Racial and Ethnic Disparities in Graft and Patient Survival Among Elderly Kidney Transplant Recipients

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ABSTRACT

Background/Objectives: The rise in the number of elderly kidney transplant recipients over the past decade makes it increasingly important to understand factors affecting post-transplant outcomes in this population. Our objective was to investigate the racial/ethnic differences in graft and patient survival among elderly kidney transplant recipients.

Design: Retrospective Cohort.

Setting & Participants: All first-time, kidney-only transplant recipients≥ 60 years of age at transplantation in the United Network for Organ Sharing (UNOS) database, transplanted between July 1996 and October 2010, N=44,013.

Measurements: Time to graft failure and death obtained from the UNOS database and linkage to the Social Security Death Index. Neighborhood poverty from 2000 U.S. Census geographic data.

Results: Of the 44,013 recipients in the sample, 20% were African American, 63% non-Hispanic white, 11% Hispanic, 5% Asian and the rest "other racial groups". In adjusted Cox models, we found that compared to whites, African Americans were more likely to experience graft failure (HR: 1.23, 95%CI: 1.15, 1.32), while Hispanics, (HR: 0.77, 95%CI: 0.70, 0.85) and Asians (HR: 0.70, 95%CI: 0.61, 0.81) were less likely to experience graft failure. Secondly, compared to whites, African Americans (HR: 0.84, 95%CI: 0.80, 0.88), Hispanics (HR: 0.68, 95%CI: 0.64, 0.72), and Asians (HR: 0.62, 95%CI: 0.57, 0.68) all were less likely to die after renal transplantation.

Conclusion: Elderly African Americans are at increased risk of graft failure compared to white transplant recipients, but survive longer after transplantation. Asians have the highest patient and graft survival followed by the Hispanics. Further studies are needed to assess additional factors affecting graft and patient survival including outcomes such as quality of life.

INTRODUCTION

Over the past decade, the number of elderly patients living with End Stage Renal Disease (ESRD) has increased, with about 48% of the ESRD population now over the age of 60 (1, 2). Similarly, the number of kidney transplant recipients who are over age 65 has increased from 2.4% to 16% over the past two decades (3-6). Kidney transplantation is the preferred treatment for most patients with ESRD because it offers increased patient survival and improved quality of life as compared to dialysis for both younger and older recipients (2, 7, 8).

The rise in the number of older kidney transplant recipients makes it increasingly important to understand the factors affecting graft and patient survival in the elderly population. Race has been shown to be an important factor affecting graft and patient survival in kidney transplant recipients (9-11). In the general population, African American kidney transplant recipients have been shown to have worse graft and patient survival compared to white recipients for living and deceased donor transplants (10-14). However, it is not known if the racial differences in graft and patient survival in the general kidney transplant population is also seen among the elderly transplant recipient population. A consensus workshop held on organ transplantation in the elderly emphasized the critical need to identify factors underlying disparities in transplant outcomes in the elderly (15). Understanding the role of race and other factors in graft and patient survival in the elderly is crucial in reducing disparities and improving outcomes in this unique patient population

The purpose of this study was to evaluate the association of race/ethnicity with graft and patient survival following transplantation among elderly (age >60) kidney transplant recipients. We also aimed to determine potentially modifiable factors that may be associated with graft and patient survival in the elderly kidney transplant population. We hypothesized that, consistent with results in the general kidney transplant recipient population, elderly African Americans would have worse graft and patient survival compared to white recipients and Asians and Hispanics would have better graft and patient survival compared to white recipients.

METHODS

Data Sources

Data was obtained from three databases: the United Network for Organ Sharing (UNOS), Social Security Death Index (SSDI) and US Census geographic data for year 2000. UNOS is a private organization contracted by the government to manage the transplant waiting list, match donors to recipients, and maintain information about every transplant recipient in the U.S. including follow-up data. The SSDI database is a publicly available national database of death records extracted from the U.S. Social Security Administration's Death Master File. The Census 2000 data on neighborhood poverty were linked to the recipient's residential zip codes in the UNOS data using zip code tabulation areas.

Data from UNOS was merged with death date information from the SSDI using unique encrypted recipient codes to calculate post-transplant survival time.

Study Population

Our study population was drawn from the Organ Procurement and Transplantation Network (OPTN) data received from UNOS. We restricted our population to kidney transplant recipients aged 60 and older who were transplanted between July 1996 and October 2010. Patients were followed for outcomes through December 2011. A total of 44,013 patients were included in our analysis.

Measures

The main study outcomes were time from kidney transplantation until death (patient survival time) and time from kidney transplantation until graft failure (graft survival time). People who did not experience any of the two study outcomes were censored at the end of the follow-up period (December 31, 2011). In the analysis of graft survival, recipients who died before graft failure occurred were censored at the time of death (i.e. death with a functioning graft was censored rather than treated as graft failure). This was done in an attempt to capture only those with a recorded graft failure event, since death could be a result of multiple causes and not just a failed allograft.

The primary variable of interest was recipient race/ethnicity (self-reported in most cases or as assessed by the transplant center coordinator). Race/ethnicity was classified into five groups: Black/African American, White, Hispanic, Asian and Other. Recipient demographic factors examined included age at transplant and sex. Primary health insurance at transplantation and neighborhood poverty were considered proxies for socio-economic status (SES). Insurance was categorized as private, public (Medicaid, Medicare Fee for Service, Medicare & Choice, Department of VA, Other government insurance and Medicare (further detail not collected)) or Other (self, donation, free care, pending). The proportion of individuals residing below the federal poverty level in each 5-digit zip code was used to estimate the neighborhood poverty level using the 2000 U.S Census Bureau data. High neighborhood poverty were defined as areas in which more than 20% of the households were assigned below the federal poverty level (16).

Additional covariates of interest included recipient clinical characteristics including: the primary assigned cause of ESRD; categorized into five major groups (diabetes, hypertension, cystic kidney disease, glomerulonephritis and other) and years on dialysis defined as the number

of years on dialysis prior to transplantation. Donor characteristics assessed included age and type of donor kidney (living or deceased) and for deceased donor whether the implanted allograft was a standard criteria or extended criteria donor (ECD).

Transplant characteristics were also assessed as covariates as described below. In order to account for changes in kidney transplantation practices over time such as immunosuppression medications and allocation systems, a covariate for the year of kidney transplantation was created and then categorized into three time periods; 1996-2000, 2001-2005 and 2006-2010. Other transplant factors evaluated were HLA mismatch, cold ischemia time and reported incidence of any acute rejection. An individual was classified as having experienced an acute rejection episode if they were reported in UNOS to have experienced acute, or hyper-acute rejection prior to graft failure or any episode of acute rejection recorded (whether or not they were treated for it) or if they had a kidney biopsy that confirmed acute rejection. Recipient age, donor age and cold ischemic time were analyzed as continuous variables.

Analysis

We performed a retrospective cohort analysis of the UNOS database. Kaplan-Meier product-limit curves were generated and stratified by race/ethnicity and we calculated log-rank statistics for differences between groups. All predictor variables were evaluated for adherence to the proportional hazards assumption using log-log survival curves, an extended Cox approach using time dependent variables, and a correlation analysis between Schoenfeld residuals and ranked follow-up time.

To evaluate the effect of race/ethnicity on patient and graft survival, separate multivariable Cox proportional hazard regression models were constructed for graft and patient survival time as a function of race/ethnicity. Crude and adjusted hazard ratios, along with 95% confidence intervals (CI), were computed for race/ethnicity and for all other covariates. Effect estimates for continuous variables, such as recipient age, donor age, years on dialysis and cold ischemia time, were calculated for a 10-unit change. Variables were considered to be confounders if they were associated with the exposure, race/ethnicity and the outcomes; graft failure and death. Employment was excluded because more than 30% of the variables were missing. We used the fully conditional specification method of multiple imputation for other missing covariate information (n=15,903 individuals) (17). For sensitivity analysis, we also conducted a complete case analysis. Our final model was adjusted for recipient age, gender,

insurance, ESRD etiology, years on dialysis, neighborhood poverty level, donor type, donor age, period of transplantation, cold ischemia time, HLA mismatch and any acute rejection. All analyses were conducted using SAS 9.4 and data were evaluated at the 0.05 significance level.

Approval for this study was obtained from the Emory University IRB (#IRB00065148).

RESULTS

Table 1 shows the baseline demographic and clinical characteristics of patients in our sample stratified by racial/ethnic groups. Of the 44,013 transplant recipients analyzed, the median age was 65 (inter-quartile range = 7.0). The population was predominantly male (62.5%) and white (62.4%). Diabetes was the most common cause of ESRD (33.7%) among all races/ethnicities except African Americans, where it was hypertension (40.0%). African Americans had the highest percentage of acute rejection episodes (11.8%); pre-transplant dialysis (93.9%) and non-ECD kidneys (55.2%). Asians received the largest percentage of ECD kidneys (31.5%). Hispanics had the largest (41.1%) and whites had the lowest (7.8%) percentage of people living in the high neighborhood poverty areas.

Graft survival

Race/Ethnicity

A total of 14.1% of patients experienced a graft failure event over the median of 4.3 years of follow up (IQR 2.2 - 7.0 years), and a greater proportion of African Americans had graft failure compared to whites, Hispanics, and other races (19.2% vs. 13%, 11.6%, and 16.6%) respectively. Table 2 depicts the crude and adjusted hazard ratios for graft failure for all the covariates examined. Compared to whites, African Americans were more likely to experience graft failure (HR: 1.23, 95%CI: 1.15, 1.32) while Hispanics (HR: 0.77, 95%CI: 0.70, 0.85) and Asians (HR: 0.70, 95%CI: 0.61, 0.81) were less likely to experience graft failure after adjusting for covariates (Table 2).

Recipient Demographics

Compared to those with private insurance, recipients with public/other insurance were more likely to experience graft failure after adjusting for covariates (HR:1.09, 95%CI: 1.03, 1.16). Compared to those with low neighborhood poverty, those with high neighborhood

poverty were more likely to experience graft failure, (HR: 1.25, 95%CI 1.18, 1.33) in the crude model but this association was not significant in the adjusted model (1.06, 0.99, 1.14).

Recipient Clinical Characteristics

After adjusting for covariates, compared to diabetics, patients with cystic kidney disease (HR: 0.65, 95%CI: 0.59, 0.73) and glomerulonephritis (HR: 0.84, 95%CI: 0.77, 0.91) were less likely to experience graft failure. Hypertension was not associated with graft failure (HR: 0.95, 95%CI 0.89, 1.02). A 10-year increase in years on dialysis was associated with a 27% higher risk of graft failure (HR: 1.27, 95%CI: 1.17, 1.38) (Table 2).

Donor Characteristics

Compared to persons who received living donor kidneys, those who received a deceased non-ECD kidneys (HR: 1.38, 95%CI: 1.26, 1.51) and those who received ECD kidneys (HR: 1.78, 95%CI: 1.61, 1.97) were more likely to experience graft failure (Table 2). A 10-year increase in donor age, was associated with a 16% higher risk of graft failure (HR: 1.16, 95%CI: 1.13, 1.19) in the adjusted models.

Transplant Characteristics

Compared to individuals transplanted between 1996 and 2000, recipients transplanted between 2001 and 2005 were less likely to experience graft failure in the crude model (HR: 0.89, 95%CI: 0.84, 0.95) but in the adjusted model, the HR was not statistically significant (HR: 0.94, 95%CI: 0.88, 1.01). Those transplanted between 2006 and 2010 were also less likely to experience graft failure when compared to those transplanted between 1996 and 2000, both in crude (HR: 0.74, 95%CI: 0.69, 0.80) and adjusted models (HR: 0.74, 95%CI: 0.69, 0.80).

Having 2 or more HLA mismatches was significantly associated with a higher likelihood of graft failure compared to zero HLA mismatches.

Recipients who experienced any acute rejection episode were significantly more likely to have graft failure compared to those without an acute rejection episode in crude (HR: 2.53; 95%CI: 2.38, 2.69) and adjusted models (HR: 2.25, 95%CI: 2.11, 2.40).

Figure 1 shows Kaplan-Meier estimates for unadjusted graft survival comparing African Americans, Hispanics and Asians to whites among elderly renal transplant recipients from July 1996 to October 2010 with a follow up until December 2011 (median follow up of 4.3 years).

Patient Survival

Race/Ethnicity

A total of 37.4% of patients died over the median of 4.6 years of follow up (IQR 2.5-7.3years), and a greater proportion of whites died compared to African Americans, Hispanics, and other races (38.8% vs. 37.7%, 32.3%, and 27.6%), respectively. The median survival time for all patients in our study population was 9.1 years, in whites it was 8.8 years, African Americans at 8.9 years, Asians at 11.3 years, Hispanics at 10.3 years and persons of other race/ethnicities at 8.7 years. Table 2 depicts the crude and adjusted hazard ratios for patient death by race and other covariates examined. Compared to whites, African Americans (HR: 0.84, 95%CI: 0.80, 0.88), Hispanics (HR: 0.68, 95%CI: 0.64, 0.72), and Asians (HR: 0.62, 95%CI: 0.57, 0.68) all had a lower likelihood of death.

Recipient Demographics

Compared to females, male recipients had a 15% higher likelihood of death (HR: 1.15, 95%CI: 1.11, 1.19). Compared to those with private insurance, recipients with public insurance had a 15% higher likelihood of death (HR: 1.15, 95%CI: 1.11, 1.19) in the adjusted model. A 10-year increment in recipient age was associated with a 55% (HR: 1.55, 95%CI: 1.50, 1.60) and 47% (HR: 1.47, 95%CI: 1.42, 1.52) higher rate of death in the crude and adjusted models, respectively. Neighborhood poverty was not associated patient survival (HR1.01, 95%CI: 0.97, 1.06).

Recipient Clinical Characteristics

After adjusting for covariates, recipients with hypertension as the primary etiology of ESRD (HR: 0.72, 95%CI: 0.69, 0.75), cystic kidney disease (HR: 0.43, 95%CI: 0.40, 0.46) and glomerulonephritis (HR: 0.54, 95%C.I: 0.51, 0.57) had a lower likelihood of death compared to persons with diabetes. A 10-year increase in years on dialysis, was associated with a 39% higher likelihood of death (HR: 1.39, 95%CI: 1.33, 1.45). Having 3 or more HLA mismatches was significantly associated with a higher likelihood of death compared to those with zero HLA mismatches.

Donor Characteristics

Persons who received deceased non-ECD kidneys (HR: 1.33, 95%CI: 1.25, 1.41) and more so, those who received deceased ECD kidneys (HR: 1.42, 95%CI: 1.33, 1.52) were at a higher risk of death compared to those who received living donor kidneys (Table 2). A 10-year increase in donor age was associated with a 6% higher likelihood of death (HR: 1.06, 95%CI: 1.05, 1.08).

Transplant Characteristics

Compared to individuals transplanted from 1996-2000, those transplanted from 2001 - 2005 (HR: 0.86, 95%CI: 0.83, 0.90) and 2006-2010 (HR: 0.66, 95%CI: 0.63, 0.70) all had a lower likelihood of death. Persons who experienced any acute rejection episode had a higher likelihood of death in the crude (HR: 1.35, 95%CI: 1.29, 1.41) and adjusted (HR: 1.26, 95%CI: 1.20, 1.32) model. Figure 2 a-c shows Kaplan-Meir estimates for unadjusted patient survival in African Americans, Hispanics and Asians compared to whites respectively over a median follow up of 4.6 years.

Using complete case analysis, multivariable results for effect of race/ethnicity on patient or graft survival did not differ significantly from the main analysis, similarly, stratifying by age did not yield significant differences in trends for patient and graft survival in ages 60-70 vs >70 (supplemental tables 1 & 2).

DISCUSSION

This study sought to evaluate the effect of race/ethnicity on graft and patient survival among elderly (age >60) kidney transplant recipients and also to determine other factors that may be associated with graft and patient survival. A consensus paper on organ transplantation in the elderly observed that there was lack of data addressing age in minority and non-minority transplant recipients and stressed the need for studies identifying biologic, behavioral, and social mechanisms contributing to long- term post-transplant outcomes in the elderly (15).

The major findings in this study were, compared to whites, African Americans were more likely to experience graft failure (HR: 1.23, 95%CI: 1.15, 1.32), while Hispanics, (HR: 0.77, 95%CI: 0.70, 0.85) and Asians (HR: 0.70, 95%CI: 0.61, 0.81) were less likely to experience graft failure. Secondly, compared to whites, African Americans (HR: 0.84, 95%CI: 0.80, 0.88), Hispanics (HR: 0.68, 95%CI: 0.64, 0.72), and Asians (HR: 0.62, 95%CI: 0.57, 0.68) all were less likely to die after renal transplantation. These results indicate that race/ethnicity may be an independent risk factor for graft failure in the elderly, but does not necessarily impact patient survival in the same manner. Our findings support previous studies in the general kidney transplant population showing superior patient and graft survival in Hispanics (18-20), and Asians (21) and worse graft survival in African Americans compared to whites (9, 11, 22).

Although patient survival has been shown to be equivalent (11, 23) or worse (10, 24, 25) in blacks versus non-blacks, we demonstrate higher patient survival in African Americans aged 60 and above compared to whites.

Previous studies have shown that the half-life of renal allografts after transplantation appears to be 30%-40% shorter in African Americans compared to whites (10, 26). In pediatric transplant recipients, Patzer et al showed that African Americans had the lowest graft survival rates prior to the three-year mark when Medicare eligibility ends (27). One may speculate that biological factors more than socio-economic factors affect graft loss in the elderly African Americans since these patients remain eligible for Medicare even after 3-years post-transplant and are better able to afford immunosuppression medication.

Our results on graft survival support the "Hispanic paradox" which has shown that although Hispanics have similarly low SES as African Americans, they have comparable or lower mortality rates than non-Hispanic whites in the US (18, 28). This paradox is described in the transplant population and hypothesized to be related to age, occurring predominantly in middle-aged and older Hispanics (18, 29, 30). Previous studies showed that characteristics of individual neighborhoods may have a vital but underappreciated impact on health outcomes even above individual-level SES (31-34). This study showed that insurance but not neighborhood poverty was associated with graft and patient survival. However, SES is complex and multifactorial and may not be fully represented by a single variable (34, 35). Therefore, an observed racial/ethnic disparity may not be completely independent of SES, (36) neither can these differences be completely accounted for by socioeconomic issues (37-39). In addition to psycho-social factors and access to care, other biological factors such as genetic, immune and pharmacokinetic factors can contribute to poorer graft outcomes in African Americans.

Our findings differ from previous studies which showed no difference in five-year patient survival rates between African Americans and white recipients (11). Foster et al. also found no significant difference in one and five year patient survival rates in African American and non-African Americans for both living and deceased donor kidney transplants (23). Our study showed that patients receiving ECD kidneys have the highest likelihood of death in the elderly (40, 41). This may be explained by increased immunosuppression use and a higher rate of acute rejection which also contributes to heightened immunosuppression and thus, more deaths (40).

African Americans, Hispanics and Asians were less likely to die after renal transplantation compared to whites, however; African Americans had worse graft survival than whites. We do not know the reason for this paradox, however, one possible explanation is that African Americans and Hispanics who are selected for transplant may have a lower cardiovascular disease burden and less severe co-morbidities compared to whites thus creating a survival bias as the healthiest candidates are being presented for transplantation. It has also been suggested that older, sicker Hispanics return to their country of origin resulting in less reported deaths (42, 43). On the other hand, heightened immunologic response to the allograft may cause a higher rate of graft loss in African Americans (44-47) but not necessarily lead to an increased risk of death. It is interesting to note that a survival paradox also exists in Hispanics and older non-Hispanics blacks on dialysis. Compared to non-Hispanic whites, Yan et al found that Hispanic dialysis patients had the lowest mortality risk, followed by non-Hispanic blacks above 30 years (48). Rhee et al found that Hispanics on dialysis had lower mortality compared to whites in all age groups but in blacks the lower mortality was only evident over the age of 40 years (42).

Hypertension was the leading cause of ESRD among African American recipients supporting previous studies showing that blacks are more likely to be labelled as having hypertensive renal disease even when other causes for ESRD exist (49, 50).

Our study is limited by its retrospective nature and the inability to adjust for unknown or unmeasured confounders. The acute rejection variable may not have captured everyone with an acute rejection. Also, according to UNOS, as of November, 2011, the percentage of deaths accessible in the SSDMF data decreased significantly due to data release issues with the Social Security Administration. As such, persons who died during the last month of follow up in our study, i.e. between November 2011 and December 2011, might not have been accurately captured. In addition, since we were interested in actual records of graft failure, recipients who died with a functioning graft were censored and not counted as failed grafts, even though it is possible that incipient graft failure was the reason for death. A unique strength of our study is the fact that we examined all persons in the UNOS database who received a transplant during the specified period and thus our results are representative of the elderly US transplant population.

Conclusion

In elderly transplant recipients, compared to whites, African Americans, Hispanics and Asians had higher patient survival, but only African Americans had worse graft survival relative to whites. Further studies may be needed to identify specific immunologic and non-immunological factors such as currently unmeasured socio-economic effects that may be implicated in graft loss. Identifying potentially novel factors that may explain these differences is essential in order to improve graft survival in the elderly and ensure equity in outcomes across all racial/ethnic groups.

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Author Contributions

The author responsibilities were as follows: Titilayo O. Ilori, William McClellan and Rachel Patzer designed the research study. Titilayo O. Ilori was responsible for writing the manuscript and had full access to all of the data in the study and takes primary responsibility for the integrity of the data, accuracy of the data analysis and final content of the manuscript. Demilade Adedinsewo, Nosayaba Enofe and Titilayo O. Ilori performed the data analysis; Demilade Adedinsewo, Oluwaseun Odewole, Nosayaba Enofe, Akinlolu Ojo, William McClellan and Rachel Patzer participated in writing the manuscript. All authors read and approved the final manuscript for submission.

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Table 1. Baseline Characteristics of Elderly (≥60 years) Renal Transplant Recipients from July 1996 - October 2010 By Race/Ethnicity

Characteristic		Overall- n (%)	White- n (%)	Black- n (%)	Hispanic- n (%)	Asian- n (%)	Other- n (%)
		44,013 (100)	27,481 (62.4)	8,903 (20.2)	4,669 (10.6)	2,095 (4.8)	865 (2.0)
Recipient Demographics							
Recipient Age	Median (IQR)	65 (7.0)	65 (7.0)	64 (6.0)	64 (6.0)	65 (6.0)	64 (5.0)
Gender	Male	27,512 (62.5)	17,669 (64.3)	5,128 (57.6)	2,957 (63.3)	1,238 (59.1)	520 (60.1)
	Total	44,013	27,481	8,903	4,669	2,095	865
Insurance Type[#]	Private	13,585(31.1)	9,407(34.3)	2,183(24.5)	1,097(23.5)	1,664(31.7)	234(27.1)
	Public or other	30,394(68.9)	18,050(65.77)	6,716(75.5)	3,568(76.5)	1,429(68.3)	631(72.9)
	Total	43,979	27,457(100)	8,899(100)	4,665(100)	2,093(100)	865(100)
Neighborhood Poverty[#]	>20% (high)	7,653 (17.39)	2,008 (7.56)	3,267 (37.83)	1,835 (41.08)	245 (12.09)	298 (35.65)
	≤20% (low)	34,858 (79.20)	24,536 (92.44)	5,370 (62.17)	2,632 (58.92)	1,782 (87.91)	538 (64.35)
	Total	42,511	26,437	8,623	4,456	2,022	833
Employment[#]	No	19,393 (81.1)	11,341 (77.9)	4,212 (86.2)	2,417 (88.1)	1,053 (82.0)	370 (84.7)
	Yes	4,513 (18.9)	3,211 (22.1)	676 (13.8)	328 (11.9)	231 (18.0)	67 (15.3)
	Total	23,906	14,552	4,888	2,745	1,284	437
Recipient Clinical Characteristics							
ESRD Etiology[#]	Diabetes	13,488 (33.7)	6,759 (27.8)	3,233 (38.1)	2,225 (50.8)	782 (38.9)	489 (60.4)
	Hypertension	10,039 (25.1)	5,082 (20.9)	3,389 (40.0)	935 (21.4)	503 (25.0)	130 (16.0)
	Cystic kidney Disease	3,598 (9.0)	2,964 (12.2)	290 (3.4)	228 (5.2)	91 (4.5)	25 (3.1)
	Glomerulonephritis	6,128 (15.3)	4,536 (18.6)	703 (8.3)	469 (10.7)	321 (16.0)	99 (12.2)
	Other	6,774 (16.9)	5,011 (20.6)	862 (10.2)	519 (11.9)	315 (15.7)	67 (8.3)
	Total	40,027	24,352	8,477	4,376	2,012	810
Pre-transplant Dialysis[#]	No	6,122 (13.9)	5,045 (18.4)	545 (6.1)	294 (6.3)	178 (8.5)	60 (7.0)
	Yes	37,848 (86.1)	22,408 (81.6)	8,355 (93.9)	4,366 (93.7)	1,916 (91.5)	803 (93)
	Total	43,970	27,453	8,900	4,660	2,094	863
Years on Dialysis[#]	Median (IQR)	2.47 (2.81)	2.02(2.29)	3.44(3.27)	3.15(3.30)	3.09(3.11)	3.35(3.09)
Donor Characteristics							
Type of Donor[#]	Living	13,212 (30.0)	9,761 (35.5)	1,588 (17.8)	1,234 (26.4)	422 (20.1)	207 (23.9)
	Deceased (non-ECD)	21,387 (48.6)	12,646 (46.0)	4,914 (55.2)	2,375 (50.9)	1,014 (48.4)	438 (50.6)
	ECD- Cadaveric	9,412 (21.4)	5,073 (18.5)	2,400 (27)	1,060 (22.7)	659 (31.5)	220 (25.4)
	Total	44,011	27,480	8,902	4,669	2,095	865

Donor Age	Mean (SD)	43.2 (16.0)	43.3 (15.7)	43.1 (16.4)	42.2 (16.0)	44.7 (17.6)	43.4 (16.0)
Transplant Characteristics							
Period of Transplant	1996-2000	8,389 (19.1)	5,546 (20.2)	1,614 (18.1)	775 (16.6)	282 (13.5)	172 (19.9)
	2001-2005	15,210 (34.6)	9,606 (35)	2,960 (33.2)	1,626 (34.8)	688 (32.8)	330 (38.2)
	2006-2010	20,414 (46.4)	12,329 (44.9)	4,329 (48.6)	2,268 (48.6)	1,125 (53.7)	363 (42)
	Total	44,013	27,481	8,903	4,669	2,095	865
HLA Mismatch[#]	Zero	3,897 (8.9)	3,046 (11.1)	294 (3.3)	419 (9.0)	80 (3.8)	58 (6.7)
	One	1,901 (4.3)	1,446 (5.3)	222 (2.5)	157 (3.4)	46 (2.2)	30 (3.5)
	Two	4,605 (10.5)	3,300 (12.1)	609 (6.9)	470 (10.1)	142 (6.8)	84 (9.7)
	Three	8,535 (19.5)	5,834 (21.3)	1,411 (15.9)	880 (18.9)	254 (12.2)	156 (18.1)
	Four	8,948 (20.4)	5,342 (19.5)	2,003 (22.6)	950 (20.4)	479 (23.0)	174 (20.1)
	Five	10,402 (23.7)	5,557 (20.3)	2,745 (30.9)	1,184 (25.5)	691 (33.2)	225 (26.0)
	Six	5,536 (12.6)	2,827 (10.3)	1,590 (17.9)	591 (12.7)	391 (18.8)	137 (15.9)
	Total	43,824	27,352	8,874	4,651	2,083	864
Cold Ischemia Time	Median (IQR)	15 (18.0)	14 (19.0)	16.3 (13.0)	15.5 (15.0)	15 (14.3)	14 (13.5)
Any Acute Rejection	No	39,577 (89.9)	24,698 (89.9)	7,852 (88.2)	4,289 (91.9)	1,956 (93.4)	782 (90.4)
	Yes	4,436 (10.1)	2,783 (10.1)	1,051 (11.8)	380 (8.1)	139 (6.6)	83 (9.6)
	Total	44,013	27,481	8,903	4,669	2,095	865

Missing data insurance type=0.08%, neighborhood poverty=3.41%, employment =46%, ESRD etiology =9.06%, pre-transplant dialysis=0.01%, years on dialysis= 20.24%, donor type=0.004%, HLA mismatch=0.43%, cold ischemia time = 7.88%. * Significant p value <0.05, ECD = Extended criteria donor, IQR= Interquartile range, ESRD = End Stage Renal Disease, HLA= Human Leukocyte Antigen, hrs. =hours.

Table 2- Unadjusted and Adjusted Hazard Ratios for Death and Graft Failure among Elderly (≥60 years) Renal Transplant Recipients from July 1996 - October 2010 by Race/Ethnicity

Characteristic		Death		Graft Failure	
		Crude HR (95% CI)	**Adjusted HR (95% CI)**	**Crude HR (95% CI)**	**Adjusted HR (95% CI**
Recipient Demographics					
Race/Ethnicity	White	Ref	Ref	Ref	Ref
	African American	1.02 (0.98, 1.07)	**0.84 (0.80, 0.88)**	**1.60 (1.51, 1.69)**	**1.23 (1.15, 1.32)**
	Hispanic	**0.81 (0.76, 0.86)**	**0.68 (0.64, 0.72)**	**0.89 (0.81, 0.98)**	**0.77 (0.70, 0.85)**

	Asian	**0.71 (0.65, 0.78)**	**0.62 (0.57, 0.68)**	**0.85 (0.74, 0.97)**	**0.70 (0.61, 0.81)**
	Other	1.02 (0.92, 1.14)	**0.82 (0.74, 0.92)**	**1.27 (1.08, 1.50)**	1.05 (0.88, 1.25)
Recipient Age [a]		**1.55 (1.50, 1.60)**	**1.47 (1.42, 1.52)**	1.02 (0.96, 1.08)	0.94 (0.89, 1.00)
Gender	Female	Ref	Ref	Ref	Ref
	Male	**1.23 (1.19, 1.27)**	**1.15 (1.11, 1.19)**	**1.07 (1.02, 1.13)**	1.04 (0.98, 1.09)
Insurance Type	Private	Ref	Ref	Ref	Ref
	Public and other	**1.39 (1.34, 1.44)**	**1.15 (1.11, 1.19)**	**1.26 (1.19, 1.33)**	**1.09 (1.03, 1.16)**
Neighborhood Poverty	≤20% (low poverty)	**Ref**	**Ref**	**Ref**	**Ref**
	>20% (high poverty)	1.03 (0.99, 1.07)	1.01 (0.97, 1.06)	**1.25 (1.18, 1.33)**	1.06 (0.99, 1.14)
Recipient Clinical Characteristics					
ESRD Etiology	Diabetes	Ref	Ref	Ref	Ref
	Hypertension	**0.79 (0.76, 0.82)**	**0.72 (0.69, 0.75)**	1.05 (0.98, 1.12)	0.95 (0.89, 1.02)
	Cystic kidney Disease	**0.46 (0.43, 0.50)**	**0.43 (0.40, 0.46)**	**0.66 (0.59, 0.73)**	**0.65 (0.59, 0.73)**
	Glomerulonephritis	**0.59 (0.56, 0.62)**	**0.54 (0.51, 0.57)**	**0.82 (0.75, 0.89)**	**0.84 (0.77, 0.91)**
	Other	**0.76 (0.72, 0.80)**	**0.67 (0.64, 0.70)**	0.95 (0.88, 1.03)	0.93 (0.87, 1.01)
Years on Dialysis[b]		**1.39 (1.33, 1.46)**	**1.39 (1.33, 1.45)**	**1.49 (1.39, 1.59)**	**1.27 (1.17, 1.38)**
Donor Characteristics					
Type of Donor	Living	Ref	Ref	Ref	Ref
	Deceased non-ECD	**1.43 (1.38, 1.49)**	**1.33 (1.25, 1.41)**	**1.54 (1.44, 1.65)**	**1.38 (1.26, 1.51)**
	Deceased - ECD-	**1.88 (1.80, 1.97)**	**1.42 (1.33, 1.52)**	**3.06 (2.85, 3.28)**	**1.78 (1.61, 1.97)**
Donor Age[a]		**1.09 (1.08, 1.10)**	**1.06 (1.05, 1.08)**	**1.25 (1.23, 1.27)**	**1.16 (1.13, 1.19)**
Transplant Characteristics					
Period of Transplant	1996-2000	Ref	Ref	Ref	Ref
	2001-2005	**0.88 (0.85, 0.92)**	**0.86 (0.83, 0.90)**	**0.89 (0.84, 0.95)**	0.94 (0.88, 1.01)
	2006-2010	**0.73 (0.69, 0.76)**	**0.66 (0.63, 0.70)**	**0.74 (0.69, 0.80)**	**0.74 (0.69, 0.80)**
HLA Mismatch	Zero	Ref	Ref	Ref	Ref
	One	1.05 (0.97, 1.15)	**1.10 (1.01, 1.20)**	0.99 (0.84, 1.17)	1.04 (0.87, 1.23)
	Two	**0.93 (0.86, 1.00)**	1.07 (0.99, 1.15)	1.06 (0.93, 1.20)	**1.16 (1.01, 1.33)**
	Three	1.00 (0.94, 1.07)	**1.10 (1.03, 1.17)**	1.22 (1.09, 1.37)	**1.25 (1.11, 1.40)**
	Four	**1.16 (1.09, 1.23)**	**1.12 (1.05, 1.20)**	**1.68 (1.50, 1.88)**	**1.35 (1.20, 1.51)**
	Five	**1.19 (1.12, 1.27)**	**1.15 (1.08, 1.22)**	**1.76 (1.58, 1.96)**	**1.39 (1.24, 1.56)**
	Six	**1.22 (1.14, 1.31)**	**1.18 (1.10, 1.26)**	**1.99 (1.77, 2.23)**	**1.52 (1.34, 1.71)**

		1.14 (1.12, 1.15)	1.03 (1.01, 1.05)	1.21 (1.19, 1.24)	1.08 (1.05, 1.11)
Cold Ischemia Time[c]					
Any Acute Rejection	No	Ref	**Ref**	Ref	Ref
	Yes	1.35 (1.29, 1.41)	1.26 (1.20, 1.32)	2.53 (2.38, 2.69)	2.25 (2.11, 2.40)

[a] Effect estimate calculated for a 10-year change in age. [b] Effect estimate calculated for a 10-year change in time on dialysis [c] Effect estimate calculated for a 10-hr change in time ischemia time. HR-Hazard ratio, Bold numbers represent statistically significant estimates Adjusted model adjusted for race/ethnicity, any acute rejection, ESRD etiology, Gender, HLA mismatch, pre-transplant dialysis, type of donor, recipient age, donor age and cold ischemia time, insurance and period of transplantation HR- Hazard ratio, Bold numbers represent statistically significant estimates.

Figure Legends

Figure 1: Kaplan-Meier estimates showing Unadjusted Graft Survival among Elderly Renal Transplant Recipients from July 1996 - October 2010 with recipient follow-up until December 2011

Figure 2: Kaplan-Meier estimates showing Unadjusted Patient Survival among Elderly Renal Transplant Recipients from July 1996 - October 2010 with recipient follow-up until December 2011

Figure 1: Graft Survival among Elderly (≥60 years) U.S. Renal Transplant Recipients from July 1996 to October 2010 with Follow-up through December 2011
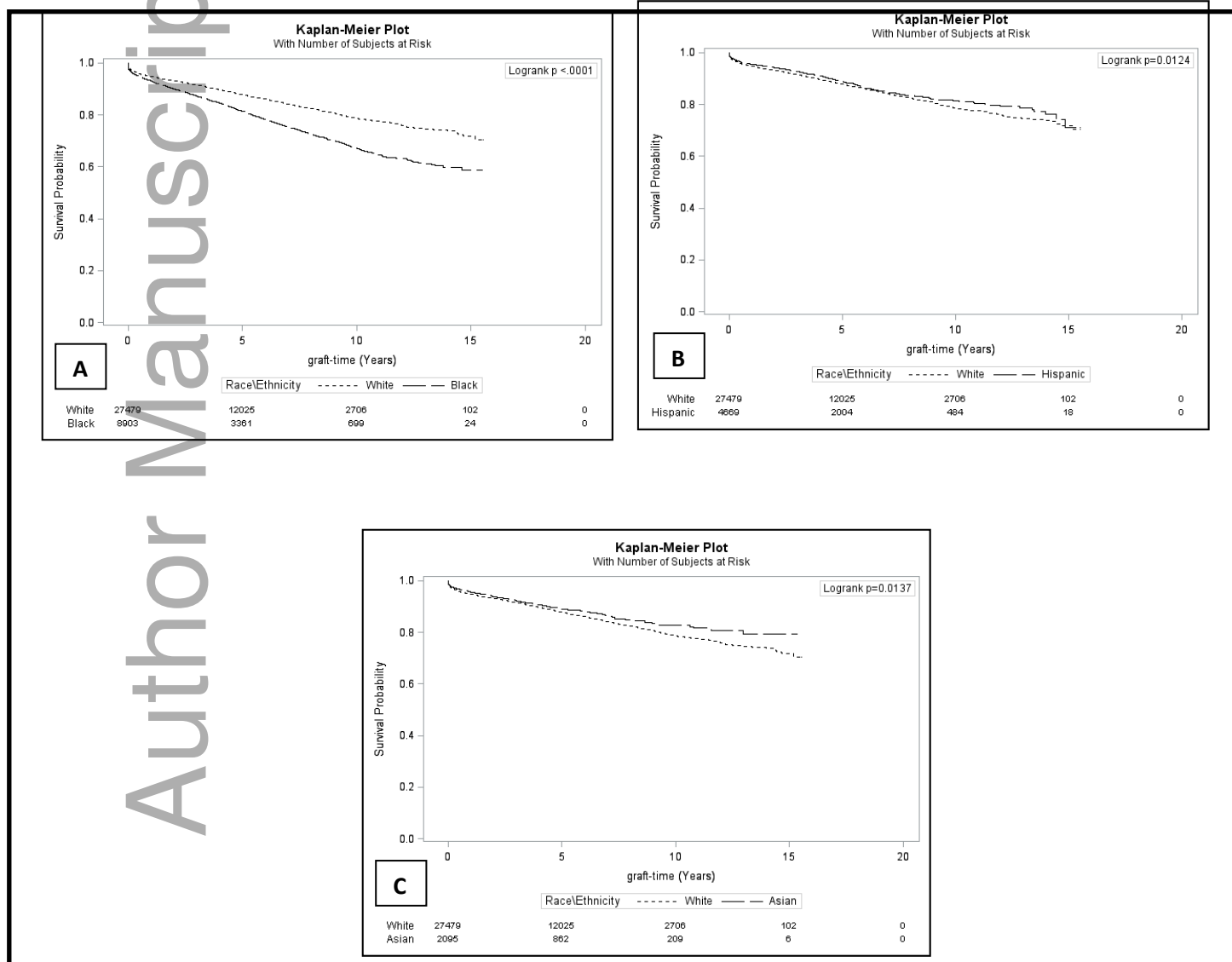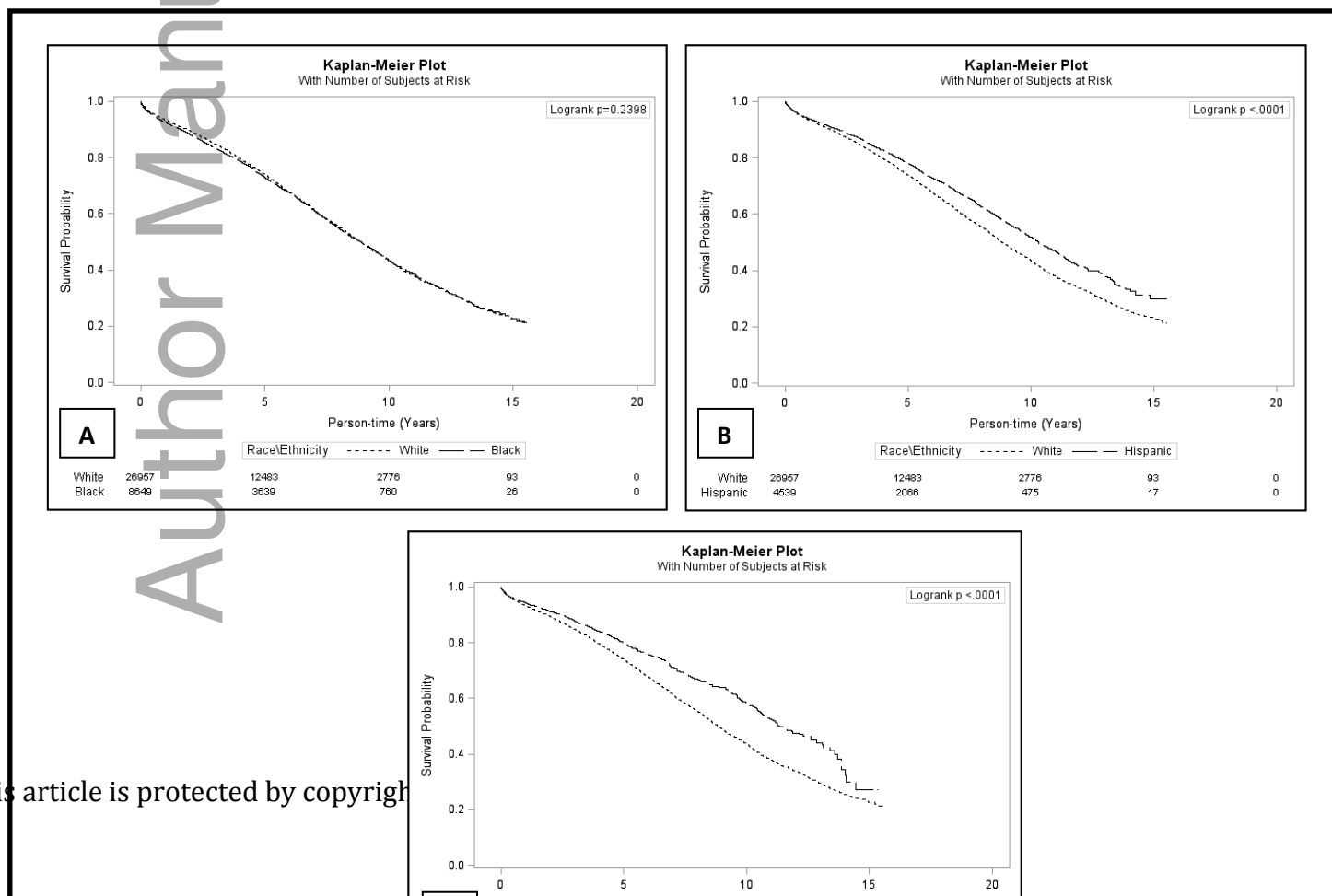
Figure 2: Patient Survival among Elderly (>60 years) U.S. Renal Transplant Recipients from July 1996 to October 2010 with Follow-up through December 2011

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