Differential Mortality and Transplantation Rates among Asians and Pacific Islanders with ESRD

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Few studies in patients with ESRD have examined outcomes in Asian or Pacific Islander subgroups compared with white individuals. The objective of this study was to assess ethnic disparities in mortality and kidney transplantation among a multiethnic cohort of incident dialysis patients. A total of 24,963 patients who initiated dialysis within the TransPacific Renal Network (Network 17) between April 1, 1995, and September 30, 2001, were studied to ascertain death and kidney transplantation through September 30, 2002. Overall, 12,902 deaths and 2258 kidney transplantations were observed during 59,075 person-years of follow-up. Mortality on dialysis among Asians and Pacific Islanders (except Chamorros) was lower than that of white individuals after controlling for differences in sociodemographic characteristics, comorbid conditions, and other risk factors for death (adjusted hazard ratio [95% confidence interval] *versus* white individuals: Japanese 0.64 [0.57 to 0.72], Chinese 0.64 [0.52 to 0.78], Filipino 0.64 [0.57 to 0.72], Native Hawaiian 0.84 [0.72 to 0.96], Samoan 0.62 [0.48 to 0.82], and Chamorro 0.96 [0.84 to 1.20]). In contrast, Asians and Pacific Islanders were much less likely to undergo kidney transplantation (adjusted rate ratio [95% confidence interval] *versus* white individuals: Japanese 0.34 [0.24 to 0.46], Chinese 0.54 [0.30 to 0.88], Filipino 0.32 [0.26 to 0.47], Native Hawaiian 0.17 [0.10 to 0.30], Samoan 0.17 [0.07 to 0.38], and Chamorro 0.04 [0.01 to 0.14]). Despite wide variations in primary cause of ESRD, clinical characteristics, and body size at dialysis initiation, Asians and Pacific Islanders experience better survival but substantially lower transplantation rates compared with white individuals. Strategies that are aimed at improving access to transplantation in Asian and Pacific Islander communities may further enhance survival among Asians and Pacific Islanders with ESRD.

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Asians and Pacific Islanders comprise the largest aggregate race or ethnic group worldwide. From April 1, 2000, to July 1, 2003, the US Asian and Pacific Islander population surged by 12.5% to 13.5 million, representing 5% of the total US population. Asians and Pacific Islanders are collectively considered the fastest growing racial or ethnic minority in the United States (1).

Several studies have shown that among patients with ESRD, Asians and Pacific Islanders as a group experience improved survival on dialysis compared with white individuals (2–6). In addition, data from the United Network of Organ Sharing indicate that Asians and Pacific Islanders overall are less likely to be placed on a transplant waiting list or undergo kidney transplantation (7), even after adjustment for differences in sociodemographic and clinical data (8). The US Asian and Pacific Islander populations are ethnically diverse groups representing different Asian and Pacific Islander ancestries, socioeconomic backgrounds, metabolic phenotypes, and access to care (1,9). Despite this marked heterogeneity and societal impetus toward disaggregated classifications (1,10), few studies have examined ESRD outcomes in Asian or Pacific Islander subgroups (3,11).

To address these issues, we compared rates of mortality and kidney transplantation in Asians, Pacific Islanders, and non-Latino white individuals (hereinafter referred to as "white") from a multiethnic cohort of 24,963 people who initiated dialysis within the TransPacific Renal Network. We sought to establish whether disparities in rates of mortality and kidney transplantation exist among Asian and Pacific Islander subgroups relative to white individuals after controlling for differences in sociodemographic and clinical characteristics at dialysis initiation.

Materials and Methods

Study Population

The study population was a multiethnic cohort of people who had ESRD and initiated dialysis in the TransPacific Renal Network (Network 17) between April 1, 1995, and September 30, 2001. Network 17 is one of 18 Centers for Medicare and Medicaid Services (CMS)–spon-

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sored organizations that provide oversight for dialysis facilities and transplant programs (12). Network 17 is responsible for the 45 counties of Northern California, Hawaii, American Samoa, Guam, and Saipan. Since 1995, Network 17 has further subclassified Asian and Pacific Islander patients who initiate dialysis in Hawaii and the Pacific Islands using self-reported ethnicity. In this study, "Pacific Islander" collectively refers to individuals whose ancestry originates from the Pacific Islands, including Hawaii, American Samoa, Western Micronesia (Guam, Palau, Yap, and Northern Mariana Islands), Central Micronesia (Kosrae, Pohnpei, and Chuuk), Eastern Micronesia (Gilbert Islands and Marshall Islands), and other South Pacific Islands (Tonga, Fiji, *etc.*). "Asian" collectively refers to individuals who originated from East Asia (Japan, China, Philippines, Korea, Taiwan, *etc.*), Southeast Asia (Vietnam, Cambodia, Malaysia, *etc.*), or the Indian subcontinent.

We linked patient identifiers from Network 17 (including these extended ethnicity codes) with the nationally comprehensive United States Renal Data System (USRDS) registry (12). Linkage was performed blinded to race or ethnicity using USRDS identification numbers.

Patient data were obtained from the USRDS Standard Analysis Files. We used data from the CMS Medical Evidence form (Form 2728); the Cause of Death form (Form 2746); and standard files that track the dialysis modality, mortality, and kidney transplantation. We identified deaths and kidney transplants through September 30, 2002, to allow for a potential follow-up of at least 1 yr after dialysis initiation. We classified the cause of death as cardiac, vascular, infectious, gastrointestinal, related to liver disease (hepatic), or other on the basis of previously described methods (12). Institutional Review Boards at the collaborating institutions approved the study.

Predictor Variables

Sociodemographic predictor variables included age, race or ethnicity (Asian, Pacific Islander, white, black, or Latino), employment status (employed full or part time, retired, homemaker, student, or unemployed), and insurance status (Medicare, Medicaid, employer group insurance, other insurance, or no insurance).

Asians and Pacific Islanders who initiated dialysis in Hawaii and the Pacific Islands were further subclassified on the basis of self-report into one of the following subgroups: Japanese, Chinese, Filipino, Native Hawaiian, Samoan, Chamorro, or other Pacific Islander (Chuukese, Marshall Islands, Micronesian, Palauan, Pohnpean, Tongan, and Yapese). Body mass index (BMI; kg/m^2) was calculated from measured height and weight and divided into the following categories to conform to World Health Organization classifications: <19, 19 to 37 (in increments of 3 units), and ≥ 37 kg/m^2. The reference BMI category for all analyses was 22 to 25 kg/m^2 (13).

Coexisting illnesses included the following from the USRDS Medical Evidence form: Alcohol dependence, cerebrovascular disease, cancer diagnosis, cardiac arrest, cardiac arrhythmia, chronic obstructive pulmonary disease, cigarette smoking, congestive heart failure, drug dependence, hypertension, inability to ambulate, inability to transfer, ischemic heart disease, myocardial infarction, and peripheral vascular disease. Laboratory data included blood urea nitrogen (BUN), serum creatinine concentration, serum albumin concentration, and hematocrit at the time of dialysis initiation. Additional variables included initial dialysis modality, primary cause of ESRD, and predialysis erythropoietin use.

Estimated GFR was calculated using the Modification of Diet in Renal Disease Study equation (14). We calculated person-time as years elapsed from dialysis initiation until transplantation, death, or end of follow-up on September 30, 2002, whichever occurred first. We did not include in our analysis individuals of other race or ethnicity ($n = 406$) or individuals whose race or ethnicity was unknown or missing ($n = 661$). The final study population included 24,963 eligible people.

Statistical Analyses

We compared baseline characteristics by race or ethnicity using the χ^2 test for categorical variables and one-way ANOVA for continuous variables. In cases in which significant differences across race or ethnic groups were detected, we performed pairwise comparisons using the Tukey test. The relations among race or ethnic groups and subsequent risk for death and transplantation were analyzed using time-to-event methods. After checking and failing to find a violation of the proportional hazards assumption, we conducted multivariable analyses using Cox proportional hazards models to calculate adjusted hazard ratios (and associated 95% confidence intervals) as an estimate of the relative risk or rate ratio (RR) for Asians and Pacific Islanders compared with white individuals (12). We specified a series of Cox regression models that added potential explanatory variables to the unadjusted base model. We then specified fully adjusted models to assess the combined effect of all predictors. Predictors that were entered into the final model included age; gender; BMI; dialysis modality; primary cause of ESRD; comorbid conditions, including alcohol dependence, cancer diagnosis, cardiac arrest, cardiac arrhythmia, cerebrovascular accident, chronic obstructive pulmonary disease, cigarette smoking, congestive heart failure, drug dependence, hypertension, inability to ambulate, inability to transfer, ischemic heart disease, myocardial infarction, and peripheral vascular disease; BUN; serum creatinine concentration; hematocrit and predialysis erythropoietin use. Because of missing observations ($n = 7821$), serum albumin was entered as a categorical variable (<2.5, 2.5 to 2.9, 3.0 to 3.4, 3.5 to 3.9, and ≥ 4.0 g/dl) with a category for missing observations.

As previous literature has suggested that the association of BMI and mortality differs by race (4,11,13,16), we specifically tested for interactions between race or ethnicity and BMI on mortality using multiplicative interaction terms. To address potential selection bias in transplantation as a result of obesity (17–19), we also repeated models excluding individuals with BMI ≥ 34 kg/m^2. Stratified analyses by gender and cause of death were also performed. Last, we repeated all models with a separate race category for white individuals from Hawaii and the Pacific Islands to address potential confounding by geographic location on mortality and transplantation rates. Analyses were performed using SAS statistical software version 8.2 (Cary, NC) and Stata SE 8.0 (College Station, TX).

Results

Study Population Characteristics

Overall, we identified 24,963 adults who initiated dialysis in Network 17 between April 1, 1995, and September 30, 2001, for whom race or ethnicity data were available. This study population included 5502 (22%) Asians, 1087 (4%) Pacific Islanders, 10,119 (41%) white individuals, 3724 (15%) black individuals, and 4531 (18%) Latinos, who were collectively followed for 59,075 person-years (mean follow-up 2.3 yr per person). Asians and Pacific Islanders were further subclassified as follows: 688 (10% of Asians and Pacific Islanders) Japanese, 196 (3%) Chinese, 705 (11%) Filipino, 436 (7%) Native Hawaiian, 162 (2%) Samoan, 352 (5%) Chamorro, 137 (2%) other Pacific Islanders, and 3913 (59%) Asians and Pacific Islanders (not subclassified) from Northern California.

In general, Asians (except Japanese and Chinese) and Pacific Islanders were younger, more likely to be female, and less

likely to have insurance compared with white individuals. Specifically, Filipinos, Native Hawaiians, Samoans, and Chamorros were younger, whereas Japanese and Chinese were older than their white counterparts. In addition, Asians (except Japanese and Chinese) and Pacific Islanders were more likely to have Medicaid or lack insurance coverage at dialysis initiation compared with white individuals. Similar patterns were observed in employment status, with Asians (except Japanese and Chinese) and Pacific Islanders more likely to be unemployed and less likely to be retired compared with white individuals (Table 1).

Substantial differences in reported cause of ESRD were also observed: Asians and Pacific Islanders were much more likely to have ESRD as a result of diabetes and less likely to have ESRD attributed to hypertension compared with white individuals. At dialysis initiation, Asians and Pacific Islanders had significantly lower mean serum albumin concentrations and estimated GFR and significantly higher mean BUN (except Chamorros) and serum creatinine concentrations relative to white individuals (Table 1).

With regard to comorbid conditions, all Asian and Pacific Islander subgroups were more likely to have prevalent hypertension and diabetes compared with white individuals. Japanese had significantly higher prevalences of diagnosed congestive heart failure, ischemic heart disease, and cerebrovascular disease compared with white individuals. In addition, Native Hawaiians were more likely to have prevalent congestive heart failure and peripheral vascular disease compared with white individuals. Conversely, Asians and Pacific Islanders from Northern California had significantly less documented cardiovascular disease, whereas Samoans had significantly less peripheral vascular disease compared with white individuals. Notably, a higher fraction of Pacific Islanders and a lower fraction of Asians were obese compared with their white counterparts (Table 1).

Mortality Rates in Asians and Pacific Islanders

A total of 12,902 dialysis-related deaths were identified during 59,075 person-years of observation (21.8 per 100 person-years). The unadjusted mortality rate in Asians and Pacific Islanders ranged from 11.7 (Samoans) to 19.9 (Japanese) per 100 person-years, in contrast to 30.3 per 100 person-years in white individuals. Differences in age and gender attenuated the reduced RR of death in Filipinos (from 0.54 to 0.60), Native Hawaiians (0.63 to 0.82), Samoans (0.40 to 0.56), Chamorros (0.74 to 0.99), and other Pacific Islanders (0.59 to 0.81) relative to white individuals. Conversely, adjustment for age and gender magnified slightly the reduced RR of death in Japanese and Chinese and did not notably alter the RR of death in Asians and Pacific Islanders from Northern California relative to white individuals (Table 2). Additional adjustment for insurance status, employment status, primary cause of ESRD, and comorbid conditions did not materially affect the RR of death in Asian or Pacific Islander subgroups compared with white individuals. Further adjustment for "process variables" that may reflect predialysis care (serum creatinine, serum albumin, hematocrit at the start of dialysis, and preinitiation of dialysis erythropoietin use) slightly attenuated the reduced RR of death in all Asian and Pacific Islander subgroups (except Chamorros and other Pacific Islanders) relative to white individuals (Table 2). Final adjustment for "behaviorally modifiable" factors (cigarette smoking and BMI) resulted in small changes in the RR of death in Japanese, Chinese, Filipino, and Asians and Pacific Islanders from Northern California but little change in the RR of death in Native Hawaiians, Samoans, Chamorros, and other Pacific Islanders compared with white individuals (Table 2).

As expected, an independent, graded association between lower serum albumin and risk for death was observed (4). Higher BMI was associated with lower risk for death (3,4,16), and the BMI–mortality association was not influenced by race or ethnicity. Adjusted RR of death attributed to cardiac (n = 6367), vascular (n = 1007), infectious (n = 1870), and other (n = 3494) causes showed similar patterns as all-cause mortality (data not shown), except that Chamorros had a higher RR of death from infection (adjusted HR 1.54 [1.12 to 2.12]) and a lower RR of death from other causes (adjusted HR 0.53 [0.36 to 0.79]) compared with white individuals. Adjusted RR of death that was attributed to gastrointestinal (n = 192) and hepatic (n = 98) causes were similar among Asians, Pacific Islanders, and white individuals, likely as a result, in part, of the rarity of events. Although women had a lower RR of death compared with men (adjusted HR 0.88 [0.84 to 0.92]), we found no significant interactions between gender and Asian or Pacific Islander ethnicity.

Transplantation Rates in Asians and Pacific Islanders

Overall, 2258 patients underwent kidney transplantation during the follow-up period. Transplantation rates were universally low in Asians and Pacific Islanders compared with white individuals (Figure 1), even after controlling for differences in sociodemographic and clinical characteristics (Table 3). In particular, Native Hawaiians, Samoans, and Chamorros experienced markedly lower transplantation rates relative to white individuals.

Because the distribution of BMI differed significantly in Asians and Pacific Islanders compared with white individuals and previous literature has suggested selection bias in kidney transplantation as a result of obesity (17–19), we repeated our analyses excluding people with BMI $\geq$34 kg/m^2. Despite excluding these individuals, transplantation rates remained remarkably low in Asians and Pacific Islanders relative to white individuals (data not shown). Furthermore, we found no significant interactions between Asian or Pacific Islander ethnicity and BMI on transplantation rates. Similar results were obtained when analyses were restricted to individuals who received deceased donor kidney transplants. To address the concern that selection bias by race or ethnicity could result in a higher proportion of healthy white individuals (relative to Asians and Pacific Islanders) who undergo kidney transplantation, we examined mortality after first kidney transplantation (3,17). Consistent with previous reports (3,20), we found that adjusted mortality after first kidney transplantation was not worse in Asians and Pacific Islanders relative to white individuals (adjusted HR for Asians and Pacific Islanders *versus* white indi-

Table 1. Baseline characteristics of study population stratified by race or ethnic group[a]

Characteristic	White (n = 10,119)	Subclassified Asians and Pacific Islanders (Hawaii and Pacific Islands)							N.CA A/PI[b] (n = 3913)
		Japanese (n = 688)	Chinese (n = 196)	Filipino (n = 705)	Hawaiian (n = 436)	Samoan (n = 162)	Chamorro (n = 352)	Other PI[c] (n = 137)	
Age (yr; mean [SD])	64.8 (15.4)	67.8 (13.6)[d]	68.0 (14.0)[d]	61.3 (15.2)[d]	57.7 (13.2)[d]	55.8 (13.2)[d]	56.7 (13.9)[d]	57.1 (13.0)[d]	62.9 (15.6)[d]
Female (%)	43.0	48.3[d]	45.4[d]	50.2[d]	52.1[d]	46.9[d]	57.1[d]	46.7[d]	49.9[d]
Insurance status (%)									
no insurance	2.0	1.2	1.0	2.3	2.3	8.0[d]	4.6[d]	8.8[d]	4.0[d]
Medicaid	18.9	8.9[d]	10.2[d]	22.1	30.1[d]	27.2[d]	12.2[d]	36.5[d]	38.2[d]
Medicare	56.8	64.0[d]	57.1	47.2[d]	38.1[d]	42.0[d]	21.9[d]	21.2[d]	45.5[d]
employer group	25.9	48.3[d]	52.6[d]	40.3[d]	44.0[d]	13.8[d]	38.6[d]	24.8	26.1
Employment status (%)									
employed	11.5	14.0	13.8	14.3	14.2	13.6	9.1	15.3	11.8
homemaker	4.4	9.0[d]	10.2[d]	10.5[d]	11.0[d]	18.5[d]	10.5[d]	11.7[d]	6.3[d]
retired	60.9	64.0	60.2	44.1[d]	41.5[d]	39.5[d]	37.2[d]	34.3[d]	44.4[d]
unemployed	16.7	7.9[d]	7.7[d]	22.6[d]	22.7[d]	22.8	34.7[d]	32.9[d]	28.3[d]
student	0.6	0.2	0.0	0.9	0.2	1.2	0.6	0.0	0.8
Primary ESRD cause (%)									
diabetes	38.8	61.5[d]	51.0[d]	56.7[d]	74.5[d]	66.1[d]	75.6[d]	62.0[d]	48.7[d]
hypertension	25.6	17.7[d]	21.9	16.2[d]	9.2[d]	8.0[d]	12.2[d]	21.2	23.5[d]
glomerulonephritis	12.0	11.8	13.3	17.3[d]	9.2	13.6	5.4[d]	11.7	14.4[d]
cystic disease	3.5	1.7	2.0	1.6	0.5[d]	1.2	0.3[d]	0.0	1.8[d]
other	2.4	0.2[d]	1.0	1.8	0.7	4.9	2.8	2.2	1.2[d]
unknown	17.7	7.1[d]	10.7	6.4[d]	6.0[d]	6.2[d]	5.7[d]	2.9[d]	10.5[d]
Comorbid conditions (%)									
hypertension	65.0	88.5[d]	87.2[d]	84.3[d]	83.0[d]	88.9[d]	71.0[e]	78.8[d]	70.3[d]
congestive heart failure	29.7	38.5[d]	34.2	29.4	41.7[d]	29.0	32.7	27.0	25.8[d]
ischemic heart disease	22.4	28.5[d]	20.9	23.7	25.5	16.1	23.9	23.4	17.5[d]
PVD	13.3	13.5	10.7	11.8	16.7[e]	4.9[d]	8.8[e]	11.7	8.1[d]
CVA	8.2	12.1[d]	9.7	10.6[e]	8.0	8.0	9.1	11.7	8.1
myocardial infarction	9.4	7.0	6.6	5.5[d]	7.6	4.3[e]	6.5	8.8	5.5[d]
cigarette smoker	4.6	1.7[d]	2.0	1.7[d]	4.1	2.5	6.8[e]	7.3	1.5[d]
COPD	7.6	1.0[d]	2.6[e]	2.1[d]	2.5[d]	1.2[e]	2.3[d]	4.4	2.5[d]
cancer	5.9	4.7	2.6[e]	2.3[d]	3.2[e]	3.1	1.7[d]	2.9	2.9[d]
inability to ambulate	4.1	1.7[d]	3.6	1.6[d]	2.1[e]	3.7	2.6	5.8	2.9[d]
inability to transfer	1.3	0.7	1.5	0.6	1.2	0.6	0.3	0.0	1.3
alcohol dependence	1.3	0.3	0.0	0.1	0.7	0.0	0.0[e]	1.5	0.5[d]
drug dependence	0.6	0.0	0.0	0.1[e]	0.0	0.0	0.0	0.0	0.1[d]
Hemodialysis (%)	90.1	93.3[d]	95.4[e]	93.5[d]	90.8	95.7[e]	94.6[d]	94.9	89.1
Transplant recipient (%)	11.2	5.1[d]	7.7	7.1[d]	3.2[d]	4.9[e]	1.1[d]	5.1[e]	8.8[d]
Serum albumin (g/dl; mean [SD])	3.3 (0.6)	3.0 (0.6)[d]	3.1 (0.6)[d]	3.0 (0.7)[d]	2.9 (0.6)[d]	2.8 (0.6)[d]	2.7 (0.7)[d]	2.9 (0.7)[d]	3.2 (0.7)[d]
BUN (mg/dl; mean [SD])	90.3 (33.4)	105.5 (33.8)[d]	108.8 (35.2)[d]	104.2 (37.0)[d]	107.0 (35.1)[d]	109.3 (34.7)[d]	89.8 (30.4)	104.4 (38.2)[d]	93.7 (35.2)[d]
Serum creatinine (mg/dl; mean [SD])	7.3 (3.1)	9.1 (3.6)[d]	9.7 (4.5)[d]	9.7 (4.3)[d]	9.9 (3.7)[d]	12.6 (5.0)[d]	8.7 (3.8)[d]	10.5 (4.6)[d]	8.4 (3.8)[d]
Estimated GFR (ml/min; mean [SD])	8.3 (4.0)	5.9 (2.6)[d]	6.1 (4.0)[d]	5.9 (3.4)[d]	5.5 (2.5)[d]	4.4 (1.8)[d]	6.7 (3.5)[d]	5.6 (3.1)[d]	7.2 (3.4)[d]
Hematocrit (%; mean [SD])	29.9 (5.2)	29.3 (5.4)	29.9 (5.5)	28.5 (5.8)[d]	28.9 (5.3)[d]	27.2 (5.4)[d]	28.5 (5.4)[d]	28.4 (5.4)[d]	28.8 (5.6)[d]
Erythropoietin use (%)	34.8	51.5[d]	55.6[d]	38.4[e]	39.9[e]	33.3[d]	16.2[d]	22.6[d]	35.9[d]
BMI (kg/m^2; %)									
<19.0	9.0	16.4	18.7	15.8	5.9	4.4	9.4	7.7	15.9
19.0 to 21.9	17.9	25.9	30.6	24.9	8.5	10.6	12.3	17.7	27.4
22.0 to 24.9	23.3	23.1	21.2	24.7	17.5	19.4	19.7	24.6	25.6
25.0 to 27.9	19.3	16.2	13.0	15.7	19.1	15.0	20.0	16.9	14.8
28.0 to 30.9	12.3	7.3	9.3	10.8	16.8	15.3	14.9	19.9	7.7
31.0 to 33.9	6.9	5.4	3.6	4.5	11.4	12.7	8.6	7.4	4.0
34.0 to 36.9	4.2	2.1	1.0	1.6	9.2	8.9	6.6	2.2	2.1
≥37.0	7.1	3.7	2.6	2.0	11.6	13.4	8.6	3.7	2.4

[a]Because of rounding, percentages may not total 100. A/PI, Asian and Pacific Islander; COPD, chronic obstructive pulmonary disease; CVA, cerebrovascular accident; PVD, peripheral vascular disease; BUN, blood urea nitrogen; BMI, body mass index.

[b]Registered in Network 17 with primary dialysis unit in Northern California.

[c]Carolinian, Chuukese, Marshall Islands, Micronesian, Palauan, Pohnpean, Tongan, and Yapese.

[d]$P < 0.01$, [e]$P < 0.05$ *versus* white individuals.

Table 2. Multivariable association of the risk for death from any cause in Asians and Pacific Islanders compared with white individuals

Model	Asian or Pacific Islander *versus* White Hazard Ratio (95% Confidence Interval)							
	Japanese	Chinese	Filipino	Hawaiian	Samoan	Chamorro	Other PI[a]	N.CA A/PI[b]
Unadjusted	0.67 (0.60 to 0.75)	0.65 (0.53 to 0.79)	0.54 (0.48 to 0.61)	0.63 (0.55 to 0.72)	0.40 (0.31 to 0.51)	0.74 (0.64 to 0.86)	0.59 (0.46 to 0.75)	0.57 (0.54 to 0.60)
Adjusted for age and gender	0.61 (0.55 to 0.68)	0.58 (0.48 to 0.71)	0.60 (0.53 to 0.67)	0.82 (0.72 to 0.94)	0.56 (0.43 to 0.72)	0.99 (0.85 to 1.15)	0.81 (0.63 to 1.03)	0.59 (0.56 to 0.63)
Additional adjustment for insurance status[c] and employment status[d]	0.63 (0.57 to 0.70)	0.60 (0.49 to 0.73)	0.60 (0.54 to 0.68)	0.83 (0.73 to 0.95)	0.56 (0.43 to 0.72)	1.01 (0.87 to 1.17)	0.80 (0.63 to 1.03)	0.58 (0.55 to 0.62)
Additional adjustment for primary cause of ESRD and comorbid conditions[e]	0.64 (0.58 to 0.72)	0.63 (0.51 to 0.73)	0.64 (0.57 to 0.72)	0.80 (0.70 to 0.92)	0.57 (0.44 to 0.74)	0.98 (0.84 to 1.14)	0.83 (0.63 to 1.06)	0.62 (0.58 to 0.65)
Additional adjustment for serum creatinine, serum albumin, hematocrit, and predialysis erythropoietin use[f]	0.68 (0.61 to 0.76)	0.68 (0.56 to 0.83)	0.67 (0.60 to 0.76)	0.82 (0.70 to 0.93)	0.61 (0.46 to 0.79)	0.96 (0.82 to 1.12)	0.83 (0.62 to 1.09)	0.64 (0.60 to 0.68)
Additional adjustment for BMI and tobacco smoking	0.64 (0.57 to 0.72)	0.64 (0.52 to 0.78)	0.64 (0.57 to 0.72)	0.84 (0.72 to 0.96)	0.62 (0.48 to 0.82)	0.96 (0.84 to 1.20)	0.81 (0.62 to 1.04)	0.60 (0.56 to 0.63)

[a]Carolinian, Chuukese, Marshall Islands, Micronesian, Palauan, Pohnpean, Tongan, and Yapese.
[b]Registered in Network 17 with primary dialysis unit in Northern California.
[c]Medicare, Medicaid, uninsured, or other insurance.
[d]Employed part/full time, homemaker, retired, or unemployed.
[e]Alcohol dependence, cancer diagnosis, cardiac arrest, cardiac arrhythmia, cerebrovascular accident, chronic obstructive pulmonary disease, congestive heart failure, drug dependence, hypertension, inability to ambulate, inability to transfer, ischemic heart disease, myocardial infarction, and peripheral vascular disease.
[f]Values at initiation of dialysis.

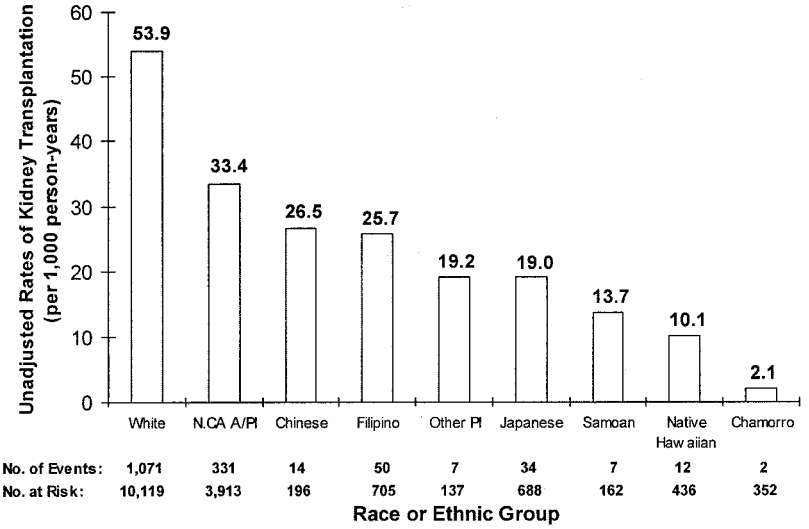

Figure 1. Unadjusted rates of kidney transplantation by race or ethnic group.

viduals 0.90 [0.59 to 1.38]). We further found no substantial changes in the RR of death in companion analyses in which we did not censor for transplantation.

Influence of Geographic Location on Mortality and Transplantation Rates

Notable differences in clinical characteristics, mortality, and transplantation rates were observed among Asians and Pacific Islanders by geographic location. In general, Asians (except Japanese and Chinese) and Pacific Islanders from Hawaii and the Pacific Islands were significantly younger than their counterparts from Northern California ($P < 0.001$) and had process variables (reflecting predialysis care) that were comparably worse. Specifically, Asians and Pacific Islanders from Hawaii and the Pacific Islands had significantly lower serum albumin concentrations and significantly higher BUN and serum creatinine concentrations at dialysis initiation compared with their counterparts from Northern California ($P < 0.001$, respectively). Among Asian and Pacific Islander subgroups, Chamorros had the highest adjusted mortality, whereas Asians and Pacific Islanders from Northern California had the lowest adjusted mortality relative to white individuals (Table 2).

Over the study period, Asians and Pacific Islanders from Northern California also had a higher adjusted transplantation rate compared with their counterparts from Hawaii and the Pacific Islands ($P < 0.001$). Being Asian or Pacific Islander, however, was associated with a lower likelihood for kidney transplantation regardless of geographic location (Northern California, Hawaii, and the Pacific Islands). To address potential selection bias by geography, we performed companion analyses with a separate race category for white individuals from Hawaii or the Pacific Islands ($n = 511$). After adjustment, white individuals from Hawaii and the Pacific Islands had similar mortality (adjusted HR 0.92 [0.81 to 1.05]) but a higher transplantation rate (adjusted RR 1.39 [1.13 to 1.72]) compared with white individuals from Northern California.

Discussion

Asians and Pacific Islanders are the largest aggregate race or ethnic group worldwide and the fastest growing racial or ethnic minority in the United States. Previous studies have reported a strong association between Asian race and survival (relative to white individuals) in patients with ESRD (2–6). Despite wide variation in sociodemographic characteristics, BMI, and access to care, few studies have assessed ESRD-related outcomes in Asian or Pacific Islander subgroups compared with white individuals (3,11).

In a large, multiethnic incident ESRD cohort, we found that after accounting for many of the previously described risk factors for death, mortality on dialysis (although varied) was lower in most Asian and Pacific Islander subgroups compared with white individuals. In models that adjusted for sociodemographic and clinical characteristics at dialysis initiation, Japanese, Chinese, Filipinos, Samoans, and Asians and Pacific Islanders from Northern California experienced significantly lower mortality on dialysis relative to white individuals. After multivariable adjustment, Native Hawaiians experienced only a small survival advantage, whereas Chamorros and other Pacific Islanders experienced no survival benefit compared with white individuals. Transplantation rates, conversely, were markedly lower in all Asian and Pacific Islander subgroups, with Native Hawaiians, Samoans, and Chamorros at a particular disadvantage relative to white individuals

Our study provides further insight into the association between Asian and Pacific Islander ethnicities and ESRD-related outcomes. Previously, using data from USRDS, Wong *et al.* (4) reported that Asians with ESRD had a lower RR of death compared with white individuals after adjustment for demographic and clinical characteristics. Compared with Wong *et al.* (4), an important advantage of our study was the ability to compare mortality rates in disaggregated Asian and Pacific Islander subgroups (subclassified by self-report as opposed to race or ethnicity assignment by dialysis staff) with white indi-

Table 3. Multivariable association of the rate of transplantation in Asians and Pacific Islanders compared with white individuals

Model	Asian or Pacific Islander *versus* White Rate Ratio (95% Confidence Interval)							
	Japanese	Chinese	Filipino	Hawaiian	Samoan	Chamorro	Other PI[a]	N.CA A/PI[b]
Unadjusted	0.33 (0.23 to 0.46)	0.45 (0.27 to 0.77)	0.45 (0.34 to 0.60)	0.18 (0.10 to 0.32)	0.23 (0.10 to 0.48)	0.04 (0.01 to 0.18)	0.34 (0.16 to 0.72)	0.59 (0.52 to 0.67)
Adjusted for age and gender	0.44 (0.31 to 0.62)	0.67 (0.41 to 1.18)	0.41 (0.31 to 0.54)	0.14 (0.08 to 0.24)	0.15 (0.07 to 0.32)	0.03 (0.01 to 0.12)	0.23 (0.11 to 0.49)	0.56 (0.49 to 0.63)
Additional adjustment for insurance status[c] and employment status[d]	0.36 (0.26 to 0.51)	0.56 (0.33 to 0.95)	0.37 (0.28 to 0.49)	0.15 (0.09 to 0.26)	0.15 (0.07 to 0.31)	0.03 (0.01 to 0.11)	0.27 (0.13 to 0.57)	0.56 (0.49 to 0.63)
Additional adjustment for primary cause of ESRD and comorbid conditions[e]	0.37 (0.27 to 0.53)	0.60 (0.36 to 1.02)	0.36 (0.27 to 0.48)	0.16 (0.09 to 0.29)	0.15 (0.07 to 0.32)	0.03 (0.01 to 0.12)	0.26 (0.12 to 0.56)	0.50 (0.44 to 0.57)
Additional adjustment for serum creatinine, serum albumin, hematocrit, and predialysis erythropoietin use[f]	0.34 (0.24 to 0.46)	0.54 (0.31 to 0.91)	0.35 (0.24 to 0.44)	0.15 (0.09 to 0.27)	0.15 (0.07 to 0.33)	0.03 (0.01 to 0.14)	0.26 (0.12 to 0.54)	0.51 (0.45 to 0.57)
Additional adjustment for BMI and cigarette smoking	0.34 (0.24 to 0.46)	0.51 (0.30 to 0.88)	0.32 (0.26 to 0.47)	0.17 (0.10 to 0.30)	0.17 (0.07 to 0.38)	0.04 (0.01 to 0.14)	0.24 (0.12 to 0.52)	0.48 (0.42 to 0.53)

[a]Carolinian, Chuukese, Marshall Islands, Micronesian, Palauan, Pohnpean, Tongan, Yapese.
[b]Registered in Network 17 with primary dialysis unit in Northern California.
[c]Medicare, Medicaid, uninsured, or other insurance.
[d]Employed part/full time, homemaker, retired, or unemployed.
[e]Alcohol dependence, cancer diagnosis, cardiac arrest, cardiac arrhythmia, cerebrovascular accident, chronic obstructive pulmonary disease, congestive heart failure, drug dependence, hypertension, inability to ambulate, inability to transfer, ischemic heart disease, myocardial infarction, and peripheral vascular disease.
[f]Values at initiation of dialysis.

viduals (non-Latino) from the same geographic region. Pei *et al.* (3) described higher adjusted survival among Southeast Asians (defined as Japanese, Chinese, Korean, and Indo-Chinese), South Asian (defined as East Indian, Pakistani, and Punjabi), and black individuals relative to white individuals from the Toronto Regional Dialysis Registry ($n = 4844$). In contrast to Pei *et al.* (3), our study included a substantially larger cohort of Asians and Pacific Islanders with more pronounced variation in body size and clinical characteristics. Because of this added power, we were able to adjust for more extensive baseline sociodemographic and clinical data and assessed further for disparities in rates of kidney transplantation across different Asian and Pacific Islander ethnicities.

In general, differences in age, gender, insurance status, employment, and clinical characteristics at dialysis initiation explained varying proportions of the reduced mortality observed in Filipinos, Native Hawaiians, Samoans, Chamorros, and other Pacific Islanders relative to white individuals. It is interesting that the RR estimates in these subgroups moved in the same direction as the RR estimates of black individuals and Latinos in our study cohort. In contrast, differences in sociodemographic and clinical data accounted for little of the survival benefit seen in Japanese, Chinese, and Asians and Pacific Islanders from Northern California relative to white individuals.

Although genetic factors undoubtedly contribute to some of these differences in mortality on dialysis among Asian and Pacific Islander subgroups, environmental factors such as access to quality nephrology care likely play important roles as well. Previous studies have shown that the presence and the duration of nephrology care before dialysis initiation relate directly to patient survival on dialysis (21,22). In our study, among Asian and Pacific Islander subgroups, Chamorros had the poorest outcomes relative to white individuals. Markedly fewer opportunities for transplantation may have contributed to their higher RR of infectious death compared with white individuals. Notably, Asians and Pacific Islanders from Northern California had the lowest adjusted mortality relative to white individuals. Such data suggest that considerable disparities in nephrology care exist even within the US Asian and Pacific Islander populations by geographic location. The lower mortality rates among Pacific Islanders on ESRD is particularly noteworthy, given that mortality rates among the non-ESRD Pacific Islanders are substantially higher than corresponding rates for white individuals (23).

In contrast to mortality on dialysis, kidney transplantation rates were markedly lower in all Asian and Pacific Islander subgroups relative to white individuals. This large discrepancy in kidney transplantation rates was not explained by differences in sociodemographic and clinical characteristics at dialysis initiation. In fact, adjustment for these data not only failed to explain but also seemed to increase the discrepancy in transplantation rates in most Asian and Pacific Islander subgroups (except Japanese and Chinese) compared with white individuals. Such inequalities in care have also been documented in liver transplantation, in which Asians wait longer for transplantation and have a higher risk for dying before transplantation compared with white individuals (24). In other medical conditions, such as coronary heart disease, Asians and Pacific Islanders were also less likely to receive invasive procedures such as coronary angiography and coronary arterial revascularization (percutaneous coronary intervention or coronary artery bypass surgery) compared with white individuals in some (25) but not all studies (26,27), although this has been relatively understudied. In the National Registry of Myocardial Infarction, Asians and Pacific Islanders with confirmed acute myocardial infarction were less likely to receive thrombolytic therapy than white individuals, but there were no significant differences in the use of revascularization procedures during the index hospitalization (28). Variation in invasive cardiovascular procedure use and use of other acute therapies across different Asian and Pacific Islander subgroups in the United States is less well understood.

On the basis of relatively large differences in estimated GFR at dialysis initiation, it is possible that Asians and Pacific Islanders received less predialysis care than did white individuals, especially off the mainland. Such disparities in predialysis care could have resulted in delayed transplantation referral and subsequently lower transplantation rates (8). Whereas organ procurement and geographic isolation may have contributed to varying transplantation rates among Asian and Pacific Islander subgroups, being Asian or Pacific Islander decreased the likelihood for kidney transplantation regardless of geographic location compared with being white. Hence, racial bias on the basis of nephrologists' attitudes toward kidney transplantation might also be operative. In a national random survey of US nephrologists, Asian (but not black) race conferred a decreased likelihood of being recommended for kidney transplantation in patients with ESRD compared with white race (29).

Data on South Asians living in the United Kingdom suggested that in addition to traditional clinical factors, patient awareness and cultural attitudes toward organ donation may have contributed to differential rates of kidney transplantation (30). Whether cultural and related factors influenced transplantation rates among Asians and Pacific Islanders warrants further investigation.

Our study was strengthened by the large, diverse sample of incident ESRD patients and comprehensive, longitudinal follow-up for death and transplantation. In addition, we incorporated self-reported ethnicity and were able to control for differences in important demographic and clinical factors at dialysis initiation. It is interesting to note that most studies that have compared mortality on dialysis and transplantation rates in Asians *versus* non-Asians have been performed largely in Japanese, Chinese, or Asian Indian populations (3,5,6).

Our study was also limited in several respects. Differential migration of certain race or ethnic groups to other geographic regions (*e.g.*, Samoans moving to Alaska) before dialysis initiation could have confounded our results. Residual confounding by comorbidity and socioeconomic status might also be operative, because certain comorbid conditions, including diabetes, on the Medical Evidence form are underascertained and socioeconomic data are limited (14,31). In Hawaii, the median household income of Native Hawaiians and Pacific Islanders is roughly $13,000 less than that of Asians (Japanese, Chinese, and

Filipino). Moreover, fewer than 10% of Native Hawaiian and Pacific Islander adults have attained a college or higher level education. In American Samoa, the median household income is only $18,219; <8% of the adult population has attained college or higher level education (www.census.gov). More detailed information on income, education, and language might have refined estimates of mortality risk and may have partially explained lower transplantation rates. The association between estimated GFR and outcomes may be subject to misclassification, as the Modification of Diet in Renal Disease and Cockcroft Gault equations perform suboptimally when applied in South Asians (32) and have not been validated in Pacific Islanders (14,32,33). The mechanism(s) for improved survival among Asians and Pacific Islanders cannot be explained with these data. No data were available on the overall quality of medical care, and we had no detailed information on the efficiency of dialysis and related therapies (34). We were unable to compare living donor kidney transplants among Asian and Pacific Islander subgroups because of the paucity of events ($n = 130$). Because relatively few posttransplantation deaths ($n = 173$) were observed during the follow-up period, we cannot rule out differential mortality in Asian or Pacific Islander subgroups *versus* white individuals after first kidney transplant. Although large proportions of the US Asian and Pacific Islander ESRD populations receive dialysis care in Network 17 (12), our cohort may also not completely represent the environmental or genetic make-up of all US Asians and Pacific Islanders.

In summary, our results suggest that despite wide variations in primary cause of ESRD, clinical characteristics, and body size at dialysis initiation, Asians and Pacific Islanders experience better survival but substantially lower transplantation rates compared with white individuals. Strategies aimed at improving access to transplantation in Asian and Pacific Islander communities may further enhance survival among Asians and Pacific Islanders with ESRD.

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See related editorial, "Race and Kidney Disease Outcomes: Genes or Environment?" on pages 3461–3463.