

Similar Outcomes among Black and White Renal Allograft Recipients

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ABSTRACT

Black renal transplant recipients experience shorter graft survival than white recipients, but no published data describe the graft outcomes among black Canadian recipients. Here, we analyzed data from the Canadian national renal replacement therapy registry, which included 20,243 incident dialysis patients (3% black, 97% white), 5036 of whom received a renal transplant during the study period. Black patients were significantly less likely to receive a renal transplant (deceased and living-donor combined) when compared with white patients (hazard ratio 0.59; 95% confidence interval 0.51 to 0.69; $P < 0.0001$). Among patients who underwent a renal transplant, there was no significant difference in the likelihood of graft failure between black and white patients, even after adjustment for comorbidities and socio-economic status; black patients, however, had significantly lower posttransplantation mortality compared with white patients (hazard ratio 0.49; 95% confidence interval 0.28 to 0.88; $P = 0.02$). In conclusion, graft outcomes between black and white Canadian renal transplant patients are similar. Because this differs from the experience reported from the United States, further direct comparisons between the two populations is warranted.

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Since the first renal transplant more than 50 yr ago, there has been significant improvement in both patient and graft survival.^{1–4} Despite this, disparities continue to exist in access to renal transplantation and posttransplantation outcomes for certain minority groups. In the United States, renal allograft survival is significantly lower in black than in white patients,^{5–10} which might be due to higher immunologic risk, poorer medication adherence, or decreased access to pre- and posttransplantation care.^{8,11–23} Whether black Canadian transplant recipients also have decreased transplant survival is unclear because there are no published data describing transplant outcomes among this patient group. A recent study comparing outcomes in Canada and the United States demonstrated that American transplant recipients had an increased risk for mortality. In the subgroup of black recipients, the

higher risk for death seemed to be magnified in American *versus* Canadian black transplant recipients.²⁴

It has been suggested that black Canadians are comparable to black Americans, because the ancestry of both populations lies in the slave trade of people who migrated from sub-Saharan Africa to the Caribbean; however, unlike black Americans, black Canadians are entitled to free access to renal

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transplantation and follow-up care at all kidney transplant centers. Therefore a detailed analysis of transplant outcomes in black Canadians may provide useful insights into the factors contributing to the inferior transplant outcomes among black Americans. We used national data from the Canadian Organ Replacement Register (CORR) to compare the likelihood of transplantation as well as patient and graft survival in renal transplant recipients among black and white Canadians treated for kidney failure in Canada.

RESULTS

There were 26,098 incident dialysis patients in this study, representing a random sample of approximately 75% of all patients initiating dialysis in Canada during the study period. Of

these, 3459 (13%) were of neither black nor white race and 2396 (9%) were of unknown race and were therefore excluded. All analyses were performed on the remaining 20,243 individuals, 3% were black of whom of whom and 97% of whom were white (Table 1). By study end, 12,409 (61%) died before receiving a transplant and 214 (1%) were lost to follow-up. Black patients were significantly more likely than white patients to have diabetic nephropathy listed as their primary renal disease (37 versus 27%). Among comorbid conditions, coronary disease was significantly higher among white compared with black patients (33 versus 24%), as was current smoking status (15 versus 6%). Black patients were significantly more likely to be in the lowest quintile of socioeconomic status (SES; 38 versus 23%).

During the study period, 5036 individuals underwent kidney transplantation. Table 2 presents the relative rates of renal

Table 1. Demographics and clinical characteristics in dialysis patients^a

Parameter	Black	White	P
n (%)	699 (3)	19,544 (97)	
Age (yr; median [IQR])	55 (42 to 66)	64 (50 to 73)	<0.0001 ^b
Male, n (%)	378 (54)	11,895 (61)	0.0003
Cause of ESRD, n (%)			
diabetic nephropathy	260 (37)	5342 (27)	<0.0001
glomerulonephritis	110 (16)	3352 (17)	0.3300
hypertensive/ischemic renal disease	150 (21)	4038 (21)	0.6100
polycystic kidney disease	27 (4)	1169 (6)	0.0200
other	152 (22)	5643 (29)	<0.0001
Comorbidity, n (%)			
diabetes ^c	42 (6)	1322 (7)	0.4300
coronary disease ^d	166 (24)	6514 (33)	<0.0001
chronic heart failure	229 (33)	5524 (28)	0.0100
stroke or TIA	64 (9)	2041 (10)	0.2700
chronic lung disease	25 (4)	2127 (11)	<0.0001
peripheral vascular disease	91 (13)	3589 (18)	0.0003
malignancy	36 (5)	1852 (9)	0.0001
Current smoker, n (%)	40 (6)	2895 (15)	<0.0001
Initial peritoneal dialysis modality, n (%)	245 (35)	5502 (28)	0.0001
Lowest quintile of SES, n (%)	263 (38)	4407 (23)	<0.0001
Rural, n (%)	16 (2)	4220 (22)	<0.0001
Geographic region, n (%)			
Atlantic Canada	29 (4)	1990 (10)	<0.0001
Quebec	152 (22)	5250 (27)	0.0030
Ontario	458 (66)	7502 (38)	<0.0001
Manitoba	7 (1)	765 (4)	0.0001
Saskatchewan	3 (0)	697 (4)	<0.0001
Alberta	34 (5)	1471 (8)	0.0080
British Columbia	16 (2)	1869 (10)	<0.0001
Year of dialysis initiation, n (%)			
1990 to 1992	115 (16)	4017 (21)	0.0080
1993 to 1994	111 (16)	3242 (17)	0.6200
1995 to 1996	124 (18)	3638 (19)	0.5600
1997 to 1998	175 (25)	4170 (21)	0.0200
1999 to 2000	174 (25)	4477 (23)	0.2200

^aIQR, interquartile range; TIA, transient ischemic attack.

^bKruskal-Wallis test; all others χ^2 test.

^cIn participants for whom the primary cause of ESRD was not diabetic nephropathy.

^dIncludes angina, previous myocardial infarction, or previous coronary revascularization.

Table 2. Likelihood of transplantation by race

Parameter	Any Transplant			Deceased-Donor Transplant Only			Living-Donor Transplant Only		
	n (%)	Age Adjusted (HR [95% CI])	Fully Adjusted (HR [95% CI]) ^a	n (%)	Age Adjusted (HR [95% CI])	Fully Adjusted (HR [95% CI]) ^a	n (%)	Age Adjusted (HR [95% CI])	Fully Adjusted (HR [95% CI]) ^a
Black	195 (28)	0.53 (0.46 to 0.61)	0.59 (0.51 to 0.69)	161 (23)	0.58 (0.50 to 0.68)	0.70 (0.59 to 0.82)	34 (5)	0.37 (0.26 to 0.52)	0.35 (0.25 to 0.50)
White	4841 (25)	1.0	1.0	3576 (18)	1.0	1.0	1265 (6)	1.0	1.0
P		<0.0001	<0.0001		<0.0001	<0.0001		<0.0001	<0.0001

^aAdjusted for age, gender, primary cause of ESRD, year of diagnosis, comorbidities (diabetes, coronary heart disease, hypertension, chronic heart failure, stroke or TIA, chronic lung disease, serious medical illness, peripheral vascular disease, malignancy), smoking status, initial dialysis modality, SES, geographic region, and rural status.

transplantation by black *versus* white race. After adjustment, black patients were significantly less likely to receive a renal transplant (deceased and living donor combined) when compared with white patients (hazard ratio [HR] 0.59; 95% confidence interval [CI] 0.51 to 0.69; $P < 0.0001$). The difference between black and white patients seemed to be less pronounced for deceased as compared with living donors. The interaction between race and age and between race and diabetes status was significant ($P < 0.0001$ and $P = 0.005$, respectively), suggesting that it would be appropriate to present the rate of transplantation after stratification by age and diabetes status.

For patients aged <40 yr, black patients had a 51% lower rate of transplantation as compared with white patients (HR 0.49; 95% CI 0.38 to 0.62; $P < 0.0001$), whereas those in the 50.0- to 59.9-yr age group had a 41% lower rate than comparably aged white patients (HR 0.59; 95% CI 0.42 to 0.82; $P = 0.002$). Among those aged ≥ 60 yr, the rate of transplantation was nonsignificantly higher for black than for white patients (HR 1.47; 95% CI 0.97 to 2.23; $P = 0.07$). Among those with diabetes, there was no significant difference in the rate of renal transplantation for black compared with white patients (HR 0.90; 95% CI 0.66 to 1.22; $P = 0.50$); however, among those without diabetes, black patients had a significantly lower rate of transplantation compared with white patients (HR 0.57; 95% CI 0.48 to 0.67; $P < 0.001$).

Table 3 compares the characteristics of black and white transplant recipients during the study period. Of these 5036 patients, 4841 (96%) were white and 195 (4%) were black. Overall, differences between black and white transplant recipients were similar to those in the general dialysis population. For example, black renal transplant patients were slightly younger, more often lived in lower income urban communities, and were significantly more likely than white patients to have hypertensive/ischemic nephropathy as their primary renal diagnosis.

Table 4 compares transplant outcomes between black and white patients. The median follow-up time among transplant recipients was 5.2 yr; 857 (15%) experienced graft failure, death occurred in 641 (13%) of patients, and 14 (0.3%) were lost to follow-up. In this analysis, there was no significant difference in the adjusted rate of graft failure between black and white patients (HR 1.16; 95% CI 0.82 to 1.64; $P = 0.40$) or the

adjusted rate of graft failure or death (HR 0.90; 95% CI 0.67 to 1.21; $P = 0.48$; Table 4). After adjustment, black transplant recipients had significantly lower posttransplantation mortality compared with white patients (HR 0.49; 95% CI 0.28 to 0.88; $P = 0.02$). The bootstrapped 95% CI were similar (graft failure 0.82 to 1.67; graft failure or death 0.67 to 1.23; death 0.28 to 0.94).

DISCUSSION

As in multiple other countries, black patients treated with dialysis in Canada waited longer for a kidney transplant after initiation of dialysis and were less likely to undergo transplantation than white patients, especially for transplants from a living donor; however, black transplant recipients had similar graft survival and lower all-cause mortality compared with white patients, a finding that is strikingly different from that reported in American studies.^{2–5,18,25,26}

Black Americans have lower access to renal transplantation than white Americans, probably because of lower referral rates for transplantation assessment, which may themselves be due to physician attitudes about poor adherence and lower graft success rates among black patients.^{17,22,27,28} Numerous studies from the United States also show inferior graft outcomes among black transplant recipients. Data from the United Network for Organ Sharing registry showed that between 1995 and 1999, the 5-yr graft survival rates for deceased donor transplants was 70 and 55%, respectively, for white and black patients. Among living donor transplants, the graft survival rates were 80 and 64%, respectively, for white and black patients. These differences were observed even in HLA-identical sibling transplants, which provided the best results for people of both races but led to markedly superior graft half-lives in white patients (42 *versus* 27 yr).⁵

In theory, the lack of disparity in graft failure rates between black and white patients in Canada *versus* the United States might depend on both macro-level factors (health care system and population) and micro-level factors (biologic and other determinants) that affect the transplant recipient. It is possible, although less plausible, that black Americans and the Canadian black population are “biologically” different as a result of historical patterns of immigration. This biologic argument has

Table 3. Demographics and clinical characteristics in transplant recipients

Parameter	Black	White	P
n (%)	195 (4)	4841 (96)	
Age (yr; median [IQR])	43 (30 to 52)	45 (35 to 55)	0.0400 ^a
Male	129 (66)	3104 (64)	0.5600
Cause of ESRD, n (%)			
diabetic nephropathy	38 (19)	984 (20)	0.7800
glomerulonephritis	55 (28)	1540 (32)	0.2900
hypertensive/ischemic renal disease	43 (22)	343 (7)	<0.0001
polycystic kidney disease	11 (6)	636 (13)	0.0020
other	48 (25)	1338 (28)	0.3500
Comorbidity, n (%) ^b			
diabetes ^c	7 (4)	116 (2)	0.2900
coronary disease ^d	22 (11)	439 (9)	0.2900
chronic heart failure	30 (15)	459 (9)	0.0060
stroke or TIA	9 (5)	120 (2)	0.0600
chronic lung disease	2 (1)	120 (2)	0.2000
peripheral vascular disease	6 (3)	176 (4)	0.6800
malignancy	4 (2)	125 (3)	0.6500
Current smoker, n (%)	12 (6)	748 (15)	0.0004
Initial peritoneal dialysis modality, n (%)	61 (31)	1655 (34)	0.400
Lowest quintile of SES	70 (36)	961 (20)	<0.0001
Rural	4 (2)	1032 (21)	<0.0001
Geographic region, n (%)			
Atlantic Canada	8 (4)	482 (10)	0.0070
Quebec	40 (21)	1182 (24)	0.2100
Ontario	115 (59)	1747 (36)	<0.0001
Manitoba	2 (1)	145 (3)	0.1100
Saskatchewan	1 (1)	175 (4)	0.0200
Alberta	18 (9)	519 (11)	0.5100
British Columbia	11 (6)	591 (12)	0.0060
Year of dialysis initiation, n (%)			
1990 to 1992	46 (24)	1217 (25)	0.6200
1993 to 1994	35 (18)	914 (19)	0.7400
1995 to 1996	44 (23)	920 (19)	0.2200
1997 to 1998	38 (19)	962 (20)	0.8900
1999 to 2000	32 (16)	828 (17)	0.8000

^aKruskal-Wallis test; all others χ^2 test.

^bComorbidity data collected at dialysis initiation.

^cIn participants for whom the primary cause of ESRD was not diabetic nephropathy.

^dIncludes angina, previous myocardial infarction, or previous coronary revascularization.

been used to explain differences in outcomes among black and white Americans for decades, but recent studies have shown that it likely plays a minor role in influencing transplant outcomes.^{11,13,14,19,25,29,30}

A second possible explanation for differences in graft failure in black Americans *versus* black Canadians is that relative levels of comorbidity may differ between the two populations. For example, a large proportion of black Americans have hypertension listed as their primary renal diagnosis,¹ whereas this was not the case in our study of the Canadian dialysis population during 1990 through 2000. In our analysis, black patients had significantly higher rates of diabetes as a primary renal diagnosis, but white dialysis patients were significantly older than black patients, with a higher prevalence of comorbid diseases including coronary disease, smoking, and peripheral vascular disease. This likely reflects that a higher proportion of white patients

undergo transplantation in Canada and are therefore likely to have more comorbidity. Because we did not perform a direct comparison of Canadian and American data, we are unable to compare the level of comorbidity between either white or black patient groups in either of the two countries.

The third (and, in our opinion, the most probable) potential explanation for our findings may relate to differential access to health services. All Canadians who receive government assistance (welfare) are eligible for immunosuppressive medications through provincial drug programs. Recipients who are employed and have private insurance may receive coverage for the majority of their medications through a blend of private and public drug coverage. In contrast, the poor seem to have substantially reduced access to immunosuppressive drugs in the United States. Under the current US system, the cost of immunosuppressive medication is reimbursed in the first 3 to

Table 4. Likelihood of graft failure or death by race

	Parameter		P
	Black	White	
Graft Failure or Death			
n (%)	48 (25)	1450 (30)	
Age Adjusted (HR [95% CI])	0.930 (0.700 to 1.240)	1.000	0.63
Fully Adjusted (HR [95% CI]) ^a	0.900 (0.670 to 1.210)	1.000	0.48
Graft Failure			
n (%)	36 (18)	821 (17)	
Age Adjusted (HR [95% CI])	1.170 (0.840 to 1.640)	1.000	0.35
Fully Adjusted (HR [95% CI]) ^a	1.160 (0.820 to 1.640)	1.000	0.40
Death			
n (%)	12 (6)	629 (13)	
Age Adjusted (HR [95% CI])	0.560 (0.320 to 0.999)	1.000	0.05
Fully Adjusted (HR [95% CI]) ^a	0.490 (0.280 to 0.880)	1.000	0.02

^aAdjusted for age, gender, primary cause of ESRD, year of diagnosis, comorbidities (diabetes, coronary heart disease, hypertension, chronic heart failure, stroke or TIA, chronic lung disease, serious medical illness, peripheral vascular disease, malignancy), smoking status, initial dialysis modality, SES, geographic region, rural status, and time on dialysis (<1.0, 1.0 to 1.9, ≥2.0 yr).

5 yr after renal transplantation, and much of the graft loss among lower income recipients occurs after reimbursement ends.²⁹ Because black Americans are more likely to be uninsured compared with white Americans, this policy may contribute to their higher risk for graft loss^{28,31}; however, graft survival was lower in black than white patients even among US veterans, all of whom are eligible for medication coverage through the Veterans Administration medical system,³² and the explanation for this finding remains unclear.

We also found that black transplant recipients had 51% lower mortality after transplantation than white recipients, which is also out of keeping with published US data.³³ The reasons for this are unclear but may again be related to differential access to pre- and posttransplantation care for comorbid disease or differences in the relative burden of comorbidity between the two black populations. Alternatively, because black Canadian patients are less likely than seemingly comparable white patients to receive a kidney transplant, their lower posttransplantation mortality relative to white patients may be due to selection bias. No recent studies have examined characteristics of black *versus* white Canadian renal transplant patients; however, the lower number of black renal transplant patients in Canada suggests that perhaps there is a disparity in referral or placement on the waiting list for black *versus* white patients. This may have resulted in only relatively healthier black patients' receiving a renal transplant. This disparity in the total number of black Canadians' receiving renal transplantation is concerning and supports previously published studies that showed decreased access to renal transplantation among other minority patient groups in Canada^{34,35} and warrants further investigation into possible causes.

Our argument that renal transplant outcomes are influenced by medical systems rather than biology is supported by recently published data from other countries that have medical systems that are similar in structure and funding to Canada's. A recent study from France showed comparable renal transplant outcomes for both white patients and patients of African

descent.³⁶ Although less comparable to Canada, Brazil has also been shown to have similar graft survival among black *versus* white patients in the recipients of living-donor kidneys.³⁷

There are a number of limitations to our study. The use of registry data has inherent shortcomings, including limited availability of clinical variables collected by the Canadian Renal Replacement Registry, the renal database we used for our analysis. Important transplant variables such as HLA typing, cold/warm ischemic time, and donor characteristics would allow for a more in-depth analysis but are not currently available through this national registry. For instance, racial differences in HLA types may have influenced graft survival in white renal transplant recipients, as compared with those who were black. Although we cannot exclude the possibility that cold/warm ischemic time and clinical donor characteristics systematically differed by race, we believe that this is unlikely. Although CORR has a comprehensive collection of prospectively collected data from all Canadian transplant centers, like most registries, it has no formal validation process. The CORR data collection manual indicates that patient racial identity should be coded through self-reported ethnicity, although some (10%) patients had missing data for race. For this to have influenced our results, patients with missing data on race would have had to be systematically different in terms of both race and outcomes compared with those with complete data. We carried out a sensitivity analysis of missing or unknown race data and found no difference between substitution of black or white patients. Similarly, our findings could have been confounded by unmeasured comorbidity or socioeconomic factors. Although we believe that residual confounding is unlikely to have changed our conclusions, the possibilities that missing or incorrect information was partially responsible for our findings should be considered. In addition, we were unable to obtain comorbidities at the time of renal transplantation but had to rely on comorbidity data collected when the patients were on dialysis. Third, we did not have information on the date of placement on the waiting list for transplantation, which would

have allowed us to examine whether longer waiting time influenced graft or patient outcomes, and little is known about access to placement on the waiting list for transplantation among Canadian ethnic minorities. This might be especially relevant for black patients, given that patients from ethnic minorities have longer average waiting times in multiple countries such as Australia (Aboriginals) and the United States (black and Native Americans).^{38–40} Fourth, we did not have data on the cause of death or graft failure, which would have helped us to speculate as to why our findings differed from those in the United States. Fifth, data regarding donor and immunologic characteristics (e.g., HLA type, cold/warm ischemia time) were not available and would have strengthened our analyses significantly. Sixth, we did not include data on preemptive transplantation; however, this type of transplantation was infrequently performed in Canada during the study period, and thus we believe that this omission is unlikely to have affected our conclusions. Finally, although we studied a large and representative sample from a national database, the number of black patients in our study was relatively small ($n = 195$). We investigated the stability of our time to graft failure and/or death models using the bootstrap method (with 5000 iterations), which did not change our findings. For example, the 95% CI for the fully adjusted time to death bootstrap model was 0.28 to 0.94 (*versus* 0.28 to 0.88 from our original model).⁴¹ Although our findings suggest that the risk for graft failure is similar in black and white Canadians, the low number of black patients treated in Canada during the study period means that we cannot exclude a clinically relevant increased risk for graft failure in this population.

Our data suggest that Canada, unlike the United States, has similar renal transplant outcomes for both black and white renal transplant patients. Our results are consistent with the hypothesis that these between-country differences may be due to differences in health care delivery and raises potentially important questions about whether better access to health services for black Americans would improve outcomes after kidney transplantation in this population.

CONCISE METHODS

Data Collection

CORR is a population-based, national registry that includes all reported cases of renal replacement therapy (RRT) as well as each patient's demographic and baseline clinical data, as collected by the treating center. Patients are followed with respect to treatment, transplantation data, and mortality. To comply with CORR privacy regulations, the data set used for this analysis was a random sample of 75% of all patients initiating dialysis in Canada for the stated calendar period.

Patient Population

We studied all patients who initiated RRT between January 1, 1990, and December 31, 2000, and were aged ≥ 18 yr at the date of RRT

initiation. Race subgroups as recorded in CORR included East Asian; black; white; Indian subcontinent; Aboriginal; and other, consisting of Mid-Eastern/Arabians, Pacific Islanders, and patients of unknown race. For our analysis, we compared black and white patient groups only and excluded all other groups. SES was estimated using the neighborhood income per person equivalent, which is an estimate of household income that is adjusted for the size of the household on the basis of data provided by the 1996 Canadian census.⁴⁰

Study Outcomes

The main outcome measure for all patients was adjusted rate of receiving a renal transplant. For all patients who received a primary renal transplant, we also considered additional outcome measures: (1) Adjusted rate of graft failure, (2) adjusted rate of death, and (3) adjusted rate of graft failure or death.

Statistical Analysis

Differences between groups were compared using χ^2 tests for categorical variables and Kruskal-Wallis tests for all continuous variables. To compare races for time-to-event outcomes, we used the Cox proportional hazards model. For analyses with time to kidney transplantation as the dependent variable, patients were followed from dialysis initiation until they either received a kidney transplant or were censored (at death; loss to follow-up; or end of study, December 31, 2004). Among patients receiving a transplant, we used posttransplantation mortality as the dependent variable; censoring events were loss to follow-up and end of study only. Analyses with graft survival as the dependent variable considered both death-censored graft loss and the composite of death or graft loss.

Analyses were adjusted for factors potentially associated with the response of interest: Age (<40.0 , 40.0 to 49.9 , 50.0 to 59.9 , ≥ 60.0 yr), gender, primary renal disease (diabetic nephropathy, glomerulonephritis, hypertensive/ischemic renal disease, polycystic kidney disease, and other renal diseases), calendar period of transplant (1990 to 1992, 1993 to 1994, 1995 to 1996, 1997 to 1998, 1999 to 2000), comorbidities present at the start of RRT (malignancy, diabetes, coronary disease, chronic heart failure, stroke or transient ischemic attack, chronic lung disease, peripheral vascular disease, hypertension, other serious illnesses), geographic region, current smoking status and SES. These comorbidity data are collected in CORR at the time of dialysis initiation and then updated annually thereafter. Follow-up comorbidity data are currently collected at the time of transplantation, but these data were added to the registry in 1999 and thus were not available for the entire period of our study. The early years were not collected by all centers. We therefore relied on the data that are collected at the time of dialysis initiation to describe comorbidity in transplant recipients.

Analyses evaluating posttransplantation outcomes adjusted for the previously listed covariates in addition to donor type (deceased *versus* living) and the duration of dialysis treatment before transplantation (<1.0 yr, 1 to 1.9 yr, ≥ 2.0 yr). Because the number of graft failures and/or deaths was small in the black transplant recipient population, we tested the robustness of our findings using the bootstrap method (with 5000 iterations). We report the 95% CI.⁴²

We quantified the effect of race by the covariate-adjusted HR, with

white patients chosen as the reference category. We dealt with missing comorbidity data (representing approximately 10% of all information on comorbidity) by assuming that the characteristic was absent (results did not differ when analyses were repeated after deletion of all patients with missing data). In addition, we assessed the potential for informative censoring (because those who die early are less likely to have received a kidney transplant) by assuming that those who died would not have received a transplant if they had survived until the end of the study (*i.e.*, patients who died were assigned a date of last follow-up of December 31, 2004). Cross-product interaction terms were used to determine whether race was modified by age, gender, diabetes, or SES.

The proportional hazard assumption was checked and satisfied by examination of plots of the log-negative-log of the within-group survivorship functions *versus* log time as well as comparing Kaplan-Meier (observed) with Cox (expected) survival curves. Statistical significance was defined as $P < 0.05$. All analyses were carried out using SAS 8.2 (SAS Institute, Cary, NC). The study was approved by the institutional review board at Queen's University (Kingston, ON, Canada).

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DISCLOSURES

None.

REFERENCES

1. US Renal Data System. *2002 Annual Data Report: Atlas of End-Stage renal Disease in the United States*, Bethesda, National Institutes of Health, National Institute of Diabetes and Digestive Diseases, 2001, 2002
2. Cecka J: The UNOS Scientific Renal Transplant Registry: 2000. *Clin Transpl* 1–18, 2000
3. Cecka J: The OPTN/UNOS renal transplant registry. *Clin Transpl* 1–16, 2004
4. U.S. Organ Procurement and Transplantation Network and the Scientific Registry of Transplant Recipients. *2003 Annual Report: Transplant Data 1993–2002*. Department of Health and Human Services. Health Resources and Service Administration, 2003
5. Cecka J: The UNOS Scientific Renal Transplant Registry. *Clinical Transpl* 1–21, 1999
6. *1998 Annual report of the U.S. Scientific Registry for Transplant Recipients and the Organ Procurement and Transplantation Network: Transplant Data—1988–1997*, Richmond, VA, United Network for Organ Sharing, 1999
7. Gaston R, Hudson S, Deierhoi M, Barber WH, Laskow DA, Julian BA, Curtis JJ, Barger BO, Shroyer TW, Diethelm AG: Improved survival of primary cadaveric renal allografts in blacks with quadruple immunosuppression. *Transplantation* 53: 103–109, 1992
8. Hardinger K, Stratta R, Egidi M, Alloway RR, Shokouh-Amiri MH, Gaber LW, Grewal HP, Honaker MR, Vera S, Gaber AO: Renal allograft outcomes in African American versus Caucasian transplant recipients in the tacrolimus era. *Surgery* 130: 738–747, 2001
9. Hariharan S, Johnson C, Bresnahan B, Taranto S, McIntosh M, Stablein D: Improved graft survival after renal transplantation in the United States, 1988 to 1996. *N Engl J Med* 342: 605–612, 2000
10. Terasaki P, Cecka J, Gjertson D, Takemoto S, Cho Y, Yuge J: Risk rate and long-term kidney transplant survival. *Clinical Transpl* 443–458, 1997
11. Press R, Carrasquillo O, Nickolas T, Radhakrishnan J, Shae S, Barr G: Race/ethnicity, poverty status, and renal transplant outcomes. *Transplantation* 80: 917–924, 2005
12. Pereira B: The key to improved dialysis outcomes. *Kidney Int* 57: 351–365, 2000
13. Pascual M, Theruvath T, Kawai T, Tolkoff-Rubin N, Cosimi A: Strategies to improve long-term outcomes after renal transplantation. *N Engl J Med* 346: 580–590, 2002
14. Neylan JF: Racial differences in renal transplantation after immunosuppression with tacrolimus versus cyclosporine. FK506 Kidney Transplant Study Group. *Transplantation* 65: 515–523, 1998
15. Neylan JF: Immunosuppressive therapy in high-risk transplant patients: Dose-dependant efficacy of mycophenolate mofetil in African-American renal allograft recipients. U.S. renal Transplant Mycophenolate Study Group. *Transplantation* 64: 1277–1282, 1997
16. Lindholm A, Welsh M, Alton C, Kahan B: Demographic factors influencing cyclosporine pharmacokinetic parameters in patients with uremia: Racial differences and bioavailability. *Clin Pharmacol Ther* 52: 359–371, 1992
17. Kasiske BL, Neylan JF 3rd, Riggio RR, Danovitch GM, Kahana L, Alexander SR, White MG: The effect of race on access and outcome in transplantation. *N Engl J Med* 324: 302–307, 1991
18. Isaacs R, Nock S, Spencer C, Connors AF Jr, Wang XQ, Sawyer R, Lobo PI: Racial disparities in renal transplant outcomes. *Am J Kidney Dis* 34: 706–712, 1999
19. Curtis J: Kidney transplantation: Racial or socioeconomic disparities? *Am J Kidney Dis* 34: 756–758, 1999
20. Butkus D, Meydrech E, Raju S: Racial differences in the survival of cadaveric renal allografts: Overriding effects of HLA matching and socioeconomic factors. *N Engl J Med* 327: 840–845, 1992
21. Light J, Barhyte D, Lahman L: Kidney transplants in African Americans and non-African Americans: Equivalent outcomes with living but not deceased donors. *Transplant Proc* 37: 699–700, 2005
22. Weng F, Israni A, Joffe MM, Hoy T, Gaughan CA, Newman M, Abrams JD, Kamoun M, Rosas SE, Mange KC, Strom BL, Brayman KL, Feldman HI: Race and electronically measured adherence to immunosuppressive medications after deceased donor renal transplantation. *J Am Soc Nephrol* 16: 1839–1848, 2005
23. Norris KC, Agodoa LY: Unraveling the racial disparities associated with kidney disease. *Kidney Int* 68: 914–924, 2005

24. Kim J, Schaubel D, Fenton S, Leichtman A, Port FK: Mortality after kidney transplantation: A comparison between the United States and Canada. *Am J Transplant* 6: 100–114, 2005
25. Young C, Gastob R: Renal transplantation in black Americans. *Am J Kidney Dis* 343: 1545–1552, 2000
26. US Renal Data System: *USRDS 2004 Annual Data Report: Atlas of End-Stage Renal Disease in the United States*, Bethesda, National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, 2004
27. Ayanian JZ, Cleary PD, Keogh JH, Noonan SJ, David-Kasdan J, Epstein AM: Physicians' beliefs about racial differences in referral for renal transplantation. *Am J Kidney Dis* 43: 350–357, 2004
28. Alexander GC, Sehgal AR: Barriers to cadaveric renal transplantation among blacks, women and the poor. *JAMA* 280: 1148–1152, 1998
29. Woodward R, Soares R, Schnitzler M, Brennan D: Income-related disparities in kidney transplant graft failures are eliminated by Medicare's immunosuppression coverage. *Am J Transplant* 6 (Suppl 2): 113, 2006
30. Geiger H: Race and health care: An American dilemma? *N Engl J Med* 335: 815–816, 1996
31. Alter DA, Naylor CD, Austin P, Tu JV: Effects of socioeconomic status on access to invasive cardiac procedures and on mortality after acute myocardial infarction. *N Engl J Med* 341: 1359–1367, 1999
32. Chakkeria H, O'Hare A, Johansen K, Hynes D, Stroupe K, Colin PM, Chertow GM: Influence of race on kidney transplant outcomes within and outside the Department of Veterans Affairs. *J Am Soc Nephrol* 16: 269–277, 2005
33. Foster C, Philosophe B, Schweitzer E, Colonna JO, Farney AC, Jarrell B, Anderson L, Bartlett ST: A decade of experience with renal transplantation in African-Americans. *Ann Surg* 236: 794–804, 2002
34. Tonelli M, Hemmelgarn B, Manns B, Pylypchuk G, Bohm C, Yeates K, Gourishankar S, Gill JS: Death and renal transplantation among Aboriginal people undergoing dialysis. *CMAJ*. 171: 577–582, 2004
35. Yeates KE, Schaubel DE, Cass A, Sequist TD, Ayanian JZ: Access to renal transplantation for minority patients with ESRD in Canada. *Am J Kidney Dis* 44: 1083–1089, 2004
36. Pallet N, Thervet E, Alberti C, Emal-Agláé V, Bedrossian J, Martinez F, Roy C, Legendre C: Kidney transplant in black recipients: Are African Europeans different from African Americans? *Am J Transplant* 5: 2682–2687, 2005
37. Dutra M, Lopes A, Miranda E, Vinhaes AJ, Monte N, Siqueira Filho J, Moura LK, Leite EB, Barcia MT, Lemaire D, Silva IC: The influence of race on kidney graft survival. *Transplant Proc* 31: 3021–3022, 1999
38. Cass A, Cunningham J, Snelling P, Wang Z, Hoy W: Renal transplant in Aboriginal Australians: Access, timing and outcomes [Abstract]. *J Am Soc Nephrol* 12: 881A, 2001
39. Narva A, Stiles S, Karp S, Turak A: Access of native Americans to renal transplantation in Arizona and New Mexico. *Blood Purif* 14: 293–304, 1996
40. Ayanian JZ, Cleary PD, Weissman JS, Epstein AM: The effect of patients' preferences on racial differences in access to renal transplantation. *N Engl J Med* 341: 1661–1669, 1999
41. Altman DG, Anderson RC: Bootstrap Investigation of the stability of a Cox regression model. *Stat Med* 8: 771–783, 1989
42. Ng E, Wilkins R, Perras A: How far is it to the nearest hospital? Calculating distances using the Statistics Canada Postal Code Conversion File. *Health Rep* 5: 179–188, 1993