Published in final edited form as:

Transplantation. 2017 February ; 101(2): 402–410. doi:10.1097/TP.0000000000001119.

Overall Graft Loss versus Death Censored Graft Loss: Unmasking the Magnitude of Racial Disparities in Outcomes among U.S. Kidney Transplant Recipients

David J. Taber, PharmD, BCPS¹, Mulugeta Gebregziabher, PhD², Elizabeth H. Payne, BS²,
Titte Srinivas, MD³, Prabhakar K. Baliga, MD¹, and Leonard E. Egede, MD, MS⁴

¹Division of Transplant Surgery, College of Medicine, Medical University of South Carolina,
Charleston, SC

²Department of Public Health Sciences, College of Medicine, Medical University of South
Carolina, Charleston, SC

³Division of Transplant Nephrology, College of Medicine, Medical University of South Carolina,
Charleston, SC

⁴Veteran Affairs HSR&D Health Equity and Rural Outreach Innovation Center (HEROIC), Ralph H
Johnson VAMC, Charleston, SC

Abstract

Background—Black kidney transplant recipients experience disproportionately high rates of graft loss. This disparity has persisted for 40 years and improvements may be impeded based on the current public reporting of overall graft loss by U.S. regulatory organizations for transplantation.

Methods—Longitudinal cohort study of kidney transplant recipients using a dataset created by linking Veterans Affairs and U.S. Renal Data System information, including 4,918 veterans transplanted between Jan 2001 and Dec 2007, with follow up through Dec 2010. Multivariable analysis was conducted using two-stage joint modeling of random and fixed effects of longitudinal data (linear mixed model) with time to event outcomes (Cox regression).

Results—3,306 Non-Hispanic Whites (67%) were compared to 1,612 Non-Hispanic Black (33%) recipients with 6.0±2.2 years of follow-up. In the unadjusted analysis, Black recipients were significantly more likely to have overall graft loss (HR 1.19, 95%CI 1.07–1.33), death censored graft loss (HR 1.67, 1.45–1.92) and lower mortality (HR 0.83, 0.72–0.96). In fully

Corresponding Author: David J Taber, PharmD, BCPS, Division of Transplant Surgery, Medical University of South Carolina, 96 Jonathan Lucas Street, MSC 611, Charleston, SC 29425, Tele: (843) 792 3368, Fax: (843) 792 8596, taberd@musc.edu.

Authorship Contributions:

David J Taber: Participated in the research design, gathering of data, data analysis, and writing of paper

Mulugeta Gebregziabher: Participated in the research design, data analysis and writing of paper.

Elizabeth Payne: Participated in data clean-up, data analysis and writing of paper.

Titte R Srinivas: Participated in the research design and writing of paper.

Prabhakar K Baliga: Participated in the research design and writing of paper.

Leonard E Egede: Participated in the research design, data analysis and writing of paper.

Disclosure

The authors have no conflicts of interest to disclose as it relates to the content of this manuscript.

adjusted models, only death censored graft loss remained significant (HR 1.38, 1.12–1.71; overall graft loss [HR 1.08, 0.91–1.28]; mortality [HR 0.84, 0.67–1.06]). A composite definition of graft loss reduced the magnitude of disparities in Blacks by 22%.

Conclusions—Non-Hispanic Black kidney transplant recipients experience a substantial disparity in graft loss, but not mortality. This study of U.S. data provides evidence to suggest that researchers should focus on using death censored graft loss as the primary outcome of interest to facilitate a better understanding of racial disparities in kidney transplantation.

INTRODUCTION

The burden of chronic kidney disease (CKD), end-stage renal disease (ESRD) and kidney transplant (KTX) in the U.S. non-Hispanic Black (NHB) population cannot be overstated. Based on the 2010 Census and 2014 USRDS data, NHBs represent 12.6% of the U.S. population, yet 32.2% of those with ESRD, 33.9% of those on the KTX waiting list and 22.2% of those that received a KTX are NHB. Thus, NHBs are substantially over-represented among the ESRD and KTX waiting list populations, but are significantly less likely to receive a KTX, as compared to non-Hispanic Whites (NHWs).^{1,2} Following transplant, NHBs are at significantly higher risk of graft loss. The most recent U.S.-based data from the United Network of Organ Sharing (UNOS) registry data demonstrates NHB KTXs have a 5-year graft/patient survival rate of 61%, which compares to 74% in NHWs; a 13% absolute lower graft survival rate. Unfortunately, based on the definition used in public reporting of U.S. data, it is not easy to gain an appreciation of the magnitude of this disparity for death censored graft failure.³

The current definition for graft loss used by the U.S. registry and regulatory bodies overseeing transplantation, including UNOS, the Scientific Registry of Transplant Recipients (SRTR) and the Centers for Medicare and Medicaid Services (CMS) encompass a composite of both graft loss (return to dialysis or retransplantation) and death;^{4–6} this is otherwise referred to as overall graft loss. This definition has been in place since the U.S. Congress passed the National Organ Transplantation Act (NOTA) in 1984, which established the Organ Procurement and Transplantation Network (OPTN) and contracted with UNOS to be the steward of this data. The choice of a composite overall graft loss definition is logical from a regulatory oversight standpoint, as death is a clinically meaningful event and a kidney allograft cannot be deemed as functional in a deceased recipient. Thus, utilizing this composite definition to compare and benchmark transplant programs' performance metrics is appropriate.⁶

Unfortunately, within the realm of racial disparities reporting, a composite definition of graft loss that includes death as an outcome is potentially troublesome on a number of levels. This is because the mortality rates across racial cohorts in the KTX population are not uniform, and depending on the time period and data source, NHBs actually accrue a survival advantage while on dialysis and potentially post-transplant, despite their disproportionately high incidence of allograft failure.^{3,7} Thus, this composite definition of graft loss likely masks the true magnitude of the disparity NHB KTX recipients experience. Furthermore, concentrating on death as the event of interest may detract from intervening early on

mutable factors impacting graft loss based on a signal of deteriorating allograft function that can be yielded by monitoring death censored graft survival. This issue can be highlighted from a recently published study analyzing the impact of advanced age on NHB disparities for graft loss in KTX using the U.S. registry data. The authors found that advanced age attenuated the rates of overall graft loss, as the relative hazard for overall graft loss decreased with advancing age. However, when death censored graft loss was used as the primary outcome of interest, this attenuation in the disparity was not as dramatic, a finding that remained significant even in those > 65 years of age.⁸ As little has changed in the magnitude of racial disparities in KTX over the past 40 years, despite significant research efforts, this issue has real-life implications, as most large-scale studies utilize this national registry data to conduct detailed analyses of the prevailing etiologies surrounding racial disparities in KTX.⁹⁻¹¹

The aim of this analysis was to use a unique U.S.-based dataset that contains detailed baseline and longitudinal clinical data to establish and quantify the impact of the current overall graft loss definition on suppressing the true disparity magnitude in U.S. NHB KTX outcomes.

MATERIALS AND METHODS

Study Design and Patients

This was an IRB and VA HSR&D approved longitudinal cohort study analyzing U.S. national data of adult solitary KTX recipients. This cohort of KTX recipients was developed by obtaining data compiled from the United States Renal Data System (USRDS) and national Veteran Affairs (VA) patient medical and administrative databases obtained over a 10-year period, with transplants that were performed between Jan 2001 and Dec 2007 and followed until Dec 2010 or death. Data from the National Patient Care Databases (NPCD) was used to construct a national sample of all veterans who are identified via ICD-9 codes as having a renal transplant, are at least 18 years of age at the time of transplant, of any race, ethnicity, or gender, with baseline and follow-up data available to analyze. Exclusion criteria included, non-VA patients, those transplanted outside of the specified timeframe or recipients of multi-organ transplants. After initial analysis demonstrated that there were only 367 patients (0.7%) that were not either non-Hispanic Whites (NHW) or Blacks (NHB), the study was focused on these two racial cohorts.

Data Variables and Definitions

A summary of the data variables, definitions and outcomes used in this study is displayed in Supplemental Table 1. The NPCD was the source for the VA data, which is essentially the complete electronic medical record for veterans receiving care within the VA system. The Decision Support System Clinical National Data Extracts Lab Results (DSS NDEs LAR) database contains laboratory data for VA patients, including hemoglobin A1Cs (A1Cs) and lipid levels. This VA data was linked to the USRDS data using scrambled social security numbers. Data variables for baseline transplant characteristics and graft outcomes were captured using the USRDS/CMS databases. The primary dependent outcomes of interest included time to graft loss, death (overall, either prior to or after graft loss), and death

censored graft loss. Independent variables used in multivariable models included transplant characteristics, sociodemographics, and the presence and control of diabetes, hypertension and dyslipidemia.

Statistical Analysis

Univariate summary results are reported in means $\pm$ standard deviations (SD) for continuous variables, with categorical data presented in percentages. Adjusted estimates from multivariable models are presented as hazard ratios (HR) with 95% confidence intervals (CI). Continuous variables were compared using t-tests, while categorical variables were compared using the Pearson chi square test. Kaplan Meier analyses were used to estimate univariate survival rates, with the Log Rank test used for statistical comparison. For multivariate modeling, we employed a two-stage approach to jointly model the random and fixed effects longitudinal data with the baseline fixed variables for the outcomes of time to graft loss, death and death censored graft loss. This methodology is commonly utilized with longitudinal data and has been well-validated with previous studies (see Supplemental Methodology). In the first stage, a linear mixed model (LMM) is used, where both covariate effects and subject-specific random effects are modeled parametrically. In the second stage, a Cox model for time to event is used. The mixed model for the longitudinal process and the Cox model for the survival process are associated through common covariates in both models and the stochastic dependence between the random-effects terms and outcomes.^{12,13} For a full description of this modeling methodology, assumptions made and justification of this approach, please see the Supplemental Methodology section, which also includes assessment of missing data. Covariates that were included in the models are listed in Table 1 and include sociodemographics, comorbidities, immunologic characteristics and donor characteristics. Concordance was excellent for linked variables. These were then entered into the model in a forward sequential blocked method, first starting with only race, then adding demographics, comorbidities, immunologic characteristics and finally, post-transplant characteristics. For the Cox model, appropriateness of the assumption of proportionality of hazards was determined by examining $\log\{-\log(\text{time})\}$ plots and by testing the coefficients of the interactions of time with the respective covariate in a multivariate analyses. Residual analysis was used to assess goodness of fit of the models from each stage and to check the assumption of normality in the longitudinal part. None of these assumptions were violated. Models were compared using standard goodness of fit analyses. Statistical significance was based on a p-value of less than 0.05. Statistical analyses were performed using SAS (version 9.4, SAS Institute Inc, Cary, NC).

RESULTS

Study Population and Characteristics

This study included 4,918 U.S. veterans that received solitary kidney transplants between 2001 and 2007; which includes 3,306 NHW (67%) and 1,612 NHB (33%) recipients. The mean follow up time for the entire cohort was 6.0 ± 2.2 years, which was similar between NHB and NHW patients (6.0 ± 2.2 vs. 6.1 ± 2.2 , respectively; $p=0.1436$). The study flow diagram, detailing how this cohort was developed is displayed in Figure 1.

Table 1 presents the baseline and follow up characteristics for the total study cohort and compares these between NHW and NHB patients. At the time of transplant, there were a number of significant differences, when comparing NHW to NHB recipients. The NHB cohort was younger, less likely to be married, more likely to reside in the South, more likely to be unemployed, and more likely to have hypertension as the primary disease causing ESRD. NHB recipients were also less likely to receive a living donor, but more likely to receive a donor organ from a NHB or DCD. Finally, NHB recipients had more HLA mismatches, spent longer on dialysis and were less likely to have a preemptive transplant, as compared to NHW patients.

Posttransplant, there were also a number of notable differences between groups. NHB patients were more likely to receive cytolytic induction therapy, develop delayed graft function (DGF), develop new onset diabetes after transplant (NODAT) and have graft loss. NHB were less likely to die following transplant.

Clinical Outcomes

NHB recipients had an estimated 5 year overall graft survival rate of 77%, which was significantly lower, as compared to NHW patients (81%, $p=0.006$). The estimated five year patient survival rates were higher in NHB recipients, as compared to NHWs (90% vs. 87%, $p=0.001$), while five year death censored graft survival rates demonstrated the largest disparity (84% NHB vs. 90% NHW, $p<0.001$). Figure 2 displays a Forest plot of the unadjusted hazard ratios and 95% confidence intervals (CIs) for the association between recipient race (NHB vs. NHW) and the three outcomes of interest (graft loss, death and death censored graft loss). NHB recipients had 19% higher risk of graft loss, 17% lower risk of death and 67% higher risk of death censored graft loss, all of which were statistically significant ($p=0.002$, 0.0118 and <0.0001 , respectively).

Table 2 displays the covariates and associated hazard ratios, 95% CIs and p-values for the outcomes of graft loss, death and death censored graft loss for the fully adjusted model. After controlling for all covariates, NHB race was no longer a significantly predictor for overall graft loss (HR 1.08, 95% CI 0.91–1.28) or death (HR 0.84, 95% CI 0.67–1.06); however, NHB recipients had 38% higher risk of death censored graft loss, after full adjustment (HR 1.38, 95% CI 1.12–1.71, $p=0.0044$). These fully adjusted HRs and 95% CIs are also displayed in Figure 2, to allow for direct comparison to the unadjusted values.

For overall graft loss, other covariates, outside of race, that were independent predictors included recipient age, residing in the Midwest or Northeast, primary disease of hypertension, history of PVD, previous kidney transplant, donor age, receiving a living donor, donor race, HLA mismatches, current PRA, corticosteroid use and CVD risk factor control measures (A1C and LDL intercepts and slopes). For death, independent predictors included recipient age, residing in the West, Midwest or Northeast, marital status, primary disease of hypertension, history of PVD, baseline diabetes, previous kidney transplant, living donor, current PRA and CVD risk factor control measures (LDL intercept and slope). For death censored graft loss, independent predictors included recipient race, recipient age, residing in the Northeast, donor age, living donor, ECD, and all CVD risk factor control measures (A1C, LDL and SBP intercepts and slopes). Variables that were significant

predictors across all three outcomes included recipient age, residing in the Northeast, receiving a living donor and CVD risk factor control measures.

The sequential modelling results for the three outcomes of interest are displayed in Table 3, along with the models goodness of fit. For overall graft loss, the fully adjusted model demonstrated that NHB race was no longer a significant risk factor (HR 1.08, 95% CI 0.91 to 1.28). Sequential modelling demonstrated that the domain that provided the greatest degree of confounding was transplant characteristics and donor information, which decreased the HR from 1.35 to 1.09. The analysis of mortality demonstrated that in univariate analysis, NHB race was a significant protective factor (HR 0.83, 0.72–0.96); after sequential modelling, the magnitude of this effect was unchanged, but statistical significance was lost (HR 0.84, 0.67–1.06). Finally, for the outcome of death censored graft failure, sequential modelling demonstrated that after full adjustment, NHB race continued to be a strong risk factor. As compared to NHWs, NHBs had a 38% higher risk of death censored graft loss (HR 1.38, 1.12–1.71). The models for mortality and death censored graft loss both had substantially lower Akaike information criteria (AIC), indicating better goodness of fit, as compared to the model for overall graft loss.

DISCUSSION

The results of this analysis demonstrate that U.S. NHB KTX recipients experience significant disparities in graft survival rates, when death is censored as an event. This disparity persists even after controlling for numerous covariates. When the composite definition of overall graft loss is used, the magnitude of this disparity is reduced by more than 20%, to the point where statistical significance is lost. These results have important implications for public policy and reporting of outcomes in transplantation, as the current definition of graft loss within the U.S. regulatory oversight bodies, UNOS, SRTR and CMS, all use the composite graft loss/death classification for public reporting and evaluation of program performance; thus, racial disparities are likely under-appreciated through these reporting criteria.^{3,6,7} This designation of overall graft loss has also become the standard used for U.S.-based research analyses assessing this outcome, including a number of those analyzing racial disparities.^{8,10,14–17} Based on these results, we propose that U.S. transplant regulatory agencies consider also reporting death censored graft loss as a publicly reported outcome, with the hopes of helping researchers, clinicians and the greater transplant community understand if racial equity in graft outcomes is truly being achieved. There are two important reasons why this should be done: 1) The current measure under-estimates the magnitude of disparity and, 2) deterioration in graft function often precedes death censored graft loss and could be used as a signal to trigger interventions impacting mutable risk factors for graft loss.

Previous pivotal studies assessing the magnitude and etiologies of disparities in NHB KTX recipients have utilized varying methodology to define graft loss. The original landmark study published in 1977 that first recognized racial disparities in KTX by Opelz and Terasaki separated graft and patient survival and analyzed each outcome independently. These authors demonstrated a 10% absolute difference in graft survival at 3 years post-transplant (25% in Blacks vs. 35% in Whites, $p < 0.0001$), while patient survival rates were similar.¹⁸ In

1983, researchers from the University of Alabama published a study demonstrating a 16% absolute difference in graft survival rates between Black and White recipients (57% vs. 73%, $p=0.002$). Yet, contrary to the Opelz et al analysis, these authors defined graft loss as a composite of return to dialysis, nephrectomy or death with a function graft.¹⁹ Following this, in a comprehensive review article published by Kasiske et al in 1991, which, similar to the Opelz paper, analyzed graft and patient survival separately, demonstrated that NHB recipients had a significant disparity in graft outcomes, ranging from 7 to 20%, which was not demonstrated with patient survival in that race did not have an independent impact on recipient survival.²⁰ In a more recent publication, Keith et al conducted a donor-paired racial analysis that compared specific causes of graft loss between NHB and Caucasians. The results demonstrated that all causes of graft loss, particularly rejection and chronic allograft nephropathy, were significantly higher in NHB recipients. However, graft loss due to death (death with function) was similar between racial cohorts.²¹ Over the past 30 years, there are numerous additional examples within the transplant literature that demonstrate that racial disparities in graft outcomes are specifically related to loss of graft function, while mortality rates are similar between NHB and Caucasian KTX recipients.^{10,11,22,23} Thus, it is clear that to gain a better understanding of the true magnitude and etiology of this disparity, analyses should consistently focus on graft loss, without including death as an event (censure at the time of death). Given that there has been little change in the scope of this disparity, despite significant research efforts over the past 40 years, focusing on the true difference in outcomes may help elucidate the true etiologies of this public health issue.^{7,18}

In this study, we report the results of the first systematic analysis of U.S. national data to directly compare racial disparities as it specifically relates to three outcomes, overall graft loss, death and death censored graft loss. We did so using a unique database that linked USRDS and VA data to create a cohort that was rich in both baseline and follow up clinical information. Furthermore, data demonstrates that VA patients do not have race based differences in access to care. Our results thus demonstrate the robust and true contribution of a flawed metric to the estimation of disparity. Our results clearly demonstrate differences in disparity based on how graft loss is defined. Using the composite definition demonstrates that controlling for baseline covariates mitigates outcomes disparity based on race; yet, using pure graft loss as a definition (censoring for death), it is clear that racial disparities persist, despite accounting for detailed donor and recipient variables. Thus, to gain a precise appreciation of the magnitude of racial disparities in transplant, these results support the use of death censored graft loss as a more accurate definition. As patients who have graft loss either go back on dialysis or are re-transplanted, this definition has important patient and societal implications.^{24,25}

The fact that racial disparities for death censored graft loss persist despite controlling for numerous donor, recipient and transplant characteristics is an interesting finding and may point to other potential etiologies. Although this analysis controlled for education and marital status, we did not account for other socioeconomic and ecologic factors, including income, substance abuse, family support, community support or health literacy. Some of these clearly differ across race and have been associated with outcomes in transplantation.^{26–28} Medication nonadherence was not accounted for, which may impact racial disparities as well.^{29–31} Genetic factors, including gene variants in the donor (APOL1)

and recipient (CYP P450 3A5) are more common in NHBs and have been associated with kidney transplant outcomes.^{32,33} Finally, outside of patient-level factors, this study did not account for provider or systems-level issues (beyond geographical region) that may propagate racial disparities. Provider prescribing patterns and access to expert high quality care are well known to differ across racial cohorts and influence outcomes in high risk populations.^{34–36} These patient, provider and systems variables, which were not captured or controlled for in this analysis, may help to explain why NHB race continues to be a significant risk factor for death censored graft loss, even after accounting for numerous sociodemographic factors.

There are a number of limitations to this analysis that are worthy of discussion. First, this analysis was confined to a veteran transplant population and the number of female recipients was quite low at 2.4% of the study population. Thus, these results are not applicable to female transplant recipients. Using a veteran population also restricts the ability of this analysis to study the impact of insurance coverage and access to care on outcomes. As insurance coverage may greatly impact medication nonadherence, this is likely a major mediator for racial disparities in transplantation. However, previous studies have demonstrated that racial disparities are similar in magnitude between VA and non-VA populations, and using VA data allowed us to include numerous clinical variables that are missing or not available from previous studies that solely utilized the USRDS or CMS datasets.³⁷ Therefore, for the purposes of this analysis, which focused on racial disparities, the benefits provided by the use of VA data greatly outweigh the limitations of solely focusing on veteran patients. Another limitation of this analysis was its retrospective design and relatively short follow-up time, which may increase the risk for confounding and misclassification, potentially biasing the results. However, because we were able to link two databases with unique and overlapping data in a longitudinal format, we dramatically minimized these risks. We validated race, gender and age by comparing them between the two data sets for accuracy, demonstrating high rates of congruence (100% for gender, 99.8% for age, and 97.0% for race). Using a national database with relatively large numbers of patients, as compared to previous studies, also strengthens these results. Thus, we feel this analysis provides a precise and unbiased estimate of the true magnitude of racial disparities within contemporary KTX. Finally, it is important to note that this analysis focused on U.S.-based data sources and regulatory body definitions. Studies conducted outside of the U.S. use varying definitions of graft loss, either including or excluding death as an event.^{38–42} Thus, these results should only be applied to U.S.-based transplant programs and U.S.-based transplant regulatory agencies.

Our major finding is that death censored graft survival is substantially different between NHB and NHW. Furthermore, this difference in death censored graft survival was significantly associated with surrogates for the quality of clinical care including BP, diabetes and lipids control. The fact that this outcome is associated with process measures such as CVD and BP control suggests that adequate control of these issues could impact graft loss. We have previously demonstrated that disparate CVD control is an important underpinning that could explain disparities of outcome among NHBs.^{43–45} Thus, these often overlooked metrics could point towards ways to improve transplant outcomes amongst transplant recipients.

In summary, NHB KTX recipients experience significant outcomes disparities, which are primarily related graft function and not mortality. This large-scale national study, using detailed baseline and longitudinal clinical data, provides strong evidence to suggest that disparity researchers consider using death censored graft loss the primary outcome of interest, in hopes of better elucidating causal factors for racial disparities in transplantation and determining whether equity is being achieved.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Funding

Research reported in this publication was supported by the National Institute of Diabetes and Digestive and Kidney Diseases of the National Institutes of Health under Award Number K23DK099440.

Abbreviations

A1c	hemoglobin A1Cs
CKD	chronic kidney disease
CMS	Centers for Medicare and Medicaid Services (CMS)
DSS NDEs LAR	Decision Support System Clinical National Data Extracts Lab Results
ESRD	end-stage renal disease
KTX	kidney transplant
HR	hazard ratio
NPCD	National Patient Care Databases
NOTA	National Organ Transplantation Act
OPTN	Organ Procurement and Transplantation Network
NHW	non-Hispanic White
NHB	non-Hispanic Black
SRTR	Scientific Registry of Transplant Recipients
UNOS	United Network of Organ Sharing
USRDS	United States Renal Data System
VA	Veteran Affairs

References

1. [Accessed August 16, 2015] United States Renal Data System. <http://www.usrds.org/2014/view/Default.aspx>. Updated 2014
2. [Accessed August 16, 2015] United States Census Bureau. <http://www.census.gov/population/race/data/cen2010.html>. Updated 2010
3. [Accessed 08/15, 2015] United Network for Organ Sharing. <http://optn.transplant.hrsa.gov/converge/latestData/rptData.asp>. Updated 2014
4. Cameron AM, Sullivan BE. Regulatory oversight in transplantation: There and back again. *JAMA Surgery*. 2013; 148(11):997–998. [PubMed: 24005678]
5. Ho B, Skaro AI, Abecassis MM. Should both UNOS and CMS provide regulatory oversight in kidney transplantation? *Current Transplantation Reports*. 2015; 2(2):127–134.
6. Leppke S, Leighton T, Zaun D, et al. Scientific registry of transplant recipients: Collecting, analyzing, and reporting data on transplantation in the united states. *Transplant Rev*. 2013; 27(2): 50–56.
7. Matas A, Smith J, Skeans M, et al. OPTN/SRTR 2012 annual data report: Kidney. *Am J Transplant*. 2014; 14(S1):11–44. [PubMed: 24373166]
8. Schold JD, Srinivas TR, Braun WE, Shoskes DA, Nurko S, Poggio ED. The relative risk of overall graft loss and acute rejection among African American renal transplant recipients is attenuated with advancing age. *Clin Transplant*. 2011; 25(5):721–730. [PubMed: 20964717]
9. Young CJ, Gaston RS. Renal transplantation in Black Americans. *N Engl J Med*. 2000; 343(21): 1545–1552. [PubMed: 11087885]
10. Young CJ, Gaston RS. African Americans and renal transplantation: Disproportionate need, limited access, and impaired outcomes. *Am J Med Sci*. 2002; 323(2):94–99. [PubMed: 11863086]
11. Eckhoff DE, Young CJ, Gaston RS, et al. Racial disparities in renal allograft survival: A public health issue? *J Am Coll Surg*. 2007; 204(5):894–902. [PubMed: 17481506]
12. Guo X, Carlin BP. Separate and joint modeling of longitudinal and event time data using standard computer packages. *The American Statistician*. 2004; 58(1):16–24.
13. Ye W, Lin X, Taylor JM. Semiparametric modeling of longitudinal measurements and time-to-event data—a two-stage regression calibration approach. *Biometrics*. 2008; 64(4):1238–1246. [PubMed: 18261160]
14. Gralla J, Le CN, Cooper JE, Wiseman AC. The risk of acute rejection and the influence of induction agents in lower-risk African American kidney transplant recipients receiving modern immunosuppression. *Clin Transplant*. 2014; 28(3):292–298. [PubMed: 24476453]
15. Hall E, Segev D, Engels E. Racial/ethnic differences in cancer risk after kidney transplantation. *Am J Transplant*. 2013; 13(3):714–720. [PubMed: 23331953]
16. Pelletier RP, Phillips GS, Rajab A, Pesavento TE, Henry ML. Effects of cardiovascular comorbidity adjustment on SRTR risk-adjusted cox proportional hazard models of graft survival. *Transplantation*. 2014; 97(6):686–693. [PubMed: 24637867]
17. Rana A, Gruessner A, Agopian VG, et al. Survival benefit of solid-organ transplant in the United States. *JAMA Surgery*. 2015; 150(3):252–259. [PubMed: 25629390]
18. Opelz G, Mickey MR, Terasaki PI. Influence of race on kidney transplant survival. *Transplant Proc*. 1977; 9(1):137–142. [PubMed: 325754]
19. Diethelm AG, Blackstone EH, Naftel DC, et al. Important risk factors of allograft survival in cadaveric renal transplantation. A study of 426 patients. *Ann Surg*. 1988; 207(5):538–548. [PubMed: 3288138]
20. Kasiske BL, Neylan JF III, Riggio RR, et al. The effect of race on access and outcome in transplantation. *N Engl J Med*. 1991; 324(5):302–307. [PubMed: 1898431]
21. Keith D, Patrie JT. Short-term kidney transplant outcomes among African American recipients do not predict long-term outcomes: Donor pair analysis. *Clin Transplant*. 2011; 25(1):69–76. [PubMed: 20201952]
22. Malat GE, Culkun C, Palya A, Ranganna K, Kumar MSA. African American kidney transplantation survival. *Drugs*. 2009; 69(15):2045–2062. [PubMed: 19791826]

23. Meier-Kriesche H, Ojo A, Magee JC, et al. African-american renal transplant recipients experience decreased risk of death due to infection: Possible implications for immunosuppressive strategies. *Transplantation*. 2000; 70(2):375–379. [PubMed: 10933166]
24. Gill JS, Abichandani R, Kausz AT, Pereira BJ. Mortality after kidney transplant failure: The impact of non-immunologic factors. *Kidney Int*. 2002; 62(5):1875–1883. [PubMed: 12371992]
25. Rao PS, Schaubel DE, Jia X, Li S, Port FK, Saran R. Survival on dialysis post-kidney transplant failure: Results from the scientific registry of transplant recipients. *American Journal of Kidney Diseases*. 2007; 49(2):294–300. [PubMed: 17261432]
26. Butkus DE, Dottes AL, Meydrech EF, Barber WH. Effect of poverty and other socioeconomic variables on renal allograft survival. *Transplantation*. 2001; 72(2):261–266. [PubMed: 11477350]
27. Goldfarb-Rumyantzev AS, Sandhu GS, Barenbaum A, et al. Education is associated with reduction in racial disparities in kidney transplant outcome. *Clin Transplant*. 2012; 26(6):891–899. [PubMed: 22694749]
28. Hod T, Goldfarb-Rumyantzev AS. The role of disparities and socioeconomic factors in access to kidney transplantation and its outcome. *Ren Fail*. 2014; 36(8):1193–1199. [PubMed: 24988495]
29. Chisholm MA, Vollenweider LJ, Mulloy LL, et al. Renal transplant patient compliance with free immunosuppressive medications. *Transplantation*. 2000; 70(8):1240–1244. [PubMed: 11063348]
30. Chisholm-Burns M, Pinsky B, Parker G, et al. Factors related to immunosuppressant medication adherence in renal transplant recipients. *Clin Transplant*. 2012; 26(5):706–713. [PubMed: 22324912]
31. Greenstein S, Siegal B. Compliance and noncompliance in patients with a functioning renal transplant: A multicenter Study 1, 2. *Transplantation*. 1998; 66(12):1718–1726. [PubMed: 9884266]
32. Bruckmueller H, Werk AN, Renders L, et al. Which genetic determinants should be considered for tacrolimus dose optimization in kidney transplantation? A combined analysis of genes affecting the CYP3A locus. *Ther Drug Monit*. 2015; 37(3):288–295. [PubMed: 25271728]
33. Reeves-Daniel AM, DePalma JA, Bleyer AJ, et al. The APOL1 gene and allograft survival after kidney transplantation. *Am J Transplant*. 2011; 11(5):1025–1030. [PubMed: 21486385]
34. Copeland VC. African Americans: Disparities in health care access and utilization. *Health Soc Work*. 2005; 30(3):265. [PubMed: 16190303]
35. Goonesekera SD, Yang MH, Hall SA, Fang SC, Piccolo RS, McKinlay JB. Racial ethnic differences in type 2 diabetes treatment patterns and glycaemic control in the Boston area community health survey. *BMJ Open*. 2015; 5(5):e007375. 2014-007375.
36. Peek ME, Cargill A, Huang ES. Diabetes health disparities: A systematic review of health care interventions. *Med Care Res Rev*. 2007; 64(5 Suppl):101S–56S. [PubMed: 17881626]
37. Chakkeria HA, O'Hare AM, Johansen KL, et al. Influence of race on kidney transplant outcomes within and outside the department of veterans affairs. *J Am Soc Nephrol*. 2005; 16(1):269–277. [PubMed: 15563568]
38. Pallet N, Thervet E, Alberti C, Emal-Algae V, Bedrossian J, et al. Kidney transplant in Black recipients: are African Europeans different from African Americans? *American Journal of Transplantation*. 2005; 5:2682–87. [PubMed: 16212627]
39. Rudge C, Johnson RJ, Fuggle SV, Forsythe JLR. Renal transplantation in the United Kingdom for patients from ethnic minorities. *Transplantation*. 2007; 83:1169–73. [PubMed: 17496531]
40. Yeates KE, Wiebe N, Gill J, et al. Similar outcomes among black and white renal allograft recipients. *American Journal of Kidney Disease*. 2009; 20:172–9.
41. McDonald SP, Russ GR. Current incidence, treatment patterns and outcome of end stage renal disease among indigenous groups in Australia and New Zealand. *Nephrology*. 2003; 8:42–8. [PubMed: 15012749]
42. Malek SK, Keys BJ, Kumar S, Milford E, Tullius SG. Racial and ethnic disparities in kidney transplantation. *Transplant International*. 2011; 24:419–24. [PubMed: 21166727]
43. Palanisamy AP, Schiltz CE III, Pilch NA, et al. Cardiovascular risk factors contribute to disparities in graft outcomes in african american renal transplant recipients: A retrospective analysis. *Blood Press*. 2015; 24(1):14–22. [PubMed: 25048253]

44. Taber DJ, Douglass K, Srinivas T, et al. Significant racial differences in the key factors associated with early graft loss in kidney transplant recipients. *Am J Nephrol*. 2014; 40(1):19–28. [PubMed: 24969370]
45. Taber DJ, Pilch NA, Meadows HB, et al. The impact of cardiovascular disease and risk factor treatment on ethnic disparities in kidney transplant. *J Cardiovasc Pharmacol Ther*. 2013; 18(3): 243–250. [PubMed: 23258931]

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Figure 1.
Study flow diagram and breakdown of number of patients during the entire follow-up period

Figure 2.

Forest plot displaying the unadjusted and fully adjusted hazard ratios in NHB, as compared to NHW, for the outcomes of graft loss, death and death censored graft loss. In the unadjusted analyses, NHB race is a significant risk factor for overall graft loss and death censored graft loss, while NHB race is a protective factor for death. In the fully adjusted models, NHB race is only a significant risk factor for death censored graft loss.

Table 1

Study characteristics for the entire cohort and compared between NHW and NHB patients

Characteristic	Total (n=4,918)	NHW (n=3,306)	NHB (n=1,612)
Age (mean $\pm$ SD)	57.6 $\pm$ 10.6	59.7 $\pm$ 10.1	53.5 $\pm$ 10.3
Gender			
Male (%)	97.6	98.0	96.7
Female (%)	2.4	2.0	3.4
BMI (mean $\pm$ SD)	27.9 $\pm$ 5.9	27.9 $\pm$ 5.9	27.9 $\pm$ 6.1
Marital Status			
Married (%)	62.3	66.7	49.0
Single (%)	27.9	24.6	38.6
Other (%)	9.9	8.8	12.4
Education			
Less than High School (%)	1.7	1.7	0.9
High School (%)	38.0	38.2	36.6
Attended College/Technical School (%)	24.7	23.7	26.7
Associate/Bachelor Degree (%)	13.4	14.14	12.11
Graduate School (%)	4.5	4.9	3.7
Unknown (%)	17.8	17.4	20.1
Region			
West (%)	17.7	18.6	10.1
Midwest (%)	26.8	27.4	25.5
South (%)	36.6	34.0	45.1
Northeast (%)	18.9	20.0	19.3
Employment Status			
Full-Time (%)	22.4	23.8	20.1
Part-Time (%)	5.6	5.4	6.3
Unemployed (%)	34.6	30.0	41.9
Retired (%)	25.9	30.2	16.6
Unknown (%)	11.6	10.7	15.1
Any Tobacco Use (% yes)	23.8	23.4	26.3
Current Smoker (% yes)	8.7	8.8	9.9
Primary Disease			
IgA Nephropathy (%)	3.39	4.4	1.1
Focal Segmental Glomerulosclerosis (%)	6.3	4.8	9.4
Any Glomerulonephropathy (%)	13.1	12.4	14.3
Hypertension (%)	24.8	18.7	39.3
Diabetes (%)	28.1	27.7	25.0
Comorbidity History			
Angina or Coronary Artery Disease (%)	13.1	15.7	8.4
Peripheral Vascular Disease (%)	5.9	6.8	3.9
Hypertension (%)	82.1	80.9	85.0

Characteristic	Total (n=4,918)	NHW (n=3,306)	NHB (n=1,612)
Diabetes (%)	38.1	36.9	37.2
Cancer (%)	5.3	6.7	3.2
Cerebrovascular Accident (%)	3.4	3.9	2.6
Number of Previous Kidney Transplants			
0 (%)	90.6	89.8	91.5
1 (%)	8.9	9.5	8.1
2 (%)	0.6	0.7	0.4
Donor Information			
Age (mean ± SD)	40.5 ± 15.2	41.2 ± 15.2	39.5 ± 15.2
Living (%)	33.4	38.4	21.7
Deceased (%)	66.6	61.6	78.4
Black (%)	13.9	4.7	35.1
Non-Black (%)	86.1	95.3	65.0
Male (%)	52.6	50.9	55.5
Female (%)	47.4	49.1	44.5
Hypertension (%)	20.3	19.3	23.8
Extended Criteria Donor (ECD, %)	14.9	15.3	14.7
Deceased After Cardiac Death (DCD, %)	4.6	4.2	5.7
BMI (mean ± SD)	26.7 ± 9.2	26.7 ± 10.8	26.6 ± 6.2
Immunologic Risks			
Cold Ischemic Time (hrs, mean ± SD)	14.2 ± 10.4	13.4 ± 10.6	15.8 ± 9.8
Warm Ischemic Time (min, mean ± SD)	40.9 ± 24.5	39.9 ± 23.8	42.95 ± 26.4
HLA Mismatches (mean ± SD)	3.5 ± 1.8	3.2 ± 1.8	4.1 ± 1.5
Current Panel Reactive Antibody (mean ± SD)	4.2 ± 14.8	3.6 ± 13.9	5.4 ± 16.7
Peak Panel Reactive Antibody (mean ± SD)	11.4 ± 23.6	9.7 ± 22.1	15.4 ± 26.6
Years on Dialysis (median)	1.7	1.3	2.9
Preemptive Transplant (%)	21.4	24.5	15.5
CMV Serostatus Donor +/Recipient – (%)	11.0	11.9	9.9
Immunosuppression			
IL2 Receptor Blocker Induction (%)	30.0	32.0	24.2
Cytolytic Induction (%)	36.2	34.5	41.7
No Induction (%)	33.9	33.6	34.1
Tacrolimus (%)	72.8	70.6	76.7
Cyclosporine (%)	21.3	23.6	17.6
Mycophenolate (%)	86.9	86.9	86.5
Azathioprine (%)	1.7	1.8	1.6
Sirolimus or Everolimus (%)	11.1	11.0	11.6
Corticosteroids (%)	95.0	94.7	95.3
Died (%)	18.0	19.7	15.3
Graft Failure (%)	28.1	27.5	30.6
Death Censored Graft Failure (%)	16.0	13.6	21.4
Acute Rejection (%)	16.6	15.9	19.0

Characteristic	Total (n=4,918)	NHW (n=3,306)	NHB (n=1,612)
Delayed Graft Function (%)	18.2	14.6	26.1
New Onset Diabetes After Transplant (NODAT, %)	16.6	14.9	20.4
Time to NODAT (mean $\pm$ SD)	1.1 $\pm$ 2.0	1.10 $\pm$ 2.1	1.2 $\pm$ 2.1

Multivariable analysis for single fully adjusted model, associating each variable with the three outcomes of overall graft loss, death and death censored graft loss

Table 2

VARIABLE	GRAFT LOSS		DEATH		DEATH CENSORED GRAFT LOSS	
	Hazard Ratio (95% CI)	P-Value	Hazard Ratio (95% CI)	P-Value	Hazard Ratio (95% CI)	P-Value
Race (NHB vs. NHW)	1.08 (0.91, 1.28)	0.3683	0.84 (0.67, 1.06)	0.1371	1.38 (1.12, 1.71)	0.0030
Age (by 5 years)	1.06 (1.02, 1.10)	0.0027	1.28 (1.21, 1.35)	<0.0001	0.92 (0.88, 0.97)	0.0005
Region (vs. South)						
West	0.81 (0.65, 1.01)	0.0659	0.68 (0.50, 0.92)	0.0131	0.96 (0.73, 1.27)	0.7868
Midwest	1.37 (1.17, 1.61)	<0.0001	1.58 (1.29, 1.94)	<0.0001	1.20 (0.97, 1.48)	0.0920
Northeast	1.34 (1.11, 1.61)	0.0018	1.29 (1.01, 1.65)	0.0405	1.49 (1.19, 1.87)	0.0006
Gender (Female vs. Male)	0.93 (0.57, 1.52)	0.7847	0.84 (0.39, 1.79)	0.6469	1.04 (0.60, 1.78)	0.8934
Married (vs. Single)	0.91 (0.79, 1.05)	0.1774	0.81 (0.67, 0.97)	0.0203	1.05 (0.88, 1.26)	0.5966
Education (vs. High School)						
Less Than High School	1.27 (0.78, 2.08)	0.3421	1.17 (0.66, 2.07)	0.5827	1.16 (0.54, 2.50)	0.6981
College/Technical School	0.92 (0.78, 1.09)	0.3590	0.87 (0.69, 1.09)	0.2359	0.90 (0.73, 1.12)	0.3390
Associate/Bachelor Degree	0.86 (0.70, 1.06)	0.1569	0.93 (0.71, 1.21)	0.5632	0.78 (0.60, 1.02)	0.0710
Grad School	0.83 (0.59, 1.18)	0.2998	0.95 (0.64, 1.41)	0.7905	0.67 (0.41, 1.10)	0.1142
Unknown or N/A	0.83 (0.69, 1.00)	0.0541	0.81 (0.63, 1.04)	0.1003	0.82 (0.64, 1.05)	0.1125
Primary Disease						
IgA (vs. None)	0.84 (0.52, 1.35)	0.4640	0.58 (0.26, 1.33)	0.2013	0.89 (0.51, 1.55)	0.6823
FSGS (vs. None)	1.17 (0.81, 1.70)	0.4010	1.27 (0.71, 2.28)	0.4164	0.88 (0.57, 1.36)	0.5706
Any GN (vs. None)	0.97 (0.73, 1.31)	0.8595	0.79 (0.52, 1.21)	0.2765	1.15 (0.81, 1.62)	0.4338
Hypertension (vs. None)	1.23 (1.01, 1.48)	0.0357	1.43 (1.12, 1.84)	0.0049	1.10 (0.87, 1.40)	0.4351
Diabetes (vs. None)	0.98 (0.76, 1.26)	0.8814	1.20 (0.87, 1.65)	0.2634	0.72 (0.52, 1.01)	0.0539
Angina or CAD (vs. None)	0.96 (0.80, 1.17)	0.7071	1.09 (0.87, 1.37)	0.4390	0.95 (0.73, 1.23)	0.6949
PVD (vs. None)	1.35 (1.04, 1.76)	0.0251	1.60 (1.19, 2.15)	0.0019	1.10 (0.74, 1.65)	0.6374
Hypertension (vs. None)	0.98 (0.81, 1.17)	0.7879	0.86 (0.68, 1.08)	0.2038	0.95 (0.75, 1.20)	0.6773
Baseline Diabetes (vs. None)	1.22 (0.99, 1.50)	0.0604	1.44 (1.11, 1.87)	0.0065	1.24 (0.95, 1.20)	0.1182
Cancer (vs. None)	1.06 (0.79, 1.43)	0.6780	0.98 (0.68, 1.40)	0.8950	1.15 (0.77, 1.71)	0.4958
CVA (vs. None)	1.03 (0.71, 1.48)	0.8948	1.05 (0.69, 1.60)	0.8198	0.92 (0.52, 1.61)	0.7678

VARIABLE	GRAFT LOSS		DEATH		DEATH CENSORED GRAFT LOSS	
	Hazard Ratio (95% CI)	P-Value	Hazard Ratio (95% CI)	P-Value	Hazard Ratio (95% CI)	P-Value
Previous Kidney Transplant	1.28 (1.01, 1.62)	0.0386	1.48 (1.08, 2.02)	0.0137	1.04 (0.76, 1.43)	0.8113
Donor Information						
Age (by 5 years)	1.03 (1.00, 1.06)	0.0363	1.03 (0.96, 1.07)	0.1434	1.05 (1.02, 1.09)	0.0056
Living (vs. Deceased)	0.71 (0.59, 0.84)	<0.001	0.67 (0.54, 0.84)	0.0005	0.73 (0.58, 0.92)	0.0065
Black (vs. Non-Black)	1.23 (1.01, 1.49)	0.0358	1.19 (0.91, 1.56)	0.2006	1.21 (0.96, 1.54)	0.1085
Female (vs. Male)	1.13 (0.99, 1.29)	0.0679	1.04 (0.87, 1.24)	0.6556	1.12 (0.95, 1.33)	0.1883
ECD (vs. None)	1.38 (0.11, 1.72)	0.0038	1.20 (0.90, 1.60)	0.2123	1.59 (1.21, 2.09)	0.0010
DCD (vs. None)	1.99 (0.72, 1.36)	0.9343	1.00 (0.66, 1.51)	0.9954	1.02 (0.69, 1.52)	0.9167
Immunologic Risks						
HLA Mismatch	1.04 (1.00, 1.08)	0.0341	1.05 (1.00, 1.10)	0.0787	1.04 (0.99, 1.09)	0.1633
Current PRA	1.01 (1.00, 1.01)	0.0051	1.01 (1.00, 1.01)	0.0035	1.00 (1.00, 1.01)	0.2022
Years on Dialysis	1.00 (0.97, 1.03)	0.8096	1.02 (0.98, 1.06)	0.3862	1.00 (0.96, 1.04)	0.8773
Preemptive (vs. Not)	0.89 (0.73, 1.08)	0.2213	0.81 (0.62, 1.05)	0.1065	0.93 (0.71, 1.20)	0.5803
CMV D+/R- (vs. Not)	0.94 (0.77, 1.16)	0.5855	0.90 (0.68, 1.18)	0.4432	0.93 (0.71, 1.22)	0.5990
EBV Negative (vs. Not)	0.84 (0.66, 1.07)	0.1576	0.97 (0.72, 1.31)	0.8508	0.83 (0.60, 1.16)	0.2724
Immunosuppression						
IL2 Receptor Blocker	1.05 (0.88, 1.24)	0.6074	1.18 (0.95, 1.46)	0.1412	0.92 (0.73, 1.15)	0.4414
Cytolytic Induction	1.17 (0.99, 1.37)	0.0608	1.03 (0.83, 1.28)	0.7979	1.17 (0.96, 1.43)	0.1271
Tacrolimus (%)	0.89 (0.66, 1.18)	0.4167	0.72 (0.50, 1.05)	0.0893	0.99 (0.69, 1.44)	0.9702
Cyclosporine (%)	0.87 (0.64, 1.19)	0.3795	0.87 (0.59, 1.30)	0.5014	0.91 (0.61, 1.35)	0.6216
Mycophenolate (%)	1.04 (0.83, 1.32)	0.7164	0.96 (0.71, 1.30)	0.7893	1.07 (0.80, 1.42)	0.6657
Azathioprine (%)	1.26 (0.78, 2.05)	0.3482	1.45 (0.80, 2.61)	0.2237	1.40 (0.76, 2.60)	0.2804
Sirolimus or Everolimus (%)	1.03 (0.82, 1.30)	0.8083	0.88 (0.64, 1.20)	0.4164	1.13 (0.84, 1.51)	0.4104
Corticosteroids (%)	1.56 (1.02, 2.39)	0.0387	1.45 (0.85, 2.46)	0.1716	1.52 (0.90, 2.57)	0.1199
CVD Risk Factor Control						
A1C Intercept (by 1 unit)	0.90 (0.83, 0.98)	0.0161	1.03 (0.93, 1.15)	0.5582	0.75 (0.66, 0.84)	<0.001
A1C Slope (by 1 unit)	0.21 (0.10, 0.44)	<0.001	0.53 (0.20, 1.40)	0.2000	0.06 (0.02, 0.16)	<0.001
LDL Intercept (by 1 unit)	0.99 (0.99, 0.99)	<0.001	0.99 (0.98, 0.99)	<0.001	0.99 (0.98, 0.99)	<0.001
LDL Slope (by 1 unit)	0.93 (0.90, 0.97)	0.0003	0.96 (0.91, 1.01)	0.0932	0.90 (0.86, 0.94)	<0.001
SBP Intercept (by 1 unit)	1.01 (1.00, 1.02)	0.1657	1.00 (0.99, 1.01)	0.4782	1.02 (1.01, 1.03)	0.0002

VARIABLE	GRAFT LOSS		DEATH		DEATH CENSORED GRAFT LOSS	
	Hazard Ratio (95% CI)	P-Value	Hazard Ratio (95% CI)	P-Value	Hazard Ratio (95% CI)	P-Value
SBP Slope (by 1 unit)	1.03 (0.96, 1.10)	0.4567	0.92 (0.84, 1.01)	0.0671	1.14 (1.05, 1.24)	0.0027

* Red bolded font indicates statistically significant associations (p<0.05)

Table 3

Sequential multivariable modelling displaying the hazard ratios for NHB, as compared to NHW, for the three outcomes of graft loss, death and death censored graft loss

Model	Adjustment	Joint Modelling Analyses		
		AIC	N	Hazard Ratio (95% CI)
Graft Loss				
Model 1	None	22467	4918	1.19 (1.07, 1.33)
Model 2	Demographics	16828	4187	1.44 (1.27, 1.64)
Model 3	Demographics, Comorbidities	15299	3849	1.35 (1.17, 1.56)
Model 4	Demographics, Comorbidities, Transplant	14463	3675	1.09 (0.93, 1.29)
Model 5	Demographics, Comorbidities, Transplant, CVD risk control	14386	3670	1.08 (0.91, 1.28)
Mortality				
Model 1	None	14457	4918	0.83 (0.72, 0.96)
Model 2	Demographics	9982	4187	1.19 (1.00, 1.42)
Model 3	Demographics, Comorbidities	8848	3849	1.05 (0.86, 1.27)
Model 4	Demographics, Comorbidities, Transplant	8359	3675	0.85 (0.68, 1.07)
Model 5	Demographics, Comorbidities, Transplant, CVD risk control	8320	3670	0.84 (0.67, 1.06)
Death Censored Graft Loss				
Model 1	None	12750	4918	1.67 (1.45, 1.92)
Model 2	Demographics	10156	4187	1.72 (1.46, 2.02)
Model 3	Demographics, Comorbidities	9409	3849	1.68 (1.41, 2.01)
Model 4	Demographics, Comorbidities, Transplant	8839	3675	1.40 (1.14, 1.72)
Model 5	Demographics, Comorbidities, Transplant, CVD risk control	8728	3670	1.38 (1.12, 1.71)