Racial Ethnic Differences in Rates and Determinants of Deceased Donor Kidney Transplantation

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ABSTRACT

Contemporary studies have not comprehensively compared waiting times and determinants of deceased donor kidney transplantation across all major racial ethnic groups in the Unites States. Here, we compared relative rates and determinants of waitlisting and deceased donor kidney transplantation among 503,090 nonelderly adults of different racial ethnic groups who initiated hemodialysis between1995 and 2006 with follow-up through 2008. Annual rates of deceased donor transplantation from the time of dialysis initiation were lowest in American Indians/Alaska Natives (2.4%) and blacks (2.8%), intermediate in Pacific Islanders (3.1%) and Hispanics (3.2%), and highest in whites (5.9%) and Asians (6.4%). Lower rates of deceased donor transplantation among most racial ethnic minority groups appeared primarily to reflect differences in time from waitlisting to transplantation, but this was not the result of higher rates of waitlist inactivity or removal from the waitlist. The fraction of the reduced transplant rates attributable to measured factors (*e.g.*, demographic, clinical, socioeconomic, linguistic, and geographic factors) varied from 14% in blacks to 43% in American Indians/Alaska Natives compared with whites. In conclusion, adjusted rates of deceased donor kidney transplantation remain significantly lower among racial ethnic minorities compared with whites; generally, differences in time to waitlisting were not as pronounced as differences in time between waitlisting and transplantation. Determinants of delays in time to transplantation differed substantially by racial ethnic group. Area-based efforts targeted to address racial- and ethnic-specific delays in transplantation may help to reduce overall disparities in deceased donor kidney transplantation in the United States.

J Am Soc Nephrol 22: ●●●–●●●, 2010. doi: 10.1681/ASN.2010080819

In the United States, inequities in receiving a deceased donor kidney transplant have been described for most racial ethnic minority groups compared with non-Hispanic whites.[1–8] However, recent studies have tended to focus on select racial ethnic groups and provide only limited comparisons among different groups.[5,9–12] Most prior studies identifying determinants of low rates of waitlisting and deceased donor transplantation after waitlisting have been limited primarily to black Americans.[2,6,9,11,13,14] Relatively few U.S.-based studies have examined determinants of delayed transplantation among patients of other racial ethnic minority groups.[5,10,12] In addition, it is difficult to compare transplant-related outcomes such as access to the waitlist and movement up the waitlist across racial ethnic groups because studies have not consistently reported results for discrete steps along the path to

Received August 9, 2010. Accepted October 29, 2010.

Published online ahead of print. Publication date available at www.jasn.org.

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transplantation. Furthermore, no prior studies have examined race-specific factors that contribute to diminished access to, or delayed completion of, deceased donor kidney transplantation among all major racial ethnic groups in the United States. Thus, despite the continued growth of diverse populations on dialysis, the relative influence on transplantation rates of clinical factors, including histocompatibility, health insurance coverage, poverty, and other socioeconomic factors remains poorly understood.

To compare rates and determinants of deceased donor kidney transplantation across U.S. racial ethnic groups, we examined the associations of demographic, clinical, socioeconomic, and linguistic factors with time to transplantation among nonelderly adults who initiated dialysis during 1995 to 2006. We also disaggregated the time to transplantation into (*1*) time to waitlisting and (*2*) time from waitlisting to transplantation to determine whether there were race- or ethnicity-specific delays in either component. We hypothesized that transplantation rates would be lower among racial ethnic minorities compared with whites and that the determinants of delays in time to waitlisting and time from waitlisting to transplantation would differ significantly among racial ethnic minority groups.

RESULTS

Patient Characteristics

Overall, 213,229 non-Hispanic whites, 182,429 non-Hispanic blacks, 11,990 Asians, 78,449 Hispanics, 5292 Pacific Islanders, 6982 American Indians, and Alaska Natives (AIAN), and 3719 persons of other race ethnicity initiated dialysis in the United States during the study period. Mean age at dialysis initiation was youngest among blacks, intermediate among Asians, Hispanics, Pacific Islanders, and AIANs, and oldest among whites. AIANs had the highest rates of Medicaid, whereas Hispanics were the least likely to have health insurance coverage. In contrast, Asians and Pacific Islanders had the highest rates of employer group health coverage, and whites had the highest rate of Medicare coverage at the time of dialysis initiation ($P < 0.001$ for all comparisons).

Comorbidities were highly prevalent in this nonelderly dialysis population. American Indians and Alaska Natives had the highest and Asians had the lowest prevalence of major comorbidities including diabetes and cardiovascular disease among all racial ethnic groups (Table 1).

Notable racial ethnic differences were evident in waitlisting before dialysis initiation, with whites having the highest and AIANs having the lowest fraction of persons waitlisted before initiating dialysis. Table 2 shows important differences in clinical characteristics among waitlisted patients that generally mirror population-wide differences; notably, racial ethnic differences in the distribution of ABO blood group were more pronounced than in the distribution of panel reactive antibody levels or most other clinical factors.

Residential Zip Code Characteristics

The study population was distributed across 29,747 residential zip codes in the United States. Approximately 60% of AIANs, 45% of blacks, and 47% of Hispanics on dialysis lived in the most impoverished areas. These zip codes corresponded to areas with the lowest median per capita income and the lowest percentage of college graduates. Conversely, >20% of non-Hispanic whites and Asians lived in the most affluent areas. Approximately 40% of Asians and Pacific Islanders and 57% of Hispanics lived in areas where ≥20% of households were linguistically isolated compared with 6% of whites and 10% of blacks (Table 1). Similar patterns in the distribution of area-based measures were observed among patients waitlisted for transplant (Table 2).

Time from Dialysis Initiation to Deceased Donor Transplantation

A total of 153,613 (31%) patients were waitlisted and 68,767 (14%, or 42% of waitlisted patients) received a first deceased donor kidney transplant during 1696,091 person-years of follow-up. Annual transplant rates from the time of dialysis initiation were lowest among AIANs (2.4% [95% confidence interval: 2.2 to 2.6%]) and blacks (2.8% [2.8 to 2.9%]), intermediate among Pacific Islanders (3.1% [2.9 to 3.4%]) and Hispanics (3.2% [3.1 to 3.3%]), and highest among whites (5.9% [5.8 to 5.9%]) and Asians (6.4% [6.2 to 6.6%]).

In analyses adjusted for individual-level clinical factors and individual- and zip code–level sociodemographic factors, the lower transplant rates among racial ethnic minority groups compared with whites were attenuated in all groups except Asians. Among non-Asian minority groups, the degree to which reduced rates of transplantation were attributable to adjustment for measured factors varied significantly (14% in blacks to 43% in AIANs) by race ethnicity (Table 3).

Among blacks, Hispanics, and AIANs, the largest fractions (18, 14, and 23%, respectively) of the disparity in transplant rates compared with whites were attributed to adjustment for health insurance coverage and zip code poverty. Among Hispanics and Pacific Islanders, notable fractions were attributed to geographic variation in organ availability (14 and 19%, respectively) and to household linguistic isolation (7 and 6%, respectively). In contrast, household linguistic isolation accounted for little to none of the reduced rate of deceased donor transplantation among blacks and AIANs (Table 3).

Time to Waitlisting

Among all patients initiating dialysis, annual rates of waitlisting were lowest among AIANs and blacks, intermediate among Hispanics, whites, and Pacific Islanders, and highest among Asians (Figure 1A). In bootstrap analyses, the degree to which adjustment for sociodemographic and clinical factors accounted for differences in waitlisting rates varied by race eth-

Table 1. Characteristics of all patients 18 to 64 years of age who initiated dialysis during 1995 to 2006 by race ethnicity

	Race Ethnicity						
	White (n = 214,229)	Black (n = 182,429)	Asian (n = 11,990)	Hispanic (n = 78,449)	Pacific Islander (n = 5,292)	American Indian/Alaska Native (n = 6,982)	Missing Race Ethnicity (n = 33,273)
Patient-level characteristic[a,b]							
age, mean (SD), years	51.7 (10.5)	49.2 (10.9)	49.7 (11.5)	49.7 (11.6)	50.9 (10.8)	51.1 (10.0)	46.6 (11.4)
age category, *N* (%), years							
18 to 29	10,300 (4.8)	11,902 (6.5)	949 (7.9)	6,528 (8.3)	315 (6.0)	300 (4.3)	3,167 (9.5)
30 to 39	22,350 (10.4)	26,155 (14.3)	1,545 (12.9)	9,561 (12.2)	588 (11.1)	708 (10.1)	6,155 (18.5)
40 to 49	45,269 (21.1)	47,540 (26.1)	2,671 (22.3)	17,255 (22.0)	1,103 (20.8)	1,670 (23.9)	9,646 (29.0)
50 to 59	80,882 (37.8)	63,330 (34.7)	4,200 (35.0)	28,428 (36.2)	2,083 (39.4)	2,875 (41.2)	9,768 (29.4)
60 to 64	55,428 (25.9)	33,502 (18.4)	2,625 (21.9)	16,677 (21.3)	1,203 (22.7)	1,429 (20.5)	4,537 (13.6)
female, *N* (%)	90,055 (42.0)	85,123 (46.7)	5,347 (44.6)	33,496 (42.7)	2,560 (48.3)	3,613 (51.7)	14,149 (42.5)
health insurance coverage,[c] *N* (%)							
employer group	85,057 (39.7)	48,191 (26.4)	4,490 (37.4)	15,836 (20.2)	2,048 (38.7)	1,109 (15.9)	10,937 (32.9)
Medicare	58,158 (27.1)	41,501 (22.7)	1,000 (8.3)	15,371 (19.6)	688 (13.0)	1,596 (22.9)	15,186 (45.6)
Medicaid	46,214 (21.6)	63,738 (34.9)	3,057 (25.4)	28,244 (36.0)	1,378 (26.0)	2,742 (39.3)	9,583 (28.8)
no coverage	19,705 (9.2)	31,495 (17.3)	1,702 (14.2)	14,957 (19.1)	540 (10.2)	770 (11.0)	2,281 (6.9)
other coverage	49,185 (23.0)	25,434 (13.9)	2,449 (20.4)	13,827 (17.6)	1,298 (24.5)	2,506 (35.9)	6,672 (20.1)
cause of ESRD, *N* (%)							
diabetes	105,485 (49.2)	74,698 (40.9)	4,934 (41.1)	45,423 (57.9)	3,124 (61.0)	5,376 (76.9)	5,174 (15.6)
hypertension	28,200 (13.2)	58,938 (32.3)	2,390 (19.9)	11,007 (14.5)	695 (13.6)	377 (5.4)	2,284 (6.9)
glomerulonephritis	26,691 (12.5)	17,875 (9.8)	2,613 (21.8)	8,111 (10.7)	750 (14.6)	624 (8.9)	1,416 (4.3)
other	27,621 (12.9)	21,344 (11.7)	910 (7.6)	5,543 (7.3)	259 (5.1)	345 (4.9)	1,580 (4.8)
unknown or missing	7302 (3.4)	5,285 (2.9)	615 (5.1)	2,887 (3.8)	138 (2.7)	137 (2.0)	22,475 (67.6)
clinical and laboratory measures, *N* (%)							
diabetes	109,120 (50.9)	81,860 (44.9)	4,910 (41.0)	44,625 (56.9)	3,220 (60.8)	5,261 (75.4)	11,589 (34.8)
CVD	90,817 (42.4)	62,505 (34.2)	3,075 (25.6)	27,339 (34.8)	2,010 (37.9)	3,082 (44.1)	10,320 (31.0)
poor functional status	10,013 (4.7)	6,507 (3.6)	239 (2.0)	2,736 (3.5)	137 (2.7)	269 (3.9)	986 (3.0)
drug or tobacco use	21,465 (10.0)	18,693 (10.2)	233 (1.9)	2,795 (3.6)	213 (4.0)	447 (6.4)	2,394 (7.2)
cancer	10,275 (4.8)	4,520 (2.5)	185 (1.5)	1,390 (1.8)	101 (1.9)	139 (2.0)	1,136 (3.4)
BMI > 30 kg/m^2	85,734 (40.0)	71,852 (39.4)	2,142 (17.9)	24,608 (31.3)	1,849 (34.9)	2,821 (40.4)	10,186 (30.6)
serum albumin <3.5 g/dL	98,900 (46.2)	91,904 (50.4)	5,515 (46.0)	39,688 (50.6)	2,914 (55.1)	4,119 (59.0)	14,837 (61.5)
hemoglobin <10 g/dl	94,977 (44.3)	102,155 (56.0)	6,042 (50.4)	42,131 (53.7)	2,771 (52.4)	3,204 (45.9)	17,058 (60.2)
predialysis ESA[d]	68,339 (31.9)	43,418 (23.8)	4,017 (33.5)	19,612 (25.0)	1,778 (33.6)	1,746 (25.0)	11,803 (36.1)
ZIP code–level characteristic							
percentage of residents living in poverty, *N* (%)							
<5%	38,586 (18.0)	8,549 (4.7)	2,112 (17.6)	3,151 (4.0)	489 (9.2)	168 (2.4)	1,431 (4.3)
5 to 9%	70,163 (32.8)	25,789 (14.1)	3,648 (30.4)	12,825 (16.3)	1,765 (33.3)	665 (9.5)	25,046 (75.4)
10 to 14%	55,348 (25.8)	32,216 (17.7)	2,475 (20.6)	12,251 (15.6)	1,345 (25.4)	910 (13.0)	2,219 (7.2)
15 to 19%	28,076 (13.1)	34,684 (19.0)	1,703 (14.2)	13,308 (17.0)	637 (12.0)	1,048 (15.0)	1,528 (4.8)
≥20%	22,056 (10.3)	81,191 (44.5)	2,052 (17.1)	36,914 (47.0)	1,056 (11.3)	4,191 (60.0)	2,711 (8.2)
mean per capita income							
$ (SD)	20,857 (7,462)	17,267 (6,280)	22,520 (9,373)	15,770 (7,120)	20,003 (7,035)	13,240 (5,812)	19,696 (7,974)
percentage of linguistically isolated households, *N* (%)							
<1%	33,843 (15.8)	14,566 (8.0)	95 (0.8)	683 (0.9)	43 (0.8)	563 (8.1)	915 (2.7)
1 to 4%	108,064 (50.4)	90,696 (49.7)	1,906 (15.9)	7,008 (8.9)	627 (11.8)	2,500 (35.8)	4,903 (14.8)
5 to 9%	37,721 (17.6)	34,411 (18.9)	1,993 (16.6)	8,321 (10.6)	949 (17.9)	1,363 (19.5)	1,600 (4.8)
10 to 19%	20,971 (9.8)	23,490 (12.9)	3,017 (25.2)	17,213 (21.9)	1,558 (29.4)	1,047 (15.0)	24,025 (72.3)
≥20%	13,630 (6.4)	19,266 (10.5)	4,979 (41.5)	45,224 (57.7)	2,115 (40.0)	1,509 (21.6)	1,482 (4.5)
percentage of adults with 4-year college degree							
% (SD)	21.3 (12.9)	17.9 (11.5)	27.2 (14.7)	16.6 (11.0)	22.4 (10.9)	13.7 (9.1)	23.5 (7.8)

CVD, cardiovascular disease; BMI, body mass index.
[a]At initiation of renal replacement therapy.
[b]Because of rounding, percentages may not total 100%.
[c]Health insurance coverage may sum to >100% in patients with multiple sources of coverage.
[d]Prescribed erythropoiesis-stimulating agent.

Table 2. Characteristics of patients 18 to 64 years of age who were waitlisted for kidney transplantation

	Race Ethnicity					
	White (*n* = 65,994)	Black (*n* = 48,218)	Asian (*n* = 6619)	Hispanic (*n* = 27,384)	Pacific Islander (*n* = 2008)	American Indian/Alaska Native (*n* = 1753)
Patient-level characteristic[a,b]						
age, mean (SD), years	47.9 (11.3)	45.6 (11.5)	46.7 (11.7)	45.7 (12.1)	47.3 (11.6)	48.3 (10.8)
age category, *N* (%), years						
<40	15,969 (24.2)	15,087 (31.3)	1,874 (28.3)	8,573 (31.3)	544 (27.1)	378 (21.6)
40 to 49	17,549 (26.6)	13,702 (28.4)	1,757 (26.5)	7,249 (26.5)	484 (24.1)	479 (27.3)
50 to 59	22,531 (34.1)	14,507 (30.1)	2,108 (31.9)	8,386 (30.6)	711 (35.4)	674 (38.5)
60 to 64	9,945 (15.1)	4,922 (10.2)	880 (13.3)	3,176 (11.6)	269 (13.4)	222 (12.7)
female, *N* (%)	25,331 (38.4)	20,880 (43.3)	2,921 (44.1)	10,636 (38.4)	933 (46.5)	829 (47.3)
waitlisted before dialysis, *N* (%)	9,885 (15.0)	3,159 (6.6)	766 (11.6)	2,907 (10.6)	263 (13.1)	100 (5.7)
health insurance,[c] *N* (%)						
employer group	34,633 (52.5)	19,727 (40.9)	3,021 (45.6)	7,915 (28.9)	1,015 (50.6)	439 (25.0)
Medicare	11,561 (17.5)	7,337 (15.2)	381 (5.8)	4,527 (16.5)	229 (11.4)	317 (18.1)
Medicaid	8,603 (13.0)	11,003 (22.8)	1,291 (19.5)	8,530 (31.2)	374 (18.6)	512 (29.2)
no coverage	5,453 (8.3)	7,684 (16.0)	826 (12.5)	4,963 (18.1)	156 (7.8)	197 (11.2)
other coverage	15,323 (23.2)	7,918 (16.4)	1,410 (21.3)	4,692 (17.1)	499 (24.9)	681 (38.9)
comorbid conditions, *N* (%)						
diabetes	26,422 (40.0)	18,651 (38.7)	2,306 (34.8)	13,175 (48.1)	921 (45.9)	1,280 (73.0)
cardiovascular disease	14,717 (22.3)	9,460 (19.6)	998 (15.1)	5,405 (19.7)	431(21.5)	477 (27.2)
body mass index, *N* (%)						
<18.5 kg/m^2	2,701 (4.1)	1,953 (4.1)	504 (7.6)	1,200 (4.4)	125 (6.2)	42(2.4)
18.5 to 24.9 kg/m^2	20,979 (31.8)	12,855 (26.7)	3,460 (52.3)	9,450 (34.5)	813 (40.5)	405 (23.1)
25.0 to 29.9 kg/m^2	18,270 (27.7)	13,516 (28.0)	1,490 (22.5)	8,503 (31.1)	495 (24.7)	579 (33.0)
≥30.0 kg/m^2	24,044 (36.4)	19,894 (41.3)	1,165 (17.6)	8,231 (30.1)	575 (28.6)	727 (41.5)
ABO blood group, *N* (%)						
O	30,239 (45.8)	24,120 (50.0)	2,618 (39.6)	15,782 (57.6)	842 (41.9)	1,200 (68.5)
A	26,318 (39.9)	12,206 (25.3)	1,697 (25.6)	8,153 (29.8)	592 (29.5)	474 (27.0)
B	6,984 (10.6)	9,875 (20.5)	1,869 (28.2)	2,776 (10.1)	460 (22.9)	70 (4.0)
AB	2,453 (3.7)	2,017 (4.2)	435 (6.6)	673(2.5)	114 (5.7)	9 (0.5)
Most recent PRA,[d] *N* (%)						
<20%	53,868 (87.9)	37,295 (82.1)	5,046 (87.0)	20,438 (83.7)	1,469 (86.2)	1,414 (85.0)
20 to 79%	4,819 (7.9)	5,105 (11.2)	502 (8.7)	2,520 (10.3)	143 (8.4)	146 (8.8)
≥80%	2,613 (4.3)	3,022 (6.7)	256 (4.4)	1,474 (6.0)	93 (5.5)	104 (6.3)
ZIP code–level characteristic						
ZIP code poverty, *N* (%)						
<5%	15,038 (22.8)	3,399 (7.1)	1,362 (20.6)	1,358 (5.0)	269 (13.4)	58 (3.3)
5 to 9%	22,323 (33.8)	8,939 (18.5)	2,108 (31.9)	6,318 (23.1)	831 (41.4)	210 (12.0)
10 to 14%	14,536 (22.0)	9,069 (18.8)	1,201 (18.1)	4,440 (16.2)	435 (21.7)	233 (13.3)
15 to 19%	7,082 (10.7)	7,518 (15.6)	854 (12.9)	4,168 (15.2)	212 (10.6)	226 (12.9)
≥20%	5,227 (7.9)	17,690 (36.7)	968 (14.6)	10172 (37.1)	216 (10.8)	959 (54.7)
mean per capita income, $ (SD)	22,091 (8,271)	18,119 (6,501)	23,434 (9,823)	16,895 (7,175)	21,460 (7,214)	13,626 (6,403)
ZIP code linguistically isolated households, *N* (%)						
<1%	9,467 (14.7)	3,475 (7.5)	60 (0.9)	191 (0.7)	21 (1.1)	139 (8.2)
1 to 4%	33,274 (51.8)	23,876 (51.2)	1,102 (17.0)	2,444 (9.2)	250 (12.7)	629 (37.3)
5 to 10%	10,676 (16.6)	7,631 (16.4)	1,161 (17.9)	2,916 (11.0)	337 (17.2)	317 (18.8)
10 to 19%	6,636 (10.3)	6,553 (14.1)	1,563 (24.1)	7,341 (27.8)	648 (33.0)	242 (14.4)
≥20%	4,153 (6.5)	5,080 (10.9)	2,607 (40.2)	13,564 (51.3)	707 (36.0)	359 (21.3)
mean percentage of adults with 4-year college degree, % (SD)	23.4 (13.8)	19.1 (12.0)	28.6 (15.1)	17.6 (11.3)	24.3 (11.4)	14.4 (9.8)

[a]At initiation of renal replacement therapy.
[b]Because of rounding, percentages may not total 100%.
[c]Health insurance coverage may sum to >100% in patients with multiple sources of coverage.
[d]Panel reactive antibodies.

Table 3. Models for race ethnicity and time from dialysis initiation to deceased donor transplantation among persons 18 to 64 years of age initiating dialysis during 1995 to 2006

	Race Ethnicity					
	White (n = 214,229)	Black (n = 182,429)	Asian (n = 11,990)	Hispanic (n = 78,449)	Pacific Islander (n = 5,292)	American Indian/Alaska Native (n = 6,982)
Unadjusted model						
hazard ratio (95% CI)	Referent	0.46 (0.45, 0.47)	1.04 (0.99, 1.08)	0.56 (0.54, 0.57)	0.54 (0.47, 0.62)	0.39 (0.35, 0.43)
Race ethnicity effect attributed to adjustment for clinical factors						
percent (95% CI)	—	0.2 (−0.2, 0.7)	−9.8 (−10.9, −8.8)	−2.1 (−2.7, −1.4)	−0.6 (−2.1, 0.9)	7.1 (5.4, 8.8)
Race-ethnicity effect attributed to adjustment for health insurance coverage and zip code poverty						
percent (95% CI)	—	17.9 (17.0, 18.8)	−3.7 (−4.5, −2.9)	14.3 (13.4, 15.1)	−5.0 (−6.3, −3.6)	23.2 (21.3, 25.2)
Race ethnicity effect attributed to adjustment for household linguistic isolation						
percent (95% CI)	—	0.5 (0.2, 0.8)	5.7 (4.8, 6.5)	7.0 (6.0, 8.0)	6.2 (5.3, 7.1)	−1.0 (−1.3, −0.6)
Race ethnicity effect attributed to adjustment for regional (OPO) organ availability						
percent (95% CI)	—	2.6 (2.1, 3.0)	1.1 (0.5, 1.7)	13.5 (12.7, 14.3)	19.1 (16.1, 22.1)	0.5 (−0.5, 1.6)
Percentage of the race ethnicity effect explained by adjustment for all measured factors						
percent (95% CI)	—	13.7 (12.4, 15.0)	−8.7 (−10.8, −6.7)	37.6 (35.1, 40.1)	28.2 (24.0, 32.3)	42.8 (38.7, 47.0)
Fully adjusted model[a] (residual difference after covariate adjustment)						
hazard ratio (95% CI)	Referent	0.52 (0.51, 0.53)	0.95 (0.91, 0.99)	0.72 (0.70, 0.74)	0.63 (0.58, 0.70)	0.56 (0.51, 0.61)

Negative values indicate that, after adjustment for the specific factors, differences in time to transplant compared with whites were larger than observed in the unadjusted model.

[a]Fully adjusted model includes age, gender, health insurance coverage (employer group insurance, Medicare, Medicaid, other insurance, or no insurance), clinical factors (cardiovascular disease, diabetes [insulin or non-insulin requiring], poor functional status [institutionalized, requires assistance with daily activities, inability to walk, inability to transfer], cancer, drug or tobacco use, hypoalbumemia [serum albumin < 3.5 g/dl], low hemoglobin [<10 g/dl], prescribed predialysis erythropoiesis-stimulating agent, and body mass [body mass index <18.5, 18.5 to 24.9, 25.0 to 29.9, ≥30.0 kg/m^2]), UNOS/OPO region, zip code poverty (<5, 5 to 9, 10 to 14, 15 to 19, ≥20%), and household linguistic isolation (<1, 1 to 4, 5 to 10, 10 to 19, ≥20%).

nicity. For example, adjustment for health insurance coverage and zip code poverty accounted for substantial fractions of the reduced rate of waitlisting among blacks (21% [95% confidence interval: 20 to 22%]) and AIANs (26% [24 to 28%]), respectively, compared with whites.

Time from Waitlisting to Deceased Donor Transplantation

Lower rates of deceased donor transplantation experienced by most racial ethnic minority groups seemed to be primarily a result of longer time spent on the transplant waitlist. Transplant rates calculated from the time of waitlisting were highest among non-Hispanic whites: >40% higher than any other group (Figure 1B). In bootstrap analyses, the degree to which differences in time from waitlisting to transplantation among nonwhites *versus* whites that could be attributed to measured factors varied widely (from 8% in blacks to 78% in Hispanics) by race ethnicity. Histocompatibility (as assessed by ABO blood group) and sensitization (as assessed by panel reactive antibody levels) explained a modest fraction of the delay in transplantation observed among nonwhites (specifically, in blacks [8%], Asians [3%], Hispanics [7%], Pacific Islanders [2%], and AIANs [10%]). Similar fractions (7, 9, and 8%, respectively) among waitlisted Asians, Hispanics, and Pacific Islanders could be attributed to household linguistic isolation. Geographic differences in organ availability were responsible for substantial fractions (24, 16, and 16%, respectively) of the disparity in transplantation among AIANs, Hispanics, and Pacific Islanders compared with whites. In contrast, health insurance coverage and zip code poverty accounted for little to none (range, 0 to 5%) of the reduced rate of deceased donor transplantation after waitlisting among nonwhite compared with white patients. Rather, these factors were more strongly associated with time to waitlisting, perhaps exerting influence at an earlier step in the transplant process.

Differential rates of waitlist inactivity and removal (because of reasons other than death or receipt of a deceased or living donor transplant such as medical unsuitability or refusal) did not seem to explain reduced transplant rates among minorities. Rates of waitlist inactivity were highest among AIANs (28%) and blacks (25%), intermediate among whites (20%), Hispanics (19%), and Pacific Islanders (18%), and lowest among Asians (15%). In contrast, rates of waitlist removal were higher among Pacific Islanders (15%) and AIANs (14%) than among Asians (12%), whites (11%), blacks (11%), and Hispanics (10%).

Companion analyses stratified by age, gender, and ABO blood group, as well as those excluding patients who were inactivated or removed from the waitlist, yielded similar results. Although the degree of disparity differed by Organ Procurement Organization (OPO) region, in all OPO regions, racial ethnic minority groups were significantly less likely to receive a deceased donor kidney (Supplemental Table 1). Moreover, differential rates of deceased donor transplantation, calculated either from dialysis initiation or

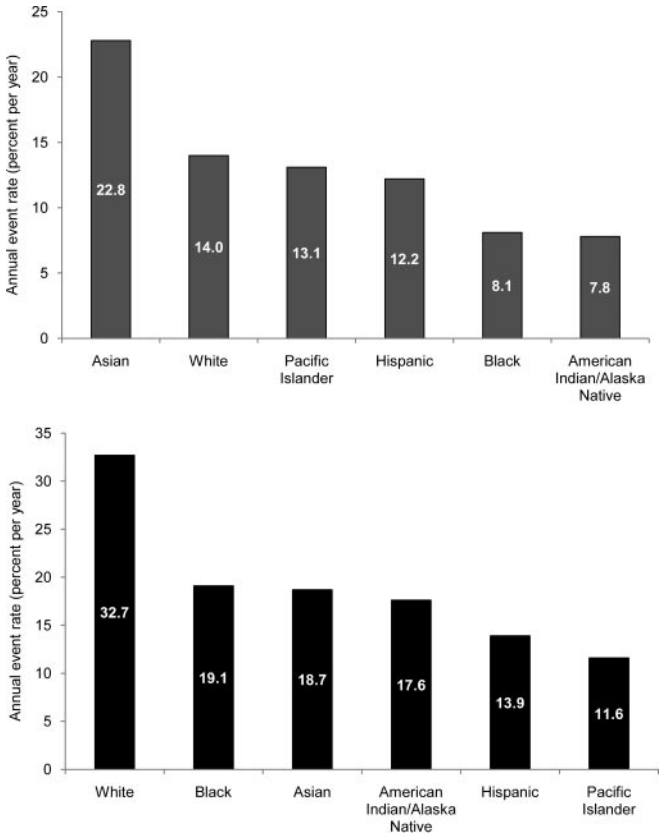

Figure 1. The reduced rate of deceased donor transplantation among AIANs and blacks reflects both lower rates of waitlisting and lower rates of transplantation among those waitlisted. The reduced rate of deceased donor transplantation among Asians, Pacific Islanders, and Hispanics primarily reflects delays in receiving a transplant from the waitlist. (A) Differential rates of waitlisting among 503,090 persons 18 to 64 years of age initiating dialysis in 1995 to 2006 by race ethnicity. (B) Differential rates of deceased donor transplantation among 153,613 waitlisted persons 18 to 64 years of age initiating dialysis in 1995 to 2006 by race ethnicity.

from waitlisting, were not explained by higher relative rates of living donor transplantation or death on the waitlist (data not shown).

DISCUSSION

In a comprehensive national registry of nonelderly patients initiating maintenance dialysis in the United States, we observed lower relative rates of deceased donor kidney transplantation among nonwhite compared with white patients. The reduced rate of deceased donor transplantation among American Indians, Alaska Natives, and blacks reflected both lower rates of waitlisting and lower rates of transplantation among those waitlisted. However, among Asians, Pacific Islanders, and Hispanics, access to the waitlist was similar or better than among whites, but time to transplantation among those waitlisted was longer. There were substantial differences by race ethnicity in determinants of the delay in transplantation and the extent to which observed disparities were explained by these determinants. These findings may provide the foundation for future race- or ethnicity-specific interventions to reduce disparities in deceased donor kidney transplantation.

Prior studies described a lower likelihood of being referred for transplant and of completing the pretransplant evaluation process among black compared with white patients.[2,6,9,13] However, comparative data for patients of other races or ethnicities are sparse. Eggers[2] described racial ethnic disparities in rates of waitlisting and kidney transplantation (living and deceased donor) among 79,527 patients who were younger than 55 and who initiated dialysis between 1988 and 1992. Unlike this study, that study did not examine outcomes among Hispanics and Pacific Islanders and did not investigate specific determinants of waitlisting or transplantation. Similar to our study, waitlisting rates were highest among Asians and lowest among blacks, and transplant rates were highest among whites and lowest among blacks.[2] In a smaller study of 1335 American Indians and Hispanics living in New Mexico and Arizona who were receiving dialysis as of December 1994, Sequist *et al.*[12] observed a similar likelihood of transplant referral but lower relative rates of waitlisting and transplantation among those waitlisted compared with whites.

Recent efforts toward reducing health disparities in kidney transplantation have focused on improving access to the kidney transplant waitlist.[9,13,15–18] Although these efforts may have resulted in better access to transplantation for some racial ethnic minority groups, their impact has been constrained by the limited organ supply.[2,19] Thus, racial ethnic differences in overall rates of deceased donor transplantation seem to increasingly reflect differences in time to transplantation after waitlisting rather than in time to waitlisting. Our study findings suggest that, although efforts such as expanding health insurance coverage will likely improve transplant access for some groups (*e.g.*, AIANs and blacks), over time, interventions to increase deceased donor transplant rates once waitlisted will likely have more consistent benefits in reducing waiting times for all racial ethnic minority groups.

There is an established algorithm that guides allocation of deceased donor organs among patients waitlisted for transplant that incorporates the degree of histocompatibility and sensitization, waiting time, and donor organ quality.[20] Although the algorithm is not intended to favor or discriminate against members of specific racial ethnic groups, we found that, compared with whites, all racial ethnic minority groups experienced lower rates of deceased donor transplantation after waitlisting. At the same time, there was considerable heterogeneity in the extent to which these delays were attributable to measured factors. For example, waitlisted Asians, Hispanics, and Pacific Islanders encountered modest delays in accessing a deceased donor transplant because of residence in an area with a high degree of household linguistic isolation.[21–25] It follows

that in a complex healthcare setting, linguistic and/or cultural barriers are likely magnified; our results suggest that among some racial ethnic groups, such factors might serve as stronger determinants of waiting times than individual-level clinical factors, on which most transplant centers focus extensive attention.[26–28] Accordingly, increasing provider awareness and training to better identify patients with limited English proficiency or inadequate health literacy might allow for more efficient use of interpreters and culturally appropriate educational materials to increase transplants in these racial ethnic groups.[24,27] On the other hand, differences in immunologic profiles, in particular histocompatibility, contributed significantly to longer waiting times for a deceased donor kidney among waitlisted patients of all racial ethnic minority groups.[3,8] Similar to liver transplantation, regional organ availability may also play a prominent role in delaying time to deceased donor transplant among waitlisted AIANs, Hispanics, and Pacific Islanders.[29] Thus, local-level programs to advocate and educate diverse populations about the benefits of organ donation and transplantation will remain central to reducing immunologic mismatch and improving transplant rates among all racial ethnic groups. The use of patient navigators might further enhance access to kidney transplantation for certain populations.[30] Collectively, our findings suggest the need for re-evaluation of current kidney allocation algorithms in an effort to reduce persistent racial ethnic disparities.

Our study's strengths included analysis of a national cohort of patients with comprehensive, long-term follow-up for death and kidney transplantation, and the inclusion of comparative data for Asians, Hispanics, Pacific Islanders, American Indians, and Alaska Natives—groups that are rarely featured in U.S.-based studies on chronic kidney disease. Our study also had several limitations. First, our results are potentially limited by residual confounding from underascertainment of comorbid conditions, such as cardiac disease or diabetes, based on the Medical Evidence Form.[31] However, given the magnitude of the racial ethnic differences in the relative rates of transplantation, it seems unlikely that the key findings were caused by residual confounding alone. Second, the observational nature of our study precluded us from identifying specific mechanisms by which racial ethnic minority groups experienced delays in kidney transplantation. Third, we were unable to assess rates of preemptive deceased donor transplantation using our study design, which likely accounted for $<2\%$ of all deceased donor kidney transplants.[15,20] Fourth, information on measures of poverty and linguistic isolation were only available at the zip code level. These results must be interpreted with some caution because they may differ with results at the individual level or at finer levels of geographic resolution (*e.g.,* census tract or block).[32,33] Finally, because of the substantial heterogeneity of the U.S. Asian, Hispanic, and AIAN populations, our inability to further subcategorize these groups may have masked health disparities within more disadvantaged subgroups such as Cambodian, Hmong, and Vietnamese refugees, Dominican immigrants, Puerto Ricans, and some AIAN tribes.[34]

Despite having been recognized for two decades, relative rates of deceased donor kidney transplantation remain significantly lower among racial ethnic minorities compared with whites. Determinants of delays in time to transplantation differ substantially by race ethnic group. Blacks and AIANs face continued difficulty in accessing the transplant waitlist, primarily because of socioeconomic factors. Hispanics, Asians, and Pacific Islanders encounter delays from the waitlist, which may be adversely influenced by regional organ availability, linguistic isolation, and perhaps cultural isolation. Thus regional- and center-level efforts targeted to address local racial ethnic specific delays in transplantation may help to reduce overall disparities in kidney transplantation.

CONCISE METHODS

Data Sources

We obtained individual patient-level data from the U.S. Renal Data System (USRDS) registry[35] and the United Network for Organ Sharing Kidney Wait List file, and area socioeconomic data from the 2000 U.S. Census at the level of the five-digit zip code.

Study Sample

We identified all persons 18 to 64 years of age who initiated dialysis in the United States between January 1, 1995 and July 31, 2006 ($n = 538{,}642$). To align with the goals of Healthy People 2010 (to increase care access for nonelderly patients) and to minimize the risk of age bias, we restricted the primary analyses to patients younger than 65. We chose the initial time period because, before 1995, dialysis units and transplant centers were required to file the Medical Evidence Report only for Medicare-eligible patients. To reduce the potential for race ethnicity misclassification bias, we excluded 33,273 (6%) patients who did not have a race or ethnicity assignment in the USRDS Patients file or Medical Evidence file or in whom race was reported differently in these two files. Because we were interested in examining time from dialysis initiation to first deceased donor kidney transplantation, we excluded an additional 2279 (0.4%) persons who had previously received a living or deceased donor kidney transplant. The analytic sample consisted of the remaining 503,090 patients.

Outcome Variables

The primary outcome was time from dialysis initiation to receipt of a first deceased donor kidney transplant. Because prior studies have shown reduced access to waitlisting among selected racial ethnic minority groups,[2,9,11] we further examined two distinct steps on the path to deceased donor transplantation: (*1*) time from dialysis initiation to transplant waitlisting and (*2*) time from waitlisting to kidney transplantation among patients who were waitlisted. Approximately 3% of patients ($n = 17{,}324$) were waitlisted before dialysis initiation; to accommodate modeling assumptions, we assigned these patients a time of 1 day. For all analyses, we censored patients at the time of death ($n = 282{,}471$), living donor transplantation ($n = 34{,}747$), waitlist inactivity ($n = 32{,}948$), removal from the waitlist because of medical unsuitability ($n = 4854$), refusal or loss of interest ($n = 1313$), or other reasons ($n = 10{,}806$), or the

end of the study observation period on September 30, 2008. We considered patients who received a living donor kidney but who had not been previously waitlisted as having accessed the waitlist.

Primary Explanatory Variable

The primary explanatory variable for all analyses was patient race ethnicity based on information collected at the time of dialysis initiation. We defined race ethnicity as non-Hispanic white, non-Hispanic black, Asian, Hispanic, Pacific Islander, AIAN, or multiracial/other race ethnicity.[35]

Patient-Level Covariates

Additional patient-level sociodemographic covariates included age, gender, and health insurance coverage (Medicare, Medicaid, employer group insurance, other insurance, or no insurance). We examined the following comorbid conditions from the USRDS Medical Evidence form: cardiovascular disease, diabetes (insulin- or noninsulin-requiring), poor functional status (requiring assistance with daily activities, inability to ambulate or transfer, or institutionalized at an assisted living or nursing home facility), and active drug or tobacco use at the time of dialysis initiation. We further identified patients who were prescribed erythropoietin before dialysis initiation and those with low serum albumin ($<$3.5 g/dl) and hemoglobin concentrations ($<$10 g/dl).[36] We divided patients into World Health Organization–designated categories of body mass index (Quetélet's). For waitlisted patients, we ascertained ABO blood group status and the most recent level of panel reactive antibodies ($\leq$20, 21 to 79, $\geq$80%). Finally, we assigned each patient to the OPO region in which she or he initiated dialysis.[20]

Zip Code–Level Covariates

We included a variable for poverty based on U.S. Census estimates of the percentage of residents living in poverty within the zip code where each patient resided when they initiated maintenance dialysis ($<$5, 5 to 9, 10 to 14, 15 to 19, or $\geq$20% of the population).[11,32,33] The U.S. Census defines a "poverty area" as an area where at least 20% of residents are poor.[37] We further included a variable corresponding to the percentage of linguistically isolated households in each patient's zip code of residence ($<$1, 1 to 4, 5 to 9, 10 to 19, or $\geq$20% of the population). The U.S. Census defines a linguistically isolated household as one in which all members 14 years of age and over speak a non-English language and also speak English less than "very well."[38]

Statistical Analysis

We calculated annual crude event rates stratified by race ethnicity. We analyzed the associations of race ethnicity and times to waitlisting and deceased donor transplantation from dialysis initiation and after waitlisting using proportional hazards ("Cox") regression. The referent group for all analyses was non-Hispanic whites. We incorporated potential explanatory variables in the final adjusted model that were significant at the $P < 0.05$ level from bivariate analyses including patient-level variables described above, as well as proxies for residential (zip code) poverty and household linguistic isolation. We used scaled Schoenfeld residual plots against time and estimated log ($-$log [survivor function]) *versus* time survival curves to assess the proportionality assumption and found no violations. We used the likelihood ratio test to assess for interactions between patient race ethnicity with age, gender, and ABO blood group. We found no evidence of collinearity among the vector of explanatory variables using the variance inflation factor, tolerance, and Eigen values. To account for potential correlations within zip codes, we obtained robust sandwich estimates for the Cox model using the five-digit zip code as a cluster variable.[39,40] To address potential confounding by regional organ availability and practice, we performed supplemental analyses using the OPO as the cluster variable and analyses in which we stratified patients by the OPO in which they resided. To assess the potential impact of changes in the kidney allocation algorithm on racial ethnic disparities in deceased donor transplant rates, we conducted a sensitivity analysis restricting the cohort to patients waitlisted after October 1, 2002.[41] To examine for potential bias from including patients who were inactive or eventually removed from the waitlist, we performed additional analyses in which these patients were excluded.

To assess the degree of delayed transplantation attributable to measured demographic, clinical, socioeconomic, and linguistic factors, as well as regional organ availability, we calculated the proportion of the reduced rate of waitlisting and transplantation attributed to adjustment for the specific factors of interest among waitlisted patients for each racial ethnic group.[42] We performed bootstrap analyses (with 100 replications) to calculate the normal-approximation confidence intervals around point estimates for each race ethnicity when describing the proportion of the difference in waitlisting and transplantation attributable to adjustment for specific factors.[43] We confirmed model fit using Cox-Snell residuals. Two-tailed $P < 0.05$ was considered statistically significant. All statistical analyses were conducted using Stata Statistical Software (Stata MP version 11.0; Stata Corp., College Station, TX).

ACKNOWLEDGMENTS

We dedicate the manuscript to our dear friend and colleague, Dr. Andy Choi, who died suddenly during final revision of the study manuscript. Dr. Choi's commitment to research in underserved populations and his mastery of analytic methods continue to inspire all of those who were fortunate to have worked with him. The study was funded by the Norman S. Coplon Extramural Grant Program of Satellite Healthcare. Y.N.H. received support from National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) Grant K23 DK 087900. A.I.C. received support from NIDDK Grant K23 DK 080645. A.M.O. received support from National Institute of Aging Grant K23 AG 028980. G.M.C. received support from National Institutes of Health/NIDDK Grants N01 DK 012450, U01 DK 066481, and K24 085446.

DISCLOSURES

A.M.O. has received royalties from UpToDate. All other authors declare no competing financial interests.

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