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# INFLUENCE OF SPATIAL TOPOGRAPHY OF POVERTY ON HOSPITALIZATION STATUS FOLLOWING RENAL TRANSPLANTATION

By

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Master of Public Health

Department of Epidemiology

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# INFLUENCE OF SPATIAL TOPOGRAPHY OF POVERTY ON HOSPITALIZATION STATUS FOLLOWING RENAL TRANSPLANTATION

By

Yama Afshar

Bachelor of Science

University of California, Los Angeles

2010

Faculty Thesis Advisor: Rachel Patzer, PhD, MPH

An abstract of

A thesis submitted to the Faculty of the

Rollins School of Public Health of Emory University

in partial fulfillment of the requirements for the degree of

Master of Public Health in Epidemiology

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Background: Previous studies suggest that neighborhood poverty contributes to disparities among patients with End Stage Renal Disease (ESRD). It is unclear whether spatial topography of poverty across geographical regions in the United States influences hospitalization status following renal transplantation.

Methods: We examined 18,736 adult (18+), first-time, kidney-only transplant recipients from the United Network for Organ Sharing database between 2004-2005. Both adjusted and unadjusted logistic regression models were used to explore the relationship between a previously described index and whether a patient was hospitalized approximately 1.5 years (620 days) post renal transplantation. Patients missing data on the exposure (n=428)—spatial topography of poverty—or outcome (n=501)—hospitalization status—were excluded from the analysis.

Results: In multivariable models adjusted for age, race, sex, BMI, diabetes, hypertension, donor type, primary form of payment, HLA match, and serum albumin at registration, we found that the odds of hospitalization among patients living in counties with high poverty rates that were categorized as spatial outliers was 1.14 (95% CI 1.01-1.28, p = 0.01) times that of patients living in counties with poverty rates within 1 standard deviation of the mean county poverty rate in the United States (14.2%) that were categorized as neither spatial outliers nor part of a concentrated cluster.

Conclusions: Our analysis demonstrates that the number of hospitalizations in a county is influenced by the economic prosperity of its surrounding counties in addition to its own poverty rate.

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Table of Contents

# Chapter I: Background

Chronic Kidney Disease (CKD) is the presence of kidney damage or decreased kidney function. The National Kidney Foundation defines CKD as an estimated glomerular filtration rate (eGFR) less than 60 ml/min/1.73m$^2$ for three or more months with or without evidence of kidney damage.(1) Glomerular filtration rate (GFR)—estimated using serum creatinine with adjustments for age, race, and gender—is the volume of fluid filtered from the glomerular capillaries per unit time. As kidney function deteriorates, eGFR decreases. There are five different stages of CKD; the fifth and final stage (eGFR < 15) corresponds to end stage renal disease (ESRD) or renal failure. Adjusted five-year survival probabilities among white and black ESRD patients are just 0.32 and 0.39, respectively.(2)

One of the primary goals of Healthy People 2020—the national objectives for improving the health of all Americans—is to "reduce the incidence of CKD and its complications, disability, death, and economic costs."(3) There are 14 objectives specific to CKD alone, including a 10 percent reduction in the proportion of the US population with CKD.(3) Unfortunately, none of the objectives directly address health disparities in CKD and ESRD incidence, risk factors, and disease treatment among socioeconomic and racial groups. This chapter will provide an overview of CKD and ESRD before taking a closer look at health disparities in kidney disease.

## Disease Burden

*Incidence and Prevalence*

CKD is a major public health problem. Between 1988-1994 and 2005-2010, the prevalence of CKD in the National Health and Nutrition Examination Survey (NHANES) population—a nationally representative sample of adults and children in the United States—increased from 12.3 to 14.0 percent, representing roughly 44 million individuals.(2) Similarly, the incidence and prevalence of end-stage renal disease (ESRD) has increased. Since 2000, the greatest adjusted incidence rates were observed in patients aged 75 and older (12.2% increase to 1,773 per million population) and blacks (7.0% decrease to 924 per million population).(2) Overall rates have remained steady in recent years. In 2010, the incidence rate fell 2.0 percent from the previous year to 348 per million population while the prevalence rose 1.7 percent to 593,086 individuals.(2)

*Risk Factors*

The National Kidney foundation conducted a review of longitudinal studies in order to determine risk factors associated with susceptibility, initiation, and progression of CKD.(1) Potential risk factors can be used to identify individuals at increased risk for CKD. Examples include age, gender, race, family history, diabetes, hypertension, hyperlipidemia, smoking, diet, obesity, and protein consumption.(1) Hypertension and diabetes mellitus, for instance, account for over 60% of incident ESRD.(2)

*Screening*

Screening individuals at high risk for CKD may prevent the incidence and progression of CKD. Both urine albumin and creatinine are noninvasive and cost-effective tests that can

be used to detect early signs of kidney damage.(2) In 2010, the probability of creatinine testing in Medicare patients was 0.77; the probability increases to 0.93 in patients with both diabetes and hypertension.(2) The probability of urine albumin testing is less common. In 2010, the probability of testing all patients was just 10%, although the probability of testing patients with both diabetes and hypertension was 36%.(2)

*Treatment*

Treatment of ESRD typically requires renal replacement therapy in the form of dialysis or renal transplantation. There are two types of dialysis: peritoneal dialysis and hemodialysis. They primarily differ in the location of filtration: peritoneal dialysis occurs in the body and hemodialysis occurs in a dialyzer. While patient survival is similar for both modalities, hemodialysis may be associated with lower quality of life.(4, 5) As clinical outcomes improved in the 1980s, renal transplantation surpassed maintenance dialysis as the preferred treatment modality for ESRD.(6) A review of 110 studies found that transplantation is associated with lower mortality and improved quality of life compared with dialysis.(7) Moreover, despite high initial costs, long-term costs of transplantation are less than that of dialysis: in 2010, total Medicare expenditures per person per year for dialysis patients was nearly five times that of transplant patients.(3, 8) Unfortunately, there is a shortage of kidneys available for transplant. The gap between the number of patients waiting for a transplant and the number of patients receiving a transplant continues to increase.(9) There are two main forms of renal transplantation: deceased donor and living donor. The use of kidneys from live donors is preferred as living donor

transplantation is associated with increased survival.(9) Therefore, expansion of living donor transplantation is a priority.

In 1972, Congress extended Medicare coverage to the vast majority of individuals with ESRD to ensure equitable access to renal replacement therapy. Nevertheless, disparities in access to transplantation among racial and socioeconomic groups persist. In 1985, black Medicare beneficiaries with ESRD received transplants at half the rate of white beneficiaries.(6) The same difference existed fifteen years later. In 2010, 9.0% of black ESRD patients received a kidney transplant within 3 years of initiation compared to 20.4% of whites.(2) Moreover, although blacks comprise approximately 50% of prevalent ESRD patients, they received just 33% of deceased donor transplants and 14% of living donor transplants in the same year.(2) This discrepancy in transplant rates by race is cause for concern. Living donor transplants are associated with reduced morbidity and mortality compared to deceased donor transplants; nearly twice as many living donor transplant recipients survive and maintain graft function for at least ten years (82% vs. 44%).(2)

Racial disparities also exist in the process leading to transplantation. Studies have documented the existence of racial and socioeconomic disparities in referral to a transplant center, evaluation for transplant suitability, and placement on the United Network for Organ Sharing (UNOS) deceased donor waiting list. An analysis of 2,291 black and white patients in the Southeastern United States found that a greater proportion of white versus black patients proceeded in starting the evaluation, wait listing, and

receiving a transplant.(10) As a result, improving access to healthcare may reduce some of the racial disparities observed in kidney transplantation.

*Costs*

Unfortunately, the aforementioned treatment modalities are costly: total Medicare expenditures per person per year in 2010 was $87,561 for hemodialysis patients, $66,751 for peritoneal dialysis patients, and $32,914 for transplant patients.(2) In general, patients with ESRD consume a disproportionate amount of health care resources. Only 1.3% of Medicare patients have ESRD but they account for 7.5% of Medicare spending.(2) Economic costs only partially capture the full burden, as individuals with renal failure experience chronic disability, premature mortality, and diminished quality of life.(11)

*Renal Transplant Outcomes*

Renal transplant outcomes such as mortality, all-cause graft failure, and return to dialysis or retransplant have improved considerably over time. In 2010, the total death rate for persons with functioning kidney transplants decreased 2.2% from 2000 to 32.3 deaths per 1,000 patient years at risk.(2) The leading causes of death were cardiovascular disease (29.9%), infection (20.8%) and malignancy (9.4%).(2) Moreover, In 1968, only 38.8% of deceased donor transplant recipients survived and had a functioning graft two years after renal transplantation.(12) Today, over 80% of living donor transplant recipients and 44% of deceased donor transplant recipients survive and maintain graft function for at least ten years.(2) Many patients with graft failure resume dialysis and relist for repeat transplantation,

increasing the demand for donations. Approximately 4.8% of dialysis patients and 14% of patients on the kidney wait list had a failed transplant.(2, 13) Nevertheless, the probability of a return to dialysis or retransplant has decreased. Between 1991 and 2000, the aforementioned probability among deceased donor transplant recipients and living donor transplant recipients decreased by 26 and 23 percent, respectively.(13)

**Racial and SES Disparities**

In 2010, 46.2 million Americans lived at or below the poverty rate. Poverty or low socioeconomic status (SES) disproportionately affects minorities in the United States. Blacks suffer the highest poverty level at 27.4%. Low socioeconomic status (SES) is associated with both individual and community level factors that affect the incidence and progression of poor health outcomes, including CKD and ESRD.(14) The prevalence of CKD among blacks and whites is similar.(2) However, even after a 7.0% decrease since the previous year, the rate of ESRD among blacks was 3.4 times greater than that among whites in 2010 (262 per million population).(2) Despite comparable prevalence of CKD, the risk of ESRD for blacks is higher. The reasons for this pattern are unclear. Moreover, adjusted incidence rates of ESRD caused by diabetes vary widely by race and ethnicity. Among whites aged 30 to 39, the incident rate was 35.4 per million population, a 1.0 percent decrease from 2000.(2) For blacks of the same age, the incident rate was 133.8 per million population, a 69 percent increase from 2000.(2) A similar pattern was observed for adjusted incident rates of ESRD caused by hypertension.

*Geographic variation in incidence*

There is also substantial variation in the incidence of ESRD between and within different countries(2, 11, 15, 16). In 2010, the reported incidence rate was highest in Mexico (425 per million population), followed by the United States (369 per million population) and Taiwan (361 per million population).(2) On the other end of the spectrum, Bangladesh (20 per million population), Russia (40 per million population), Scotland (81 per million population), and Denmark (99 per million population) all reported incidence rates below 100 per million population.(2) In the United States, incidence rates and prevalence counts are highest in the Ohio Valley, portions of Texas and California, and the Southwestern states.(2) This geographic variation in risk reflects socioeconomic factors: Young et al. found an inverse association between the incidence of ESRD and income level.(17)

**Spatial Topography of Poverty**

The purpose of this study is to determine the association between a novel measure of poverty, the spatial topography of poverty, and hospitalization post renal transplantation. Spatial topography differs from mere descriptive epidemiology in the use of Moran's I to measure spatial autocorrelation, which refers to "the degree to which attributes or values at some place on the earth's surface are similar to attributes or values of nearby locations."(18) Therefore, spatial autocorrelation allows us to identify county-level "clusters" and "outliers" of poverty. We will then examine the influence of this geographical variation in the intensity of poverty on the incidence of hospitalization among adult, first-time, kidney-only transplant recipients by county.

## Chapter II: Manuscript

### Title, Author, Abstract

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## Introduction

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In the United States, health disparities persist in CKD and ESRD incidence, risk factors, and disease treatment. Low socioeconomic status (SES) and race in particular are associated with individual and community level factors that affect the incidence and progression of poor health outcomes.(14) Although the prevalence of CKD among blacks and whites is similar, the rate of ESRD among blacks was 3.4 times greater than that among whites in 2010.(2) The reasons for this pattern are unclear.

Neighborhood poverty has been shown in previous studies to contribute to disparities in access to treatment among ESRD patients.(19-21) However, it is unclear whether the

influence of contextual-level poverty extends to hospitalization following kidney transplantation. Nevertheless, a higher hospitalization rate in transplant recipients was observed among minorities vs. whites in a study of 32961 Medicare primary kidney transplant recipients.(22)

The purpose of this study is to examine the influence of a novel measure of neighborhood poverty—the spatial topography of poverty—on hospitalization following renal transplantation among a cohort of transplant recipients in the United States (US).

## Methods

### *Study Population and Data Sources*

The United Network for Organ Sharing (UNOS) is a non-profit organization that maintains the Organ Procurement and Transplantation Network (OPTN) Database. OPTN contains information regarding every organ donation and transplant event in the US since October 1, 1987. For this study, we used the Standard Transplant Analysis and Research (STAR) files based on OPTN data for kidney, pancreas, and kidney-pancreas waiting list and transplant/follow up patients between October 1, 1987 and October 31, 2011. STAR data was linked to the SAS ZIP code data file by ZIP code at transplantation, which was subsequently linked to a previously described index(18) by the counties' five-digit Federal Information Processing Standard (FIPS) code. The index contains a novel measure of community-level poverty, the spatial topography of poverty.

We restricted our analyses to data from 6/30/2004 to 1/1/2007 for adult (18 years or older), first-time, kidney-only transplant recipients where the transplant was received

before 1/1/2006, based on the availability of UNOS hospitalization data (Table 1). Analyses were further restricted by excluding those with missing information on both the exposure—spatial topography of poverty (n = 428)—and outcome (n = 501)—number of hospitalizations within a year and a half following renal transplantation. Patients who died or were lost to follow-up during the study period (n= 455) were similarly excluded Unreasonable values for body mass index (less than 10 and greater than 100) (n=231) and eGFR (greater than 125) were set to missing (n=2). The patients who were excluded for missing data on exposure or outcome were compared with those who were included in this analysis and found to be similar. Therefore, we believe that these data are missing at random.

*Primary Exposure*

The primary exposure was a novel measure of community-level poverty with a spatial component described by Dr. James Holt.(18) Using Census data from 2000, the poverty rate for each county was compared with the overall mean poverty rate for the United States (14.2%). Counties with a poverty rate greater than 1 standard deviation above the mean poverty rate were categorized as “high” poverty counties. On the other end of the spectrum, counties with a poverty rate less than 1 standard deviation below the mean poverty rate were categorized as “low” poverty counties. In order to measure spatial autocorrelation, local Moran indices were calculated for each county and converted to z scores.(18) A local Moran’s z score greater than or equal to 2 indicates that the county was located in a concentrated cluster; a z score less than or equal to -2 indicates that the county was a spatial outlier; and a z score between -2.0 and 2.0 is neither.(18) The

poverty levels and spatial situations were combined in order to create four distinct categories. A fifth category, "other," included counties with a poverty rate within 1 standard deviation of the mean poverty rate and belonged to neither a spatial concentration nor spatial outlier.

*Primary Outcome*

The primary outcome for this study was hospitalization status (yes vs. no) in approximately 1.5 years (620 days) post renal transplantation. Only hospitalizations experienced after the transplant visit were considered for these analyses.

*Statistical Analyses*

We performed descriptive analyses on the spatial topography of poverty, number of hospitalizations, and several potential confounders including recipient characteristics, comorbidities, socioeconomic status, donor characteristics, and transplant characteristics. Covariates under consideration included age; race; sex; BMI ($kg/m^2$); education level (none, grade school, high school, attended college, associate/bachelor degree, post-college graduate degree, missing); HLA match level (zero-six, missing); serum albumin (<=3.5, >3.5 g/dL, missing); diabetes (yes, no, missing); hypertension (yes, no, missing); primary form of payment (private insurance, public insurance, missing); donor type (living, deceased, deceased-expanded criteria); cold ischemia time (0-10, 11-20, 21-30, >30 hours, missing); and an interaction term between race and spatial topography of poverty. Multiple logistic regression models were developed, beginning with an unadjusted analysis of hospitalization status by spatial topography of poverty. Variables

that were found to be associated with both exposure and outcome during descriptive analyses were included in the preliminary multivariable ("gold standard") model. A stepwise backwards elimination procedure, described by Kleinbaum,(23) was used in the determination of the final model (Table 3). The least significant (highest p-value above α) covariate was dropped from the gold standard. This process was repeated until only statistically significant covariates remained. We assessed confounding and precision by comparing the odds ratios (OR) and confidence interval (CI) width in the model resulting from backwards elimination to the gold standard OR, respectively. The final model adjusted for age, race, sex, BMI, diabetes, hypertension, donor type, primary form of payment, HLA match, and serum albumin at registration. The absence of multicollinearly was confirmed.

*Statistical Significance*

All tests were two-sided, with statistical significance set at the $\alpha = 0.05$ level. Analyses were conducted using SAS 9.3 (North Carolina).

**Results**

A total of 18,736 adult, first-time, kidney-only transplant recipients were identified who met the inclusion criteria for this analysis. The mean age of the study population was 50 years (±14), 3,799 (25%) were black, 11,251 were men (60%), and the majority of patients had body mass indices greater than 24.9 $kg/m^2$ with 5,548 (30%) overweight, 4,468 (24%) obese, and 360 (2%) morbidly obese.

The characteristics of these subjects stratified by spatial topography of poverty and hospitalization status are presented in Table 1 and Table 2, respectively. Approximately 41% of the sample lived in low poverty counties, 18% lived in high poverty counties, and 41% lived in counties within 1 standard deviation of the mean poverty rate for the United States ("Other"). Compared to white patients, black patients were more likely to live in high poverty counties regardless of spatial status (30% black vs. 11% white, $p < 0.001$). The difference was even greater for high poverty counties classified as spatial outliers (16% black vs. 4% white, $p < 0.001$) (Figures 3 and 4). Moreover, while the distributions of sex was similar across categories of spatial topography of poverty; race, age, BMI, donor type, HLA match level, total serum albumin, cold ischemia time, diabetes, hypertension, education level, and primary form of payment were associated with spatial topography of poverty ($p < 0.001$ for all comparisons).

Roughly 40% of patients were hospitalized within 1.5 years post renal transplantation. Blacks were significantly more likely to be hospitalized than whites (43% black vs. 39% white, $p < 0.001$). Age, race, BMI, donor type, HLA match level, total serum albumin, diabetes, hypertension and primary form of payment were all significantly associated with hospitalization status ($p < 0.001$ for all comparisons). Sex ($p = 0.02$) and education ($p = 0.03$) were also significantly associated with hospitalization status.

Figure 1 shows the proportion of hospitalizations by spatial topography of poverty. Among low poverty counties, a higher proportion of patients living in clusters were hospitalized compared to patients living in outliers (40.7% cluster vs. 38.6%, $p = 0.17$).

This difference was not statistically significant. However, among high poverty counties, there was a statistically significant increase in the proportion of hospitalizations in outlier counties compared to counties belonging to a cluster (43.5% outlier vs. 39.1% cluster, p = 0.01).

In unadjusted logistic regression of hospitalization status by spatial topography of poverty found, the odds of hospitalization was 1.26 (95% CI 1.13, 1.41) times higher among patients living in high poverty outlier counties and 1.13 (1.05, 1.20) times higher among patients living in low poverty cluster counties compared to patients living in counties that neither belong to a spatial category nor have a poverty rate within 1 standard deviation of the mean for the United States ("Other"). However, the odds of hospitalization among patients living in high poverty cluster counties (OR 1.05, 195% CI 0.95-1.17) and low poverty outlier counties (OR 1.03, 0.91-1.17) were not significantly different from patients living in the previously described other category.

Following adjustment for potential confounders, the odds of hospitalization among patients living in high poverty cluster counties was 1.14 times higher than patients living in the "Other" category (95% CI 1.04-1.42). Significant associations between covariates and hospitalization status were also observed. For instance, the odds of hospitalization among patients with diabetes and hypertension was 1.3 (95% CI 1.22–1.39) and 1.4 (1.05-1.24) times that of patients without diabetes or hypertension, respectively. Moreover, the odds of hospitalization among extended criteria deceased donor transplant recipients was 1.53 (95% CI 1.37-1.71) times that of patients who received a living donor

transplant. There was no statistically significant difference in the odds of hospitalization between black and white (1.06, 95% CI 0.98-1.15) patients. In multivariable analyses, we did not observe interaction between race and spatial topography of poverty. In other words, their joint effect did not significantly differ from their independent effects ($p = 0.73$)

**Discussion**

In this analysis, we examined the effect of spatial topography of poverty on hospitalization status following renal transplantation. Patients living in counties with high poverty rates that were categorized as spatial outliers and counties with low poverty rates belonging to a concentrated cluster had significantly higher odds of hospitalization 1.5 years post renal transplantation compared to patients living in counties with poverty rates within 1 standard deviation of the mean county poverty rate in the United States (14.2%) that were categorized as neither spatial outliers nor part of a concentrated cluster. These differences were observed in crude analyses and after adjustment in multivariable models. Patients living in counties with high poverty rates belonging to a concentrated cluster and counties with low poverty rates that were categorized as spatial outliers had similar odds as the aforementioned referent group. Therefore, while neighborhood poverty has been shown to contribute to disparities in ESRD, our analysis demonstrates that the number of hospitalizations in a county is also influenced by the economic prosperity of its surrounding counties. The reasons for this association are unclear.

Hospitalizations are an important proxy for poor health outcomes post renal transplantation, such as mortality and loss of graft function. Our finding that

neighborhood poverty is associated with poor health outcomes is supported by a number of earlier studies. For instance, in a study of graft failure and graft function after transplantation, Press *et al.* found a lower incidence of graft survival among transplant recipients living in the poorest level of zip code poverty (173/1000 persons years) compared to the richest level (125/1000 person years).(24) Furthermore, a review of sociocultural and socioeconomic disparities in kidney transplant outcomes found consistent evidence of worse outcomes for patients with low income, less education, and black patients.(25) Although the proportion of blacks versus whites hospitalized in our study was greater for every category of spatial topography of poverty except the other category, we did not find a statistically significant association between black race and hospitalization in our adjusted multivariable model. There was also no association between patient education level and hospitalization.

Our findings also contribute to the growing body of disparities research in CKD and ESRD. Several studies have examined the association between race, poverty, and access to renal transplantation. Volkova *et al.* found a strong association between neighborhood poverty and ESRD incidence in both blacks and whites.(20) Similarly, Patzer *et al*. concluded that neighborhood poverty was associated with placement on the renal transplant waitlist. Relatively few studies, however, have examined the association between race, poverty and post-transplant outcomes.

The reasons for increased hospitalization in high poverty (spatial outlier) counties and low poverty (concentrated) counties are not immediately clear. Axelrod *et al.* found that

patients living further away from transplant centers had increased risk of post-transplant death.(26) Since affluent areas are more likely to have better healthcare resources, high and low poverty counties surrounded by prosperous counties would be expected to have decreased risk of poor health outcomes post-transplant. In that regard, hospitalization may have different meaning for high and low poverty counties. For instance, affluent individuals may be more likely to seek care for less severe conditions because they have the means to do so. Impoverished individuals, on the other hand, only do so out of necessity.

Nevertheless, there are several potential social and ecological explanations for the patterns observed in this study. The Gini coefficient is one of several measures of wealth distribution. A lower coefficient corresponds to greater equality; a higher coefficient corresponds to lesser equality. Wilkinson and Pickett found that health and social problems are more common in areas with a higher Gini coefficient.(27) As a result, areas with increased wealth distribution—such as a high poverty county surrounded by low poverty counties—may have increased risk of poor health outcomes. Residential segregation is another measure that may be associated with ESRD outcomes. It refers to the manner in which two or more groups live separately from one another.(28) Kimmel et al. found that black residents living in highly segregated areas had a 13% increased mortality risk.(29) Therefore, residential segregation may help explain the influence of surrounding counties on hospital readmission post-transplant.

*Strengths and Limitations*

Our study had several limitations. For instance, the analysis did not account for the potential correlation of patients living within the same county. Moreover, the UNOS database contains information regarding the number of transplant related hospitalizations during follow-up between 6/30/2004 and 1/1/2007; more recent data on hospitalizations was not available, and thus we are unable to evaluate whether the association between spatial topography of poverty and hospitalization is consistent in a more recent era of increased scrutiny and regulation on hospitalization readmissions following transplantation. The index we used to characterize the geographic concentration of poverty, however, was calculated using Census data from the year 2000. Despite this discrepancy, the poverty rate in the United States was relatively constant between 2000 and 2006.(30) Our study is also limited by the lack of individual-level poverty data in the UNOS database, although we did have individual proxies of poverty with the measurement of health insurance status and patient education level. Another limitation is that we do not have information on the date of hospitalization. As a result, it's difficult to assess the effect of early versus late hospital readmission. Patients who died or were lost to follow-up during the study period were excluded. Strengths of this research include the use of a nationally-representative surveillance database that contains information regarding every organ donation and transplant event in the United States. As a result, the population is sufficiently large and racial categories are well represented.

In summary, despite near universal coverage under Medicare, discrepancies in transplant outcomes by neighborhood poverty persist. Our findings show that the number of hospitalizations in a county is also influenced by the economic prosperity of its

surrounding counties in addition to its own poverty rate. These results will aid in the identification of areas at increased risk for poor health outcomes post renal transplantation.

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## Tables

**Table 1. Baseline Demographics of Study Population by Spatial Topography of Poverty - United Network for Organ Sharing (2004-2007)**

| | | | Spatial Topography of Poverty | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Overall** | | **Low Cluster** | | **Low Outlier** | | **High Cluster** | | **High Outlier** | | **Other** | | |
| | **N** | **%** | **N** | **%** | **N** | **%** | **N** | **%** | **N** | **%** | **N** | **%** | **P-value** |
| | 18,736 | 100.00 | 6,564 | 35.03 | 1,145 | 6.11 | 1,836 | 9.80 | 1,446 | 7.72 | 7,745 | 41.34 | |
| Ethnicity | | | | | | | | | | | | | <.001 |
| White | 10,363 | 55.31 | 4,714 | 71.82 | 723 | 63.14 | 686 | 37.36 | 421 | 29.11 | 3,819 | 49.31 | |
| Black | 4,632 | 24.72 | 1,158 | 17.64 | 288 | 25.15 | 626 | 34.10 | 760 | 52.56 | 1,800 | 23.24 | |
| Hispanic | 2,416 | 12.89 | 364 | 5.55 | 93 | 8.12 | 446 | 24.29 | 180 | 12.45 | 1,333 | 17.21 | |
| Asian | 943 | 5.03 | 265 | 4.04 | 34 | 2.97 | 18 | 0.98 | 49 | 3.39 | 577 | 7.45 | |
| Amer Ind/Alaska Native | 169 | 0.90 | 30 | 0.46 | - | - | 47 | 2.56 | 21 | 1.45 | 71 | 0.92 | |
| Native Hawaiian/other Pacific Islander | 89 | 0.48 | 11 | 0.17 | 1 | 0.09 | 3 | 0.16 | - | - | 74 | 0.96 | |
| Multiracial | 124 | 0.66 | 22 | 0.34 | 6 | 0.52 | 10 | 0.54 | 15 | 1.04 | 71 | 0.92 | |
| Gender | | | | | | | | | | | | | 0.52 |
| M | 11,251 | 60.05 | 3,966 | 60.42 | 690 | 60.26 | 1,120 | 61.00 | 842 | 58.23 | 4,633 | 59.82 | |
| Age | | | | | | | | | | | | | <.001 |
| <30 | 1,772 | 9.46 | 575 | 8.76 | 94 | 8.21 | 184 | 10.02 | 138 | 9.54 | 781 | 10.08 | |
| 30 to 39 | 2,731 | 14.58 | 886 | 13.50 | 161 | 14.06 | 268 | 14.60 | 209 | 14.45 | 1,207 | 15.58 | |
| 40 to 49 | 4,141 | 22.10 | 1,497 | 22.81 | 242 | 21.14 | 434 | 23.64 | 312 | 21.58 | 1,656 | 21.38 | |
| 50 to 59 | 5,2 | 28.20 | 1,846 | 28.12 | 320 | 27.95 | 544 | 29.63 | 401 | 27.73 | 2,173 | 28.06 | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 84 | | | | | | | | | | | |
| 60 to 69 | 3,7 | 20.26 | 1,359 | 20.70 | 258 | 22.53 | 348 | 18.95 | 312 | 21.58 | 1,518 | 19.60 | |
| | 95 | | | | | | | | | | | |
| >=70 | 1,0 | 5.41 | 401 | 6.11 | 70 | 6.11 | 58 | 3.16 | 74 | 5.12 | 410 | 5.29 | |
| | 13 | | | | | | | | | | | |
| BMI* | | | | | | | | | | | | | <.001 |
| <18.5 | 480 | 2.56 | 155 | 2.36 | 30 | 2.62 | 38 | 2.07 | 37 | 2.56 | 220 | 2.84 | |
| 18.5 to 24.9 | 5,5 | 29.66 | 1,910 | 29.10 | 332 | 29.00 | 503 | 27.40 | 453 | 31.33 | 2,360 | 30.47 | |
| | 58 | | | | | | | | | | | |
| 25 to 29.9 | 5,5 | 29.61 | 1,963 | 29.91 | 349 | 30.48 | 518 | 28.21 | 419 | 28.98 | 2,299 | 29.68 | |
| | 48 | | | | | | | | | | | |
| 30 to 39.9 | 4,4 | 23.85 | 1,668 | 25.41 | 256 | 22.36 | 487 | 26.53 | 338 | 23.37 | 1,719 | 22.19 | |
| | 68 | | | | | | | | | | | |
| >=40 | 360 | 1.92 | 165 | 2.51 | 20 | 1.75 | 32 | 1.74 | 32 | 2.21 | 111 | 1.43 | |
| Missing | 2,3 | 12.39 | 703 | 10.71 | 158 | 13.80 | 258 | 14.05 | 167 | 11.55 | 1,036 | 13.38 | |
| | 22 | | | | | | | | | | | |
| Donor Type | | | | | | | | | | | | | <.001 |
| Living | 8,0 | 43.16 | 3,301 | 50.29 | 452 | 39.48 | 627 | 34.15 | 529 | 36.58 | 3,177 | 41.02 | |
| | 86 | | | | | | | | | | | |
| Deceased | 8,7 | 46.85 | 2,635 | 40.14 | 578 | 50.48 | 1,035 | 56.37 | 721 | 49.86 | 3,809 | 49.18 | |
| | 78 | | | | | | | | | | | |
| Expanded Criteria | 1,8 | 9.99 | 628 | 9.57 | 115 | 10.04 | 174 | 9.48 | 196 | 13.55 | 759 | 9.80 | |
| | 72 | | | | | | | | | | | |
| HLA Match Level** | | | | | | | | | | | | | <.001 |
| Zero | 3,2 | 17.53 | 1,071 | 16.32 | 207 | 18.08 | 307 | 16.72 | 315 | 21.78 | 1,385 | 17.88 | |
| | 85 | | | | | | | | | | | |
| One | 5,0 | 27.03 | 1,671 | 25.46 | 297 | 25.94 | 528 | 28.76 | 442 | 30.57 | 2,126 | 27.45 | |
| | 64 | | | | | | | | | | | |
| Two | 3,2 | 17.29 | 1,128 | 17.18 | 203 | 17.73 | 324 | 17.65 | 234 | 16.18 | 1,351 | 17.44 | |
| | 40 | | | | | | | | | | | |
| Three | 3,8 | 20.34 | 1,448 | 22.06 | 235 | 20.52 | 348 | 18.95 | 244 | 16.87 | 1,535 | 19.82 | |
| | 10 | | | | | | | | | | | |
| Four | 1,3 | 7.32 | 504 | 7.68 | 95 | 8.30 | 131 | 7.14 | 96 | 6.64 | 546 | 7.05 | |
| | 72 | | | | | | | | | | | |
| Five | 1,0 | 5.37 | 357 | 5.44 | 57 | 4.98 | 99 | 5.39 | 64 | 4.43 | 429 | 5.54 | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 06 | | | | | | | | | | | |
| Six | 893 | 4.77 | 367 | 5.59 | 48 | 4.19 | 80 | 4.36 | 48 | 3.32 | 350 | 4.52 | |
| Missing | 66 | 0.35 | 18 | 0.27 | 3 | 0.26 | 19 | 1.03 | 3 | 0.21 | 23 | 0.30 | |
| Total Serum Albumin | | | | | | | | | | | | | <.001 |
| <=3.5 | 3,2 | 17.28 | 1,110 | 16.91 | 209 | 18.25 | 365 | 19.88 | 207 | 14.32 | 1,346 | 17.38 | |
| | 37 | | | | | | | | | | | | |
| >3.5 | 10, | 55.70 | 3,612 | 55.03 | 743 | 64.89 | 1,135 | 61.82 | 835 | 57.75 | 4,111 | 53.08 | |
| | 436 | | | | | | | | | | | | |
| Missing | 5,0 | 27.02 | 1,842 | 28.06 | 193 | 16.86 | 336 | 18.30 | 404 | 27.94 | 2,288 | 29.54 | |
| | 63 | | | | | | | | | | | | |
| Cold Ischemia Time | | | | | | | | | | | | | <.001 |
| 0-10 | 6,4 | 34.62 | 2,584 | 39.37 | 349 | 30.48 | 424 | 23.09 | 448 | 30.98 | 2,682 | 34.63 | |
| | 87 | | | | | | | | | | | | |
| 10-20 | 4,4 | 23.58 | 1,305 | 19.88 | 290 | 25.33 | 453 | 24.67 | 430 | 29.74 | 1,940 | 25.05 | |
| | 18 | | | | | | | | | | | | |
| 20-30 | 2,9 | 15.57 | 806 | 12.28 | 237 | 20.70 | 360 | 19.61 | 207 | 14.32 | 1,308 | 16.89 | |
| | 18 | | | | | | | | | | | | |
| >30 | 764 | 4.08 | 220 | 3.35 | 48 | 4.19 | 84 | 4.58 | 80 | 5.53 | 332 | 4.29 | |
| Missing | 4,1 | 22.14 | 1,649 | 25.12 | 221 | 19.30 | 515 | 28.05 | 281 | 19.43 | 1,483 | 19.15 | |
| | 49 | | | | | | | | | | | | |
| Diabetes | | | | | | | | | | | | | <.001 |
| No | 12, | 67.11 | 4,407 | 67.14 | 816 | 71.27 | 1,201 | 65.41 | 908 | 62.79 | 5,241 | 67.67 | |
| | 573 | | | | | | | | | | | | |
| Yes | 5,7 | 30.91 | 1,994 | 30.38 | 314 | 27.42 | 613 | 33.39 | 464 | 32.09 | 2,407 | 31.08 | |
| | 92 | | | | | | | | | | | | |
| Missing | 371 | 1.98 | 163 | 2.48 | 15 | 1.31 | 22 | 1.20 | 74 | 5.12 | 97 | 1.25 | |
| Hypertension | | | | | | | | | | | | | <.001 |
| No | 2,9 | 15.51 | 1,011 | 15.40 | 149 | 13.01 | 288 | 15.69 | 178 | 12.31 | 1,280 | 16.53 | |
| | 06 | | | | | | | | | | | | |
| Yes | 14, | 79.96 | 5,234 | 79.74 | 936 | 81.75 | 1,476 | 80.39 | 1,139 | 78.77 | 6,196 | 80.00 | |
| | 981 | | | | | | | | | | | | |
| Missing | 849 | 4.53 | 319 | 4.86 | 60 | 5.24 | 72 | 3.92 | 129 | 8.92 | 269 | 3.47 | |
| Education | | | | | | | | | | | | | <.001 |
| None | 110 | 0.59 | 32 | 0.49 | 5 | 0.44 | 13 | 0.71 | 7 | 0.48 | 53 | 0.68 | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Grade School | 977 | 5.21 | 193 | 2.94 | 49 | 4.28 | 161 | 8.77 | 95 | 6.57 | 479 | 6.18 | |
| High School | 7,295 | 38.94 | 2,622 | 39.95 | 450 | 39.30 | 805 | 43.85 | 611 | 42.25 | 2,807 | 36.24 | |
| Attended College | 3,786 | 20.21 | 1,255 | 19.12 | 261 | 22.79 | 383 | 20.86 | 226 | 15.63 | 1,661 | 21.45 | |
| College Degree | 2,435 | 13.00 | 994 | 15.14 | 162 | 14.15 | 180 | 9.80 | 152 | 10.51 | 947 | 12.23 | |
| Graduate Degree | 1,050 | 5.60 | 472 | 7.19 | 65 | 5.68 | 66 | 3.59 | 77 | 5.33 | 370 | 4.78 | |
| Missing | 3,083 | 16.45 | 996 | 15.17 | 153 | 13.36 | 228 | 12.42 | 278 | 19.23 | 1,428 | 18.44 | |
| Primary Payment | | | | | | | | | | | | | <.001 |
| Private Insurance | 7,872 | 42.02 | 3,330 | 50.73 | 471 | 41.14 | 486 | 26.47 | 474 | 32.78 | 3,111 | 40.17 | |
| Public Insurance | 10,832 | 57.81 | 3,222 | 49.09 | 671 | 58.60 | 1,345 | 73.26 | 969 | 67.01 | 4,625 | 59.72 | |
| Other | 32 | 0.17 | 12 | 0.18 | 3 | 0.26 | 5 | 0.27 | 3 | 0.21 | 9 | 0.12 | |
| | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** | **P-value** |
| Age | 49.58 | 13.55 | 50.12 | 13.49 | 50.28 | 13.51 | 48.65 | 13.05 | 49.91 | 13.64 | 49.18 | 13.69 | <.001 |
| BMI | 27.38 | 5.62 | 27.71 | 5.85 | 27.22 | 5.44 | 27.73 | 5.56 | 27.33 | 5.61 | 27.04 | 5.44 | <.001 |
| Cold Ischemic Time | 12.83 | 10.72 | 11.21 | 10.66 | 14.13 | 10.77 | 15.28 | 10.43 | 13.74 | 10.78 | 13.23 | 10.63 | <.001 |
| Total Serum Albumin | 3.89 | 0.60 | 3.89 | 0.59 | 3.91 | 0.62 | 3.87 | 0.57 | 3.94 | 0.59 | 3.89 | 0.61 | 0.03 |
| County Poverty | 12.55 | 5.77 | 7.76 | 2.46 | 9.38 | 2.02 | 21.05 | 5.62 | 21.56 | 4.66 | 13.37 | 3.07 | <.001 |

*Body Mass Index (kg/$m^2$)
**Human Leukocyte Antigen Match Level

**Table 2. Baseline Demographics of Study Population by Hospitalization Status - United Network for Organ Sharing (2004-2007)**

| | | | By Hospitalization Status | | | | |
|---|---|---|---|---|---|---|---|
| | Overall | | Yes | | No | | |
| | N | % | N | % | N | % | P-value |
| | 18,736 | 100.00 | 7,400 | 39.50 | 11,336 | 60.50 | |
| **Ethnicity** | | | | | | | <.001 |
| **White** | 10,363 | 55.31 | 4,056 | 54.81 | 6,307 | 55.64 | |
| **Black** | 4,632 | 24.72 | 2,012 | 27.19 | 2,620 | 23.11 | |
| **Hispanic** | 2,416 | 12.89 | 874 | 11.81 | 1,542 | 13.60 | |
| **Asian** | 943 | 5.03 | 315 | 4.26 | 628 | 5.54 | |
| **Amer Ind/Alaska Native** | 169 | 0.90 | 72 | 0.97 | 97 | 0.86 | |
| **Native Hawaiian/other** | 89 | 0.48 | 32 | 0.43 | 57 | 0.50 | |
| **Pacific Islander** | | | | | | | |
| **Multiracial** | 124 | 0.66 | 39 | 0.53 | 85 | 0.75 | |
| **Gender** | | | | | | | 0.018 |
| **M** | 11,251 | 60.05 | 4,366 | 59.00 | 6,885 | 60.74 | |
| **Age** | | | | | | | 0.001 |
| **<30** | 1,772 | 9.46 | 701 | 9.47 | 1,071 | 9.45 | |
| **30 to 39** | 2,731 | 14.58 | 1,019 | 13.77 | 1,712 | 15.10 | |
| **40 to 49** | 4,141 | 22.10 | 1,591 | 21.50 | 2,550 | 22.49 | |
| **50 to 59** | 5,284 | 28.20 | 2,094 | 28.30 | 3,190 | 28.14 | |
| **60 to 69** | 3,795 | 20.26 | 1,544 | 20.86 | 2,251 | 19.86 | |
| **>=70** | 1,013 | 5.41 | 451 | 6.09 | 562 | 4.96 | |
| **BMI*** | | | | | | | <.001 |
| **<18.5** | 480 | 2.56 | 190 | 2.57 | 290 | 2.56 | |
| **18.5 to 24.9** | 5,558 | 29.66 | 2,171 | 29.34 | 3,387 | 29.88 | |
| **25 to 29.9** | 5,548 | 29.61 | 2,183 | 29.50 | 3,365 | 29.68 | |
| **30 to 39.9** | 4,468 | 23.85 | 1,880 | 25.41 | 2,588 | 22.83 | |
| **>=40** | 360 | 1.92 | 176 | 2.38 | 184 | 1.62 | |
| **Missing** | 2,322 | 12.39 | 800 | 10.81 | 1,522 | 13.43 | |
| **Donor Type** | | | | | | | <.001 |
| **Living** | 8,086 | 43.16 | 2,956 | 39.95 | 5,130 | 45.25 | |
| **Deceased** | 8,778 | 46.85 | 3,525 | 47.64 | 5,253 | 46.34 | |
| **Expanded Criteria** | 1,872 | 9.99 | 919 | 12.42 | 953 | 8.41 | |
| **HLA Match Level**** | | | | | | | <.001 |
| **Zero** | 3,285 | 17.53 | 1,428 | 19.30 | 1,857 | 16.38 | |
| **One** | 5,064 | 27.03 | 2,050 | 27.70 | 3,014 | 26.59 | |
| **Two** | 3,240 | 17.29 | 1,315 | 17.77 | 1,925 | 16.98 | |
| **Three** | 3,810 | 20.34 | 1,465 | 19.80 | 2,345 | 20.69 | |
| **Four** | 1,372 | 7.32 | 489 | 6.61 | 883 | 7.79 | |
| **Five** | 1,006 | 5.37 | 340 | 4.59 | 666 | 5.88 | |
| **Six** | 893 | 4.77 | 289 | 3.91 | 604 | 5.33 | |
| **Missing** | 66 | 0.35 | 24 | 0.32 | 42 | 0.37 | |
| **Total Serum Albumin** | | | | | | | <.001 |
| **<=3.5** | 3,237 | 17.28 | 1,410 | 19.05 | 1,827 | 16.12 | |
| **>3.5** | 10,436 | 55.70 | 4,054 | 54.78 | 6,382 | 56.30 | |
| **Missing** | 5,063 | 27.02 | 1,936 | 26.16 | 3,127 | 27.58 | |
| **Cold Ischemia Time** | | | | | | | <.001 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **0-10** | 6,487 | 34.62 | 2,401 | 32.45 | 4,086 | 36.04 | |
| **10-20** | 4,418 | 23.58 | 1,879 | 25.39 | 2,539 | 22.40 | |
| **20-30** | 2,918 | 15.57 | 1,217 | 16.45 | 1,701 | 15.01 | |
| **>30** | 764 | 4.08 | 334 | 4.51 | 430 | 3.79 | |
| **Missing** | 4,149 | 22.14 | 1,569 | 21.20 | 2,580 | 22.76 | |
| **Diabetes** | | | | | | | <.001 |
| **No** | 12,573 | 67.11 | 4,673 | 63.15 | 7,900 | 69.69 | |
| **Yes** | 5,792 | 30.91 | 2,559 | 34.58 | 3,233 | 28.52 | |
| **Missing** | 371 | 1.98 | 168 | 2.27 | 203 | 1.79 | |
| **Hypertension** | | | | | | | <.001 |
| **No** | 2,906 | 15.51 | 1,051 | 14.20 | 1,855 | 16.36 | |
| **Yes** | 14,981 | 79.96 | 5,984 | 80.86 | 8,997 | 79.37 | |
| **Missing** | 849 | 4.53 | 365 | 4.93 | 484 | 4.27 | |
| **Education** | | | | | | | <.001 |
| **None** | 110 | 0.59 | 41 | 0.55 | 69 | 0.61 | |
| **Grade School** | 977 | 5.21 | 382 | 5.16 | 595 | 5.25 | |
| **High School** | 7,295 | 38.94 | 2,980 | 40.27 | 4,315 | 38.06 | |
| **Attended College** | 3,786 | 20.21 | 1,491 | 20.15 | 2,295 | 20.25 | |
| **College Degree** | 2,435 | 13.00 | 905 | 12.23 | 1,530 | 13.50 | |
| **Graduate Degree** | 1,050 | 5.60 | 390 | 5.27 | 660 | 5.82 | |
| **Missing** | 3,083 | 16.45 | 1,211 | 16.36 | 1,872 | 16.51 | |
| **Primary Payment** | | | | | | | <.001 |
| **Private Insurance** | 7,872 | 42.02 | 2,849 | 38.50 | 5,023 | 44.31 | |
| **Public Insurance** | 10,832 | 57.81 | 4,543 | 61.39 | 6,289 | 55.48 | |
| **Other** | 32 | 0.17 | 8 | 0.11 | 24 | 0.21 | |
| | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** | **P-value** |
| **Age** | 49.58 | 13.55 | 49.97 | 13.70 | 49.33 | 13.45 | 0.002 |
| **BMI** | 27.38 | 5.62 | 27.62 | 5.81 | 27.22 | 5.49 | <.001 |
| **Cold Ischemic Time** | 12.83 | 10.72 | 13.55 | 10.71 | 12.35 | 10.71 | <.001 |
| **Total Serum Albumin** | 3.89 | 0.60 | 3.86 | 0.61 | 3.91 | 0.59 | <.001 |
| **County Poverty** | 12.55 | 5.77 | 12.47 | 5.64 | 12.60 | 5.85 | 0.14 |

***Body Mass Index ($kg/m^2$)**

****Human Leukocyte Match Level**

## Table 3. Multivariable Modeling Results - Final Model

| | FINAL MODEL | | |
|---|---|---|---|
| | **Odds Ratio** | **Lower 95% CI** | **Upper 95% CI** |
| **MAIN EFFECTS** | | | |
| **Spatial Topography of Poverty (Ref = Other)** | | | |
| Low poverty (concentrated) | 0.99 | 0.89 | 1.10 |
| Low poverty (spatial outlier) | 1.14 | 1.01 | 1.28 |
| High poverty (concentrated) | 1.12 | 1.05 | 1.20 |
| High poverty (spatial outlier) | 0.99 | 0.87 | 1.13 |
| **COVARIATES** | | | |
| **Race (Ref=White)** | | | |
| Black | 1.06 | 0.98 | 1.15 |
| Hispanic | 0.83 | 0.76 | 0.92 |
| Asian | 0.74 | 0.64 | 0.86 |
| American Indian/Alaskan Native | 0.95 | 0.69 | 1.30 |
| Pacific Islander | 0.82 | 0.53 | 1.27 |
| Multiracial | 0.68 | 0.46 | 1.00 |
| **Sex (Ref = Female)** | | | |
| Male | 0.92 | 0.86 | 0.97 |
| **Age (Ref = <30)** | | | |
| 30 to 39 | 0.85 | 0.75 | 0.97 |
| 40 to 49 | 0.86 | 0.76 | 0.96 |
| 50 to 59 | 0.85 | 0.76 | 0.96 |
| 60 to 69 | 0.82 | 0.73 | 0.93 |
| >=70 | 0.92 | 0.78 | 1.09 |
| **BMI (Ref = <18.5)*** | | | |
| 18.5 to 24.9 | 0.98 | 0.81 | 1.19 |
| 25 to 29.9 | 0.96 | 0.79 | 1.17 |
| 30 to 39.9 | 1.03 | 0.85 | 1.25 |
| >=40 | 1.29 | 0.97 | 1.70 |
| Missing | 0.77 | 0.63 | 0.95 |
| **Donor Type (Ref = Living Donor)** | | | |
| Deceased | 1.12 | 1.04 | 1.20 |
| Deceased - Expanded Criteria | 1.53 | 1.37 | 1.71 |
| **HLA Match Level (Ref = 0)** | | | |
| One | 0.89 | 0.81 | 0.97 |
| Two | 0.91 | 0.82 | 1.00 |
| Three | 0.89 | 0.81 | 0.99 |
| Four | 0.78 | 0.69 | 0.89 |
| Five | 0.70 | 0.61 | 0.82 |
| Six | 0.67 | 0.57 | 0.79 |
| Missing | 0.86 | 0.52 | 1.44 |
| **Diabetes (Ref = No)** | | | |

| | | | |
|---|---|---|---|
| Yes | 1.30 | 1.22 | 1.39 |
| Missing | 1.35 | 1.07 | 1.71 |
| **Hypertension (Ref = No)** | | | |
| Yes | 1.14 | 1.05 | 1.24 |
| Missing | 1.26 | 1.06 | 1.50 |
| **Primary Payment (Ref = Private Insurance)** | | | |
| Public Insurance | 1.21 | 1.14 | 1.30 |
| Other | 0.64 | 0.28 | 1.43 |
| **Serum Albumin (Ref = <= 3.5)** | | | |
| > 3.5 | 0.84 | 0.77 | 0.91 |
| Missing | 0.80 | 0.73 | 0.88 |

*Body Mass Index (kg/m2)

## Figures

**Figure 1. Proportion of Patients Hospitalized by Spatial Topography of Poverty**

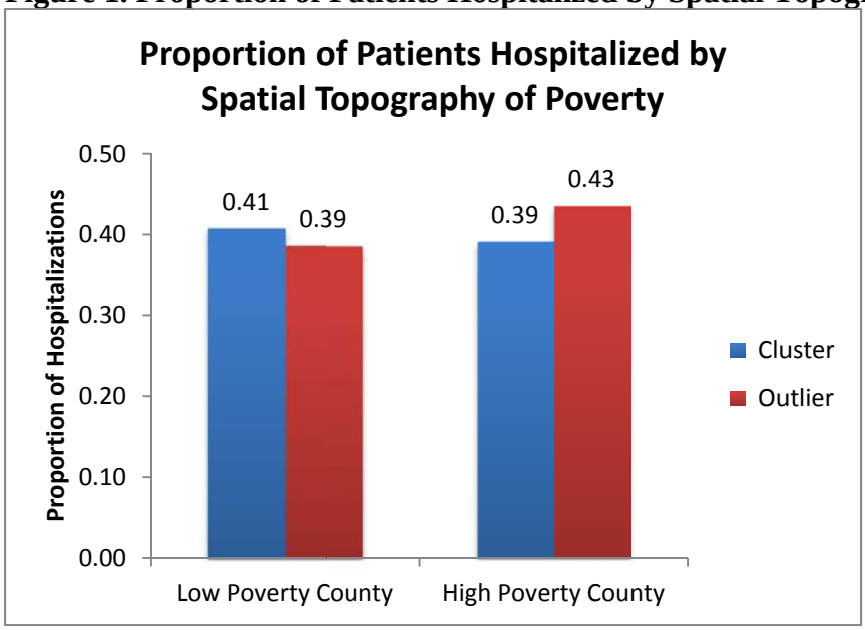


**Figure 2. Proportion of Patients Hospitalized by Spatial Topography of Poverty and Race**

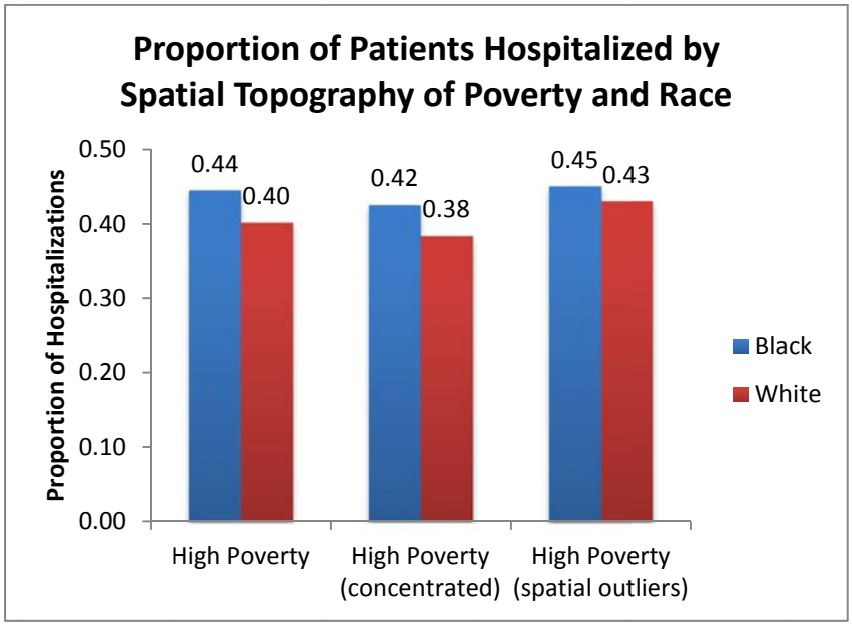


**Figure 3. Patient Distribution by Spatial Topography of Poverty and Race: Low Poverty Categories**

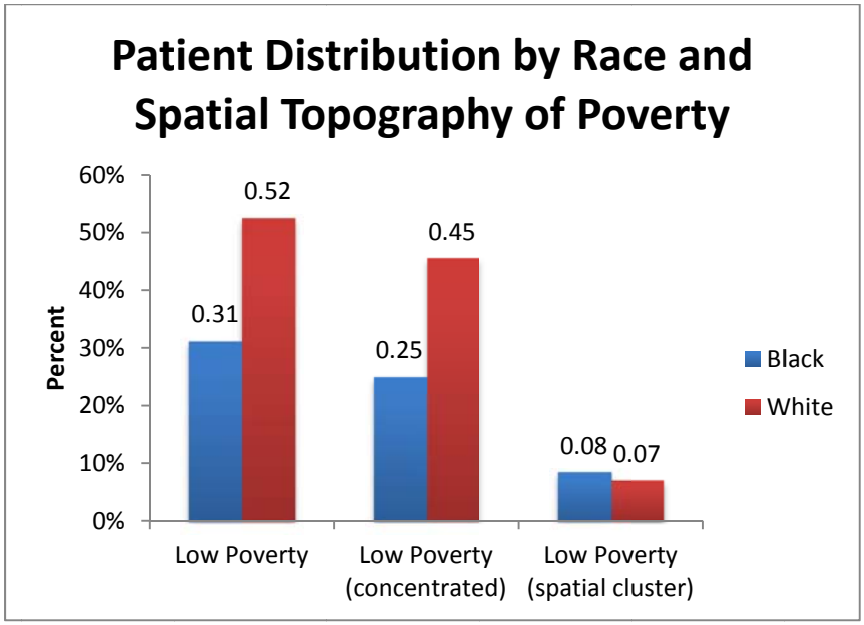
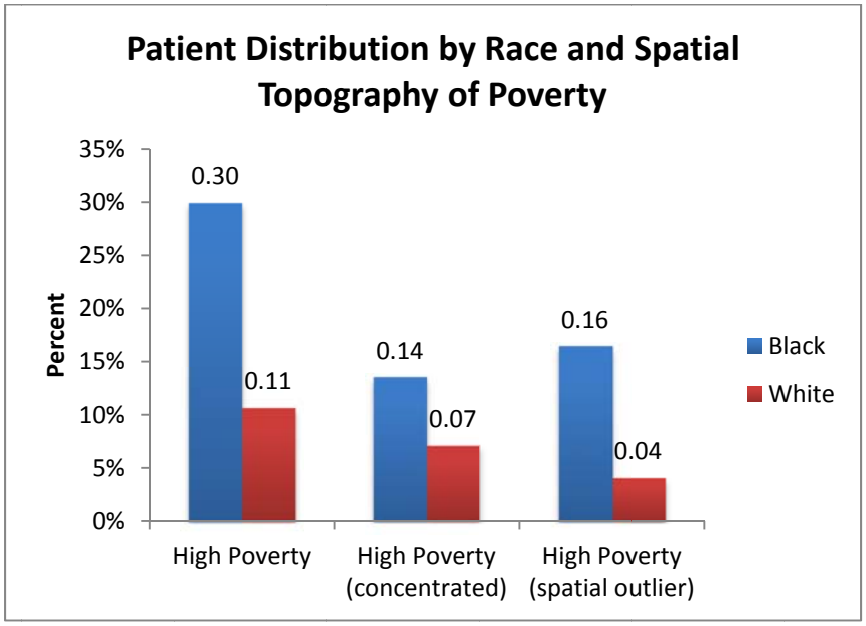


**Figure 4. Patient Distribution by Spatial Topography of Poverty and Race: High Poverty Categories**

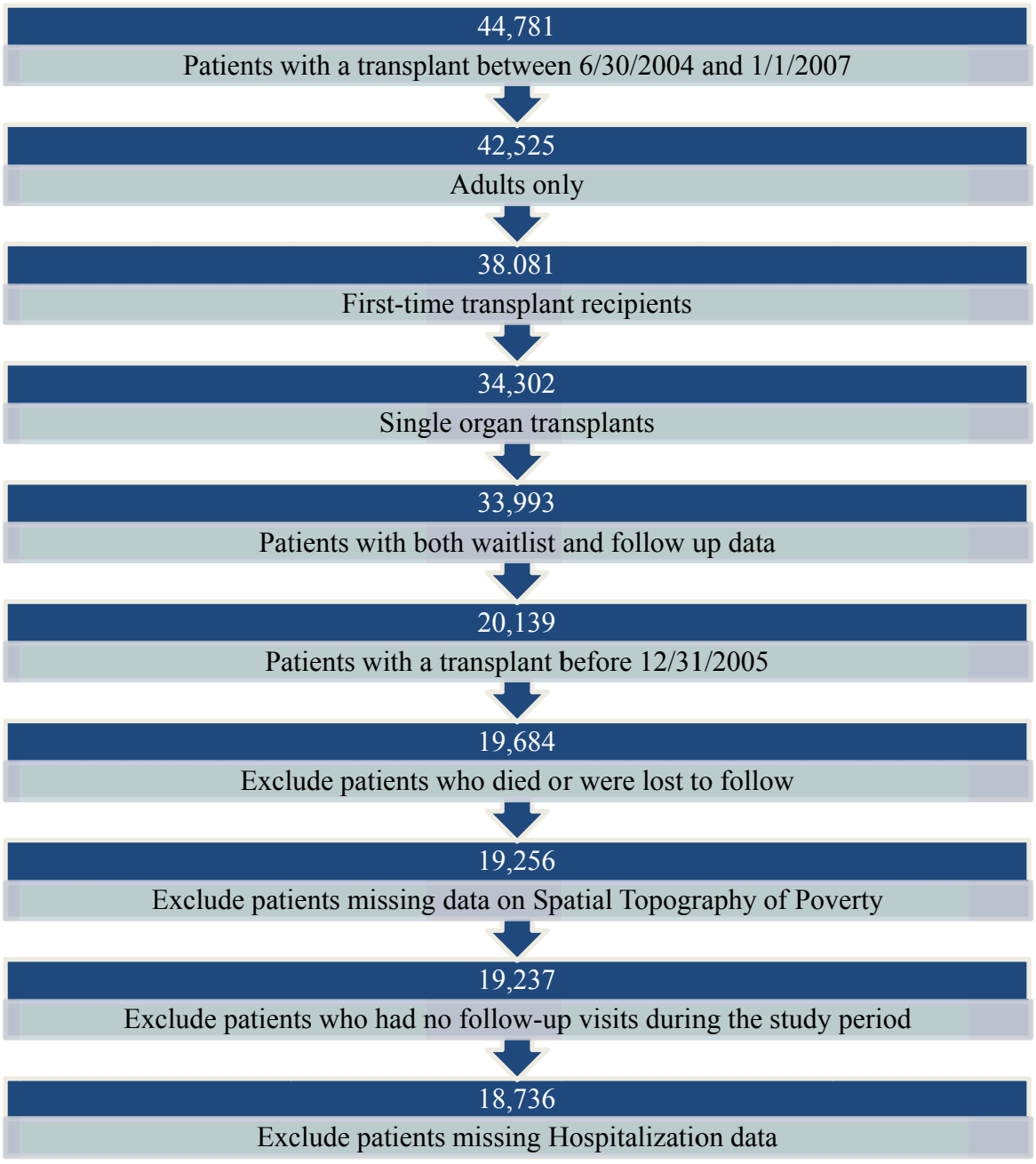


## Chapter III: Public Health Implications and Possible Future Directions

Previous studies suggest that socioeconomic status contributes to disparities among patients with End Stage Renal Disease. In this analysis, we assessed the association of a novel measure of neighborhood poverty, spatial topography of poverty, on transplant related hospitalization post renal transplant. We found that patients residing in high and low poverty counties surrounded by affluent areas are more likely to be hospitalized than patients residing in counties with a poverty rate within 1 standard deviation of the mean poverty rate for the United States. Therefore, our analysis demonstrates that the number of hospitalizations in a county is also influenced by the economic prosperity of its surroundings. The reasons for this association are not immediately clear. Nevertheless, these results will contribute to the growing body of disparities research and aid in the identification of geographic areas at increased risk for poor health outcomes post renal transplantation. Further research is required in order to verify the association between neighborhood poverty and hospital readmission post-transplant. Replication should be conducted for a follow up period longer than 1.5 years and at more granular levels of geography, such as the census tract given the variability possible with zip codes.

## Appendices

Exclusion flow-chart


44,781
Patients with a transplant between 6/30/2004 and 1/1/2007
42,525
Adults only
38.081
First-time transplant recipients
34,302
Single organ transplants
33,993
Patients with both waitlist and follow up data
20,139
Patients with a transplant before 12/31/2005
19,684
Exclude patients who died or were lost to follow
19,256
Exclude patients missing data on Spatial Topography of Poverty
19,237
Exclude patients who had no follow-up visits during the study period
18,736
Exclude patients missing Hospitalization data

| | GOLD STANDARD: Drop the interaction term | | | REDUCED MODEL 1: Drop Education | | | REDUCED MODEL 2: Drop Cold Ischemia Time | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Odds Ratio** | **Lower 95% CI** | **Upper 95% CI** | **Odds Ratio** | **Lower 95% CI** | **Upper 95% CI** | **Odds Ratio** | **Lower 95% CI** | **Upper 95% CI** |
| **MAIN EFFECTS** | | | | | | | | | |
| **Spatial Topography of Poverty (Ref = Other)** | | | | | | | | | |
| Low poverty (concentrated) | 0.98 | 0.88 | 1.10 | 0.99 | 0.89 | 1.10 | 0.99 | 0.89 | 1.10 |
| Low poverty (spatial outlier) | 1.13 | 1.01 | 1.28 | 1.14 | 1.01 | 1.28 | 1.14 | 1.01 | 1.28 |
| High poverty (concentrated) | 1.12 | 1.05 | 1.21 | 1.13 | 1.05 | 1.21 | 1.12 | 1.05 | 1.20 |
| High poverty (spatial outlier) | 0.99 | 0.87 | 1.13 | 0.99 | 0.87 | 1.13 | 0.99 | 0.87 | 1.13 |
| **COVARIATES** | | | | | | | | | |
| **Race (Ref=White)** | | | | | | | | | |
| Black | 1.057 | 0.978 | 1.142 | 1.062 | 0.983 | 1.147 | 1.063 | 0.984 | 1.148 |
| Hispanic | 0.827 | 0.747 | 0.916 | 0.834 | 0.757 | 0.92 | 0.834 | 0.757 | 0.919 |
| Asian | 0.75 | 0.64 | 0.86 | 0.74 | 0.64 | 0.86 | 0.739 | 0.639 | 0.855 |
| American Indian/Alaskan Native | 0.94 | 0.69 | 1.29 | 0.95 | 0.70 | 1.31 | 0.95 | 0.694 | 1.3 |
| Pacific Islander | 0.82 | 0.53 | 1.27 | 0.82 | 0.53 | 1.27 | 0.82 | 0.528 | 1.273 |
| Multiracial | 0.67 | 0.46 | 0.99 | 0.68 | 0.46 | 1.00 | 0.68 | 0.46 | 1.00 |
| **Sex (Ref = Female)** | | | | | | | | | |
| Male | 0.92 | 0.86 | 0.98 | 0.92 | 0.86 | 0.97 | 0.92 | 0.86 | 0.97 |
| **Age (Ref = <30)** | | | | | | | | | |
| 30 to 39 | 0.86 | 0.76 | 0.97 | 0.85 | 0.75 | 0.97 | 0.85 | 0.75 | 0.97 |
| 40 to 49 | 0.86 | 0.765 | 0.968 | 0.853 | 0.758 | 0.96 | 0.855 | 0.76 | 0.962 |
| 50 to 59 | 0.86 | 0.77 | 0.97 | 0.85 | 0.76 | 0.96 | 0.85 | 0.76 | 0.96 |
| 60 to 69 | 0.827 | 0.73 | 0.936 | 0.819 | 0.724 | 0.926 | 0.822 | 0.726 | 0.929 |
| >=70 | 0.93 | 0.79 | 1.10 | 0.92 | 0.78 | 1.08 | 0.921 | 0.781 | 1.086 |
| **BMI (Ref = <18.5)** | | | | | | | | | |
| 18.5 to 24.9 | 0.98 | 0.81 | 1.18 | 0.98 | 0.81 | 1.19 | 0.98 | 0.81 | 1.19 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 25 to 29.9 | 0.96 | 0.79 | 1.16 | 0.96 | 0.79 | 1.17 | 0.961 | 0.791 | 1.167 |
| 30 to 39.9 | 1.03 | 0.84 | 1.25 | 1.03 | 0.85 | 1.25 | 1.03 | 0.85 | 1.25 |
| >=40 | 1.28 | 0.97 | 1.70 | 1.29 | 0.97 | 1.70 | 1.286 | 0.972 | 1.702 |
| Missing | 0.767 | 0.624 | 0.942 | 0.771 | 0.628 | 0.947 | 0.771 | 0.628 | 0.947 |
| **Donor Type (Ref = Living Donor)** | | | | | | | | | |
| Deceased | 1.02 | 0.93 | 1.13 | 1.03 | 0.93 | 1.13 | 1.12 | 1.04 | 1.20 |
| Deceased - Expanded Criteria | 1.39 | 1.22 | 1.58 | 1.40 | 1.22 | 1.59 | 1.529 | 1.367 | 1.712 |
| **HLA Match Level (Ref = 0)** | | | | | | | | | |
| One | 0.89 | 0.81 | 0.97 | 0.89 | 0.81 | 0.97 | 0.89 | 0.81 | 0.97 |
| Two | 0.90 | 0.82 | 1.00 | 0.91 | 0.82 | 1.00 | 0.906 | 0.82 | 1.001 |
| Three | 0.89 | 0.80 | 0.98 | 0.89 | 0.81 | 0.98 | 0.89 | 0.81 | 0.99 |
| Four | 0.775 | 0.678 | 0.887 | 0.78 | 0.682 | 0.891 | 0.783 | 0.685 | 0.894 |
| Five | 0.69 | 0.60 | 0.81 | 0.70 | 0.60 | 0.81 | 0.70 | 0.61 | 0.82 |
| Six | 0.66 | 0.56 | 0.78 | 0.66 | 0.56 | 0.78 | 0.67 | 0.57 | 0.79 |
| Missing | 0.871 | 0.521 | 1.454 | 0.87 | 0.521 | 1.452 | 0.864 | 0.518 | 1.442 |
| **Diabetes (Ref = No)** | | | | | | | | | |
| Yes | 1.30 | 1.21 | 1.39 | 1.30 | 1.21 | 1.39 | 1.30 | 1.22 | 1.39 |
| Missing | 1.35 | 1.07 | 1.71 | 1.34 | 1.06 | 1.69 | 1.349 | 1.067 | 1.706 |
| **Hypertension (Ref = No)** | | | | | | | | | |
| Yes | 1.15 | 1.05 | 1.25 | 1.15 | 1.05 | 1.25 | 1.143 | 1.051 | 1.244 |
| Missing | 1.27 | 1.07 | 1.51 | 1.26 | 1.06 | 1.50 | 1.26 | 1.06 | 1.50 |
| **Education (Ref = None)** | | | | | | | | | |
| Grade School (0-8) | 1.11 | 0.74 | 1.68 | | | | | | |
| High School (9-12) or GED | 1.14 | 0.77 | 1.69 | | | | | | |
| College/Technical School | 1.10 | 0.74 | 1.64 | | | | | | |
| Associate/Bachelor Degree | 1.02 | 0.682 | 1.525 | | | | | | |
| Post-College Graduate Degree | 1.038 | 0.686 | 1.57 | | | | | | |
| Missing | 1.079 | 0.724 | 1.609 | | | | | | |
| **Primary Payment (Ref = Private Insurance)** | | | | | | | | | |
| Public Insurance | 1.201 | 1.124 | 1.282 | 1.21 | 1.14 | 1.29 | 1.21 | 1.14 | 1.30 |
| Other | 0.626 | 0.279 | 1.405 | 0.63 | 0.28 | 1.40 | 0.636 | 0.284 | 1.427 |
| **Serum Albumin (Ref = <= 3.5)** | | | | | | | | | |
| > 3.5 | 0.837 | 0.771 | 0.908 | 0.84 | 0.77 | 0.91 | 0.84 | 0.77 | 0.91 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Missing | 0.796 | 0.725 | 0.874 | 0.797 | 0.726 | 0.874 | 0.801 | 0.73 | 0.879 |
| **Cold Ischemia Time (Ref = 0-10)** | | | | | | | | | |
| 11-20 | 1.154 | 1.041 | 1.279 | 1.155 | 1.042 | 1.28 | | | |
| 21-30 | 1.138 | 1.017 | 1.273 | 1.139 | 1.018 | 1.274 | | | |
| >30 | 1.205 | 1.021 | 1.422 | 1.201 | 1.018 | 1.417 | | | |
| Missing | 1.056 | 0.972 | 1.146 | 1.055 | 0.971 | 1.145 | | | |