Published in final edited form as:

Am J Transplant. 2009 March ; 9(3): 543–549. doi:10.1111/j.1600-6143.2008.02530.x.

Racial Disparity Trends for Graft Failure in the US Pediatric Kidney Transplant Population, 1980–2004

BM Chavers, MD^{1,2}, JJ Snyder, MS², MA Skeans, MS², ED Weinhandl, MS², and BL Kasiske, MD^{1,2,3}

¹University of Minnesota, Minneapolis, Minnesota

²United States Renal Data System, Minneapolis, Minnesota

³Hennepin County Medical Center, Minneapolis, Minnesota

Abstract

Graft survival among adult African American kidney transplant patients remains low compared to whites, but little information is available for children and adolescents. We examined trends in graft failure among US incident primary kidney transplant patients aged < 19 years ($n = 13,692$), 1980–2004. Trends in 1-year and 2–5 year graft failure (for patients whose grafts survived the first year) were analyzed in 5-year intervals. One-year graft failure declined 70% for white and 77% for African American patients over the 25-year period, and 1-year graft failure rates improved at a slightly higher rate for African American compared to white patients ($p = 0.02$). In contrast, the graft failure rates for years 2–5 declined 53% for white and only 41% for African American patients over the 25-years ($p = 0.29$). In fully adjusted Cox proportional hazards analysis, the rate of graft failure among African Americans was approximately 2-fold higher than for white patients over the entire study period. Graft survival has improved slightly more for African American than white pediatric patients over the past 25 years. However, graft survival for African American pediatric patients remains poor compared with white patients.

Introduction

Multiple studies of adult kidney transplant patients have addressed racial and ethnic disparities in access to transplant and outcomes, including graft survival, for African American patients in the United States.^{1–7} Graft survival among adult African American kidney transplant patients was consistently lower compared with whites from 1980 to 2003.⁸ African American children (aged < 20 years) in the United States have twice the incident rate of reported end-stage renal disease (ESRD) (24 per million population) of white children (13 per million population), are 12% less likely than white children to be waitlisted for a kidney transplant, and have prolonged waiting time to first kidney transplant after initiation of dialysis compared with white children.^{9,10} After transplant, African American children have poorer overall graft survival than white children.^{11–13} Detailed data are not available on the trends in graft failure rates by race for a national population of children with ESRD. We therefore evaluated US pediatric first kidney transplant patients between 1980 and 2004 to identify trends in racial disparities in graft failure rates.

Materials and Methods

Data Sources

From the United States Renal Data System (USRDS), we identified white and African American children (aged < 19 years) who underwent a first kidney transplant during 1980 to 2004 ($n = 13,692$). Demographic data, including age at transplant, sex, race, donor type, pretransplant dialysis duration, primary cause of ESRD (glomerulonephritis, cystic/congenital/hereditary, diabetes, hypertension, other), comorbidity (hypertension, diabetes, congestive heart failure, obesity [body mass index ≥ 85 percentile]), panel reactive antibodies (most recent), number of HLA mismatches, cold ischemia time, baseline immunosuppressive regimen, use of induction antibodies, and delayed graft function were obtained from the ESRD Medical Evidence Report (Centers for Medicare & Medicaid Services form 2728) or the Organ Procurement and Transplantation Network (OPTN) Transplant Recipient Registration form. Donor age, sex, and race were obtained from the OPTN Cadaveric Donor Registration and Living Donor Registration forms. Median incomes of patient zip codes were obtained from the United States Census Bureau.

Data Analysis

We analyzed trends in graft failure rates 1 year posttransplant for all patients, and 2–5 years posttransplant for patients whose grafts survived the first year. All patient follow-up was censored at 5 years posttransplant. Trends were analyzed in 5-year intervals to improve the stability of rate estimates. A Poisson regression model was used to estimate graft failure rates by era and race (white and African American) from 1980 to 2004, with adjustment for age (ages ≤ 4 , 5–9, 10–14, 15–19 years), sex, donor type, primary cause of ESRD, and patient median zip code income. Rates were then standardized to the characteristics of the 2000–2004 pediatric transplant population to facilitate comparisons across time. The analyses were repeated for patients undergoing transplants in 1990–2004, with further adjustment for variables available after OPTN was started, including number of HLA mismatches, cold ischemia time, immunosuppressive regimen, use of induction antibodies, and donor age, sex, and race. Models assessing trends in graft failure rates during years 2–5 posttransplant were also adjusted for the presence of at least one reported acute rejection episode during year 1. All covariates were analyzed as categorical variables with bivariate statistical significance determined by the chi-squared test. A p -value < 0.05 was considered statistically significant. Covariates with statistically significant associations with graft failure were retained in final models. Analyses were performed using SAS version 9.1 (Cary, NC).

Results

Patient Characteristics

In 1980 to 2004 combined, 13,692 first kidney transplants were performed for US white and African American pediatric patients (Table 1). Mean age at transplant was 12 ± 5 years and mean follow-up period 45 ± 21 months. Overall, 41% of the population were female, 19% were African American, 46% received deceased-donor grafts, 23% received preemptive transplants, and 30% had glomerulonephritis as primary cause of ESRD. White and African American patients differed regarding age, sex, donor type, donor age, donor race, ESRD duration, primary cause of ESRD, congestive heart failure comorbidity pretransplant, percent panel reactive antibodies, incidence of delayed graft function, use of induction antibodies, and median zip code income. The proportion of African American patients increased over the study period, from 15% of the 1980–1984 cohort to 21% of the 2000–2004 cohort ($p < 0.0001$). Proportions of adolescents (ages 15–18 years) were 38% for white and 46% for African American patients. African American patients were more likely to

receive deceased-donor kidneys (61% versus 43% for white patients, $p < 0.0001$), and less likely to receive preemptive transplants (15% versus 25% for white patients, $p < 0.0001$). After the first year posttransplant, African American patients were more likely to experience graft failure due to chronic rejection (Table 2).

Trends in Graft Failure Rates

One-year graft failure rates adjusted for age, sex, donor type, cause of ESRD, and median zip code income declined considerably for both white and African American pediatric patients over the 25-year period, a decline of 70% for whites and 77% for African Americans (Figure 1). One-year graft failure rates in the 1980–1984 cohort were 20 per 100 patient-years for white and 33 per 100 patient-years for African American patients; rates were 6 per 100 patient-years for white and 8 per 100 patient-years for African American patients in the 2000–2004 cohort. The adjusted hazard ratios show that the rate of graft failure in the first year posttransplant was 27%–64% higher for African American patients in all eras except 1990–1994 (Table 3).

Trends in the conditional 2–5 year graft failure rates also declined over the 25-year period, a 53% decline for white and a 41% decline for African American patients (Figure 2). The conditional 2–5 year graft failure rate for the 1980–1984 cohort was 7 per 100 patient-years for white and 13 per 100 patient-years for African American patients; rates were 3 per 100 patient-years for white and 8 per 100 patient-years for African American patients in the 2000–2004 cohort. The adjusted hazard ratios show that the rate of graft failure at 2–5 years among African American patients was approximately twice that of white patients over the entire study period (Table 3).

One-year graft failure rates for 1990–2004 cohorts were also adjusted for HLA mismatches, cold ischemia time, baseline immunosuppressive regimen, use of induction antibodies, delayed graft function, and donor age and sex. Adjusted rates, significantly different only for the 1995–1999 cohort, were 7 per 100 patient-years for white and 10 per 100 patient-years for African American patients. The adjusted hazard ratios show that graft failure rates in the first year posttransplant were 33%–47% higher for African American patients in 1995–1999 and 2000–2004 (Table 4).

Trends in conditional 2–5 year graft failure rates also declined over the 14-year period, by 11% for white and 17% for African American patients. Rates were 4 per 100 patient-years for white and 8 per 100 patient-years for African American patients in the 1990–1994 cohort, and 3 per 100 patient-years for white and 7 per 100 patient-years for African American patients in the 2000–2004 cohort. The adjusted hazard ratios show that graft failure rates at 2–5 years for African American patients were approximately twice those of white patients over the 14-year period.

One-year graft failure rates remained significantly different for the 1995–1999 cohort after additional adjustment for donor race (Table 5) and censoring for death (Table 6). After adjustment for donor race, rates were 7 per 100 patient-years for white and 9 per 100 patient-years for African American patients; after censoring for death, rates were 6 per 100 patient-years for white and 8 per 100 patient-years for African American patients. The adjusted hazard ratios show that graft failure rates in the first year posttransplant for the 1995–1999 cohort, adjusted for donor race, were 41% higher for African American than white patients, and, after censoring for death, 59% higher for African American patients.

After adjustment for donor race and acute rejection during the first year posttransplant, conditional 2–5 year graft failure rates also declined from 1990–2004, by 8% for white and 12% for African American patients (Table 5). After censoring for death, rates declined by

12% for white and 16% for African American patients (Table 6). The adjusted hazard ratios show that graft failure rates at 2–5 years posttransplant for African American patients were approximately twice those of white patients over the 14-year period after adjustment for donor race and acute rejection during year 1, and censoring for death.

Discussion

A recent study from the Australia and New Zealand Dialysis and Transplant Registry reported improved long-term patient survival rates for 1634 children (ages < 20 years) who underwent kidney transplants between 1963 and 2002.¹⁴ However, the data were not analyzed for the effect of race or ethnicity on transplant outcomes. Ours is the largest pediatric study of trends in graft failure rates by race, and of risk factors associated with short- and long-term graft outcomes. Our data show that African American race is an independent risk factor for graft failure in pediatric kidney transplant patients. We show a significant decline in overall graft failure rates for both African American and white pediatric kidney transplant patients over the 25-year study period. African American race appears to be less of a risk factor for early compared to late graft failure. One-year graft failure rates improved faster for African American than for white patients.

What explains this finding? We speculate that the overall improvement in graft failure rates can be attributed in part to improved pretransplant medical management, improved surgical techniques, and better immunosuppressive protocols. More potent immunosuppressive medications were introduced during the study period; however, our analyses of the 1990–2004 cohort show racial differences in graft failure rates even after adjustment for immunosuppression and other immunological factors. The relative risk for graft failure at 1 year was higher for African American patients in all study eras except 1990–1994. In the most recent era, 2000–2004, relative risk was 26% higher for African American patients. This study could not address issues such as closer follow-up of African American patients by transplant centers or improved medication compliance in the early posttransplant period, or better availability of antirejection medication in the immediate postoperative period. Such changes might account for faster improvement in 1-year graft failure rates for African American patients. Perhaps this finding may be best evaluated further in a large, randomized, controlled, pediatric trial.

Beyond the first year, the relative risk of graft failure remains higher for African American patients across all eras, and is twice as high at 2–5 years posttransplant for the 2000–2004 cohort. Factors associated with poor long-term graft survival rates have been studied in adult African American kidney transplant patients. In a large study from the United Network for Organ Sharing Scientific Registry, Isaacs et al³ found that African American patients were 1.7 times more likely than white patients to experience kidney graft failure after controlling for matching and rejection, suggesting that non-HLA or socioeconomic mechanisms contributed to racial differences. In a study using USRDS data, Goldfarb-Rumyantsev et al¹⁵ reported poorer graft survival among patients with low education levels or without private insurance, who were more often African American. More non-compliance leading to graft loss has been reported for African American transplant patients; however, in one study non-compliance was associated with higher incidence of lower socioeconomic status,¹⁶ and in another study was found not to account for racial differences in graft survival.¹⁷ Cosio et al reported that poorly controlled posttransplant systemic hypertension was associated with poor graft survival in African American but not white patients.¹⁸ Previous studies have also reported racial differences in graft failure due to differences in drug absorption, and immunologic factors such as matching, hyperimmune responsiveness, and major histocompatibility complex polymorphism; these studies are excellently reviewed by Young and Kew.⁴

Similar to these studies of adults, in our pediatric study cohort, African American patients had longer ESRD duration and lower socioeconomic status; a higher percentage had > 10% panel reactive antibodies. Our data show that pediatric African American patients have 47% lower odds of preemptive kidney transplant than white patients, and 53% lower odds of receiving a living-donor kidney. However, we found that racial disparities persist even after adjustment of the data for age, sex, donor type, donor age, donor sex, donor race, income, primary cause of ESRD, number of HLA mismatches, cold ischemia time, baseline immunosuppressive regimen, use of induction antibodies, delayed allograft function, and acute rejection during the first year posttransplant. What additional factors can be studied to explain racial differences in pediatric graft failure rates? We did not find a difference in incidence of hypertension and obesity between African American and white patients pretransplant, but we did find a difference in incidence of chronic rejection as a cause of late graft failure. We were unable to evaluate the effect of transition to adult health care providers, inability to cover medication co-pays, loss of Medicare coverage for immunosuppressive medications, or access to health care beyond the first 36 months posttransplant on racial differences in long-term graft failure rates. Possibly, unidentified immunological factors may also play a role.

Our analysis has several strengths. Our study population is large and represents a broad national US population of African American and white pediatric kidney transplant patients; our 25-year study period is long; we include socioeconomic data; we analyzed trends in 5-year intervals to improve the stability of rate estimates in each time period; and we standardized rates to the 2000–2004 cohort to facilitate comparisons across time. Our study thus allows for accurate detection of trends in both short- and long-term graft failure rates among African American and white pediatric kidney transplant patients. A study limitation is our inability to analyze for causes of graft loss before 1990 or posttransplant hypertension, which might affect graft failure rates in children.

Our study provides new data showing that over a 25-year period in the US from 1980 to 2004, African American pediatric kidney transplant patients have had persistently higher 1- and 2–5 year graft failure rates compared with white pediatric kidney transplant patients. While pediatric graft failure rates have shown improvement over the 25-year period in both racial groups, graft failure rates remain higher for African American patients compared with white patients across eras despite medical progress. We find no evidence that the impact of race on pediatric kidney transplant outcomes has decreased in the more modern immunosuppression era. African American pediatric kidney transplant patients have a disproportionately high rate of graft failure. Reasons for racial disparities in pediatric kidney transplant graft failure rates remain unclear and warrant further study.

Acknowledgments

This study was performed as a deliverable under Contract No. HHSN267200715002C (National Institute of Diabetes and Digestive and Kidney Diseases, National Institutes of Health, Bethesda, Maryland). The authors have no conflicts of interest with its subject matter. We thank United States Renal Data System colleagues Beth Forrest for regulatory assistance, Shane Nygaard, BA, for manuscript preparation and submission assistance, and Nan Booth, MSW, MPH, for editorial assistance.

Reference List

1. Epstein AM, Ayanian JZ, Keogh JH, et al. Racial disparities in access to renal transplantation--clinically appropriate or due to underuse or overuse? *N Engl J Med*. 2000; 343:1537–1544. 2. [PubMed: 11087884]

2. Ayanian JZ, Cleary PD, Keogh JH, Noonan SJ, vid-Kasdan JA, Epstein AM. Physicians' beliefs about racial differences in referral for renal transplantation. *Am J Kidney Dis.* 2004; 43:350–357. [PubMed: 14750101]
3. Isaacs RB, Nock SL, Spencer CE, et al. Racial disparities in renal transplant outcomes. *Am J Kidney Dis.* 1999; 34:706–712. [PubMed: 10516353]
4. Young CJ, Kew C. Health disparities in transplantation: focus on the complexity and challenge of renal transplantation in African Americans. *Med Clin North Am.* 2005; 89:1003–1031. ix. [PubMed: 16129109]
5. Navaneethan SD, Singh S. A systematic review of barriers in access to renal transplantation among African Americans in the United States. *Clin Transplant.* 2006; 20:769–775. [PubMed: 17100728]
6. Higgins RS, Fishman JA. Disparities in solid organ transplantation for ethnic minorities: facts and solutions. *Am J Transplant.* 2006; 6:2556–2562. [PubMed: 16952299]
7. Eckhoff DE, Young CJ, Gaston RS, et al. Racial disparities in renal allograft survival: a public health issue? *J Am Coll Surg.* 2007; 204:894–902. [PubMed: 17481506]
8. U.S. Renal Data System. *USRDS 2007 Annual Data Report: Atlas of Chronic Kidney Disease & End-Stage Renal Disease in the United States.* Bethesda, MD: National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases; 2007.
9. U.S. Renal Data System. *USRDS 2006 Annual Data Report.* National Institutes of Health. Bethesda, MD: National Institute of Diabetes and Digestive and Kidney Diseases; 2006.
10. Furth SL, Garg PP, Neu AM, Hwang W, Fivush BA, Powe NR. Racial differences in access to the kidney transplant waiting list for children and adolescents with end-stage renal disease. *Pediatrics.* 2000; 106:756–761. [PubMed: 11015519]
11. Ishitani M, Isaacs R, Norwood V, Nock S, Lobo P. Predictors of graft survival in pediatric living-related kidney transplant recipients. *Transplantation.* 2000; 70:288–292. [PubMed: 10933150]
12. Hwang AH, Cho YW, Cicciarelli J, Mentser M, Iwaki Y, Hardy BE. Risk factors for short- and long-term survival of primary cadaveric renal allografts in pediatric recipients: a UNOS analysis. *Transplantation.* 2005; 80:466–470. [PubMed: 16123719]
13. Omolaja A, Mitsnefes M, Talley L, Benfield M, Neu A. Racial differences in graft survival: a report from the North American Pediatric Renal Trials and Collaborative Studies (NAPRTCS). *Clin J Am Soc Nephrol.* 2007; 2:524–528. [PubMed: 17699460]
14. McDonald SP, Craig JC. Long-term survival of children with end-stage renal disease. *N Engl J Med.* 2004; 350:2654–2662. [PubMed: 15215481]
15. Goldfarb-Rumyantzev AS, Koford JK, Baird BC, et al. Role of socioeconomic status in kidney transplant outcome. *Clin J Am Soc Nephrol.* 2006; 1:313–322. [PubMed: 17699222]
16. Schweitzer R, Rovelli M, Palmeri D, Vossler E, Hull D, Bartus S. Noncompliance in organ transplant recipients. *Transplantation.* 1990; 49(2):374–377. [PubMed: 2305467]
17. Isaacs RB, Connors A Jr, Nock S, Spencer C, Lobo P. Noncompliance in living-related donor renal transplantation: the United Network of Organ Sharing experience. *Transplant Proc.* 1999; 31:19S–20S. [PubMed: 10372037]
18. Cosio FG, Dillon JJ, Falkenhain ME, et al. Racial differences in renal allograft survival: the role of systemic hypertension. *Kidney Int.* 1995; 47:1136–1141. [PubMed: 7783411]

Figure 1.

First-year graft failure rates, 1980–2004, by race; adjusted for age, sex, donor type, primary cause of renal disease, and patient median zip code income. The declines in rates of graft failure were statistically significant for both groups (both $p < 0.001$). The decline in the rate of graft failure was significantly greater for African American than for white patients ($p = 0.0234$).

Figure 2.

Graft failure rates during years 2–5 posttransplant, 1980–2004, by race; adjusted for age, sex, donor type, primary cause of renal disease, and patient median zip code income. The declines in rates of graft failure were statistically significant for both groups (both $p < 0.001$). The decline in the rate of graft failure was not significantly different for African American than for white patients ($p = 0.2907$).

Table 1

Population Characteristics

Characteristic	African		<i>p</i>
	White, % <i>n</i> = 11,035	American, % <i>n</i> = 2657	
Transplantation year			< 0.0001
1980–1984	16.1	11.4	
1985–1989	20.9	19.3	
1990–1994	20.6	22.0	
1995–1999	22.9	25.9	
2000–2004	19.4	21.3	
Patient age (years)			< 0.0001
< 1	1.3	0.3	
1–4	14.7	10.3	
5–9	16.7	15.6	
10–14	28.9	27.4	
15–18	38.4	46.4	
Sex			0.0044
Female	41.8	38.8	
Male	58.2	61.2	
Donor type			< 0.0001
Deceased	42.7	61.2	
Living	57.3	38.8	
ESRD duration (years)			
0 (preemptive transplantation)	24.7	14.8	< 0.0001
< 1	42.9	38.5	
1–< 2	18.7	25.3	
2–< 3	7.3	12.1	
≥ 3	6.5	9.3	
Primary cause of ESRD			< 0.0001
Glomerulonephritis	28.0	39.3	
Cystic kidney disease	6.5	2.6	
Hypertension	2.9	6.4	
Diabetes	0.7	0.6	
Other	61.9	51.1	
Comorbid conditions reported at ESRD certification*			
Diabetes	1.0	1.3	0.4470
Hypertension	26.8	28.9	0.1345
Congestive heart failure	1.0	2.2	0.0015
Body mass index [†]			0.1533
< 85th percentile	77.0	75.4	
≥ 85th percentile	23.0	24.6	

Characteristic	African		p
	White, % n = 11,035	American, % n = 2657	
Panel reactive antibodies (most recent) [‡]			< 0.0001
≤ 10%	72.3	69.5	
> 10%	9.1	13.4	
Unknown	18.6	17.1	
Baseline calcineurin inhibitor use (cyclosporine or tacrolimus) [‡]	87.9	88.5	0.5110
Baseline adjunctive therapy use (azathioprine or MMF) [‡]	79.1	78.2	0.3820
Baseline rapamycin use [‡]	4.2	4.3	0.7840
Baseline steroid use [‡]	90.8	91.2	0.5790
Induction antibodies [‡]			< 0.0001
None	64.4	61.0	
IL-2	19.0	17.5	
Other	16.6	21.4	
Delayed graft function [‡]			< 0.0001
No	94.6	88.9	
Yes	5.3	11.0	
Unknown	0.1	0.1	
Median zip code income, \$			< 0.0001
Lowest tertile, ≤ 34,167	27.2	48.0	
Mid-upper tertiles, > 34,167	67.5	45.4	
Unknown	5.2	6.6	
Donor age (years) [‡]			< 0.0001
< 18	14.1	21.5	
18–34	36.5	39.1	
35–49	43.0	31.7	
≥ 50	5.9	7.3	
Unknown	0.4	0.4	
Donor sex [‡]			0.1480
Female	48.5	46.7	
Male	51.4	53.2	
Unknown	0.1	0.1	
Donor race [‡]			< 0.0001
White	87.4	51.2	
African American	4.1	44.0	
Other/unknown	8.5	4.8	

ESRD, end-stage renal disease; MMF, mycophenolate mofetil.

* From the Medical Evidence Report (Centers for Medicare & Medicaid form 2728). Denominator excludes transplants before 1995.

[‡] Computed for patients aged ≥ 24 months. Denominator excludes transplants before 1990.

[‡]Denominator excludes transplants before 1988 when data collection began.

Table 2

Causes of Graft Failure, Years 2–5 Posttransplant*

Cause of Graft Failure	African		p
	White, % n 1532 failures	American, % 721 failures	
Acute rejection	14.9	19.1	< 0.0001
Chronic rejection	25.0	34.8	
Primary non-function	2.7	3.3	
Graft thrombosis	11.0	5.3	
Recurrent disease	6.5	2.6	
Non-compliance	5.2	6.4	
Other	6.5	6.2	
Unknown	28.1	22.2	

* As reported to the Organ Procurement and Transplantation Network. Excludes transplants before 1990.

Table 3

Graft Failure Rates and Adjusted Hazard Ratios, 1980–2004

Transplant Year	1 Year Posttransplant				2–5 Years Posttransplant			
	Graft Failure Rates*		Adjusted Hazard Ratio [†] (95% CI)		Graft Failure Rates*		Adjusted Hazard Ratio [†] (95% CI)	
	White	African American	White	African American	White	African American	White	African American
1980–1984	20.0	32.9	1.64 (1.30–2.07)	< 0.0001	7.3	12.8	1.64 (1.31–2.06)	< 0.0001
1985–1989	19.8	28.5	1.44 (1.19–1.75)	0.0002	6.5	13.7	2.11 (1.77–2.52)	< 0.0001
1990–1994	16.5	16.4	1.00 (0.79–1.25)	0.9682	4.7	10.3	2.19 (1.83–2.62)	< 0.0001
1995–1999	8.0	11.8	1.49 (1.15–1.94)	0.0023	4.5	8.8	1.96 (1.65–2.33)	< 0.0001
2000–2004	6.0	7.5	1.27 (0.90–1.78)	0.1669	3.4	7.5	2.18 (1.71–2.78)	< 0.0001

CI, confidence interval. Adjusted for age, sex, donor type, primary cause of kidney disease, and median zip code income.

* Per 100 patient-years.

[†] African American versus white.

Graft Failure Rates and Adjusted Hazard Ratios, 1990–2004

Table 4

Transplant Year	1 Year Posttransplant				2–5 Years Posttransplant			
	Graft Failure Rates*		Adjusted Hazard Ratio [†] (95% CI)		Graft Failure Rates*		Adjusted Hazard Ratio [†] (95% CI)	
	White	African American	White	African American	White	African American	White	African American
1990–1994	15.5	15.0	1.00 (0.80–1.26)	0.9681	3.8	8.4	2.01 (1.68–2.42)	<0.0001
1995–1999	7.1	10.1	1.47 (1.13–1.90)	0.0038	4.1	7.5	1.80 (1.51–2.15)	<0.0001
2000–2004	5.9	7.3	1.33 (0.94–1.86)	0.1058	3.4	7.0	2.05 (1.61–2.61)	<0.0001

CI, confidence interval. First-year rates adjusted for age, sex, donor type, primary cause of kidney disease, degree of HLA mismatches, cold ischemia time, immunosuppressive regimen, and donor sex. Rates for years 2–5 adjusted for age, sex, donor type, primary cause of kidney disease, median zip code income, degree of HLA mismatches, acute rejection in first year, and use of induction antibodies.

* Per 100 patient-years.

[†] African American versus white.

Table 5

Graft Failure Rates and Adjusted Hazard Ratios, 1990–2004, Adjusted for Donor Race

Transplant Year	1 Year Posttransplant			2–5 Years Posttransplant		
	Graft Failure Rates*			Graft Failure Rates*		
	White	African American	Adjusted Hazard Ratio [†] (95% CI)	White	African American	Adjusted Hazard Ratio [†] (95% CI)
1990–1994	15.0	15.3	0.97 (0.76–1.23)	3.7	7.8	1.98 (1.65–2.39)
1995–1999	7.0	9.2	1.41 (1.08–1.84)	3.8	6.9	1.80 (1.50–2.14)
2000–2004	5.9	8.1	1.26 (0.89–1.78)	3.4	6.9	2.03 (1.59–2.58)

CI, confidence interval. First year rates adjusted for age, sex, donor type, primary cause of kidney disease, degree of HLA mismatches, cold ischemia time, immunosuppressive regimen, donor sex, and donor race. Rates for years 2–5 adjusted for age, sex, donor type, primary cause of kidney disease, median zip code income, degree of HLA mismatches, acute rejection in first year, delayed graft function, use of induction antibodies, and donor sex.

* Per 100 patient-years.

[†] African American versus white.

Table 6

Death-Censored Graft Failure Rates and Adjusted Hazard Ratios, 1990–2004

Transplant Year	1 Year Posttransplant				2–5 Years Posttransplant			
	Death-Censored Graft Failure Rates [*]		Adjusted Hazard Ratio [†] (95% CI)		Death-Censored Graft Failure Rates [*]		Adjusted Hazard Ratio [†] (95% CI)	
	White	African American	White	African American	White	African American	White	African American
1990–1994	11.5	11.2	1.01 (0.78–1.31)	0.9286	3.4	7.6	2.00 (1.65–2.43)	<0.0001
1995–1999	5.5	8.4	1.59 (1.20–2.10)	0.0013	3.6	6.8	1.84 (1.53–2.21)	<0.0001
2000–2004	4.9	6.1	1.32 (0.92–1.91)	0.1366	3.0	6.4	2.17 (1.68–2.80)	<0.0001

CI, confidence interval. First year rates adjusted for age, sex, donor type, primary cause of kidney disease, degree of HLA mismatches, cold ischemia time, immunosuppressive regimen, and donor sex. Rates for years 2–5 adjusted for age, sex, donor type, primary cause of kidney disease, median zip code income, degree of HLA mismatches, acute rejection in first year, and use of induction antibodies.

^{*} Per 100 patient-years.

[†] African American versus white.