Continuous distribution simulations for lung transplant

This report was provided to HRSA by SRTR in support of ongoing policy consideration by the OPTN Lung Committee. The analysis described herein was conducted at the specific request of the OPTN Committee and does not represent a full or final analysis related to the policy issue under consideration.

Prepared by:

Andrew Wey, PhD; Jon Miller, PhD; Melissa Skeans, MS; Tim Weaver, MS; Katie Audette, MS; Maryam Valapour, MD, MPP

Data Request ID#: LU2020_05

Timeline:

Request made December 3, 2020

Analysis plan submitted December 14, 2020

Analysis submitted February 12, 2021

Next Committee meeting February 18, 2021

Table of Contents

Data request: Continuous distribution simulations for lung transplant

Background:

The OPTN Lung Committee is currently working on adopting the Continuous Distribution framework for lung allocation. At the November 19, 2020, meeting of the OPTN Lung Committee, the Committee requested simulations for 4 different scenarios, plus current rules. Each model, a run of the Thoracic Simulated Allocation Model (TSAM) software, represents a different set of weights for each of the 6 attributes that will define continuous distribution.

Strategic Goal or Committee Project Addressed:

Increase equity in access to transplants.

Request:

The continuous distribution framework for lung transplant includes 6 components: waitlist survival, posttransplant survival, candidate biology, pediatric priority, prior living donor, and proximity efficiency. The OPTN Lung Committee has spent considerable time discussing and evaluating how each component should be prioritized. Their priorities are defined in terms of weights per component. They requested TSAM runs for the current allocation rules, as well as 4 different continuous allocation rules.

Weights per component (proportion)

Component	2.1 LAS	1.1 LAS	High Prox	Cand Biology
Waitlist Survival	0.28	0.21	0.14	0.14
Posttransplant Survival	0.14	0.21	0.14	0.14
Candidate Biology	0.17	0.17	0.11	0.40
Pediatric	0.31	0.31	0.20	0.20
Prior Living Donor	0.04	0.04	0.01	0.01
Proximity Efficiency	0.06	0.06	0.40	0.11

Each component has a rating scale. The committee chose the following rating scales:

1. Waitlist survival: A curve between the shallow and steep nonlinear curve that has been under discussion, where y=points and x=WLAUC, based on the recent LAS update (which is not yet implemented).
2. Posttransplant survival: A linear relationship, where y=points and x=PTAUC, based on the recent LAS update.
3. Candidate biology: A steep non-linear curve for each of blood type, CPRA, and candidate height. Each component is assigned a third of the weight given to "candidate biology" in the table.
4. Pediatric: This is binary, with increased points for candidates aged 0-<18 years at listing.
5. Prior living donor: This is binary, with increased points for candidates who previously donated a lobe of a lung for transplant.
6. Proximity efficiency: There are two components here (proximity and travel cost), each of which gets half the weight given to "proximity efficiency" in the table. For example, in the 2:1 LAS run, proximity is weighted .03, and travel efficiency is weighted .03, for a total of .06 weight. The proximity efficiency curve is a combination of a sigmoidal curve and a line segment, capturing the efficiencies of proximity other than cost. The rating based on cost is a piecewise linear curve, with 4 segments between 0 and 100 miles and one segment from 100 to 6000 miles.

Each continuous distribution TSAM run will compute one global score per patient each time a donor organ arrives in the system, using an equation based on the weights given above.

Study Population

The TSAM cohort includes transplant candidates listed on the lung, heart, and heart-lung waiting lists on January 1, 2018, and candidates added to those waiting lists from January 1, 2018, through December 31, 2019. The posttransplant survival model was estimated with recipients who underwent transplant from January 1, 2018, through December 31, 2019. Recipients were administratively censored on March 12, 2020. The offer acceptance models, used to determine the probability of accepting an offer, were estimated with offers recovered from donors between January 1, 2018, and December 31, 2018. Results for heart transplant candidates were not included in this report.

Methods

To compare the effects of each continuous distribution scenario on different segments of the cohort population, we examined waitlist outcomes (waitlist mortality, transplant rates) and posttransplant outcomes per scenario by several stratification variables: age, sex, race, ethnicity, height, blood type, LAS, WLAUC, PTAUC, and diagnosis group. Among simulated transplants, we examined transplant counts, distribution, and posttransplant outcomes by distance between donor and recipient. Waitlist outcomes are not available by distance, because distance is not defined until a simulated offer acceptance generates a donor/recipient pair. Among transplants, we also examined median donor-to-recipient distance for each non-distance stratification variable. Outcomes based on likelihood of driving versus flying were requested. We defined a metric as "expected to fly" if the donor-to-recipient distance was greater than 75 nautical miles (NM). In the analysis plan, we planned to infer driving and flying by distance category, but the 75-NM cut point addresses the question more directly. Distances were computed as straight-line distances.

Each simulation was repeated 10 times. The average, minimum, and maximum of each outcome were calculated overall and by subgroup and given in graphs and tables. Further details about the models used in the simulation are given in the appendix.

Summary

• The number of waitlist deaths declined considerably in all 4 continuous allocation scenarios (e.g., 52% fewer deaths for the 2:1 LAS scenario) compared with current allocation rules, and those declines were larger for scenarios with less emphasis on proximity or candidate biology.

• Distances between donor and recipient hospitals were higher when fewer restrictions (distance and candidate biology) were imposed. For example, the median distance almost doubled for the 2:1 LAS scenario compared with the current allocation but decreased for the high-proximity scenario.

• Two-year predicted posttransplant deaths were similar across scenarios, a finding that held for most subgroups.

Notable group-specific findings:

1. By age group: Under continuous allocation, transplant rates increased for the pediatric population, especially those aged 12-17. Waitlist death counts decreased for adolescents to almost none. Median donor-to-recipient distances were high for the pediatric population

regardless of scenario. Among adults, median distances were higher within scenarios with less emphasis on allocation efficiency, and lower when efficiency was prioritized more.

2. By LAS: Under all continuous allocation scenarios except high proximity, transplant rates for low LAS candidates declined compared with current rules; for high-LAS candidates, transplant rates increased markedly under all continuous allocation scenarios, though less so for the high-proximity scenario. Waitlist deaths declined considerably for candidates with LAS >= 60, and donor-to-recipient distances increased more for high-LAS patients.

3. By height: Under continuous allocation, transplant rates for the shortest and tallest candidates increased compared with current rules, especially in the candidate biology scenario.

4. By race/ethnicity: Transplant rates for Asians and Latinos increased, and decreased for Whites, under most continuous allocation scenarios compared with current rules. Declines in waitlist deaths were more pronounced for Latino candidates (43%-75% declines, compared with 24%-50% declines in other groups).

5. By blood type: Under continuous allocation, transplant rates for blood type O candidates increased considerably, and rates for all other blood types decreased, compared with current rules. Type O recipients were 45.7% of the transplant cohort under current rules and 54.3% under the candidate biology scenario.

6. By WLAUC: Patterns by WLAUC were similar to patterns by LAS, in which transplant rates increased for the most severely ill quartile of patients in all continuous allocation scenarios and more so when candidate disease severity was prioritized over efficiency. In the current rules simulation, 75% of the waitlist deaths were in the lowest WLAUC quartile, and most of the declines in waitlist deaths occurred among candidates with low WLAUC. These low-WLAUC patients also had the largest increases in median donor-to-recipient distances under continuous allocation.

7. By PTAUC: Transplant rates within PTAUC quartiles were more similar across all scenarios than were observed by WLAUC and LAS, reflecting the low variability of PTAUC in the population.

8. By diagnosis group: Under 1:1 LAS, 2:1 LAS, and candidate biology scenarios, transplant rates declined in diagnosis group A compared with current rules, and the number of waitlist deaths was similar. In group B, transplant rates declined for all continuous allocation scenarios, and waitlist deaths did, too. In groups C and D, transplant rates increased and waitlist deaths decreased under continuous allocation. Median distances increased for all continuous allocation scenarios except high proximity, though less so in group A.

9. By distance: The high-proximity scenario maximized the number and percent of simulated transplants from donors within 50 NM (31.2%), and the current rules scenario maximized the number and percent from donors within 250 NM (71%). The three other continuous allocation scenarios had larger proportions of transplants using donors 500-<1000 NM (23.8%-26.7%) and 1000 NM or more (9.2%-13.3%).

Results

Overall Outcomes

Overall, waitlist deaths declined considerably in all continuous allocation scenarios compared with current rules (Figure 2, Table 1). Under the current rules scenario, 438 candidates died awaiting transplant, compared with 208 in the 2:1 LAS, 267 in the candidate biology, and 313 in the high-proximity scenarios. The lowest number of waitlist deaths occurred in the scenario with the highest weight for WLAUC and minimal distance restrictions; the highest number of deaths among continuous allocation scenarios occurred when distance was prioritized.

The scenarios with lowest numbers of waitlist deaths were also the scenarios with higher median organ travel distances (Table 1). Median distance was 194 NM under current rules and ranged from 156 NM (high proximity) to 392 NM (2:1 LAS). The percent of organs expected to have been flown was somewhat less variable, as most donor-recipient pairs were outside of driving range under current rules.

Figure 3 shows the distributions of distances by scenario, and Table 11 shows number and percent of transplants by distance category. Though Figure 3 shows some transplants occurring out to 4000 NM, the number of patients in this group was small. Under current rules and high-proximity scenarios, fewer than 200 cases (<4%) had donor-to-recipient distances of 1000 NM or more, compared with 9%-13% in scenarios in which the efficiency rating had low allocation weight. The high-proximity scenario gave more weight to very nearby candidates, resulting in 31% recipients within 50 NM of their donors, compared with 14% under current rules.

Two-year posttransplant deaths for all scenarios were similar. Though the mean was slightly lower for current rules, the ranges observed across all scenarios overlapped considerably.
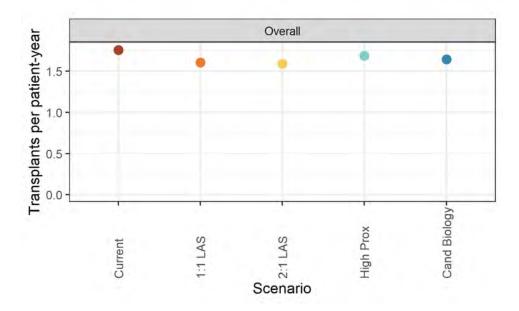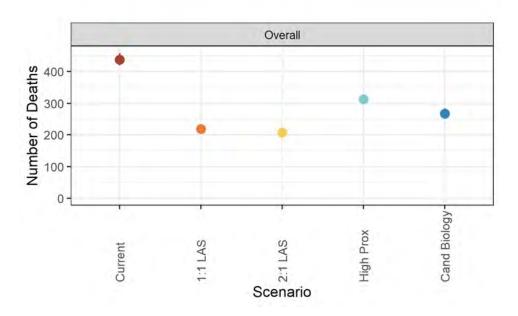

Figure 1: Transplant Rates - Overall
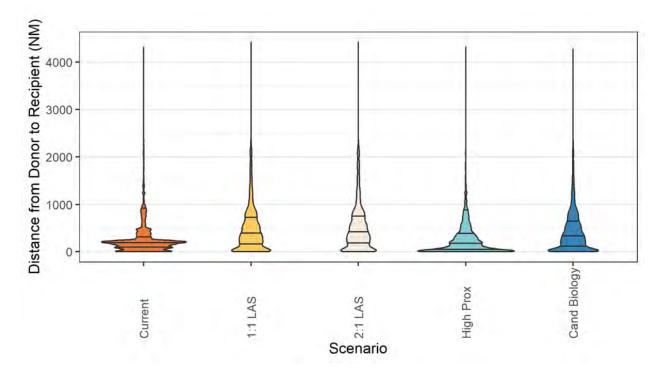
Figure 2: Waitlist Death Counts - Overall

Figure 3: Distribution of Distance from Donor - By Scenario

Table 1: Outcome Counts and Rates by Scenario

Outcome	Current	1.1 LAS	2.1 LAS	High Prox	Cand Biology
Transplant Rate per Patient-Year	1.76 (1.74,1.77)	1.6 (1.59,1.62)	1.59 (1.59,1.6)	1.69 (1.66,1.7)	1.65 (1.64,1.66)
Transplant Count (N)	5053 (5031,5066)	5108 (5097,5113)	5104 (5095,5122)	5117 (5099,5126)	5111 (5101,5121)
Waitlist Mortality Count (N)	438 (419,458)	219 (207,230)	208 (203,210)	313 (303,321)	267 (259,284)
Percent Died by 2 Years Posttransplant	23.7 (22.81,24.61)	23.96 (23.47,24.34)	24.03 (23.41,24.53)	23.99 (23.1,25.25)	24.07 (23.33,24.95)
Median Donor to Recipient Distance	194 (191,198)	365 (355,378)	392 (382,403)	156 (149,158)	304 (299,308)
Percent Expected to Fly (>75NM)	81.07 (80.06,81.68)	79.92 (79.39,80.31)	81.92 (81.72,82.22)	62.91 (62.26,63.47)	75.24 (74.17,75.73)

Outcomes by Age

Simulated outcomes by age-group differed from overall outcomes, especially in children (Table 2). Transplants rates among children aged 0-11 increased from 0.70 transplants per patient-year under current rules to 1.15-1.19 under all continuous allocation scenarios (Figure 4). Transplant rates among children aged 12-17 increased from 1.91 transplants per patient-year to 7.19-8.41 under all continuous allocation scenarios, an approximate 4-fold increase. The proportion of children among transplant recipients increased for all continuous allocation scenarios, though they remained at less than 3% of all recipients.

Adults aged 18-49 also had higher transplant rate point estimates under continuous allocation compared with current rules, though in some cases there was considerable overlap in the rate ranges. Transplant rates declined among 50-64 year olds in the 1:1 LAS, 2:1 LAS, and candidate biology scenarios compared with current rules; the high-proximity scenario had similar rates as current rules in this age group. Compared with current rules, transplant rates declined among candidates aged 65 and older for all continuous allocation scenarios.

Waitlist deaths were similar for children aged 0-11, ranging from 9 in the high-proximity scenario to 12 under current rules (Table 2, Figure 6). Waitlist deaths among children aged 12-17 declined from 8 under current rules to 1 or 2 under all continuous allocation rules. Among adults, declines in waitlist deaths were most dramatic under 2:1 LAS and 1:1 LAS scenarios and still considerable under candidate biology and high-proximity scenarios.

The number and percent of 2-year posttransplant deaths among children appears concerning, with considerable increases in death among the continuous distribution scenarios compared with current rules (Table 2, Figure 7). Due to the small number of patients aged 17 and younger, the posttransplant model for this group included a predictor for only donor age older than 20 years. The increase in posttransplant death among children was likely the result of an increase in the average donor age for transplants among children aged 12-18. Among adults, the percent of posttransplant deaths was similar in all scenarios.

Among children aged 0-11 years, median distance from donor to recipient was high (>500 NM) and variable (495-813 NM for current rules), and range across scenarios overlapped widely (Table 2). Among children aged 12-17 years, median distances increased for all continuous allocation scenarios compared with current rules, possibly reflecting the high priority given to all children under continuous allocation. Under current rules, children aged 12-17 had high priority for pediatric donors out to 1000 NM but similar priority to adults for more numerous adult donors. In all continuous allocation scenarios, all children had increased priority for all donors through the pediatric weight scale, and many pediatric candidates got increased priority to all donors through the candidate biology scale.

Among adults, patterns of donor-to-recipient distance were similar to the overall data, in which distances under current rules and high-proximity scenarios were lower than distances under rules that give allocation efficiency little weight.

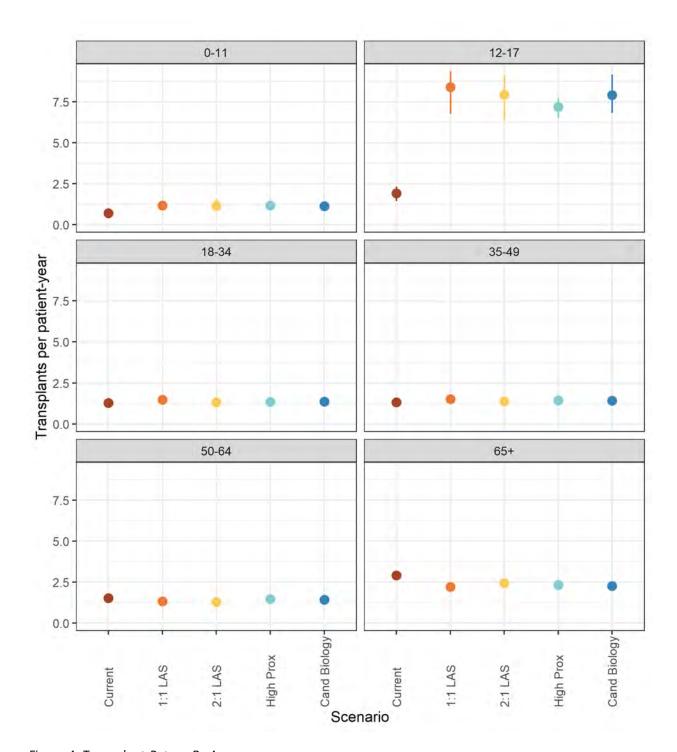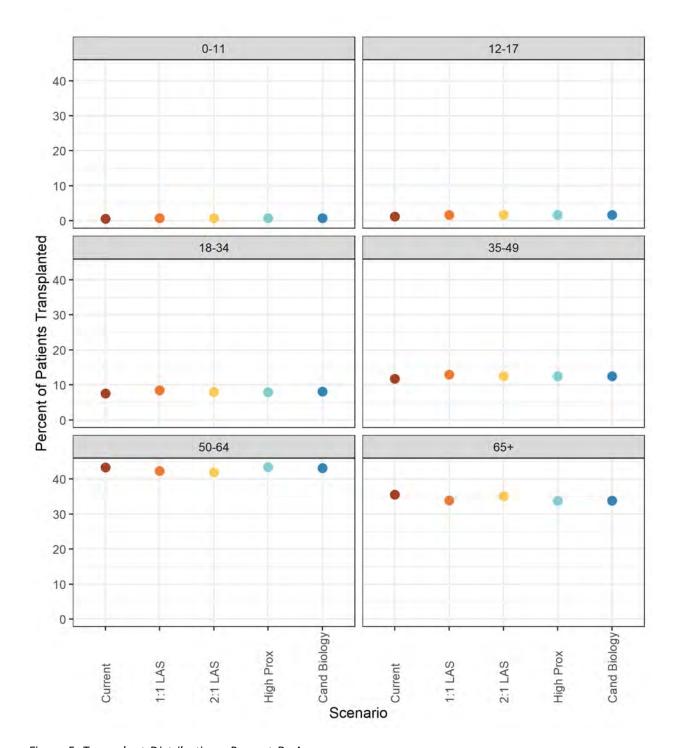Figure 4: Transplant Rates - By Age
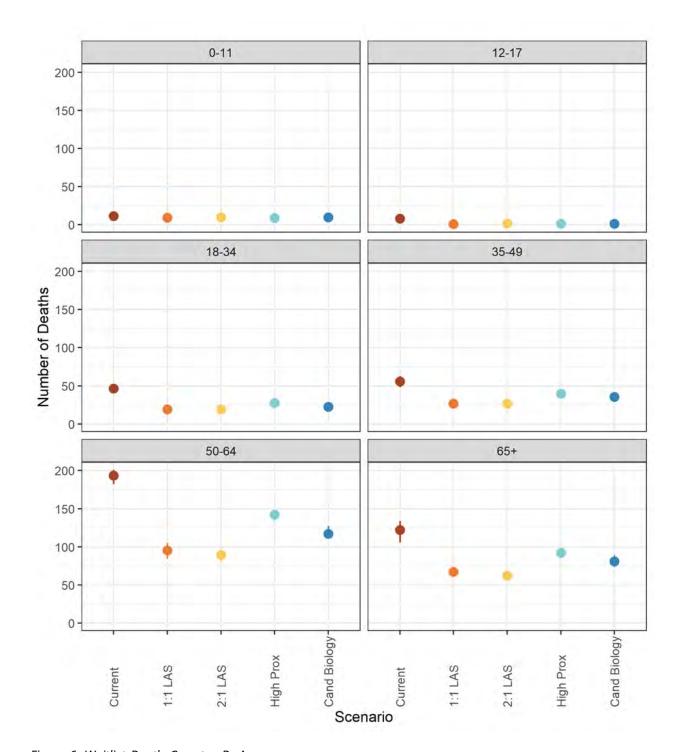
Figure 5: Transplant Distribution - Percent By Age
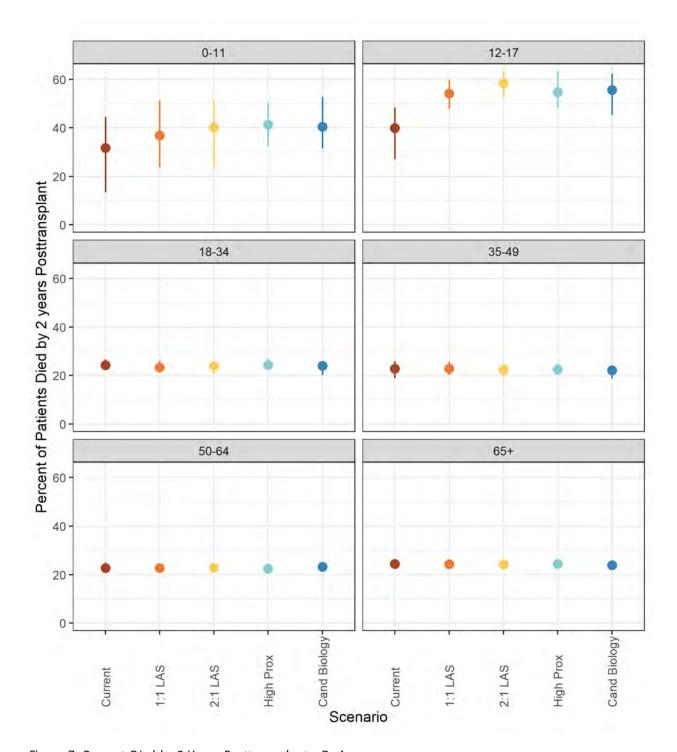
Figure 6: Waitlist Death Counts - By Age

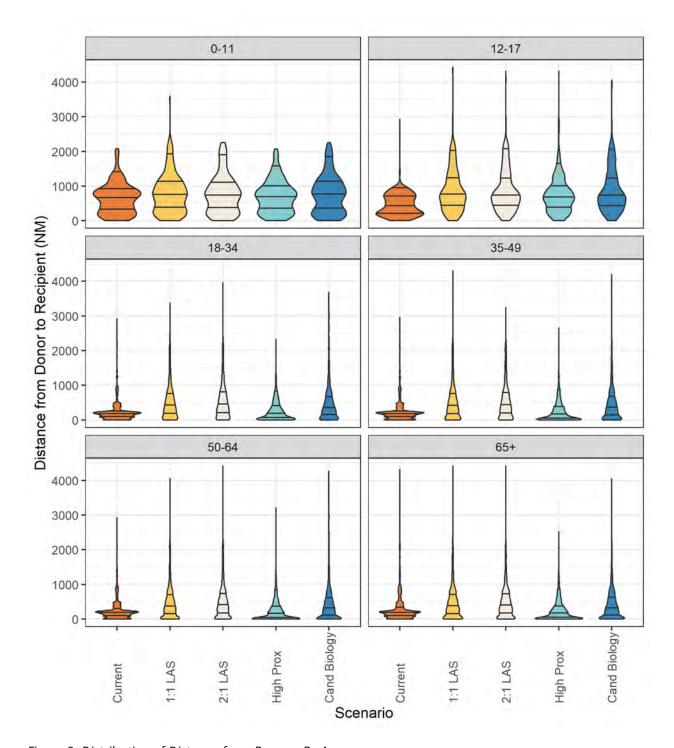Figure 7: Percent Died by 2 Years Posttransplant - By Age

Figure 8: Distribution of Distance from Donor - By Age

Table 2: Outcome Counts and Rates by Scenario by Age

Outcome	Age (Years)	Current	1.1 LAS	2.1 LAS	High Prox	Cand Biology
Transplant Count (N)						
	0-11	29 (24,35)	39 (34,42)	38 (35,44)	38 (36,42)	38 (34,42)
	12-17	59 (53,66)	87 (84,89)	86 (83,89)	84 (82,87)	85 (84,87)
	18-34	384 (373,394)	432 (420,443)	411 (404,421)	406 (391,418)	415 (406,428)
	35-49	594 (585,601)	660 (649,668)	638 (623,647)	638 (615,664)	637 (628,652)
	50-64	2189 (2162,2208)	2160 (2132,2178)	2142 (2120,2158)	2220 (2198,2242)	2206 (2186,2221)
	65+	1798 (1775,1823)	1731 (1704,1745)	1790 (1773,1804)	1731 (1716,1766)	1730 (1716,1741)
Transplant Rate per Patient-Year						
	0-11	0.7 (0.53,0.91)	1.19 (0.97,1.34)	1.16 (0.98,1.57)	1.18 (0.98,1.45)	1.15 (0.95,1.42)
	12-17	1.91 (1.46,2.33)	8.4 (6.75,9.35)	7.93 (6.39,9.15)	7.18 (6.51,7.71)	7.91 (6.81,9.15)
	18-34	1.29 (1.19,1.38)	1.49 (1.39,1.57)	1.33 (1.29,1.38)	1.35 (1.27,1.44)	1.37 (1.33,1.46)
	35-49	1.31 (1.29,1.34)	1.51 (1.45,1.57)	1.37 (1.29,1.41)	1.44 (1.34,1.56)	1.42 (1.37,1.5)
	50-64	1.53 (1.47,1.56)	1.33 (1.3,1.35)	1.29 (1.27,1.32)	1.48 (1.45,1.52)	1.42 (1.39,1.45)
	65+	2.92 (2.83,3.05)	2.2 (2.15,2.27)	2.44 (2.39,2.49)	2.33 (2.26,2.37)	2.27 (2.24,2.31)
Transplant Distribution (Percent)						
	0-11	0.58 (0.47,0.7)	0.76 (0.66,0.82)	0.75 (0.69,0.86)	0.75 (0.7,0.82)	0.74 (0.67,0.82)
	12-17	1.17 (1.05,1.31)	1.7 (1.64,1.75)	1.68 (1.63,1.74)	1.65 (1.6,1.7)	1.67 (1.64,1.7)

Table 2: Outcome Counts and Rates by Scenario by Age

Outcome	Age (Years)	Current	1.1 LAS	2.1 LAS	High Prox	Cand Biology
	18-34	7.59 (7.4,7.78)	8.45 (8.24,8.67)	8.05 (7.92,8.26)	7.93 (7.65,8.16)	8.12 (7.93,8.38)
	35-49	11.76 (11.58,11.95)	12.91 (12.71,13.07)	12.5 (12.23,12.67)	12.46 (12.01,12.99)	12.46 (12.29,12.75)
	50-64	43.31 (42.76,43.76)	42.28 (41.72,42.61)	41.96 (41.52,42.36)	43.38 (43.02,43.78)	43.16 (42.78,43.44)
	65+	35.58 (35.18,36.03)	33.89 (33.33,34.16)	35.06 (34.8,35.33)	33.83 (33.52,34.57)	33.84 (33.57,34.05)
Waitlist Mortality Count (N)						
	0-11	12 (7,14)	10 (8,11)	10 (8,11)	9 (7,12)	10 (8,11)
	12-17	8 (5,12)	1 (1,1)	2 (1,3)	2 (1,2)	1 (1,2)
	18-34	46 (41,51)	19 (16,21)	19 (16,21)	28 (21,31)	23 (19,25)
	35-49	56 (48,63)	27 (24,32)	27 (23,29)	40 (36,44)	36 (31,40)
	50-64	194 (182,201)	96 (85,105)	89 (80,94)	142 (134,149)	117 (113,127)
	65+	122 (106,134)	67 (62,74)	62 (57,68)	92 (85,99)	81 (74,89)
Number Died by 2 Years Posttransplant						
	0-11	9 (4,13)	14 (9,20)	15 (9,22)	16 (13,20)	15 (11,20)
	12-17	24 (16,28)	47 (42,51)	50 (45,54)	46 (41,55)	48 (38,53)
	18-34	93 (86,105)	100 (95,110)	98 (85,107)	99 (88,107)	99 (83,106)
	35-49	136 (113,153)	150 (132,171)	143 (124,159)	144 (126,160)	141 (118,153)
	50-64	498 (475,544)	490 (478,515)	488 (463,506)	499 (475,530)	513 (490,530)

Table 2: Outcome Counts and Rates by Scenario by Age

Outcome	Age (Years)	Current	1.1 LAS	2.1 LAS	High Prox	Cand Biology
	65+	438 (411,457)	422 (404,448)	432 (412,444)	424 (393,447)	414 (385,439)
Percent Died by 2 Years Posttransplant						
	0-11	31.75 (13.33,44.44)	36.82 (23.68,51.28)	40.14 (23.68,51.35)	41.33 (32.5,50)	40.44 (31.43,52.63)
	12-17	39.91 (27.12,48.28)	54.18 (47.73,59.52)	58.33 (52.81,63.1)	54.71 (48.24,63.22)	55.61 (45.24,62.35)
	18-34	24.24 (22.99,26.65)	23.29 (21.44,26.13)	23.84 (20.58,26.03)	24.42 (22.17,26.62)	23.92 (20.1,25.67)
	35-49	22.85 (18.9,25.8)	22.81 (20.18,25.79)	22.43 (19.44,24.92)	22.58 (20.13,24.96)	22.19 (18.64,23.74)
	50-64	22.74 (21.56,25)	22.68 (22.18,23.67)	22.8 (21.56,23.87)	22.47 (21.28,23.91)	23.26 (22.3,23.97)
	65+	24.38 (23.1,25.62)	24.36 (23.35,25.69)	24.14 (22.86,24.93)	24.48 (22.68,25.78)	23.92 (22.44,25.39)
Median Donor to Recipient Distance						
	0-11	652 (495,813)	741 (496,961)	734 (586,825)	689 (550,752)	734 (451,935)
	12-17	402 (322,538)	756 (659,852)	734 (643,830)	673 (591,764)	706 (625,803)
	18-34	181 (173,187)	388 (346,424)	411 (382,450)	162 (140,176)	315 (288,350)
	35-49	184 (174,191)	382 (357,415)	405 (381,444)	134 (105,164)	320 (292,339)
	50-64	193 (190,198)	352 (337,374)	382 (368,397)	143 (135,156)	292 (268,302)
	65+	197 (186,200)	353 (333,378)	376 (347,399)	154 (145,160)	292 (273,304)
Percent Expected to Fly (>75NM)						
	0-11	94.88 (92.59,96.67)	95.66 (92.31,100)	94.47 (91.67,97.56)	95.57 (91.89,97.5)	93.36 (91.18,97.14)
	12-17	93.44 (89.23,100)	96.68 (94.38,98.85)	98.36 (96.43,100)	96.22 (93.1,98.8)	97.2 (95.35,98.82)

Table 2: Outcome Counts and Rates by Scenario by Age

Outcome	Age (Years)	Current	1.1 LAS	2.1 LAS	High Prox	Cand Biology
	18-34	80.47 (78.89,83.89)	82.06 (79.91,85.55)	83.33 (80.98,86)	64.43 (60.2,67.66)	77.55 (73.4,81.27)
	35-49	79.69 (77.65,82.39)	80.11 (78.14,83.77)	81.93 (79.78,83.23)	60.14 (55.9,62.99)	76.23 (74.88,78.61)
	50-64	80.94 (79.78,82.65)	78.85 (78.22,80.07)	81 (79.74,81.78)	60.85 (60.11,62.17)	73.65 (72.03,74.44)
	65+	81.17 (79.21,82.17)	79.45 (78.91,80.92)	81.64 (80.24,83.43)	63.86 (62.63,65)	74.87 (73.66,75.53)

Outcomes by Sex

Simulated outcomes by sex were similar to overall outcomes (Table 3, Figures 9-13).
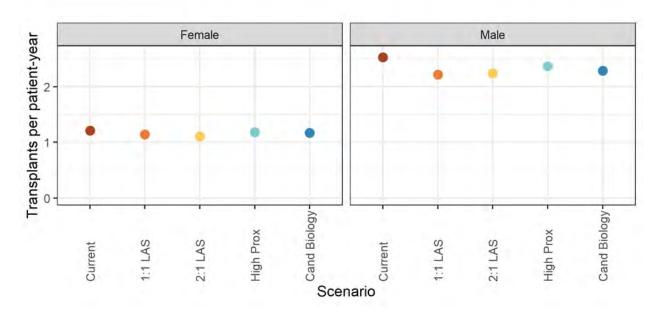

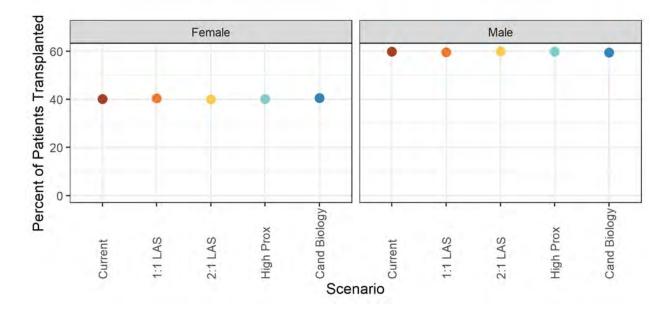*Figure 9: Transplant Rates - By Sex*

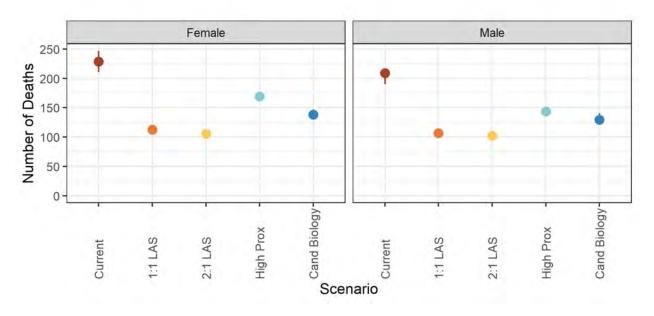*Figure 10: Transplant Distribution - Percent By Sex*
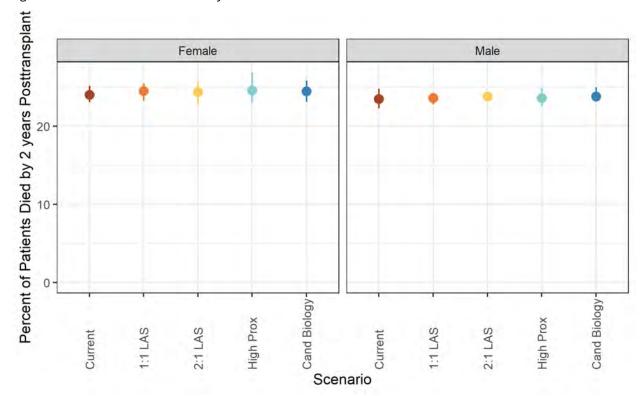
Figure 11: Waitlist Death Counts - By Sex

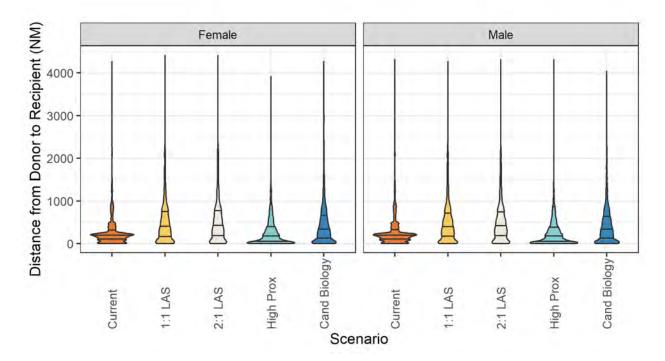Figure 12: Percent Died by 2 Years Posttransplant - By Sex

Figure 13: Distribution of Distance from Donor - By Sex

Table 3: Outcome Counts and Rates by Scenario by Sex

Outcome	Sex	Current	1.1 LAS	2.1 LAS	High Prox	Cand Biology
Transplant Count (N)						
	Female	2024 (2000,2048)	2062 (2044,2079)	2039 (2022,2058)	2052 (2032,2078)	2070 (2054,2097)
	Male	3028 (3008,3051)	3046 (3024,3064)	3066 (3043,3079)	3066 (3047,3087)	3041 (3022,3053)
Transplant Rate per Patient-Year						
	Female	1.21 (1.18,1.23)	1.14 (1.13,1.15)	1.11 (1.09,1.12)	1.18 (1.16,1.21)	1.17 (1.15,1.19)
	Male	2.53 (2.5,2.61)	2.22 (2.17,2.27)	2.24 (2.19,2.29)	2.37 (2.32,2.41)	2.28 (2.23,2.33)
Transplant Distribution (Percent)						
	Female	40.07 (39.69,40.43)	40.36 (40.02,40.72)	39.94 (39.69,40.35)	40.09 (39.72,40.55)	40.5 (40.23,40.97)
	Male	59.93 (59.57,60.31)	59.64 (59.28,59.98)	60.06 (59.65,60.31)	59.91 (59.45,60.28)	59.5 (59.03,59.77)
Waitlist Mortality Count (N)						
	Female	229 (211,247)	112 (106,119)	105 (99,112)	170 (162,177)	138 (131,147)
	Male	209 (190,216)	106 (100,114)	102 (97,109)	143 (138,151)	129 (123,141)
Percent Died by 2 Years Posttransplant						
	Female	24.01 (23.05,25.14)	24.5 (23.23,25.45)	24.38 (22.79,25.69)	24.6 (22.98,26.87)	24.48 (23.13,25.81)
	Male	23.49 (22.31,24.8)	23.6 (22.79,24.31)	23.8 (23.07,24.42)	23.58 (22.58,24.88)	23.8 (23.39,24.95)
Median Donor to Recipient Distance						
	Female	194 (191,196)	363 (347,381)	392 (380,405)	151 (137,164)	299 (287,310)

Table 3: Outcome Counts and Rates by Scenario by Sex

Outcome	Sex	Current	1.1 LAS	2.1 LAS	High Prox	Cand Biology
	Male	194 (191,200)	367 (360,380)	391 (380,409)	158 (152,163)	307 (298,314)
Percent Expected to Fly (>75NM)						
	Female	80.21 (78.98,81.21)	79.05 (78.44,79.69)	81.45 (80.47,82.32)	61.87 (60.65,63.13)	74.65 (73.14,75.89)
	Male	81.64 (79.91,83.33)	80.51 (79.65,81.15)	82.23 (81.34,82.95)	63.61 (62.97,65.08)	75.64 (74.88,76.64)

Outcomes by Race/Ethnicity

Simulated outcomes by race and ethnicity differed from overall outcomes for some groups. Compared with the current rules scenario, transplants rates among Asian candidates increased under all continuous allocation scenarios except high proximity (Figure 14, Table 4). Transplant rates among Latino candidates increased under all continuous allocation scenarios, though the increase was smaller under the high-proximity scenario. Among Black candidates, point estimates for transplant rates were slightly lower under all continuous allocation scenarios compared with current rules, though the ranges of the simulations overlapped in all except the 1:1 LAS scenario. Rates among white candidates declined under all continuous allocation scenarios. As a share of all transplants performed, representation among Asian candidates increased slightly, from 2.6% to 2.7%-3.1%; Latino representation increased from 10.0% to 10.8%-11.8%; Black representation was similar, 10.1% of transplants under current rules to 10.1%-10.2% under continuous allocation rules. White representation declined from 76.5% under current rules to 74.0%-75.5%.

For most race and ethnicity groups, waitlist deaths under 1:1 LAS and 2:1 LAS scenarios declined 40%-50% compared with the number of deaths under current rules. In the high-proximity and candidate biology scenarios, death counts were 25%-35% lower. Declines among Latino candidates were even larger, 72% and 75% for 1:1 LAS and 2:1 LAS scenarios, 43% lower for high proximity, and 60% lower for candidate biology.

The percent of 2-year posttransplant deaths was similar by race and ethnicity groups (Figure 17, Table 4).

The patterns of median distance from donor to recipient by race and ethnicity group were similar to overall patterns, in which distances under current rules and high-proximity scenarios were lower than distances under rules that give allocation efficiency little weight.
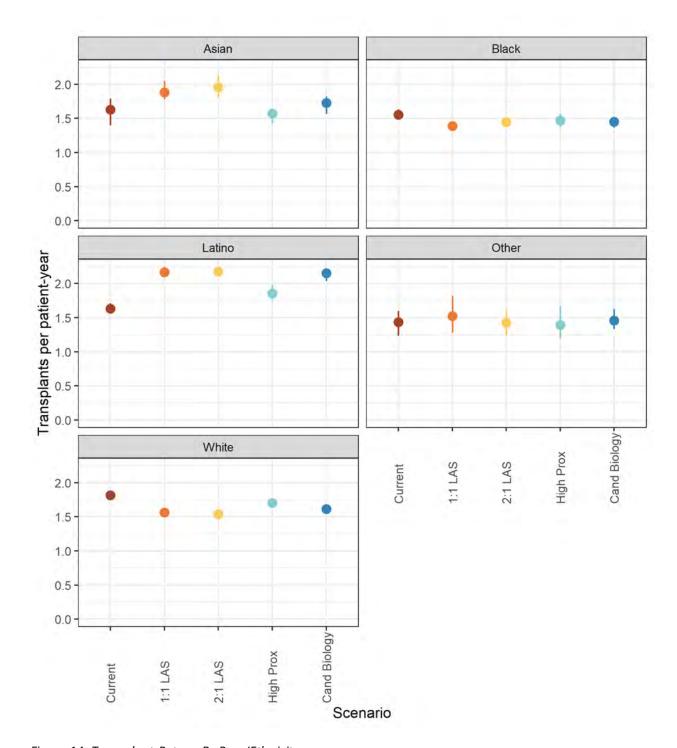
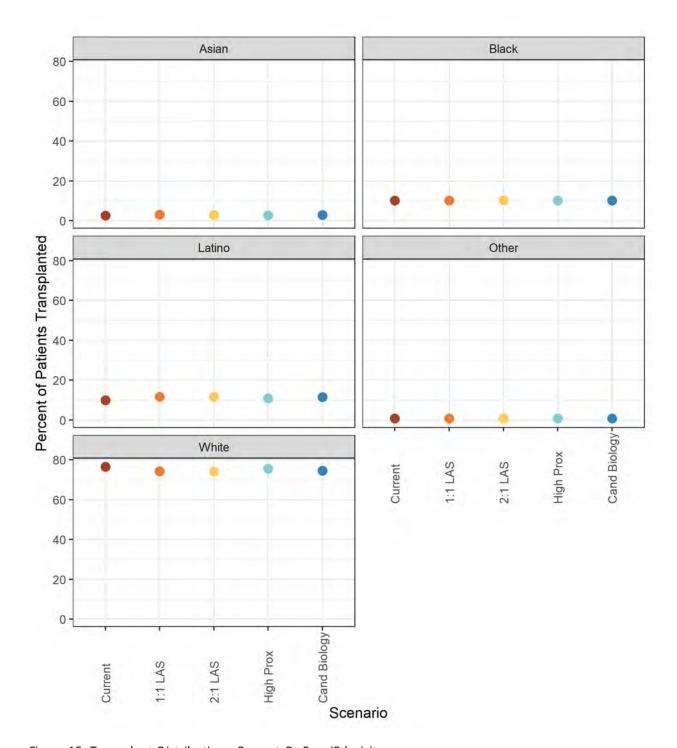Figure 14: Transplant Rates - By Race/Ethnicity

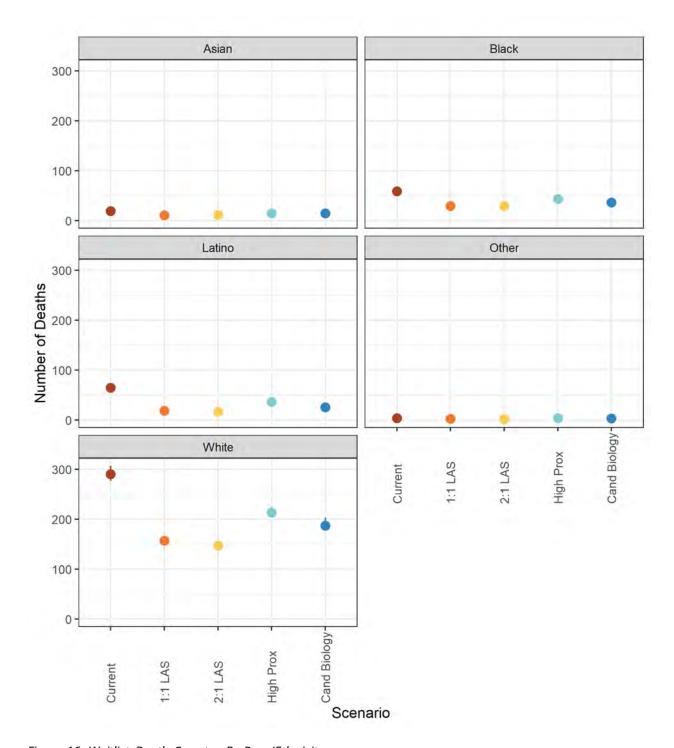*Figure 15: Transplant Distribution - Percent By Race/Ethnicity*

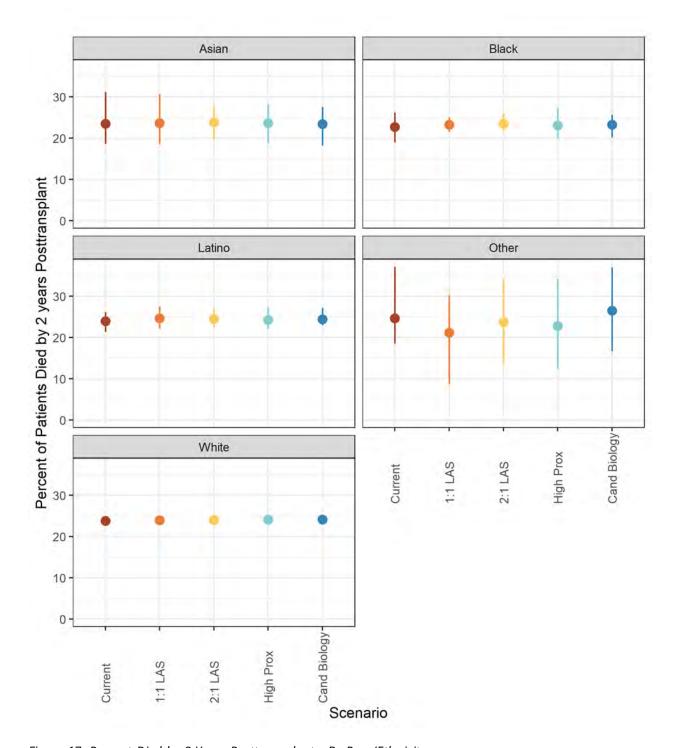Figure 16: Waitlist Death Counts - By Race/Ethnicity

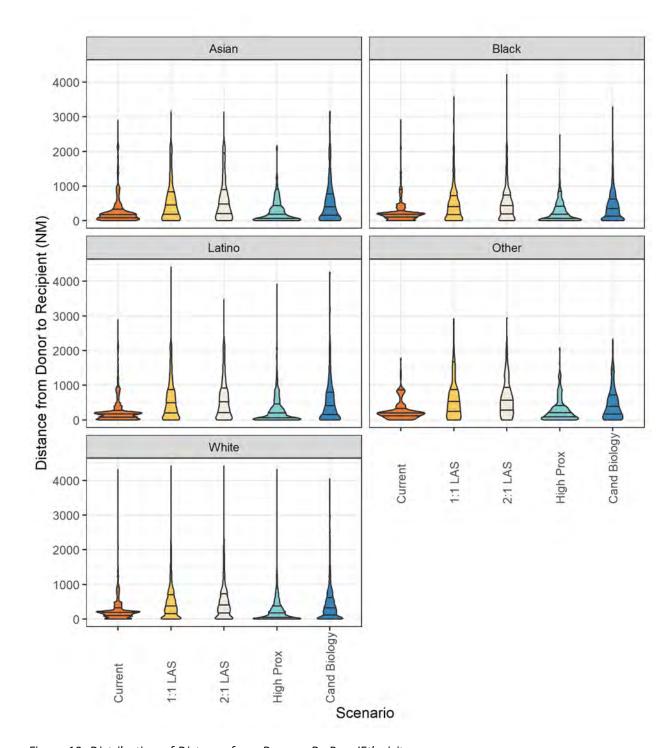*Figure 17: Percent Died by 2 Years Posttransplant - By Race/Ethnicity*

Figure 18: Distribution of Distance from Donor - By Race/Ethnicity

Table 4: Outcome Counts and Rates by Scenario by Race/Ethnicity

Outcome	Race/Ethnicity	Current	1.1 LAS	2.1 LAS	High Prox	Cand Biology
Transplant Count (N)						
	Asian	132 (124,139)	156 (152,160)	154 (149,158)	140 (132,145)	147 (139,151)
	Black	512 (500,523)	517 (509,528)	528 (516,541)	519 (503,531)	520 (502,529)
	Latino	506 (498,517)	598 (584,613)	601 (591,613)	554 (541,569)	592 (577,606)
	Other	38 (35,42)	43 (41,46)	43 (41,44)	40 (38,42)	42 (39,46)
	White	3866 (3847,3898)	3793 (3774,3810)	3779 (3762,3807)	3864 (3852,3880)	3811 (3796,3830)
Transplant Rate per Patient-Year						
	Asian	1.63 (1.4,1.79)	1.88 (1.78,2.05)	1.96 (1.81,2.12)	1.57 (1.43,1.64)	1.73 (1.57,1.82)
	Black	1.56 (1.49,1.63)	1.39 (1.32,1.44)	1.44 (1.38,1.51)	1.47 (1.38,1.56)	1.45 (1.37,1.49)
	Latino	1.63 (1.6,1.71)	2.17 (2.1,2.25)	2.17 (2.11,2.25)	1.86 (1.76,1.98)	2.15 (2.03,2.19)
	Other	1.44 (1.24,1.6)	1.52 (1.28,1.82)	1.43 (1.25,1.62)	1.39 (1.19,1.67)	1.46 (1.33,1.62)
	White	1.82 (1.8,1.84)	1.56 (1.55,1.59)	1.54 (1.52,1.55)	1.71 (1.68,1.72)	1.62 (1.59,1.64)
Transplant Distribution (Percent)						
	Asian	2.6 (2.46,2.75)	3.05 (2.97,3.13)	3.01 (2.92,3.1)	2.74 (2.58,2.84)	2.88 (2.72,2.95)
	Black	10.13 (9.89,10.37)	10.13 (9.96,10.36)	10.35 (10.09,10.6)	10.13 (9.81,10.39)	10.17 (9.82,10.35)
	Latino	10 (9.86,10.23)	11.71 (11.43,12)	11.77 (11.58,12.01)	10.83 (10.59,11.1)	11.58 (11.27,11.86)
	Other	0.76 (0.69,0.83)	0.85 (0.8,0.9)	0.83 (0.8,0.86)	0.78 (0.74,0.82)	0.82 (0.76,0.9)

Table 4: Outcome Counts and Rates by Scenario by Race/Ethnicity

Outcome	Race/Ethnicity	Current	1.1 LAS	2.1 LAS	High Prox	Cand Biology
	White	76.51 (76.14,76.99)	74.26 (74.01,74.59)	74.03 (73.69,74.4)	75.52 (75.22,75.77)	74.56 (74.33,74.79)
Waitlist Mortality Count (N)						
	Asian	20 (17,23)	11 (9,12)	12 (11,13)	15 (12,17)	15 (13,19)
	Black	59 (55,64)	30 (24,35)	30 (26,33)	44 (40,50)	36 (33,39)
	Latino	65 (56,72)	18 (14,22)	16 (13,20)	37 (32,44)	26 (23,29)
	Other	4 (2,6)	2 (2,3)	2 (2,3)	4 (3,4)	3 (2,3)
	White	290 (277,307)	157 (150,165)	148 (142,155)	214 (206,225)	187 (178,203)
Percent Died by 2 Years Posttransplant						
	Asian	23.47 (18.66,31.2)	23.67 (18.59,30.63)	23.79 (19.74,27.81)	23.65 (18.75,28.26)	23.41 (18.24,27.52)
	Black	22.71 (18.96,26.2)	23.29 (21.57,25.05)	23.5 (21.67,25.94)	23.12 (19.92,27.29)	23.32 (20.2,25.71)
	Latino	23.96 (21.3,26.11)	24.6 (22.19,27.4)	24.5 (22.52,26.92)	24.27 (22.06,27.22)	24.43 (22.91,27.14)
	Other	24.61 (18.42,37.14)	21.16 (8.7,30.23)	23.73 (13.64,34.15)	22.79 (12.5,34.15)	26.47 (16.67,36.96)
	White	23.8 (23.07,24.69)	24 (23.49,24.53)	24.05 (23.67,24.59)	24.09 (22.95,25.1)	24.11 (23.05,25.16)
Median Donor to Recipient Distance						
	Asian	172 (153,197)	384 (328,443)	406 (341,513)	135 (89,168)	320 (226,436)
	Black	185 (171,198)	374 (357,408)	403 (382,445)	153 (131,167)	312 (280,349)
	Latino	171 (166,177)	438 (401,493)	473 (409,535)	159 (140,169)	346 (332,367)
	Other	195 (162,223)	476 (297,589)	529 (465,574)	167 (84,236)	326 (163,435)

Table 4: Outcome Counts and Rates by Scenario by Race/Ethnicity

Outcome	Race/Ethnicity	Current	1.1 LAS	2.1 LAS	High Prox	Cand Biology
	White	198 (194,199)	356 (344,375)	381 (370,391)	155 (147,158)	298 (287,307)
Percent Expected to Fly (>75NM)						
	Asian	74 (69.35,81.25)	77.25 (71.15,82.8)	79.78 (77.22,84.08)	59.54 (54.48,66.42)	73.27 (70.47,77.55)
	Black	81 (79.57,82.56)	80.71 (78.82,82.4)	82.26 (80.57,84.23)	62.88 (59.92,65.21)	74.86 (71.35,78.53)
	Latino	74.39 (72.6,77.8)	81.07 (78.79,82.53)	82.11 (80.42,84.14)	61.24 (58.96,63.3)	75.8 (73.31,77.72)
	Other	82.11 (75.61,89.74)	80.6 (73.81,88.1)	86.12 (78.05,90.24)	65.75 (50,78.05)	75.1 (61.9,86.05)
	White	82.18 (80.83,82.77)	79.73 (79.1,80.59)	81.88 (81.25,82.46)	63.25 (62.47,64.41)	75.28 (74.42,75.69)

Outcomes by Quintile of Height

Compared with the current rules scenario, transplants rates among the shortest (<158 cm) and tallest (>177.8 cm) candidates increased under all continuous distribution scenarios and increased the most for the candidate biology scenario (Table 5, Figure 19). Rates for the middle three height groups declined somewhat. The height distributions of transplant recipients under continuous allocation scenarios showed a small increase in the proportion of recipients under 158 cm tall (Figure 20).

The patterns for waitlist deaths were similar to the overall patterns. For example, waitlist deaths under 1:1 LAS and 2:1 LAS scenarios declined the most compared with number of deaths under current rules (Figure 21, Table 5).

The percent of 2-year posttransplant deaths was similar across scenarios for each height group (Figure 22, Table 5).

The patterns of median distance from donor to recipient by height group were similar to overall patterns, in which distances under current rules and high-proximity scenarios were lower than distances under rules that give allocation efficiency little weight.
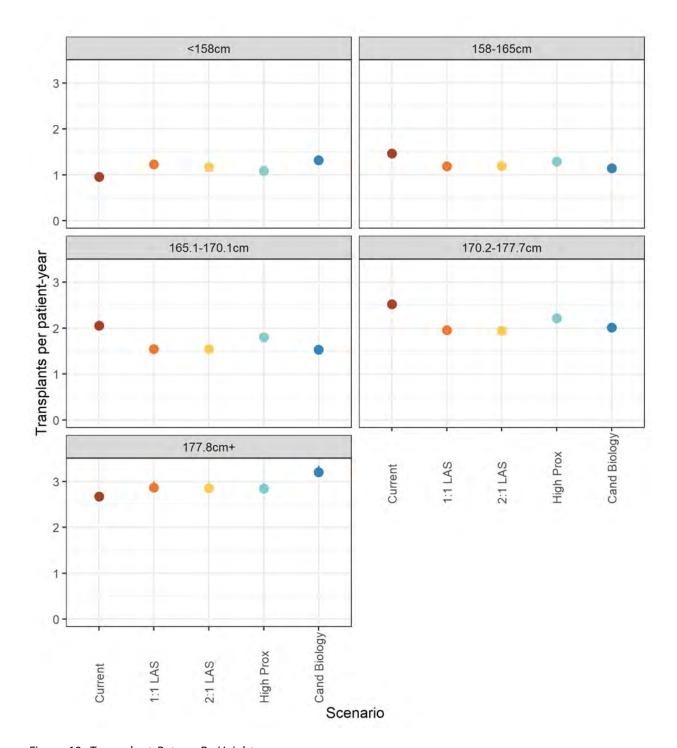
Figure 19: Transplant Rates - By Height
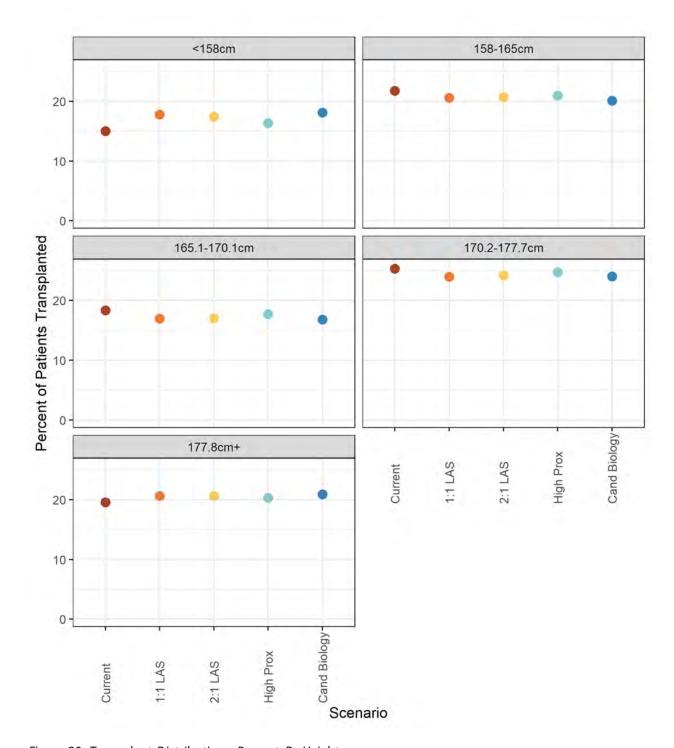
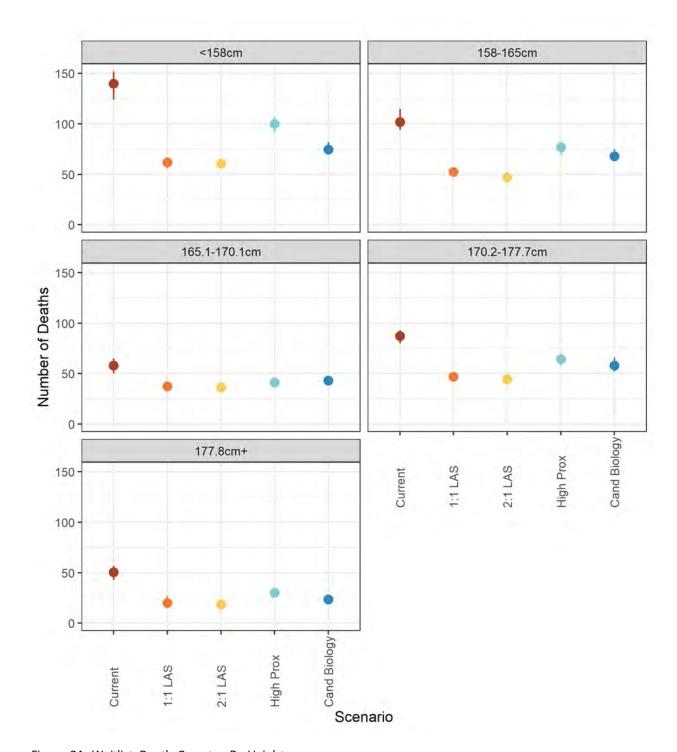*Figure 20: Transplant Distribution - Percent By Height*
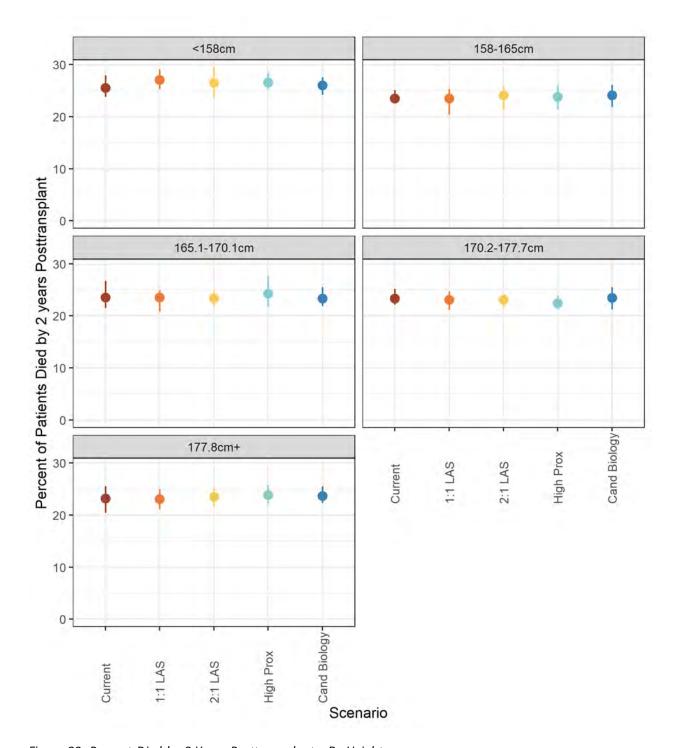
Figure 21: Waitlist Death Counts - By Height

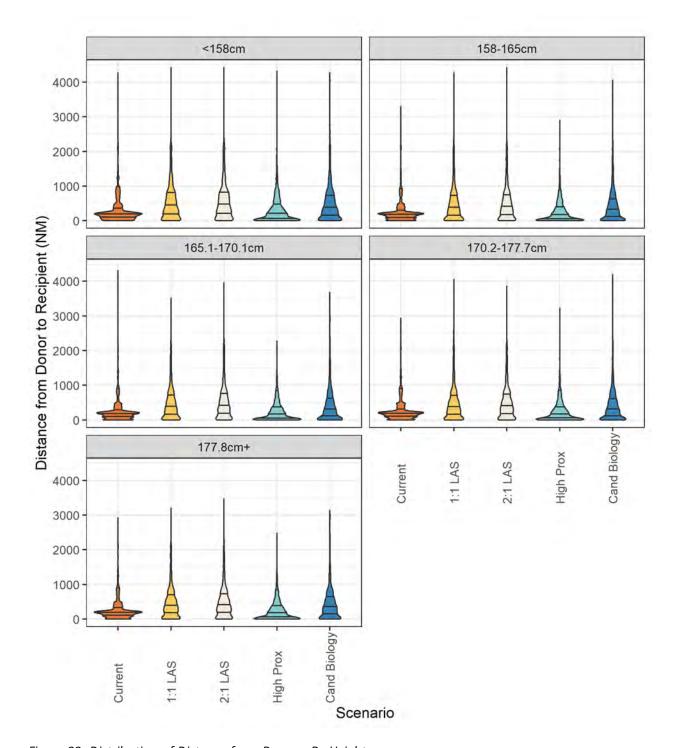*Figure 22: Percent Died by 2 Years Posttransplant - By Height*

Figure 23: Distribution of Distance from Donor - By Height

Table 5: Outcome Counts and Rates by Scenario by Height Category

Outcome	Height Category	Current	1.1 LAS	2.1 LAS	High Prox	Cand Biology
Transplant Count (N)						
	<158cm	759 (742,777)	909 (894,928)	890 (876,902)	836 (812,857)	927 (907,945)
	158-165cm	1098 (1075,1121)	1052 (1041,1071)	1057 (1046,1070)	1071 (1041,1092)	1028 (1010,1036)
	165.1-170.1cm	927 (905,945)	868 (850,879)	870 (852,889)	906 (886,927)	860 (847,868)
	170.2-177.7cm	1279 (1263,1292)	1226 (1209,1242)	1235 (1225,1246)	1265 (1256,1283)	1229 (1218,1243)
	177.8cm+	990 (975,1008)	1053 (1039,1072)	1052 (1045,1061)	1039 (1022,1055)	1068 (1058,1083)
Transplant Rate per Patient-Year						
	<158cm	0.96 (0.92,0.99)	1.23 (1.18,1.27)	1.17 (1.14,1.21)	1.09 (1.04,1.12)	1.32 (1.26,1.37)
	158-165cm	1.46 (1.41,1.55)	1.19 (1.14,1.23)	1.19 (1.17,1.22)	1.29 (1.24,1.36)	1.15 (1.12,1.16)
	165.1-170.1cm	2.05 (1.94,2.17)	1.55 (1.5,1.6)	1.55 (1.5,1.59)	1.8 (1.75,1.85)	1.53 (1.49,1.56)
	170.2-177.7cm	2.52 (2.44,2.63)	1.95 (1.87,2.01)	1.95 (1.87,2.01)	2.21 (2.15,2.26)	2.01 (1.96,2.04)
	177.8cm+	2.67 (2.58,2.74)	2.86 (2.79,3)	2.85 (2.76,2.98)	2.84 (2.74,2.97)	3.2 (3.09,3.34)
Transplant Distribution (Percent)						
	<158cm	15.03 (14.68,15.37)	17.8 (17.5,18.2)	17.43 (17.19,17.68)	16.33 (15.89,16.74)	18.13 (17.75,18.49)
	158-165cm	21.74 (21.32,22.2)	20.6 (20.42,20.95)	20.71 (20.52,20.98)	20.93 (20.33,21.33)	20.11 (19.76,20.29)
	165.1-170.1cm	18.34 (17.99,18.7)	16.98 (16.65,17.23)	17.04 (16.7,17.41)	17.71 (17.38,18.1)	16.83 (16.57,17)
	170.2-177.7cm	25.31 (24.99,25.66)	24.01 (23.68,24.31)	24.2 (23.99,24.46)	24.73 (24.51,25.08)	24.04 (23.83,24.32)

Table 5: Outcome Counts and Rates by Scenario by Height Category

Outcome	Height Category	Current	1.1 LAS	2.1 LAS	High Prox	Cand Biology
	177.8cm+	19.59 (19.32,19.94)	20.61 (20.33,20.98)	20.62 (20.47,20.82)	20.3 (19.94,20.6)	20.9 (20.72,21.19)
Waitlist Mortality Count (N)						
	<158cm	140 (124,152)	62 (56,67)	61 (56,65)	100 (92,107)	75 (70,82)
	158-165cm	102 (94,115)	52 (49,55)	47 (45,49)	77 (69,83)	68 (64,75)
	165.1-170.1cm	58 (50,65)	37 (34,40)	36 (32,41)	41 (36,46)	43 (38,46)
	170.2-177.7cm	87 (80,93)	47 (43,51)	44 (41,48)	64 (58,70)	58 (52,66)
	177.8cm+	51 (43,57)	20 (16,27)	19 (15,23)	30 (27,34)	24 (19,28)
Percent Died by 2 Years Posttransplant						
	<158cm	25.52 (23.81,27.94)	27.08 (25.33,29.08)	26.48 (23.62,29.45)	26.56 (25.26,28.47)	26 (24.16,27.55)
	158-165cm	23.48 (22.57,25.07)	23.52 (20.37,25.36)	24.12 (21.31,25.92)	23.81 (21.38,26.09)	24.12 (21.87,26.1)
	165.1-170.1cm	23.55 (21.48,26.73)	23.51 (20.84,24.91)	23.38 (21.8,24.91)	24.23 (21.73,27.69)	23.33 (21.88,25.47)
	170.2-177.7cm	23.33 (22.13,25.18)	23.11 (21.13,24.7)	23.1 (21.51,24.12)	22.4 (21.27,23.87)	23.44 (21.24,25.46)
	177.8cm+	23.18 (20.41,25.51)	23.07 (21.08,24.98)	23.52 (21.72,25.17)	23.84 (22.25,25.78)	23.69 (22.34,25.54)
Median Donor to Recipient Distance						
	<158cm	198 (187,206)	409 (394,426)	442 (422,466)	185 (167,197)	348 (327,364)
	158-165cm	192 (183,198)	352 (333,374)	378 (354,395)	142 (126,158)	291 (271,308)
	165.1-170.1cm	187 (178,196)	352 (329,370)	384 (347,412)	138 (118,152)	272 (257,296)
	170.2-177.7cm	193 (183,198)	355 (339,377)	382 (365,405)	151 (131,159)	281 (273,292)

Table 5: Outcome Counts and Rates by Scenario by Height Category

Outcome	Height Category	Current	1.1 LAS	2.1 LAS	High Prox	Cand Biology
	177.8cm+	198 (194,205)	373 (350,389)	388 (380,400)	159 (144,169)	331 (314,343)
Percent Expected to Fly (>75NM)						
	<158cm	80.73 (78.17,83.31)	82.24 (80.39,83.35)	83.9 (82.04,86.11)	65.59 (63.13,68.23)	78.96 (75.94,80.32)
	158-165cm	80.02 (77.67,81.26)	77.59 (76.44,79.18)	80.42 (79.21,81.56)	61.1 (59.18,62.85)	73.14 (71.61,75.12)
	165.1-170.1cm	79.33 (77.44,80.95)	78.62 (75.51,80.57)	81.16 (78.12,83.14)	60.64 (57.77,61.92)	71.91 (70.44,73.61)
	170.2-177.7cm	82.05 (80.84,83.19)	79.6 (78.18,81.41)	81.19 (79.43,83.37)	63.33 (61.08,65.44)	73.31 (71.7,74.49)
	177.8cm+	82.84 (80.04,84.44)	81.7 (80.75,83.25)	83.25 (82.28,84.46)	64.09 (61.56,66.76)	78.93 (77.51,80.15)

Outcomes by Blood Type

Compared with the current rules scenario, transplant rates among blood type O candidates increased considerably in all continuous allocation scenarios, and rates among blood types A, B, and AB declined (Table 6, Figure 24). Rates among type O candidates increased from 1.53 transplants per patient-year under current rules to 1.9-2.3 under continuous allocation. Rates among type AB candidates declined from 2.5 to 1.4-1.6; type A from 2.1 to 1.2-1.4; and type B from 1.8 to 1.3-1.4. As a share of all patients who received a simulated transplant, type O increased from 45.7% of the cohort under current rules to 54.3% under the high candidate biology scenario, while type A declined from 38.8% to 32.0% (Figure 25, Table 6). Among the 7786 candidates in the simulation, 36.3% were type A, 3.9% type AB, 11.4% type B, and 48.4% type O.

For all blood types, waitlist deaths under 2:1 LAS and 1:1 LAS scenarios declined the most compared with number of deaths under current rules (Figure 21, Table 6), with declines of 45%-50% for types AB and B, 34%-38% for type A, and 61%-63% declines among type O. Declines from current rules to high candidate biology were considerable but more modest.

The percent of 2-year posttransplant deaths was similar across scenarios for each blood type (Figure 27, Table 6).

The patterns of median distance from donor to recipient by blood type were similar to overall patterns, in which distances under current rules and high-proximity scenarios were lower than distances under rules that give allocation efficiency little weight.
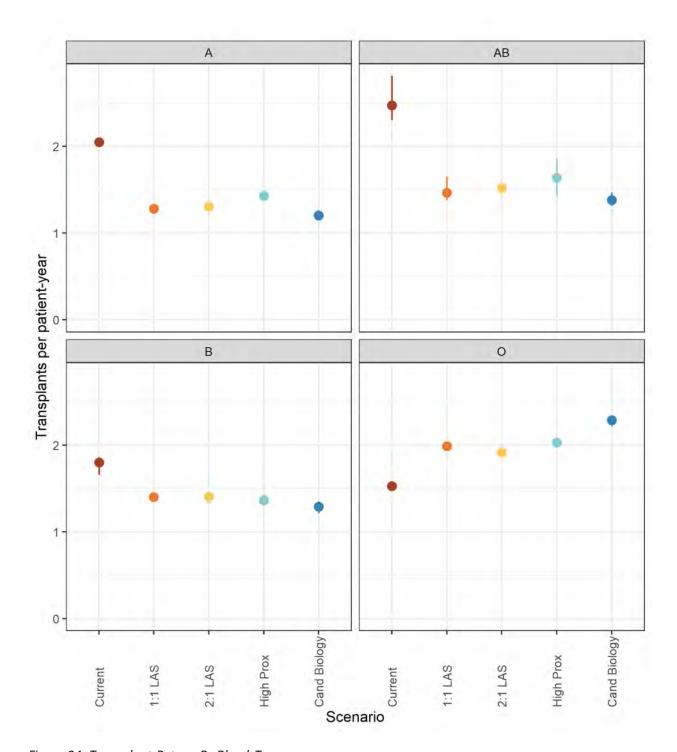
Figure 24: Transplant Rates - By Blood Type
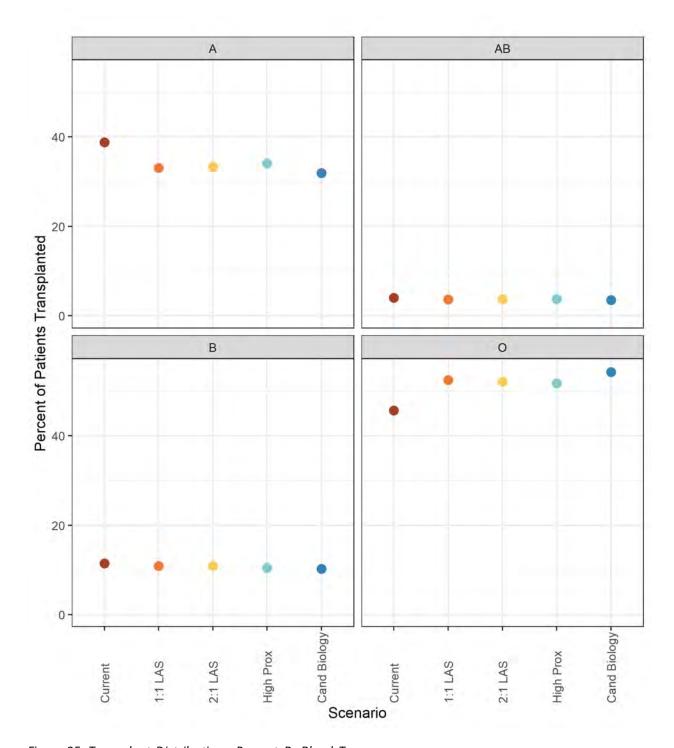
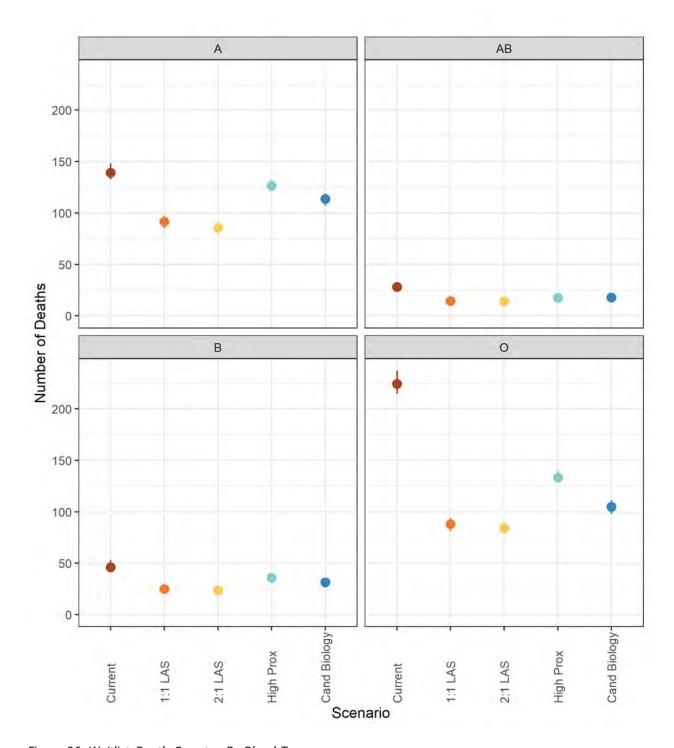*Figure 25: Transplant Distribution - Percent By Blood Type*
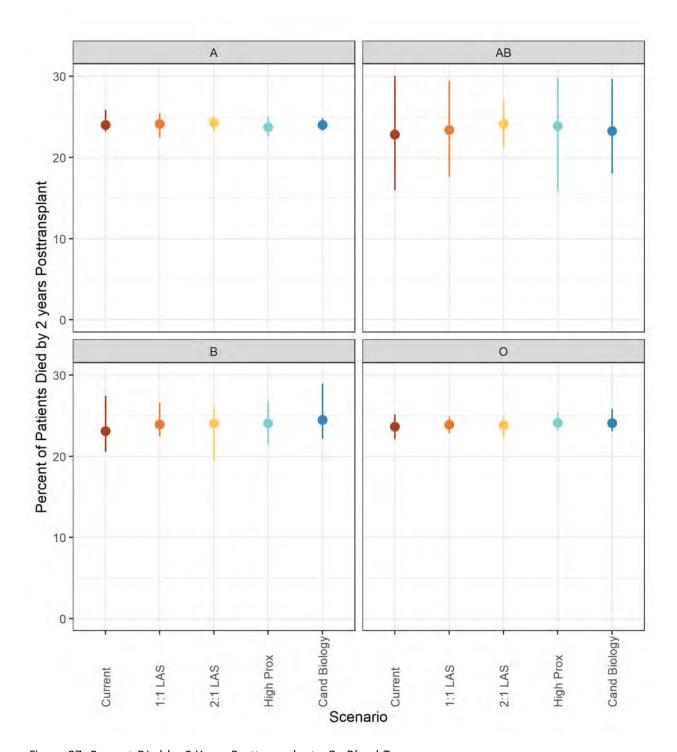
Figure 26: Waitlist Death Counts - By Blood Type

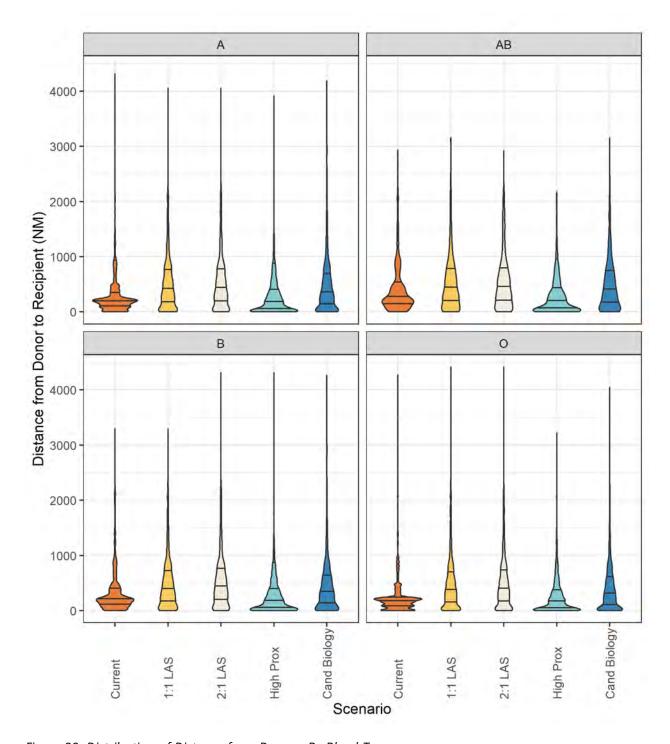*Figure 27: Percent Died by 2 Years Posttransplant - By Blood Type*

Figure 28: Distribution of Distance from Donor - By Blood Type

Table 6: Outcome Counts and Rates by Scenario by Blood Type

Outcome	Blood Type	Current	1.1 LAS	2.1 LAS	High Prox	Cand Biology
Transplant Count (N)						
	A	1962 (1949,1978)	1688 (1657,1710)	1702 (1684,1718)	1745 (1731,1761)	1634 (1624,1643)
	AB	205 (200,215)	187 (182,195)	191 (188,195)	191 (183,203)	181 (175,188)
	B	580 (561,587)	555 (548,561)	555 (543,568)	535 (525,546)	524 (503,538)
	O	2306 (2296,2318)	2678 (2663,2695)	2657 (2644,2670)	2646 (2634,2656)	2773 (2746,2791)
Transplant Rate per Patient-Year						
	A	2.05 (2,2.08)	1.28 (1.24,1.32)	1.31 (1.29,1.33)	1.43 (1.42,1.44)	1.2 (1.18,1.22)
	AB	2.47 (2.3,2.81)	1.47 (1.38,1.65)	1.52 (1.45,1.59)	1.64 (1.42,1.86)	1.38 (1.31,1.47)
	B	1.8 (1.66,1.86)	1.4 (1.36,1.43)	1.41 (1.35,1.46)	1.37 (1.3,1.43)	1.29 (1.22,1.35)
	O	1.53 (1.49,1.55)	1.99 (1.97,2.02)	1.92 (1.9,1.94)	2.03 (1.97,2.08)	2.29 (2.22,2.34)
Transplant Distribution (Percent)						
	A	38.82 (38.62,39.12)	33.05 (32.51,33.48)	33.33 (33.01,33.72)	34.11 (33.88,34.39)	31.96 (31.77,32.13)
	AB	4.06 (3.96,4.25)	3.66 (3.56,3.81)	3.74 (3.68,3.82)	3.74 (3.57,3.98)	3.54 (3.42,3.68)
	B	11.47 (11.15,11.62)	10.86 (10.73,10.97)	10.87 (10.66,11.09)	10.45 (10.24,10.65)	10.25 (9.83,10.54)
	O	45.65 (45.44,46.07)	52.43 (52.08,52.87)	52.06 (51.89,52.34)	51.7 (51.55,51.81)	54.26 (53.78,54.52)
Waitlist Mortality Count (N)						
	A	139 (133,148)	92 (85,97)	86 (80,89)	126 (122,132)	114 (107,119)

Table 6: Outcome Counts and Rates by Scenario by Blood Type

Outcome	Blood Type	Current	1.1 LAS	2.1 LAS	High Prox	Cand Biology
	AB	28 (27,32)	14 (13,17)	14 (12,16)	17 (14,22)	18 (15,20)
	B	46 (42,53)	25 (23,28)	24 (21,27)	36 (32,39)	31 (27,35)
	O	224 (215,237)	88 (81,94)	84 (80,90)	133 (128,140)	105 (98,111)
Percent Died by 2 Years Posttransplant						
	A	24.04 (23.19,25.87)	24.16 (22.4,25.46)	24.29 (23.22,25.09)	23.77 (22.56,25.01)	24.02 (23.32,24.82)
	AB	22.85 (16,30.05)	23.39 (17.58,29.47)	24.16 (21.28,27.08)	23.93 (15.87,29.79)	23.28 (18.03,29.67)
	B	23.1 (20.55,27.43)	23.94 (22.45,26.62)	24.05 (19.28,26.13)	24.06 (21.5,26.77)	24.48 (22.18,28.96)
	O	23.64 (22.13,25.14)	23.89 (22.85,24.89)	23.85 (22.24,24.96)	24.13 (23.15,25.52)	24.08 (23.05,25.82)
Median Donor to Recipient Distance						
	A	200 (198,202)	385 (374,397)	408 (398,425)	163 (155,171)	322 (303,342)
	AB	253 (234,287)	391 (321,476)	417 (358,455)	154 (128,203)	355 (297,454)
	B	208 (201,213)	365 (337,398)	411 (390,451)	151 (122,166)	313 (277,342)
	O	179 (175,189)	354 (341,373)	379 (363,394)	149 (141,161)	290 (282,299)
Percent Expected to Fly (>75NM)						
	A	82.58 (81.57,83.41)	80.95 (80.19,81.78)	83.44 (82.67,84.7)	64.63 (63.17,66.17)	77.04 (75.99,78.34)
	AB	85.38 (82.33,88.18)	80.82 (75.79,85.16)	82.78 (78.95,86.15)	61.99 (58.25,64.97)	77.47 (70.74,82.29)
	B	82.73 (80.31,85.35)	80.46 (77.56,82.37)	82.5 (80.75,84.23)	61.49 (59.59,63.05)	75.87 (72.94,79.72)
	O	78.98 (78.07,80.46)	79.1 (78.07,80.1)	80.76 (79.88,81.94)	62.13 (61.16,63.49)	73.92 (72.8,74.67)

Outcomes by LAS

Outcomes by LAS use a LAS as defined by the most recent LAS update in 2020. Though all continuous distribution scenarios use LAS components WLAUC and PTAUC and weight the components differently, here we provided outcomes by LAS values with which clinicians are familiar. LAS values per patient are the same across all scenarios.

In all continuous allocation scenarios, transplant rates followed LAS in a dose-response relationship. That is, lowest transplant rates occurred in the lowest LAS groups, with increasingly higher rates as LAS rose (Table 7, Figure 29). The "slope" of that dose response varied by scenario. In the current rules simulation, this was generally true, except that the rate among the highest LAS group was lower than the rate for those with LAS 40-<60. For candidates with LAS <35, transplant rates declined for 1:1 LAS and 2:1 LAS scenarios, increased for the high-proximity scenario, and were similar for the candidate biology scenario. For LAS 35-<40, all continuous distribution scenarios had lower transplant rates than under current rules. For LAS >=50, transplant rates increased markedly compared with current rules.

Figure 30 and Table 7 show the distribution of patients who underwent a simulated transplant by LAS group. The percent of patients with low LAS declined considerably in the 1:1 LAS and 2:1 LAS scenarios, while the percent of high LAS patients increased. This is expected; removing hard boundaries increased access to organs for high LAS candidates; keeping hard boundaries improved access for less medically urgent candidates.

Under the current rules simulation, patients with LAS of 60 or greater were 17% of all simulated transplants and 60% of all waitlist deaths. Under all continuous allocation scenarios, the number of waitlist deaths declined considerably among these high LAS patients, from 263 under current rules to 120 under high proximity, 74 under candidate biology, 43 for 1:1 LAS, and 39 for 2:1 LAS (Table 7, Figure 31). In the LAS 50-<60 group, waitlist deaths decreased modestly under the 1:1 and 2:1 LAS scenarios (from 36 to 23 and 18, respectively), and were similar in the high-proximity and candidate biology scenarios. For LAS <40, point estimates for death counts slightly increased, but the ranges of the simulations all overlapped with current rules.

The percent of 2-year posttransplant deaths was similar across scenarios for each LAS group (Figure 32, Table 7).

The patterns of median distance from donor to recipient by LAS were different from the overall pattern in that for low LAS recipients, median distances were similar in all scenarios except high proximity, which had a much smaller median distance. For higher LAS patients, distances increased for all continuous distribution scenarios, although the increase was more dramatic under the 2:1 LAS and 1:1 LAS scenarios. Similarly, donor organs to lower LAS (<40) patients were less likely to have been flown under all continuous allocation rules and much more likely to have been flown for high LAS candidates, with the 1:1 LAS and 2:1 LAS scenarios having a notably larger increase.
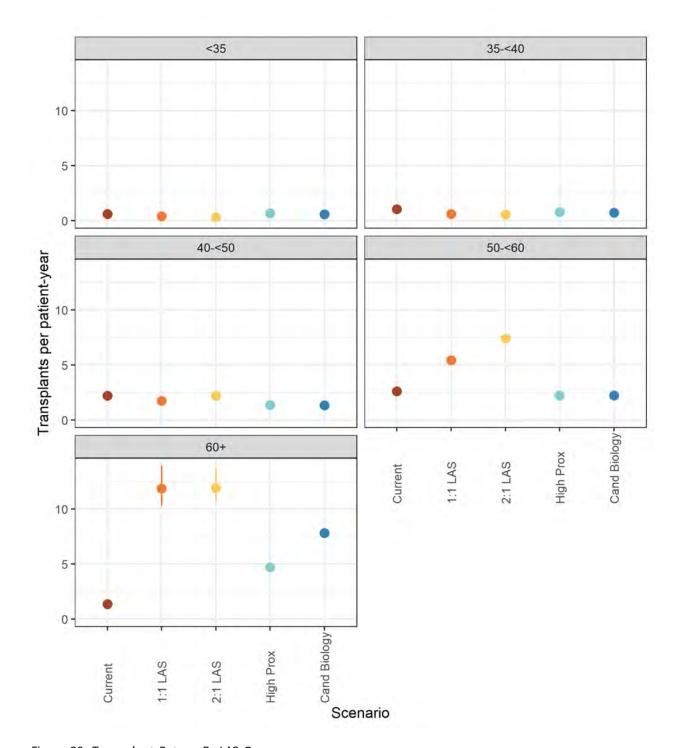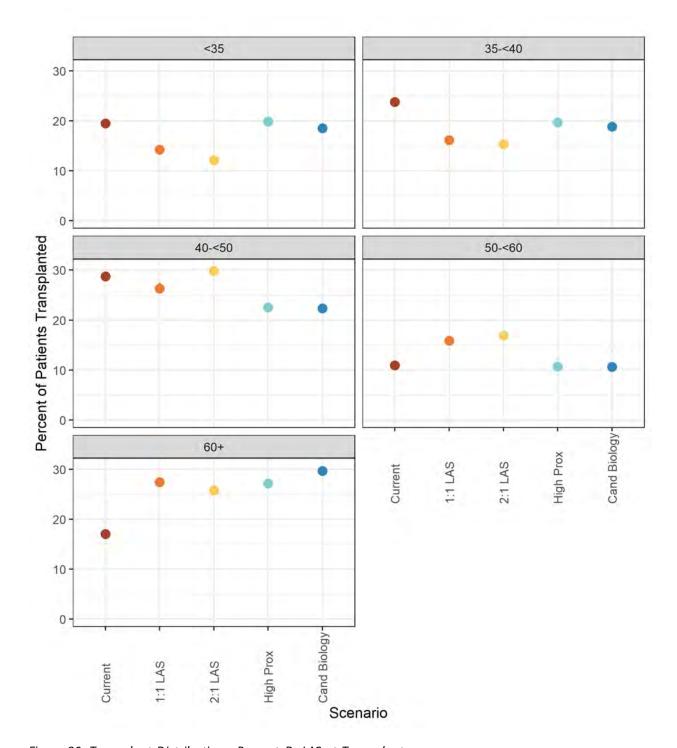
Figure 29: Transplant Rates - By LAS Group

Figure 30: Transplant Distribution - Percent By LAS at Transplant
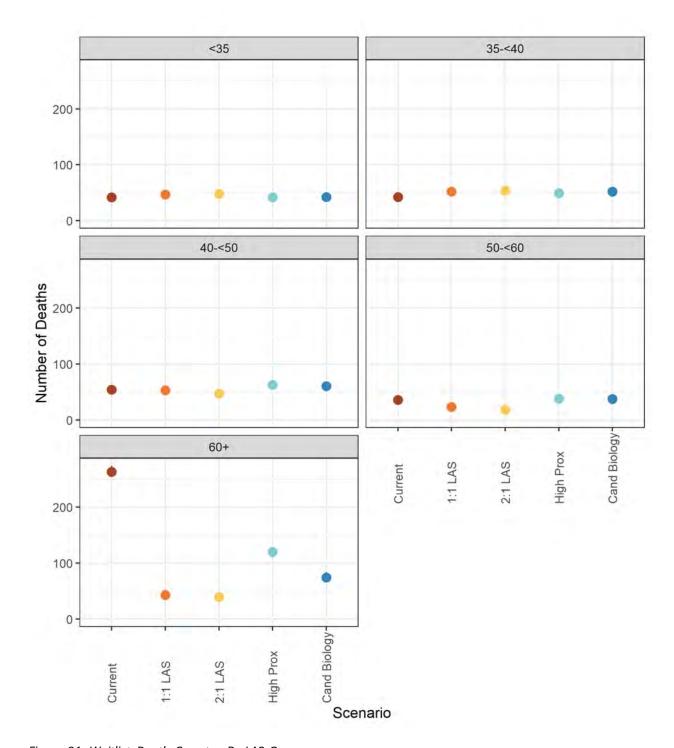
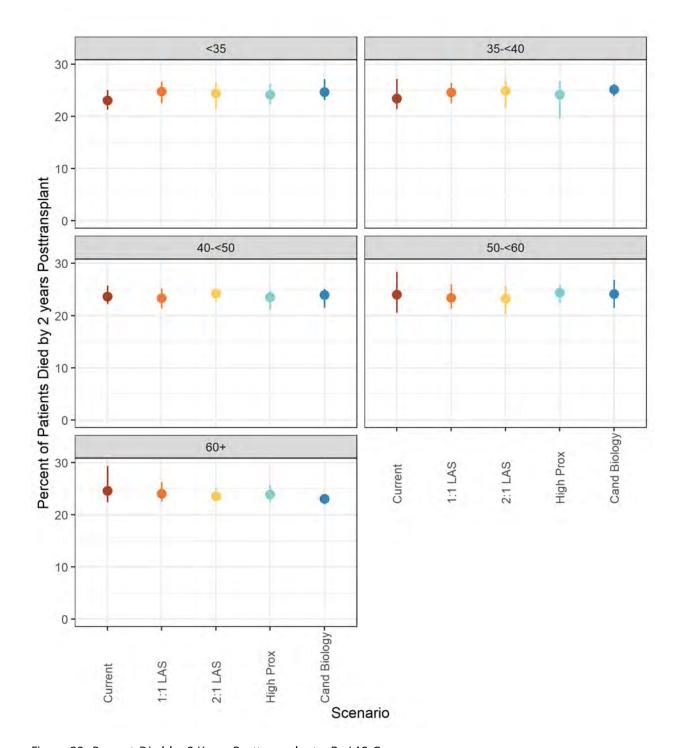Figure 31: Waitlist Death Counts - By LAS Group

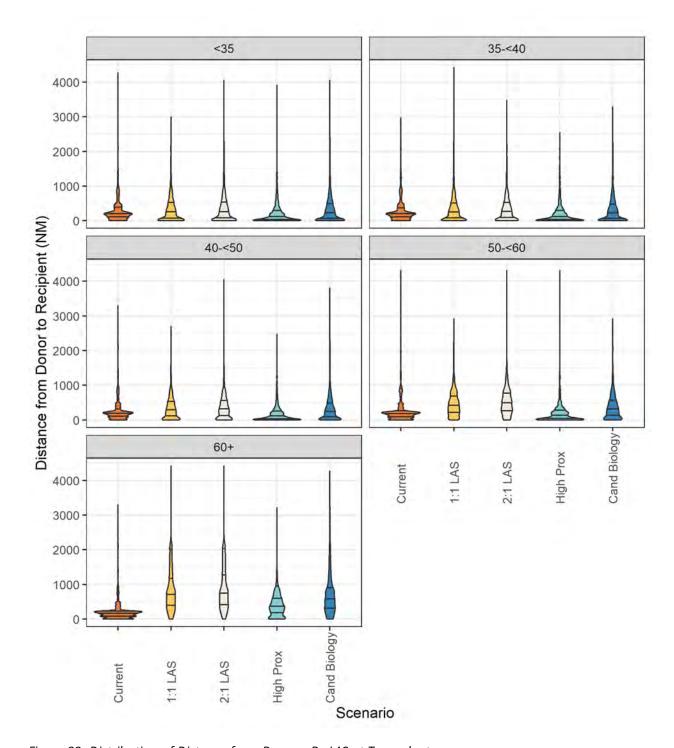*Figure 32: Percent Died by 2 Years Posttransplant - By LAS Group*

Figure 33: Distribution of Distance from Donor - By LAS at Transplant

Table 7: Outcome Counts and Rates by Scenario by LAS Category

Outcome	LAS Group	Current	1.1 LAS	2.1 LAS	High Prox	Cand Biology
Transplant Count (N)						
	<35	984 (950,1006)	727 (712,739)	620 (594,642)	1019 (999,1036)	947 (925,972)
	35-<40	1200 (1167,1232)	826 (796,853)	782 (762,820)	1009 (965,1049)	964 (926,995)
	40-<50	1453 (1426,1473)	1345 (1310,1403)	1523 (1490,1567)	1154 (1119,1200)	1142 (1123,1170)
	50-<60	553 (533,566)	809 (788,822)	866 (831,893)	546 (526,571)	544 (528,560)
	60+	863 (849,885)	1400 (1356,1442)	1314 (1304,1331)	1390 (1352,1425)	1516 (1492,1536)
Transplant Rate per Patient-Year						
	<35	0.62 (0.59,0.64)	0.4 (0.39,0.41)	0.33 (0.31,0.34)	0.66 (0.65,0.68)	0.6 (0.58,0.62)
	35-<40	1.06 (1.03,1.1)	0.61 (0.58,0.63)	0.57 (0.56,0.6)	0.81 (0.77,0.84)	0.75 (0.72,0.78)
	40-<50	2.22 (2.17,2.31)	1.75 (1.7,1.81)	2.21 (2.16,2.28)	1.37 (1.33,1.44)	1.32 (1.28,1.34)
	50-<60	2.6 (2.44,2.74)	5.42 (5.14,5.71)	7.4 (6.94,7.86)	2.25 (2.15,2.45)	2.24 (2.07,2.35)
	60+	1.38 (1.35,1.43)	11.86 (10.3,13.93)	11.92 (10.74,13.67)	4.73 (4.41,5.04)	7.82 (7.35,8.18)
Transplant Distribution (Percent)						
	<35	19.48 (18.88,19.86)	14.23 (13.94,14.45)	12.14 (11.64,12.53)	19.91 (19.49,20.23)	18.53 (18.1,19.06)
	35-<40	23.76 (23.04,24.49)	16.17 (15.58,16.69)	15.31 (14.95,16.08)	19.72 (18.89,20.46)	18.85 (18.12,19.45)
	40-<50	28.75 (28.26,29.15)	26.34 (25.62,27.46)	29.84 (29.24,30.7)	22.56 (21.95,23.49)	22.33 (21.97,22.9)
	50-<60	10.94 (10.53,11.19)	15.84 (15.42,16.09)	16.96 (16.28,17.5)	10.66 (10.29,11.2)	10.64 (10.34,10.97)

Table 7: Outcome Counts and Rates by Scenario by LAS Category

Outcome	LAS Group	Current	1.1 LAS	2.1 LAS	High Prox	Cand Biology
	60+	17.08 (16.8,17.48)	27.42 (26.54,28.2)	25.75 (25.54,26.12)	27.16 (26.38,27.89)	29.66 (29.2,30.05)
Waitlist Mortality Count (N)						
	<35	42 (37,47)	47 (42,51)	48 (45,52)	42 (39,44)	42 (39,46)
	35-<40	42 (35,51)	52 (48,57)	54 (50,57)	49 (46,52)	52 (47,55)
	40-<50	54 (49,60)	53 (49,61)	48 (43,51)	63 (56,69)	61 (56,67)
	50-<60	36 (30,43)	23 (21,26)	18 (16,23)	38 (34,44)	38 (32,42)
	60+	263 (254,274)	43 (34,53)	39 (30,47)	120 (110,125)	74 (68,84)
Percent Died by 2 Years Posttransplant						
	<35	23.09 (21.28,25.05)	24.77 (22.52,26.61)	24.4 (21.32,26.48)	24.19 (22.35,26.22)	24.64 (23.13,27.16)
	35-<40	23.45 (21.39,27.16)	24.59 (22.55,26.39)	24.9 (21.68,27)	24.16 (19.54,26.83)	25.17 (23.89,26.17)
	40-<50	23.66 (22.23,25.75)	23.38 (21.37,25.17)	24.24 (22.74,25.03)	23.52 (21.11,24.74)	23.96 (21.48,25.15)
	50-<60	24.04 (20.54,28.36)	23.39 (21.32,26.03)	23.29 (20.11,25.76)	24.39 (22.43,25.93)	24.17 (21.43,26.86)
	60+	24.61 (22.38,29.38)	24.08 (22.54,26.31)	23.58 (22.57,25)	23.95 (22.42,25.77)	23.08 (22.03,23.77)
Median Donor to Recipient Distance						
	<35	205 (202,210)	206 (193,228)	209 (194,235)	96 (86,109)	185 (164,206)
	35-<40	201 (198,209)	214 (198,228)	229 (207,248)	94 (84,110)	191 (176,202)
	40-<50	195 (190,200)	269 (255,280)	296 (284,306)	90 (82,100)	221 (212,228)
	50-<60	184 (174,191)	409 (385,424)	487 (472,500)	112 (104,121)	291 (274,317)

Table 7: Outcome Counts and Rates by Scenario by LAS Category

Outcome	LAS Group	Current	1.1 LAS	2.1 LAS	High Prox	Cand Biology
	60+	168 (158,178)	716 (695,739)	748 (736,770)	358 (350,367)	575 (565,598)
Percent Expected to Fly (>75NM)						
	<35	82.34 (80.58,83.85)	64.15 (61.34,66.94)	65.4 (63.48,69.74)	55.6 (54.12,58.33)	63.9 (62.03,66.05)
	35-<40	81.57 (78.45,82.55)	66.35 (64.22,67.91)	68.09 (65.74,70.47)	54.83 (52.69,57.84)	63.75 (61.42,65.38)
	40-<50	81.54 (79.86,82.79)	75.24 (73.21,76.69)	77.41 (75.3,78.65)	53.92 (51.6,55.89)	69.55 (68.4,70.79)
	50-<60	79.5 (76.68,81.45)	88 (86.67,89.69)	91.58 (90.51,92.54)	57.1 (54.63,58.4)	76.9 (74.81,79.31)
	60+	79.1 (77.06,82.68)	95.93 (94.89,97.12)	96.8 (96.24,97.4)	83.87 (82.95,84.92)	93.31 (91.71,94.09)

Outcomes by WLAUC Quartile

As with LAS, transplant rates by quartile of WLAUC followed a dose-response relationship, but it was not linear. All continuous allocation scenarios had higher transplant rates in the lowest WLAUC quartile (those expected to have the lowest waitlist survival), but that rate increased from 1.9 transplants per patient-year under current rules to 6.5 under 2:1 LAS, 5.3 under 1:1 LAS, 3.3 under candidate biology, and 2.9 under high-proximity scenarios (Table 8, Figure 34). Higher transplant rates occurred in scenarios in which WLAUC was prioritized and few other restrictions were codified. In the second and third quartiles of WLAUC, transplant rates declined under all continuous allocation scenarios compared with current rules.

Figure 35 and Table 8 show the distribution of patients who underwent a simulated transplant by WLAUC quartile. The percent of patients in the lowest quartile increased considerably in all continuous scenarios but increased the most in the 2:1 LAS scenario, as expected.

Changes in number of waitlist deaths by WLAUC quartile followed the LAS pattern, in which the patients most likely to die on the waitlist (first WLAUC quartile) represented 75% of waitlist deaths under current rules and declined precipitously under all continuous allocation scenarios (Figure 36, Table 8). In all other WLAUC quartiles, the number of waitlist deaths was similar across all simulations, including current rules.

The percent of 2-year posttransplant deaths was similar across scenarios for each WLAUC quartile (Figure 37, Table 8).

The patterns of median distance from donor to recipient by WLAUC quartile were similar to the pattern by LAS, with the most severely ill patients seeing the biggest increases in median distance in the 2:1 LAS, 1:1 LAS, and candidate biology scenarios. These all prioritized WLAUC over distance. In the high-proximity scenario, distances for all but the three less severely ill groups were halved compared with current rules. Percent of donor organs expected to have been flown declined for the three less severely ill quartiles of WLAUC compared with current rules under all continuous scenarios.
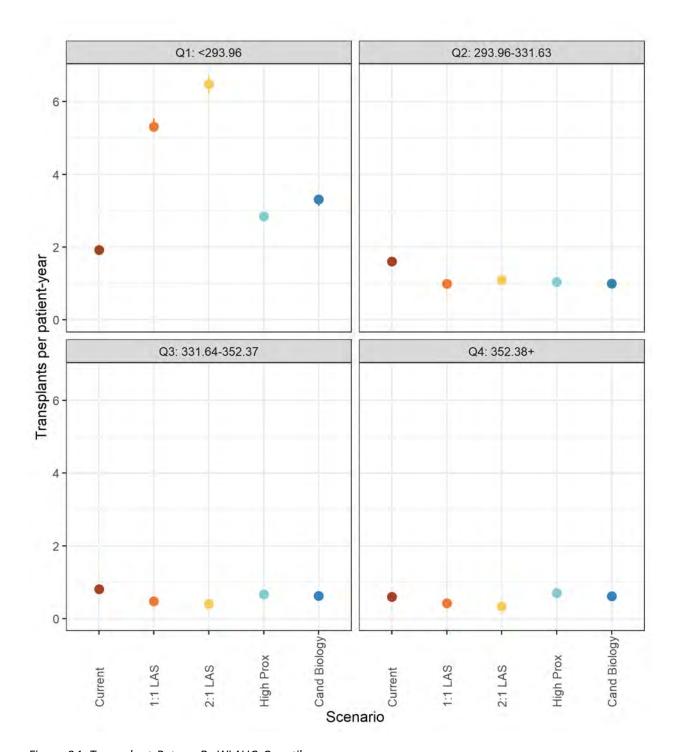
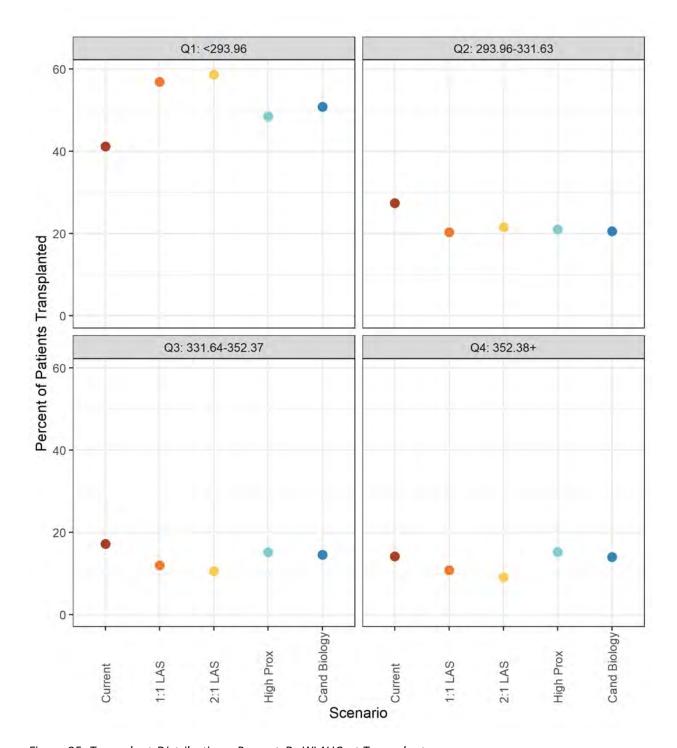Figure 34: Transplant Rates - By WLAUC Quartile

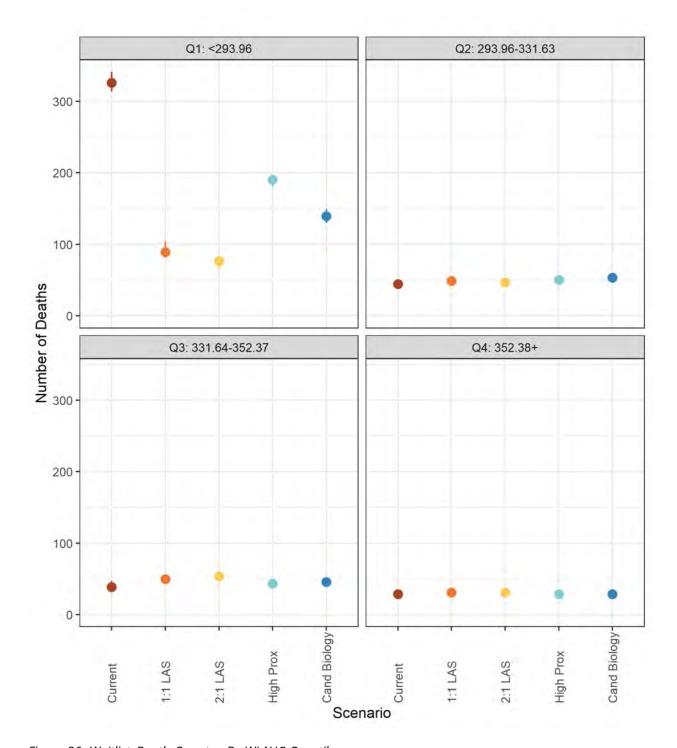*Figure 35: Transplant Distribution - Percent By WLAUC at Transplant*

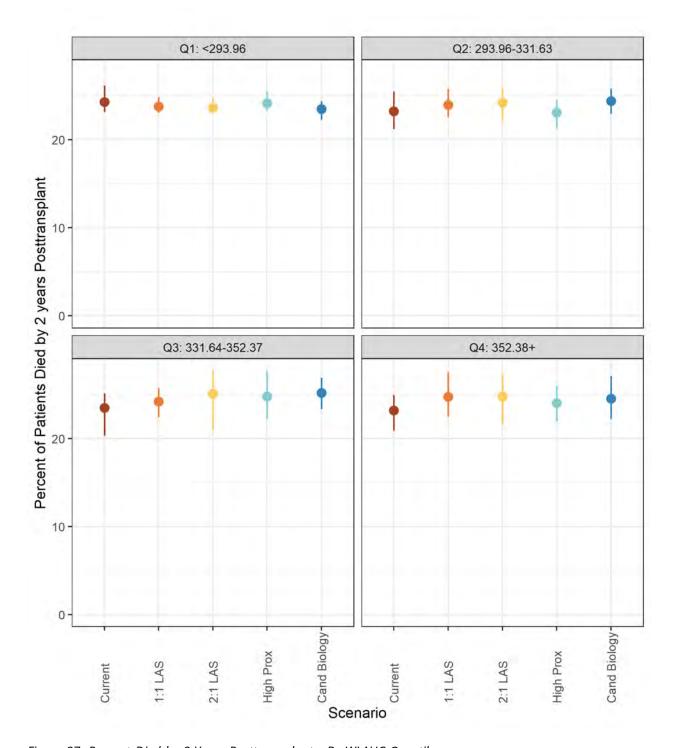*Figure 36: Waitlist Death Counts - By WLAUC Quartile*

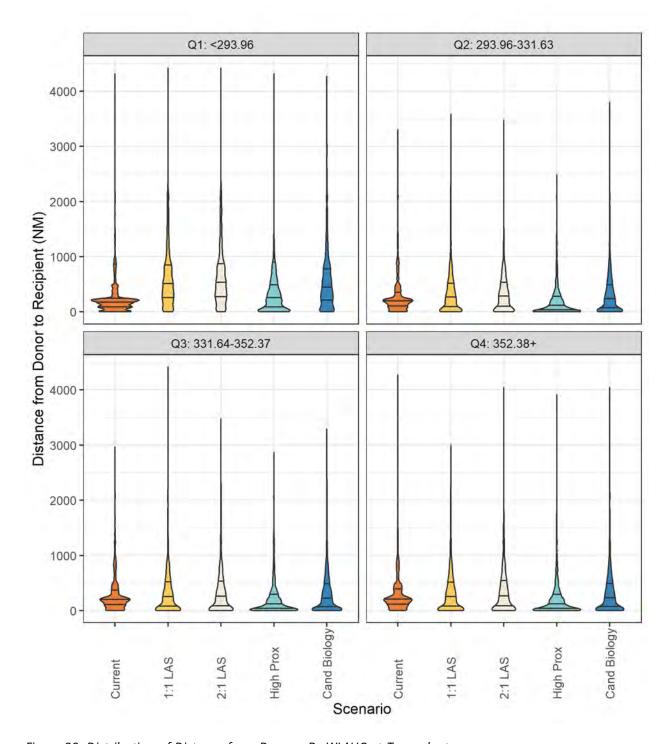*Figure 37: Percent Died by 2 Years Posttransplant - By WLAUC Quartile*

Figure 38: Distribution of Distance from Donor - By WLAUC at Transplant

Table 8: Outcome Counts and Rates by Scenario by WLAUC Quartile

Outcome	WLAUC Quartile	Current	1.1 LAS	2.1 LAS	High Prox	Cand Biology
Transplant Count (N)						
	Q1: <293.96	2079 (2062,2105)	2905 (2879,2939)	2995 (2978,3027)	2483 (2461,2504)	2598 (2553,2630)
	Q2: 293.96-331.63	1386 (1372,1397)	1040 (1008,1080)	1101 (1064,1139)	1079 (1059,1100)	1053 (1017,1080)
	Q3: 331.64-352.37	871 (841,907)	612 (597,629)	542 (527,562)	775 (745,800)	745 (722,762)
	Q4: 352.38+	717 (701,730)	551 (533,570)	466 (442,492)	780 (758,802)	715 (691,734)
Transplant Rate per Patient-Year						
	Q1: <293.96	1.92 (1.9,1.96)	5.31 (5.18,5.54)	6.48 (6.22,6.7)	2.85 (2.79,2.95)	3.31 (3.14,3.43)
	Q2: 293.96-331.63	1.61 (1.56,1.64)	0.99 (0.96,1.04)	1.1 (1.05,1.14)	1.05 (1.01,1.08)	0.99 (0.96,1.04)
	Q3: 331.64-352.37	0.81 (0.78,0.85)	0.48 (0.47,0.49)	0.41 (0.4,0.43)	0.67 (0.65,0.7)	0.63 (0.61,0.64)
	Q4: 352.38+	0.6 (0.58,0.62)	0.42 (0.4,0.44)	0.33 (0.32,0.35)	0.7 (0.69,0.73)	0.62 (0.59,0.65)
Transplant Distribution (Percent)						
	Q1: <293.96	41.15 (40.79,41.66)	56.87 (56.32,57.53)	58.68 (58.36,59.29)	48.53 (48.15,48.85)	50.82 (50.05,51.46)
	Q2: 293.96-331.63	27.43 (27.14,27.73)	20.37 (19.71,21.15)	21.57 (20.88,22.31)	21.08 (20.66,21.46)	20.61 (19.9,21.13)
	Q3: 331.64-352.37	17.24 (16.64,17.93)	11.98 (11.69,12.3)	10.62 (10.34,11.01)	15.15 (14.55,15.61)	14.58 (14.13,14.91)
	Q4: 352.38+	14.18 (13.9,14.44)	10.78 (10.44,11.15)	9.12 (8.66,9.61)	15.24 (14.79,15.66)	13.99 (13.52,14.39)
Waitlist Mortality Count (N)						
	Q1: <293.96	326 (314,341)	89 (81,104)	76 (66,84)	190 (180,196)	140 (130,149)

Table 8: Outcome Counts and Rates by Scenario by WLAUC Quartile

Outcome	WLAUC Quartile	Current	1.1 LAS	2.1 LAS	High Prox	Cand Biology
	Q2: 293.96-331.63	44 (40,49)	49 (45,52)	47 (41,51)	50 (46,54)	53 (48,58)
	Q3: 331.64-352.37	39 (32,47)	50 (45,54)	54 (50,59)	43 (40,48)	46 (40,50)
	Q4: 352.38+	29 (26,34)	31 (27,33)	31 (29,32)	28 (27,31)	29 (27,31)
Percent Died by 2 Years Posttransplant						
	Q1: <293.96	24.28 (23.14,26.15)	23.77 (23.06,24.83)	23.65 (22.97,24.77)	24.13 (23.26,25.52)	23.51 (22.26,24.36)
	Q2: 293.96-331.63	23.24 (21.19,25.47)	23.98 (22.53,25.8)	24.23 (22.16,25.87)	23.08 (21.25,24.5)	24.39 (22.96,25.83)
	Q3: 331.64-352.37	23.49 (20.32,25.12)	24.21 (22.41,25.75)	25.09 (21,27.7)	24.78 (22.25,27.59)	25.18 (23.32,26.91)
	Q4: 352.38+	23.17 (20.85,24.93)	24.74 (22.46,27.54)	24.8 (21.59,27.24)	24.04 (21.94,25.99)	24.52 (22.25,27.07)
Median Donor to Recipient Distance						
	Q1: <293.96	181 (177,184)	500 (479,510)	524 (513,534)	226 (221,232)	422 (411,433)
	Q2: 293.96-331.63	199 (196,204)	230 (220,242)	256 (234,268)	91 (85,100)	205 (193,221)
	Q3: 331.64-352.37	201 (198,205)	206 (182,222)	213 (193,240)	93 (82,100)	181 (160,201)
	Q4: 352.38+	206 (198,214)	207 (191,233)	213 (190,267)	95 (83,106)	190 (168,210)
Percent Expected to Fly (>75NM)						
	Q1: <293.96	79.88 (78.27,81.29)	89.55 (88.87,90.07)	90.9 (90.3,91.56)	71.47 (70.57,72.7)	85.26 (83.47,85.97)
	Q2: 293.96-331.63	81.53 (80.47,82.96)	69.78 (68.08,71.05)	71.88 (70.25,73.62)	54.5 (52.74,57.78)	66.62 (64.83,68.29)
	Q3: 331.64-352.37	81.82 (79.46,83)	65.43 (63.27,68.2)	66.47 (64.06,67.82)	54.99 (52.12,57.05)	62.86 (58.99,65.86)
	Q4: 352.38+	82.68 (79.86,86.08)	64.38 (60.64,67.1)	65.92 (63.66,69.76)	55.19 (52.77,57.92)	64.45 (62.94,67)

Outcomes by PTAUC Quartile

Transplant rates within a PTAUC quartile were more similar across scenarios than rates within WLAUC and LAS groups, reflecting the low variability in PTAUC in the population (Table 9, Figure 39). This is also demonstrated by the ranges of PTAUC: the middle 50% of the population has a PTAUC range from 342.5 to 348.7 days. The lowest PTAUC quartile (patients with worse expected outcomes) had the highest transplant rate in the 2:1 LAS scenario, in which waitlist outcomes were more heavily weighted.

For all quartiles of PTAUC, there were fewer deaths under continuous allocation scenarios compared with current rules, with the sharpest declines in the 2:1 LAS and 1:1 LAS scenarios (Figure 41, Table 9).

The percent of 2-year posttransplant deaths was similar across scenarios for each PTAUC quartile (Figure 42, Table 9).

The patterns of median distance from donor to recipient by PTAUC quartile were similar to the overall pattern, with distance increases in 2:1 LAS, 1:1 LAS, and candidate biology scenarios, compared with current rules, and decreases in the high-proximity scenario (Table 9).
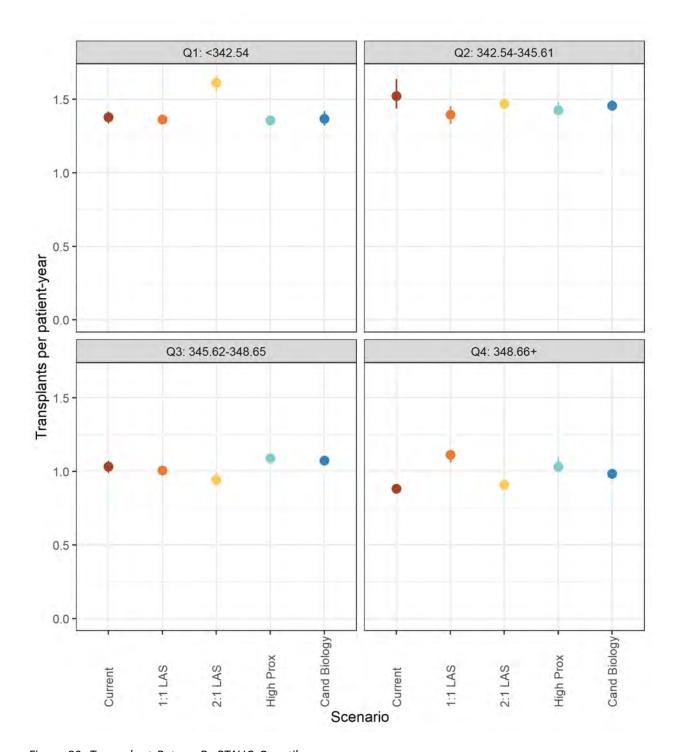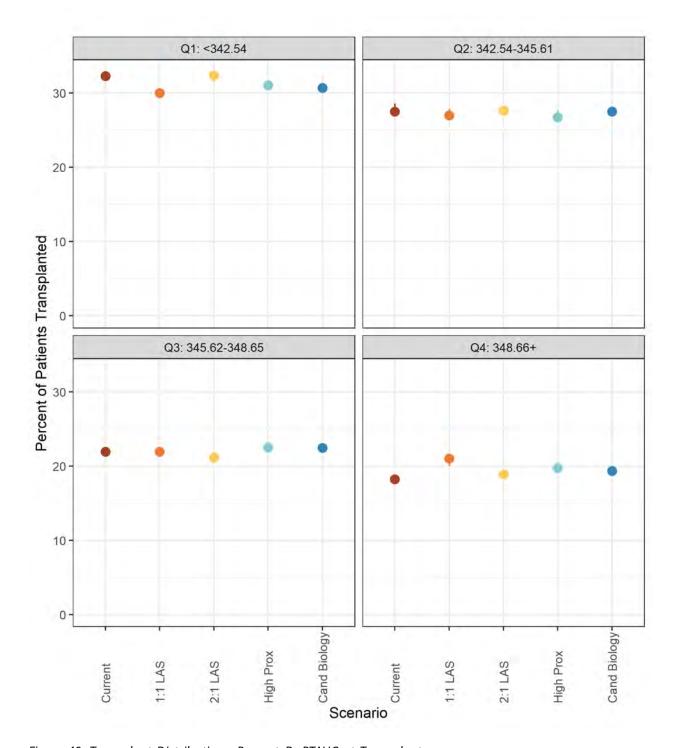
Figure 39: Transplant Rates - By PTAUC Quartile

Figure 40: Transplant Distribution - Percent By PTAUC at Transplant

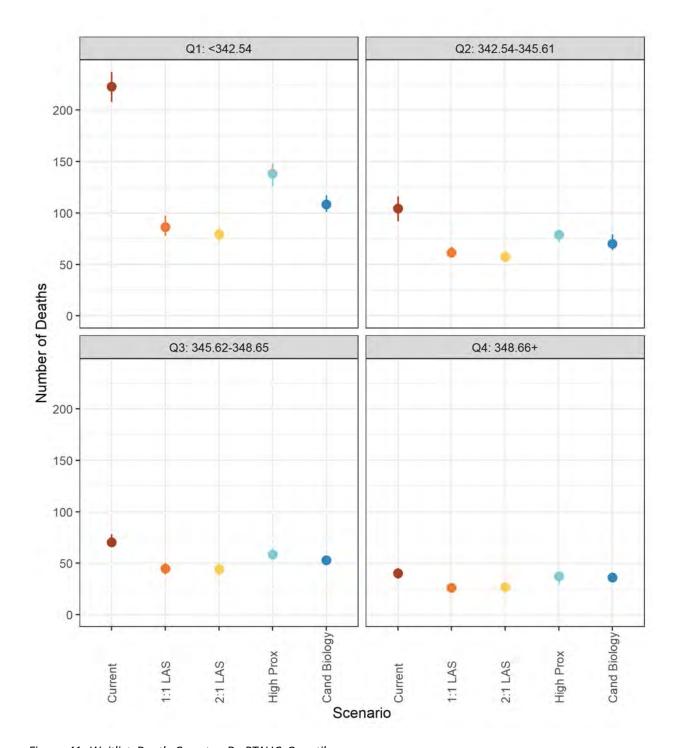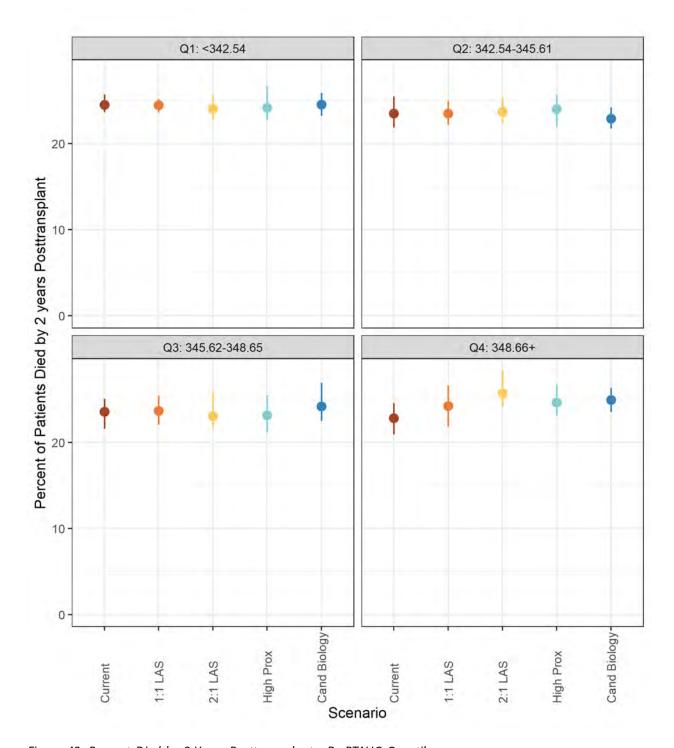*Figure 41: Waitlist Death Counts - By PTAUC Quartile*

SCIENTIFIC REGISTRY OF
TRANSPLANT RECIPIENTS

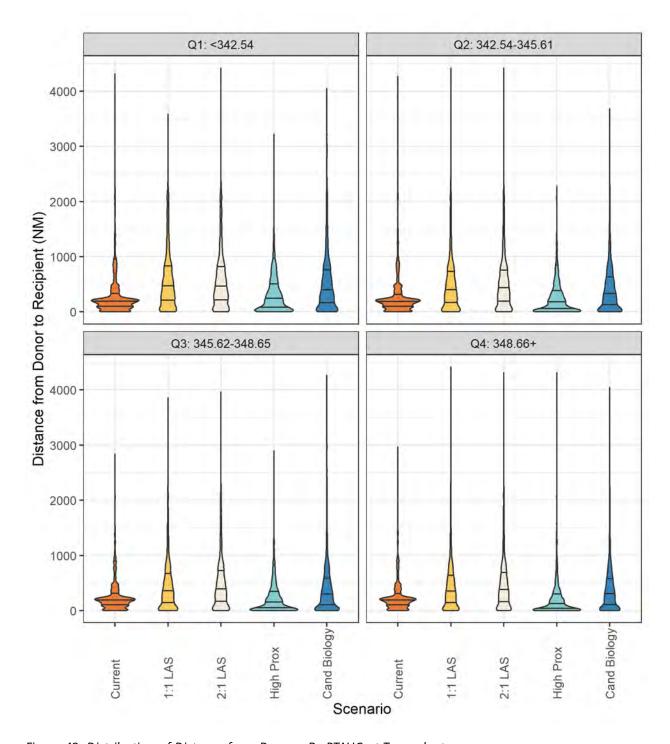Figure 42: Percent Died by 2 Years Posttransplant - By PTAUC Quartile

Figure 43: Distribution of Distance from Donor - By PTAUC at Transplant

Table 9: Outcome Counts and Rates by Scenario by PTAUC Quartile

Outcome	PTAUC Quartile	Current	1.1 LAS	2.1 LAS	High Prox	Cand Biology
Transplant Count (N)						
	Q1: <342.54	1632 (1600,1660)	1533 (1517,1546)	1652 (1609,1674)	1588 (1551,1629)	1570 (1539,1604)
	Q2: 342.54-345.61	1390 (1365,1447)	1378 (1347,1422)	1411 (1401,1437)	1369 (1349,1415)	1405 (1378,1421)
	Q3: 345.62-348.65	1109 (1078,1139)	1121 (1094,1152)	1079 (1045,1119)	1151 (1130,1175)	1147 (1128,1167)
	Q4: 348.66+	922 (890,954)	1075 (1025,1100)	963 (940,987)	1009 (986,1036)	989 (971,1019)
Transplant Rate per Patient-Year						
	Q1: <342.54	1.38 (1.33,1.41)	1.36 (1.34,1.38)	1.61 (1.56,1.66)	1.36 (1.32,1.39)	1.37 (1.32,1.42)
	Q2: 342.54-345.61	1.52 (1.44,1.64)	1.4 (1.33,1.45)	1.47 (1.43,1.51)	1.42 (1.4,1.48)	1.46 (1.42,1.49)
	Q3: 345.62-348.65	1.03 (0.99,1.07)	1.01 (0.99,1.04)	0.94 (0.9,0.99)	1.09 (1.07,1.11)	1.08 (1.04,1.11)
	Q4: 348.66+	0.88 (0.85,0.91)	1.11 (1.06,1.15)	0.91 (0.89,0.94)	1.03 (0.99,1.09)	0.98 (0.95,1.02)
Transplant Distribution (Percent)						
	Q1: <342.54	32.3 (31.63,32.84)	30.02 (29.68,30.33)	32.36 (31.54,32.72)	31.04 (30.35,31.79)	30.71 (30.14,31.33)
	Q2: 342.54-345.61	27.5 (27.01,28.6)	26.98 (26.38,27.84)	27.64 (27.39,28.14)	26.75 (26.32,27.69)	27.5 (26.99,27.81)
	Q3: 345.62-348.65	21.95 (21.31,22.5)	21.94 (21.42,22.56)	21.14 (20.46,21.95)	22.49 (22.07,22.92)	22.44 (22.04,22.84)
	Q4: 348.66+	18.25 (17.6,18.88)	21.05 (20.05,21.52)	18.86 (18.44,19.33)	19.72 (19.3,20.23)	19.36 (19,19.95)
Waitlist Mortality Count (N)						
	Q1: <342.54	223 (208,237)	86 (78,97)	79 (73,85)	138 (126,148)	108 (101,117)

Table 9: Outcome Counts and Rates by Scenario by PTAUC Quartile

Outcome	PTAUC Quartile	Current	1.1 LAS	2.1 LAS	High Prox	Cand Biology
	Q2: 342.54-345.61	104 (92,116)	61 (57,67)	58 (53,63)	79 (72,84)	70 (64,79)
	Q3: 345.62-348.65	70 (66,78)	45 (39,50)	44 (38,50)	58 (54,64)	53 (50,56)
	Q4: 348.66+	40 (35,45)	26 (23,29)	27 (23,30)	37 (30,41)	36 (34,39)
Percent Died by 2 Years Posttransplant						
	Q1: <342.54	24.5 (23.62,25.66)	24.45 (23.61,25.16)	24.03 (22.69,25.64)	24.17 (22.68,26.68)	24.51 (23.21,25.86)
	Q2: 342.54-345.61	23.49 (21.86,25.47)	23.5 (22.15,24.96)	23.68 (22.36,25.34)	24.03 (21.97,25.62)	22.9 (21.75,24.2)
	Q3: 345.62-348.65	23.54 (21.57,25.02)	23.66 (22.04,25.4)	23.04 (21.63,25.82)	23.13 (21.16,25.45)	24.18 (22.46,26.91)
	Q4: 348.66+	22.79 (20.93,24.57)	24.2 (21.8,26.58)	25.66 (24.19,28.3)	24.63 (23.07,26.66)	24.93 (23.52,26.35)
Median Donor to Recipient Distance						
	Q1: <342.54	193 (190,196)	438 (415,460)	440 (425,465)	214 (202,222)	364 (352,374)
	Q2: 342.54-345.61	194 (184,202)	367 (348,386)	401 (363,419)	154 (137,166)	298 (283,306)
	Q3: 345.62-348.65	193 (188,199)	325 (309,348)	355 (339,379)	129 (121,138)	266 (242,285)
	Q4: 348.66+	196 (188,202)	323 (299,344)	353 (324,366)	99 (84,111)	271 (258,293)
Percent Expected to Fly (>75NM)						
	Q1: <342.54	80.91 (80.31,81.7)	84.26 (82.69,85.3)	85.19 (84.03,86.26)	70.49 (69.17,72.02)	79.58 (78.69,80.6)
	Q2: 342.54-345.61	81.19 (79.61,82.29)	79.83 (78.34,81.13)	82.16 (80.51,83.3)	62.37 (61.23,63.22)	75.08 (73.99,77)
	Q3: 345.62-348.65	81.23 (79.2,83.38)	76.53 (74.6,79.02)	78.88 (77.7,81.13)	59.57 (58.02,61.77)	71.98 (70.05,74.33)
	Q4: 348.66+	80.97 (79.34,82.39)	77.38 (75.8,78.27)	79.37 (77.89,80.65)	55.53 (52.2,58.06)	72.35 (70.89,73.46)

Outcomes by Diagnosis Group

Outcomes by diagnosis group parallel outcomes by LAS, as diagnosis group is an important predictor in the LAS equations.

Compared with current rules, transplant rates among group A candidates under continuous allocation declined for the 1:1 LAS, 2:1 LAS and candidate biology scenarios, which prioritize the patients with the highest waitlist mortality (Figure 44, Table 10). Increases in transplant rates occurred in group D candidates. Transplant rates among diagnosis B candidates declined, and rates among group C candidates increased slightly.

The number of waitlist deaths among group A candidates was similar across all scenarios, from 71 to 78 (Table 10, Figure 46). For diagnosis group B, waitlist deaths dropped under the 1:1 LAS, 2:1 LAS, and candidate biology scenarios and were similar to current rules under the high proximity scenario. Waitlist deaths in group C were low under current rules (35) and dropped to 7-12 under continuous allocation scenarios. The largest declines in waitlist deaths occurred among diagnosis group D candidates, from 286 under current rules to 95 under 2:1 LAS, 105 under 1:1 LAS, 152 under candidate biology, and 189 under high proximity.

The percent of 2-year posttransplant deaths was similar across scenarios for each diagnosis group (Figure 47, Table 10).

The patterns of median distance from donor to recipient by diagnosis were generally similar to the overall pattern, with distance increases in 2:1 LAS, 1:1 LAS, and candidate biology scenarios, compared with current rules, and decreases in the high-proximity scenario (Table 10). This pattern did not hold for diagnosis group A, however. This group had the highest median distance under current rules of all diagnosis groups but smaller increases in distance under 2:1 LAS and 1:1 LAS scenarios than other diagnosis groups and larger decreases in distance under the high-proximity scenario.
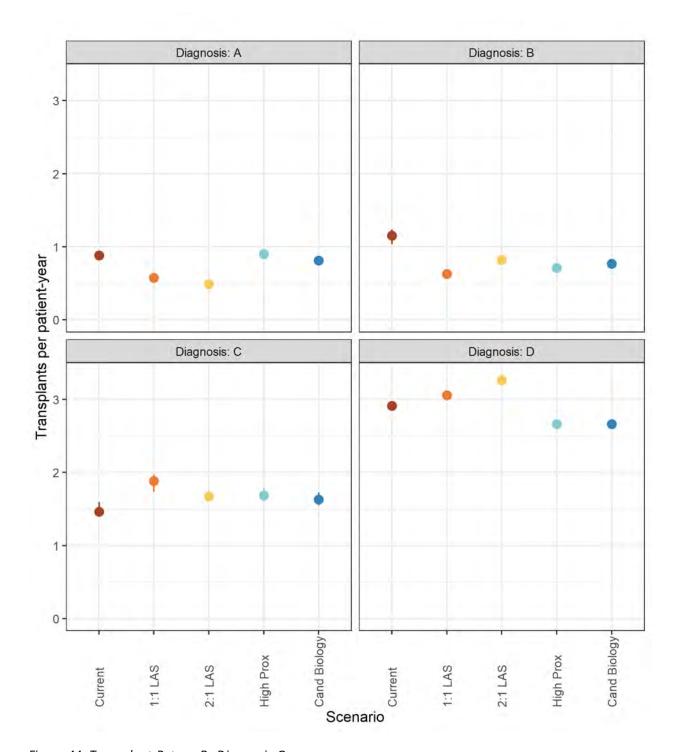
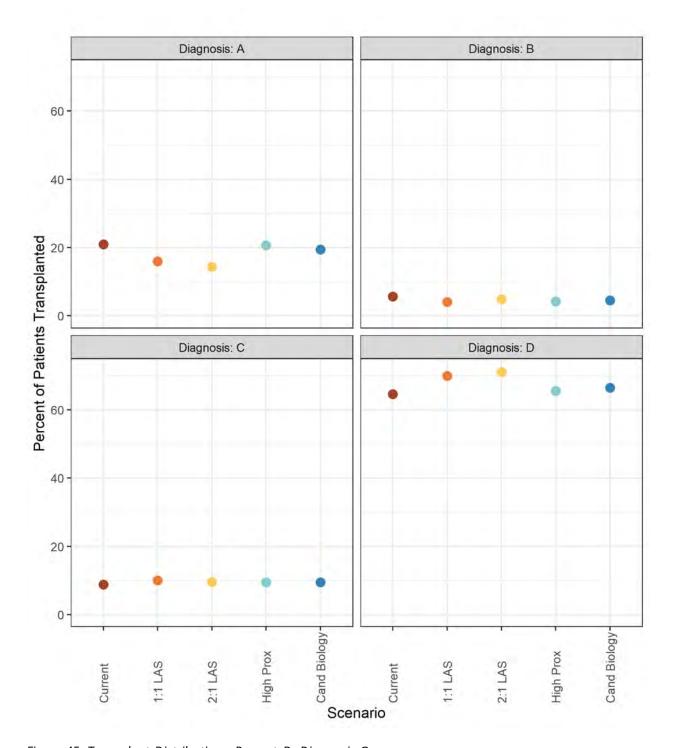Figure 44: Transplant Rates - By Diagnosis Group

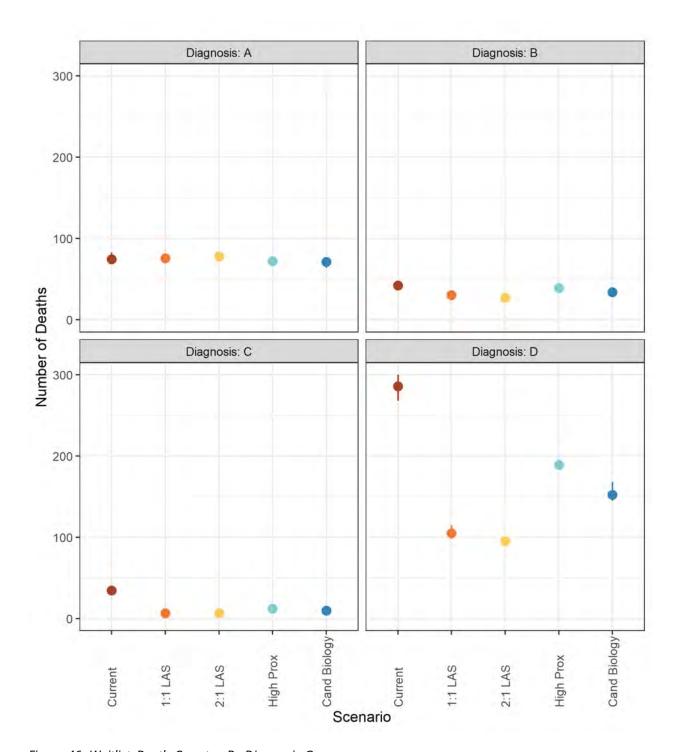*Figure 45: Transplant Distribution - Percent By Diagnosis Group*

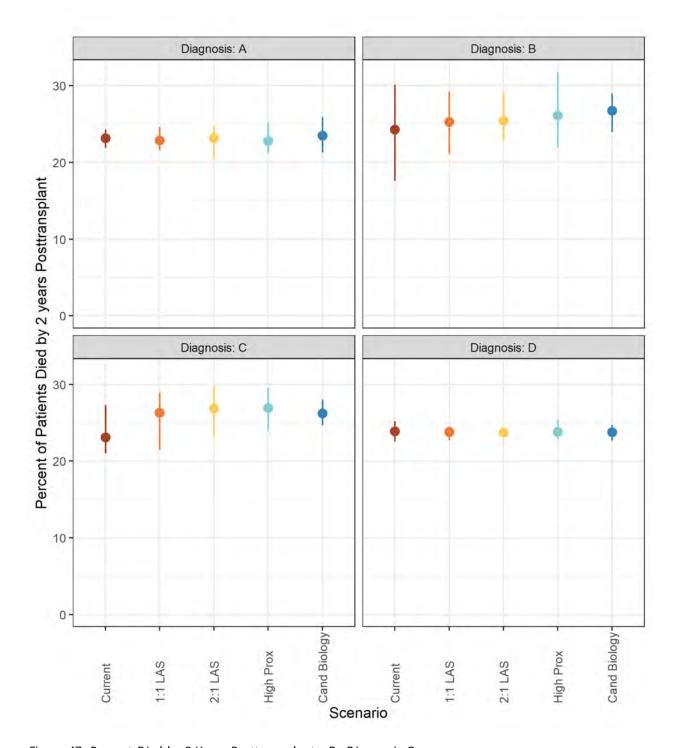Figure 46: Waitlist Death Counts - By Diagnosis Group

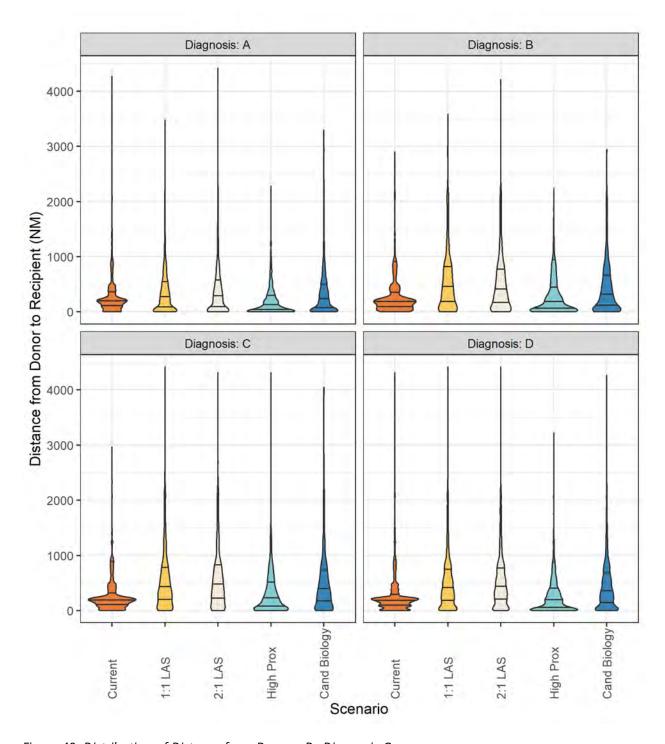*Figure 47: Percent Died by 2 Years Posttransplant - By Diagnosis Group*

Figure 48: Distribution of Distance from Donor - By Diagnosis Group

Table 10: Outcome Counts and Rates by Scenario by Diagnosis

Outcome	Diagnosis	Current	1.1 LAS	2.1 LAS	High Prox	Cand Biology
Transplant Count (N)						
	Diagnosis: A	1058 (1041,1080)	815 (792,834)	733 (713,765)	1060 (1048,1078)	995 (966,1022)
	Diagnosis: B	285 (263,295)	207 (195,215)	252 (247,265)	218 (206,230)	233 (222,244)
	Diagnosis: C	446 (433,461)	511 (500,522)	489 (483,497)	485 (472,498)	484 (474,498)
	Diagnosis: D	3265 (3242,3302)	3574 (3550,3602)	3630 (3615,3647)	3354 (3328,3365)	3399 (3369,3421)
Transplant Rate per Patient-Year						
	Diagnosis: A	0.88 (0.85,0.91)	0.58 (0.56,0.6)	0.49 (0.47,0.51)	0.9 (0.88,0.93)	0.81 (0.77,0.84)
	Diagnosis: B	1.15 (1.03,1.24)	0.63 (0.58,0.65)	0.82 (0.79,0.89)	0.71 (0.66,0.76)	0.77 (0.72,0.81)
	Diagnosis: C	1.46 (1.4,1.6)	1.88 (1.73,1.97)	1.67 (1.61,1.76)	1.69 (1.61,1.79)	1.63 (1.55,1.73)
	Diagnosis: D	2.91 (2.89,2.95)	3.06 (3.01,3.09)	3.26 (3.2,3.34)	2.66 (2.6,2.71)	2.66 (2.6,2.71)
Transplant Distribution (Percent)						
	Diagnosis: A	20.93 (20.58,21.4)	15.96 (15.54,16.32)	14.36 (13.97,14.94)	20.71 (20.44,21.05)	19.46 (18.9,19.96)
	Diagnosis: B	5.64 (5.2,5.84)	4.06 (3.83,4.2)	4.94 (4.84,5.19)	4.26 (4.03,4.5)	4.56 (4.34,4.77)
	Diagnosis: C	8.82 (8.55,9.14)	10 (9.78,10.21)	9.58 (9.47,9.75)	9.49 (9.23,9.72)	9.48 (9.26,9.74)
	Diagnosis: D	64.61 (64.21,65.35)	69.97 (69.43,70.67)	71.12 (70.58,71.46)	65.54 (65.18,65.82)	66.5 (65.96,66.95)
Waitlist Mortality Count (N)						
	Diagnosis: A	75 (69,83)	76 (71,80)	78 (74,83)	72 (69,75)	71 (64,77)

Table 10: Outcome Counts and Rates by Scenario by Diagnosis

Outcome	Diagnosis	Current	1.1 LAS	2.1 LAS	High Prox	Cand Biology
	Diagnosis: B	42 (39,47)	31 (26,36)	27 (24,30)	39 (34,46)	34 (31,38)
	Diagnosis: C	35 (32,39)	7 (5,8)	7 (5,9)	12 (11,16)	10 (8,12)
	Diagnosis: D	286 (268,300)	105 (98,115)	95 (90,98)	189 (183,196)	152 (145,168)
Percent Died by 2 Years Posttransplant						
	Diagnosis: A	23.17 (21.93,24.26)	22.87 (21.58,24.6)	23.16 (20.38,24.8)	22.84 (21.13,25.17)	23.5 (21.29,25.89)
	Diagnosis: B	24.27 (17.63,30.14)	25.3 (21.08,29.25)	25.43 (22.89,29.15)	26.12 (21.93,31.78)	26.76 (23.95,28.95)
	Diagnosis: C	23.11 (21.02,27.33)	26.32 (21.48,28.94)	26.85 (23.17,29.71)	26.92 (23.88,29.55)	26.22 (24.7,28.04)
	Diagnosis: D	23.9 (22.58,25.18)	23.8 (22.72,24.53)	23.73 (23.29,24.12)	23.79 (22.9,25.4)	23.75 (22.65,24.67)
Median Donor to Recipient Distance						
	Diagnosis: A	202 (198,204)	224 (206,245)	245 (219,269)	96 (88,105)	193 (172,211)
	Diagnosis: B	185 (171,201)	388 (311,468)	355 (305,417)	136 (119,155)	251 (220,271)
	Diagnosis: C	194 (191,198)	399 (360,427)	453 (409,502)	191 (170,214)	354 (314,382)
	Diagnosis: D	192 (187,196)	393 (383,403)	419 (412,436)	169 (161,177)	330 (316,336)
Percent Expected to Fly (>75NM)						
	Diagnosis: A	82 (80.6,83.7)	67.08 (65.56,69.84)	68.7 (66.41,72.95)	55.42 (54.09,57.55)	64.95 (63.74,67.04)
	Diagnosis: B	77.24 (74.56,80.48)	76.77 (73.56,79.9)	76.56 (72.14,80.97)	60.15 (55.71,63.29)	69.05 (65.16,73.25)
	Diagnosis: C	81.93 (79.12,85.62)	83.2 (81.3,84.84)	84.84 (83.44,87.01)	66.86 (65.25,68.71)	79.27 (76.39,81.93)
	Diagnosis: D	80.97 (80.1,82.19)	82.56 (81.92,83.3)	84.57 (83.79,85.1)	64.89 (64.18,65.8)	78.1 (76.38,78.85)

Outcomes by Distance from Donor

Distribution of simulated transplant by distance category varied considerably by scenario (Table 11), and 2-year posttransplant outcomes were similar across scenarios (Figure 49).

Under current rules, there is a hard boundary at 250 NM, but otherwise organs are generally allocated by LAS. Consequently, most (71%) of the simulated transplants under current rules used donors within 250 NM, and few organs (657, 13%) came from donors more than 500 NM away. All continuous allocation scenarios used an efficiency score that increased priority for nearby transplants, and the weight of that efficiency score varied with scenario. The score was most highly weighted, and its impact most evident, in the high-proximity scenario, in which 31.1% of transplants used donors within 50 NM (within driving distance), and 3.2% used donors more than 1000 NM away. The other three continuous allocation scenarios used more donors within 50 NM than current rules did. In the 1:1 LAS, 2:1 LAS, and candidate biology scenarios, efficiency had low allocation weight, resulting in a larger proportion of organs (>30%) from more distant donors (>500 NM).
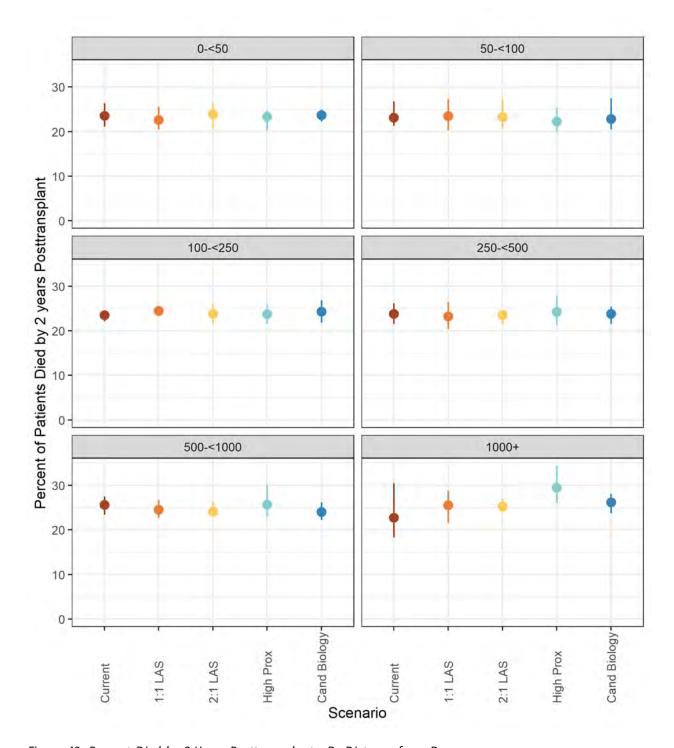
Figure 49: Percent Died by 2 Years Posttransplant - By Distance from Donor

Table 11: Outcome Counts and Rates by Scenario by Distance between Donor and Recipient

Outcome	Distance (NM)	Current	1.1 LAS	2.1 LAS	High Prox	Cand Biology
Transplant Count (N)						
	0-<50	727 (704,772)	846 (822,892)	763 (736,783)	1590 (1559,1612)	1059 (1036,1111)
	50-<100	595 (572,622)	337 (309,352)	313 (301,344)	584 (556,622)	386 (370,405)
	100-<250	2275 (2227,2312)	759 (728,782)	723 (691,753)	1070 (1052,1092)	813 (762,854)
	250-<500	798 (778,820)	1184 (1146,1223)	1204 (1164,1256)	1007 (967,1051)	1164 (1139,1203)
	500-<1000	474 (457,490)	1361 (1320,1423)	1425 (1375,1467)	704 (673,743)	1218 (1163,1275)
	1000+	183 (162,198)	620 (588,661)	677 (624,729)	162 (145,174)	471 (439,503)
Transplant Distribution (Percent)						
	0-<50	14.39 (13.9,15.26)	16.56 (16.08,17.46)	14.95 (14.45,15.29)	31.08 (30.44,31.55)	20.71 (20.27,21.75)
	50-<100	11.78 (11.32,12.29)	6.6 (6.04,6.89)	6.13 (5.88,6.75)	11.41 (10.85,12.15)	7.56 (7.24,7.92)
	100-<250	45.03 (44.06,45.75)	14.86 (14.28,15.32)	14.16 (13.55,14.78)	20.92 (20.56,21.32)	15.91 (14.94,16.73)
	250-<500	15.8 (15.38,16.25)	23.19 (22.43,23.92)	23.58 (22.8,24.6)	19.68 (18.96,20.5)	22.78 (22.24,23.54)
	500-<1000	9.38 (9.08,9.71)	26.65 (25.9,27.91)	27.92 (26.93,28.74)	13.76 (13.17,14.49)	23.83 (22.77,24.9)
	1000+	3.61 (3.21,3.92)	12.15 (11.51,12.94)	13.26 (12.25,14.28)	3.16 (2.83,3.39)	9.21 (8.57,9.85)
Percent Died by 2 Years Posttransplant						
	0-<50	23.56 (21.09,26.33)	22.61 (20.48,25.55)	23.91 (20.68,26.53)	23.36 (20.18,24.69)	23.7 (22.25,24.9)
	50-<100	23.15 (21.24,26.81)	23.46 (20.29,27.27)	23.23 (20.93,27.24)	22.27 (19.93,25.34)	22.82 (20.47,27.44)

Table 11: Outcome Counts and Rates by Scenario by Distance between Donor and Recipient

Outcome	Distance (NM)	Current	1.1 LAS	2.1 LAS	High Prox	Cand Biology
	100-<250	23.55 (22.09,24.43)	24.48 (23.36,25.61)	23.81 (21.67,26.08)	23.7 (21.58,25.86)	24.27 (21.81,26.84)
	250-<500	23.77 (21.48,26.18)	23.26 (20.33,26.43)	23.61 (21.44,24.69)	24.2 (21.25,27.88)	23.79 (21.49,25.47)
	500-<1000	25.63 (23.42,27.47)	24.55 (22.74,26.69)	24.15 (22.84,26.39)	25.69 (23.08,30.04)	24.08 (22.24,26.22)
	1000+	22.75 (18.29,30.51)	25.55 (21.51,28.89)	25.27 (23.88,26.99)	29.52 (26,34.38)	26.2 (23.69,28.03)

Appendix

TSAM was rebuilt for this data request; model cohorts were updated to include candidates and donors, January 1, 2018-December 31, 2019. Models underlying the TSAM were updated as well.

The offer acceptance model is a logistic model predicting whether an offered organ will be accepted for transplant. The offer acceptance models included offers from donors recovered between January 1, 2018, and December 31, 2019. The match runs had at least 1 acceptance, and offers after the last acceptance were excluded. The lung offer acceptance model included candidate factors (age, sex, blood type, smoking history, prior malignancy, prior cardiac surgery, hypertension, LAS, diagnosis group), donor factors (age, sex, blood type, BMI, cause of death, smoking history, history of hypertension, height, donor-to-recipient height and weight ratios, public health service increased risk of disease transmission, HBV and HCV status, PO2, DCD status, offer number). Three separate lung offer acceptance models were estimated: (1) a model for offers to pediatric candidates, (2) a model for offers to adult candidates from donors without a previous acceptance, and (3) a model for offers to adult candidates willing to accept single lungs from donors with a previous acceptance. The second model was used when a donor had 2 lungs available, and the third model was used when a donor had only 1 lung available.

Distance has been included in previous TSAM acceptance models but was explicitly excluded in the current acceptance models. Models are based on historic data, and historically, nearby offers were prioritized. Thus, offers accepted at greater distances would likely have been rejected by many before being accepted. In a continuous allocation system, this may no longer be the case.

The adult lung posttransplant model included recipient factors (age, sex, prior transplant, LAS, diagnosis group), and donor factors (age, cause of death, smoking history, pH, DCD status, donor-recipient weight ratio). Ischemia time was not included, as TSAM cannot estimate this value. Previous analyses suggested that distance was an insufficient proxy for ischemia time to use in posttransplant models. The pediatric lung posttransplant model included only donor age. The small number of pediatric recipients did not support a more complex model.

The estimation of both the offer acceptance and posttransplant models used the least absolute shrinkage and selection operator (LASSO). The LASSO 'shrinks' covariate effects towards 0, which can improve predicted error and set effects to exactly 0, effectively performing model selection. Linear splines estimated the effect of continuous covariates, and knots were evenly spaced throughout the covariate distribution.