Analysis Report, KI2018_01:
Rerun using Donor-only Acceptance Model

Data Request from the OPTN Kidney Transplantation Committee: Provide KPSAM simulation data on effect of removing DSA and region from kidney/pancreas/kidney-pancreas organ allocation policy

Prepared By
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Data Request ID#: KI2018_01_rerun

Timeline
Original Request made: September 10, 2018
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Original Analysis plan submitted: September 24, 2018
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Rerun Analysis report due: June 17, 2019
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Rerun Analysis report update submitted: June 21, 2019
Next committee meeting: June 25, 2019

Table of Contents

Analysis Report, KI2018_01: .............................................................................................................................. 1
Rerun using Donor-only Acceptance Model ................................................................................................... 1
Data Request from the OPTN Kidney Transplantation Committee: Provide KPSAM simulation data on effect of removing DSA and region from kidney/pancreas/kidney-pancreas organ allocation policy .......................................................................................................................... 1
**Executive Summary**

Using a donor-only acceptance model, SRTR reran the updated kidney-pancreas simulated allocation model (KPSAM) to assess the simulated impact of five allocation frameworks based on nautical miles (NM) between candidate listing program and donor hospital. These results can be contrasted with those from the original KI2018_01 report published in December 2018, which was run using an acceptance model with candidate, donor, and candidate/donor interactions, including whether an organ offer was from the candidate's local DSA. In interpreting the modeling results it is important to consider that KPSAM cannot model changes in program behaviors under new allocation policies.

**Description of Runs**

<table>
<thead>
<tr>
<th>Model Nickname</th>
<th>Number of Circles</th>
<th>Inner Circle Size</th>
<th>Outer Circle Size</th>
<th>Inner Circle Maximum Points</th>
<th>Outer Circle Maximum Points</th>
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The baseline model (referred to as “BL” in all tables and figures) was the current allocation system. Models 2CR_150 and 2CR_250 are nested two-circle allocation systems, and Models 1CR_nopts, 1CR_shallow, and 1CR_steep are single-circle allocation systems. Model 2CR_150 uses the distances of 150 NM and 300 NM in place of local and regional designation, and Model 2CR_250 will use the distances of 250 NM and 500 NM in place of local and regional designations.

Models 1CR_nopts, 1CR_shallow, and 1CR_steep use the distance of 500 NM in place of the local designation, and regional sharing is eliminated. Instead, organs are shared nationally when beyond the 500 NM border.

Additionally, Models 1CR_shallow and 1CR_steep include proximity points awarded for distance between candidate program and donor hospital zip code centroids. Proximity points within the circle were assigned linearly, starting at X points for a 0 NM distance between the donor hospital and transplant program, and tapering to 0 points at the circle edge. Likewise, proximity points outside the circle were assigned linearly, starting at Y points at the circle's edge, and tapering to 0 points at 2500 NM.

Main Findings

Total Transplants

The simulated total number of transplants varied by fewer than 100 across all runs. The allocation systems for kidney and kidney-pancreas/pancreas-alone transplants are highly related, with kidney-pancreas and pancreas-alone candidates receiving absolute priority over kidney-alone candidates through the first (formerly “local”) level of allocation. Additionally, kidney-pancreas candidates outnumber pancreas-alone candidates by over 3 to 1; therefore, under broader sharing schemes, kidney-pancreas candidates tend to benefit more than pancreas-alone candidates. In general, as the size of the first level of allocation (circle size) increases, relatively more kidney-pancreas transplants are performed, and relatively fewer pancreas-alone and kidney-alone.

Distance Between Transplant Recipient and Donor Hospital

Distance traveled is greatest in the larger single-circle models, and minimized in smallest two-circle model. Proximity points within the circle tend to reduce the distance traveled. For example, the median distance in run 1CR_nopts for a kidney transplant was 304 NM, but in run 1CR_steep (which employed a maximum of two proximity points within the circle, and four outside the circle) the median distance for a kidney transplant was 248 NM. The effect of proximity points outside the circle was less strong, likely because relatively few transplants were predicted to occur there (10%-20%). Kidney-pancreas transplants traveled the shortest distances, and pancreas-alone transplants traveled the furthest.

Variance in Metrics by Candidate DSA

The variance in transplant rate by listing DSA was minimized in the largest distribution circles, and maximized in the smallest circles. The pattern was consistent for all organ types. The variance in median donor-recipient distance by DSA tended to be highest in the largest distribution circles, and minimized in the smallest circles. In contrast, variance in median time on dialysis at transplant (a surrogate metric for disease severity) was minimized under the broadest sharing scenarios.
Subgroups

Kidney-alone:

In general, the largest changes in transplant rates were observed under the broadest sharing scenarios, and the smallest under the most conservative scenario (2CR_150). Transplant rates for pediatric candidates increased under all proposals, with the greatest increases under the broadest sharing scenarios. Rates for adults aged ≥50 years, and particularly aged ≥65, declined somewhat. Transplant rates were generally higher for African American and Latino candidates in all proposals, and slightly lower for whites and non-Latinos. Transplant rates increased for female candidates; this was maximized in the broadest sharing scenarios. Transplant rates by primary cause of disease were relatively constant across proposals, with the exception of Congenital and Rare Metabolic Disorders (CRMD), which are most common in pediatric candidates. Transplant rates were higher for candidates with >5 years of dialysis under all proposals, and the increase was maximized under the broadest sharing proposals. Transplant rates for candidates with cPRA 80-99 likewise increased under broader sharing scenarios, but changed minimally in the 2-CR scenarios. Transplant rates among Medicaid and “other” payer candidates also increased, with a concomitant decrease in rates for those with private payers. There were small decreases in transplant rates among non-metropolitan candidates (where the rural-urban commuting area [RUCA] grouping is defined by candidates' permanent zip codes). Transplant rates for candidates with EPTS ≤20% (excluding pediatric candidates) also declined under broader sharing proposals; this decline minimized in the smallest circles.

Kidney-Pancreas:

As with kidney-alone transplants, the largest changes in transplant rates were observed under the broadest sharing (e.g., 1CR proposals), and the smallest under the most conservative sharing (e.g., 2CR_150). Kidney-pancreas transplant rates and counts increased globally. Nonetheless, some subgroups underwent a greater proportion of transplants under alternate sharing scenarios, as compared with baseline. In particular, African American candidates underwent slightly more transplants under broader sharing, and white candidates slightly fewer. Non-Latino candidates underwent slightly more transplants, and Latino candidates slightly fewer. Likewise, female candidates underwent slightly more transplants, and male candidates slightly fewer. Candidates with cPRA <80% underwent relatively fewer transplants, and more highly sensitized candidates relatively more. Candidates with Medicare as primary payer underwent relatively more transplants, and those with private insurance relatively fewer. Transplants did not change by urbanicity.

Pancreas-Alone:

In contrast to kidney-alone and kidney-pancreas transplants, pancreas-alone transplant rates decreased globally under alternate sharing scenarios, and decreases were greatest under the broadest sharing (i.e., largest circle sizes). Because of the relatively small number of pancreas-alone transplants performed, results are more variable (i.e., much wider ranges associated with transplant rates and counts) and therefore, less certain regarding changes in subgroups. Candidates aged 18-34 years underwent slightly fewer transplants under alternate sharing, and those aged ≥35 years slightly more. Candidates with cPRA <80% underwent relatively fewer transplants, and more highly sensitized candidates relatively more. Transplants did not change by race or urbanicity.
Acceptance Model

All KPSAM runs were performed using a donor-only acceptance model. The report from data request KI2018_01, published in December 2018, was negatively received due to notable decreases in the number of transplants. This was potentially related to inclusion of a local indicator in the offer acceptance models. In response, SRTR began investigating the effect of different decisions in the offer acceptance model on KPSAM results. The KPSAM acceptance models are always created with historical data (match run data), and by their nature, they assume that acceptance behavior will remain the same under any new allocation system. However, under different allocation systems, different types of candidates receive relatively more or less priority than under the current systems, and consequently, programs are likely to change their acceptance behavior to compensate. By removing candidate factors from the acceptance model, we no longer make assumptions about how candidate factors may influence acceptance behavior. Removing these assumptions about how candidate factors interact with acceptance means that KPSAM is less likely to predict a decrease in deceased-donor transplants. However, that means KPSAM also has less ability to predict differences in acceptance rates by candidate characteristics under different policy scenarios.

Limitations

One aspect of the simulation results strongly affected by acceptance probability is the number of projected transplants. KPSAM uses a simple model of organ discard: if an organ is offered 200 times without an acceptance, it is marked as discarded. This approach is computationally efficient but does not identify most behavioral or clinical factors for which organs are discarded, and this means that KPSAM in general is not a good tool for predicting an overall number of transplants in any given policy scenario. Specifically in this analysis, lower overall acceptance probabilities related to the removal of the local/regional/national distribution system likely affect the number of transplants across all allocation proposals. However it is not possible to determine whether proposals are affected equally. SRTR will continue to investigate potential improvements to the modeling approach.

Data Request

Using the most recently available KPSAM version and data, model the kidney, pancreas, and kidney-pancreas distribution systems outlined in the KI2018_01 Analysis Plan as Allocation Framework 1 and Allocation Framework 2.

Study population

KPSAM input files were updated to include transplant candidates listed on the kidney, kidney-pancreas, or pancreas transplant waiting lists between January 1, 2017, and December 31, 2017, and donors whose kidneys or pancreata were recovered for transplant in the same time period.

Updates to KPSAM

The unacceptable antigen equivalences and antigen splits used by KPSAM have been updated to match current (September 2018) OPTN policy. In addition, all predictive models used by KPSAM have
been updated to incorporate newer data and methodology, including but not limited to the acceptance models and posttransplant outcomes models.

**Metrics assessed**

As noted in the OPTN data request, SRTR assessed the following outcome metrics for the simulations:

- Count (%) of transplants
- Transplant rates
- Time on dialysis distribution at transplant, kidney-alone
- Time on waiting list distribution at transplant
- Organ travel distance (NM) distribution at transplant
- Percent of organs traveling over 250 NM
- Variance in transplant rates
- Variance of median time on dialysis at transplant
- Variance in median time on waiting list at transplant

Relevant DSA-level metrics are shown choropleth maps and provided in an appendix of tables:

- Transplant rates
- Median dialysis time at transplant
- Median time on waiting list at transplant
- Median cPRA at transplant, kidney-alone
- Waitlist mortality rates
- Change in count of waitlist deaths^  

^In tables only

Metrics by organ should also be assessed by the following subgroup populations (including a comparison of percentage of waiting list vs. percentage of transplants where applicable):

- **Candidate/recipient age:** 0-5, 6-10, 11-17, 18-34, 35-49, 50-64, ≥ 65 years  
- **Candidate/recipient race:** white, African American, Asian, other/unknown  
- **Candidate/recipient sex:** male vs. female  
- **Candidate/recipient ethnicity:** Latino, Not Latino  
- **Candidate/recipient blood type (ABO):** A, B, AB, O  
- **Candidate/Recipient cPRA:** 0-79, 80-89, 90-94, 95-97, 98, 99, 100  
- **Candidate/recipient diagnosis:** diabetes, hypertension, GN, cystic kidney disease, other  
- **Candidate/recipient time on dialysis:** pre-emptive transplant, 0-< 1, 1-< 3, 3-< 5, 5-< 10, ≥ 10 years  
- **SES-related:**  
  - **Candidate/recipient insurance status:** public vs. private  
  - **Median income by recipient zip code at listing/transplant distribution:** using the ACS zip code level publically available dataset
- **Urbanicity**: urban vs. rural, based on RUCA codes (individually, and grouped by metropolitan vs. micropolitan + small town + rural)
  - **KDPI**: 0-20%, 21-34%, 35-85%, 86-100%
  - **EPTS**: 0-20%, 21-100%
  - **Donor type**: DCD vs DBD
  - **Candidate/recipient sensitization**:
    - 0-HLA mismatch: 0 vs. non-0
    - DR mismatch level: 0, 1, 2
- **Geography**:
  - Percentage local (DSA), regional, national
  - By OPTN Region: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11

Additional figures by subgroup can be found in Appendix A:

- Waitlist mortality rate
- Post-transplant graft failure rate (1 year)
- Post-transplant death rate (1 year)

**Analytic approach**

Each of the six requested changes to the allocation system was run with 10 iterations (repetitions) in KPSAM, to provide some measure of variability. Because the same donors and candidates are used in each of the simulations, and they are the actual donors and candidates from 2017 rather than independent samples from a larger population, statistical tests for comparison have no validity. Instead, the average and range of results (minimum - maximum) for the 10 iterations are provided.

**Results**

Results for the simulated scenarios are reported primarily in the form of plots, with each plot displaying the values for a given metric across the eleven scenarios simulated. In viewing these results, it is important to compare the new scenarios with the current allocation policy scenario to identify changes in outcome metrics due to the proposed policy changes. Each scenario was simulated 10 times, and the plot displays the range of results across the 10 simulations as a vertical line extending from the minimum value to the maximum value found for that metric and scenario. A point along that line marks the mean value of the metric across the 10 iterations.
# Transplant Counts

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Transplant Count (N), Overall</th>
<th>Transplant Count (N), Kidney-Alone</th>
<th>Transplant Count (N), Kidney-Pancreas</th>
<th>Transplant Count (N), Pancreas-Alone</th>
</tr>
</thead>
<tbody>
<tr>
<td>BL</td>
<td>14044 (13928,14143)</td>
<td>13062 (12947,13175)</td>
<td>822 (811,834)</td>
<td>160 (155,169)</td>
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<tr>
<td>1CR_nopts</td>
<td>13957 (13803,14094)</td>
<td>12754 (12600,12897)</td>
<td>1113 (1103,1121)</td>
<td>91 (86,95)</td>
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<tr>
<td>1CR_shallow</td>
<td>13990 (13835,14051)</td>
<td>12785 (12633,12846)</td>
<td>1114 (1109,1125)</td>
<td>91 (85,95)</td>
</tr>
<tr>
<td>1CR_steep</td>
<td>13976 (13910,14041)</td>
<td>12770 (12707,12835)</td>
<td>1120 (1112,1132)</td>
<td>87 (80,93)</td>
</tr>
<tr>
<td>2CR_150</td>
<td>14006 (13909,14056)</td>
<td>12918 (12830,12977)</td>
<td>965 (950,985)</td>
<td>123 (113,134)</td>
</tr>
<tr>
<td>2CR_250</td>
<td>13990 (13926,14059)</td>
<td>12839 (12776,12912)</td>
<td>1054 (1041,1064)</td>
<td>98 (92,106)</td>
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</table>
Transplant Counts by Organ

Transplant Counts by Organ

Counts

Scenario

BL  1CR_nopps  1CR_shallow  1CR_steep  2CR_150  2CR_250

BL  1CR_nopps  1CR_shallow  1CR_steep  2CR_150  2CR_250

Transplant Counts by Organ
## Transplant Counts

### Main Metrics for Kidney-Alone

**Overview of Main Metrics for Kidney**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Transplant Rate per Patient-Year</th>
<th>Transplant Count (N)</th>
<th>Waitlist Mortality Rate per Patient-Year</th>
<th>Waitlist Mortality Count (N)</th>
<th>Graft Failure Rate per Patient-Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>BL</td>
<td>0.118 (0.117,0.119)</td>
<td>13062 (12947,13175)</td>
<td>0.047 (0.047,0.048)</td>
<td>5243 (5213,5260)</td>
<td>0.075 (0.072,0.079)</td>
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<tr>
<td>1CR_nopts</td>
<td>0.115 (0.114,0.116)</td>
<td>12754 (12600,12897)</td>
<td>0.048 (0.047,0.048)</td>
<td>5266 (5249,5279)</td>
<td>0.081 (0.076,0.085)</td>
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<tr>
<td>1CR_shallow</td>
<td>0.115 (0.114,0.116)</td>
<td>12785 (12633,12846)</td>
<td>0.047 (0.047,0.048)</td>
<td>5262 (5243,5285)</td>
<td>0.079 (0.075,0.083)</td>
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<td>0.115 (0.115,0.116)</td>
<td>12770 (12707,12835)</td>
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<td>5264 (5252,5277)</td>
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### Main Metrics for Kidney-Pancreas

**Overview of Main Metrics for Kidney-Pancreas**

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<tr>
<th>Scenario</th>
<th>Transplant Rate per Patient-Year</th>
<th>Transplant Count (N)</th>
<th>Waitlist Mortality Rate per Patient-Year</th>
<th>Waitlist Mortality Count (N)</th>
<th>Graft Failure Rate per Patient-Year</th>
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<td>0.054 (0.053,0.057)</td>
<td>96 (94,100)</td>
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<td>1CR_shallow</td>
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<td>2CR_150</td>
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<td>0.581 (0.573,0.59)</td>
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<td>0.054 (0.05,0.057)</td>
<td>97 (91,102)</td>
<td>0.135 (0.11,0.179)</td>
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**Graft Failure is modeled as the earlier failure of either the kidney or pancreas allograft. Note that predictive models for posttransplant pancreas graft failure were built on data that do not yet incorporate the new pancreas graft failure definition implemented in 2018.**
Main Metrics for Pancreas-Alone

Overview of Main Metrics for Pancreas

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Transplant Rate per Patient-Year (N)</th>
<th>Transplant Count (N)</th>
<th>Waitlist Mortality Rate per Patient-Year</th>
<th>Waitlist Mortality Count (N)</th>
<th>Graft Failure Rate per Patient-Year</th>
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<tbody>
<tr>
<td>BL</td>
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<td>2CR_250</td>
<td>0.126 (0.119,0.138)</td>
<td>98 (92,106)</td>
<td>0.02 (0.018,0.022)</td>
<td>16 (14,17)</td>
<td>0.205 (0.14,0.334)</td>
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</table>

** Note that predictive models for posttransplant pancreas graft failure were built on data that do not yet incorporate the new pancreas graft failure definition implemented in 2018.

Distance from Candidate's Listing Program to Donor Hospital (Nautical Miles), Transplant Recipients Only

Distance is calculated as the linear distance in nautical miles between zip code centroids of the candidate's listing program and the donor hospital.
Distribution of Organ Travel Distance, Kidney-Alone

Distribution of Organ Travel Distance, Kidney-Alone

Distribution of Organ Travel Distance, Kidney-Alone
Distribution of Organ Travel Distance, Kidney-Pancreas
Distribution of Organ Travel Distance, Pancreas-Alone

Distribution of Organ Travel Distance, Pancreas-Alone

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Page 14 of 161

SRTR, KI2018_01 Analysis Report Rerun

Version 1.1, 6/21/2019
Percentage of Organs Traveling More Than 250 NM

Percentage of Organs Traveling More Than 250 NM

- **KI**

- **KP**

- **PA**

Scenarios:
- BL
- 1CR_noPrep
- 1CR_shallow
- 1CR_steep
- 2CR_150
- 2CR_250

Percentage of Organs Traveling More Than 250 NM
Percentage of Organs Traveling More Than 500 NM
Percentage of Organs Traveling Beyond First Circle

### Percentage of Organs Traveling Beyond First Circle

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<th>KP</th>
<th>PA</th>
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<tr>
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**Scenario**

**Percentage of Organs Traveling Beyond First Circle**
## Distribution of Travel Distance: Kidney-Alone Transplants

**Recipient - Donor Distance Statistics (in NM), Kidney-Alone Transplants**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>5th %ile</th>
<th>Q1</th>
<th>Median</th>
<th>Mean</th>
<th>Q3</th>
<th>95th %ile</th>
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<td>163.86</td>
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<td>420.37</td>
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<td>323.08</td>
<td>405.55</td>
<td>831.83</td>
<td>347.07</td>
</tr>
<tr>
<td>1CR_steep</td>
<td>5.58</td>
<td>109.96</td>
<td>247.48</td>
<td>304.21</td>
<td>388.71</td>
<td>826.57</td>
<td>345.72</td>
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<tr>
<td>2CR_150</td>
<td>0.00</td>
<td>23.45</td>
<td>89.24</td>
<td>187.21</td>
<td>137.75</td>
<td>965.67</td>
<td>382.91</td>
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<tr>
<td>2CR_250</td>
<td>3.33</td>
<td>76.57</td>
<td>162.62</td>
<td>232.30</td>
<td>221.96</td>
<td>868.53</td>
<td>361.75</td>
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</table>

## Distribution of Travel Distance: Kidney-Pancreas Transplants

**Recipient - Donor Distance Statistics (in NM), Kidney-Pancreas Transplants**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>5th %ile</th>
<th>Q1</th>
<th>Median</th>
<th>Mean</th>
<th>Q3</th>
<th>95th %ile</th>
<th>Std Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>BL</td>
<td>0.00</td>
<td>4.07</td>
<td>29.60</td>
<td>75.20</td>
<td>93.40</td>
<td>236.41</td>
<td>154.76</td>
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<tr>
<td>1CR_nopts</td>
<td>11.72</td>
<td>147.81</td>
<td>277.53</td>
<td>275.10</td>
<td>395.83</td>
<td>482.78</td>
<td>206.10</td>
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<tr>
<td>1CR_shallow</td>
<td>3.58</td>
<td>91.00</td>
<td>207.11</td>
<td>227.83</td>
<td>339.74</td>
<td>469.23</td>
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<td>1CR_steep</td>
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<td>300.68</td>
<td>452.84</td>
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<td>119.78</td>
<td>147.59</td>
<td>205.18</td>
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<td>2.93</td>
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<td>146.09</td>
<td>145.14</td>
<td>199.86</td>
<td>242.31</td>
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</table>

## Distribution of Travel Distance: Pancreas-Alone Transplants

**Recipient - Donor Distance Statistics (in NM), Pancreas Transplants**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>5th %ile</th>
<th>Q1</th>
<th>Median</th>
<th>Mean</th>
<th>Q3</th>
<th>95th %ile</th>
<th>Std Deviation</th>
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<tbody>
<tr>
<td>BL</td>
<td>20.07</td>
<td>207.45</td>
<td>495.34</td>
<td>659.21</td>
<td>898.23</td>
<td>1855.04</td>
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<tr>
<td>1CR_nopts</td>
<td>45.02</td>
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<td>1879.93</td>
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<td>1CR_shallow</td>
<td>22.82</td>
<td>151.67</td>
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<td>456.17</td>
<td>421.93</td>
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<td>689.59</td>
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<td>1CR_steep</td>
<td>9.20</td>
<td>125.68</td>
<td>239.16</td>
<td>432.64</td>
<td>386.88</td>
<td>1693.87</td>
<td>705.64</td>
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<tr>
<td>2CR_150</td>
<td>13.97</td>
<td>148.84</td>
<td>555.71</td>
<td>755.94</td>
<td>1137.47</td>
<td>2033.95</td>
<td>775.55</td>
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<td>2CR_250</td>
<td>19.76</td>
<td>143.71</td>
<td>248.07</td>
<td>607.17</td>
<td>864.09</td>
<td>2043.26</td>
<td>777.87</td>
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**Time on Dialysis**

Distribution of Time on Dialysis at Transplant

Distribution of Years on Dialysis at Transplant, Kidney-Alone

*Distribution of Years on Dialysis at Transplant, Kidney-Alone*
**Years on Dialysis at Transplant, Kidney-Alone Transplants**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>5th %ile</th>
<th>Q1</th>
<th>Median</th>
<th>Mean</th>
<th>Q3</th>
<th>95th %ile</th>
<th>Std Deviation</th>
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<td>6.43</td>
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<td>2.13</td>
<td>4.89</td>
<td>5.23</td>
<td>7.44</td>
<td>11.99</td>
<td>4.06</td>
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<tr>
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<td>0</td>
<td>2.13</td>
<td>4.87</td>
<td>5.22</td>
<td>7.45</td>
<td>11.97</td>
<td>4.06</td>
</tr>
<tr>
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<td>2.13</td>
<td>4.84</td>
<td>5.21</td>
<td>7.42</td>
<td>11.97</td>
<td>4.06</td>
</tr>
<tr>
<td>2CR_150</td>
<td>0</td>
<td>2.14</td>
<td>4.43</td>
<td>4.83</td>
<td>6.78</td>
<td>11.05</td>
<td>3.76</td>
</tr>
<tr>
<td>2CR_250</td>
<td>0</td>
<td>2.21</td>
<td>4.69</td>
<td>5.07</td>
<td>7.13</td>
<td>11.52</td>
<td>3.91</td>
</tr>
</tbody>
</table>

**DSA Level Variability**

*Variance in Transplant Rates Across Listing DSAs*

**Variance of Transplants Rates Across Listing DSAs**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Transplant Rate, KI</th>
<th>Transplant Rate, KP</th>
<th>Transplant Rate, PA</th>
</tr>
</thead>
<tbody>
<tr>
<td>BL</td>
<td>0.0071 (0.0064,0.0076)</td>
<td>0.11 (0.09,0.14)</td>
<td>2 (0.17,8.31)</td>
</tr>
<tr>
<td>1CR_nopts</td>
<td>0.002 (0.0019,0.0022)</td>
<td>0.12 (0.09,0.14)</td>
<td>0.21 (0.02,1.2)</td>
</tr>
<tr>
<td>1CR_shallow</td>
<td>0.0019 (0.0016,0.0021)</td>
<td>0.11 (0.09,0.13)</td>
<td>0.15 (0.03,0.44)</td>
</tr>
<tr>
<td>1CR_steep</td>
<td>0.0016 (0.0015,0.0018)</td>
<td>0.13 (0.1,0.16)</td>
<td>0.23 (0.03,1.24)</td>
</tr>
<tr>
<td>2CR_150</td>
<td>0.009 (0.0078,0.0101)</td>
<td>0.13 (0.1,0.16)</td>
<td>0.55 (0.13,1.6)</td>
</tr>
<tr>
<td>2CR_250</td>
<td>0.0021 (0.0021,0.0022)</td>
<td>0.16 (0.12,0.2)</td>
<td>1.48 (0.02,10.99)</td>
</tr>
</tbody>
</table>

**Standard Deviation in Metrics Across Listing DSAs**

*Standard Deviation of Metrics Across Listing DSAs For Transplant Recipients*

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Median Donor-Recipient Distance</th>
<th>Median Time on Dialysis, KI</th>
<th>Median Time on Waitlist: KI</th>
<th>Median Time on Waitlist: KP</th>
<th>Median Time on Waitlist: PA</th>
</tr>
</thead>
<tbody>
<tr>
<td>BL</td>
<td>53.9 (52.1,56.9)</td>
<td>427.5 (414.4,438)</td>
<td>299.2 (279.3,312.4)</td>
<td>209 (189.3,234.1)</td>
<td>304.3 (222.7,534.1)</td>
</tr>
<tr>
<td>1CR_nopts</td>
<td>91.4 (90.1,93.7)</td>
<td>414.9 (399,435.2)</td>
<td>322.7 (304.3,331.6)</td>
<td>233 (224.5,247.6)</td>
<td>453.4 (375.4,631.1)</td>
</tr>
<tr>
<td>1CR_shallow</td>
<td>88.4 (84.4,91.2)</td>
<td>418.1 (404.9,434.4)</td>
<td>325.1 (318.4,337.6)</td>
<td>232.4 (208.4,255.2)</td>
<td>463.1 (349.1,522.1)</td>
</tr>
<tr>
<td>1CR_steep</td>
<td>86.4 (83.9,90.6)</td>
<td>409.7 (379,439.6)</td>
<td>319.8 (310.9,335.3)</td>
<td>226 (195.4,242.9)</td>
<td>443.2 (359.6,533.7)</td>
</tr>
<tr>
<td>2CR_150</td>
<td>39.4 (38.6,40.6)</td>
<td>417.3 (376.9,449.9)</td>
<td>305.3 (283.7,324)</td>
<td>213.5 (185.1,234.9)</td>
<td>392.9 (238.8,587.2)</td>
</tr>
<tr>
<td>2CR_250</td>
<td>60.1 (57,62.4)</td>
<td>414.7 (392.9,444.7)</td>
<td>317.4 (300.3,329.4)</td>
<td>214.5 (178.5,236.1)</td>
<td>418.2 (343.3,541)</td>
</tr>
</tbody>
</table>
Subgroup Analyses

The dot plots below display the range of results across the 10 simulations as a vertical line extending from the minimum value to the maximum value found for that metric and scenario. A point along that line marks the mean value of the metric across the 10 iterations.
Transplant Rates

Transplant Rates: Age 0-17

Transplant Rates by Age 0-17: Kidney

Transplant Rates by Age 0-17: Kidney
Transplant Rates: Age 18+

Transplant Rates by Age 18+: Kidney

Transplant Rates by Age 18+: Kidney
Transplant Rates by Age 18+: Kidney-Pancreas
Transplant Rates by Age 18+: Pancreas

Transplant Rates by Age 18+: Pancreas
Transplant Rates: Race

Transplant Rates by Race: Kidney

Transplant Rates by Race: Kidney
Transplant Rates by Race: Kidney-Pancreas

Transplant Rates by Race: Kidney-Pancreas
Transplant Rates by Race: Pancreas
Transplant Rates: Ethnicity

Transplant Rates by Ethnicity: Kidney

Transplant Rates by Ethnicity: Kidney
Transplant Rates by Ethnicity: Kidney-Pancreas

Transplant Rates by Ethnicity: Kidney-Pancreas
Transplant Rates by Ethnicity: Pancreas

Transplant Rates by Ethnicity: Pancreas
Transplant Rates: Sex

Transplant Rates by Sex: Kidney

Transplant Rates by Sex: Kidney
Transplant Rates by Sex: Kidney-Pancreas

Transplant Rates by Sex: Kidney-Pancreas
Transplant Rates by Sex: Pancreas

![Graph showing transplant rates by sex for pancreas transplants.]
Transplant Rates: ABO Group

Transplant Rates by ABO Group: Kidney

Transplant Rates by ABO Group: Kidney
Transplant Rates by ABO Group: Kidney-Pancreas
Transplant Rates by ABO Group: Pancreas
Transplant Rates: Diagnosis

Transplant Rates by Diagnosis: Kidney

Transplant Rates by Diagnosis: Kidney

Transplant Rates by Diagnosis: Kidney
Transplant Rates by Diagnosis: Kidney-Pancreas

Transplant Rates by Diagnosis: Kidney-Pancreas
Transplant Rates by Diagnosis: Pancreas

**Hypertension**

**Other**

**Type 1 Diabetes**

**Type 2 Diabetes**

Transplant Rates by Diagnosis: Pancreas
Transplant Rates: Dialysis Time

Transplant Rates by Dialysis Time: Kidney

Transplant Rates by Dialysis Time: Kidney
Transplant Rates: cPRA

Transplant Rates by cPRA: Kidney

Transplant Rates by cPRA: Kidney
Transplant Rates by cPRA: Kidney-Pancreas

Transplant Rates by cPRA: Kidney-Pancreas
Transplant Rates by cPRA: Pancreas

Transplant Rates by cPRA: Pancreas
Transplant Rates by Payment Status: Kidney
Transplant Rates by Payment Status: Kidney-Pancreas

Transplant Rates by Payment Status: Kidney-Pancreas
Transplant Rates by Payment Status: Pancreas

**Medicaid**

**Medicare**

**Private**

**Scenario**

BL, 1CR_nopis, 1CR_shallow, 1CR_steep, 2CR_150, 2CR_250

*Transplant Rates by Payment Status: Pancreas*
Transplant Rates: Urbanicity

Transplant Rates by Urbanicity: Kidney

Transplant Rates by Urbanicity: Kidney
Transplant Rates by Urbanicity: Kidney-Pancreas

Graph showing transplant rates for different urbanicity categories: Metropolitan, Not Metropolitan, Micropolitan, Small Town, and Rural. The x-axis represents different scenarios, and the y-axis represents transplants per patient-year. The graph illustrates the distribution of transplant rates across various urbanicity levels.

Transplant Rates by Urbanicity: Kidney-Pancreas
Transplant Rates by Urbanicity: Pancreas

Transplant Rates by Urbanicity: Pancreas
Transplant Rates: EPTS

Transplant Rates by EPTS: Kidney

Transplant Rates by EPTS: Kidney
Transplant Rates: Median Household Income of Candidate Permanent Zip Code

Transplant Rates by Median Household Income of Candidate Permanent Zip Code: Kidney

Transplant Rates by Median Household Income of Candidate Permanent Zip Code: Kidney
Transplant Rates by Median Household Income of Candidate Permanent Zip Code: Kidney-Pancreas
Transplant Rates by Median Household Income of Candidate Permanent Zip Code: Pancreas

Transplants per patient-year

Scenario

0-35,000
35,000-45,000
45,000-55,000
55,000-70,000
>= 70,000

BL 1CR_nopsl 1CR_shallow 1CR_deep 2CR_150 2CR_250
Transplant Counts

**Transplant Counts: Age at Transplant 0-17**

*Transplant Counts by Age at Transplant 0-17: Kidney*

---

*Transplant Counts by Age at Transplant 0-17: Kidney*
Transplant Counts: Age at Transplant 18+

Transplant Counts by Age at Transplant 18+: Kidney

Transplant Counts by Age at Transplant 18+: Kidney
Transplant Counts by Age at Transplant 18+: Kidney-Pancreas

Transplant Counts by Age at Transplant 18+: Kidney-Pancreas
Transplant Counts by Age at Transplant 18+: Pancreas

Transplant Counts by Age at Transplant 18+: Pancreas
Transplant Counts: Race

Transplant Counts by Race: Kidney

Transplant Counts by Race: Kidney
Transplant Counts by Race: Kidney-Pancreas

Transplant Counts by Race: Kidney-Pancreas
Transplant Counts by Race: Pancreas
Transplant Counts: Ethnicity

Transplant Counts by Ethnicity: Kidney

Transplant Counts by Ethnicity: Kidney
Transplant Counts by Ethnicity: Kidney-Pancreas

Transplant Counts by Ethnicity: Kidney-Pancreas
Transplant Counts by Ethnicity: Pancreas

Transplant Counts by Ethnicity: Pancreas
Transplant Counts: Sex

Transplant Counts by Sex: Kidney

Transplant Counts by Sex: Kidney
Transplant Counts by Sex: Kidney-Pancreas
Transplant Counts by Sex: Pancreas

Transplant Counts by Sex: Pancreas
Transplant Counts: ABO Group

Transplant Counts by ABO Group: Kidney

Transplant Counts by ABO Group: Kidney
Transplant Counts by ABO Group: Kidney-Pancreas

Graph showing transplant counts by ABO group for kidney-pancreas transplants in different scenarios.
Transplant Counts by ABO Group: Pancreas
Transplant Counts: Diagnosis

Transplant Counts by Diagnosis: Kidney

![Graph showing transplant counts by diagnosis for Kidney transplants. The graph compares different conditions such as CRMD, Diabetes, Glomerular Disease, Hypertension, Other, and PKD across various scenarios such as BL, 1CR_noplate, 1CR_shallow, 1CR_sleep, 2CR_150, and 2CR_250. The data is represented in a bar chart format, showing the number of transplants per year.]
Transplant Counts by Diagnosis: Kidney-Pancreas

Transplant Counts by Diagnosis: Kidney-Pancreas
Transplant Counts by Diagnosis: Pancreas

Transplant Counts by Diagnosis: Pancreas
Transplant Counts: Dialysis Time

Transplant Counts by Dialysis Time: Kidney
Transplant Counts: cPRA

Transplant Counts by cPRA: Kidney
Transplant Counts by cPRA: Kidney-Pancreas

Transplant Counts by cPRA: Kidney-Pancreas
Transplant Counts by cPRA: Pancreas

Transplant Counts by cPRA: Pancreas
Transplant Counts: Payment Status

Transplant Counts by Payment Status: Kidney

Transplant Counts by Payment Status: Kidney
Transplant Counts by Payment Status: Kidney-Pancreas
Transplant Counts by Payment Status: Pancreas

[Graph showing transplant counts by payment status (Medicaid, Medicare, Private) across different scenarios (BL, 1CR_nopls, 1CR_shallow, 1CR_sleep, 2CR_150, 2CR_250).]

Transplant Counts by Payment Status: Pancreas
Transplant Counts: Urbanicity

Transplant Counts by Urbanicity: Kidney

Transplant Counts by Urbanicity: Kidney
Transplant Counts by Urbanicity: Kidney-Pancreas

Transplant Counts by Urbanicity: Kidney-Pancreas
Transplant Counts by Urbanicity: Pancreas
Transplant Counts: Local/Regional/National

Transplant Counts by Local/Regional/National: Kidney

Transplant Counts by Local/Regional/National: Kidney
Transplant Counts by Local/Regional/National: Kidney-Pancreas

Transplant Counts by Local/Regional/National: Kidney-Pancreas
Transplant Counts by Local/Regional/National: Pancreas

Transplant Counts by Local/Regional/National: Pancreas
Transplant Counts: Region

Transplant Counts by Region: Kidney

![Graph showing transplant counts by region for Kidney transplants.](image-url)
Transplant Counts by Region: Kidney-Pancreas

Transplant Counts by Region: Kidney-Pancreas
Transplant Counts by Region: Pancreas
Transplant Counts: EPTS

Transplant Counts by EPTS: Kidney

Transplant Counts by EPTS: Kidney
Transplant Counts by Median Household Income of Candidate Permanent Zip Code: Kidney
Transplant Counts by Median Household Income of Candidate Permanent Zip Code: Kidney-Pancreas
Transplant Counts by Median Household Income of Candidate Permanent Zip Code: Pa

Transplant Counts by Median Household Income of Candidate Permanent Zip Code: Pancreas
Transplant Counts: Donor KDPI

Transplant Counts by Donor KDPI: Kidney

Transplant Counts by Donor KDPI: Kidney
Transplant Counts: DCD Donor

Transplant Counts by DCD Donor: Kidney
Transplant Counts: Number of DR mismatches

Transplant Counts by Number of DR mismatches: Kidney

Transplant Counts by Number of DR mismatches: Kidney
Transplant Percentages

**Transplant Percentages: Age at Transplant 0-17**

*Percent of Transplants by Age at Transplant 0-17: Kidney*

---

*Percent of Transplants by Age at Transplant 0-17: Kidney*
Transplant Percentages: Age at Transplant 18+

Percent of Transplants by Age at Transplant 18+: Kidney

Percent of Transplants by Age at Transplant 18+: Kidney
Percent of Transplants by Age at Transplant 18+: Kidney-Pancreas

Percent of Transplants by Age at Transplant 18+: Kidney-Pancreas
Percent of Transplants by Age at Transplant 18+: Pancreas

Percent of Transplants by Age at Transplant 18+: Pancreas
Transplant Percentages: Race

Percent of Transplants by Race: Kidney

Percent of Transplants by Race: Kidney
Percent of Transplants by Race: Kidney-Pancreas

- **Asian**
- **Black**
- **Other**
- **White**

Percent of Transplants by Race: Kidney-Pancreas
Percent of Transplants by Race: Pancreas
Transplant Percentages: Ethnicity

Percent of Transplants by Ethnicity: Kidney

---

Percent of Transplants by Ethnicity: Kidney
Percent of Transplants by Ethnicity: Kidney-Pancreas

Percent of Transplants by Ethnicity: Kidney-Pancreas
Percent of Transplants by Ethnicity: Pancreas
Transplant Percentages: Sex

Percent of Transplants by Sex: Kidney

Percent of Transplants by Sex: Kidney
Percent of Transplants by Sex: Kidney-Pancreas

Percent of Transplants by Sex: Kidney-Pancreas
Percent of Transplants by Sex: Pancreas
Transplant Percentages: ABO Group

Percent of Transplants by ABO Group: Kidney

Percent of Transplants by ABO Group: Kidney
Percent of Transplants by ABO Group: Kidney-Pancreas

---

Percent of Transplants by ABO Group: Kidney-Pancreas
Percent of Transplants by ABO Group: Pancreas

---

Percent of Transplants by ABO Group: Pancreas
Transplant Percentages: Diagnosis

Percent of Transplants by Diagnosis: Kidney

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<th>Diabetes</th>
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<th>Hypertension</th>
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<table>
<thead>
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<tbody>
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Percent of Transplants by Diagnosis: Kidney
Percent of Transplants by Diagnosis: Kidney-Pancreas
Percent of Transplants by Diagnosis: Pancreas

Percent of Transplants by Diagnosis: Pancreas
Transplant Percentages: Dialysis Time

Percent of Transplants by Dialysis Time: Kidney

Percent of Transplants

Scenario

BL 1CR_nopls 1CR_shallow 1CR_steep 2CR_150 2CR_250

BL 1CR_nopls 1CR_shallow 1CR_steep 2CR_150 2CR_250

Percent of Transplants by Dialysis Time: Kidney
Transplant Percentages: cPRA

Percent of Transplants by cPRA: Kidney
Percent of Transplants by cPRA: Kidney-Pancreas
Percent of Transplants by cPRA: Pancreas
Transplant Percentages: Payment Status

Percent of Transplants by Payment Status: Kidney

Percent of Transplants by Payment Status: Kidney
Percent of Transplants by Payment Status: Kidney-Pancreas

Percent of Transplants by Payment Status: Kidney-Pancreas
Percent of Transplants by Payment Status: Pancreas
Transplant Percentages: Urbanicity

Percent of Transplants by Urbanicity: Kidney

Percent of Transplants by Urbanicity: Kidney
Percent of Transplants by Urbanicity: Kidney-Pancreas

Percent of Transplants by Urbanicity: Kidney-Pancreas
Percent of Transplants by Urbanicity: Pancreas

---

Percent of Transplants by Urbanicity: Pancreas
Transplant Percentages: Local/Regional/National

Percent of Transplants by Local/Regional/National: Kidney

Percent of Transplants by Local/Regional/National: Kidney
Percent of Transplants by Local/Regional/National: Kidney-Pancreas

**Local**
- BL: 100%
- 1CR_nopts: 75%
- 1CR_shallow: 50%
- 1CR_deep: 25%
- 2CR_150: 0%
- 2CR_250: 0%

**National**
- BL: 100%
- 1CR_nopts: 75%
- 1CR_shallow: 50%
- 1CR_deep: 25%
- 2CR_150: 0%
- 2CR_250: 0%

**Regional**
- BL: 100%
- 1CR_nopts: 75%
- 1CR_shallow: 50%
- 1CR_deep: 25%
- 2CR_150: 0%
- 2CR_250: 0%

*Percent of Transplants by Local/Regional/National: Kidney-Pancreas*
Percent of Transplants by Local/Regional/National: Pancreas
Transplant Percentages: Region

Percent of Transplants by Region: Kidney
Percent of Transplants by Region: Kidney-Pancreas

Scenario

Percent of Transplants by Region: Kidney-Pancreas
Percent of Transplants by Region: Pancreas

Percent of Transplants

Scenario

BL, 1CR_nopt, 1CR_shallow, 1CR_steep, 2CR_150, 2CR_250
Transplant Percentages: EPTS

Percent of Transplants by EPTS: Kidney

Percent of Transplants by EPTS: Kidney
Transplant Percentages: Median Household Income of Candidate Permanent Zip Code

Percent of Transplants by Median Household Income of Candidate Permanent Zip Code: Kidney
Percent of Transplants by Median Household Income of Candidate Permanent Zip Code: Kidney-Pancreas
Percent of Transplants by Median Household Income of Candidate Permanent Zip Code: Pancreas
Transplant Percentages: Donor KDPI

Percent of Transplants by Donor KDPI: Kidney

Percent of Transplants by Donor KDPI: Kidney
Transplant Percentages: DCD Donor

Percent of Transplants by DCD Donor: Kidney

Percent of Transplants by DCD Donor: Kidney
Transplant Percentages: Number of DR mismatches

Percent of Transplants by Number of DR mismatches: Kidney

Choropleth Maps of Metrics by DSA

DSAs with either no transplant program or without the given outcome during the simulation (e.g. transplant or waitlist death) are both shown as having “No Data.”
Maps of Transplant Rate by DSA

**Kidney-Alone: By Listing DSA**

- BL
- 1CR_nepts
- 1CR_shallow
- 1CR_sleep
- 2CR_150
- 2CR_250

*Kidney-Alone: By Listing DSA*
Maps of Transplant Rate by DSA

Kidney-Pancreas: By Listing DSA

Kidney-Pancreas: By Listing DSA
Maps of Transplant Rate by DSA

Pancreas- Alone: By Listing DSA
Maps of Median Years on Dialysis at Transplant, Kidney-Alone

Maps of Median Years on Dialysis at Transplant, Kidney-Alone

Maps of Median Years on Dialysis at Transplant, Kidney-Alone
Maps of Median Years on Waitlist at Transplant, Kidney-Alone

Maps of Median Years on Waitlist at Transplant, Kidney-Alone

Maps of Median Years on Waitlist at Transplant, Kidney-Alone

Maps of Median Years on Waitlist at Transplant, Kidney-Alone

Maps of Median Years on Waitlist at Transplant, Kidney-Alone
Maps of Median Years on Waitlist at Transplant, Kidney-Pancreas

Maps of Median Years on Waitlist at Transplant, Kidney-Pancreas
Maps of Median Years on Waitlist at Transplant, Pancreas-Alone

Maps of Median Years on Waitlist at Transplant, Pancreas-Alone
Maps of Median cPRA at Transplant, Kidney-Alone
Maps of Waitlist Mortality Rate by DSA, Kidney-Alone
Maps of Waitlist Mortality Rate by DSA, Kidney-Pancreas

Maps of Waitlist Mortality Rate by DSA, Kidney-Pancreas
Maps of Waitlist Mortality Rate by DSA, Pancreas-Alone
Maps of Transplant Rate by Region, Kidney-Alone

Maps of Transplant Rate by Region, Kidney-Alone

Maps of Transplant Rate by Region, Kidney-Alone
Maps of Transplant Rate by Region, Kidney-Pancreas
Maps of Transplant Rate by Region, Pancreas-Alone
Maps of Median Organ Travel Distance by DSA, Kidney-Alone
Maps of Median Organ Travel Distance by DSA, Kidney-Pancreas
Maps of Median Organ Travel Distance by DSA, Pancreas-Alone
Distribution of Time on Waiting List at Transplant

Distribution of Years on Waitlist at Transplant, Kidney-Alone

Distribution of Years on Waitlist at Transplant, Kidney-Alone
### Time on the Waitlist at Transplant, Kidney-Alone Transplants

<table>
<thead>
<tr>
<th>Scenario</th>
<th>5th %ile</th>
<th>Q1</th>
<th>Median</th>
<th>Mean</th>
<th>Q3</th>
<th>95th %ile</th>
<th>Std Deviation</th>
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Distribution of Years on Waitlist at Transplant, Kidney-Pancreas

Distribution of Years on Waitlist at Transplant, Kidney-Pancreas
### Time on the Waitlist at Transplant, Kidney-Pancreas Transplants

<table>
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Distribution of Years on Waitlist at Transplant, Pancreas-Alone
### Time on the Waitlist at Transplant, Pancreas-Alone Transplants

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<th>Q3</th>
<th>95th %ile</th>
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