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The Influence of Socioeconomic Status and Minority Race on Referral for Kidney Transplantation in Georgia

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An abstract of

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Abstract

The Influence of Socioeconomic Status and Minority Race on Referral for Kidney Transplantation in Georgia

By Shruti Parulekar

Introduction

Racial and socioeconomic disparities in access to kidney transplantation have been previously documented, however, a prior study in Georgia found that African Americans were more likely to be referred for transplantation and yet less likely to be waitlisted. Little is known about whether racial disparities in transplant referral vary across levels of socioeconomic status (SES) of a patient and the neighborhood in which they reside.

Methods:

Patient referral data from January 2005 to September 2011 was obtained from the Reducing Disparities in Access to Kidney Transplantation (RaDIANT) Community Study and linked to the US Renal Data System (USRDS) and US Census Data. Race was defined as African American, white Hispanic, white non-Hispanic and other. Individual level SES was defined using insurance status and pre-ESRD nephrology care; neighborhood level SES was defined using neighborhood poverty levels and percentage of high school graduates. The outcome was referral for transplant evaluation. Multivariable Cox models adjusted for demographics and dialysis facility characteristics were used to examine whether racial disparities in access to referral for transplantation varied across SES measures.

Results:

Overall, 5362 (35.9%) patients were referred for kidney transplantation after starting dialysis. The median time from dialysis start to referral was 624 days (IQR: 182 – 1417). No statistically significant interaction was seen between race and SES. Among patients with no insurance, African Americans were three times more likely to be referred for transplant one year after starting dialysis compared to whites (HR= 3.32 , 95% CI: 1.31 - 8.40)). Among patients referred for transplant within one year after starting dialysis, African Americans living in neighborhoods 15-30% below the poverty level were 61% more likely to be referred for transplant compared to whites (HR= 1.61, 95% CI: (1.11 - 1.23)). Among those living in neighborhoods with less than 80% high graduates, African Americans were 94% more likely to be referred for transplant within one of starting dialysis compared to whites (HR= 1.94, 95% CI: (1.02 - 3.68)).

Conclusion:

These results suggest that racial disparities in access to kidney transplantation vary by a patient's SES.

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Chapter I: Background

Prevalence and Burden of End-Stage Renal Disease

The National Kidney Foundation defines chronic kidney disease (CKD) as the presence of kidney damage or decreased kidney function for at least 3 months (Kidney Disease Outcomes Quality Initiative CKD Guidelines). Kidney function is assessed using the Estimated Glomerular Filtration Rate (eGFR). A decrease in the eGFR below 29 mL/min/1.73m^2 leads to impairment of renal function and is characterized as end-stage renal disease (KDOQI CKD Guidelines). End-stage renal disease (ESRD) is associated with severe complications like uremia and patients with end stage renal disease require renal replacement therapy for survival.

CKD and ESRD are among the major contributors to the mortality and morbidity by non-communicable diseases in the world. In 2011, around 200 million cases of chronic kidney disease have been reported globally (Couser, Remuzzi, Mendis, & Tonelli, 2011). In the United States, the overall prevalence of ESRD is also increasing rapidly. According to the United States Renal Data System (USRDS) Report, there were around 661,648 cases of ESRD at the end of 2013 (USRDS Report 2015). A study by Hoerger TJ et al. (2015) that used a simulation model to predict the incidence of CKD in the United States, suggested that about 17% of the population above 30 years will have chronic kidney disease by 2030. Thus, an increasing trend is seen in the overall incidence and prevalence of ESRD in the United States.

Studies have shown that CKD not only reduces the quality of life of the individual patient but also puts a financial burden on them (Evans et al., 1985; Essue, Wong, Chapman, Li, & Jan, 2013). This burden is especially high among patients residing in developing countries without universal medical coverage. Patients have to bear the cost of treatment through out-of-pocket expenditures, which in turn reduces their access to treatment (Garcia-Garcia & Jha, 2015). The cost of treatment of CKD and ESRD also

contributes to the expenditure on healthcare in developed countries like the United States, which spent 30.9 billion dollars (7.1% of the overall Medicare expenditure) on the treatment of ESRD in 2013 (USRDS Report 2015).

Treatment for End-Stage Renal Disease

Patients with ESRD can be treated with either renal replacement therapy or kidney transplantation. Renal replacement therapy is performed intermittently or continuously using hemodialysis or peritoneal dialysis methods. The process of hemodialysis involves filtering blood outside the body by passing it through a dialyzer while peritoneal dialysis involves cleansing of blood with the help of a catheter surgically inserted into the peritoneal cavity (Fleming 2011). Hemodialysis is generally performed at a dialysis facility while peritoneal dialysis is performed at the patient's home. According to the USRDS 2014 report, around 88.2% of U.S. patients received hemodialysis while around 9% received peritoneal dialysis. Both peritoneal dialysis and hemodialysis are effective in treating patients with ESRD and there is no significant difference in the median survival time among patients on hemodialysis and peritoneal dialysis (Sanabria et al., 2008). However, both peritoneal dialysis and hemodialysis have long-term complications and the survival rate of patients who receive kidney transplant is higher than those on dialysis.

Kidney transplantation is an alternate treatment for patients with ESRD. There are two types of kidney transplantation: deceased donor transplant and living donor transplant. In 2013, 68% of the US patients (11878 patients) received a deceased donor transplant while around 32% received a living donor transplant (USRDS Report 2015). Various studies have shown that kidney transplantation is associated with reduced morbidity and mortality and better quality of life as compared to dialysis (Tonelli et al., 2011; Mazzuchi et al., 1999). According to the USRDS Report 2015, the five-year survival (%) of patients receiving hemodialysis was 40.2% compared to 74.6% among patients who received a deceased donor transplant. Moreover, the

cost of treatment for patients receiving a kidney transplant ($29,920 per person per year (PPPY) in 2013) was much lower compared to dialysis (hemodialysis $84,550 PPPY in 2013). A study by Rosselli, Rueda, & Diaz (2015) also suggested that kidney transplantation is a cost effective option for treating patients with ESRD compared to dialysis. Thus, due to the better health outcomes and lower treatment costs associated with transplant, kidney transplantation is a preferred treatment of choice for patients with ESRD.

Disparities in Renal Transplant

Disparities are seen in incidence, prevalence and health outcomes of many non-communicable diseases. Healthcare disparities refer to differences in access to or availability of facilities and services while health status disparities refer to the variation in rates of disease occurrence and disabilities among socioeconomic and/or geographically defined population groups (Heath Services Research Information Center: Health Disparities). Both healthcare and health status disparities have been documented in renal transplantation.

In 2012, a total of 17,305 patients received a kidney transplant in the United States. About two thirds of these patients received a deceased donor transplant. Variations are seen in the transplant rate among populations that belong to different age groups. In 2012, children (<18 years of age) had the highest transplant rate of 44.5%; patients in the age group of 18 to 44 years had a transplant rate of 8.5% while a 4.4% transplant rate was observed among those in the age group of 45 to 64 years (USRDS Report 2014). Thus, a steady decrease is observed in the rate of transplant with the increase in age.

Racial and ethnic disparities have also been documented in the transplant process in the United States. In 2012, whites had a transplant rate of 4.4% whereas African Americans and Native Americans had a transplant rate of 2.6% and 2.7% respectively. These racial disparities in the transplant rates between whites and African Americans have persisted for more than two decades. (USRDS Report 2014). In addition to racial disparities, gender differences are seen in transplant rates, with a lower transplant rate among

women (39% in 2012) as compared to men (USRDS Report 2014). A lower access to transplant is also observed among individuals with lower socioeconomic status (SES). A study by Axelrod et al. (2010) found that patients with the highest quartile of SES were 76% more likely to receive a living donor transplant compared to individuals with in the lowest quartile.

A variety of individual and neighborhood level factors are responsible for these disparities and it is necessary to understand the role of these factors in the process of transplant to reduce disparities in access to kidney transplantation.

Geographic Disparities in Access to Kidney Transplantation

In addition to demographic disparities, geographic variations are seen in the access to transplantation in the United States. A study by Ashby et al. (2007) found that the transplant rates in different states of the United States ranged from 60 % below to 150 % above the national average transplant rates. Various factors like geographic remoteness, the distance from the transplant center, and residential location in a rural (vs. urban) settings have been associated with these disparities (O'Hare, Johansen, & Rodriguez, 2006 ;Axelrod et al., 2010). In 2014, Patzer et al. found that despite the higher incidence of ESRD in the Southeast regions of United States, these regions had the lowest transplant rates.

Patient characteristics, including demographic profile and poverty level in this region, may be responsible for the lower transplant rates. Understanding these characteristics could help in explaining some of the geographic disparities in the transplant rates. ESRD Network 6 is comprised of GA, NC and SC, and is the largest network of the ESRD program with around 608 chronic dialysis facilities and 40731 prevalent cases of ESRD at the end of 2012. While no major gender differences were seen in the ESRD population of Network 6 and United States (54% males in Network 6 vs 58% in the United States), differences were observed in the racial composition in this region compared to the rest of the United States. African

Americans constitute around 67% of the population of ESRD Network 6, while whites constituted around 31% of the population. The proportion of African Americans with ESRD in Network 6 is higher compared to national average (47% vs. 26%, respectively) (Council SK ESRD Network 6, USRDS Report 2015). The proportion of African Americans in ESRD Network 6 (67%), and the higher prevalence of ESRD in this population compared to whites (prevalence ratio=3.7 in 2013) explains the higher prevalence of ESRD in Network 6(USRDS Report 2015). The percent of population below the poverty line was higher in Network 6 (16-18%) compared to the United States and less likely to be insured. (Council SK ESRD Network 6; Patzer et al. 2014). The lower SES status and reduced access to care in this region correlate with the lower transplant rates in the region.

Thus, the demographic composition and the SES status of the population in Network 6 explains some the geographic disparities in the kidney transplantation in the Southeast regions of United States.

RaDIANT Community Study

Racial disparities in access to transplant in the United States are apparent and targeting ESRD regions with maximum disparities will reduce the disparities in access to transplantation (Patzer & Pastan, 2014). The Reducing Disparities in Access to kidNey Transplantation (RaDIANT) Community study is a multi-component, randomized, dialysis facility-level trial developed and implemented by the Southeastern Kidney Transplant Coalition of Georgia, North Carolina, and South Carolina which aims at improving the referral for transplantation in Georgia and reduce racial disparities in transplant referral (Patzer et al., 2014).

As a part of the RaDIANT Community Study, dialysis facilities in Georgia were randomized two groups. The standard of care intervention group received standard quality improvement care but no educational programs, while the intervention group received multilevel quality improvement and educational

programs including educational webinars, patient and staff level educational activities, monthly monitoring of quality improvement activities and traditional quality improvement oversights (Patzer et al., 2014). To evaluate the effectiveness of the trial in improving referral to transplant and reduction in racial disparities, patient level transplant referral data from 154 dialysis facilities in Georgia was collected at the three adult transplant centers: The Emory Transplant Center (Atlanta, GA), Georgia Regents Kidney and Pancreas Transplant Program (Augusta, GA) and the Piedmont Transplant Institute (Atlanta, GA) (Patzer et al., 2014).

Process of Transplant and Referral to Transplant

The process of transplant is complex and though many transplant programs follow standardized guidelines for transplant referral, disparities exist in the rate of kidney transplantation. Racial/ethnic minorities and those with low SES residing in certain geographical areas are less likely to be evaluated and waitlisted for transplantation than their counterparts (Axelrod et al., 2010). In order to address these disparities, it is necessary to understand the transplant process and identify disparities in the different stages of transplant.

Though kidney transplant is the preferred treatment for patients with ESRD (Stage 4 -5 CKD), only 2.6% of the patients with CKD were referred for transplant prior to dialysis in 2013 (USRDS Report 2015). While dialysis is life-saving for patients, it is also the strongest modifiable risk factor for poor post-transplant outcomes. Thus, preemptive referral (referral for transplant prior to starting dialysis) is the optimal treatment option for patients (Meier-Kriesche & Kaplan, 2002). Despite these advantages, less than 5% of patients are referred preemptively every year (USRDS Report 2015). African Americans have 66% lower odds of being referred preemptively for transplant. A three times higher likelihood of referral was observed among patients having private insurance compared to those without private insurance (Grams, Chen, Coresh, & Segev, 2013).

Patient education is an important step in the transplant process and all patients with ESRD should be educated about the different options for treatment of ESRD and the process of kidney transplantation. Though patient education helps in achieving optimal outcomes throughout the transplant process, studies and focus group discussions have shown that patients have limited knowledge about the transplant process and few educational resources are available for clarifying their misconceptions (Wilson, Brown, Boothe, & Weng, 2012); Patzer et al., 2014). Interventions that provide educational training to the patients and the dialysis facility staff have shown an overall increase in the patient participation and reduction in disparities in the transplant process (Patzer et al., 2012).

Referral by a dialysis facility medical provider to a transplant center for the required medical and psychosocial evaluation from the dialysis facility is the first step in the process of transplant. Early referral for transplant provides more time for identification of living donors and providing education to the patients (Organ Procurement and Transplant Network). It also reduces the mortality and morbidity associated with transplant. A study by Kasiske et al. (2002) showed that patients who were referred preemptively had a lower risk of graft failure compared to those who received a transplant after dialysis. Thus, early referral for transplant is a critical first step in the transplant process.

Patient evaluation is the next step in the transplant process. Psycho-social evaluation and medical screening tests are performed as a part of the evaluation process. Patients need to complete the evaluation process in order to be waitlisted for transplant. Racial and gender disparities are seen in the evaluation process with African Americans and women having a lower rate of completion (Monson et al., 2015). Following the evaluation, patients approved for transplantation are either waitlisted to receive a deceased donor transplant or receive a living donor transplant. Studies have shown that racial disparities exist among those waitlisted for transplantation, with a 23% lower likelihood of wait-listing among African Americans compared to whites (Patzer et al., 2015). Various factors like age and presence of comorbid conditions also appear to be related to the process of wait-listing (Weng, Joffe, Feldman, & Mange, 2005).

Factors Associated with kidney transplantation

A variety of patient level and provider factors are likely to be related to the disparities in the process of kidney transplantation. Studies have shown that higher income and awareness about the transplant process are associated with higher wait-listing among patients (Goldfarb-Rumyantzev et al., 2012; Goldfarb-Rumyantzev et al., 2011). A study by Gillespie et al. (2014) suggested that though females are twice more likely than men to receive offers for living donor transplant, they are less likely to want living donor transplant. Previous research has also shown that females have lower odds for being waitlisted for transplant and receiving a transplant as compared to males (Alexander & Sehgal, 1998; Schaubel et al., 2000).

Race is an important factor that influences the transplant process. In general, African Americans have lower transplant rates as compared to whites. Though some of these disparities can be explained by other factors like SES and neighborhood conditions, overall the race of an individual influences access to transplant and the rate of transplant (Patzer, Perryman, Schrager, et al., 2012). Other racial minorities also tend to have a lower transplant rate after wait-listing. A study by Acre et al. (2013) found that Hispanics had 33% lower deceased donor transplant rate as compared to non-Hispanic whites.

The presence of comorbidities and other clinical conditions also affects access to transplant evaluation and wait-listing. Studies have shown that coronary artery disease, diabetes, lupus erythematous, Body Mass Index have an influence on the transplant rate and outcomes (Wolfe et al., 2000). Transplant rates are also influenced by age, with 29% lower waitlisting among patients above 65 years compared to those below 65 years of age (Lenihan, Hurley, & Tan, 2013).

In addition to individual level factors, dialysis facility characteristics and neighborhood factors also influence the referral for transplant. A higher mortality and lower referral for transplant is observed in for-

profit dialysis facilities compared to non-profit facilities. A study by Patzer, Plantinga, Krisher & Pastan (2014) has shown that dialysis facility size and patient characteristics affect the standardized transplant ratios (STR), a measure used to determine the transplant rate of the dialysis facilities. An overall higher STR is observed among facilities providing treatment to more patients and having a large staff. Other dialysis facility characteristics like the racial composition of the patients treated at the center and the number of transplant centers in the area where the dialysis facility is located are also related to access to transplant. Neighborhood factors like neighborhood poverty have also been associated with decreased wait-listing among patients undergoing renal transplantation. Provider factors, cultural preferences, lack of health literacy are some of the other factors that affect the transplant rate and increase the racial disparities in access to kidney transplantation (Ayanian, Cleary, Weissman, & Epstein, 1999; Boulware et al., 2005).

Importance of Socioeconomic Status in Access to Transplantation

SES affects the health of an individual through many direct and indirect pathways and is an important predictor of health outcomes and access to healthcare. Studies have well documented the role of socioeconomic disparities in access to kidney transplant and transplant outcomes (Goldfarb-Rumyantzev et al., 2006; Goldfarb-Rumyantzev et al., 2011; Taber et al., 2015).

SES, measured using composite individual and neighborhood factors, influences different stages in the process of kidney transplantation. A greater time to wait-listing is observed among patients with lower SES. A study by Keith et al. (2008) has shown that patients with Medicare had a longer time to wait-listing compared to those with private insurance. Similar studies conducted by Saunders MR, Cagney KA, Ross LF, Alexander GC. et al.(2010) have indicated that African Americans living in predominantly poor black neighborhoods were less likely to be waitlisted compared to African Americans living in wealthy black

neighborhoods. Lower rate of preemptive referral for wait-listing is observed among patients with poor financial resources and lower education level.

In addition to affecting the time to waitlisting, SES also affects the overall transplant rate. An increase in the transplant rate is seen as the median income increases. A study by Axelrod et al. (2010) found that patients in the highest quartile of income are 76% likely to receive living donor transplant compared to those in the lowest quartiles. The surrounding SES level also has an impact on the transplant rates, with higher transplant rates in poor counties surrounded by relatively poorer counties and lower transplant rates in poor counties surrounded by wealthy counties (Mohan et al., 2014).

Studies have shown that access to kidney transplantation is also influenced by insurance status, where individuals without private insurance have lower rates of referral (Patzer et al., 2015) and transplant waitlisting (Johansen, Zhang, Huang, Patzer, & Kutner, 2012) compared to patients with private insurance. Lower neighborhood SES has also been established as a risk factor for delayed transplant access, where patients living in the poorest (vs. wealthiest) neighborhoods have a lower odds of referral and waitlisting (Plantinga et al., 2014). While prior studies have examined racial and socioeconomic disparities separately, no study to our knowledge examined whether racial disparities exist across different levels of SES. Studying the role of race on the association socioeconomic disparities between referral for transplantation will provide a better understanding of disparities in the transplant process and drive interventions to reduce these disparities.

Indicators used for measuring socioeconomic status

Education, household income, occupation are commonly used for measuring the SES of an individual. (American Psychological Association, Education and Socioeconomic status). Other indicators like health insurance status, living standard, housing, wealth, and neighborhood socioeconomic status can also be

used to define SES. As discussed earlier SES is an important predictor of health and hence, it is necessary to use these indicators collectively to define SES.

Various studies have been conducted to understand the different ways of defining SES in health research (Shavers, 2007). Though education level is an excellent predictor of an individual's work and economic condition, it remains stable after early adulthood and does not take into consideration the variability in the career development among individual's which has an impact both on the SES and health of an individual (Winkleby, Jatulis, Frank, & Fortmann, 1992). Household income and family wealth to a large extent determines access to resources and can also be used to define SES. However, there is a high chance that an individual's income may not be reported or may be misreported. Occupation of an individual determines his or her earnings and exposure to stresses but it is subjectively difficult to classify occupation. Also, all these indicators do not consider the neighborhood of an individual, which has a significant influence on the health of an individual. Due to these shortcomings, it is necessary to consider other measures to define the SES of an individual.

Insurance status of an individual is a useful indicator of SES which has been used extensively in health research (Ducros et al., 2015). In the United States, insurance status is an important indicator of SES of an individual. According to the US Census Data Report 2014, the population living below 100 percent of poverty had the highest rate of uninsured which gradually decreased for population groups living in 100-199 and 200-399 percent of poverty. Also, the highest rate of private insurance was observed among those who had income to population ratios above 400 percent. Studies have also shown that insurance status affects the access to of healthcare resources and the uninsured are less to be evaluated or waitlisted for or kidney transplantation (Schold et al., 2011). Thus, insurance status is an important indicator of SES which can be used as a proxy indicator for SES to evaluate the association between SES and referral for transplantation. In addition to insurance status, other factors like pre-ESRD nephrology care which have

been associated with SES and are related to better health outcomes after kidney transplantation can also be used to measure SES (Patzer & McClellan 2012).

Though various individual level indicators of SES can be used collectively to define SES, information about these measures may not be obtained from medical records. Additionally, contextual poverty plays an important role in the patient's overall SES. Hence, it is necessary to include aggregate neighborhood level SES measures for defining the SES status of an individual. A study by Krieger N (1992) which compared SES measures from census data to individual SES measures to predict health outcomes, showed that census level data can be used as a valid indicator for predicting SES. Similar studies conducted in Southern Europe and the United States also support these findings (Dominguez-Berjon, Borrell, Rodriguez-Sanz, & Pastor, 2006; Diez-Roux et al., 2001). Thus, a combination of individual level measures like insurance status and pre-ESRD nephrology care and neighborhood factors like poverty level and education status can be used to define SES.

Chapter II: Manuscript

The Influence of Socioeconomic Status and Minority Race on Referral for Kidney Transplantation in Georgia

Introduction

Racial and socioeconomic disparities in access to kidney transplantation have been previously documented, however, a prior study in Georgia found that African Americans were more likely to be referred for transplantation and yet less likely to be waitlisted. Little is known about whether racial disparities in transplant referral vary across levels of socioeconomic status (SES) of a patient and the neighborhood in which they reside.

Methods:

Patient referral data from January 2005 to September 2011 was obtained from the Reducing Disparities in Access to Kidney Transplantation (RaDIANT) Community Study and linked to the US Renal Data System (USRDS) and US Census Data. Race was defined as African American, white Hispanic, white non-Hispanic and other. Individual level SES was defined using insurance status and pre-ESRD nephrology care; neighborhood level SES was defined using neighborhood poverty levels and percentage of high school graduates. The outcome was referral for transplant evaluation. Multivariable Cox models adjusted for demographics and dialysis facility characteristics were used to examine whether racial disparities in access to referral for transplantation varied across SES measures.

Results:

Overall, 5362 (35.9%) patients were referred for kidney transplantation after starting dialysis. The median time from dialysis start to referral was 624 days (IQR: 182 – 1417). No statistically significant interaction was seen between race and SES. Among patients with no insurance, African Americans were three times

more likely to be referred for transplant one year after starting dialysis compared to whites (HR= 3.32 , 95% CI: 1.31 - 8.40)). Among patients referred for transplant within one year after starting dialysis, African Americans living in neighborhoods 15-30% below the poverty level were 61% more likely to be referred for transplant compared to whites (HR= 1.61, 95% CI: (1.11 - 1.23)). Among those living in neighborhoods with less than 80% high graduates, African Americans were 94% more likely to be referred for transplant within one of starting dialysis compared to whites (HR= 1.94, 95% CI: (1.02 - 3.68)).

Conclusion:

These results suggest that racial disparities in access to kidney transplantation vary by a patient's SES.

Introduction

Kidney failure associated with ESRD is among the leading causes of death both in developed and developing countries. Over the years, the prevalence of CKD and ESRD has gradually increased in the United States and at the end of 2014, 661,648 cases of ESRD were reported in the United States (USRDS Report 2015). ESRD is associated with progressive loss of the renal function and patients have to undergo renal replacement therapy or kidney transplantation for their survival. The cost of renal replacement therapy puts a huge burden on the United States health system which spent around 30 billion dollars on the treatment of ESRD in 2014 (USRDS Report 2015).

Due to the improved quality of life, better survival and cost effectiveness renal transplant is the preferred treatment for ESRD (Wong et al. 2012). However, disparities are seen in the process of kidney transplantation. A study by Alexander & Sehgal (1998) found that African Americans had lower odds of being waitlisted and receiving a transplant as compared to whites (odds ratio=.50). An 11% lower access to transplantation is seen among women as compared to men (Segev et al., 2009). According to the USRDS Report 2015, a gradual decrease is seen in the transplant rate as age increases, with a lowest transplant

rate among patients between 65-74 years (2.5%) and above 75 years (0.3%). In addition to demographic variations in the transplant rate, geographic disparities are also seen in the transplant rate with the lowest transplant rates in the Southeastern regions of the United States (Patzer et al. 2014; USRDS Report 2015). To reduce disparities in the transplant process in the Southeastern region of the United States, ESRD Network 6 has partnered with Southeastern Coalition for Kidney Transplant (SECKT), a non-profit organization composed of voluntary stakeholders from the ESRD Community including patients, dialysis facilities, transplant centers, social workers, academic researchers and healthcare providers. SECKT has developed the RaDIANT Community study, a community based intervention study to reduce disparities in access to transplant and improve the overall transplant rates (Patzer et al., 2014). As a part of the RaDIANT study, 134 dialysis facilities from Georgia are randomized into two groups to receive either a multicomponent intervention or a standard of care intervention. To evaluate the effectiveness of the study, the referral data from the dialysis facilities is continuously collected at the three adult Transplant Centers in Georgia (the Emory Transplant Center, the Georgia Regents Kidney and Transplant Program and the Piedmont Transplant Institute (Patzer et al., 2014).

Various individual and neighborhood factors have been associated with the disparities in the transplant process. A study by Satayathum et al. (2005) found that for every 10 years increase in age the odds of being waitlisted decrease by 33%. In addition to age, gender also affects waitilisting and evaluation for transplant. A study by Garg, Furth, Fivush, & Powe (2000) found that women were 18% less likely to be activated for waitlisting as compared to men. Race and ethnicity are important predictors in the access to transplant. Compared to whites, African Americans took longer to complete evaluation (HR=0.63) and were 23% less likely to be waitlisted for transplantation within one year of starting dialysis (Weng et al. 2005; Patzer et al. 2015). Previous research has shown that patients with coronary heart disease, congestive cardiac failure and left ventricular failure have 20% - 35% lower transplant rates compared to those without diseases (Gaylin et al., 1993). Both individual SES and neighborhood poverty level have an impact on referral for

transplant (Gaylin et al., 1993). In the United States, insurance status of related to the SES of an individual; with a higher SES among those with private insurance and a comparatively lower SES among those with Medicaid or no insurance (US Census Data Report 2014). Patients with non-commercial insurance (Medicare) are 30% less likely to be evaluated for transplant compared to patients with commercial insurance (Schold et al., 2011). In addition to insurance status, indicators of SES like pre-ESRD nephrology care also influence the access to health services and health outcomes and can be used to measure the SES of an individual. Studies have shown that neighborhood poverty level is an important indicator of SES can be used as a valid estimate to measure SES (Krieger, N. (1992). Patients living in poor neighborhoods have lower odds of being waitlisted compared to those residing in wealthy neighborhoods. A study by Patzer et al. (2009) found that Africans Americans living in poor neighborhoods were 57% less likely to be waitlisted for transplant compared to whites. In addition to these patient level factors, dialysis facility characteristics, geographical location, patient and provider preferences, cultural beliefs and health literacy are also related to access to kidney transplant and wait listing for transplant(Dageforde, Box, Feurer, &Cavanaugh, 2015; Dudley, Johnson, Thomas, Ravanan, & Ansell, 2009).

As discussed earlier, racial disparities exist in the transplant rate. A recent study in Georgia showed that African Americans are 22% more likely to be referred for transplant but 23% less likely to be waitlisted. The study also showed disparities in the access to transplant by individual SES and neighborhood characteristics of dialysis facilities (Patzer et al. 2015). However, no research has been carried out to understand the influence of race on the association between SES and referral for transplant. Understanding racial disparities in referral for transplant within different levels of SES will provide a better understanding of the racial disparities in transplant and help in implementing interventions to reduce disparities in transplant.

METHODS

Data Sources

This research study used retrospective patient level referral data collected from 2005 to 2012 obtained from the RaDIANT Community study (Patzer et al., 2014). Patient level referral information from 308 dialysis facilities was collected at all three adult transplant centers in Georgia (Emory Transplant Center, Georgia Regents Kidney and Pancreas Transplant Program and the Piedmont Transplant Institution). The patient level referral data included information on patient's age, race/ethnicity, dialysis start date and the referral date for transplantation. This information was then sent to Network 6 where it was de-identified and linked to the United States Renal Data System (USRDS). The USRDS is a national surveillance system that collects, analyzes and distributes information on CKD and ESRD in the United States, and provides information on the patient's insurance status, treatment history, previous hospitalization encounters, and dialysis facility characteristics.

The 5 digit patient level zip code from the referral data was then linked to the American Community Survey Census data to obtain ZIP-code level measures to assess the patient's neighborhood-level socioeconomic status. Neighborhood level indicators of SES included the percentage of residents living below the poverty line and percent high school graduates within the ZIP code. No direct contact was made with the patients during the study. The study was approved by the Institutional Review Board of Emory University, Georgia Reagents Hospital and the Piedmont Transplant Hospital.

Study Population

The study used referral information on participants referred from dialysis facilities in Georgia from January 1, 2005 to September 30, 2011 with follow up through September 30, 2012. Participants referred after September 30, 2011 were not included as a part of the study as they could not be followed for one year to receive information about their transplant status.

Though there is no specific cut off referral depending on age, the study included populations in the age group from 18 to 69 years. Pediatric patients and participants over 70 years were excluded from the study. Patients with a BMI greater than 60kg/m^2 were also excluded from the study. The study only included participants who were referred for transplant after starting dialysis, patients referred preemptively were not included in the analysis.

Study Variables

Outcome Variable

The outcome variable was time to referral for kidney transplantation. The time to referral was defined as the number of days from the start of dialysis to the referral date for transplant from the dialysis facility. Referral information on both living donor transplant and deceased donor transplant was included in the analysis.

Exploratory Variables

The primary exploratory variable was race, obtained from the referral data from dialysis facilities. Race/ethnicity was classified into 4 groups (White non-Hispanics, African Americans, Hispanics and Other) for the analysis. The SES, secondary exploratory variable was defined using individual level measures like insurance status(Private, Medicare, Medicaid & Other and No insurance) and access to nephrology care prior to ESRD (categorized as a dichotomous variable). Neighborhood level SES measures like percent below the poverty line (categorized as 0-<15 percent below the poverty line, 15-30 percent below the poverty line ,>30 percent below the poverty line) and the percentage of high school graduates(categorized as < 80 percent high school graduates, 80 or more percent high school graduates) were also used to define SES. Information on both individual level SES measures and neighborhood level measures was obtained from the USRDS surveillance reports from 2005-2011 and the US Census Tract Data from 2007-2011.

Other Covariates:

Demographic and clinical patient level covariates included age (further classified into 5 groups: 18-29, 30-39,40-49,50-59.60-69 years), sex(female, male) and comorbidities (cardiac heart disease, atherosclerotic heart disease, other cardiac disorders, stroke, pulmonary vascular disease, chronic obstructive pulmonary disease, hypertension, diabetes, tobacco use, using other drugs and cancer) were included in the analysis. Dialysis facility characteristics included dialysis facility size (categorized as <25, 26-54, 55-79,> 79), and facility type (for profit and free standing) obtained from the USRDS data were also included in the study.

Data Analysis

Descriptive characteristics of patients referred for transplant were compared to those not referred for transplant. Chi-square tests were performed on all dichotomous and nominal variables like age, gender, race/ethnicity, year of ESRD start, comorbidities, insurance status, pre-ESRD nephrology care, percent below the poverty line and dialysis facility characteristics; while percent high school graduates and percent college graduates (continuous variables) were compared using t-tests.

A Cox Proportional hazards model was used to examine the association between race/ethnicity, SES measures, patient characteristics (demographic and clinical), and dialysis facility characteristics on referral for transplant. The follow-up time was defined as the number of days for referral after starting dialysis. The goodness of fit tests and graphical approaches were used to evaluate the proportional hazards assumption. Based on these tests, an extended cox model with a single heaviside function was used for analyzing time dependent variables including race/ethnicity, chronic obstructive pulmonary disease, hypertension, insurance status, pre-ESRD Nephrology care, percent below the poverty line and dialysis facility size. Likelihood ratio tests were used to assess model significance as well as for addition and removal of individual variables. Hazard ratios (HR) and 95% confidence intervals (CI) were calculated for the effect of patient characteristics, SES measures and dialysis facility characteristics.

The effect of race on referral for transplant within levels of SES was assessed by including interaction terms between race and SES measures in the previously fit model. Due to the small sample size of white Hispanics (n=298) and other race (n=182) which further decreased upon stratification by SES levels these racial groups were not included in the model to access interaction between SES and race and its influence on SES status. Hazard ratios (HR) and 95% confidence intervals (CI) were calculated, and the final model included demographic characteristics (age, sex,), clinical features (comorbidities) and dialysis facility characteristics (facility size, for profit, free standing) as potential confounders. A two-tailed significance level of $p<0.05$ was used for the analysis and all statistical analyses were performed with SAS 9.4 (Cary, NC).

RESULTS

Characteristics of Patients referred for transplantation

A total of 5362 (35.90%) patients were referred for kidney transplantation over the median 624 (IQR: 182-1417) days of the study. The characteristics of the patients referred for transplant compared to those not referred for transplant are summarized in Table 1 (N=14293). Statistically significant differences were seen in the demographic, clinical and SES characteristics of patients referred for transplant compared to those not referred for transplant. In general, the patients referred for transplant were younger (23.11% vs 43.53% in the age group between 60-69 years) and had a lower presence of comorbidities (except hypertension). Males were more likely to be referred for transplant as compared to females (57.94% vs 42.06% respectively). The majority of the study participants were African Americans (65.8%) while white non-Hispanics, Hispanics, and other racial groups, formed a smaller percentage of the study cohort (30.29%, 2.3% and 1.61% respectively). Racial differences were seen among those referred for transplant compared to those not referred for transplant (p-value < 0.0001). African Americans constituted around 72% of the population referred for transplant compared to around 62% among those not referred for transplant.

Patients referred for transplant had higher individual level SES measures compared to those not referred for transplant (private insurance: 36.49% vs 22.63% respectively; pre-ESRD nephrology care: 61.92% vs 58.73% respectively, p-value= .0004). Lower patient poverty levels (20% or more below poverty level) were observed among those not referred for transplant(50.24% vs 56.27%) compared to those referred for transplant while the mean percentage of high school graduates was higher among those referred for transplant (Mean(SD): 82.22(8.06) vs 80.8(8.11), p-value < 0.0001). Variations were also seen in the dialysis facility characteristics with a higher percentage of for profit and free standing facilities among the referred group.

Association between Patient Characteristics and Referral for Transplantation

Patient characteristics (age, sex, presence of comorbidities), SES measures and dialysis facility characteristics influenced the referral for transplantation (Table 2). Patients in the age group of 60- 69 years were 66% less likely to be referred compared to those in the age group of 18-29 years (HR=0.33, 95% CI: 0.29- 0.37). Females were also less likely referred for transplant as compared to males (HR=0.89, 95% CI: 0.84 - 0.95). While African Americans (HR=1.2, 95% CI: 1.11 - 1.30) and other racial groups (HR=1.83, 95% CI: 1.46 -2.30) were more likely to be referred for transplant within 1 year of starting dialysis compared to white non-Hispanics, no difference was observed in the referral for Hispanics compared to white non - Hispanics(HR=1.09, 95% CI: 0.87 - 1.36). Among those referred for transplant after 365 days, African Americans (HR=1.46, 95% CI: 1.01 - 2.12), Hispanics (HR=2.17, 95% CI: 1.86 -2.54) and other racial groups (HR=1.95, 95% CI: 1.13 - 3.36) showed a higher referral compared to white non-Hispanics. In general, patients with comorbidities were less likely to be referred for transplant compared to patients without comorbidities (except for those with hypertension).

Both individual level and neighborhood measures of SES affect the referral for those referred within the first year of ESRD. While those with private insurance were 66% more likely to be referred for transplant (HR=1.66, 95% CI: 1.51 - 1.82) compared to those with Medicare and other insurance, patients with Medicaid were 13% less likely to be referred for transplant (HR=0.87, 95% CI: 0.77 - 0.97) compared to those with Medicare and other insurance. For those referred for transplant after one year, a higher referral was seen among patients with private insurance (HR=1.37, 95% CI: 1.17 - 1.62)) and no insurance (HR=1.44, 95% CI: 1.21 - 1.71) whereas a lower referral was seen among patients with Medicare (HR= 0.77, 95% CI: 0.65 - 0.92). Patients who received pre-ESRD nephrology care were 24% more likely to be referred for transplant compared to those without pre-ESRD nephrology care. Those living 15-30% below the poverty level and more than 30% below the poverty level were less likely to be referred for transplant ((HR= 0.89, 95% CI: 0.83 - 0.96) and (HR= 0.78, 95% CI: 0.69 - 0.88)) compared to those living in less than 15% below the poverty line. A higher rates of referral was also seen among patients living in neighborhoods with more than 80% high school graduates compared to neighborhoods with less than 80% high school graduates(HR=1.09, 95% CI: 1.02 - 1.17).

Dialysis facility characteristics like facility size, for-profit and free standing also influenced the referral for transplant. A higher referral was observed among for-profit (HR=1.32, 95% CI: 1.19 -1.47) and free standing facilities (HR=1.30, 95% CI: 1.11- 1.52), while patients referred from larger facilities (>79 patients) had lower referral compared to those referred from smaller facilities (<25 patients).

Influence of interaction between race and SES on the Referral for Transplantation

Multivariable extended cox model showed the influence of race on the association between SES and referral for kidney transplantation (Table 3). No statistically significant interaction was observed among race and SES measures. Among patients with no insurance, African Americans were three times more likely

to be referred for transplant one year after starting dialysis compared to whites (HR= 3.32 , 95% CI: 1.31 - 8.40)). No difference was observed in the likelihood of referral among Blacks compared to whites among patients with private insurance (HR (Blacks vs whites): 0.71, 95% CI: (0.40 -1.23)), Medicaid (HR (Blacks vs whites): 1.12, 95% CI: (0.49 -2.56)), Medicaid (HR: 1.22, 95% CI: (0.57 -2.60)) and no insurance (HR (Blacks vs whites): 2.14, 95% CI: (0.98 -4.66)) referred within one year of starting dialysis. No interaction was seen between race and SES among patients with pre-ESRD nephrology care. Among patients referred for transplant within one year after starting dialysis, African Americans living in neighborhoods 15-30% below the poverty line were 61% more likely to be referred for transplant compared to whites (HR= 1.61, 95% CI: (1.11 - 1.23)). Among patients living in neighborhoods 15-30% below the poverty line, the HR for referral after one year of starting dialysis among African Americans vs whites was 2.59 (95% CI: 1.26 – 5.34)). No difference in the likelihood for referral was seen Blacks compared to whites among patients living in neighborhoods <15% below poverty line, referred for transplant within one year after starting dialysis (HR (Blacks vs whites):0.95, 95% CI: (0.55 - 1.67)). No difference was observed in the referral (within one year of starting dialysis) between African Americans compared to whites living in neighborhoods >30% below poverty level (HR: 1.41, 95% CI: (0.55 - 3.60)). Among those living in neighborhoods with less than 80% high graduates, African Americans were 94% more likely to be referred for transplant within one of starting dialysis compared to whites (HR= 1.94, 95% CI: (1.02 - 3.68)).

Discussion

This study showed the effect of interaction between race and SES status on referral to transplant. According to the study findings, African Americans were 20% more likely to be referred for transplant within one year of starting dialysis compared to whites (Table 2). However, it is observed that within same SES levels African Americans may not have a higher referral compared to whites (Table 3). For example, among patients with private insurance, no difference is observed in the likelihood of referral among African Americans vs whites referred within one year of starting dialysis (HR :0.71, 95% CI: (0.40-1.23)). The study findings also

show that a higher likelihood of referral is observed among African Americans vs whites within lower SES levels. This indicates that referral for transplant varies by SES levels and interventions to reduce health disparities should be focused within levels of SES.

Previous studies on have documented racial disparities in evaluation and wait-listing for kidney transplantation with a lower odds of wait-listing among African Americans (Alexander & Sehgal, 1998), but no study outside of the Southeastern US has examined racial disparities in referral for transplantation. Our study shows that though racial disparities exist among those referred for transplant, African Americans are 20% more likely to be referred for transplant compared to white non-Hispanics. The results of this study support the findings of a study by Patzer et al. (2015) in Georgia which also showed that African Americans were 22% more likely to be referred for transplant compared to whites, and yet African Americans were less likely to be waitlisted. These results suggest that racial disparities in transplantation are not due to racial disparities in transplant referral, but may be due to steps prior to referral, such as preemptive referral, and/or after referral, such as medical eligibility for a transplant.

One of the strengths of our study is that we have used different individual level and neighborhood level measures for defining SES. Both individual level and neighborhood level measures of SES are related to referral for transplantation, with a higher likelihood of referral among those with private insurance (HR=1.66, 95% CI: (1.51 - 1.82)) and living in neighborhoods with higher SES (Table 2). These findings are consistent with prior literature on transplant which suggests that a higher transplant evaluation and waitlist rate is seen among patients with higher SES (Axelrod et al., 2010;Patzer et al. 2009). In addition to SES status other factors like age, gender, presence of comorbidities and dialysis facility characteristics also influence the referral for transplantation. Older patients, females and patients with severe comorbidities chronic cardiac failure, atherosclerotic heart disease, stroke, pulmonary vascular disease and cancer were less likely to be referred for transplant. These findings also support the results obtained from studies conducted on transplant waitlisting data in the United Kingdom and United States (Akolekar, Forsythe, &

Oniscu, 2013 ; Gaylin 1993). The study also showed that patients with hypertension (HR= 1.28, 95% CI: (1.14 -1.44)) and diabetes (HR= 1.35, 95% CI: (1.11 - 1.65)) were more likely to be referred for transplant; indicating that the referral for transplant varies across patients with different comorbidities with a lower referral among patients with severe life threatening comorbidities.

Various studies have shown a lower wait-listing among patients treated at for-profit dialysis facilities compared to those treated at non-profit facilities. While a study conducted by Satayathum et al. (2005) on National Data from Centers for Medicare and Medicaid showed that there is no association between dialysis facility ownership (for-profit vs non-profit) and wait-listing for transplant, our study shows that patients treated at for-profit facilities are more likely to be referred for transplant. Changes in the dialysis facility policies over time or differences in the patients characteristics referred from the dialysis facility may be responsible for a higher referral but lower wait listing among patients treated at for- profit facilities. However, it is necessary to explore the factors that may be responsible the variations in influence of dialysis facilities on different stages in the process of kidney transplant.

Based on previous literature and results of our study we can conclude that factors associated with referral for transplant may be different from those associated with wait-listing for transplant. Our study shows a higher likelihood of referral among African Americans and other racial groups (compared to whites) and a lower likelihood of referral among patients with higher age whereas previous studies have shown racial disparities in wait-listing for transplant with a lower wait-listing and evaluation among African Americans and other minorities and no association between age and wait-listing for transplant among those referred within one year of dialysis (Patzer et al. 2015). Also, studies have also shown a lower wait-listing among patients with diabetes while our study shows a higher referral among patients with diabetes (Wolfe et al, 2000). The differences in the influence of these factors on referral and wait-listing can be explained partly by patient preferences for transplant, completion of evaluation and/or being preemptively referred for transplant. Thus, the study highlights the importance of understanding disparities in different stages of

kidney transplantation and directing interventions at different stages of transplant process to reduce these disparities.

Limitations

Despite the large study population and different measures and data sources used to define SES the study has few limitations that might influence the results. First, the study uses referral information from Georgia which has a low referral rate and huge racial disparities in the process of transplant. So the results from this study may not be applicable for other regions of the United States with average or high transplant referral and fewer disparities in access to kidney transplantation. Also, the study uses insurance status of individual as a predictor of SES and large variations are seen in the healthcare policies and insurance coverage across different health systems which might also affect the generalizability of the results.

Second, the study is restricted to the population in the age group between 18-70 years. Around one-third of the patients with ESRD are in the age group above 65 years and this population varies from the study population in terms of their health status, access to healthcare and SES level. A higher prevalence of comorbidities and Medicare coverage is seen in the older population and including this population in the study might provide a better understanding of the impact of health status (presence of comorbidities) on referral for transplant.

Thirdly, this study does not assess the role of dialysis facility staff preferences and awareness on the referral for transplant. Studies have shown that health literacy, provider preferences and knowledge about the transplant process affect referral for transplant, however, this study does not include any measures to account for these differences across dialysis facilities(Grubbs, Gregorich, Perez-Stable, & Hsu, 2009; Tong et al., 2014). Also, categories of insurance status have been combined for analysis and Hispanics and other racial groups were excluded in the analysis to access the influence of race on referral to transplant within levels of SES, which limits the conclusions that can be drawn from the results.

Future Considerations:

Through various studies have explored the factors responsible for disparities in access to transplant very few studies have studies the interaction between these factors and its effect of referral for transplantation. The results of our study imply the need to understand the role of interactions between various factors and its influence on referral for transplant. Racial disparities are seen in the referral for transplantation within levels of SES which guides planning and implementing interventions within levels of SES. The variations observed in the influence of different factors like race, age and dialysis facility characteristics on different stages of transplantation reinstates the need to study the different stages in the process of transplantation. Further research that explores the interaction between race and SES on referral data obtained from dialysis facilities across the nation could also more insight into the geographical variations in the referral for transplantation.

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Table 1. Characteristics of Patients with End Stage Renal Disease(ESRD) Referred for Renal Transplantation from 2005-2011 in Georgia (n=14932)

	Study Population (n=14932) N (%)	**Referred for Transplant (n=5362) N (%)**	**Not referred for transplant (n=9570) N (%)**	**p-value**
Patient Characteristics				
Age				<.0001
18-29	662(4.43)	362(6.75)	300(3.13)	
30-39	1417(9.49)	732(13.65)	685(7.16)	
40-49	2787(18.66)	1248(23.27)	1539(16.08)	
50-59	4661(31.21)	1781(33.22)	2880(30.09)	
60-69	5405(36.20)	1239(23.11)	4166(43.53)	
Sex				<.0001
Male	8174(54.74)	3107(57.94)	5067(52.95)	
Female	6758(45.26)	2255(42.06)	4503(47.05)	
Race/Ethnicity				<.0001
White, non-Hispanic	4523(30.29)	1231(22.96)	3292(34.4)	
White, Hispanic	343(2.3)	136(2.54)	207(2.16)	
Black	9826(65.8)	3869(72.16)	5957(62.25)	
Other	240(1.61)	126(2.35)	114(1.19)	
ESRD start year				0.0002
2005	2182(14.61)	683(12.74)	1499(15.66)	
2006	2256(15.11)	830(15.48)	1426(14.9)	
2007	2172(14.55)	776(14.47)	1396(14.59)	
2008	2201(14.74)	801(14.94)	1400(14.63)	
2009	2293(15.36)	862(16.08)	1431(14.95)	
2010	2161(14.47)	812(15.14)	1349(14.1)	
2011	1667(11.16)	598(11.15)	1069(11.17)	
Presence of Comorbidities				
Cardiac Heart Failure	4047(27.10)	1147(21.39)	2900(30.30)	<.0001
Atherosclerotic Heart Disease	1725(11.55)	427(7.96)	1298(13.56)	<.0001
Other Cardiac Disorders	1976(13.23)	543(10.13)	1433(14.97)	<.0001
Stroke	1346(9.01)	303(5.65)	1043(10.90)	<.0001
Pulmonary Vascular Disease	1461(9.78)	358(6.68)	1103(11.53)	<.0001
COPD	1009(6.76)	186(3.47)	823(8.60)	<.0001
Hypertension	13163(88.15)	4823(89.95)	8340(87.15)	<.0001
Diabetes	8192(54.86)	2758(51.44)	5434(56.78)	<.0001
Tobacco Use	1531(10.25)	450(8.39)	1081(11.30)	<.0001
Other Drugs	340(2.28)	79(1.47)	261(2.73)	<.0001
Cancer	705(4.72)	126(2.35)	579(6.05)	<.0001

Table 1(Continued). Characteristics of Patients with End Stage Renal Disease (ESRD) Referred for Renal Transplantation from 2005-2011 in Georgia((n=14932)

Measures of Socioeconomic Status				
Insurance				<.0001
Private	4121(27.61)	1956(36.49)	2165(22.63)	
Medicaid	3828(25.65)	1072(20.0)	2756(28.81)	
Medicare	3218(21.56)	793(14.79)	2425(25.35)	
Other	677(4.54)	249(4.65)	428(4.47)	
None	3082(20.65)	1290(24.07)	1792(18.73)	
Pre-ESRD Nephrology Care (Yes)	7689(59.90)	2907(61.92)	4782(58.73)	0.0004
Neighborhood Poverty Level				
Percent below poverty level				<.0001
<15	4647(30.73)	1802(34.51)	2645(28.59)	
15 - <30	7506(51.87)	2625(50.28)	4881(52.77)	
<=30	2518(17.40)	794(15.21)	1724(18.64)	
Education				
Percent High-School Graduates, Mean(SD)	81.3(8.11)	82.22(8.06)	80.8(8.11)	<.0001
Dialysis Facility Characteristics				
Facility size				0.0394
<25	3235(21.66)	1274(23.76)	1961(20.49)	
26 -54	4157(27.84)	1423(26.54)	2734(28.57)	
55-79	3756(25.15)	1285(23.96)	2471(25.82)	
>79	3784(25.34)	1380(25.74)	2404(25.12)	
For profit	12157(82.15)	4572(85.68)	7585(80.15)	<.0001
Free standing	13646(91.39)	5009(93.42)	8637(90.25)	<.0001

Abbreviations: COPD - Chronic Obstructive Pulmonary Disease

ESRD – End Stage Renal Disease

Table 2. Extended Cox Model evaluating the crude association of patient characteristics, socioeconomic status and dialysis facility factors with referral for kidney transplantation among patients referred for transplant from 2005-2011 in Georgia

	Hazard Ratio	
	Referral within 1-year of starting dialysis	**Referral after 1-year of starting dialysis**
Patient Characteristics		
Age		
18-29	Ref.	
30-39	0.79(0.69 - 0.91)	
40-49	0.64(0.56 -0.73)	
50-59	0.55(0.48 - 0.62)	
60-69	0.33(0.29 - 0.37)	
Sex		
Male	Ref	
Female	0.89(0.84 - 0.95)	
Race/Ethnicity		
White, non-Hispanic	Ref	Ref
White, Hispanic	1.09(0.87 - 1.36)	1.46(1.01 - 2.12)
Black	1.20(1.11 - 1.30)	2.17 (1.86 -2.54)
Other	1.83(1.46 -2.30)	1.95(1.13 - 3.36)
Presence of Comorbidities		
Cardiac Heart Failure	0.82(0.76- 0.88)	
Atherosclerotic Heart Disease	0.88(0.79 - 0.98)	
Other Cardiac Disorders	0.86(0.77 - 0.94)	
Stroke	0.68(0.60 - 0.77)	
Pulmonary Vascular Disease	0.83(0.73 -0.93)	
Chronic Obstructive Pulmonary Disease	0.70(0.59 -0.82)	
Hypertension	1.28(1.14 -1.44)	0.96(0.85 - 1.07)
Diabetes	1.05(0.98 - 1.13)	1.35(1.11 - 1.65)
Tobacco Use	0.88(0.79 -0.98)	
Other Drugs	0.63(0.50 - 0.80)	
Cancer	0.50(0.41 - 060)	

Table2 (Continued). Extended Cox Model evaluating the crude association of patient characteristics, socioeconomic status and dialysis facility factors with referral for kidney transplantation among patients referred for transplant from 2005-2011 in Georgia

Measures of Socio-Economic Status		
Insurance		
Medicare +Other	Ref	Ref
Medicaid	0.87(0.77 - 0.97)	0.77(0.65 -0.92)
Private	1.66(1.51 - 1.82)	1.37 (1.17 - 1.62)
None	0.99(0.89 - 1.11)	1.44(1.21 - 1.71)
Pre-ESRD Nephrology Care		
Yes	1.24(1.15- 1.33)	1.24 (1.14 -1.33)
Neighborhood Poverty Level		
Percent below poverty level		
<15	Ref.	Ref.
15 - <30	0.89(0.83 - 0.96)	0.91(0.80 - 1.04)
<=30	0.78(0.69 - 0.88)	0.96(0.81 - 1.14)
Education		
Percent High-School Graduates	1.09(1.02 - 1.17)	
Dialysis Facility Characteristics		
Facility size		
<25	Ref.	Ref.
26 -54	0.77(0.70 -0.85)	0.95(0.80 - 1.12)
55-79	0.80(0.72 -0.88)	0.83(0.70 - 0.99)
>79	0.73(0.67 -0.80)	0.83(0.71 - 0.98)
For profit	1.324(1.193 -1.469)	
Free standing	1.301(1.113- 1.521)	

Abbreviations: COPD - Chronic Obstructive Pulmonary Disease
ESRD -End Stage Renal Disease

Table3. Influence of Race and Socio-Economic Status on Referral for Transplantation among patients referred for kidney transplantation from 2005 to 2011 in Multivariable Cox Model

	Race=Black†			
	HR(95%CI) Before 365 days (n=3280)	**Interaction P-value**	**HR(95% CI) After 365 days (n=5100)**	**Interaction P-value**
Insurance Status		0.15		0.23
Medicare + other	1.22(0.57 - 2.60)		1.30(0.47 - 3.62)	
Medicaid	1.12(0.49 - 2.56)		2.20(0.70 - 6.89)	
Private	0.71(0.40 -1.23)		1.20(0.53 - 2.70)	
None	2.14(0.98 - 4.66)		3.32(1.31 - 8.40)	
Pre-ESRD Nephrology Care		0.86		0.52
Yes	1.05(0.65 - 1.68)		1.55(0.78 - 3.10)	
No	1.78(0.91 - 3.48)		2.50(0.95 - 6.60)	
Percent below poverty line		0.33		0.15
<15	0.95(0.55 - 1.67)		2.34(0.91 - 5.99)	
15 - 30	1.61(1.11 - 2.33)		2.59(1.26 - 5.34)	
>=30	1.41(0.55 - 3.60)		1.23(0.29 - 5.27)	
Percent high school graduates		0.78		0.24
80 or more	0.94(0.62 - 1.43)		1.87(0.91 - 3.84)	
Less than 80	1.94(1.02 - 3.68)		2.11(0.81 - 5.51)	

† white non - Hispanics used as a reference group

Abbreviation: ESRD -End Stage Renal Disease