

Outcomes of Deceased Donor Kidney Offers to Patients at the Top of the Waiting List

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Abstract

Background and objectives Transplant centers may accept or refuse deceased-donor kidneys that are offered to their patients at the top of the waiting list. We sought to determine the outcomes of deceased-donor kidney offers and their association with characteristics of waitlisted patients and organ donors.

Design, setting, participants, & measurements We examined all 7 million deceased-donor adult kidney offers in the United States from 2007 to 2012 that led to eventual transplantation. Data were obtained from the national organ allocation system through the United Network of Organ Sharing. The study cohort consisted of 178,625 patients waitlisted for a deceased-donor kidney transplant and 31,230 deceased donors. We evaluated offers made to waitlisted patients and their outcomes (transplantation or specific reason for refusal).

Results Deceased-donor kidneys were offered a median of seven times before being accepted for transplantation. The most common reasons for refusal of an offer were donor-related factors, *e.g.*, age or organ quality (3.2 million offers, 45.0%), and transplant center bypass, *e.g.*, minimal acceptance criteria not met (3.2 million offers, 44.0%). After adjustment for characteristics of waitlisted patients, organ donors, and transplant centers, male (odds ratio [OR], 0.93; 95% confidence interval [95% CI], 0.91 to 0.95) and Hispanic (OR, 0.96; 95% CI, 0.93 to 0.99) waitlisted patients were less likely to have an offer accepted than female and white patients, respectively. The likelihood of offer acceptance varied greatly across transplant centers (interquartile ratio, 2.28).

Conclusions Transplant centers frequently refuse deceased-donor kidneys. Such refusals differ by patient and donor characteristics, may contribute to disparities in access to transplantation, and vary greatly across transplant centers.

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Introduction

About 600,000 Americans have ESRD and require chronic dialysis treatment or a kidney transplant to survive (1). Compared with chronic dialysis, kidney transplantation results in better survival and quality of life and lower health care costs (2). Despite Medicare financing of virtually all kidney transplants, there are sizeable race, sex, and socioeconomic disparities in access to kidney transplantation (3–9).

About two-thirds of kidney transplants come from deceased-donor organs. Patients awaiting a deceased-donor organ are placed on a national waiting list and typically wait several years to receive a transplant (10). When a deceased-donor kidney becomes available, a match run list is generated that ranks patients in priority order on the basis of a combination of immunologic criteria and waiting time. A transplant center may accept or refuse a deceased-donor kidney that is offered to its patient at the top of the match run list. If refused, the kidney is then offered to the next patient on the match run list. The results of such offers are cataloged as part of a national electronic allocation system. We sought to determine the outcomes of deceased-donor kidney offers and

their association with characteristics of waitlisted patients and organ donors. We hypothesized that there are differences in offer acceptance rates due to donor and waitlisted patient characteristics for deceased-donor kidney offers for patients at the top of the waiting list.

Materials and Methods

Data

We obtained data from the United Network for Organ Sharing (UNOS) on all offers involving deceased-donor kidneys in the United States that led to a transplant from May of 2007 to July of 2012. Each offer is defined as a single match between a donor and potential kidney transplant recipient on a match run list that occurs when a donor organ becomes available. Transplant centers may accept offers (resulting in transplantation) or refuse offers (for a specific reason). UNOS categorizes 37 different reasons for refusal into the following six categories: donor-related refusal, transplant center bypassed for prespecified criteria, recipient-related refusal, histocompatibility-related refusal, program-related refusal, and other reason

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for refusal. We also obtained demographic and medical characteristics of all waitlisted patients and organ donors involved in these offers. Waitlisted patient characteristics included age, race/ethnicity, sex, cause of ESRD, body mass index, and panel of reactive antibodies. Donor characteristics included age, race/ethnicity, sex, terminal creatinine, presence of hypertension or diabetes, whether the cause of death was a cerebrovascular accident, and status of donation after cardiac death. Donor creatinine and medical conditions were included because they are commonly used as markers of donor organ quality (11,12). Because reasons for refusal may vary as the number of offers for a particular donor increases, we also analyzed number of offers as a predictor for transplantation. Number of offers was entered as quintiles to allow detection of nonlinear relationships. Transplant center characteristics included transplant volume, proportion of minority patients that were waitlisted, and number of living-donor kidney transplants at each center. The Scientific Registry of Transplant Recipients' annual program specific reports were used to determine the number of living donors per year for each center. Each offer up to and including the offer that resulted in transplantation was included in the data. We excluded kidney transplants that involved children as recipients or that were part of multi-organ transplants. This study was approved by the institutional review board of MetroHealth Medical Center, Cleveland, Ohio. The clinical and research activities being reported are consistent with the Principles of the Declaration of Istanbul as outlined in the Declaration of Istanbul on Organ Trafficking and Transplant Tourism.

This study used data from the Organ Procurement and Transplantation Network (OPTN). The OPTN data system includes data on all donors, waitlisted candidates, and transplant recipients in the United States, submitted by the members of the OPTN. The Health Resources and Services Administration, US Department of Health and Human Services provides oversight to the activities of the OPTN contractor.

Statistical Analyses

With offers as the unit of analysis, we used the chi-squared test to compare waitlisted patient and donor characteristics with each offer outcome (transplantation or six categories of reasons for refusal). We then developed separate logistic regression models to determine the independent relationship between each offer outcome and waitlisted patient and donor characteristics. We used a generalized estimating equations approach (with an independence working correlation structure) to obtain variance estimates accounting for clustering of repeated offers to multiple waitlisted patients from the same donor. We performed generalized score tests to assess the overall effect of each predictor variable on offer outcomes. A multivariate interaction model was used to determine the relationship between waitlisted patient age, ethnicity, and sex with donor characteristics for transplantation (see Supplemental Table 1). We analyzed 7,137,831 offers after waitlisted patients ($n=19,255$) or donors ($n=1059$) with incomplete data were omitted from the analysis. We performed a sensitivity analysis using multiple imputation of missing variables that found nearly identical results.

Finally, we calculated standardized ratios (analogous to standardized mortality ratios) to examine transplant center-related variability in offer outcomes after adjustment for differences in waitlisted patient and donor characteristics. We summed the expected probabilities of offer outcomes across all patients at each transplant center using the logistic regression models. This expected number takes into account the demographic and medical characteristics of waitlisted patients and donors. We then calculated the standardized ratio as the sum of the actual number of patients with each offer outcome divided by the sum of the expected number of patients with the particular offer outcome for each transplant center (13–15). Statistical analyses were conducted using JMP version 12.1.0 and SAS version 9.4 (SAS Institute, Cary, NC).

Results

The characteristics of the 178,625 waitlisted patients and 31,230 organ donors are described in Table 1. A majority of waitlisted patients were white (45%) and men (61%). Their

Table 1. Characteristics of waitlisted patients and organ donors

Characteristics	Value
Waitlisted patients ($n=178,625$)^a	
Age, yr	51 (13)
Race/ethnicity	
White	81,215 (45)
Black	54,731 (31)
Hispanic	29,236 (16)
Other	13,443 (8)
Sex	
Female	70,298 (39)
	108,327 (61)
Cause of ESRD	
Hypertension	40,781 (23)
Diabetes	54,205 (30)
GN	22,886 (13)
Other	60,753 (34)
Panel reactive antibodies, %	20.4 (34.2)
Body mass index, kg/m ²	28.2 (5.7)
Organ donors ($n=31,230$)	
Age, yr	38 (17)
Race/ethnicity	
White	21,311 (68)
Black	4453 (14)
Hispanic	4326 (14)
Other	1140 (4)
Sex	
Female	12,459 (40)
Male	18,771 (60)
Terminal creatinine, mg/dl	1.1 (0.9)
Co-morbidities	
Hypertension	8678 (28)
Diabetes	2177 (7)
Cause of death is cerebrovascular accident	10,767 (34)
Donation after cardiac death	4080 (13)

^aNumbers in parentheses represent SD for continuous variables or percent for categorical variables.

average age was 51 years, and nearly one-third had diabetes as the cause of ESRD. A majority of donors were also white (68%) and men (60%). Their average age was 38 years, and about one-fourth had hypertension.

These waitlisted patients and donors were involved in a total of 7 million deceased-donor kidney offers between May of 2007 and July of 2012. Of all offers, 49,000 (0.7%) resulted in a transplant. The median number of offers before transplantation was 7 (interquartile range, 2–73). The most common reasons for refusal of an offer were donor-related factors, *e.g.*, age or organ quality (3.2 million offers, 45.0%) and transplant center bypass, *e.g.*, minimal acceptance criteria not met (3.2 million offers, 44.0%). Less frequent reasons for offer refusal were due to recipient-related, histocompatibility-related, and program-related reasons (Table 2).

On univariate analysis, several waitlisted patient and donor characteristics were associated with outcomes of kidney offers (Table 3). For example, offers to non-White waitlisted patients were less likely to lead to transplantation compared with offers to white patients (0.7% for black and 0.5% for Hispanic patients versus 0.8% for white patients, $P<0.001$). Offers to black waitlisted patients were refused more often for histocompatibility reasons compared with offers to white patients (1.6% versus 1.3%, $P<0.001$). Offers from donors with a terminal creatinine >1.5 mg/dl were refused more often for donor-related reasons compared with offers from donors with a terminal creatinine <1.0 mg/dl (55.4% versus 42.4%, $P<0.001$). Likewise, offers from donors with hypertension, diabetes, and after cardiac death were more likely refused for donor-

related reasons (53.8% versus 40.7%, 59.8% versus 43.5%, and 54.4% versus 43.8%).

On multivariate analysis, several waitlisted patient and donor characteristics were also associated with outcomes of kidney offers (Table 4). For example, offers to Hispanic waitlisted patients were less likely to lead to transplantation compared with offers to white patients (odds ratio [OR], 0.96; 95% confidence interval [95% CI], 0.93 to 0.99). Offers to male waitlisted patients were less likely to lead to transplantation than offers to female patients (OR, 0.93; 95% CI, 0.91 to 0.95). Waitlisted patients with diabetes as the cause of their ESRD were less likely to be transplanted (OR, 0.91; 95% CI, 0.88 to 0.93) and those with a high body mass index (≥ 30 kg/m²) were also less likely to be transplanted (OR, 0.85; 95% CI, 0.83 to 0.87). Waitlisted patients with high panel reactive antibodies are more likely to be transplanted (OR, 2.43; 95% CI, 2.33 to 2.53). Offers to older patients were less likely to be refused for a histocompatibility-related reason. As in the univariate analysis, offers from donors with a terminal creatinine >1.5 mg/dl, hypertension, diabetes, or cardiac death were less likely to lead to transplantation and more likely to be refused for a donor-related reason. Compared with organs offered many times (highest quintile), donor organs offered fewer times are twice as likely to be accepted for transplant (OR, 1.98; 95% CI, 1.67 to 2.35). Reasons for refusal of organs with fewer numbers of offers were recipient- (OR, 1.75; 95% CI, 1.61 to 1.90) and histocompatibility-related (OR, 2.56; 95% CI, 2.36 to 2.78). Offers to transplant centers with more minority patients (percentage of black patients and Hispanic patients waitlisted) on the waiting list were

Table 2. Outcomes of kidney offers from 2007 to 2012 in the United States (n=7,137,831 offers)

Category, Specific Outcome	n, 1000	% ^a
Kidney transplanted	49	0.7
Donor-related refusal	3232	45.0
Donor age or quality	2194	30.7
Organ-specific donor issue such as testing unavailable or unacceptable, or abnormal biopsy	265	3.7
Other, <i>e.g.</i> , donor blood type, donor size or weight, donor social history	772	10.8
Transplant center bypassed for prespecified criteria	3167	44.0
Not offered because minimal acceptance criteria not met	949	13.3
Directed donation	765	10.7
Other, <i>e.g.</i> , offer not made due to expedited placement attempt	1453	20.3
Recipient-related refusal	141	2.0
Patient ill, unavailable, refused, or temporarily unsuitable	130	1.8
Multiple organ transplant or different laterality required	9	0.1
Other, <i>e.g.</i> , patient's condition improved or already transplanted	2	0.03
Histocompatibility-related refusal	97	1.4
Positive crossmatch	48	0.7
No serum available for crossmatch	25	0.3
Other, <i>e.g.</i> , unacceptable antigens or high panel reactive antibodies	18	0.3
Program-related refusal	29	0.4
Too far for the organ recovery team to travel or too far to ship	19	0.3
Transplant center refused due to transportation, logistics, inclement weather, or unable to travel for procurement	5	0.07
Other, <i>e.g.</i> , exceeded 1 h response time or heavy workload	5	0.07
Other reason for refusal	423	5.9

^aPercentages may not sum to 100 due to rounding.

Table 3. Univariate relationship between waitlisted patient and donor characteristics and outcomes of kidney offers

Characteristics	N	Transplant No. (%)	Reason for Offer Refusal, No. of Offers (%)					
			Donor-Related	Bypass	Recipient-Related	Histocompatibility	Program	Other
Waitlisted patient characteristics								
Age, yr								
≤25	272,425	1998 (0.7)	115,705 (42.5)	125,342 (46.0)	4569 (1.7)	6030 (2.2)	1022 (0.4)	17,759 (6.5)
26–45	2,044,703	14,854 (0.7)	890,490 (43.6)	925,077 (45.2)	39,928 (2.0)	39,403 (1.9)	7785 (0.4)	127,166 (6.2)
46–60	3,064,007	20,631 (0.7)	1,387,107 (45.3)	1,364,201 (44.5)	61,939 (2.0)	36,612 (1.2)	12,477 (0.4)	181,040 (5.9)
>60	1,756,696	11,953 (0.7)	838,281 (47.7)	752,152 (42.8)	35,018 (2.0)	14,556 (0.8)	7718 (0.4)	97,018 (5.5)
Race/ethnicity								
White	2,677,278	22,144 (0.8)	1,250,673 (46.7)	1,156,771 (43.2)	50,425 (1.9)	33,722 (1.3)	11,047 (0.4)	152,569 (5.7)
Black	2,414,103	16,513 (0.7)	1,116,771 (46.3)	1,041,417 (43.1)	55,045 (2.3)	39,335 (1.6)	9914 (0.4)	135,108 (5.6)
Hispanic	1,473,346	7015 (0.5)	616,690 (41.9)	704,587 (47.8)	23,816 (1.6)	16,806 (1.1)	5334 (0.4)	99,098 (6.7)
Other	573,104	3764 (0.7)	247,449 (43.2)	264,097 (46.1)	12,141 (2.1)	6738 (1.2)	2707 (0.5)	36,208 (6.3)
Sex								
Female	2,550,879	19,799 (0.8)	1,139,016 (44.7)	1,125,168 (44.1)	54,987 (2.2)	50,052 (2.0)	10,424 (0.4)	151,433 (5.9)
Male	4,586,952	29,637 (0.7)	2,092,567 (45.6)	2,041,604 (44.5)	86,467 (1.9)	46,549 (1.0)	18,578 (0.4)	271,550 (5.9)
Cause of ESRD								
Hypertension	1,825,703	12,175 (0.7)	836,891 (45.8)	801,214 (43.9)	38,273 (2.1)	21,390 (1.2)	7686 (0.4)	108,074 (5.9)
Diabetes	2,245,194	12,697 (0.6)	1,022,537 (45.5)	1,012,989 (45.1)	40,848 (1.8)	16,197 (0.7)	9084 (0.4)	130,842 (5.8)
GN	859,860	6612 (0.8)	380,199 (44.2)	393,008 (45.7)	13,736 (1.6)	10,296 (1.2)	3499 (0.4)	52,510 (6.1)
Other	2,207,074	17,952 (0.8)	991,956 (44.9)	959,561 (43.5)	48,597 (2.2)	48,718 (2.2)	8733 (0.4)	131,557 (6.0)
Body mass index, kg/m ²								
<18.5	134,883	1126 (0.8)	60,164 (44.6)	58,898 (43.7)	3243 (2.4)	2759 (2.1)	621 (0.5)	8075 (6.0)
18.5–24.9	1,916,567	14,763 (0.8)	852,346 (44.5)	847,563 (44.2)	42,522 (2.2)	34,827 (1.8)	8252 (0.4)	116,294 (6.1)
25–29.9	2,407,905	16,478 (0.7)	1,086,561 (45.1)	1,076,541 (44.7)	45,066 (1.9)	29,646 (1.2)	9762 (0.4)	143,851 (6.0)
≥30	2,678,476	17,069 (0.6)	1,232,515 (46.0)	1,183,770 (44.2)	50,623 (1.9)	29,369 (1.1)	10,367 (0.4)	154,763 (5.8)
Panel reactive antibodies, %								
0	5,124,898	30,397 (0.6)	2,358,703 (46.0)	2,282,876 (44.5)	97,264 (1.9)	31,153 (0.6)	20,751 (0.4)	303,754 (5.9)
1–20	630,440	3868 (0.6)	282,053 (44.7)	290,128 (46.0)	9878 (1.6)	5171 (0.8)	2557 (0.4)	36,785 (5.8)
21–80	933,274	7743 (0.8)	413,427 (44.3)	414,001 (44.4)	19,657 (2.1)	17,995 (1.9)	3745 (0.4)	56,706 (6.1)
>80	449,219	7428 (1.7)	177,400 (39.5)	179,767 (40.0)	14,655 (3.3)	42,282 (9.4)	1949 (0.4)	25,738 (5.7)
Donor characteristics								
Age, yr								
≤25	1,786,246	12,155 (0.7)	680,286 (38.1)	917,842 (52.4)	28,128 (1.6)	28,335 (1.6)	5327 (0.3)	114,173 (6.4)
26–45	2,291,158	16,169 (0.7)	911,283 (39.8)	1,101,819 (48.0)	43,058 (1.9)	32,159 (1.4)	7585 (0.3)	179,085 (7.8)
46–60	2,308,780	16,590 (0.7)	1,194,191 (51.7)	896,750 (38.8)	49,716 (2.2)	29,222 (1.3)	11,578 (0.5)	110,733 (4.8)
>60	751,647	4522 (0.6)	445,823 (59.3)	250,361 (33.3)	20,552 (2.7)	6885 (0.9)	4512 (0.6)	18,992 (2.5)
Race/ethnicity								
White	4,647,942	34,207 (0.7)	2,150,083 (46.3)	2,070,482 (44.5)	81,711 (1.8)	58,619 (1.3)	19,651 (0.4)	233,189 (5.0)
Black	1,096,086	6844 (0.6)	504,678 (46.0)	472,082 (43.1)	26,947 (2.5)	16,269 (1.5)	3450 (0.3)	65,816 (6.0)

Table 3. (Continued)

Characteristics	N	Transplant No. (%)	Reason for Offer Refusal, No. of Offers (%)					
			Donor-Related	Bypass	Recipient-Related	Histocompatibility	Program	Other
<i>Hispanic</i>	1,166,205	6555 (0.6)	462,689 (39.7)	536,049 (46.0)	26,276 (2.3)	18,897 (1.6)	4335 (0.4)	111,404 (9.6)
<i>Other</i>	227,598	1830 (0.8)	114,133 (50.2)	88,159 (38.7)	6520 (2.9)	2816 (1.2)	1566 (0.7)	12,574 (5.5)
Sex								
<i>Female</i>	2,766,595	19,968 (0.7)	1,317,442 (47.6)	1,164,028 (42.1)	57,022 (2.1)	38,343 (1.4)	13,585 (0.5)	156,207 (5.7)
<i>Male</i>	4,371,236	29,468 (0.7)	1,914,141 (43.8)	2,002,744 (45.8)	84,432 (1.9)	58,258 (1.3)	15,417 (0.4)	266,776 (6.1)
Creatinine, mg/dl								
<1.0	2,940,673	23,944 (0.8)	1,245,287 (42.4)	1,368,411 (46.5)	61,783 (2.1)	41,467 (1.4)	13,848 (0.5)	185,933 (6.3)
1.0-1.5	2,131,043	15,666 (0.7)	842,420 (39.5)	1,038,867 (48.8)	42,120 (2.0)	31,846 (1.5)	8209 (0.4)	151,915 (7.1)
>1.5	2,066,115	9826 (0.5)	1,143,876 (55.4)	759,494 (36.8)	37,551 (1.8)	23,288 (1.1)	6945 (0.3)	85,135 (4.1)
Hypertension								
<i>Yes</i>	2,492,647	14,896 (0.6)	1,342,057 (53.8)	968,470 (38.9)	51,700 (2.1)	24,868 (1.0)	9814 (0.4)	80,842 (3.2)
<i>No</i>	4,645,184	34,540 (0.7)	1,889,526 (40.7)	2,198,302 (47.3)	89,754 (1.9)	71,733 (1.5)	19,188 (0.4)	342,141 (7.4)
Diabetes								
<i>Yes</i>	767,404	3750 (0.5)	458,863 (59.8)	251,887 (32.8)	16,536 (2.2)	7582 (1.0)	2276 (0.3)	26,510 (3.5)
<i>No</i>	6,370,427	45,686 (0.7)	2,772,720 (43.5)	2,914,885 (45.8)	124,918 (2.0)	89,019 (1.4)	26,726 (0.4)	396,473 (6.2)
Cerebrovascular accident								
<i>Yes</i>	2,507,248	17,984 (0.7)	1,273,700 (50.8)	989,225 (39.5)	59,254 (2.4)	33,654 (1.3)	12,965 (0.5)	120,466 (4.8)
<i>No</i>	4,630,583	31,452 (0.7)	1,957,883 (42.3)	2,177,547 (47.0)	82,200 (1.8)	62,947 (1.4)	16,037 (0.4)	302,517 (6.5)
Cardiac death								
<i>Yes</i>	1,011,936	7073 (0.7)	550,474 (54.4)	377,848 (37.3)	17,171 (1.7)	13,609 (1.3)	4973 (0.5)	40,788 (4.0)
<i>No</i>	6,125,895	42,363 (0.7)	2,681,109 (43.8)	2,788,924 (45.5)	124,283 (2.0)	82,992 (1.4)	24,029 (0.4)	382,195 (6.2)
Number of offers (quintiles)								
0-182	1,422,885	41,829 (2.9)	867,025 (60.9)	278,620 (19.6)	88,151 (6.2)	76,787 (5.4)	9206 (0.7)	61,267 (4.3)
183-575	1,430,312	3319 (0.2)	880,864 (61.6)	446,095 (31.2)	23,375 (1.6)	10,805 (0.8)	5942 (0.4)	59,912 (4.2)
576-1376	1,429,288	2290 (0.2)	778,881 (54.5)	547,366 (38.3)	19,648 (1.4)	6325 (0.4)	5991 (0.4)	68,787 (4.8)
1377-3648	1,427,728	1503 (0.1)	542,679 (38.0)	776,688 (54.4)	9157 (0.6)	2244 (0.2)	5933 (0.4)	89,524 (6.3)
≥3649	1,427,618	495 (0.03)	162,134 (11.4)	1,118,003 (78.3)	1123 (0.08)	440 (0.03)	1930 (0.1)	143,493 (10.1)

Table 4. Multivariate relationship between waitlisted patient and donor characteristics and outcomes of kidney offers

Characteristics	Reason for Offer Refusal						
	Transplant	Donor-Related	Bypass	Recipient-Related	Histocompatibility	Program	Other
Waitlisted patient characteristics							
Age, yr							
≤25	1.00	1.00	1.00	1.00	1.00	1.00	1.00
26–45	1.05 (1.01 to 1.11)	1.01 (1.00 to 1.01)	0.99 (0.98 to 0.99)	1.16 (1.13 to 1.20)	0.98 (0.96 to 1.01)	1.02 (0.96 to 1.09)	1.00 (0.98 to 1.01)
46–60	1.05 (1.00 to 1.10)	1.03 (1.02 to 1.04)	0.97 (0.96 to 0.98)	1.25 (1.21 to 1.29)	0.81 (0.79 to 0.84)	1.07 (1.00 to 1.15)	0.99 (0.97 to 1.00)
>60	1.02 (0.97 to 1.08)	1.07 (1.06 to 1.08)	0.95 (0.94 to 0.96)	1.20 (1.16 to 1.25)	0.68 (0.66 to 0.70)	1.11 (1.04 to 1.19)	0.96 (0.94 to 0.97)
Race/ethnicity							
White	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Black	0.99 (0.96 to 1.01)	0.97 (0.96 to 0.97)	1.01 (1.01 to 1.02)	1.10 (1.08 to 1.12)	1.14 (1.12 to 1.16)	1.03 (1.01 to 1.07)	1.03 (1.02 to 1.04)
Hispanic	0.96 (0.93 to 0.99)	0.98 (0.97 to 0.98)	1.03 (1.02 to 1.03)	0.93 (0.91 to 0.95)	0.94 (0.92 to 0.97)	0.97 (0.93 to 1.01)	1.04 (1.02 to 1.05)
Other	0.92 (0.88 to 0.96)	0.93 (0.92 to 0.94)	1.07 (1.06 to 1.08)	1.12 (1.09 to 1.15)	0.91 (0.88 to 0.93)	1.16 (1.10 to 1.21)	1.02 (1.00 to 1.04)
Sex							
Female	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Male	0.93 (0.91 to 0.95)	1.01 (1.01 to 1.02)	1.00 (1.00 to 1.00)	0.95 (0.94 to 0.96)	0.83 (0.81 to 0.84)	0.98 (0.96 to 1.01)	0.99 (0.99 to 1.00)
Cause of ESRD ^a							
Hypertension	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Diabetes	0.91 (0.88 to 0.93)	1.00 (0.99 to 1.00)	1.02 (1.01 to 1.02)	0.98 (0.96 to 0.99)	0.77 (0.75 to 0.79)	0.98 (0.95 to 1.01)	0.98 (0.97 to 0.99)
GN	1.04 (1.01 to 1.07)	0.98 (0.97 to 0.98)	1.04 (1.03 to 1.05)	0.85 (0.83 to 0.87)	0.93 (0.90 to 0.95)	0.99 (0.95 to 1.04)	0.99 (0.98 to 1.01)
Other	0.99 (0.97 to 1.02)	0.99 (0.99 to 1.00)	0.99 (0.98 to 0.99)	1.10 (1.08 to 1.12)	1.32 (1.29 to 1.34)	0.93 (0.90 to 0.96)	0.99 (0.98 to 1.00)
Body mass index, kg/m ²							
<18.5	1.00	1.00	1.00	1.00	1.00	1.00	1.00
18.5–24.9	0.93 (0.91 to 0.95)	1.00 (1.00 to 1.01)	1.02 (1.02 to 1.02)	0.87 (0.86 to 0.89)	0.89 (0.87 to 0.90)	0.93 (0.91 to 0.96)	1.00 (0.99 to 1.01)
25–29.9	1.02 (0.96 to 1.09)	1.03 (1.01 to 1.04)	0.98 (0.97 to 0.99)	1.07 (1.03 to 1.06)	0.91 (0.87 to 0.95)	1.06 (0.98 to 1.15)	0.98 (0.96 to 1.00)
≥30	0.85 (0.83 to 0.87)	1.03 (1.02 to 1.03)	1.00 (1.00 to 1.01)	0.88 (0.86 to 0.89)	0.81 (0.80 to 0.82)	0.89 (0.87 to 0.92)	0.99 (0.98 to 1.00)
Panel reactive antibodies, %							
0	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1–20	0.99 (0.94 to 1.03)	0.94 (0.93 to 0.95)	1.08 (1.07 to 1.09)	0.83 (0.81 to 0.85)	1.26 (1.21 to 1.31)	0.99 (0.95 to 1.04)	0.98 (0.97 to 1.00)
21–80	1.31 (1.27 to 1.35)	0.92 (0.92 to 0.93)	1.01 (1.01 to 1.02)	1.06 (1.04 to 1.08)	2.79 (2.71 to 2.88)	0.97 (0.94 to 1.01)	1.02 (1.01 to 1.04)
>80	2.43 (2.33 to 2.53)	0.75 (0.74 to 0.75)	0.86 (0.85 to 0.87)	1.48 (1.44 to 1.51)	12.17 (11.74 to 12.61)	1.04 (0.98 to 1.09)	0.97 (0.94 to 0.99)
Donor characteristics							
Age, yr							
≤25	1.00	1.00	1.00	1.00	1.00	1.00	1.00
26–45	1.13 (1.10 to 1.16)	0.88 (0.86 to 0.90)	0.98 (0.96 to 1.00)	1.31 (1.26 to 1.36)	0.98 (0.95 to 1.01)	1.14 (1.05 to 1.24)	1.59 (1.48 to 1.70)
46–60	1.19 (1.15 to 1.23)	1.25 (1.22 to 1.28)	0.73 (0.71 to 0.75)	1.52 (1.47 to 1.57)	0.93 (0.90 to 0.97)	1.77 (1.63 to 1.90)	1.26 (1.15 to 1.38)
>60	1.01 (0.96 to 1.06)	1.80 (1.75 to 1.85)	0.54 (0.52 to 0.55)	1.84 (1.76 to 1.91)	0.73 (0.69 to 0.76)	2.16 (1.99 to 2.35)	0.71 (0.63 to 0.79)
Race/ethnicity							
White	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Black	0.91 (0.88 to 0.94)	1.01 (0.99 to 1.03)	0.91 (0.89 to 0.93)	1.44 (1.38 to 1.50)	1.13 (1.09 to 1.16)	0.82 (0.76 to 0.88)	1.27 (1.17 to 1.38)
Hispanic	0.81 (0.78 to 0.84)	0.93 (0.91 to 0.95)	0.90 (0.87 to 0.92)	1.31 (1.27 to 1.36)	1.23 (1.19 to 1.27)	0.95 (0.89 to 1.01)	1.71 (1.61 to 1.82)
Other	1.21 (1.14 to 1.29)	1.08 (1.12 to 1.14)	0.83 (0.79 to 0.88)	1.56 (1.48 to 1.64)	1.05 (0.99 to 1.12)	1.69 (1.58 to 1.81)	1.26 (1.14 to 1.40)

Table 4. (Continued)

Characteristics	Reason for Offer Refusal						
	Transplant	Donor-Related	Bypass	Recipient-Related	Histocompatibility	Program	Other
Sex							
Female	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Male	1.01 (0.99 to 1.03)	0.89 (0.87 to 0.91)	1.12 (1.10 to 1.14)	1.04 (1.02 to 1.07)	0.96 (0.93 to 0.98)	0.82 (0.78 to 0.86)	1.03 (0.98 to 1.08)
Creatinine, mg/dl							
<1.0	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.0–1.5	0.92 (0.89 to 0.94)	0.92 (0.91 to 0.94)	1.07 (1.05 to 1.09)	0.88 (0.85 to 0.90)	1.10 (1.07 to 1.13)	0.87 (0.82 to 0.92)	1.06 (0.99 to 1.12)
>1.5	0.57 (0.55 to 0.59)	1.85 (1.81 to 1.89)	0.63 (0.62 to 0.65)	0.78 (0.75 to 0.80)	0.83 (0.80 to 0.85)	0.78 (0.74 to 0.83)	0.60 (0.55 to 0.65)
Hypertension							
Yes	0.81 (0.79 to 0.84)	1.27 (1.25 to 1.29)	0.96 (0.94 to 0.98)	0.83 (0.81 to 0.85)	0.68 (0.66 to 0.70)	0.71 (0.68 to 0.75)	0.49 (0.46 to 0.53)
No	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Diabetes							
Yes	0.74 (0.71 to 0.78)	1.48 (1.44 to 1.52)	0.70 (0.68 to 0.72)	1.03 (1.00 to 1.07)	0.89 (0.86 to 0.93)	0.66 (0.61 to 0.71)	0.84 (0.76 to 0.93)
No	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Cerebrovascular accident							
Yes	1.14 (1.11 to 1.17)	1.11 (1.09 to 1.13)	0.90 (0.88 to 0.92)	1.13 (1.10 to 1.16)	1.21 (1.17 to 1.24)	1.32 (1.26 to 1.38)	0.88 (0.83 to 0.94)
No	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Cardiac death							
Yes	0.84 (0.81 to 0.86)	1.79 (1.75 to 1.83)	0.63 (0.62 to 0.64)	0.87 (0.85 to 0.90)	1.02 (0.98 to 1.05)	1.19 (1.10 to 1.27)	0.60 (0.56 to 0.64)
No	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Number of offers (quintiles)							
0–182	1.98 (1.67 to 2.35)	1.07 (1.03 to 1.10)	0.85 (0.83 to 0.87)	1.75 (1.61 to 1.90)	2.56 (2.36 to 2.78)	1.32 (1.24 to 1.41)	0.86 (0.81 to 0.91)
183–575	1.33 (1.13 to 1.58)	1.11 (1.07 to 1.14)	0.92 (0.89 to 0.95)	1.24 (1.14 to 1.35)	1.09 (1.00 to 1.18)	1.07 (0.99 to 1.14)	0.87 (0.82 to 0.92)
576–1376	1.26 (1.07 to 1.48)	1.09 (1.05 to 1.13)	0.92 (0.90 to 0.95)	1.35 (1.24 to 1.47)	1.01 (0.92 to 1.11)	1.13 (1.06 to 1.22)	0.91 (0.86 to 0.96)
1377–3648	1.27 (1.09 to 1.47)	1.02 (0.99 to 1.05)	0.97 (0.94 to 0.99)	1.38 (1.28 to 1.49)	1.08 (1.00 to 1.17)	1.16 (1.08 to 1.24)	0.96 (0.91 to 1.01)
≥3649	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Transplant center characteristics							
Volume							
Per 100 transplants	1.10 (1.10 to 1.11)	1.07 (1.07 to 1.07)	0.92 (0.92 to 0.92)	1.19 (1.18 to 1.19)	0.96 (0.95 to 0.97)	1.02 (1.01 to 1.03)	0.97 (0.97 to 0.98)
Living transplants	0.99 (0.99 to 0.99)	1.00 (1.00 to 1.00)	1.00 (1.00 to 1.00)	0.99 (0.99 to 0.99)	1.00 (1.00 to 1.00)	0.99 (0.99 to 0.99)	1.00 (1.00 to 1.00)
Minority waitlisted patients							
Per 10% black	0.83 (0.82 to 0.84)	0.99 (0.99 to 0.99)	1.01 (1.01 to 1.02)	1.04 (1.03 to 1.05)	1.05 (1.04 to 1.06)	0.97 (0.95 to 0.99)	0.97 (0.97 to 0.98)
Per 10% Hispanic	0.81 (0.80 to 0.82)	0.96 (0.96 to 0.97)	1.03 (1.03 to 1.04)	1.04 (1.03 to 1.05)	1.02 (1.01 to 1.03)	0.97 (0.96 to 0.99)	1.01 (1.00 to 1.01)

Data are displayed as odds ratios (95% confidence intervals).

less likely to be accepted for transplant (OR, 0.83; 95% CI, 0.82 to 0.84, per 10% increase in number of black patients waitlisted; and OR, 0.81; 95% CI, 0.80 to 0.82, per 10% increase in the number of Hispanic waitlisted patients). Offers to transplant centers with higher volumes were more likely to be accepted for transplant (OR, 1.10; 95% CI, 1.10 to 1.11, per 100 transplants). The number of living-donor kidney transplants did not affect likelihood of offer acceptance. The outcomes of offers varied greatly across transplant centers after adjustment for the characteristics of waitlisted patients and organ donors (Figure 1). The likelihood of offer acceptance varied across transplant centers (interquartile ratio, 2.28). Refusal of offers due to recipient-, histocompatibility-, and program-related reasons also showed marked variation across transplant centers.

Discussion

We found that deceased-donor kidneys are typically offered and declined many times before being accepted for transplantation. Such refusals differ by patient and donor characteristics and may contribute to racial and ethnic disparities in access to transplantation. We (and other researchers) define disparities as racial or sex differences that are not explained by clinical or biologic factors. Offers to Hispanic patients were less likely to lead to transplantation and more likely to be refused for transplant center bypass. Offers to male patients were less likely to lead to transplantation and more likely to be refused for donor-related reasons. Moreover, both the acceptance of offers and specific reasons for declining offers vary greatly across transplant centers. Strengths of this study include a

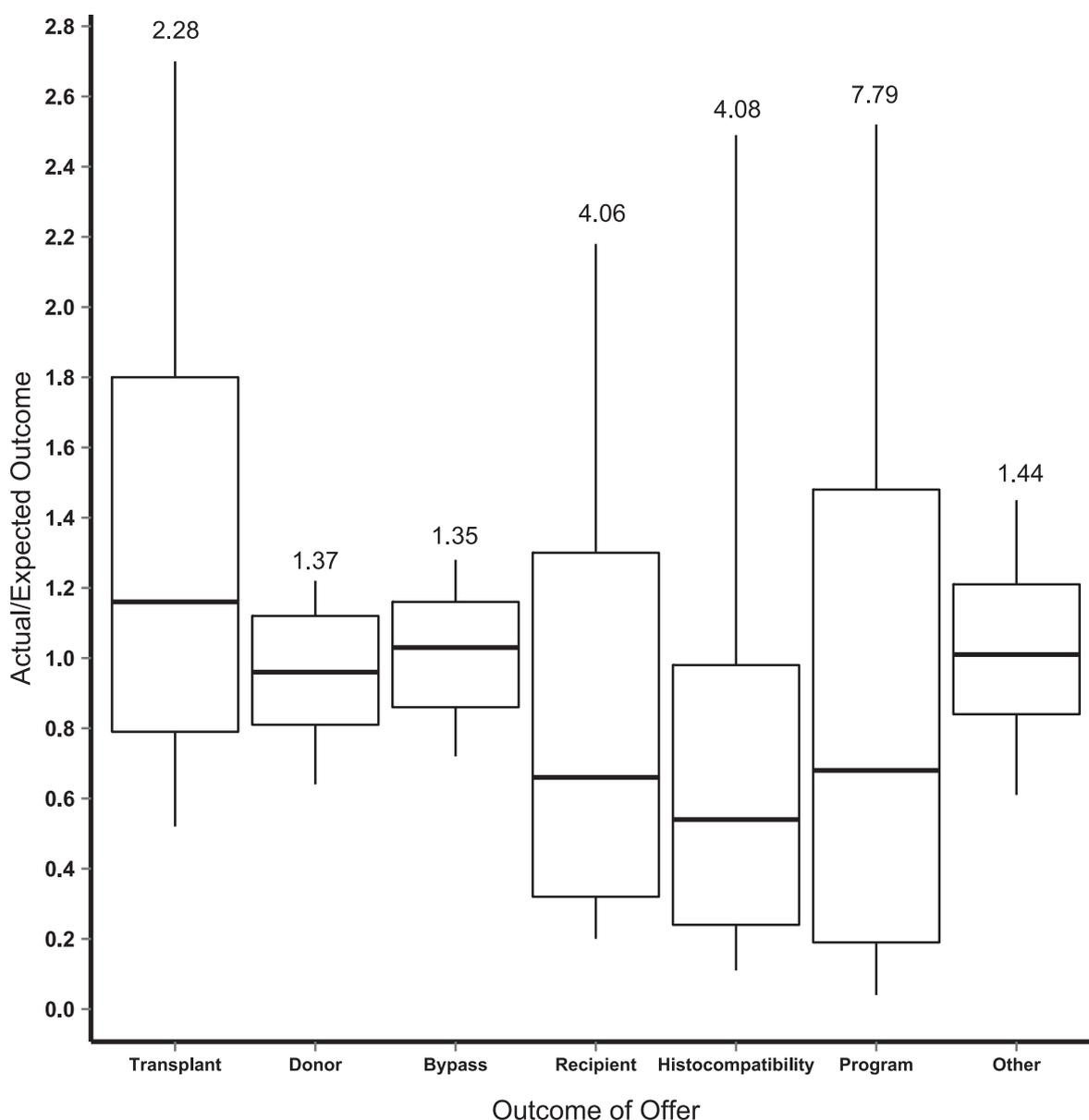


Figure 1. | Outcomes of offers varied greatly across transplant centers. Distribution of actual/expected outcomes (standardized ratios) of offers across 221 transplant centers. Boxes show the median as the line across the middle and the 25th and 75th percentiles as ends. Lines represent the 10th and 90th percentiles. The interquartile ratio (ratio of 75th to 25th percentile) is above each box.

large sample size and the availability of uniformly collected data on demographic and medical characteristics. Many observations may be statistically significant simply because of the large sample size; therefore, it is important to focus on associations with large effect sizes.

Several previous studies have examined placement on the deceased-donor waiting list or transplantation after being placed on the waiting list. Those studies have found that lower rates of kidney transplantation are associated with black race, Hispanic ethnicity, female sex, low socioeconomic status, rural geographic location, and specific dialysis facilities (3–8,16,17). Only one previous study examined the process of accepting or refusing kidneys for patients at the top of the waiting list. That study focused on transplants involving 4967 kidneys but excluded another 4051 kidneys that were suboptimal or were refused multiple times. As a result, its findings may not be generalizable to all kidney offers. Moreover, that study did not examine correlates of specific reasons for offer refusal (18).

Our findings on differences in organ acceptance may be due to clinical appropriateness, biologic factors, or subconscious biases. For example, black patients are more likely to be highly sensitized, *i.e.*, to have exceptionally high antibody levels that might react to a donor kidney. As a result, it would be clinically inappropriate to proceed with a transplant if there is a positive cross-match test when recipient and donor blood cells are mixed together (19). This is supported by our finding that black patients are more likely to have histocompatibility-related refusals. Similarly, younger waitlisted patients (who may have a more robust immune system) and women (who are exposed to fetal antigens during pregnancy) were more likely to have histocompatibility-related refusals. An example of a biologic factor is a mismatch in body size between a small donor and larger recipient. This may lead to insufficient nephrons for adequate renal function and could be a reason for declining an offer (20–22). Not unexpectedly, certain donor characteristics including higher creatinine, or history of hypertension, diabetes, or cardiac death, were associated with donor-related refusals. Subconscious biases have been examined in other health care areas but our data do not directly address this possibility (23,24).

Our results have implications for patients, providers, researchers, and policy makers. Waitlisted patients should be aware of how the offer process works and may consider selecting transplant centers on the basis of their acceptance practices. Providers should accurately categorize reasons for refusal and determine if the categories need to be revised. They should also monitor refusals of offers, both among all waitlisted patients and among specific subgroups. Our results will allow transplant providers to compare their rates of and reasons for offer refusal with national rates and reasons. Researchers should study the effect of the offer process on short- and long-term outcomes of kidney transplantation. Policy makers may be able to develop performance metrics to assess the offer process and disseminate best practices to providers at centers with lower acceptance rates (18).

Several limitations must be considered in interpreting our findings. We did not independently validate

the reasons for offer refusal. Nevertheless, the findings reflect providers' stated reasons for refusing organ offers as reported to the national electronic allocation system. The data source did not separate ethnicity and race, so Hispanics are categorized as a distinct racial/ethnic group. We did not have information on some variables of interest that may influence offer acceptance, such as cold ischemia time. Individual physicians make decisions about accepting or refusing deceased-donor offers but our data only links patients to transplant centers. As a result, we were unable to examine variability in acceptance practices across physicians. Furthermore, data about prespecified, unacceptable organ criteria that may be entered into the electronic allocation system whereby centers forego offers for their entire match run list likely vary by center, but were not available. In 2014, movement of patients on the waiting list was changed to better account for expected post-transplant survival and time since onset of ESRD (25). Although these changes will affect which patients are at the top of the waiting list, they are unlikely to alter how transplant centers accept or refuse kidney offers. Finally, it is worth noting that patients' relative positions on the deceased-donor waiting list are not fixed. Instead, their positions are reordered as each new kidney becomes available. In conclusion, transplant centers frequently refuse deceased-donor kidneys. Such refusals differ by patient and donor characteristics, may contribute to disparities in access to transplantation, and vary greatly across transplant centers. Further work is needed to better understand and improve the offer process to maximize the efficiency and equity of organ allocation.

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None.

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