

Chapter X

Access and Outcomes among Minority Transplant Patients, 1999-2008, With a Focus on Determinants of Kidney Graft Survival

Overview

- Coincident with an increasing national interest in equitable health care, a number of studies have described disparities in access to solid organ transplantation for minority patients. In contrast, relatively little is known about differences in posttransplant outcomes between patients of specific racial and ethnic populations.
- In this chapter, a review is provided of trends in access to solid organ transplantation and posttransplant outcomes by organ type, race, and ethnicity. In addition, an analysis is presented of categories of factors that contribute to the racial/ethnic variation seen in kidney transplant outcomes.
- Disparities in minority access to transplantation among wait-listed candidates are improving, but persist for those awaiting kidney, simultaneous kidney and pancreas, and intestine transplantation. In general, graft and patient survival among recipients of solid organ transplants is highest for Asians and Hispanic/Latinos, intermediate for Whites, and lowest for African-Americans.
- Although much of the difference in outcomes between racial/ethnic groups can be accounted for by adjusting for patient characteristics, important observed differences remain. Age and duration of pre-transplant dialysis exposure emerge as the most important determinants of survival in an investigation of the relative impact of center-related versus patient-related variables on kidney graft outcomes.

Introduction

The existence of disparities in access to solid organ transplantation among minority patients with end-stage organ failure has been recognized for many years (1-3). However, relatively little is known about differences in posttransplant outcomes between patients of specific racial and ethnic populations (4-6). Nevertheless, it is widely believed that graft and patient survivals for minority transplant recipients are inferior to those observed for Whites. This chapter will review trends in access to solid organ transplantation and posttransplant outcomes by race and ethnicity for candidates and recipients of kidney, liver, heart, lung, simultaneous kidney and pancreas, pancreas-alone, and intestine transplants. Specific differences by race and ethnicity in access, transplant trends, and outcomes are demonstrated. In addition, an analysis is presented of the relative contribution of center-related and patient-related factors on the racial/ethnic variation seen in kidney graft outcomes.

Methods

These analyses are based on the Organ Procurement and Transplantation Network/Scientific Registry of Transplant Recipients (OPTN/SRTR) database, which includes information on all wait-listed transplant candidates, transplant recipients, and donors in the United States (7). The OPTN/SRTR data source was supplemented with end-stage renal disease (ESRD) statistics from the Centers for Medicare and Medicaid Services (CMS) and with vital status information from the Social Security Death Master File (SSDMF). (For survival adjustments and diagnosis categories see Tables TN-4 and TN-5 in the Technical Notes of the OPTN/SRTR Annual Report (8)). The models for time at risk for graft and patient survival began on the date of transplant. Graft failure for kidney transplants was defined as the earliest date among death, retransplant of the same organ type, or initiation of maintenance dialysis. Adjusted survival probabilities for each organ type by race/ethnicity were computed using separate Cox regression models, with adjustments for age, sex, and primary diagnosis. Analyses were performed in SAS 9.2 (SAS Institute; Cary, NC). Following the OPTN data collection format, Hispanic and non-Hispanic blacks were counted as African-American. Hispanic and non-Hispanic Asians were counted as Asians. Non-Hispanic Whites (Whites) and Hispanic Whites (Hispanic/Latinos) were tabulated and evaluated separately. Results for Native Americans and patients of other racial/ethnic groups are not reported because of small numbers.

Results

Kidney Transplant Trends and Outcomes

Access to Kidney Transplantation. The number and distribution by race/ethnicity for 3 representative years is shown for active waiting list patients and transplants for seven organ types (kidney, liver, heart, lung, kidney-pancreas, pancreas, intestine) in Table X-1. Deceased donor (DD) kidney transplant percentages for African-Americans, Hispanic/Latinos, and Asians lag behind their respective proportions of the waiting list.

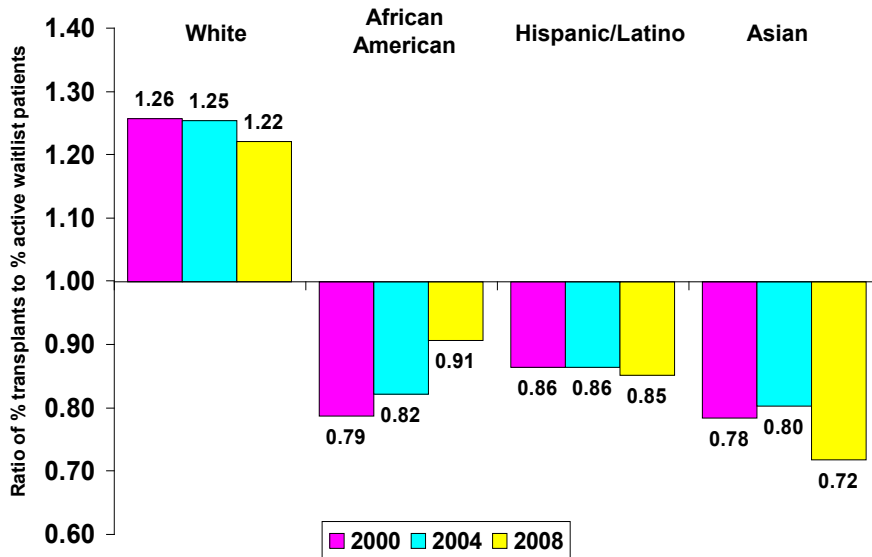
With an ideal kidney allocation system, there would be no barriers to transplantation except for the availability of donor organs. A consequence of such a system would be that, over time, the proportion of racial/ethnic groups receiving transplants would approximate the proportions of the same groups on the waiting list. In such a system, the ratio of the proportion transplanted to the proportion wait-listed would approach 1. Significant deviations from a value of 1 would suggest the presence of barriers or advantages in access to transplantation for a particular group. To evaluate racial/ethnic access to kidney transplantation, the proportion of DD transplant recipients from each of the reported racial/ethnic groups (White, African-American, Hispanic/Latino, and Asian) during 3 representative years (2000, 2004, and 2008) was divided by the proportion of patients on the waiting list from the same group on December 31 of the preceding year. The results are expressed as ratios and are shown for kidney transplantation in Figure X-1. Similar results are presented for the other organ-types later in this chapter. A value over 1.0 indicates that more patients of a racial/ethnic group received DD organs than would be expected from that group's proportion of the waiting list. Conversely, a value below 1.0 signifies that the group has received DD transplants at a rate below its prevalence on the waiting list. Among kidney transplant recipients, Whites were transplanted at a rate greater than their representation on the waiting list. In contrast, African-Americans, Hispanic/Latinos, and Asians were transplanted at rates lower than expected from their waiting list prevalence. The difference between the ethnic/racial composition of the waiting list and the distribution of kidney transplant recipients appears to be narrowing over time for Whites and African-Americans; it is stable among Hispanics/Latinos but may be increasing for Asians.

Table X-1. Active Waiting List and Deceased Donor Transplants by Organ Type and Race/Ethnicity, 2000-2008

Organ Race/Ethnicity	2000		2004		2008	
	WL ¹	TX ²	WL ¹	TX ²	WL ¹	TX ²
Kidney (N)	36,951	8,124	45,475	9,357	48,677	10,551
White (%)	42.7	53.7	38.9	48.8	37.9	46.3
African-American (%)	36.5	28.7	35.9	29.5	34.1	30.9
Hispanic/Latino (%)	13.2	11.4	16.2	14.0	18.1	15.4
Asian (%)	6.5	5.1	7.6	6.1	8.5	6.1
Liver (N)	12,049	4,595	12,627	5,848	12,198	6,069
White (%)	75.3	74.0	72.3	71.8	71.4	69.7
African-American (%)	7.1	9.0	7.1	10.0	6.8	10.3
Hispanic/Latino (%)	12.6	12.9	15.2	12.5	16.5	13.9
Asian (%)	4.4	3.3	4.8	4.9	4.5	5.0
Heart (N)	2,477	2,199	1,808	2,015	1,406	2,163
White (%)	79.3	77.2	74.9	70.4	73.5	65.5
African-American (%)	13.4	13.3	14.9	16.8	16.6	20.2
Hispanic/Latino (%)	6.0	6.7	7.7	9.0	7.3	9.9
Asian (%)	0.8	2.2	1.9	2.8	1.6	3.3
Lung (N)	2,429	941	2,315	1,157	1,006	1,478
White (%)	85.5	89.7	83.6	86.2	83.5	83.1
African-American (%)	9.7	7.1	9.5	7.6	9.1	8.9
Hispanic/Latino (%)	3.4	2.7	5.1	5.0	5.4	5.5
Asian (%)	1.2	0.2	1.4	0.8	1.5	1.6
Intestine (N)	71	82	127	152	168	185
White (%)	59.2	61.0	66.1	68.4	60.7	67.0
African-American (%)	25.4	17.1	15.7	11.2	22.6	16.8
Hispanic/Latino (%)	11.3	19.5	14.2	15.1	13.1	11.4
Asian (%)	4.2	2.4	2.4	3.9	2.4	3.2
SPK ³ (N)	1,818	915	1,907	881	1,349	836
White (%)	80.9	84.9	70.7	75.3	66.5	70.7
African-American (%)	12.2	9.2	18.4	14.1	16.1	17.0
Hispanic/Latino (%)	5.3	4.8	8.8	8.9	13.3	10.5
Asian (%)	1.0	0.4	1.4	1.1	3.0	1.2
Pancreas ⁴ (N)	359	439	836	603	474	437
White (%)	87.5	92.3	85.9	88.4	80.6	80.6
African-American (%)	7.2	3.9	6.7	5.1	11.2	11.4
Hispanic/Latino (%)	3.9	3.4	6.6	5.5	6.8	6.4
Asian (%)	1.1	0.2	0.4	0.7	0.6	1.1

Source: OPTN/SRTR special analysis, Sept 2009; data as of May 2009. Reference Tables 5.1a, 5.4, 6.1a, 6.4, 7.1a, 7.4, 8.1a, 8.4, 9.1a, 9.4, 10.1a, 10.4, 11.1a, 11.4, 12.1a, and 12.4. ¹Patients with active waiting list status at the end of the prior year; ²Transplants performed during the given year; ³Simultaneous pancreas and kidney transplants; ⁴Includes pancreas-transplant-alone (PTA) and pancreas-after-kidney (PAK) transplants.

Figure X-1. Ratio of Percent of Kidney Transplants and Percent on Active Waiting List at End of Prior Year, 2000-2008

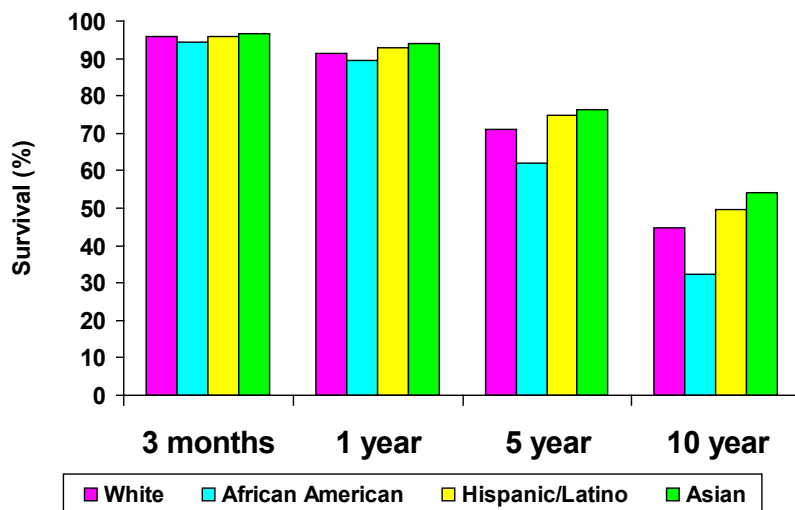


Source: OPTN/SRTR Special Analysis, September 2009; data as of May 2009

Kidney Transplant Trends. Between 1999 and 2006, the total number of kidney transplants increased for all race/ethnicity groups. However, between 2006 and 2008, the number of White recipients of standard criteria donor (SCD) transplants declined from 4180 in 2006 to 4017 in 2008; the number of White recipients also declined for expanded criteria donor (ECD) transplants from 905 in 2006 to 867 in 2008 and for living donor (LD) transplants from 4463 in 2004 to 3995 in 2008 [Tables 5.4a, 5.4b, 5.4d]. The numbers of SCD and LD kidney transplants performed in the other racial/ethnic groups, in general, remained more stable or increased slightly; the number of ECD kidney transplants continued to increase for African-Americans and Hispanic/Latinos, perhaps as a consequence of the OPTN policy that largely allocates ECD kidneys based upon waiting time alone.

Kidney Graft and Recipient Survival. Graft outcomes varied by racial/ethnic group irrespective of donor type, and the differences tended to increase with time after transplant. As shown in Figure X-2, adjusted DD 3-month graft survival was very similar among the four race/ethnicities. One-year adjusted DD graft survival ranged from 89 percent to 94 percent; the percentages for 5 and 10-year adjusted DD graft survival were from 62 percent to 76 percent, and 32 percent to 54 percent, respectively. At each of these time points, Asian kidney recipients enjoyed the highest adjusted and unadjusted (not shown) graft survival, followed by Hispanic/Latinos, and then Whites. African-American recipients had the lowest graft survival at each interval shown.

Figure X-2. Adjusted Deceased Donor Kidney Graft Survival by Race/Ethnicity



*Transplants 2006-2007 used to calculate 1 year survival, 2002-2007 for 5 year survival, and 1997-2007 for 10 year survival.

Source: 2009 OPTN/SRTR Annual Report, Table 5.8c

Graft survival after LD transplantation followed a similar pattern. The adjusted LD kidney transplant graft survival at 3 months was 98 percent overall, ranging from 98 percent to 99 percent [Table 5.10d]. One-year adjusted LD graft survival was 96 percent overall, ranging from 95 percent to 98 percent; 5-year adjusted LD graft survival was 81 percent overall, ranging from 73 percent to 89 percent; and 10-year adjusted LD graft survival was 59 percent overall, ranging from 45 percent to 70 percent [Table 5.10d]. While LD graft survival was excellent for all groups at 3 months, differences developed by 1 year. As with DD kidney transplantation, Asian recipients enjoyed the highest adjusted LD graft survival, followed by Hispanic/Latinos, and then Whites, with African-Americans displaying the poorest outcomes.

Notably, the gap between DD graft survival for African-Americans and other racial/ethnic groups appeared to be narrowing. Both DD and LD (LD, not shown) graft survival improved more rapidly for African-Americans than for other racial/ethnic groups. Table X-2 shows outcomes among kidney transplant recipients for 1996-2001 and 2002-2007. The overall 5-year adjusted DD kidney transplant graft survival improved by 6 percent for African-Americans (from 56 percent to 62 percent); likewise, improvement was 4 percent for Hispanic/Latinos (71 percent to 75 percent), 2 percent for Asians (74 percent to 76 percent), and 3 percent for Whites (68 percent to 71 percent).

Long-term, adjusted DD patient survival among African-Americans and Whites were similar with both groups, lagging behind the 10-year survival rates seen for Hispanic/Latino and Asian transplant recipients (Figure X-3). In the first year following kidney transplant, adjusted recipient survivals were tightly grouped from 96 percent to 98

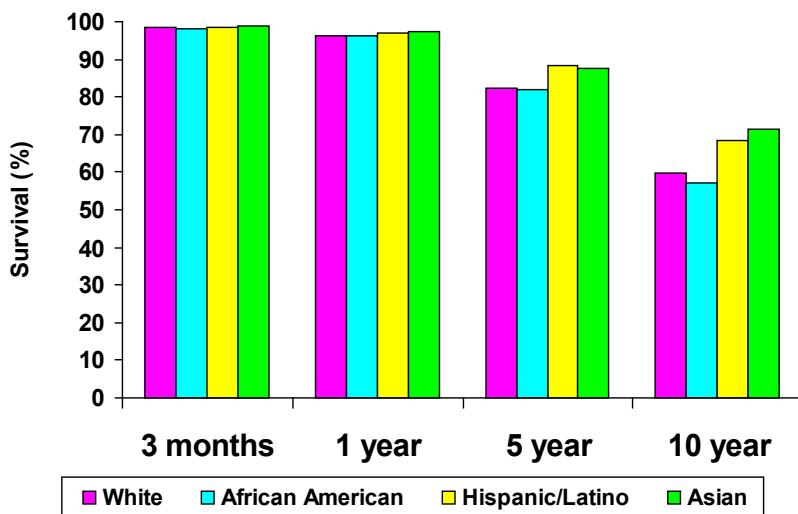
percent for the four ethnic groups considered. By the fifth year posttransplant, Hispanic/Latino and Asian recipients demonstrate superior patient survivals when compared with either White or African-American recipients at 89 percent and 87 percent versus 82 percent and 82 percent, respectively. By 10 years posttransplant, this difference increased as Whites and African-Americans had 60 percent and 57 percent patient survival, respectively, compared with Asians at 71 percent and Hispanic/Latinos at 68 percent.

Table X-2: Adjusted Deceased Donor Graft and Patient Survival at Five Years by Organ and Race/Ethnicity for Transplant Recipients from 1996-2001 and 2002-2007

Organ	Race/Ethnicity	1996-2001		2002-2007	
		N	5-year	N	5-year
Kidney graft	Overall	47,073	65.5	55,513	69.2
	White	25,912	68.3	26,726	70.9
	African-American	13,253	56.4	17,022	62.2
	Hispanic/Latino	5,115	70.8	7,740	75.0
	Asian	2,313	73.7	3,265	76.3
Kidney patient	Overall	40,516	81.0	48,242	83.5
	White	21,612	80.8	22,388	82.4
	African-American	11,829	79.0	15,242	82.1
	Hispanic/Latino	4,502	85.2	6,932	88.4
	Asian	2,124	86.0	2,997	87.6
Liver patient	Overall	22,667	72.0	29,604	73.8
	White	17,117	72.6	21,269	74.1
	African-American	1,942	64.8	2,778	66.8
	Hispanic/Latino	2,583	72.5	3,860	75.2
	Asian	868	73.3	1,445	78.1
Heart patient	Overall	12,915	72.8	11,991	75.2
	White	10,129	74.8	8,478	77.7
	African-American	1,697	61.9	2,062	64.8
	Hispanic/Latino	773	71.6	1,016	75.1
	Asian	259	75.0	339	75.9
Lung patient	Overall	5,228	44.5	7,199	53.5
	White	4,670	45.3	6,194	53.2
	African-American	357	33.9	558	57.5
	Hispanic/Latino	155	46.8	326	49.4
	Asian	30	56.2	77	61.4

Source: OPTN/SRTR special analysis, Sept 2009; data as of May 2009

Figure X-3. Adjusted Deceased Donor Kidney Patient Survival by Race/Ethnicity



*Transplants 2006-2007 used to calculate 1 year survival, 2002-2007 for 5 year survival, and 1997-2007 for 10 year survival.

Source: 2009 OPTN/SRTR Annual Report, Table 5.12c

Receipt of a LD kidney was associated with an almost 100 percent 3-month and 99 percent 1-year patient survival for each racial/ethnic group. At 5 and 10 years after transplantation, the adjusted patient survivals among African-American (91 percent and 73 percent, respectively) and White recipients (92 percent and 77 percent, respectively) were inferior to the patient survival seen for Hispanic/Latino (95 percent and 83 percent, respectively) and Asian recipients (95 percent and 84 percent, respectively) [Table 5.12d].

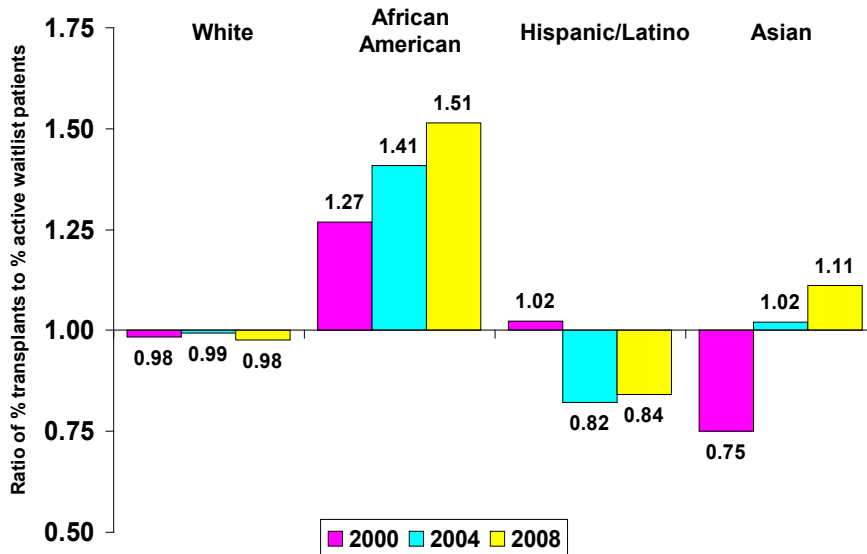
Comparing 5-year trends (1996-2001 versus 2002-2007) in adjusted DD kidney recipient survival, 3 percent improvements were seen for African-Americans (79 percent to 82 percent) and Hispanic/Latinos (85 percent to 88 percent), while Asians improved by 2 percent (86 percent to 88 percent), and Whites by 1 percent (81 percent to 82 percent) (Table X-2).

In summary, among kidney transplant recipients, several trends are evident. First, the disparity in access to DD kidney transplantation between wait-listed White and minority patients appears to be narrowing significantly for African-Americans, but less so for Hispanic/Latinos and Asians. Asian and Hispanic/Latino recipients demonstrated consistently superior long-term DD and LD graft and patient survivals compared with White recipients. African-American recipients have consistently inferior long-term LD and DD graft survival relative to other racial/ethnic groups. Factors contributing to differences in posttransplant graft survival will be examined in detail later in this chapter. Finally, DD kidney graft and patient survival is improving more rapidly for African-Americans and Hispanic/Latinos than for Whites and Asians.

Liver Transplant Trends and Outcomes

Access to Liver Transplantation. Different patterns were seen in access to liver transplantation among wait-listed candidates than those observed for kidney transplantation (Figure X-4). Among liver transplant recipients, Whites were transplanted at a rate commensurate with their proportion on the waiting list. However, African-Americans and, most recently, Asians were transplanted at rates above their representation on the waiting list. Furthermore, liver transplantation rates relative to Whites and Hispanic/Latinos appeared to be increasing for Asians and particularly for African-Americans. In contrast, the rate at which Hispanic/Latinos received liver transplants decreased between 2000 and 2008 relative to their representation on the waiting list. In 2008, the liver transplant rate deficit was 16 percent for Hispanic/Latinos and 2 percent for Whites in comparison with their waiting list representation, whereas African-Americans and Asians received 51 percent and 11 percent more liver transplants, respectively, than would be predicted based upon their waiting list prevalence. Importantly, these results were not adjusted for patient characteristics including MELD scores.

Figure X-4. Ratio of Percent of Liver Transplants and Percent on Active Waiting List at End of Prior Year, 2000-2008



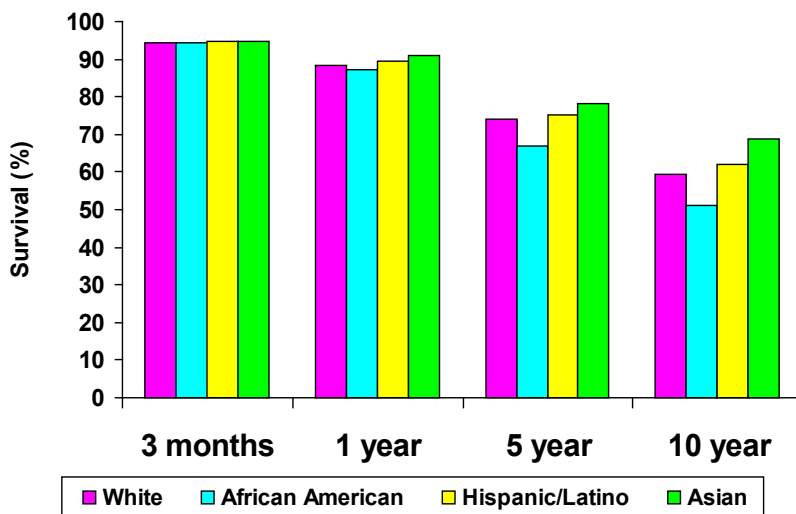
Source: OPTN/SRTR Special Analysis, September 2009; data as of May 2009

Liver Transplantation Trends. The total number of liver transplants (DD and LD) gradually increased from 4751 in 1999 to a peak of 6651 in 2006, but declined slightly over the past 2 years, falling to 6318 in 2008 [Tables 9.4a and 9.4b]. This decrease

principally reflected a drop in the number of liver transplants for Whites, as the number of liver transplants going to the other race/ethnicities remained relatively stable. As a consequence, the ethnic/racial distribution of DD liver transplant recipients has changed, with a decline in White recipients from 76 percent in 1999 to 70 percent in 2008 balanced by modest increases in the percentage transplanted for African-Americans, Asians, and Hispanic/Latinos [Table 9.4a]. The number of LD liver transplants declined from a peak of 524 in 2001 to a low of 249 in 2008 [Table 9.4b]. LD liver transplants now comprise less than 4 percent of liver transplants performed nationally, with the preponderance in 2008 going to Whites (189, [76 percent]), and very few to African-Americans (20, [8 percent]), Hispanic/Latinos (26, [10 percent]) and Asians (14, [6 percent]).

Liver Transplant Recipient Survival. As seen with kidney transplantation, patient survival varied by racial/ethnic group (Figure X-5). The adjusted 3-month patient survival for DD liver transplants in 2006-2007 was 94 percent, with little difference between racial/ethnic groups [Table 9.12a]. Patient survival for White recipients was 88 percent at 1 year and 74 percent at 5 years; African-American recipients had similar 1-year, but lower 5-year patient survival (87 percent and 67 percent, respectively) (Figure X-5). In contrast, Asian and, to a lesser extent, Hispanic/Latino recipients had superior outcomes. One- and 5-year patient survival was 89 percent and 75 percent, respectively, for Asians and 91 percent and 78 percent for Hispanic/Latinos. By 10 years, patient survival was 68 percent for Asians, 62 percent for Hispanic/Latinos, 59 percent for Whites, and 51 percent for African-Americans.

Figure X-5. Adjusted Deceased Donor Liver Patient Survival by Race/Ethnicity



*Transplants 2006-2007 used to calculate 1 year survival, 2002-2007 for 5 year survival, and 1997-2007 for 10 year survival.

Source: 2009 OPTN/SRTR Annual Report, Table 9.12a

As with kidney transplantation, there was a trend toward improved 5-year adjusted overall DD patient survival when transplants from 1996 through 2001 (66 percent) were compared with those performed in the interval of 2002-2007 (69 percent) (Table X-2). The largest increments in liver transplant patient survival occurred with Asians (73 percent to 78 percent), with lesser improvements in Hispanic/Latinos (73 percent to 75 percent) and African-Americans (65 percent to 67 percent), whereas little improvement was observed in recipient survival for Whites (73 percent to 74 percent).

In summary, access to DD liver transplantation for African-Americans and Asians was above and access for Hispanic/Latinos was below their proportional representation on the waiting list. The numbers of DD liver transplants declined for Whites, but remained stable for other racial/ethnic groups. The overall number of LD liver transplants decreased. Few racial/ethnic minorities received LD liver transplants. Similar to kidney transplantation, DD patient survival differed between racial/ethnic groups and the differences increased over time. African-Americans demonstrated the poorest and Asians the best DD posttransplant survival. DD Liver transplant results are improving, more so for Asians and Hispanic/Latinos than for Whites and African-Americans.

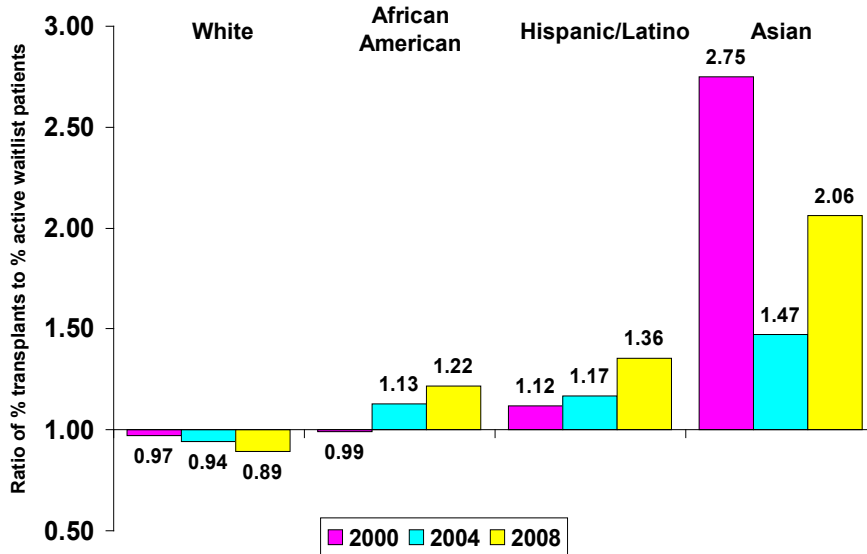
Heart Transplant Trends and Outcomes

Access to Heart Transplantation. Access to cardiac transplantation appears different from both kidney and liver transplantation (Figure X-6). Asians, Hispanic/Latinos, and African-Americans were all transplanted at rates above their representation on the waiting list. Conversely, Whites were transplanted less often than their frequency on the waiting list, and the rate for Whites declined during the study period. These results were not adjusted for recipient severity of illness at listing.

Heart Transplant Trends. As shown in Table X-1, the number of cardiac transplants declined slightly, from 2199 in 2000 to 2163 in 2008. The proportion among Whites declined, while the proportion among African-Americans, Hispanic/Latinos, and Asians increased during this time. Accordingly, the racial/ethnic distribution of the recipients changed, with White patients receiving 79 percent of cardiac transplants in 2000 and 66 percent in 2008. In contrast, the percentage of African-American, Asian, and Hispanic/Latino cardiac transplant recipients all increased. African-Americans comprised 13 percent of the recipients in 2000 and 20 percent in 2008. Cardiac transplants to Asian patients increased from 2 percent to 3 percent, while Hispanic/Latino recipients increased from 7 percent to 10 percent.

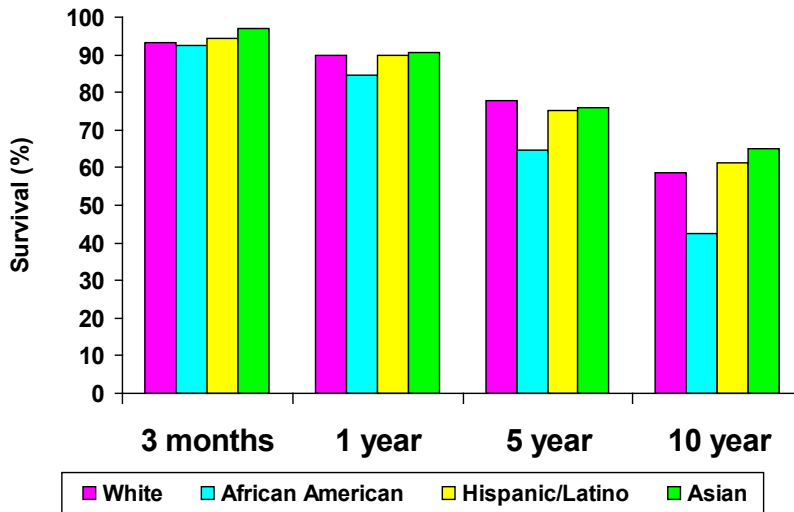
Heart Transplant Recipient Survival. Overall adjusted cardiac patient survival at 1 and 5 years was 88 percent and 75 percent, respectively [Table 11.12]. Again, there were differences in patient outcomes between racial/ethnic groups that increased over time (Figure X-7). Short-term pattern were similar to those seen with kidney and liver transplantation. Among transplant recipients in 2006-2007, adjusted patient survival at 3 months and 1 year was highest among Asians, followed by Hispanic/Latinos, Whites, and then African-Americans. Outcomes at 10 years followed this trend, with patient survival

Figure X-6. Ratio of Percent of Heart Transplants and Percent on Active Waiting List at End of Prior Year, 2000-2008



Source: OPTN/SRTR Special Analysis, September 2009; data as of May 2009

Figure X-7. Adjusted Heart Patient Survival by Race/Ethnicity



*Transplants 2006-2007 used to calculate 1 year survival, 2002-2007 for 5 year survival, and 1997-2007 for 10 year survival.

Source: 2009 OPTN/SRTR Annual Report, Table 11.12

65 percent for Asians, 61 percent for Hispanic/Latinos, 59 percent for Whites, and 42 percent for African-Americans. Interestingly, at 5 years, White recipients had the best patient survival (77 percent), followed by Asians (75 percent), Hispanic/Latinos (75 percent), and African-Americans (65 percent).

As with kidney and liver transplantation, there was a trend toward improved 5-year adjusted overall patient survival when transplant survival for recipients from the interval of 1996-2001 (73 percent) was compared with survival for recipients in the interval from 2002-2007 (75 percent); this is shown in Table X-2. The largest improvements were seen with Whites (75 percent to 78 percent), African-Americans (62 percent to 65 percent), and Hispanic/Latinos (72 percent to 75 percent).

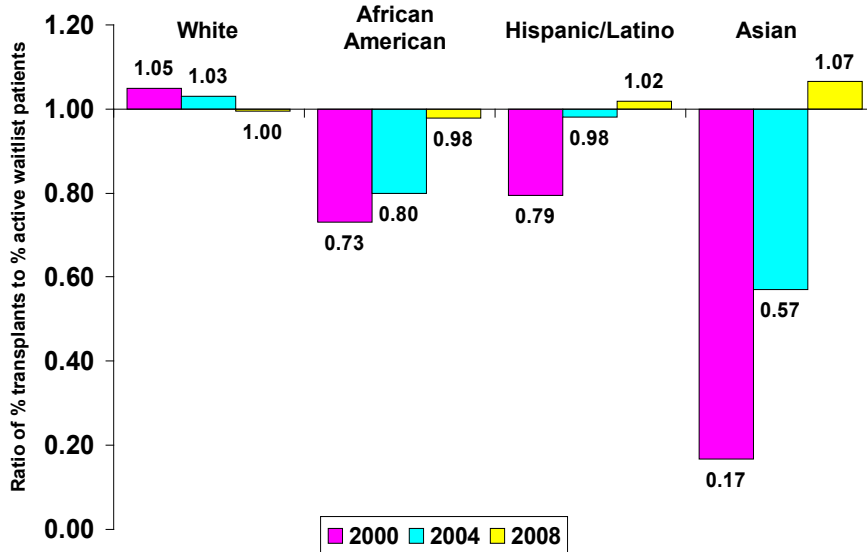
In summary, African-Americans, Asians, and Hispanic/Latinos all received heart transplants at rates that exceeded their proportion of the waiting list. While the total number of heart transplants performed has been stable, the percentage of heart transplants going to minorities has increased. Five-year patient survival was best for Whites and better for Hispanic/Latinos and Asians than for African-Americans. Ten-year patient survival was highest for Asians and Hispanics, and intermediate for Whites. The biggest improvements in 5-year graft survival were seen for Whites, African-Americans, and Hispanic/Latinos.

Lung Transplant Trends and Outcomes

Nationally, there were very few minority lung transplant recipients from 1999-2008 (ranging from 10 percent-17 percent) [Table 12.4]. The small numbers limit opportunities for analysis of access to transplant, transplant trends, and differences in graft and patient survival between racial/ethnic groups. By 2008, gaps in access seen earlier in the decade for racial/ethnicity minorities resolved (Figure X-8). Of the 1478 lung recipients in 2008, 83 percent were White, 9 percent African-American, 6 percent Hispanic/Latino, and 2 percent Asian; these percentages closely approximated the racial/ethnic composition of the active waiting list (Table X-1).

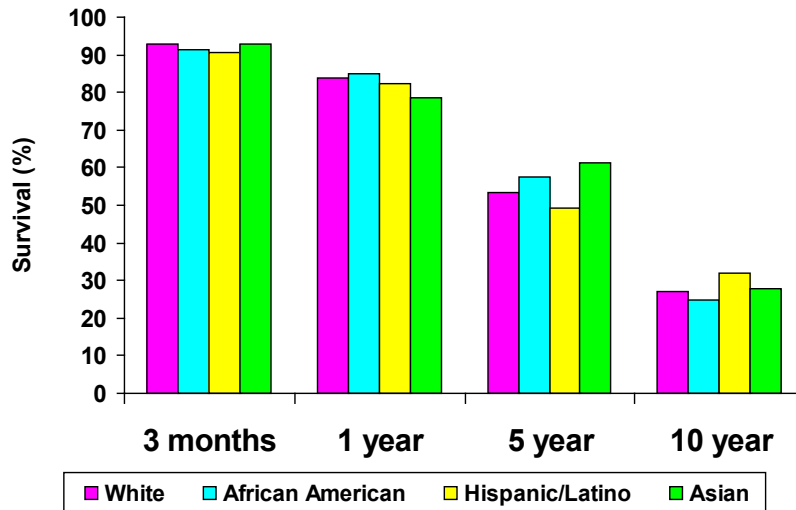
DD lung transplant patient survival outcomes also differed by race/ethnicity (Figure X-9). Adjusted patient survival was similar at 1-year among Whites and African-Americans (84 percent and 84 percent, respectively), intermediate among Hispanic/Latinos (82 percent), and lowest for Asians (78 percent). At 5-years, adjusted patient survival was 53 percent for Whites, 57 percent for African-Americans, 49 percent for Hispanic/Latinos, and 61 percent for Asians. Ten-year adjusted transplant survival ranged from 32 percent for Hispanic/Latinos to 25 percent for African-Americans. Table X-2 shows that comparisons in adjusted 5-year patient survival between the 1996-2001 and 2002-2007 cohorts demonstrated large improvements for Whites (45 percent to 54 percent) and African-Americans (34 percent to 58 percent). Improvements were more modest among Hispanic/Latinos (47 percent to 49 percent) and Asians (56 percent to 61 percent).

Figure X-8. Ratio of Percent of Lung Transplants and Percent on Active Waiting List at End of Prior Year, 2000-2008



Source: OPTN/SRTR Special Analysis, September 2009; data as of May 2009

Figure X-9. Adjusted Deceased Donor Lung Patient Survival by Race/Ethnicity



*Transplants 2006-2007 used to calculate 1 year survival, 2002-2007 for 5 year survival, and 1997-2007 for 10 year survival.

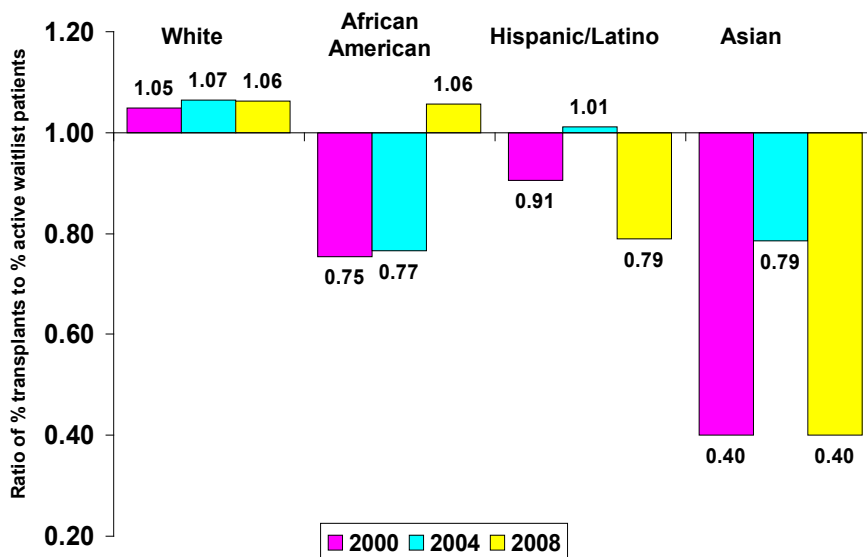
Source: 2009 OPTN/SRTR Annual Report, Table 12.12

Pancreas Transplant Alone, Pancreas after Kidney, and Simultaneous Kidney and Pancreas Transplant Trends and Outcomes

In 2008, 223 pancreas transplants alone (PTA), 214 pancreas after kidney (PAK) and 836 simultaneous kidney-pancreas (SPK) transplants were performed [Tables 6.4, 7.4, 8.4]. These small samples produce uncertainty in the interpretation of racial/ethnicity trends in access to transplant and patient survival, particularly for PTA and PAK transplants and for Asian recipients. For PTA in 2008, 80 percent went to Whites, 10 percent to African-Americans, 2 percent to Asians, and 7 percent to Hispanic/Latinos. The racial/ethnic distribution of PAK in 2008 was very similar to PTA, as 81 percent of the PAK recipients were White, 13 percent African-American, 1 percent Asian, and 6 percent Hispanic/Latino [Tables 6.4, 7.4, 8.4]. For both PTA and PAK, the racial/ethnic distribution of recipients appeared to parallel the active waiting list (not shown). Few minorities received SPK transplants (Table X-1); on a percentile basis, 71 percent of recipients were White, 17 percent African-American, 1 percent Asian, and 11 percent were Hispanic/Latino (Table X-1). Most recently, Whites and African-Americans appeared to be transplanted at a slightly higher rate, and Hispanic/Latinos and Asians minorities at substantially lower rates than expected by their prevalence on the waiting list (Figure X-10).

PTA and PAK survival for different racial/ethnic groups were not compared, given the very small number of minority recipients. One-year adjusted SPK kidney graft survival was 93 percent for Whites, 89 percent for African-Americans, 100 percent for Asians

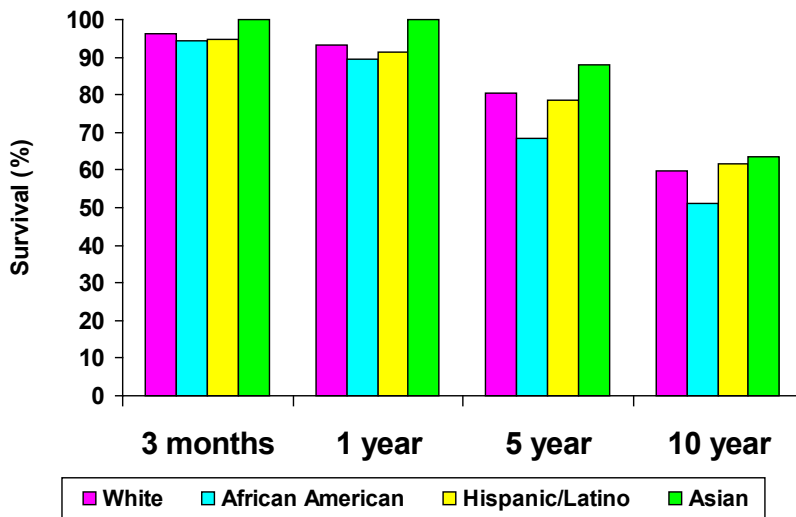
Figure X-10. Ratio of Percent of SPK Transplants and Percent on Active Waiting List at End of Prior Year, 2000-2008



Source: OPTN/SRTR Special Analysis, September 2009; data as of May 2009

(though the number of recipients was only 23) and 91 percent for Hispanic/Latinos (Figure X-11). The 1-year SPK pancreas graft survival was lower, at 85 percent for Whites, 83 percent for African-Americans, 91 percent for Asians, and 87 percent for Hispanic/Latinos (Figure X-12). At 5 years, the adjusted SPK kidney graft survival ranged from 88 percent for Asians to 68 percent for African-Americans. Whites and Hispanic/Latinos were at 81 percent and 78 percent, respectively. Five-year SPK pancreas graft survival varied from 84 percent for Asians to 66 percent for African-Americans, with Whites at 74 percent and Hispanic/Latinos at 77 percent. At 10 years, SPK kidney graft survival was very similar for Hispanic/Latinos (61 percent), Asians (63 percent), and Whites (60 percent), but only 51 percent for African-Americans. SPK pancreas graft survival varied from 59 percent for Asians, 57 percent for Hispanic/Latinos, 56 percent for Whites, to 49 percent for African-Americans.

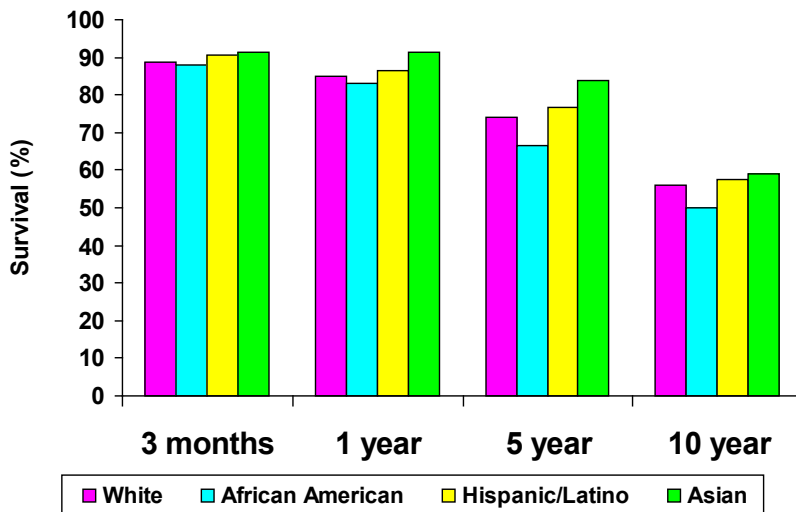
Figure X-11. Adjusted Deceased Donor SPK Kidney Graft Survival by Race/Ethnicity



*Transplants 2006-2007 used to calculate 1 year survival, 2002-2007 for 5 year survival, and 1997-2007 for 10 year survival.

Source: 2009 OPTN/SRTR Annual Report, Table 8.8

Figure X-12. Adjusted Deceased Donor SPK Pancreas Graft Survival by Race/Ethnicity



*Transplants 2006-2007 used to calculate 1 year survival, 2002-2007 for 5 year survival, and 1997-2007 for 10 year survival.

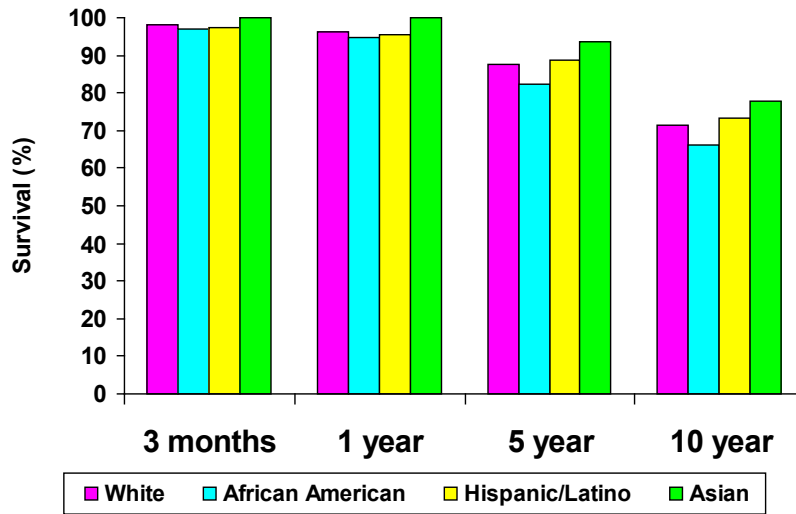
Source: 2009 OPTN/SRTR Annual Report, Table 8.8

One-year adjusted SPK patient survival was 96 percent for Whites, 95 percent for African-Americans and Hispanic/Latinos, and 100 percent for Asians (Figure X-13). Five-year adjusted patient survival was 94 percent for Asians, 89 percent for Hispanic/Latinos, 88 percent for Whites, and 83 percent for African-Americans. Ten-year adjusted patient survival ranged from 77 percent for Asians, 74 percent for Hispanic/Latinos, and 72 percent for Whites to 67 percent for African-Americans.

Intestine Transplant Trends and Outcomes

There were only 168 intestine candidates on the intestine waiting list at the end of 2008, and only 185 intestinal transplants were performed nationally in 2008 (Table X-1). Among these candidates, 61 percent were White, 23 percent were African-American, 2 percent Asian, and 13 percent Hispanic/Latino. Of these recipients, 67 percent were White, 17 percent were African-American, 3 percent Asian, and 11 percent Hispanic/Latino. Adjusted patient survival, especially for Asians, are based upon very small numbers. At 1 year, adjusted patient survival was 80 percent for Whites, 79 percent for Hispanic/Latinos, 78 percent for African-Americans, and 72 percent for Asians. Patient survival at 5 years was 65 percent for Hispanic/Latinos, 57 percent for Whites, 58 percent for Asians, and 55 percent for African-Americans. At 10 years, survival was 48 percent for Asians, 45 percent for Whites, 44 percent for Hispanic/Latinos, and 40 percent for African-Americans (Figure X-14).

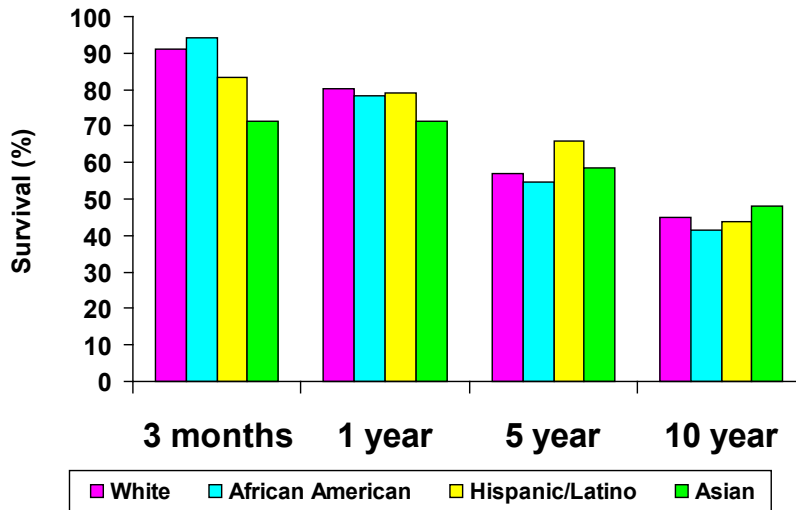
Figure X-13. Adjusted Deceased Donor SPK Patient Survival by Race/Ethnicity



*Transplants 2006-2007 used to calculate 1 year survival, 2002-2007 for 5 year survival, and 1997-2007 for 10 year survival.

Source: 2009 OPTN/SRTR Annual Report, Table 8.12

Figure X-14. Adjusted Deceased Donor Intestine Patient Survival by Race/Ethnicity



*Transplants 2006-2007 used to calculate 1 year survival, 2002-2007 for 5 year survival, and 1997-2007 for 10 year survival.

Source: 2009 OPTN/SRTR Annual Report, Table 10.12

KIDNEY TRANSPLANT OUTCOMES: SPECIAL ANALYSIS

Methods

To identify and quantify factors contributing to racial and ethnic differences in kidney transplant outcomes, the relative risks (RR) of DD kidney graft failure at 5 years posttransplant were examined using multiple Cox proportional hazards regression models for adult recipients of primary solitary DD kidney transplants performed between January 1, 2000 and December 31, 2007. Data were recorded at the time of transplant. Recipients were excluded from analysis if they were younger than 18 years of age at transplantation, had previously received a kidney or extra-renal transplant, or underwent a LD or multi-organ transplant.

Graft failure was defined as the earliest date of graft failure (as determined by OPTN/SRTR or CMS data) or death (as determined by OPTN/SRTR, CMS, or SSDMF data). Individuals were censored at the earliest of the date of 5 years posttransplant, last follow-up, or the end of the study (December 31, 2008). The RR of graft failure for three racial/ethnic groups (African-American, Hispanic/Latino, and Asian) were determined and referenced to the RR for Whites. The RR for Other racial/ethnic group is not shown due to the small population size.

The main analyses focus on the RR of graft failure for the racial/ethnic groups of White, African-American, Hispanic/Latino, and Asian kidney transplant recipients, comparing an unadjusted model and several adjusted models. Each adjusted model includes combinations of categories of variables as described below and in Table X-3. To better understand the differential effects of patient-related and center-related characteristics on kidney transplant outcomes, variables were categorized and ranked, from those that were most associated with the characteristics of the transplant center and most removed from the individual characteristics of patients to those that were most specific to individual patients and distant from the characteristics of the transplant center. Accordingly, variables were arranged in ordered categories as: center factors, OPO factors, organ factors, transplant factors, treatment protocols, socioeconomic factors, dialysis time, disease burden, and patient demographics. The variables that are included in each category are collected by the OPTN at the time of transplantation. The RR of graft failure at 5 years and the number and percentage of DD kidney transplant recipients by racial/ethnic group for selected factors related to graft failure are shown in Table X-4. The individual effects of adjustment for each category of variables are shown in Table X-5. To quantify the incremental effect of different categories of factors, RRs were sequentially analyzed using unadjusted models and then models that adjusted for specific categories of variables beginning with center characteristics and progressing to patient characteristics (Table X-6). Finally, the models were rerun in reverse sequence, from

those most patient-specific to those most center-specific to determine whether the order by which variables were added would influence the direction and magnitude of each category of variables captured in the model (Table X-7). All statistical analyses were performed using SAS 9.2.

Results

Table X-4 summarizes the number and percentage of 58,978 kidney transplant recipients by racial/ethnic group for selected categories of statistically important variables (age, duration of ESRD, diagnosis, hepatitis C status, and insurance type at transplant), and reports the overall RR of graft failure associated with subcategories of these factors. Whites were, on average, older and all other racial/ethnic groups younger, than the average age of the entire kidney transplant recipient population. The best outcomes were seen among transplant patients between 35 and 49 years of age; lesser and greater age was associated with higher rates of graft failure. There was a dose-related effect of duration of ESRD as measured by dialysis time, with an overall twofold difference in the RR of graft loss at 5 years between those receiving a preemptive kidney transplant and those who undergo transplantation after 7 or more years of dialysis. In general, Whites were far more likely to receive a preemptive kidney graft and less likely to be exposed to greater than 3 years of dialysis before transplantation. Also of significant importance were primary ESRD diagnosis, hepatitis C status, and insurance. Compared with the reference group of recipients with glomerulonephritis, those with ESRD from diabetes had an increased RR of graft loss of 1.11; those with hypertension had a RR of 1.08; and patients with other causes of ESRD had a slightly reduced RR of 0.94. Asians were most likely to have ESRD from glomerulonephritis, African-Americans from hypertension, and Whites from other causes. Hepatitis C was also associated with an increased RR of 1.37, and African-Americans were far more likely to be hepatitis C antibody positive at the time of transplant than recipients of the other racial/ethnic groups. Finally, in comparison with private insurance only, all other types of insurance were associated with increased RR of graft loss. Medicare-only insurance was most common in African-Americans, Medicaid-only in Hispanic/Latinos, and private-only and private-primary insurance in Whites.

The RRs of graft failure at 5-years are shown in Tables X-5, X-6, and X-7 by race/ethnicity for one unadjusted and several adjusted models. In each table, the RR of graft failure for African-Americans, Hispanic/Latinos, and Asians are compared with the RR for Whites (RR=1.00). Without adjustments, the RR of graft failure at 5 years when compared with Whites was 1.35 for African-Americans, 0.83 for Hispanic/Latinos, and 0.75 for Asians. All comparisons in Table X-5, X-6, and X-7 between the RR of graft failure for Whites and other race/ethnicities are statistically significant with a p value < 0.05.

Table X-3: Factors Used in the Graft Outcome Models

Center factors

Median waiting time (<2 years, >=2 years, not yet reached)
Average length of stay (< 7 days, >=7 days)
Volume (in quartiles <59 transplants, 59-99 transplants, 100-165 transplants, > 166 transplants)
Age distribution (% Age 0-17, % Age 18-34, %Age 35-49, % Age 50-64, % Age 65+)
Race/ethnicity (%White, %African-American, %Hispanic/Latino, %Asian, %Other)
PRA (% 0-9, %10-79, %80+, % missing)
Diagnosis (%glomerulonephritis, %diabetes, %hypertension, %other/ missing)
Percent deceased donor transplants among all kidney transplants

OPO

OPO (58 organ procurement organizations)

Organ factors

Donor age (<40 years, 40-49 years, 50-59 years, ≥ 60 years)
Donor race (White, Non-White)
Donor sex (Male, Female)
Donor hepatitis B (yes/no)
Donor hepatitis C (yes/no)
Donor positive CMV (yes/no)
ECD (yes/no)
DCD (yes/no)
Donor cause of death (anoxia, CVA/stroke, head trauma, CNS tumor, other)

Transplant factors

HLA mismatch A (0, 1, 2, missing)
HLA mismatch B (0, 1, 2, missing)
HLA mismatch DR (0, 1, 2, missing)
Donor-recipient weight ratio (< 0.75, 0.75-0.89, 0.90-1.14, ≥1.15, missing)
Transplant year (2000-2007)
Cold ischemia time hours (0-6, >6-12, >12-18, >18-24, >24-30, >30-36, ≥36, missing)
Shared (yes/no)
Pumped (yes/no)

Treatment protocols at hospital discharge

Induction (yes/no)
Cyclosporine (yes/no)
Tacrolimus (yes/no)
Sirolimus (yes/no)
Mycophenolate (yes/no)
Corticosteroid (yes/no)
Other maintenance immunosuppression (yes/no)

Center factors

Socioeconomic factors

Recipient insurance (Medicare only, Medicaid only, Medicare primary + other secondary, private only, private only + other, other source of payment)

Education (Less than high school, high school, college, other)

Average income in zip code (<\$20K, \$20-29K, \$30-39K, \$40-59K, ≥\$60K)

Dialysis time

Time on dialysis (Preemptive, 0-≤1 yrs, >1-2 yrs, >2-3 yrs, >3-5 yrs, >5-7 yrs, > 7 yrs)

Disease burden

Diagnosis (glomerulonephritis, diabetes, hypertension, other, missing)

PRA (0-9, 10+, missing)

Cancer (yes/no)

CVA (yes/no)

COPD (yes/no)

Diabetes with insulin (yes/no)

Diabetes (yes/no)

Albumin (<35, ≥35, missing)

Hepatitis B (yes/no)

Hepatitis C (yes/no)

Positive CMV (yes/no)

Age

Recipient age (18-34, 35-49, 50-64, 65+)

Demographic factors

Sex. Previous pregnancies (male, female never pregnant, female previously pregnant)

Blood type (A, AB, B, O)

BMI (<18.5, 18.5-24, 25-29, ≥30, missing)

Employment (yes/no)

Table X-4: Relative Risk of Deceased Donor Graft Failure at 5 Years and Number and Percentage of Deceased Donor Kidney Transplant Recipients by Racial/Ethnic Group for Selected Factors Related to Graft Failure, 2000-2008

Factor	RR**	Recipient Race/Ethnicity Group									
		All		White		Afr.-Amer.		Hispanic/Lat		Asian	
		N	%	N	%	N	%	N	%	N	%
All		58,978	100	28,245	100	18,603	100	7,772	100	3,578	100
Recipient Age											
Mean age		51.8 years		54.0 years		49.5 years		49.6 years		51.3 years	
18-34 Years	1.25*	7,218	12.2	2,597	9.2	2,755	14.8	1,318	17.0	464	13.0
35-49 Years (Ref)	1.00	17,049	28.9	7,188	25.4	6,253	33.6	2,333	30.0	1,060	29.6
50-64 Years	1.14*	25,099	42.6	12,479	44.2	7,611	40.9	3,136	40.3	1,507	42.1
65 Plus	1.56*	9,612	16.3	5,981	21.2	1,984	10.7	985	12.7	547	15.3
Recipient years of ESRD											
Mean ESRD years		3.5 years		2.7 years		4.5 years		4.1 years		3.9 years	
Preemptive	0.68*	3,653	6.2	2,701	9.6	414	2.2	351	4.5	166	4.6
0-1 years	0.85*	5,232	8.9	3,722	13.2	823	4.4	406	5.2	246	6.9
1-2 years (Ref)	1.00	9,741	16.5	5,996	21.2	2,147	11.5	1,018	13.1	474	13.2
2-3 years	1.06*	10,292	17.5	5,408	19.1	2,940	15.8	1,274	16.4	546	15.3
3-5 years	1.11*	16,106	27.3	6,702	23.7	5,702	30.7	2,339	30.1	1,079	30.2
5-7 years	1.29*	8,448	14.3	2,469	8.7	3,711	19.9	1,446	18.6	683	19.1
> 7 years	1.39*	5,506	9.3	1,247	4.4	2,866	15.4	938	12.1	384	10.7
Recipient diagnosis											
Glomerulonephritis	1.00	12,477	21.2	6,224	22.0	3,400	18.3	1,600	20.6	1,106	30.9
Diabetes	1.11*	15,069	25.6	7,101	25.1	4,178	22.5	2,573	33.1	807	22.6
Hypertension	1.08*	15,026	25.5	4,441	15.7	7,921	42.6	1,721	22.1	846	23.6
Other	0.94*	16,312	27.7	10,453	37.0	3,059	16.4	1,864	24.0	810	22.6
Hepatitis C											
No (Ref)	1.00	55,799	94.6	27,360	96.9	16,785	90.2	7,448	95.8	3,452	96.5
Yes	1.37*	3,179	5.4	885	3.1	1,818	9.8	324	4.2	126	3.5
Recipient insurance											
Medicare only	1.17*	6,595	11.2	2,712	9.6	2,685	14.4	876	11.3	254	7.1
Medicaid only	1.28*	2,216	3.8	523	1.9	790	4.2	607	7.8	263	7.4
Medicare (primary) +	1.25*	30,309	51.4	13,219	46.8	10,322	55.5	4,501	57.9	1,800	50.3
Private only (Ref)	1.00	9,532	16.2	5,810	20.6	2,184	11.7	826	10.6	643	18.0
Private (prime) +	1.12*	8,574	14.5	5,240	18.6	1,987	10.7	748	9.6	507	14.2
Other source	1.08	1,744	3.0	736	2.6	633	3.4	213	2.7	111	3.1

*p<0.05. **Adjusted for all factors in Table 3 and race/ethnicity.

Source: OPTN/SRTR special analysis, August 2009; data as of July 2009.

Table X-5: Relative Risk of Graft Failure at 5 Years by Race/Ethnicity among Deceased Donor Kidney Transplant Recipients, 2000-2008 (Single Factors into Model)

Factor**	White RR	African- American RR*	Hispanic/ Latino RR*	Asian RR*
No adjustment	1.00	1.35	0.83	0.75
Center alone	1.00	1.31	0.83	0.75
Center factors alone	1.00	1.29	0.82	0.74
OPO alone	1.00	1.33	0.86	0.76
Organ factors alone	1.00	1.33	0.82	0.71
Transplant factors alone	1.00	1.27	0.82	0.71
Treatment protocol alone	1.00	1.38	0.87	0.79
Socioeconomic factors alone	1.00	1.28	0.77	0.73
Dialysis time alone	1.00	1.22	0.76	0.69
Disease burden alone	1.00	1.26	0.79	0.74
Age alone	1.00	1.45	0.88	0.78
Demographic factors alone	1.00	1.33	0.82	0.77

*p<0.05. **See Table 3 for the list of variables included in each category of variables.

Source: OPTN/SRTR special analysis, August 2009; data as of February 2009

Table X-6: Relative Risk of Graft Failure at 5 Years by Race/Ethnicity among Deceased Donor Kidney Transplant Recipients, 2000-2008

Factor**	White RR	African- American RR*	Hispanic/ Latino RR*	Asian RR*
No adjustment	1.00	1.35	0.83	0.75
+ Center factors	1.00	1.29	0.82	0.74
+ OPO factors	1.00	1.30	0.83	0.75
+ Organ factors	1.00	1.29	0.84	0.73
+ Transplant factors	1.00	1.23	0.84	0.72
+ Treatment protocol	1.00	1.24	0.84	0.73
+ Socioeconomic factors	1.00	1.19	0.79	0.73
+ Dialysis time	1.00	1.13	0.77	0.71
+ Disease burden	1.00	1.07	0.74	0.71
+ Age	1.00	1.11	0.77	0.73
+ Demographic factors	1.00	1.12	0.77	0.74

*p<0.05. **See Table 3 for the list of variables included in each category of variables.

Source: OPTN/SRTR special analysis, August 2009; data as of February 2009

Table X-7: Relative Risk of Graft Failure at 5 years by Race/Ethnicity among Deceased Donor Kidney Transplant Recipients, 2000-2008 (Reverse Factor Entry into Model)

Factor **	White RR	African- American RR*	Hispanic/ Latino RR*	Asian RR*
No adjustment	1.00	1.35	0.83	0.75
+ Demographic factors	1.00	1.33	0.82	0.77
+ Age	1.00	1.43	0.87	0.80
+ Disease burden	1.00	1.33	0.83	0.79
+ Dialysis time	1.00	1.22	0.76	0.74
+ Socioeconomic factors	1.00	1.21	0.75	0.74
+ Treatment protocol	1.00	1.22	0.78	0.77
+ Transplant factors	1.00	1.17	0.78	0.75
+ Organ factors	1.00	1.15	0.77	0.73
+ OPO	1.00	1.12	0.78	0.74
+ Center factors	1.00	1.12	0.77	0.74

*p<0.05 . **See Table 3 for the list of variables included in each category of variables.

Source: OPTN/SRTR special analysis, August 2009; data as of February 2009

Table X-5 shows the independent effect of adjustment for each category of variables. When compared with the unadjusted results, adjustments for age, disease burden, socioeconomic status, time on dialysis prior to transplantation, and treatment factors modified the differences in the RR of graft failure compared with Whites among each of the other racial/ethnic groups. Surprisingly, adjustments for center factors and demographic characteristics (without age) had little or no effect on the rates of graft failure. Transplant factors and center-alone adjustments affected relative survival for African-Americans and Asians, and organ factors influenced outcomes for Asians.

Adjustment for age alone resulted in an apparent increase in the RR of graft failure for minorities in comparison with Whites (Table X-5). Since White recipients were older, on average, than recipients from other racial/ethnic groups (Table X-4), adjustment for age likely increased the expected number of graft failures for Whites relative to minorities and, therefore, resulted in higher RRs for African-Americans, Hispanic/Latinos, and Asians. In contrast, Whites had less pretransplant exposure to dialysis than did minority recipients. Since longer time on dialysis is associated with poorer graft survival, adjustment for time on dialysis increased the number of expected graft failures for African-Americans, Asians, and Hispanic/Latinos and decreased the RR of graft failure for these minority groups relative to Whites. Therefore, adjusting for age tends to increase and, for duration of dialysis exposure, to decrease the RR of graft failure for each minority in comparison with Whites.

It is also notable that adjustment for the center factors included in these models closely parallels the results of an adjustment for center alone. In contrast, adjustment for age alone does not mimic the effect of adjustment for additional demographic factors among

African-Americans and Hispanic/Latinos. Therefore, center-alone is not maintained as a separate category in the stepwise analyses displayed in Tables X-6 and X-7, whereas, age in these analyses continues to be analyzed separately from other demographic factors.

The RR of graft failure by race/ethnicity at 5 years is shown for 11 models (one unadjusted model and 10 models adjusted for an increasing number of factors) in Tables X-6 and X-7. These tables demonstrate a different method of comparison of graft failure rates than that used in Table X-5. As in Table X-5, unadjusted, or crude rates for African-Americans, Hispanic/Latinos, and Asians were compared with the rates for Whites (1.00). However, unlike Table X-5, the unadjusted models were followed, not by separate, stand-alone adjusted models, but by models with stepwise adjustments for the sets of variables under consideration. In these stepwise models, each subsequent model incorporates all of the adjustments preceding it, as summarized in the row immediately above. For example, in Table X-6, the model for OPO factors also includes the adjustments for center factors, and the model for organ factors includes the adjustment factors for center and OPO, etc.

In Table X-6, adjustment for center factors alone reduced the difference in the RR of graft failure observed in the unadjusted models between African-Americans and Whites. Stepwise adjustments for OPO factors and organ characteristics had little incremental effect. Further stepwise adjustment for transplant factors demonstrated additional effects only for African-Americans, but no additive effect was demonstrated through adjustment for treatment protocol. With progressive adjustments for socioeconomic factors, dialysis time, and disease burden, differences in the RR of graft failure between the unadjusted and adjusted results for Hispanic/Latinos and Asians when compared with Whites increased; differences between Whites and African-Americans decreased. Taking all of the preceding adjustments into account, further adjustments for age modestly increased the differences observed between Whites and African-Americans and modestly decreased the differences between Whites and other groups. Surprisingly, once all of the other stepwise adjustments in these models are performed, the addition of demographic factors, per se, exerted no incremental effects on graft survival. In the final complete model that accounts for all of the variables listed in Table X-3, the overall adjusted RR of graft failure was 1.12 for African-Americans, 0.77 for Hispanic/Latinos, and 0.74 for Asians compared with Whites.

As discussed above, the sequentially adjusted models were tested in reverse order. These results are shown in Table X-7, and were in general similar to those seen in Table X-6. Adjustment for demographic factors had little impact on the relationships seen in the unadjusted models. Adjustment for age increased the differences observed between Whites and African-Americans and decreased the differences between Whites and other groups. Sequential adjustments for disease burden, dialysis time, socioeconomic factors, treatment protocols, and transplant factors reduced differences between Whites and African-Americans, but increased differences between Whites and the other race/ethnicity groups. Incremental adjustment for OPO slightly decreased differences in RR of graft failure between Whites and African-Americans. When all other adjustments were taken into account, there was no discernible incremental effect for center factors.

These analyses show that African-Americans have graft failure rates at 5 years that are higher than those of all other racial/ethnic groups, even after adjusting for the variables listed in Table X-3. The adjusted RR of graft failure for African-Americans compared with Whites varied from 1.07 to 1.45, depending upon the manner in which variables were incorporated into the adjusted models (Tables X-5 to X-7). The RR for Hispanic/Latinos and Asians compared with Whites varied much less across the models considered (Hispanic/Latino: unadjusted RR = 0.83, adjusted RR range 0.74 to 0.88; Asian: unadjusted RR = 0.75, adjusted RR range 0.69 to 0.81). Adjustments for demographic characteristics, other than age, and for center factors explain few of these differences. In general, those categories (age, disease burden, duration of pretransplant dialysis exposure, socioeconomic factors, and treatment protocols) that are more closely associated with individual patients have a greater effect on the RR of graft failure than do organ or transplant-related factors or variables that are more closely associated with the transplant center or OPO.

Overall, graft survival at 5 years was best for Asians and Hispanic/Latinos, intermediate for Whites, and poorest for African-Americans. These differences were not explained in their entirety by the data from the time of transplant currently available in the OPTN/SRTR database. The range of RRs when compared with Whites in the unadjusted analyses ranged from an RR of 0.75 for Asians to an RR of 1.35 in African-Americans (first line of Tables X-6 and X-7). In the fully adjusted models, this range is compressed to an RR of 0.74 for Asians and 1.12 in African-Americans (last line of Tables X-6 and X-7). Thus, the covariates explain a greater portion of the differences observed between African-Americans and Whites than between Whites and Hispanic/Latinos or between Whites and Asians (Tables X-6 and X-7). Age and duration of pretransplant dialysis exposure seem to exert the greatest effect on differential outcomes (Table X-5).

Discussion

Sizeable differences in DD kidney transplant outcomes remain unaccounted for despite adjustments for the baseline variables included in these models. It is possible that inclusion of additional baseline variables, such as more complete information on existing medical comorbidities, socioeconomic factors, histocompatibility, or measures of new or posttransplant variables (e.g., assays of metabolic pathways for immunosuppressive medications, immune competence, adherence to medical regimen, or quality indicators for posttransplant follow-up) might improve the predictive value of these analyses and explain more of the observed differences. For example, the prevalence of gene polymorphisms associated with hypertension (9) and increased inflammation or drug metabolism (10) vary across racial and ethnic groups. In addition, adjusting for posttransplant variables may have the potential to identify factors that account for some of these racial/ethnic differences and perhaps identify appropriate posttransplant intervention. It is also possible that, even with more extensive data collection, some differences may remain unexplained.

Although much of the difference in outcomes between racial/ethnic groups can be accounted for by adjusting for patient differences, the observed unadjusted differences

remain important. While the adjustments facilitate understanding of the factors that contribute to the observed outcome disparities, the differences between racial/ethnic groups in important variables may themselves reflect inequities in the kidney transplant system and merit further evaluation. For example, the disparities in age and pretransplant dialysis time between Whites and minority transplant recipients may reflect different listing practices or inequalities in access to transplantation. If so, efforts to mitigate these inequities may, in turn, reduce the gap in outcomes between racial/ethnic groups.

Summary

Access to transplantation differs between racial/ethnic groups, but the pattern of these differences varies by organ type. In unadjusted analyses, minority patients demonstrate persistent decreased access to kidney transplantation, and Whites to cardiac transplantation. Regarding liver transplants, African-American and Asians appear to have increased and growing access, while Hispanic/Latinos have decreased access. Findings of differences in access to transplant by race among those wait-listed for different types of solid organ transplants should be interpreted with caution. While ratios above or below 1.0 quantify differences in access according to race/ethnicity, specific thresholds that might constitute clinically meaningful disparities remain undefined. Further, analyses assessing difference in access did not account for potential confounders (e.g., severity of illness at time of presentation or allocation) that could affect interpretation of these observations on access to transplant.

Graft and patient outcomes also differ between racial/ethnic groups. The pattern of these differences is similar for patient survival across organs and for kidney graft survival. In general, Asians followed by Hispanic/Latinos have the best outcomes. Whites have intermediate outcomes, superior to those of African-Americans, but lagging behind those observed for Asians and Hispanic/Latinos. This trend is apparent at multiple time points after transplant and is seen with nearly all organ types.

In our analysis of kidney transplant graft loss, adjustment for a number of demographic factors could not fully explain the differences observed between racial/ethnic groups. Compared with the rates observed for White kidney transplant recipients, adjustments partially accounted for much of the increased risk of graft loss observed for African-Americans, but explained much less of the superior graft survival noted for Asians and Hispanic/Latinos. Finally, the analysis demonstrated differences in the race/ethnicity composition of the waiting list by a number of categories of variables and quantified the contribution of these variables to the outcome disparities seen between racial/ethnic groups. In the multivariate models, patient-related factors were, in general, more explanatory than center-related variables in explaining observed differences in graft survival. Further initiatives to resolve these inequities may narrow the racial/ethnic differences in outcomes after organ transplantation.

References

1. Epstein AM, Ayanian JZ, Keogh JH, Noonan SJ, Armistead N, Cleary PD, et al. Racial disparities in access to renal transplantation — clinically appropriate or due to underuse or overuse? *N Engl J Med* 2000; 343(21):1537-1544.
2. Isaacs RB, Lobo PI, Nock SL, Hanson JA, Ojo AO, Pruett TL. Racial disparities in access to simultaneous pancreas-kidney transplantation in the United States. *Am J Kidney Dis* 2000; 36(3):526-533.
3. Eckhoff DE, McGuire BM, Young CJ, Sellers MT, Frenette LR, Hudson SL, et al. Race: a critical factor in organ donation, patient referral and selection, and orthotopic liver transplantation? *Liver Transpl Surg* 1998; 4(6):499-505.
4. Press R, Carrasquillo O, Nickolas T, Radhakrishnan J, Shea S, Barr RG. Race/ethnicity, poverty status, and renal transplant outcomes. *Transplantation* 2005; 80(7):917-924.
5. Mehra MR, Uber PA, Scott RL, Park MH. Ethnic disparity in clinical outcome after heart transplantation abrogated using tacrolimus and mycophenolate mofetil-base immunosuppression. *Transplantation* 2002; 74(11):1568-1573.
6. Rogers J, Baliga PK, Chavin KD, Lin A, Emovon O, Afzal F, et al. Effect of ethnicity on outcome of simultaneous pancreas and kidney transplantation. *Am J Transplant* 2003; 3(10):1278-1288.
7. Levine GN, McCullough KP, Rodgers AM, Dickinson DM, Ashby VB, Schaubel DE. Analytical methods and database design: Implications for transplant researchers, 2005. *Am J Transplant* 2006; 6: 1228-1242.
8. http://www.ustransplant.org/annual_reports/current/Tech_Notes_AR_CD.htm2004. In: Annual Report of the U.S. Organ Procurement and Transplantation Network and the Scientific Registry of Transplant Recipients: Transplant Data 1994-2003. Department of Health and Human Services, Health Resources and Services Administration, Healthcare Systems Bureau, Division of Transplantation, Rockville, MD; United Network for Organ Sharing, Richmond, VA; Arbor Research Collaborative for Health, Ann Arbor, MI. Accessed Nov. 4, 2009.
9. Israni AK, Li N, Sidwani S, Rosas S, Kong X, Joffe M et al. Association of hypertension genotypes and decline in renal function after kidney transplantation. *Transplantation* 2007; 84(10):1240-1247.
10. Girnita DM, Webber SA, Ferrell R, Burckart GJ, Brooks MM, McDade KK, et al. Disparate distribution of 16 candidate single nucleotide polymorphisms among racial and ethnic groups of pediatric heart transplant patients. *Transplantation* 2006; 82(12):1774-1780.