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Jane Yackley Date

Distance to Transplant Center and Referral for Transplant Evaluation within One Year among End-Stage Renal Disease Patients in Georgia

By

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MPH

Epidemiology

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Committee Chair

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By

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An abstract of
a thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
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Master of Public Health
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Abstract

Distance to Transplant Center and Referral for Transplant Evaluation within One Year among End-Stage Renal Disease Patients in Georgia

By Jane Yackley

Background: To initiate the kidney transplantation process, dialysis patients often require a referral from a dialysis facility to a transplant center for eligibility evaluation. Prior studies have shown that greater distance to a transplant center is associated with lower rates of waitlisting and transplantation, but little is known about distance and referral for kidney transplant evaluation.

Methods: We examined data on incident, adult (18-69 years) dialysis patients residing in Georgia from January 2005 to September 2011, followed until September 2012, using United States Renal Data System data linked with kidney transplant referral data from Georgia's three transplant centers. Tertiles of the straight-line distance from the center of patient residential ZIP code tabulation area to the nearest transplant center were calculated. Referral was defined as referral for evaluation within one year of dialysis start. Logistic regression was used to assess the association between distance and 1-year referral.

Results: Data on a total of 11,993 dialysis patients were examined. The mean patient age was 55 years (IQR: 45 - 62), 67% were African American, and 55% were male. The median distance to transplant center was 39.4 miles (IQR: 13.2 – 91.0). A total of 3,454 (28.8%) patients were referred for transplant evaluation within one year of dialysis start. The adjusted odds ratio of 1-year referral for kidney transplant evaluation comparing farthest (≥75 miles) to closest (<19 miles) distance was 0.76 (95% CI: 0.67-0.85). Additionally, male sex, younger age, African American race and high socioeconomic status were positively associated with 1-year referral.

Conclusion: Dialysis patients in Georgia who live farther (vs. closer) from a transplant center are 24% less likely to be referred for transplant evaluation within one year of dialysis start. Understanding the role of distance on referral could help define areas of greater need and guide interventions for increasing kidney transplantation access.

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LITERATURE REVIEW

What Is ESRD?

Kidneys are vital organs, primarily responsible for the filtration of waste and excess fluid from the bloodstream. When a person experiences kidney damage or decreased kidney function for three or more months they fit the diagnosis for chronic kidney disease (CKD) (1). If CKD progresses to the point where the kidneys are permanently damaged and kidney replacement therapy is required to support the needs of the body, either by dialysis or transplantation, a person is diagnosed with end-stage renal disease (ESRD) (1).

Without functioning kidneys, toxins build up in the body, which can lead to a host of medical concerns, including death. Major complications due to kidney disease include increased all-cause and cardiovascular mortality, among others (2). Thus, patients with ESRD require dialysis or kidney transplantation to survive. Dialysis is a clinical technique that removes waste and excess fluid from the blood through the use of a dialysate solution and semi-permeable membrane. Hemodialysis and peritoneal dialysis are the two main types of kidney dialysis. Alternatively, kidney transplantation treatment involves replacing a non-functioning kidney with a healthy kidney from either a living or deceased donor.

What Is the Global Burden of ESRD?

Chronic and end-stage kidney disease are of significant public health concern globally. The estimated global prevalence of CKD in 2013 was 10%, with estimates of more than 50% in high-risk populations (3). In 2010, the number of patients needing

kidney replacement therapy worldwide was conservatively estimated at 4.9 million people (4). Prevalence estimates were highest in Asia, North America and Europe, with ESRD affecting 968,000 patients, 637,000 patients, and 532,000 patients respectively (4).

Among those with ESRD worldwide, it was estimated that 2.6 million people received treatment, thus leaving at least 2.3 million untreated (4). Limited access to renal replacement therapy is associated with poor economic development. For example, only 0.6% of those receiving treatment worldwide are from areas of low economic development while 62.1% of those receiving treatment were from areas of high economic development (4). Furthermore, it is estimated that over 80% of those receiving treatment for ESRD are from wealthy countries with appreciable elderly populations and universal access to healthcare (2). Both ESRD incidence and treatment are expected to increase globally. In 2008, the World Health Organization estimated that incidence of renal replacement therapy was increasing annually by 8% (5). By 2030, renal replacement therapy is projected to more than double (4).

What Is the National Burden of ESRD?

Chronic kidney disease and ESRD are similarly of major concern in the United States. CKD was first included in the Healthy People Initiatives, which address the nation's most important health concerns, starting in 2010. The Healthy People 2020 initiatives contain 14 objectives aimed specifically at CKD (6). The Chronic Kidney Disease Initiative, established in 2006, was designed to develop public health strategies for the promotion of kidney health. The CKD Initiative is establishing a national

surveillance system for CKD that will help to quantify the disease burden and the efforts being made toward Healthy People 2020 objectives.

Additionally, since 1989, the United States has been collecting data on ESRD through the United States Renal Data System (USRDS). At that time, the main measures of ESRD included incidence and prevalence, but today USRDS collects comprehensive data on dialysis and the assessment of care aspects that affect morbidity and mortality (7). In 2013, USRDS reported 661,648 prevalent cases of ESRD (8). Prevalence of ESRD has been increasing over the last 20 years. For example, the prevalence of ESRD in the US population in 1996 was roughly 300,000, and in 2011 it rose to over 600,000 cases (8). The incidence of new ESRD cases has also increased, from around 75,000 cases in 1996 to approximately 115,000 in 2011 (8).

To address the substantial burden of ESRD and the essential need for treatment, the Social Security Amendments of 1972 extended US Medicare coverage to include ESRD patients. Dialysis and transplant for ESRD patients represent an appreciable amount of health care activities. In 2010, almost 25% of all Medicare spending was used to treat patients with CKD and ESRD (9). In 2011, Medicare ESRD expenditures totaled 34.3 billion dollars (10). Including private insurance claims raises the total cost for treating ESRD in 2011 to 49.2 billion dollars.

What Are the Burden and Demographics of ESRD in Network 6?

The nonprofit End Stage Renal Disease Network Program monitors treatment activities for ESRD patients in the US. The program contracts with the Centers for Medicare and Medicaid Services to ensure that Medicare patients have access to dialysis

and transplant services and monitors the quality of care (11). The ESRD Network Program oversees dialysis facilities and is funded based on the number of patients and dialysis treatments received at facilities. Responsibilities of the dialysis facilities in ESRD Networks include participation in quality improvement activities, addressing patient concerns and collecting treatment data. There were 32 ESRD Networks in 1972, which were consolidated in 1986. Today 18 ESRD Networks exist (Figure 1).

By monitoring data collected by the ESRD Network Program, information on the incidence and prevalence of ESRD can be assessed. In the 2015 USRDS Annual Data Report, the incidence rate of ESRD was highest in the Southeast, Texas, and California networks and lowest in the Northwest and Upper Midwest networks (8). The state of Georgia is a member of the Southeast ESRD Network 6, along with North and South Carolina. At the end of 2014, in this network of high ESRD burden, there were 45,365 prevalent ESRD patients receiving either dialysis or transplant (12). Network 6 facilities served 10% of all the US dialysis patients in 2014 at a total of 655 facilities (12).

The racial demographics of the Network 6 ESRD population do not match that of the general population in the area. The general population of Georgia, North and South Carolina (Network 6) identifies as 29% black and 71% white (12). In comparison, 66% percent of ESRD patients in this area identify as black, and 32% identify as white, a striking difference compared to the racial make-up of the region. African Americans experience a heavy ESRD burden in this region and are known to have a higher prevalence of ESRD compared to whites. In 2013, African Americans had a prevalence of ESRD 3.7 times that of white patients nationwide (8).

Kidney Transplantation: The Preferred ESRD Treatment

For the majority of ESRD patients, kidney transplantation is the preferred method of treatment because it provides longer survival and better quality of life compared with dialysis (13). At the end of 2013, USRDS reported that 70.5% of ESRD patients were receiving dialysis and 29.2% received a transplant (8). In 2013, 17,600 kidney transplants were performed in the United States (8). In the Network 6 Area, 1,236 ESRD patients had kidney transplants (60.5% from a deceased donor, 39.5% from a living donor) and 44,129 patients underwent dialysis in 2014 (12). Transplants were performed at one of the 10 transplant centers in the Network 6 service area.

In addition to improved survival and quality of life, transplantation is a more cost-effective treatment compared with dialysis. In general, kidney transplantation is a very cost-effective surgical intervention. Although the cost following the first year of transplant can be comparable to one-year dialysis costs due to potential re-hospitalizations and infections associated with transplant, cost savings often appear in the second year after transplant (13, 14). Network 6 estimates $54,647 annual Medicare savings per patient that undergoes transplant instead of dialysis and 169 fewer deaths per 100 person years for those undergoing transplant compared with dialysis patients (12).

Disparities in Transplantation

Despite the advantages favoring transplantation over dialysis, disparities in renal transplantation exist. In the US in 2013, the rate of transplantation was higher in men than women (2.6 versus 2.2 cases per 100 dialysis patient years), and higher in white patients than African American patients (2.6 versus 2.1 cases per 100 dialysis patient

years) (8). Additionally, although African American patients make up 26% of the US dialysis population, they make up only 11% of the population receiving transplants. In comparison, white patients make up 68% of the US dialysis population and 76% of the transplant population (8). In Network 6, 66% of dialysis patients and only 54% of transplant recipients identified as African American in 2014 (12).

Disparities also exist in access to kidney transplantation for treatment. Known racial, gender and socioeconomic disparities leave racial minorities, women and patients of low socioeconomic status (SES) at a disadvantage. Alexander and colleagues assessed each stage of the transplant process and found that African American (compared to white), female (compared to male) and poor (compared to wealthy) dialysis patients were less likely to complete the steps for kidney transplantation (15). Racial disparities in access to transplantation can be more pronounced in younger age groups and more prevalent based on geographic region in the United States (16, 17). Patients without private insurance, a common measure of SES, are also less likely to receive transplants and complete the steps of the transplant process (6, 16). Additionally, lower SES is associated with poorer health outcomes in the ESRD population (18). Improvements aimed at increasing the health of the ESRD population will need to consider the numerous disparities present in patients' access to care and overall health outcomes.

The Transplantation Process

In order to better understand the barriers to transplant access it is important to know the sequence of steps in the kidney transplantation process. In some ESRD cases, a preemptive transplant is performed and dialysis is never required. However, the vast majority (91%) of transplant patients undergo dialysis before starting the transplant

process (19). In this case, dialysis patients often receive education and a referral from their dialysis facility for transplant eligibility evaluation at a transplant center in order to begin the transplant process. Once the evaluation is completed at the transplant facility (provided eligibility criteria are met), patients are placed on the kidney transplant waitlist. The time each patient spends on the waitlist before transplantation depends on organ availability and matching. There are many steps throughout the transplantation process that may affect the aforementioned disparities in transplantation by race, gender and SES.

Distance and the Transplant Process

The role of distance to transplant center has been assessed as one possible factor adding to transplant disparities. In focus groups with urban and rural nephrologists, rural nephrologists suggested distance to transplant center as a barrier when considering patient candidacy for transplant (20). Distance may pose a geographical and/or financial barrier and decrease access for kidney transplantation in ESRD patients which could help explain the disparities in kidney transplantation. Greater travel distance may hinder patients from completing the steps to the kidney transplantation process, perhaps due to limited transportation availability, financial means or social support.

Associations between distance and multiple stages of the kidney transplantation process have been examined. Greater distance from transplant center is associated with lower transplantation rates in children with ESRD (21). Studies in adult ESRD patients show mixed results on the association between distance to transplant center and transplant stages. A large observational study (n=699,751) using USRDS data showed no significant reduction in likelihood of receiving a transplant among patients living farther

from a transplant center compared to those living close (22). However, a study among ESRD patients in the UK found that distance was associated with reduced rates of referral for transplantation among patients over 60 years old (23). Studies examining distance to transplant center and transplant waitlisting have also been examined, with race and socioeconomic status explaining the majority of variation across waitlisting outcomes compared to distance (24). In Network 6, distance to transplant center did not explain the disparities in transplant waitlisting, but neighborhood poverty and race were strongly associated with waitlisting (24). To date, no studies exist which examine the association between distance to transplant center and referral for transplant evaluation among US adult ESRD patients. Furthermore, examining and understanding the role of distance at an early stage in the transplant process, such as referral for transplant evaluation, may help unravel some of the disparities in the high burden Network 6 region.

The RaDIANT Study and USRDS Data

The Southeastern Kidney Transplant Coalition (SEKTC) was formed in 2010, to address racial disparities in access to kidney transplantation where they are especially pronounced: the southeastern states of North Carolina, South Carolina and Georgia (25). This coalition, made up of ESRD patients, dialysis facilities, transplant centers and numerous other stakeholders aimed to help Network 6 improve kidney transplantation access and reduce racial disparities through quality improvement interventions in the Reducing Disparities in Access to kidNey Transplantation (RaDIANT) Community study.(25)

The RaDIANT study allowed for the collection of transplant referral data from 134 dialysis centers in Georgia (25). In order to do this, RaDIANT evaluated referral

information from Georgia's three transplant centers: Emory Transplant Center, Piedmont Transplant Institute, and Georgia Reagents Kidney and Pancreas Transplant Program.

The United States Renal Data System (USRDS) collects information on ESRD patient demographics, diagnosis, treatment and treatment facility. This surveillance system collects patient data on prevalent and incident ESRD cases, making it a great resource for the development of a comparison group.

Importance of Assessing Distance in Georgia's ESRD Patients

The burden of ESRD is substantial at both national and international levels. Furthermore, ESRD burden is especially felt in the Southeastern region of the United States (Network 6) and the state of Georgia, the state with the lowest kidney transplantation rates in the nation. Improving transplant outcomes and reducing disparities is of great importance in this area. In addition to known risk factors, distance to transplant center may present a barrier to ESRD patients and could help explain transplant disparities. By assessing an early stage of the transplantation process, referral for transplant evaluation, it may be possible to address factors that are associated with transplantation outcomes and determine areas for future interventions.

INTRODUCTION

Kidney transplantation is the preferred method of treatment for the over 650,000 people in the United States affected by end-stage renal disease (ESRD) (8, 14). For this population, which requires renal replacement therapy for normal bodily function, transplantation provides better quality of life, longer survival and greater cost-effectiveness compared with dialysis (26). Despite the advantages of transplantation, disparities by sex, race, geographic region and socioeconomic status exist in access to transplantation. These disparities are especially present in Network 6, the Southeastern region of the United States, which includes North Carolina, South Carolina and Georgia (8).

The majority of ESRD patients begin the transplantation process with a referral from their dialysis facility to a transplant center for kidney transplant eligibility evaluation. Following evaluation, eligible patients are placed on the national deceased donor waiting list until an organ is available for transplantation. All steps in the transplantation process take place at the transplant center. Georgia, the state with the lowest rate of kidney transplantation nationwide, has three transplant centers (24). Previous studies have shown that distance to transplant center may create a barrier for patients considering transplantation (21, 22, 24, 27). Greater distance to transplant center has been associated with lower rates of waitlisting and transplantation, but little is known about the association with referral for eligibility evaluation (23). Looking at referral, an early step in the transplantation process, may help uncover important geographic associations that have not previously been found.

The Southeastern Transplant Coalition, including ESRD patients, dialysis facilities, transplant centers and numerous other stakeholders, partnered with Emory University to collect kidney transplant referral data at all three transplant centers in Georgia (25). Additional information from the United States Renal Data System (USRDS) allowed for complete follow-up and the identification of a comparison group of non-referred ESRD patients. To assess the potential role of geography on the disparities in kidney transplantation, this study examined the association between the distance from a patient's residence to transplant center and referral for transplant evaluation, one of the earliest steps in the kidney transplantation process.

METHODS

Data Sources

Data for this cohort study came from transplant referral forms from Georgia's three transplant centers: Emory Transplant Center in Atlanta, Piedmont Transplant Institute in Atlanta, and Georgia Reagents Kidney and Pancreas Transplant Program in Augusta between January 1, 2005 and December 31, 2012. Data were linked with the USRDS Standard Analytic Files for complete follow up and identification of a non-referred population of ESRD patients during the same time period.

Study Population

The study population included all patients referred to a transplant center in Georgia between January 1, 2005 and December 31, 2012. Using USRDS data, patients that began dialysis at a Georgia facility between January 1, 2005 and September 30, 2011 (inclusive) were identified. This range of start dates ensured that all patients had at least

one year of follow-up in the study. Patients that were not between the ages of 18 and 69 were excluded from the study. Referral data was then merged with USRDS data and matching patients were kept and classified as referred. Referral patients that did not match were not included. The remaining unmatched USRDS patients were classified as not referred. Patients that were pre-emptively waitlisted (n=1,675), died within the first year of dialysis (n=2,275), did not have ZIP code information or lived outside of Georgia (n=1,447) were excluded from the study. A total of 11,993 patients were included in the final study population.

Study Variables

Exposure

The exposure of interest was defined as distance from the center of patient residential zip code tabulation area (ZCTA) to the nearest Georgia transplant center. Patient self-reported zip codes at the time of dialysis start were matched with ZCTA data provided by the 2010 Census. Geographic Information Systems (GIS) software was used to calculate the straight-line distance from the centroid of patient residential ZCTA to the nearest transplant center. Exposure was categorized into evenly distributed tertiles: <19 miles (close), 19 ≤ miles < 75 (intermediate), and ≥75 miles (far); Figure 2.

Outcome

The outcome of interest was defined as referral for kidney transplant evaluation at one of Georgia's three transplant centers within one year of dialysis start. Dialysis start date was provided by USRDS and referral within one year was calculated using SAS 9.4.

Covariates

Covariates included in the analysis were sex, age, race/ethnicity, primary health insurance provider, pre-ESRD nephrology care, neighborhood poverty, neighborhood percentage of black residents, neighborhood percentage of graduates from high school and dialysis facility size. Sex, age, and race/ethnicity were patient characteristics reported by clinicians on the CMS-2728 form on the day of dialysis start. Age was categorized into ten-year age groups. Race/ethnicity was categorized into four groups: White non-Hispanic, White Hispanic, Black Hispanic or non-Hispanic, and other. Primary health insurance was used as a proxy for socioeconomic status. Primary insurance provider was classified into five groups: Medicare, Medicaid, employer-based, other or none. Pre-ESRD nephrology care was also used as a proxy for socioeconomic status and was characterized as a yes/no response. Neighborhood characteristics were collected from 2010 census data based on zip code information. Facility size was defined as the number of patients treated by a facility and was categorized into four groups: less than 26 patients, 26 – 54 patients, 55 – 78 patients and 79 or more patients.

Mapping Techniques

Maps of distance categorization and number of patients per zip code tabulation area were designed using GIS software with 2015 TIGER/Line Shapefiles available to the public from the US Census Bureau online. Patient ZIP codes were matched with zip code tabulation areas (ZCTAs), available from the US Census Bureau. There were some ZIP codes for which no ZCTA exists, due to a small number of addresses in the ZIP code. Maps were made using the North American 1983 Geographic Coordinate system and the North American Datum of 1983 Georgia Statewide Lambert Conformal Conic projection.

Statistical Analyses

Demographic characteristics were examined using univariate procedures. Associations between covariates and the exposure and outcome variables were examined using X^2 or t-tests. Logistic regression models were used for calculating crude associations between exposure tertiles and outcome. Multivariable logistic regression was used to adjust for potential confounding by sex, age, race/ethnicity, socioeconomic status, residential characteristics and facility size and to consider interactions between distance and measures of race and socioeconomic status.

For some Georgia ESRD patients, the nearest transplant center was in a state outside of Georgia. To take this information into account, demographic information was compared for patients with nearest transplant center inside Georgia and patients with nearest transplant center outside Georgia. While referral data were unavailable for states outside Georgia, waitlisting data were available through USRDS for all states. To assess the sensitivity of the main association between distance to transplant center and referral within one year, adjusted odds ratios were used to compare distance to transplant center with waitlisting as the main outcome. Similar adjusted odds ratios for distance with waitlisting and distance with referral would add strength to associations found between distance and referral.

RESULTS

Study Population

A total of 18,968 age-eligible patients were merged using USRDS data after January 1, 2005 and RaDIANT referral data from January 1, 2005 – September 30, 2012.

Full details of merging criteria and process were previously published (28). Patients that were preemptively referred (n= 1,675), listed a zip code outside of Georgia (n= 1,092) and did not have at least one year of follow-up after dialysis start either due to starting dialysis after September 30, 2011 (n= 1,779) or death within the first year of dialysis (n= 2,074) were excluded, leaving a total of 12,348 eligible patients. ZCTAs were not available for 355 patients (2.8%) after matching ZIP codes to ZCTA data, resulting in no way to calculate distance to transplant center. After this exclusion, the final study population was 11,993 patients.

Among the 11,993 Georgia ESRD patients in this study, the majority (54.9%) were male, the median age was 55 years (IQR: 45 – 62), 66.8% were African American, and 28.8% were white. Approximately 45% of patients utilized Medicare or Medicaid as their primary insurance provider, 29% utilized employer-based health insurance and 22% were uninsured. Just over half of patients (52.2%) lived in areas with less than 20% of people living below the poverty line (Table 1).

Distance to Transplant Center

The median distance from a patient's residence to a Georgia transplant center was 39.4 miles (IQR: 13.2 – 91.0; range: 0.93 - 213.0 miles). ESRD patients were not distributed evenly across the state; clusters of patients existed both near and far from transplant centers (Figure 3). The distribution of sex and age was similar across distance tertiles (close, intermediate, far). Race differed across distance tertiles, with the largest difference between patients close to a transplant center (79% black, 14.9% white) and the smallest difference between patients an intermediate distance from a transplant center

(52% black, 43.3% white). Neighborhood poverty was lowest in the intermediate distance group and highest in the far distance group (16.6% vs. 23.8%). The percentage of black residents was lowest in the intermediate distance group and highest in the close distance group (26.3% vs. 60.8%).

Referral within One Year

A total of 3,454 (28.8%) ESRD patients were referred to a transplant center for evaluation within one year of starting dialysis. Compared to non-referred patients, a larger proportion of referred patients were under 50 years old (45.3% referred; 29.8% non-referred), African American (70.6% vs. 65.3%), utilized employer-based health insurance (42.5% vs. 23.7%) and had low neighborhood poverty (58.0% vs. 49.9%).

Association between Distance and Referral for Transplant

Results from a crude logistic model comparing distance and referral showed a slight reduction in odds of referral among those an intermediate distance from a transplant center compared to those close to a transplant center, but it was not statically significant (OR: 0.93; 95%CI: 0.85-1.03); Figure 4. However, among those living far from a transplant center, the likelihood of referral within one year was 34% lower than those living close to a transplant center (OR: 0.66; 95%CI: 0.60-0.73).

A multivariable logistic model controlled for sex, categorical age, race, primary health insurance provider, pre-ESRD nephrology care, dichotomous neighborhood poverty, continuous % population black, continuous % high school graduates, categorical number of dialysis facility patients and interaction terms between distance and race,

insurance and pre-ESRD nephrology care. Percent of high school graduates was excluded from the model after assessment for collinearity problems across combinations of all covariates with distance, referral and each other. Interaction terms were non-significant and dropped from the model. Backward elimination resulted in the removal of % population black. Precision assessment confirmed greater precision in the model without interaction terms and % population black compared to the fully adjusted model. The final model adjusted for sex, age, race, health insurance, pre-ESRD care, neighborhood poverty, and number of dialysis facility patients. After adjustment, the lower likelihood of referral in patients far from a transplant center (compared to close) remained statistically significant (OR: 0.76; 95% CI: 0.67-0.85).

In the fully adjusted model, older patients (60-69 years) are 76% less likely to be referred than young (18-29 years) patients (OR:0.24; 95% CI: 0.20-0.30), African American patients are 42% more likely to be referred than white, non-Hispanic patients (OR: 1.42; 95% CI:1.28-1.58), patients with employer-based health insurance are 2.33 times more likely to be referred than those using Medicare (95% CI:2.03-2.66) and patients in areas with low poverty are 25% more likely to be referred than those in high poverty areas (OR: 1.25; 95%CI:1.13, 1.37).

Sensitivity Analysis

A sensitivity analysis was conducted to account for the fact that some Georgia patients live closer to a transplant center outside the state, and thus may not be referred to a Georgia center. When all transplant centers from neighboring states were considered, the greatest distance to nearest transplant center was reduced from 213 miles to 177

miles. A total of 2,038 (17.1%) patients lived closer to a transplant center outside of Georgia. Among these, 1,276 (62.3%) were closest to a center in Florida, 392 (19.2%) were closest to a Tennessee center, and 380 (18.6%) were closest to a South Carolina center. Compared to patients closest to a Georgia center, a smaller proportion of patients near a center outside Georgia were African American (55.5% vs. 69.1%) and utilized employer-based health insurance (23.9% vs. 30.2%). Referral to a Georgia transplant center within one year was lower in patients nearest to a center outside Georgia compared to those near a Georgia transplant center (30.9% vs. 18.6%). The proportion of waitlisted patients (n=1,910) in the two groups was similar (16.1% near GA vs. 15.2% outside GA). In an adjusted model between distance and waitlisting, there was not a statistically significant association between distance and waitlisting in the intermediate (OR: 1.08; 95%CI: 0.94- 1.24) or far (OR: 1.09; 95%CI: 0.94- 1.25) distance categories compared to the close distance category.

DISCUSSION:

End-stage renal disease patients in Georgia live up to 213 miles from a Georgia transplant center and may have limited access to the transplantation process at distances furthest from a transplant center. After taking patient, neighborhood, and dialysis facility characteristics into account, patients living 75 miles or more away from a Georgia transplant center were 24% less likely to be referred than patients within 19 miles of a transplant center (OR: 0.76; 95% CI:0.67-0.85), suggesting that greater distance hinders patients from accessing the transplantation process. Patient age, race and primary insurance provider are also associated with referral for transplant evaluation. Understanding the strength of associations between patient characteristics and referral

can help identify the populations and areas at greatest risk of not entering the transplantation process.

The present study represents the first analysis between distance to transplant center and referral for kidney transplant evaluation among adult ESRD patients in the United States. Aggregate referral data are not widely available and have not been extensively studied, thus the RaDIANT Community Study allowed for the assessment of distance on transplant referral by collecting patient referral data from all Georgia transplant centers. The primary findings of this study suggest that ESRD patients living furthest from a transplant center are less likely to be referred for transplant evaluation within one year of dialysis start. Given the availability of referral data, this study only considered ESRD patients in Georgia. However, having only Georgia referral data may limit the interpretation of the results because some Georgia ESRD patients live closer to (and may be referred to) a transplant center in a nearby state for which data are not available.

After assessing sensitivity, the main findings of this study should be interpreted with caution. Although referral data is not available for states outside of Georgia, waitlisting data is not limited by state and allows for assessment of a later stage in the transplant process among this study population. Adjusted analyses showed no statistically significant associations across distance tertiles using waitlisting as the outcome. Thus, it is possible that the differences seen across distance tertiles in referral may be due to actual distance disparities, lack of referral data for nearby states, or a combination of other factors. However, an examination of waitlisting as an outcome would miss important steps of the transplant process such as referral, starting of the transplant

evaluation process, and completion of the transplant process after determining medical eligibility.

Results from this study are consistent with previous studies addressing stages of the transplantation process in similar populations. In a large cohort study (n= 35,346) that addressed waitlisting, distance to the transplant center was not associated with waitlisting among adult ESRD patients in US Network 6 (24). Similar results are seen in the sensitivity analysis with waitlisting in the present study. Additionally, as expected, male sex, younger age, and employer-based health insurance, a proxy for higher socioeconomic status, were all associated with referral (15). Although it has been shown that African Americans are less likely to complete some steps of the transplantation process (15), in Georgia, African American ESRD patients have a higher likelihood of referral (28), which was also seen in this study. Lower neighborhood poverty was associated with referral in this and a previous study addressing waitlisting (24). This study adds to the body of research on access to transplantation, by further strengthening the associations found between sex, age, race and socioeconomic status in referral for transplant evaluation.

As referral data from other states begin to be captured, the association between distance and referral for transplant evaluation can be more fully assessed. Until widespread referral data are available, the finding that greater distance is associated with lower referral should be considered in conjunction with its limitations. The role of distance should not be ignored, however, because understanding distance as a potential barrier could help identify areas in Georgia that are in need of greater intervention for referral. If distance is truly a hindrance to referral, then understanding whether travel

time, transportation or other factors play a role will be important. Future studies could assess travel time and access to transportation in relation to distance as a potential barrier.

Referral for transplant evaluation among the 11,993 Georgia ESRD patients was best explained by sex, age, race, primary insurance provider and neighborhood poverty. These factors had stronger associations with referral than distance to transplant center and can be valuable in assessing patient risk for not entering the kidney transplant process. As referral data become more widely available, distance to transplant center could be reassessed with greater sensitivity. Future studies on distance as a barrier could define potential geographic disparities and pinpoint areas in Georgia in need of increased access to transplantation.

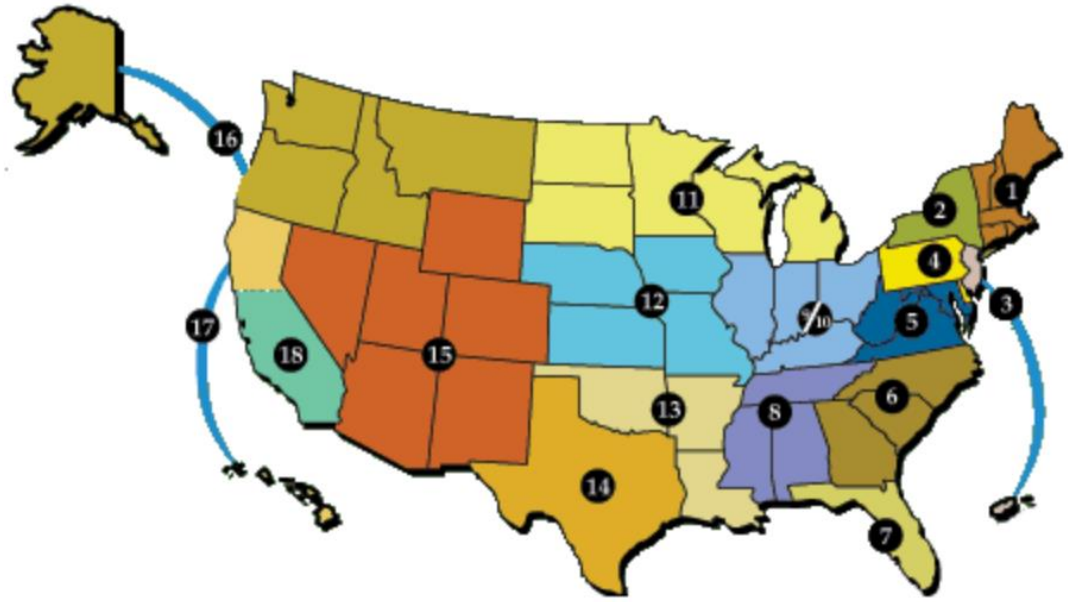

Figure 1. ESRD Network areas. Available from http://www.esrdnetworks.org

Table 1. Characteristics of 11,993 ESRD patients at dialysis start by distance tertile from residential zip code tabulation area to nearest Georgia transplant center, Georgia, 2005-2011

	Eligible ESRD Patients (n=11,993)		Distance to nearest Transplant Center					
			<19 miles Close (n =4,092)		19 ≤ miles < 75 Intermediate (n = 3,993)		≥75 miles Far (n = 3,908)	
	No.	%	No.	%	No.	%	No.	%
Patient-level characteristics								
Sex								
Male	6,586	54.9	2,287	55.9	2,212	55.4	2,087	53.4
Female	5,407	45.1	1,805	44.1	1,781	44.6	1,821	46.6
Age, years								
18 – 29	572	4.8	231	5.7	166	4.2	175	4.5
30 – 39	1,216	10.1	475	11.6	379	9.5	362	9.3
40 – 49	2,324	19.4	858	21.0	731	18.3	735	18.8
50 – 59	3,788	31.6	1,276	31.2	1,246	31.2	1,266	32.4
60 – 69	4,093	34.1	1,252	30.6	1,471	36.8	1,370	35.1
Race								
White, non-Hispanic	3,451	28.8	609	14.9	1,729	43.3	1,113	28.5
White, Hispanic	306	2.6	130	3.2	116	2.9	60	1.5
Black, Hispanic or non-Hispanic	8,013	66.8	3,242	79.2	2,078	52.0	2,693	68.9
Other	223	1.9	111	2.7	70	1.0	42	1.1
Socioeconomic status								
Primary health insurance provider[2]								
Medicare	2,420	20.2	683	16.7	864	21.6	873	22.3
Medicaid	2,908	24.3	896	21.9	916	22.9	1,096	28.1
Employer-based	3,494	29.1	1,272	31.1	1,275	31.9	947	24.2
Other	562	4.7	200	4.9	143	3.6	219	5.6
None	2,574	21.5	1,035	25.3	780	19.5	759	19.4
Pre-ESRD nephrology care[3]								
Yes	6,328	52.8	1,806	44.1	2,163	54.2	2,359	60.4
No	4,027	33.6	1,564	38.2	1,323	33.1	1,140	29.2
Residential Characteristics[1]								
Neighborhood poverty[4]								
High, ≥20%	5,713	47.6	1,717	42.0	1,509	37.8	2,487	63.6
Low, <20%	6,261	52.2	2,375	58.0	2,479	62.1	1,407	36.0
Average % black[5], mean, SD	42.9	27.4	60.8	28.4	26.3	19.1	41.0	21.5
Average % high school graduates[5], mean, SD	81.4	8.1	84.7	7.4	80.6	8.2	78.7	7.5
Patient Dialysis Facility Characteristics[6]								
Facility number of patients								
<26	2,624	21.9	778	19.0	1,208	30.3	638	16.3
26-54	3,340	27.9	1,208	29.5	1,059	26.5	1,073	27.5
55-78	2,977	24.8	976	23.9	954	23.9	1,047	26.8
≥ 79	3,046	25.4	1,130	27.6	769	19.3	1,147	29.4

[1]Residential characteristics determined by 2010 census zip code data
[2]There are 35 patients missing health insurance provider information
[3]There are 1,638 patients missing pre-ESRD nephrology care information
[4]There are 19 patients missing neighborhood poverty information
[5]There are 19 patients missing neighborhood % black and % high school graduate
[6]There are 6 patients missing facility information

Table 2. Characteristics of 11,993 ESRD patients by referral within one year of dialysis, Georgia, 2005-2011

	Eligible ESRD Patients		Referred within 1 Year (n =3,454)		Not Referred within 1 Year (n = 8,539)		P-value
	No.	%	No.	%	No.	%	
Patient-level characteristics							
Sex							<.0001
Male	6,586	54.9	2,010	58.2	4,576	53.6	
Female	5,407	45.1	1,444	41.8	3,963	46.4	
Age, years							<.0001
18 – 29	572	4.8	252	7.3	320	3.8	
30 – 39	1,216	10.1	512	14.8	704	8.2	
40 – 49	2,324	19.4	802	23.2	1,522	17.8	
50 – 59	3,788	31.6	1,106	32.0	2,682	31.4	
60 – 69	4,093	34.1	782	22.6	3,311	38.8	
Race							<.0001
White, non-Hispanic	3,451	28.8	844	24.4	2,607	30.5	
Hispanic, white	306	2.6	83	2.4	223	2.6	
Black, Hispanic or non-Hispanic	8,013	66.8	2,438	70.6	5,575	65.3	
Other	223	1.9	89	2.6	134	1.6	
Socioeconomic status							
Primary health insurance provider[2]							<.0001
Medicare	2,420	20.2	462	13.4	1,958	22.9	
Medicaid	2,908	24.3	657	19.0	2,251	26.4	
Employer-based	3,494	29.1	1,467	42.5	2,027	23.7	
Other	562	4.7	158	4.6	404	4.7	
None	2,574	21.5	706	20.4	1,868	21.9	
Pre-ESRD nephrology care							0.11
Yes	6,328	52.8	1,904	55.1	4,424	51.8	
No	4,027	33.6	1,152	33.4	2,875	33.7	
Residential Characteristics[1]							
Neighborhood poverty[4]							<.0001
High, ≥20%	5,713	47.6	1,442	41.8	4,271	50.0	
Low, <20%	6,261	52.2	2,004	58.0	4,257	49.9	
Average % black[5], mean, SD	42.9	27.4	43.3	27.4	42.7	27.4	0.29
Average % high school graduates[5], mean, SD	81.4	8.1	82.4	8.0	80.9	8.1	<.0001
Patient Dialysis Facility Characteristics[6]							
Facility number of patients							<.0001
<26	2,624	21.9	886	25.7	1,738	20.4	
26-54	3,340	27.9	875	25.3	2,465	28.9	
55-79	2,977	24.8	838	24.3	2,139	25.1	
≥ 79	3,046	25.4	854	24.7	2,192	25.7	

[1]Residential characteristics determined by 2010 census zip code data
[2]There are 35 patients missing health insurance provider information
[3]There are 1,638 patients missing pre-ESRD nephrology care information
[4]There are 19 patients missing neighborhood poverty information
[5]There are 19 patients missing neighborhood % black and % high school graduate
[6]There are 6 patients missing facility information

Table 3. Associations between distance to transplant center and transplant referral within one year from logistic regression models adjusting for selected characteristics in Georgia ESRD patients, 2005 - 2011

Effect	Model 1 (crude)		Model 2 (adjusted)[1]	
	OR	**95% CI**	**OR**	**95% CI**
Distance to transplant center, miles				
<19	Reference		Reference	
19 ≤ miles < 75	0.93	(0.85, 1.03)	1.01	(0.93, 1.13)
≥ 75	0.66	(0.60, 0.73)	0.76	(0.67, 0.85)
Patient-level characteristics				
Sex				
Female			Reference	
Male			1.11	(1.02, 1.22)
Age, years				
18 – 29			Reference	
30 – 39			0.82	(0.65, 1.02)
40 – 49			0.55	(0.45, 0.68)
50 – 59			0.41	(0.34, 0.51)
60 – 69			0.24	(0.20, 0.30)
Race				
White, non-Hispanic			Reference	
White, Hispanic			0.98	(0.73, 1.32)
Black, Hispanic or non-Hispanic			1.42	(1.28, 1.58)
Other			2.16	(1.53, 3.05)
Socioeconomic status				
Primary health insurance provider				
Medicare			Reference	
Medicaid			0.94	(0.81, 1.09)
Employer-based			2.33	(2.03, 2.66)
Other			1.39	(1.10, 1.76)
None			0.97	(0.83, 1.14)
Pre-ESRD nephrology care				
Yes			Reference	
No			0.82	(0.75, 0.91)
Residential Characteristics				
Neighborhood poverty				
High, ≥20%			Reference	
Low, <20%			1.25	(1.13, 1.37)
Dialysis Facility Characteristics				
Facility number of patients				
<26			Reference	
26-54			0.75	(0.66, 0.85)
55-78			0.83	(0.73, 0.95)
≥ 79			0.74	(0.65, 0.84)

[1] Complete covariate information available for 10,340 patients

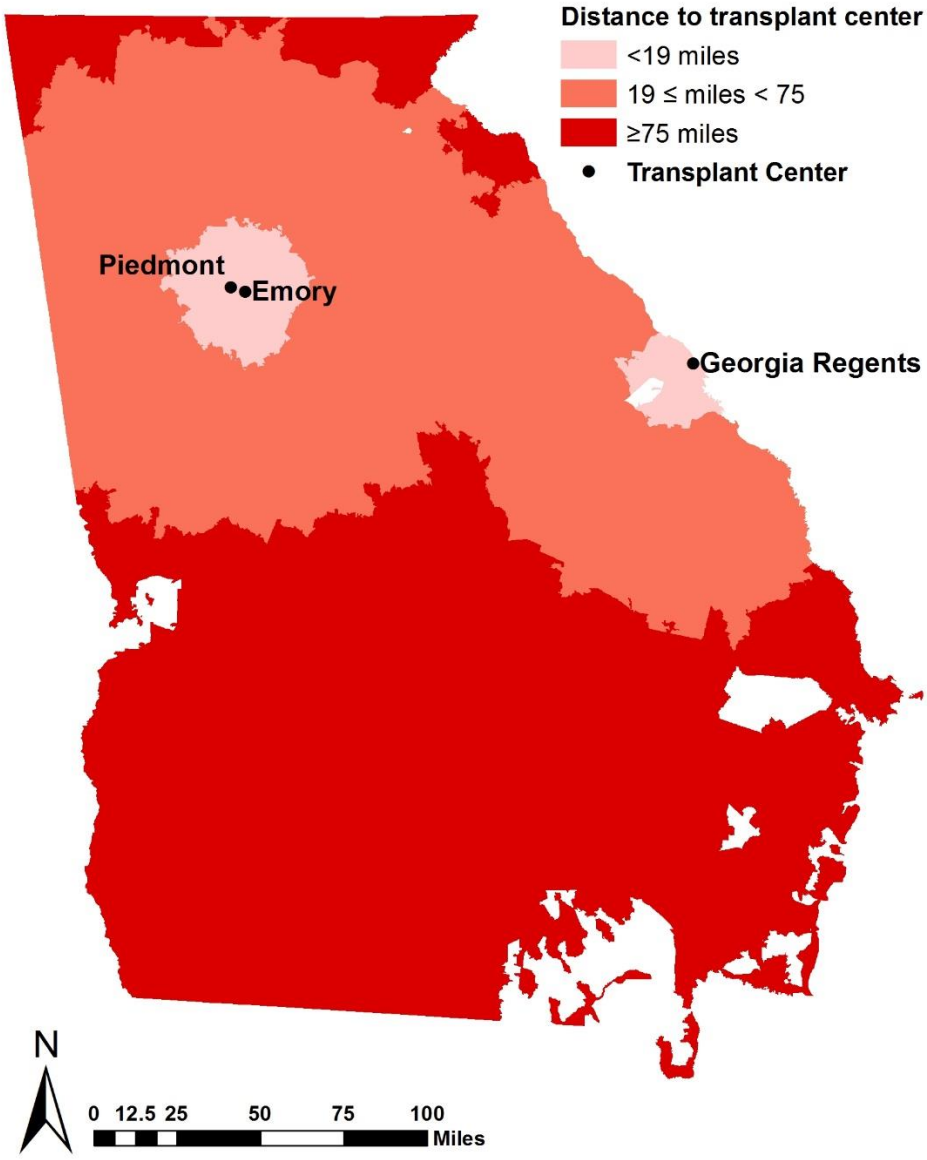

Figure 2. Distance categorization of zip code tabulation areas (ZCTA) measured from the center of ZCTA to the nearest transplant center in Georgia.

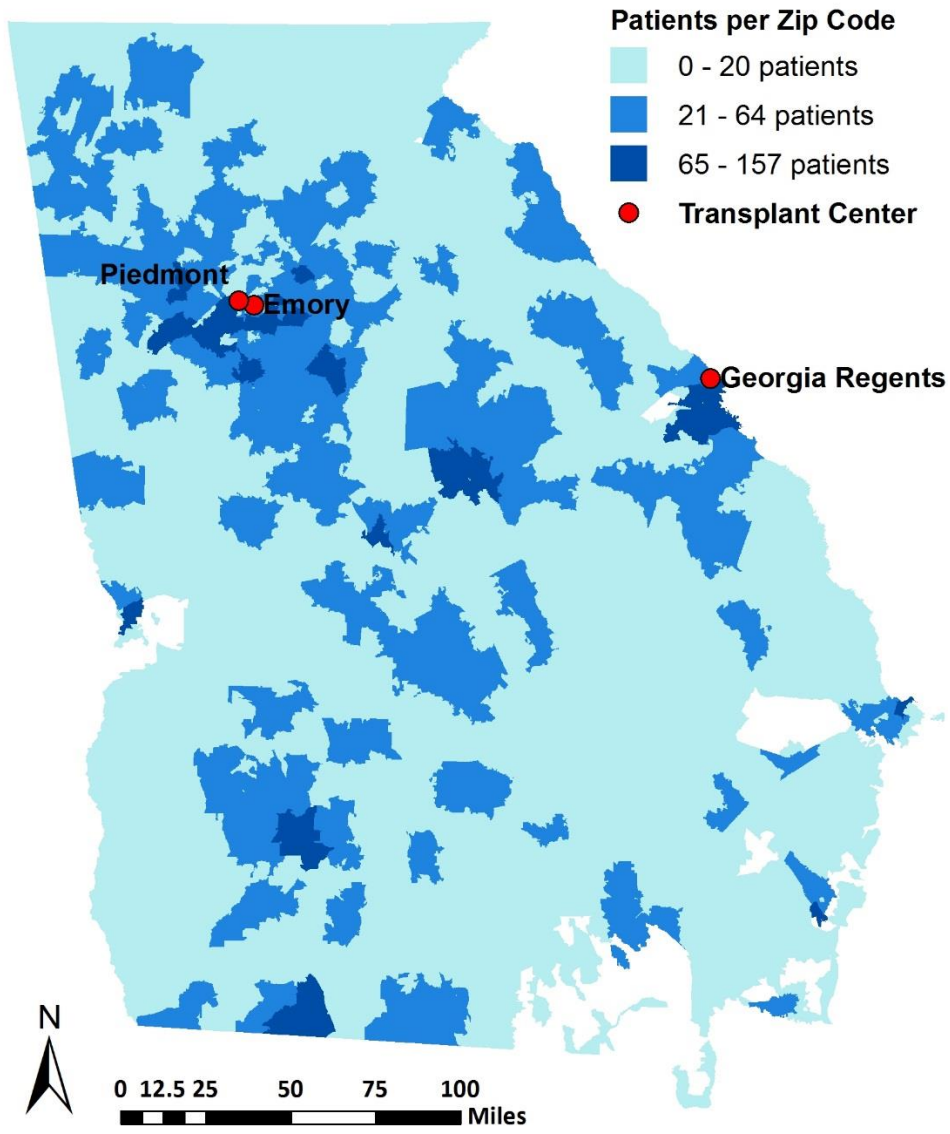

Figure 3. Distribution of ESRD patients by zip code tabulation area and location of transplant centers in Georgia, 2005 – 2011.

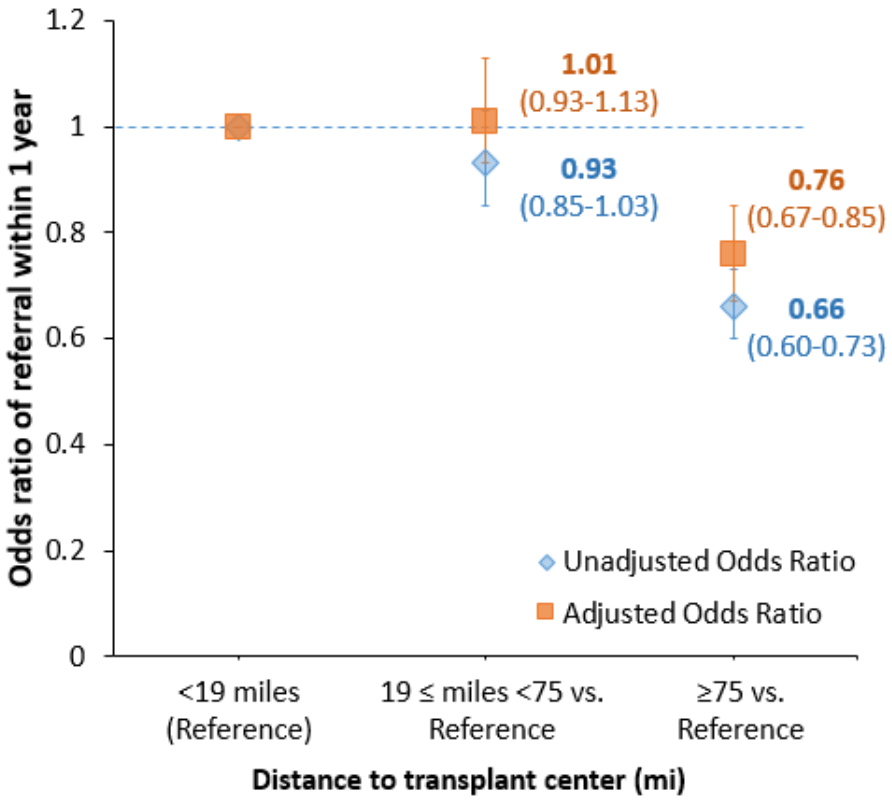

Figure 4. Unadjusted and adjusted odds ratios for referral for kidney transplant evaluation within one year of dialysis start among ESRD patients in Georgia by distance to transplant center, 2005-2011. Adjusted for sex, age, race/ethnicity, primary health insurance provider, pre-ESRD nephrology care, neighborhood poverty and dialysis facility size.

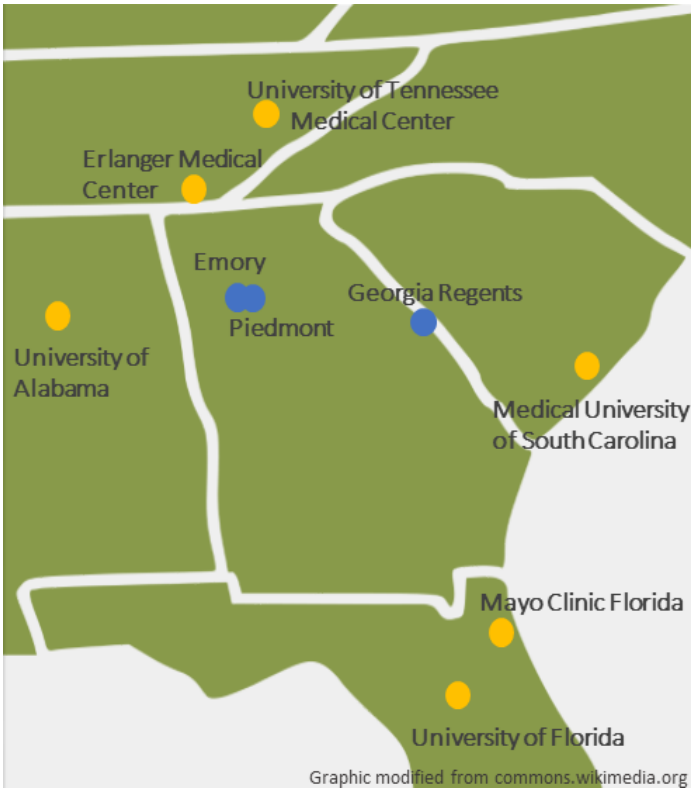

Figure 5. Location of transplant centers in Georgia and neighboring states.

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