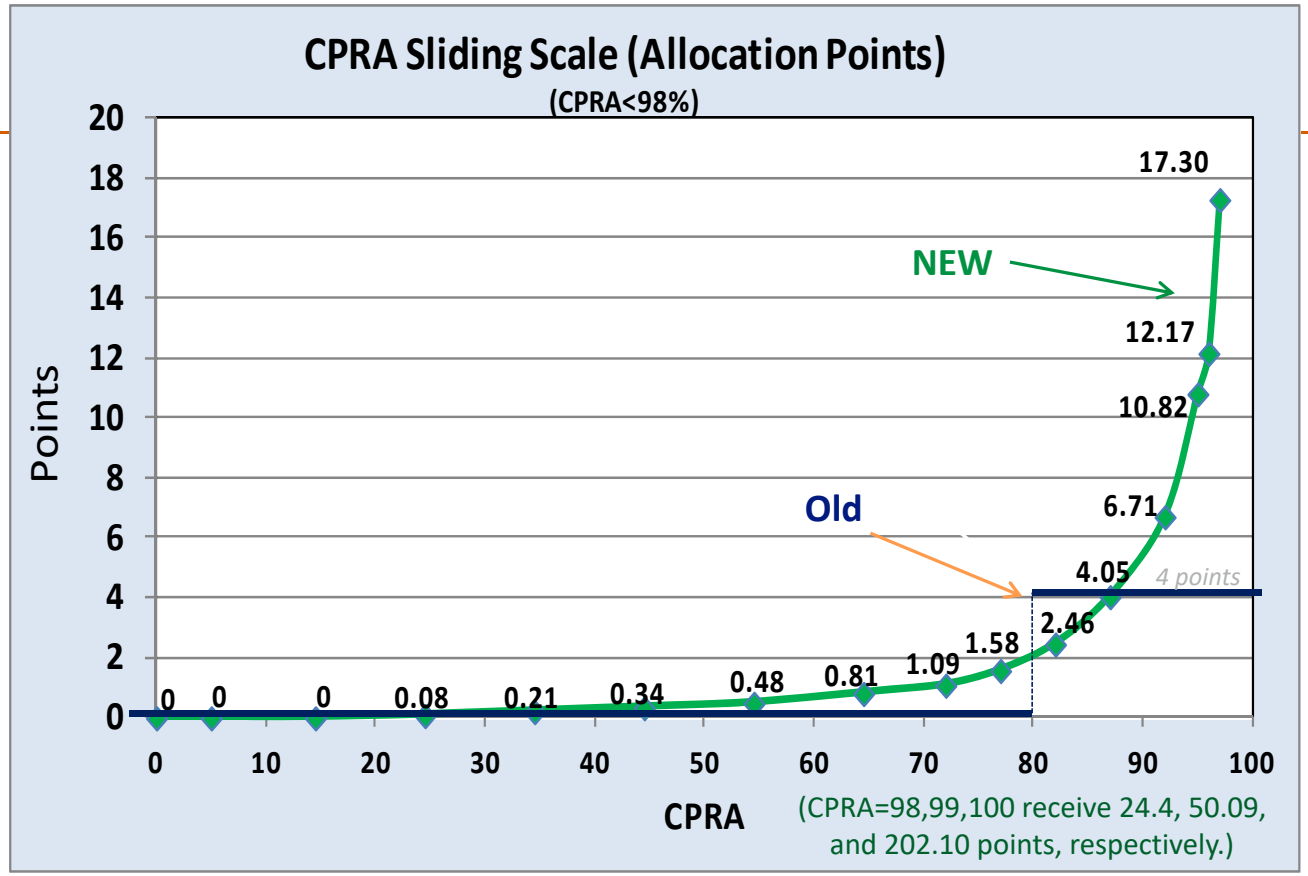
Ann Surg, 2016; 263:430-433

Organ allocation policy

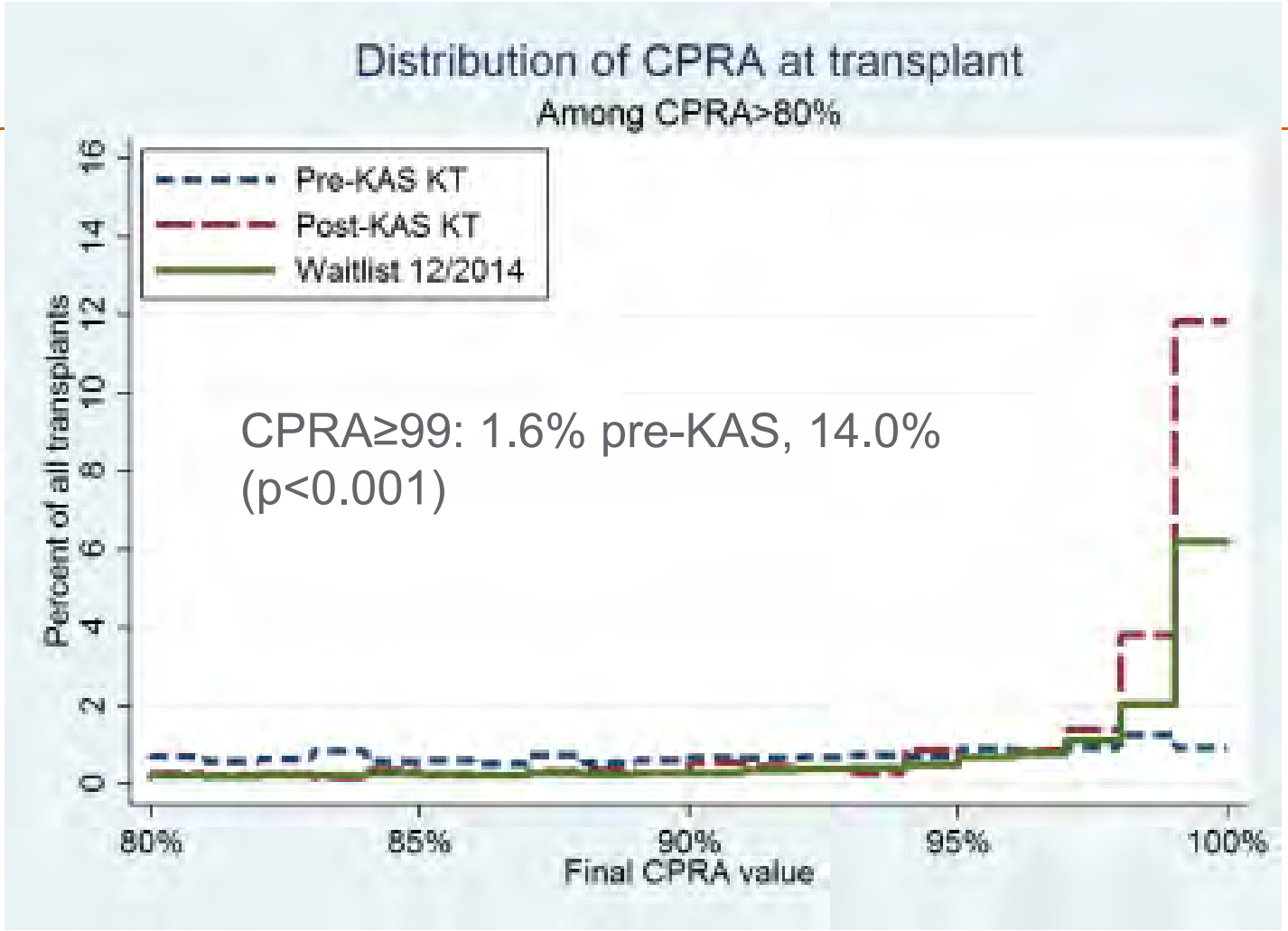
- The Organ Procurement and Transplantation Network (OPTN) sets and implements policies for allocating organs from deceased donors
- The Kidney Allocation System (KAS)
  - reduced disparities for highly sensitized candidates
  - directed the best 20% of kidneys to the healthiest 20% of recipients
  - took ten years of debate before implementation, and that was after deciding not to address geographic disparity at all
- The OPTN has attempted in recent years to hew more closely to the Final Rule (1998) which demands that “neither place of residence nor place of listing shall be a major determinant of access to a transplant”
- Policies on heart, liver, lung, and kidney allocation all changed but all those changes failed to make a dent in geographic disparity

Sequence A KDPI <=20%	Sequence B KDPI >20% but <35%	Sequence C KDPI >=35% but <=85%	Sequence D KDPI>85%
Local CPRA 100	Local CPRA 100	Local CPRA 100	Local CPRA 100
Regional CPRA 100	Regional CPRA 100	Regional CPRA 100	Regional CPRA 100
National CPRA 100	National CPRA 100	National CPRA 100	National CPRA 100
Local CPRA 99	Local CPRA 99	Local CPRA 99	Local CPRA 99
Regional CPRA 99	Regional CPRA 99	Regional CPRA 99	Regional CPRA 99
Local CPRA 98	Local CPRA 98	Local CPRA 98	Local CPRA 98
Zero mismatch (top 20% EPTS)	Zero mismatch	Regional CPRA 99	Zero mismatch
Prior living donor	Prior living donor	Local CPRA 98	Regional
Local pediatrics	Local pediatrics	Zero mismatch	
Local top 20% EPTS	Local adults	Prior living donor	
Zero mismatch (all)	Regional pediatrics	Local pediatrics	
Local (all)	Regional adults	Regional pediatrics	
Regional pediatrics	National pediatrics	National pediatrics	
Regional (top 20%)	National adults	National adults	
Regional (all)			
National pediatrics			
National (top 20%)			
National (all)			

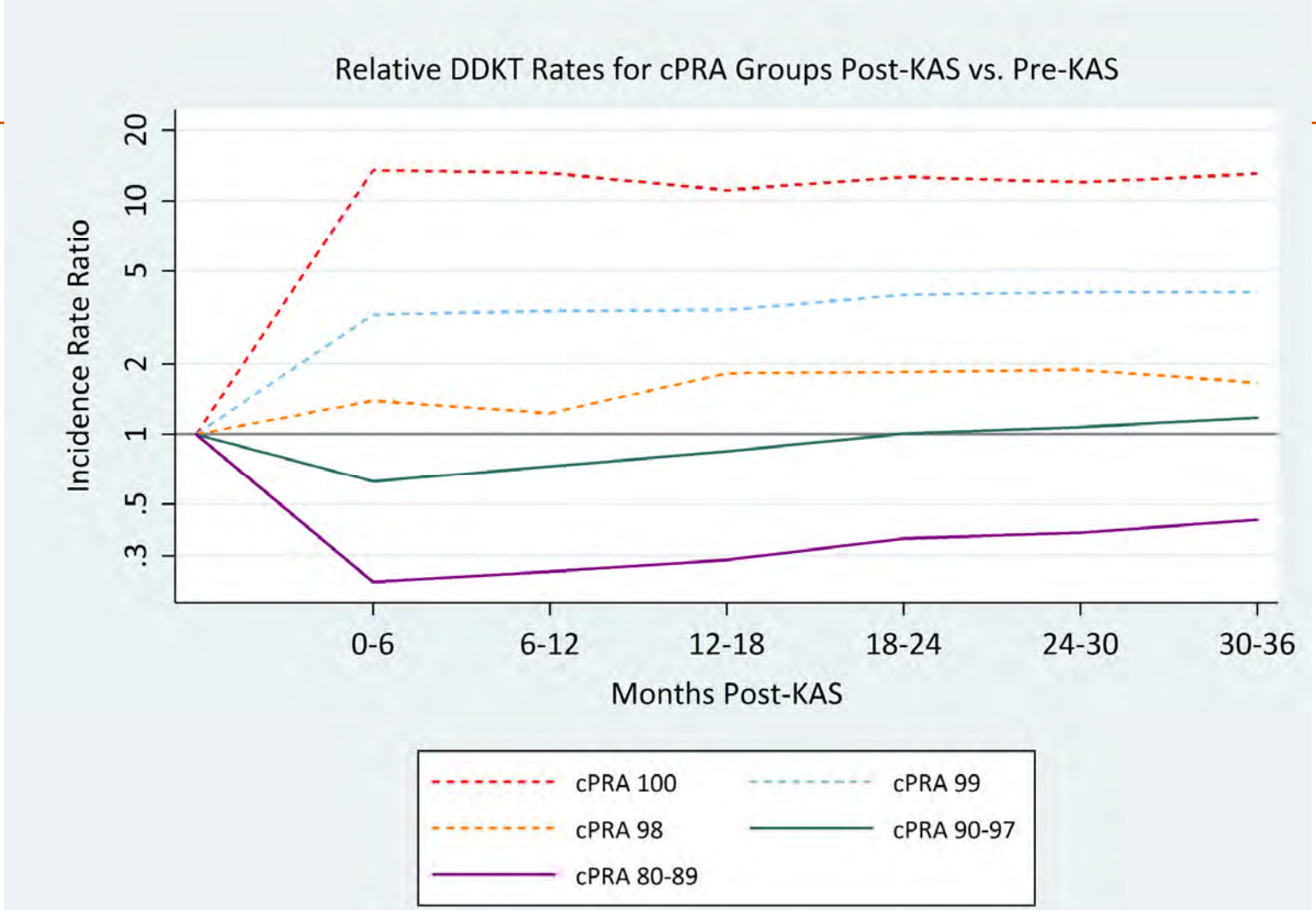
New categories for highly sensitized candidates



Old policy: 4 points for CPRA>=80%. No points for moderately sensitized.
NEW: sliding scale starting at CPRA>=20%



Massie/Segev, JASN, 2017


Relative DDKT Rates for cPRA Groups Post-KAS vs. Pre-KAS
Incidence Rate Ratio
.3
.5
1
2
5
10
20
0-6
6-12
12-18
18-24
24-30
30-36
Months Post-KAS
cPRA 100
cPRA 99
cPRA 98
cPRA 90-97
cPRA 80-89

ORIGINAL ARTICLE

AJT

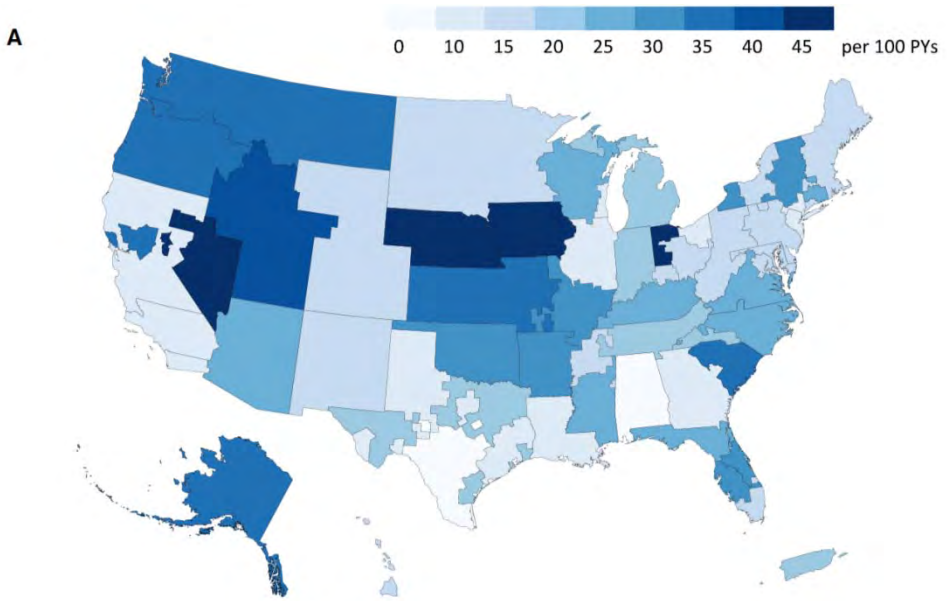
Geographic disparity in kidney transplantation under KAS

Sheng Zhou[1] | Allan B. Massie[1,2] | Xun Luo[1] | Jessica M. Ruck[1] | Eric K. H. Chow[1] | Mary G. Bowring[1] | Sunjae Bae[1,2] | Dorry L. Segev[1,2] | Sommer E. Gentry[1,3]

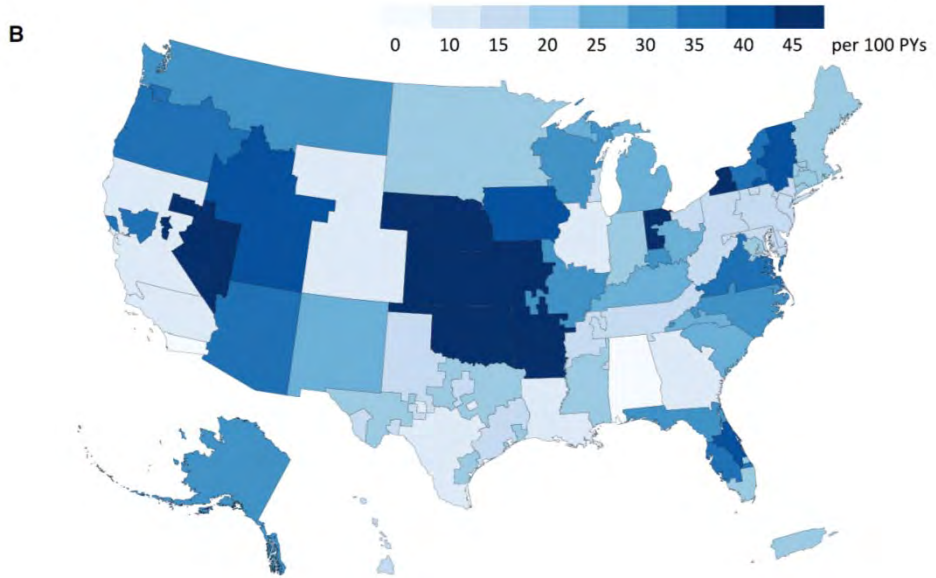
- KAS was not intended to reduce geographic disparity
- Two candidates with the same kidney allocation score in different donation service areas were expected to have a 1.81-fold difference in transplant rates
  - The healthiest candidates with EPTS score ≤20% had a 1.40-fold increase (IRR = 1.40, $P < .01$)
  - Three-year dialysis vintage was associated with a 1.57-fold increase (IRR = 1.571, $P < .001$)
- Geography influences who gets a transplant more significantly than the factors emphasized by KAS

Geographic disparity in kidney transplant rates remained high after KAS

Pre-KAS kidney transplant rate per person-year



Post-KAS kidney transplant rate per person-year



Original Clinical Science—Liver

Geographic Disparity in Deceased Donor Liver Transplant Rates Following Share 35

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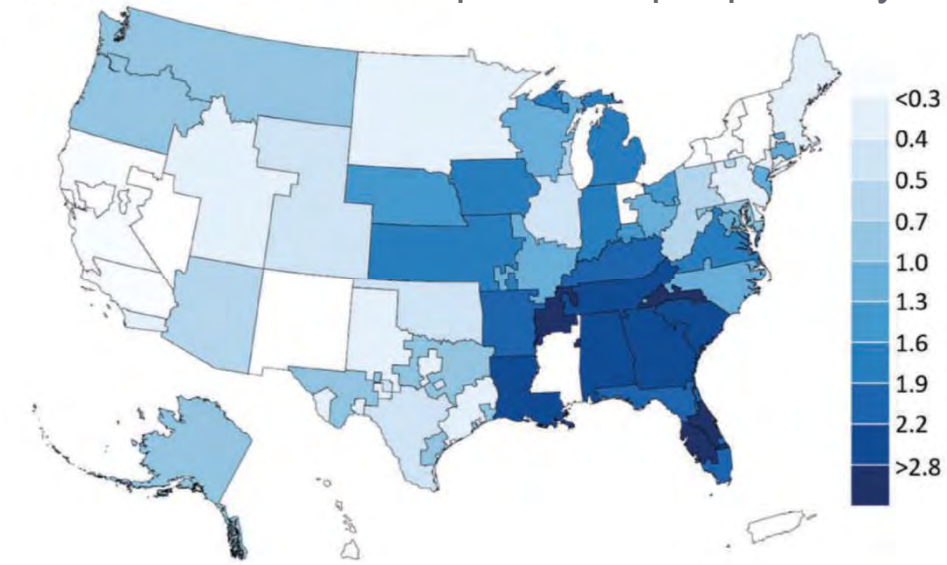
- Share35 mandated regional sharing of livers for candidates with MELD≥35
- MIRR measures geographic disparity: Both before and after Share35, two candidates with the same MELD in different donation service areas were expected to have a more-than-two-fold difference in their transplant rates

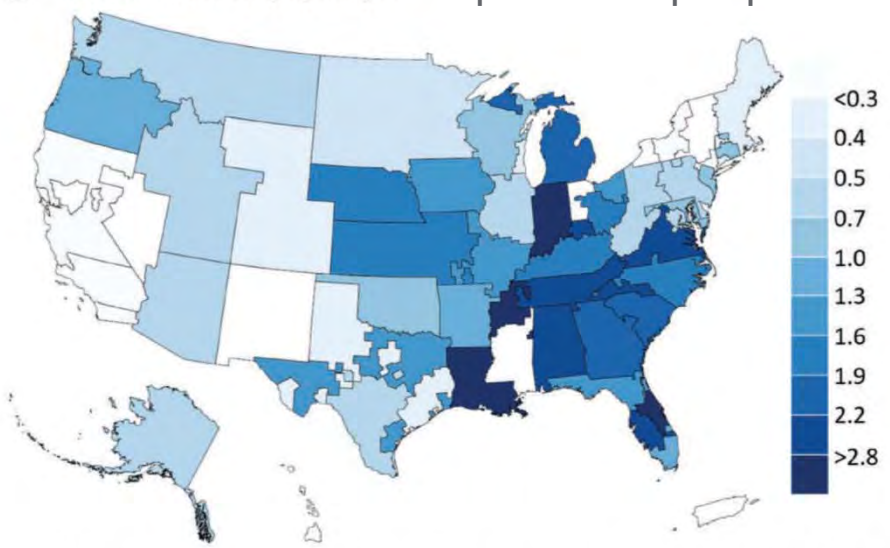
- Pre-Share35 MIRR was 2.18, and post-Share35 MIRR was 2.16

Geographic disparity in liver transplant rates remained high after Share35

Pre-Share35 liver transplant rate per person-year



Post-Share35 liver transplant rate per person-year



DSAs were excluded (white) if they did not have a liver transplant program during the study period (n=6) or included only programs with low transplant volume (n=3).

ORIGINAL ARTICLE

AJT

Geographic disparities in lung transplant rates

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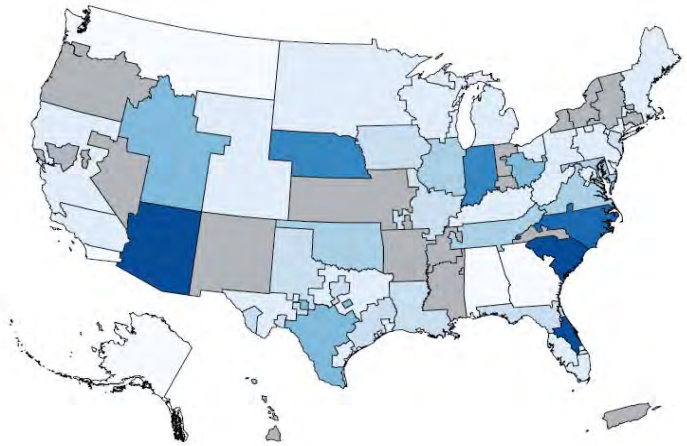
Dorry L. Segev[1,3,4] | Sommer E. Gentry[1,5]

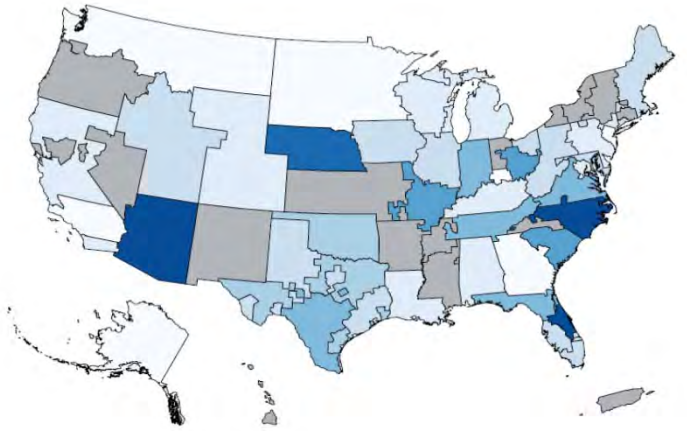
DSA-based lung transplant rate per person-year

0 1 2 3 4 5 6 7 8 No LT center



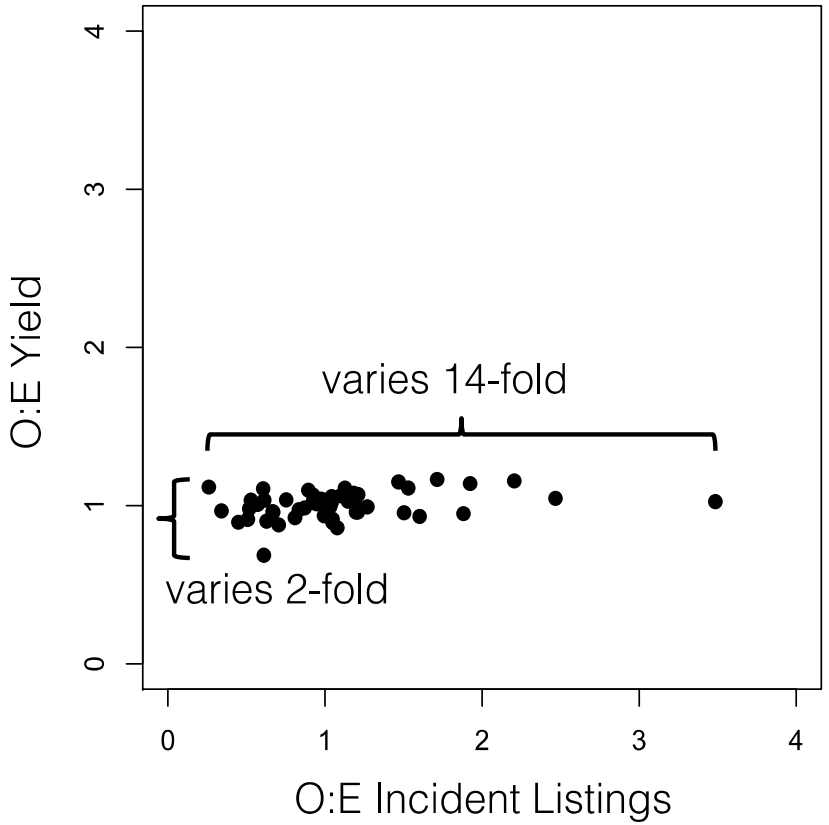
250 mi circle, lung transplant rate per person-year

0 1 2 3 4 5 6 7 8 No LT center

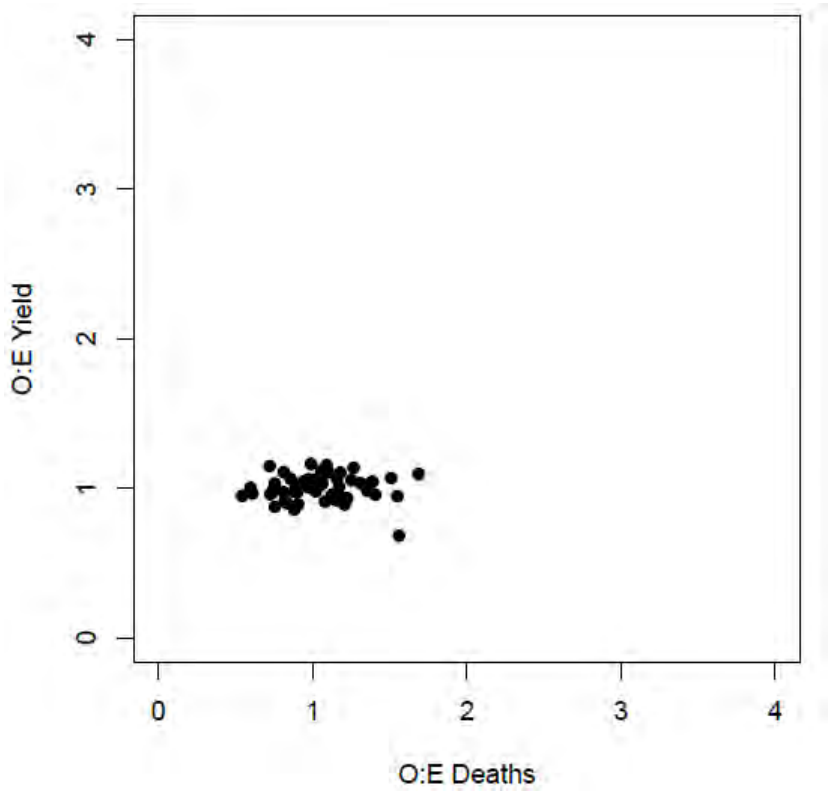


MIRR was 2.02 before the policy change, 2.09 after the policy change

Patier


O:E Yield
0
1
2
3
4
varies 14-fold
varies 2-fold
0
1
2
3
4
O:E Incident Listings

Eligible death numbers (supply) vary much more than OPO performance



Optimal Redistricting

- Redistricting uses integer programming to design geographic boundaries that partition an area into smaller areas
  - Redistricting has been applied to design voting districts and school districts, from 1950s to the present
- We use optimization to group the DSAs into new districts

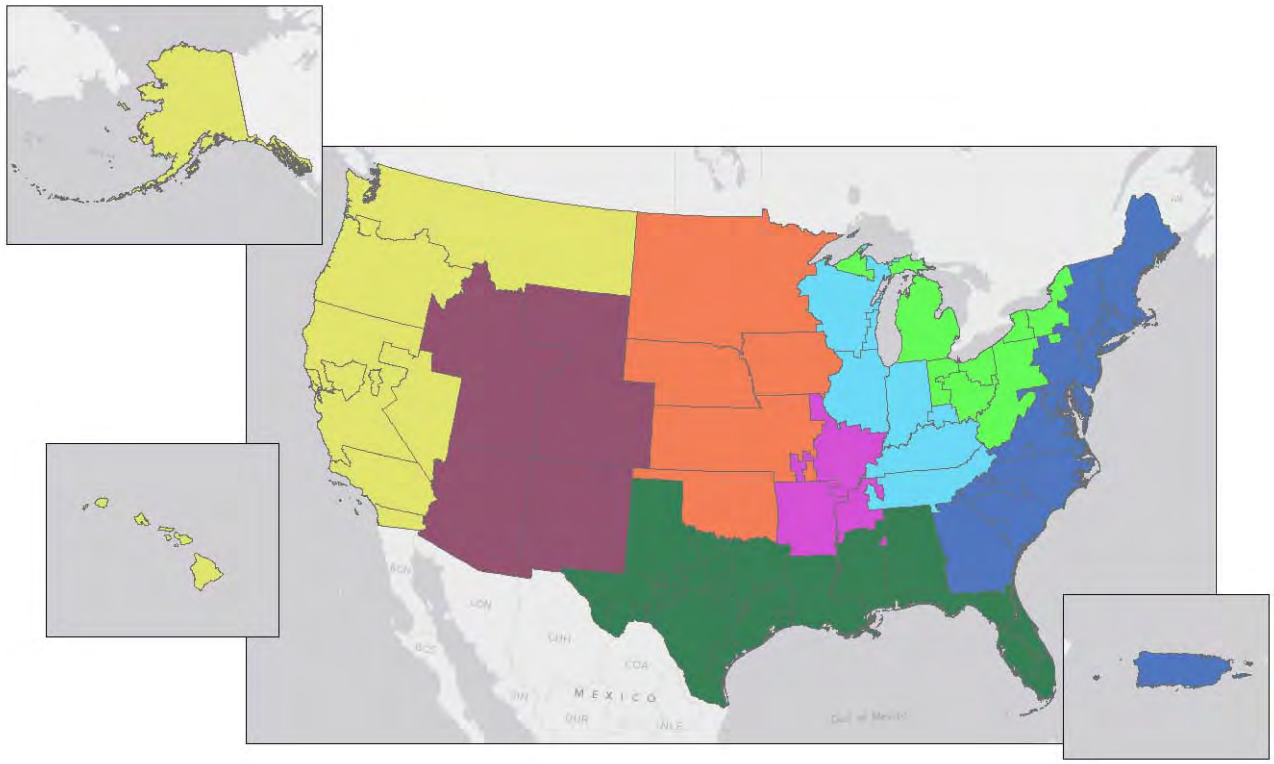
Partition DSAs into districts

Under redistricting, livers would be allocated to the sickest candidate anywhere in the district

Redistricting Objective and Constraints

- Minimize *total disparity*
  - Disparity = difference between number of donors a district *should* have (if organs went to highest MELD patient anywhere in the country) and number of donors in a proposed district
  - Minimize sum of these disparities over all districts
- Subject to constraints (the lowest geographic disparity achievable through the allocation system would be national sharing)
- The OPTN Liver Committee requested these constraints:
  - Exactly 8 districts
  - Minimum number of transplant centers per district is 6
  - The maximum allowable median travel time between DSAs placed in the same district should be 3 hours

Optimized 8 district map

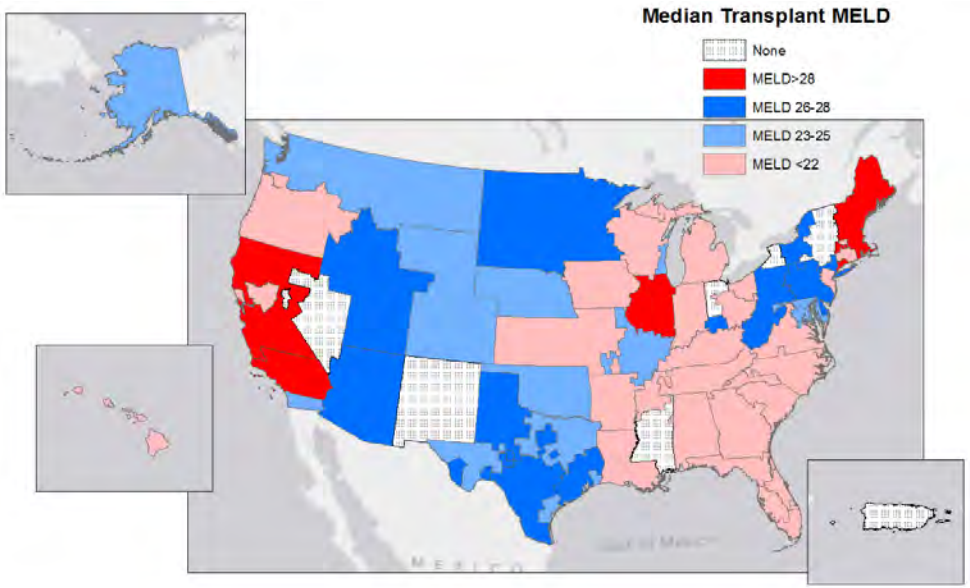


Simulated redistricting impacts over 5 years

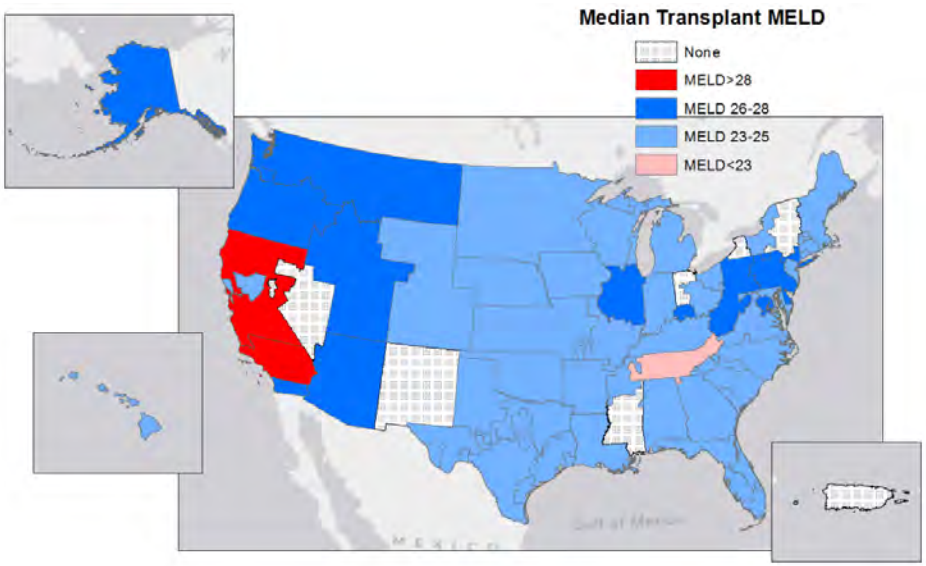
Allocation	Std Dev MELD	Net Waitlist Deaths	Net Deaths
Local	3.01	0	0
8 Districts	2.08	-332	-342

Optimized redistricting can reduce geographic disparity in liver transplant

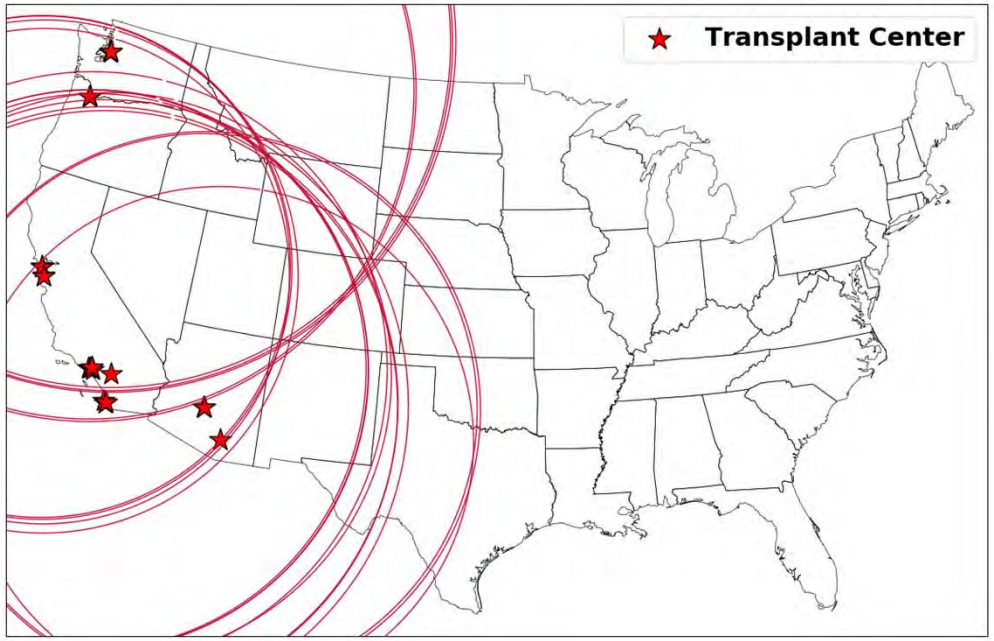
Current, MELD at transplant



Redistricting, MELD at transplant



Optimized heterogeneous circle sizes



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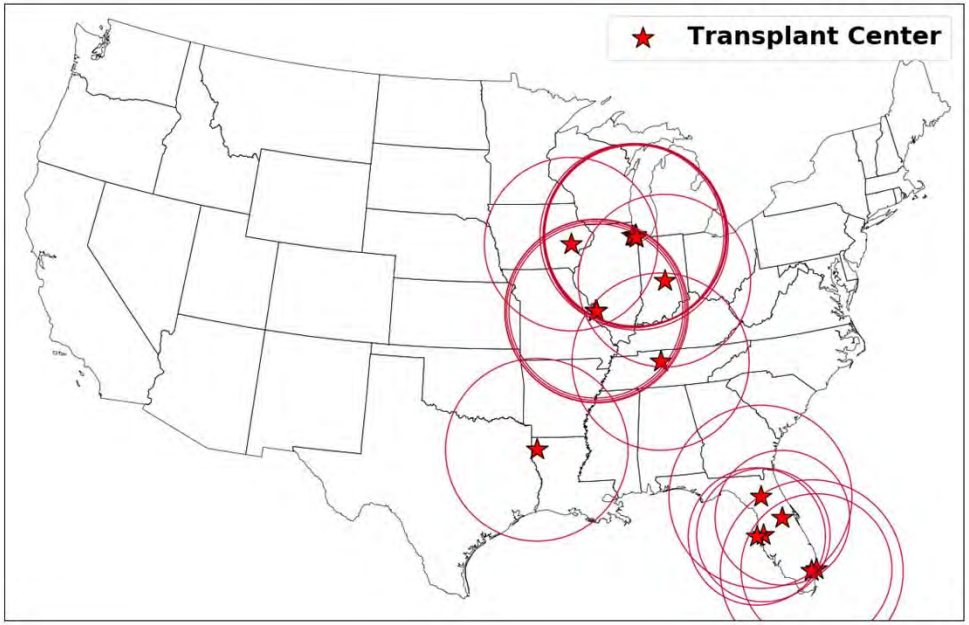
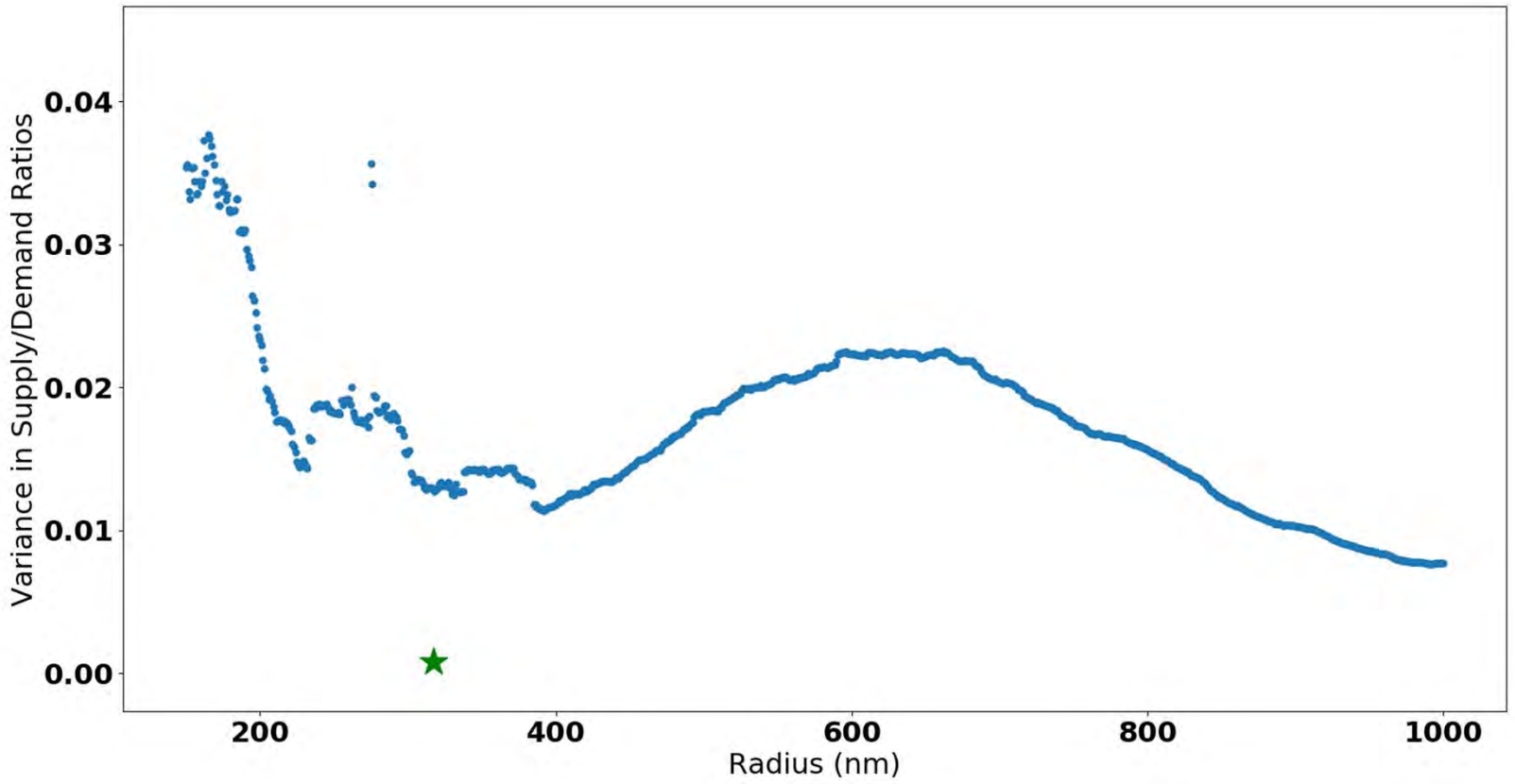


Variance in supply/demand:
identical circles (blue) versus optimized circles (green star)



The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Survival Benefit with Kidney Transplants from HLA-Incompatible Live Donors

B.J. Orandi, X. Luo, A.B. Massie, J.M. Garonzik-Wang, B.E. Lonze, R. Ahmed, K.J. Van Arendonk, M.D. Stegall, S.C. Jordan, J. Oberholzer, T.B. Dunn, L.E. Ratner, S. Kapur, R.P. Pelletier, J.P. Roberts, M.L. Melcher, P. Singh, D.L. Sudan, M.P. Posner, J.M. El-Amm, R. Shapiro, M. Cooper, G.S. Lipkowitz, M.A. Rees, C.L. Marsh, B.R. Sankari, D.A. Gerber, P.W. Nelson, J. Wellen, A. Bozorgzadeh, A.O. Gaber, R.A. Montgomery, and D.L. Segev

The clinical question is not: "Do recipients of incompatible live donors do better or worse than recipients of compatible live donors?“

The clinical question is: “Is getting an incompatible living donor transplant better or worse than waiting for the next available option?"

The NEW ENGLAND JOURNAL of MEDICINE

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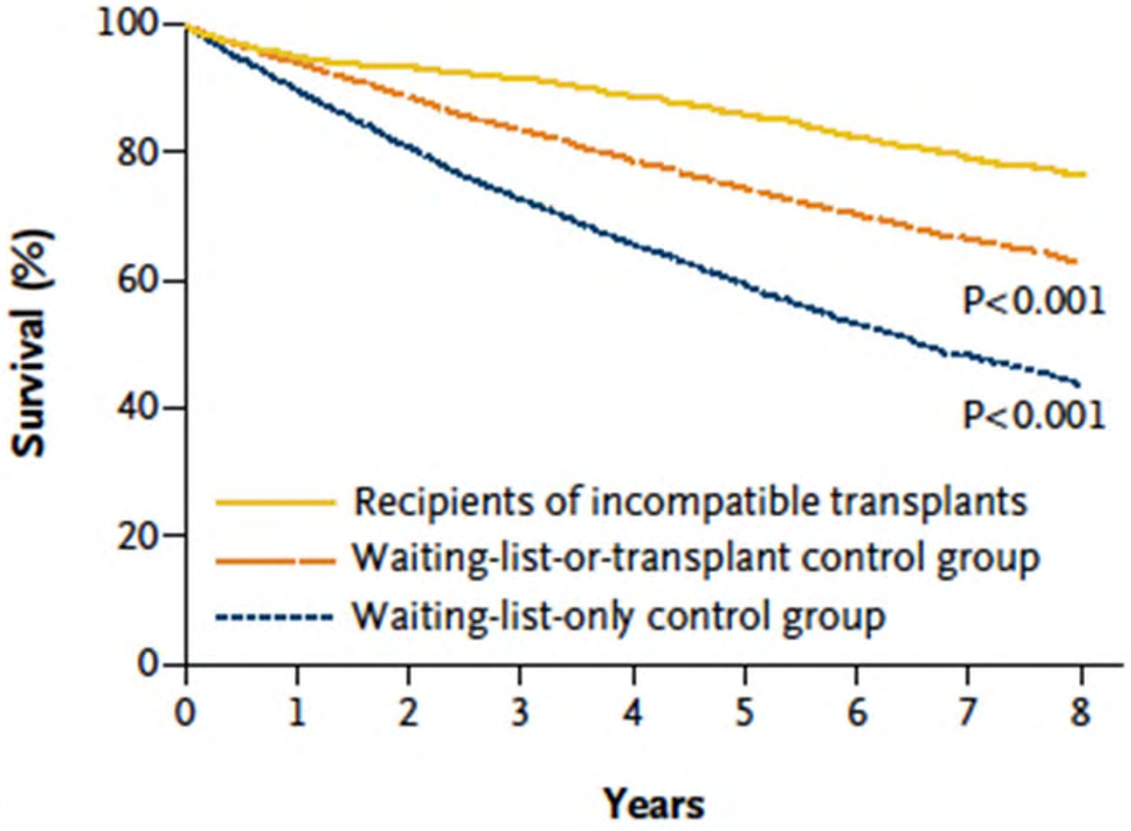
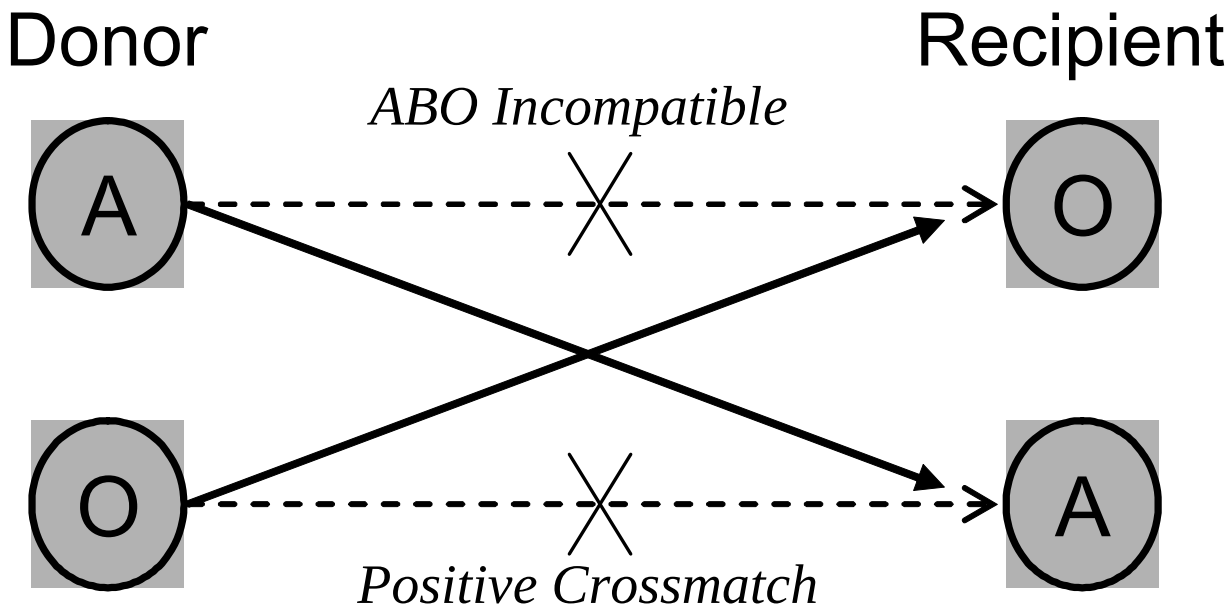


Kidney Paired Donation (KPD)



Kidney Paired Donation and Optimizing the Use of Live Donor Organs

Dorry L. Segev, MD
Sommer E. Gentry, MS
Daniel S. Warren, PhD
Brigitte Reeb, MFA
Robert A. Montgomery, MD, DPhil

Context Blood type and crossmatch incompatibility will exclude at least one third of patients in need from receiving a live donor kidney transplant. Kidney paired donation (KPD) offers incompatible donor/recipient pairs the opportunity to match for compatible transplants. Despite its increasing popularity, very few transplants have resulted from KPD.

Objective To determine the potential impact of improved matching schemes on the number and quality of transplants achievable with KPD.

Design, Setting, and Population We developed a model that simulates pools of incompatible donor/recipient pairs. We designed a mathematically verifiable optimized matching algorithm and compared it with the scheme currently used in some centers and regions. Simulated patients from the general community with characteristics drawn from distributions describing end-stage renal disease patients eligible for renal transplantation and their willing and eligible live donors.

Main Outcome Measures Number of kidneys matched, HLA mismatch of matched kidneys, and number of grafts surviving 5 years after transplantation.

RENAL TRANSPLANTATION HAS emerged as the treatment of choice for medically suitable patients with end-stage renal disease.[1] More than 60 000 patients await kidney transplantation and are listed on the United Network for Organ Sharing

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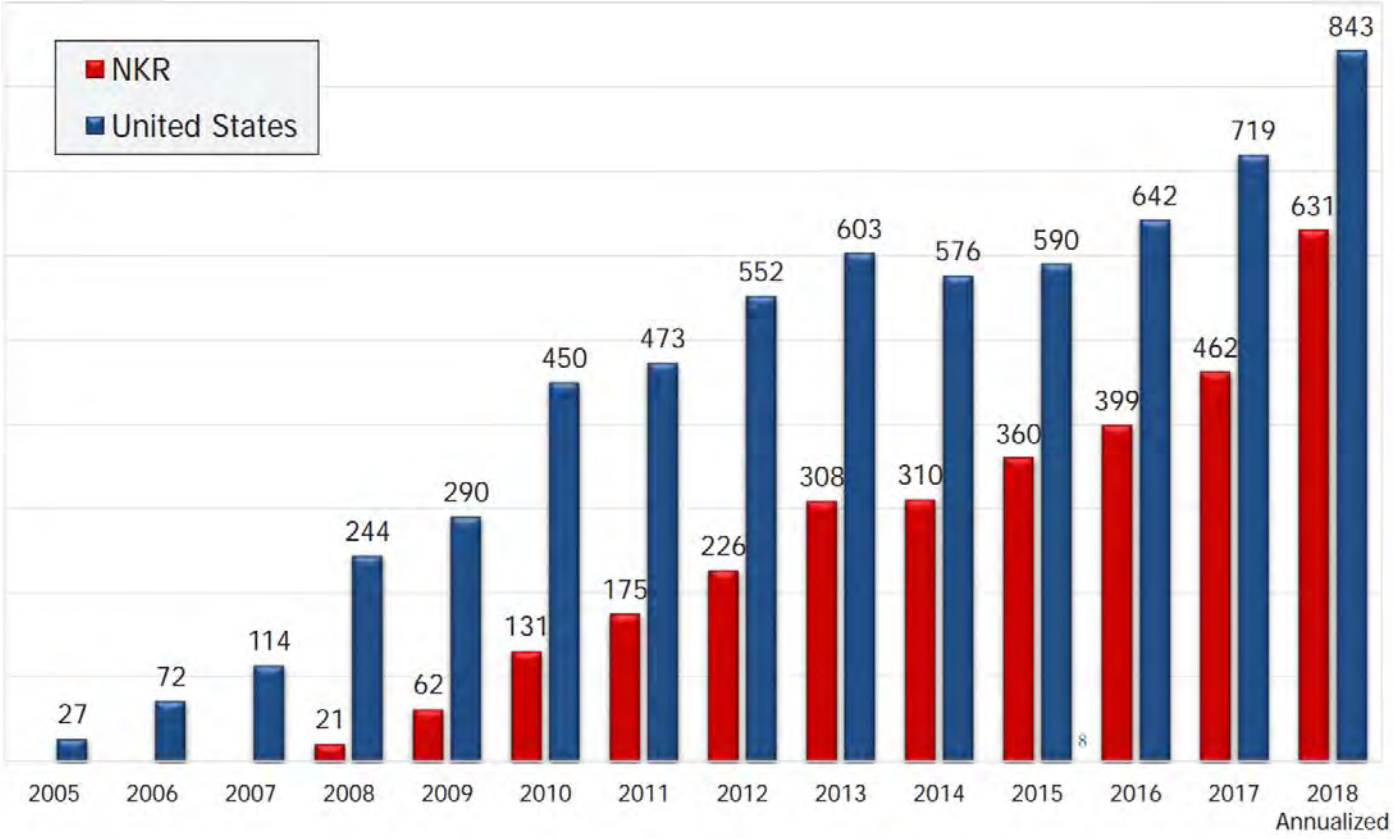
Growth in KPD in the US



*Organ Procurement and Transplantation Network. https://optn.transplant.hrsa.gov/ Accessed 10/31/18

Kidney paired donation (KPD)

- Advantages
  - Compatible transplants
    - Can be done at any center that does LDKT
    - Outcomes are just like any other transplants
    - Long-term management just like any other transplant
- Disadvantages
  - Requires a match -- so might have to wait
  - Requires coordination with other centers (sometimes)

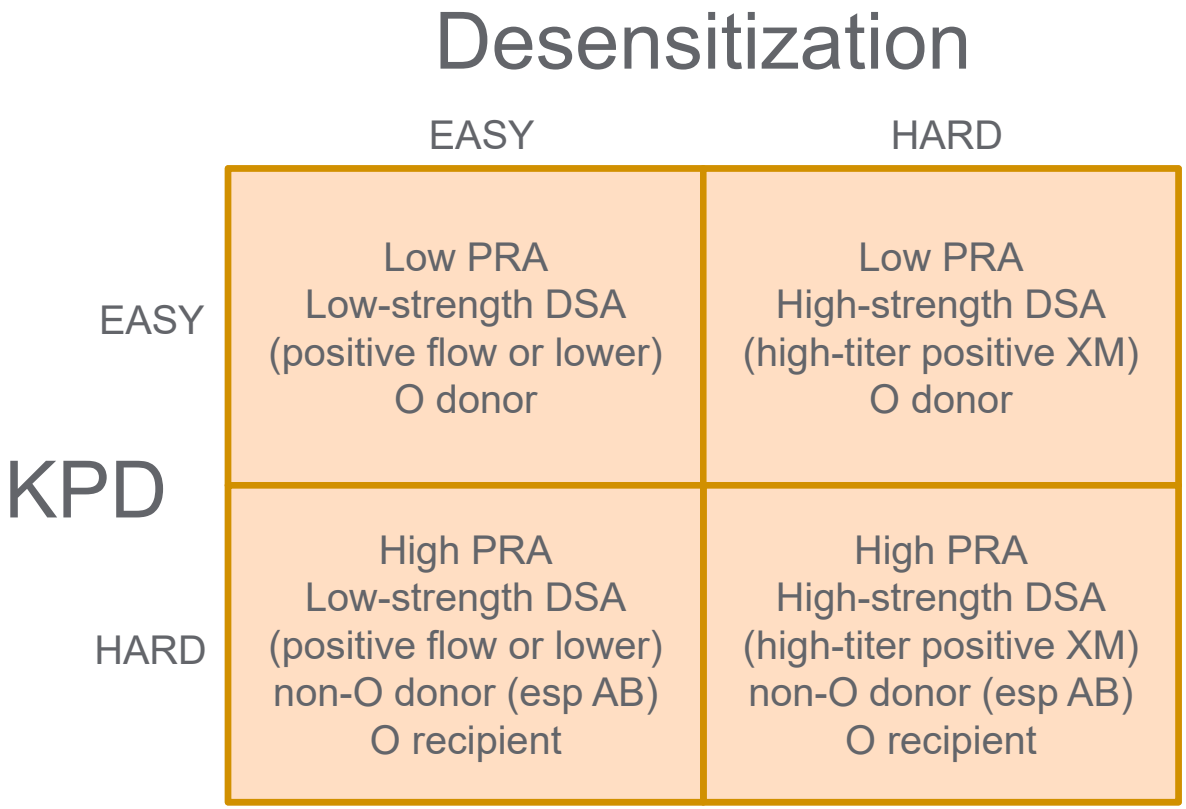
Desensitization

- Advantages
  - Can transplant immediately
  - Does not require coordination with other patients / surgeons / centers
- Disadvantages
  - Requires work and expense
    - Up-front (the desensitization itself)
    - Later (antibody monitoring, protocol biopsies, etc)
  - Magnitude of long-term risks unknown

Desensitization vs KPD = PRA vs DSA

- PRA = ability to match
  - Patient might have very high strength DSA to one particular antigen, but low PRA
  - Blood types also affect ability to match (O donors or AB recipients make a pair easier to match)
- DSA = ability to desensitize
  - Patient with many antibodies (broadly sensitized, very high PRA) might have low strength antibody to a particular donor's particular antigens

Characterizing the Donor/Recipient Pair



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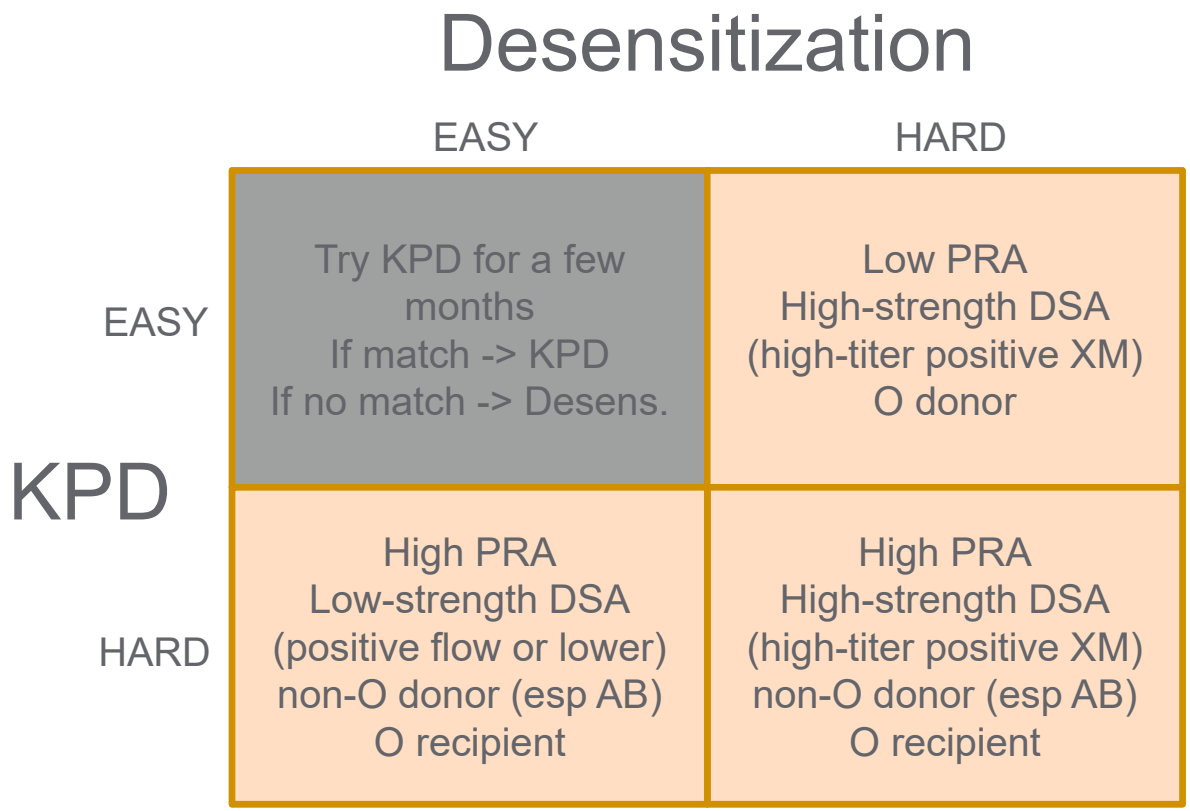

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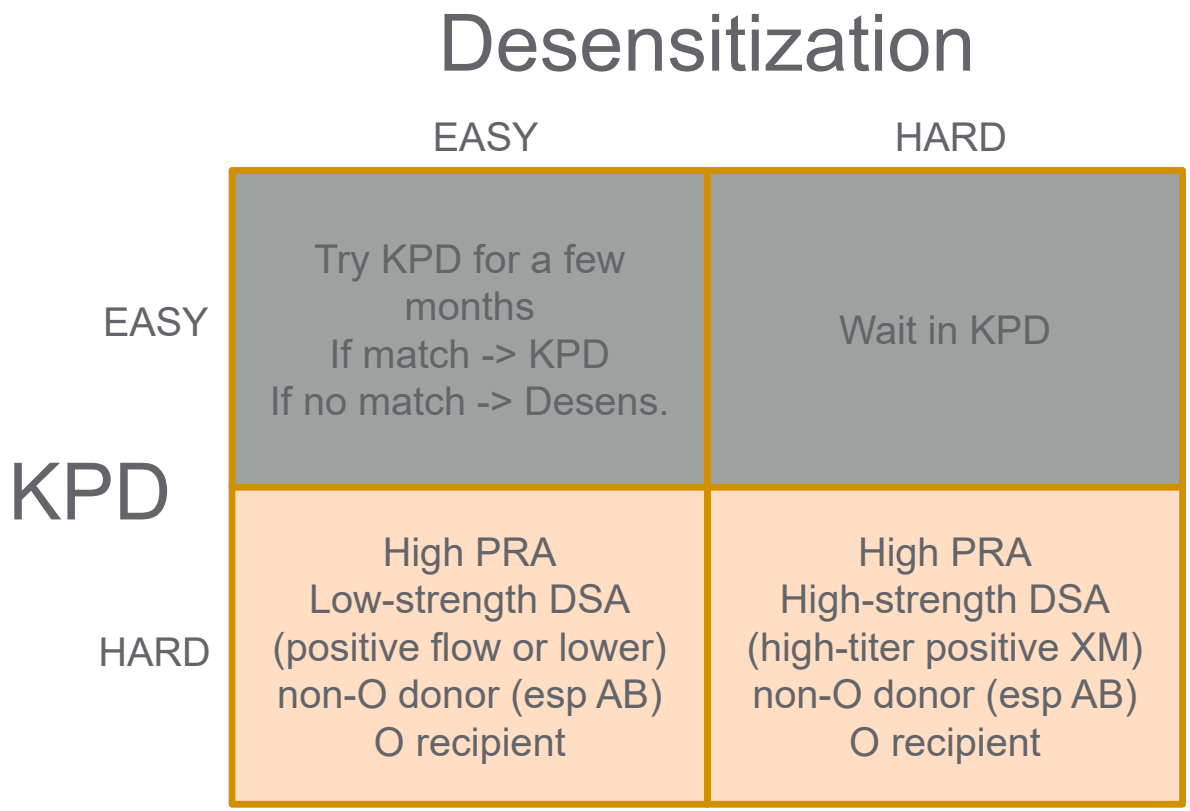

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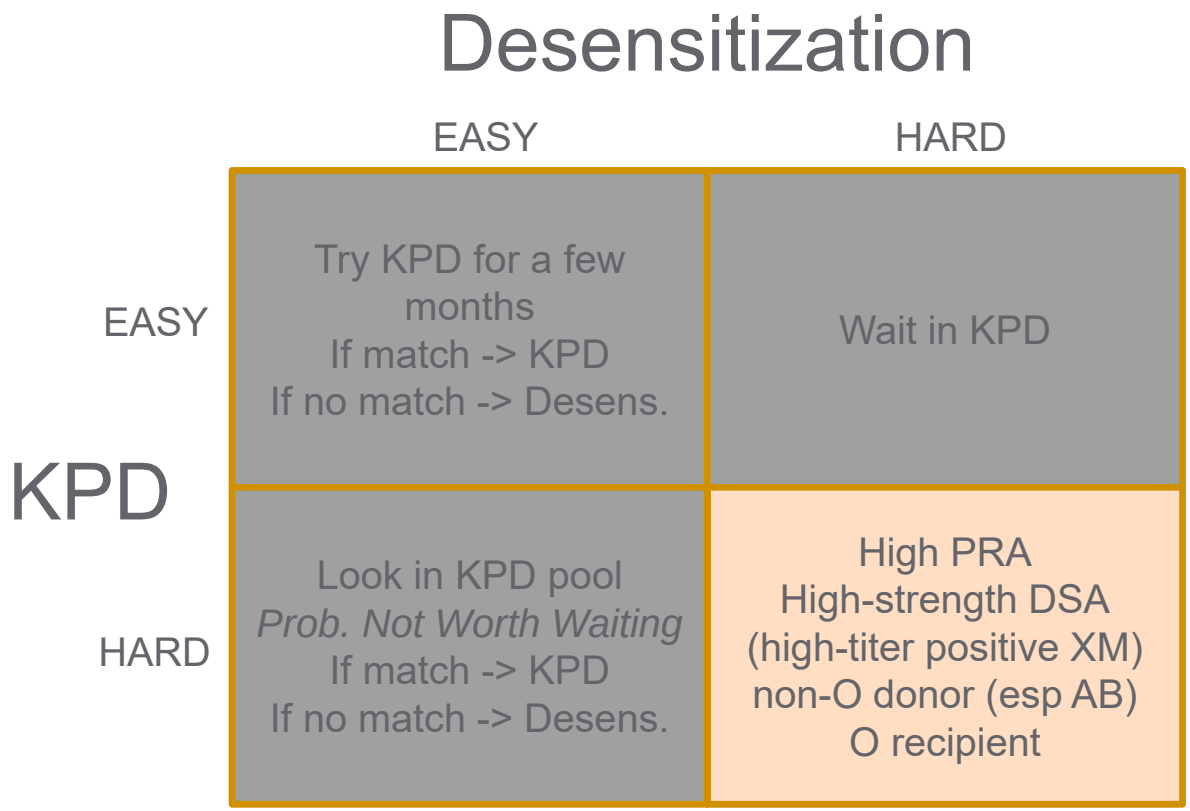

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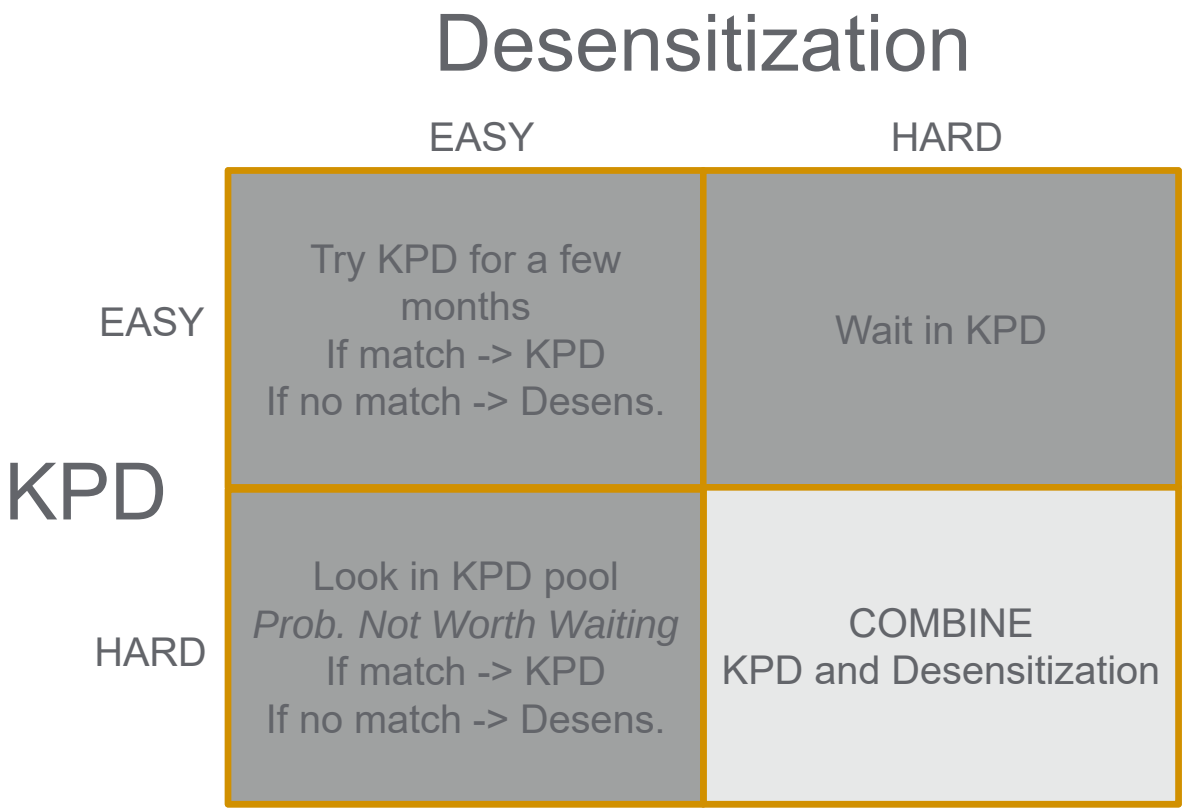

Data analytics to help providers, payers, policymakers do the right thing

- Identify opportunities to increase transplants from deceased donors and living donors (deceased donors: use more non-ideal organs from infectious risk and HCV+/HIV+ donors, living donors: desensitization and kidney paired donation)
- Build trust in the transplant system by designing more equitable allocation policies (geographic disparities)

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