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Identifying the barriers and disparities for referral to kidney transplantation faced by person living with HIV and end stage renal disease

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Abstract Cover Page

Identifying the barriers and disparities for referral to kidney transplantation faced by person living with HIV and end stage renal disease

By

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ScB, Monmouth University, 2009
MD, George Washington University School of Health Sciences, 2013

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An abstract of a thesis submitted to the Faculty of the
James T. Laney School of Graduate Studies of Emory University
in partial fulfillment of the requirements for the degree of
Master of Science in Clinical Research
2020

ABSTRACT

Identifying the barriers and disparities for referral to kidney transplantation faced by person living with HIV and end stage renal disease

By Ruth O. Adekunle

Background:
As persons living with HIV (PLWH) live longer, end-stage renal disease (ESRD) is emerging as a significant cause of morbidity and mortality. PLWH have an increased risk of ESRD, while also experiencing lower survival rates on dialysis compared with the general population. Limited data exists on access to kidney transplantation among PLWH. We describe the early steps to kidney transplantation among PLWH on dialysis in ESRD Network 6 (GA, NC, SC) and patient and dialysis facility level characteristics that serve as barriers to transplantation.

Methods:
A novel dataset inclusive of incident dialysis patients between 2012 and 2016 that identifies PLWH and the general dialysis population of ESRD Network 6, was created through merging the United States Renal Data System with the Southeast Transplant Referral Dataset. Through use of Medicare Part D Prescription Claims data, PLWH on dialysis in ESRD Network 6 were identified. Descriptive analysis was performed comparing early steps of transplantation among PLWH to the general dialysis population. Additional analysis included cumulative incidence function and Cox regression models for time to event analysis.

Results:
There were 30,221 incident dialysis patients (571 HIV positive) between 2012 and 2016. PLWH were younger (median age 49 vs 58, *P*-value<0.001), predominantly black (87% vs 57%, *P*-value<0.001) and male (69% vs 56%, *P*-value<0.001). PLWH and HIV negative persons were referred and evaluated to kidney transplantation at similar proportions, though PLWH were significantly less likely to be waitlisted (5% vs 11%, *P*-value<0.001). Longer median time to referral, evaluation and waitlisting was observed for PLWH. HIV serostatus, BMI ≥ 35 (kg/m2), cardiovascular related co-morbidities, lack of nephrology care prior to dialysis start, poverty, and limited full-time social work staff members were barriers to either referral or waitlisting.

Conclusions:
This pilot study offers the first regional-level characterization of PLWH proceeding through the early steps of transplantation. PLWH were less likely to traverse the steps of kidney transplant compared with those HIV negative, highlighting the need for targeted interventions to improve access to kidney transplant for PLWH.

Cover Page

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INTRODUCTION

End-stage renal disease (ESRD) has increased by 1000% in the past 3 decades, proving to be a significant health concern in the United Sates. In 1980, there were 60,000 persons with ESRD though in 2018 there were over 700,000 Americans living with ESRD (1). The expense of Chronic Kidney Disease (CKD) and ESRD has a significant impact on the United States economy and in 2018, CKD and ESRD accounted for approximately 7% of Medicare expenditure, equating to $114 billion per year (2,3). It is well established that kidney transplantation is the optimal therapy for ESRD as it provides increased survival, better quality of life, and is less costly when compared with conventional dialysis (4–7).

Since the advent of effective antiretroviral therapy, persons living with HIV (PLWH) are surviving longer and accumulating comorbidities. While HIV specific mortality has decreased, unfortunately, there continues to be a growing HIV epidemic, particularly in the southeastern United States. In 2017, the south accounted for 52% of the 38,739 new HIV diagnoses (8). As the HIV population ages, ESRD has emerged as a significant cause of morbidity and mortality, with PLWH being three times more likely to develop ESRD compared with the general population and is thought to compromise approximately 1.5% of the dialysis population (9,10). Additionally, compared with HIV-negative counterparts, PLWH experience a lower one- and five- year survival on dialysis (11). Despite this, there is growing evidence that PLWH are less likely to be placed on the organ waitlist and 47% less likely to receive a living donor kidney transplant (12). In

order to improve survival and increase transplant rates among PLWH, it is critical to better understand the barriers to achieving a kidney transplant in this high-risk population.

The objective of this thesis project was to identify and describe the HIV positive dialysis population in ESRD Network 6, the region with the lowest rates of kidney transplantation in the nation. Additionally, to compare their progression through the early steps (referral, evaluation, and waitlisting) of kidney transplantation to general dialysis population, and highlight patient and dialysis level characteristics that may influence access to kidney transplantation. This was accomplished through creating a novel HIV-ESRD dataset that identifies PLWH as well as those who proceeded through the early steps of transplantation.

BACKGROUND

PLWH have increasing rates of ESRD. HIV-associated nephropathy (HIVAN) was previously one of the leading causes of renal failure among PLWH. The widespread use of affective antiretroviral therapy (ART) has decreased the prevalence of HIV-associated nephropathies (13,14), however, PLWH are still developing CKD and ESRD faster than HIV negative counterparts. This is largely due to co-morbidities (diabetes mellitus, cardiovascular disease, hypertension, and metabolic syndrome), co-infection with hepatitis C virus (HCV), medication induced injury, and accelerated aging seeing in chronic HIV infection (9,15,16). PLWH of black race are especially at risk for progression from CKD to ESRD. A study performed in Baltimore, Maryland revealed that African-Americans were at an increased risk for incident CKD and developed ESRD markedly faster than white subjects (HR, 17.7 [95% CI 2.5-127.0]) (17).

ESRD among PLWH is particularly present in the southeast. In 2000, ESRD Network 6 had the 4th highest percentage of PLWH on dialysis at a proportion of 1.9% compared to an national average of 1.5%(10). Unfortunately, the southeastern region of the US continues to have the highest burden of CKD and ESRD with Georgia, North Carolina and South Carolina being states with some of the highest age-standardized CKD disability-adjusted life years (18,19). This coupled by the ongoing HIV epidemic in the southeast makes ESRD Network 6 a unique region to study the coexistence of ESRD and access to kidney transplantation among PLWH. With significant risk of progression from CKD to ESRD, it is imperative to understand access to transplantation among this vulnerable patient population.

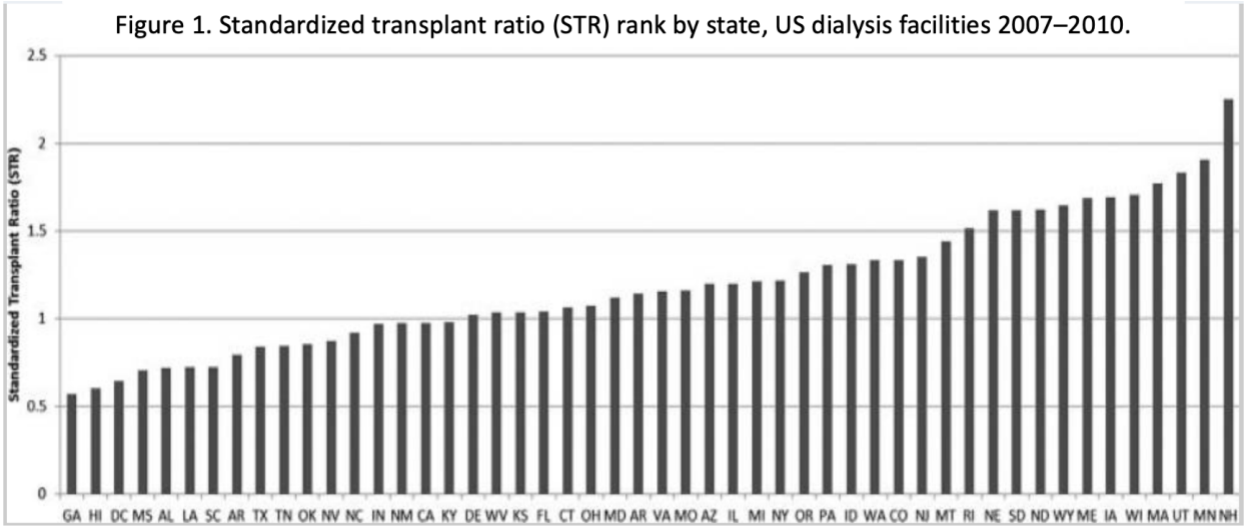
Renal transplantation is a feasible treatment option for PLWH with ESRD. In the 1980's, HIV infection was considered a contraindication for transplantation and US legal code was amended to make it a federal crime to transplant tissue from HIV positive donors (20). It was theorized that the effect of immunosuppression would contribute to progression of HIV disease, lead to more episodes of infection and increased rate of death; making it an inappropriate allocation of an organ. Between 1987 to 1997, there were 32 kidney transplants performed in the US in PLWH (mostly unintentional transplantation), with reported 3-year graft survival of 53% and patient survival 83% (21,22). These transplants though were prior to significant improvement in medications used to treat PLWH. In 2003, Stock et al published promising outcomes on 14 HIV-positive patients who underwent transplantation. At a mean follow up of 480 days, 10 out of 10 (100%) of patients who received kidney transplants were alive with functioning grafts. There was no evidence of HIV disease progression and HIV did not seem to have an impact on graft survival (23). Around the same time, driven out of lack of access to dialysis, colleagues in South Africa performed the first kidney transplants from HIV-positive organ donors to HIV-positive recipients, showing that transplantation among PLWH was safe and feasible (24).

With revived interest in transplanting PLWH, there have been a number of single center studies and a large multicenter study of 150 HIV-positive renal transplant recipients which all reported transplant outcomes for PLWH that were similar to the general transplant population [19](25–28). With better HIV care and improved understanding of medication interactions, PLWH in the United States are not only eligible for HIV-negative organs, but HIV-positive organs as well. In 2013, the HIV

Organ Procurement Equity (HOPE) Act was signed into law, reversing the 1988 amendment, allowing HIV positive organs to be transplanted into HIV positive recipients. This policy change is estimated to increase the donor pool by 300-500 organs, providing a unique opportunity to increase utilization of these organs and increase rates of kidney transplantation in HIV positive individuals [20](29).

The transplant evaluation process is a multifaceted and complex process with the southeastern region performing the least transplants. Though it is possible for patients to be referred for kidney transplant prior to starting dialysis, the majority of ESRD patients start on dialysis before they are referred to a transplant center. Within 60 days of starting dialysis, patients are required by law to be educated on the risks and benefits of transplantation and if eligible, are referred by a dialysis provider to a transplant center. The transplant center then decides on their waitlist candidacy through conducting thorough medical evaluations (often inclusive of multiple studies and specialty evaluations), performing a psychosocial evaluation, assessing their social support network and financial ability to fund kidney transplantation. When this step is completed, the patient can be waitlisted with the eventual hope of receiving a living or deceased donor kidney transplant.

To better understand how well dialysis facilities were performing in referring patients to kidney transplant, Dr. Rachel Patzer (co-I; Department of Surgery & Department of Epidemiology) and team reported in 2014 that ESRD Network 6 has the lowest rates of kidney transplantation in the nation, and that Georgia had the lowest of all 50 states (18,30,31) (Figure 1). Factors associated with decreased access to



transplant include demographic differences in the southeast, racial disparities, socioeconomic influences, distance to transplant center, provider knowledge and awareness of transplantation (18,32,33). Because no national surveillance data exist on steps prior to waitlisting, the Southeastern Kidney Transplant Coalition developed a novel data registry for referral and evaluation for transplantation among all 9 transplant centers in Georgia, North Carolina and South Carolina (U01MD010611, PI: Patzer). They found substantial variability in transplant access at the dialysis facility level where some facilities referred 0% of patients and others referred 76% (34). Dialysis facility variability in transplant rates for HIV patients have not been described because currently no data exists linking HIV and ESRD care within a state or region. Factors influencing referral to kidney transplantation in PLWH have yet to be described in ESRD Network 6 and will direct construction of future interventions.

Identifying PLWH who are on dialysis is difficult to do. Since 2005, there are scarce data on the incidence and prevalence of PLWH requiring dialysis. As part of a condition of participation in the ESRD Medicare program, Centers for Medicare and

Medicaid Services (CMS) medical evidence form (CMS 2728 form) is completed on every ESRD patient upon initiation of dialysis. CMS funds dialysis for ESRD patient and the surgical procedure and immunosuppressants for those who undergo kidney transplantation. The medical evidence form provides evidence of an ESRD condition, registers patients into a national renal registry, documents medical co-morbidities and other clinical data in dialysis patients, and ensures quality care for ERSD patients (35). In 2005, HIV serostatus was removed as an ESRD-related condition on the medical evidence form due to concerns regarding disclosure of HIV status (36). Presently, in order to identity PLWH on dialysis, HIV status is inferred through pharmacy prescription data (12). This ascertainment method is suboptimal, as it may misclassify patients on pre-exposure prophylaxis as being on ART, may fail to identify PLWH not engaged in HIV care, and lacks patient-level epidemiologic and clinical data. Nonetheless, pharmacy prescription data is the only currently available method that can be used. In this study, Medicare prescription part D claims data was used to identify PLWH on dialysis. In 2016, there was 81% participation of Medicare part D among hemodialysis patients, suggestive that majority of the HIV population is captured in this study (37).

METHODS

Hypothesis: Persons living with HIV in ESRD Network 6 are less likely to traverse through the multistep process of kidney transplantation compared to HIV-negative counterparts in the setting of ESRD.

Specific Aims

Aim 1: To identify and describe the characteristics of PLWH and ESRD in ESRD Network 6.

Aim 2: To describe the distribution and timing of early steps of kidney transplant inclusive of referral, evaluation, and waitlisting among PLWH compared with HIV negative individuals with ESRD in Network 6.

Aim 3: To identify patient-level and dialysis facility-level factors that are associated with time to referral and time to waitlisting.

Study Design

This study was a retrospective analysis on all incident ESRD patients registered with United States Renal Data System (USRDS) in ESRD Network 6 between 01/01/2012 and 12/31/2016.

Study Population

The study population consisted of patients who initiated dialysis between 2012 and 2016 within ESRD Network 6. The cohort was then further limited to the adult population between ages 18 and 70 years of age. The upper limit of 70 years of age was used as dialysis patients are significantly less likely to receive a kidney transplant after the age of 70. Those who were referred to kidney transplant prior to starting dialysis (preemptive referral) or those who were waitlisted for kidney transplant prior starting dialysis (preemptive waitlisting) were excluded from the analysis. Lastly, the unique patient's identification numbers of USRDS_ID and Person_ID were used in merging the datasets. If patients were missing either identification number, they were also excluded. In additional to having a prescription for an antiviral regimen, those who had an ICD code for AIDS nephropathy or HIV Disease were classified as being HIV positive.

Data Sources

Two main data sources were utilized to create the study population and address our research aims. First, the USRDS and the Southeast Transplant Referral Database (STRD) were combined. USRDS is a national surveillance data system that collects, analyzes and distributes information on CKD and ESRD in the United States, and was used as the source population for this retrospective cohort study (38). The USRDS allows for identification of patients who have initiated an ESRD service. Available through USRDS are patient level characteristics, facility level characteristics, census level sociodemographic variables, and Medicare Part D prescription claims data. Patient demographics and comorbidities are abstracted from the medical evidence form.

Information on dialysis facilities was obtained from the Dialysis Facility Report (DFR). The DFR is publicly available and reported annually by the University of Michigan Kidney Epidemiology and Cost Center under a contract with the Centers for Medicare & Medicaid Services (CMS) (39). Geospatial data was collected by linking patients residential zip code at the time of ESRD start and linking (geocoded) data to the 2006-2010 American Community Survey (ACS) (40). The ACS provides data annually from randomly sampled subpopulations using U.S. Census Bureau-administered questionnaires on sociodemographic variables. Through the Medicare part D prescription claims, prescription of an antiretroviral medication within 180 days of starting an ESRD service (**Supplemental 1**. List of antiretroviral medications used for Medicare Part D Prescription Claims data query) was used to classify patients as being HIV positive.

The USRDS data were merged with STRD. STRD is a surveillance dataset of early transplant steps within the Southeastern End Stage Renal Disease Network 6 region (GA, NC, SC). The methods for data collection have been previously described (34). Briefly, the registry was created from a collection of patient-level data from transplant referral forms between January 1, 2012, and December 31, 2017. This database includes patients from all 9 adult transplant centers in ESRD Network 6: Emory Transplant Center, Georgia Regents Kidney and Pancreas Transplant Program, Piedmont Transplant Institute (Atlanta), Medical University of South Carolina, Carolinas Medical Center, Duke University Transplant Center, Wake Forest Baptist, University of North Carolina Healthcare and Vidant Health. This dataset allows identification of patients with ESRD in Network 6 who have been referred and evaluated for kidney

transplant. The STRD was merged with the USRDS data using patient unique USRDS ID and Patient ID numbers.

The STRD was established in 01/01/2012 which identified the start date of the study time period. Though there is follow up in this dataset through 2017, for Medicare part D claims data, there was only follow up through 12/31/2016. This established the study duration of 01/01/2012 – 12/31/2016.

Variable Definitions

Patient characteristics: Includes demographics, cause of ESRD, proxies of socioeconomic status, incident year of ESRD service, rural, suburban, and urban neighborhoods, and cardiovascular related comorbidities at dialysis start.

Dialysis facility characteristics: Profit status (for profit vs non-profit), Type of facility (free-standing vs hospital based), facility size, and number of full-time social workers.

Sociodemographics: Age at the time of dialysis start was used as a continuous variable. Sex was defined as either male or female. Those who were not of white or black ethnicities were categorized as “other.” BMI was used as a dichotomous variable as either $\geq$35 or $\leq$ 35. This is because BMI $\geq$ 35 is considered a relative contraindication to waitlisting at our institution and nationally, 29% of institutions use the same BMI cut off (41). Definition of urban, suburban and rural areas were based off of the 2013 Rural-Urban Continuum Codes and a crosswalk file was used to link FIP and Zip codes. Neighborhood poverty, percentage of blacks per zip code, and educational level per zip

codes were obtained from the American Survey Data obtained from census data. Neighborhood poverty was dichotomized as 0-19% or ≥ 20% above the poverty line as neighborhoods that are ≥ 20% above the poverty line are considered high poverty neighborhoods.

Comorbidities: The comorbidities that are included in the medical evidence form are those that impact cardiovascular health or one's ability to be transplanted. These include hypertension, diabetes, congestive heart failure, atherosclerotic heart disease, cerebrovascular disease, peripheral vascular disease, chronic obstructive pulmonary disease, other cardiovascular conditions, cancer and tobacco use; documented from the medical evidence form at the time of ESRD start.

HIV: Persons were classified as being HIV positive if in the Medicare part D prescription claim data, they had a prescription for an antiretroviral medication or a diagnosis of HIV associated nephropathy as a cause of ESRD.

Preemptive referral: Having a referral date prior to the start of dialysis date.

Preemptive waitlisting: Having a waitlisting date prior to the start of dialysis date.

Statistical Analysis by Aim

Aim 1: To identify and describe the characteristics of PLWH and ESRD in ESRD Network 6.

The combination of the URSDS and STRD and use of Medicare Prescription claims data allowed for identification of persons on dialysis, those who were referred and evaluated to kidney transplantation, and identification of PLWH. Baseline patient level characteristics and dialysis facility were tabulated for the entire cohort. Chi-squared and t-tests (or non-parametric equivalents) were used to compare differences among the various patient and dialysis facility characteristics by HIV status. Categorical variables were presented as percentages and continuous variables as medians with interquartile range (IQR). The amount of missing data for each variable is presented at the bottom of each table. There were small percentages of missing data (missing data was <5%), thus multiple imputation methods were not used. The pattern of missing data was evaluated. It was noted that zip code type, census poverty and census race were most frequently missing together. Since these variables are all depended on the patient's zip code, if zip code was missing for a particular patient, it would make sense that variables depending on the zipcode would also be missing.

Aim 2: To describe the distribution and timing of early steps of kidney transplant inclusive of referral, evaluation, and waitlisting among PLWH compared with HIV negative individuals with ESRD in network 6.

The events of interest were referral, evaluation, and waitlisting to kidney transplant. Persons were classified as being referred to, evaluated for, or waitlisted if they had a corresponding date for those events. Descriptive statistics were performed comparing percentages of referrals, evaluations, and waitlistings of PLWH to HIV negative persons. Time of follow-up was defined as time from dialysis start to date of

first referral, date of death or end of study (12/31/2016), whichever occurred first. This approach was also used for time to evaluation and time to waitlisting. Death was included in the calculation in time to referral, evaluation and waitlisting; hence time to event is interpreted as time to either referral, evaluation or waitlisting given the patient did not die. Time was represented in days and presented as medians with IQR. It was discovered that 369 persons were identified as being waitlisted but did not have a corresponding referral date. These persons were treated as being referred given that a person has to be referred prior to being waitlisted. For these persons, referral date was set to a day prior to waitlisting date. For this aim, the denominator used for waitlisting was all ESRD patients, rather than waitlisting only among those who were referred.

Cumulative incidence of time to first referral and time to first waitlisting was also calculated. Death was incorporated as a competing risk given that 20% of the cohort died prior to being referred or waitlisted. In general, competing risks are events that occur prior to the event of interest. In this instance, if a patient has already died (the competing risk), the event of interest (referral and waitlisting) cannot occur. Conventional time to event analysis ignore competing risks and as such, are thought to overestimate the probability of the event of interest (42). The advantage of the cumulative incidence function is that it provides the probability of a cause specific event (43).

The cumulative incidence cause-specific hazard was estimated using the Aalen-Johnsen estimator. The Aalen-Johnsen estimator is a non-parametric estimation of risks and probabilities. It uses the overall survival function that is estimated by the Kaplan-Meier estimator, which produces the cumulative incidence function (44). For the

cumulative incidence function addressing time to referral, a patient either achieved the event of interest (referral), experienced a competing risk (death), or were censored at the end of the study period if they were not referred or did not die. This approach was also used for the cumulative incidence function addressing time to waitlisting. The cumulative incidence function for time to referral was compared between PLWH and HIV through assessing if the confidence intervals at 365 days (or one year) were overlapping. 365 days was chosen because it an acceptable time frame in which a person should be expected to be referred to kidney transplantation. The cumulative incidence function for time to waitlisting was compared between PLWH and HIV through assessing if the confidence intervals at 730 days (or two years) were overlapping. Likewise, this time frame was selected since it is an acceptable time frame in which a person should be expected to be waitlisted for kidney transplantation. The cumulative incidence function was performed in SAS, though the data was exported to excel in order to improve the visualization of the curves (45).

Aim 3: To identify patient-level and dialysis facility-level factors that are associated with time to referral and time to waitlisting.

In order to assess the effect of several factors on time to referral and waitlisting, a cox regression model was used to evaluate sub-distributional hazards. This approach was desired in order to account for death as a competing event. In traditional survival analysis, if a subject is lost to follow-up, they are censored. This though assumes that at a given time point, those who remain under follow-up have the same future risk for the event of interest as those subjects no longer being followed or that have been censored

(noninformative censoring) (42). This assumption is violated when death is used as a competing risk because if a patient dies, they no longer have the ability to experience the event of interest. Death as a competing risk was incorporated through the Fine and Grey method. This method is a compromise between completely censoring those who experienced a competing risk and retaining those who experienced a competing risk (46). For this analysis, deceased patients are retained in the risk set using conditional time-dependent weight. The weight of those patients who are artificially retained in the risk sets is gradually reduced according to the conditional probability of being under follow-up if the competing event had not occurred (47). This method helps to attenuate the overestimation bias that would otherwise occur with conventional time to event analysis. A covariate with a hazard ratio greater than one was interpreted as a being associated a higher probability of being referred or waitlisted and a hazard ratio less than one was interpreted as being associated with a lower probability.

Additionally, the proportional hazard (PH) assumption was evaluated. The PH assumption requires that the hazard remains constant over time, or said in a different way, the hazard for one subject is proportional to the hazard of any other subject (43). For traditional Kaplan Meirs assumption, the PH can be visualized by graphing the log(-log(survival)) versus log(time). Given that competing risks were accounted for, the aforementioned graph cannot be calculated. Time-dependent covariates were used to assess the PH assumption. The significance of the product term was tested using the Wald statistic. The PH assumption was found to be violated for the variables: BMI, hypertension, Medicare, and age (though only when evaluating the PH assumption for waitlisting). The hazard for these variables were interpreted as the average of the true

hazard. Both univariable and adjusted Cox regression models were performed to assess the effect of different variables on time to referral and waitlisting.

Lastly, the Cox model analysis treats different lines of data contributed by the same entity as independent contributions. In this dataset, a patient is nested within dialysis facilities, so the dialysis facility may be accounted for more than once. In order to address the potential of multi-level, correlated data in our population (i.e., patients nested within dialysis facilities), a robust sandwich estimator analysis was performed. This approach obtains variance estimators that adjust for correlation within dialysis facilities when previously no such correlation was assumed (48). Accounting for the correlation slightly widened the confidence intervals of variables, though did not change their statistical significance.

Sensitivity Analyses

In the development of the HIV-ERSD cohort, those who were preemptively referred or waitlisted were excluded. Those who were preemptively referred and waitlisted were compared to those to evaluate the differences between the two groups. Additionally, one of the classifications for being HIV positive was having a prescription for an antiretroviral regimen. Though, only patients who used Medicare to fill their prescriptions were captured. Differences between those who had a Medicare prescription claim and those who did not was assessed.

Approval and Funding

This study was approved by the Emory University Institutional Review Board.

Ruth Adekunle received a TL-1 grant through the Georgia Clinical and Translational Science Alliance (CTSA) to complete this work (TL1TR002382, UL1TR002378). A portion of this work was supported by the National Institute on Minority Health and Health Disparities grants R01MD010290, R24MD008077 and U01MD010611. The data reported here have been supplied in part by the USRDS. The interpretation and reporting of these data are the responsibility of the authors and in no way should be seen as official policy or interpretation of the U.S. government. Aspects of this work was presented at IDWeek 2019 in Washington, DC. Statistical analyses were conducted using SAS version 9.4 (Cary, NC).

RESULTS

Cohort Characteristics

A total of 50,441 patients initiated an ESRD service during the study time period (January 1, 2012, through December 31, 2016); of these 36,419 patients were adult persons between 18 to 70 years old. After excluding those who lacked unique patient identifiers (n=10) and those were preemptively referred or waitlisted (n, 30,221 patients were included in the primary analysis, of which 571 were HIV positive (**Figure 2).**

Demographic and clinical data on incidence dialysis patients stratified by HIV status are listed in **Table 1**, as well as the amount of missing data by variable. The median age in the study cohort was 58, with PLWH being statistically significantly younger (49 vs 58, *P*-value<0.001), higher proportion of males (69% vs 56%, *P*-value<0.001) and higher proportion of black race (87% vs 57%, *P*-value<0.001). HIV associated nephropathy was the leading primary cause of ESRD in PLWH compared with diabetic nephropathy for HIV negative persons (*P*-value<0.001). HIV negative persons had a higher percentage for all recorded co-morbid conditions (*P*-value<0.001) except for tobacco use. Regarding markers of socioeconomic status, PLWH were significantly less likely to receive pre-ESRD care, more likely to reside in an urban zip code, more likely to have Medicaid insurance or no insurance upon starting dialysis and more likely to live in neighborhoods > 20% below the poverty line (45% vs 32%, *P*-value<0.001). For dialysis characteristics, there were no significant differences in type of dialysis facility, though the general dialysis population were more likely to be in for-profit dialysis facility (85% vs 81%, *P*-value<0.001), less likely to be in large dialysis facilities

(dialysis facilities with > 75 people) and overall less access to a full-time dialysis social worker.

Referral, Evaluation and Waitlisting

Out of the 30,221 patients, 13,639 (45%) were referred to kidney transplant (**Table 2**). There were no significant differences in referral among PLWH and HIV negative counterparts (45% vs 45%, *P*-value=0.980), though PLWH were significantly less likely to be informed of transplant options (85% vs 88%, *P*-value=0.049). Similarly, there were no statistically significant differences between PLWH and the HIV-negative population, though only 26% of the entire cohort were evaluated for kidney transplant. In terms of waitlisting, 3,3425 (11%) patients were placed on the deceased donor waiting list, with a higher percentage of HIV negative persons waitlisted compared with PLWH (11% vs 5%, *P*-value<0.001).

The median time to referral in the study cohort was 240 days with PLWH significantly waiting longer for referral to kidney transplantation (331 days vs 234 days, *P*-value=0.004). An equivalent trend was observed for time to evaluation and time waitlisting in PLWH significantly waiting longer to be evaluated and waitlisted for kidney transplantation (533 days vs 420 days, *P*-value<0.001 and 671 days vs 542 days, *P*-value=0.014 respectively). During the study period, 20% of the study population died prior to receiving a kidney transplant with median time to death being 590 days. No differences were observed between PLWH and HIV negative persons.

Cumulative incidence of time to referral and waitlisting

Figures 3 and 4 demonstrate the cumulative incidence of time to referral and time to waitlisting comparing PLWH and HIV negative persons censored by death or end of study, which ever occurred first. For cumulative incidence of time to referral, there was a statistically significant difference between PLWH and HIV negative persons at 365 days evident by non-overlapping confidence intervals (0.35 95% CI (0.308 - 0.392) vs 0.41 95% CI (0.407 - 0.419)), though this difference is lost by the end of the study period. For cumulative incidence of time to waitlisting, there is an early separation between PLWH and HIV negative counterparts that is maintained at 730 days (0.06 95% CI (0.039 - 0.083) vs 0.12 95% CI (0.120 - 0.128)) and beyond.

Assessment of factors associated with probability of referral and waitlisting

Univariable assessment of factors statistically associated with a lower probability of referral included: increasing age, BMI ≥ 35 (kg/m2) (though upper limit of confidence interval was close to one), being started on hemodialysis, all comorbidities except hypertension (though only insulin dependent diabetes), starting dialysis with Medicaid or Medicare insurance **(Table 3)** and being from a non-suburban neighborhood. When adjusted in multivariable analysis **(Table 4)**, atherosclerotic heart disease was no longer significant, though having a primary cause of ESRD being HIV associated nephropathy became significant along with being a for-profit dialysis facility (though upper limit of confidence interval was close to one) and being in a dialysis facility with only one full time social worker. Factors that were associated with a higher probability of referral in univariable analysis included: male sex, being of non-white race, primary causes of ESRD being hypertensive nephrosclerosis, glomerulopathy, or “other”, having hypertension, receiving nephrology care prior to starting dialysis, having employer-

based insurance or no insurance, coming from a suburban neighborhood, being at a free-standing dialysis facility and having more than one full time social worker that the dialysis facility. When adjusted for in multivariable analysis, being of non-white race, receiving nephrology care prior to starting dialysis, having employer-based insurance, coming from a suburban neighborhood, being at a free-standing dialysis facility, and having four full time social workers at a dialysis facility remained significant. Coming from a rural neighborhood became significantly associated with a higher probability of referral in multivariable analysis.

In terms of waitlisting, in univariable analysis, factors statistically associated with a lower probability of waitlisting included: HIV positive serostatus, increasing age, HIV associated nephropathy as a primary cause of ESRD, BMI $\geq$ 35 (kg/m2), all comorbidities except hypertension (though only insulin dependent diabetes), being started on hemodialysis, starting dialysis with Medicaid or Medicare insurance, being from a non-suburban neighborhood, being from a neighborhood that was >20% below the poverty level, and being at a dialysis facility with > 55 patients. When adjusted in multivariable analysis, HIV associated nephropathy as a primary cause of ESRD was no longer significant, though having no insurance at dialysis start and being at a dialysis facility with only one full time social worker became significant. Factors that were associated with a higher probability of waitlisting in univariable analysis included: male sex, being of non-white race and Hispanic ethnicity, primary causes of ESRD, glomerulopathy or “other”, having hypertension, receiving nephrology care prior to starting dialysis, having employer-based insurance or no insurance, coming from a suburban neighborhood, and having four full time social workers that the dialysis facility.

When adjusted in multivariable analysis, being of black race, having “other” as a primary cause of ESRD, and having four full time social workers that the dialysis facility, are no longer significant. Having no insurance at dialysis start went from being associated with a higher probability of waitlisting to being associated with a lower probability of waitlisting in multivariable analysis.

Sensitivity Analysis

In comparing those who were preemptively referred and waitlisted to those who were not, there was several slight differences noted between the two groups (**Supplementary Table 1**). The most notable differences were that preemptive referred or waitlisted individuals were slightly younger in age, a higher proportion were white, there were less patients with BMI < 35 (kg/m_2), lower proportion of co-morbidities, lower proportion of non-private insurance, lower proportion of poverty, and high proportion of being on peritoneal dialysis and a lower proportion were at non-profit facilities.

Those with a Medicare prescription claim was compared to those without a Medicare prescription claim (**Supplementary Table 2)**. Similarly, several differences were noted. These included higher proportion with pre-ESRD care, lower proportion of hemodialysis, lower proportion of comorbidities, lower proportion of Medicaid, and higher proportion of private insurance.

DISCUSSION

Although there has been increasing attention on access to kidney transplantation, little is known about the role early steps to transplantation plays in access to transplantation, as national data prior to waitlisting does not exist. In this study, it was demonstrated that PLWH are less likely to proceed through the steps towards kidney transplantation compared with the general dialysis population of ESRD Network work 6. Though the percentages of referral and evaluation were not statistically different, PLWH were significantly less likely to make it onto the deceased donor waiting list. Additionally, PLWH wait longer to be referred, evaluated, and waitlisted for kidney transplantation. This study offers the first region-level characterization of PLWH with ESRD proceeding through the early steps of kidney transplantation. Additionally, factors such as increasing age, BMI $\geq$ 35 (kg/m_2), cardiovascular related comorbid conditions, Medicaid insurance, and limited number of full-time social workers at a dialysis facility, were identified as barriers to referral and waitlisting.

Description of PLWH on dialysis in ESRD Network 6

With the HIV epidemic in the southeast predominately affecting young black males, it is not surprising that the HIV population were almost 10 years younger than the general dialysis population, majority male and majority of black race. HIV associated nephropathy (HIVAN) still remained the leading cause of developing ESRD, though this may be an overestimation due to lack of renal biopsy to definitely diagnose HIVAN. In line with increasing co-morbidities in the aging HIV population, diabetic nephropathy was next leading cause of ESRD. It was identified that PLWH were less likely to have

cardiovascular related co-morbidities. This could be secondary to PLWH being younger in age and thus the general dialysis population has had more time to accumulate comorbidities. The HIV negative population also had higher percentages of insulin dependent diabetes and hypertension which could have contributed to seeing the higher spectrum of cardiovascular diseases in that population.

It was noted that PLWH were less likely to have received nephrology care prior to the start of dialysis. There are a number of speculated reasons for this. In PLWH who do not have insurance, they often receive medical care through federal programs such as Ryan White and AIDS Drug Assistance Program (ADAP). While these programs financially support prescription of antiretroviral medications and diagnostic evaluations, access to consistent specialty care is limited. It could also possible that HIV providers who service as the primary care providers may be less likely to refer patients to nephrology. This lack of access to pre-nephrology care has been associated with lower likelihood of receiving a kidney transplant (49) and possibility limits preemptive referrals to kidney transplantation. One study demonstrated that out of 42 kidney transplant eligible HIV-positive individuals, only 2 patients (5%) received a transplant evaluation prior to being started on dialysis (50). In this study, only 7.3% of PLWH compared with 17% of HIV negative individuals were preemptively referred to transplant (*P*-value<0.001).

The data suggests that PLWH were of a lower socioeconomic status (SES) compared with HIV negative counterparts. PLWH had a higher percentage of Medicaid insurance and not having insurance at all at the start of dialysis, were more likely to come from a zip code >20% below the poverty level, and were more likely to live in an

urban neighborhood. Being of a lower SES has been associated with lack of access to specialty care, delays in transplant referral, evaluation and listing (49,51). The influence of SES on access to kidney transplant has also been linked to less living related transplants among those of lower SES (13.5% vs 29.4% in those of higher SES) (52).

There were limited differences noted in dialysis facility characteristics among PLWH. PLWH had a lower percentage of being at a for profit status, being at a dialysis facility with >55 patients and being at a dialysis center with ≥ 2 full time staff members, which could be associated with increased access to kidney transplant.

Description of early steps of kidney transplantation among PLWH

Prior work identified that a higher facility-level referral rate was associated with a higher number of performed transplants and percentage of patients who were waitlisted, in a dose-response manner. The same study noted that between 2005 and 2011, Georgia had a within-facility referral to kidney transplantation at a median of 25.4% of facilities referring patients within one year (53). It was encouraging to see that collectively in Georgia, North Carolina and South Carolina, 45% of patients were referred to kidney transplantation between 2012 and 2016 and that PLWH and HIV negative persons in ESRD network 6 were being referred to transplantation at similar proportions. With no specified target or metric, it is unknown though whether this percentage is an appropriate number and if all candidates appropriate for kidney transplant evaluation are being referred. Additionally, it has also been reported that referral itself is not the main driver of disparities in access to kidney transplant, but

rather the difficulty in navigating the complex and challenging multistep process of kidney transplantation (34).

Significant dropouts were observed as individuals proceeded through the transplant steps for both PLWH and the HIV negative population, though PLWH were less likely to be waitlisted. Data in this study is not granular enough to elucidate why this may be, though single center experiences have suggested concerns surrounding uncontrolled HIV, non-compliance, substance use, insurance related issues and inability to complete transplant requirements, as to reasons why PLWH are less likely to make it to the deceased donor waitlisting list (54,55). Additionally, though patients are being referred to kidney transplant, its unknown how well patients are being educated on the transplant evaluation process which could also be a contributing factor. Most dialysis patients are interested in learning about transplant options with only 1.5% of dialysis patients declining counseling (56). Lastly, this data is unable to assess if patients met clinical criteria for transplant. In order to be eligible to be placed on the deceased donor waitlisting list, PLWH have to have a CD4 count >200 cells/mm_3 and be virally suppressed for at least 6 weeks. Other considerations include compliance, history of opportunistic infections, nutritional status, and co-infection with hepatitis B and C (57). These findings of potentially appropriate candidates not making it to the waitlist, highlight a need for national reporting of factors contributing to post-referral barriers, in order to better understand potential disparities that prevent individuals from achieving the ultimate goal of transplantation.

It was additionally observed that PLWH waited longer to be referred, evaluated and waitlisted compared with the general ESRD Network 6 population. Locke et al

reported out of the 308,735 kidney-only adult transplant candidates on the waitlist between 2001 and 2012, only 1,698 were identified as being HIV positive and these individuals were more likely to spend time on dialysis compared with HIV negative individuals (12). The time to transplant evaluation and waitlisting can vary from institution to institution. Sawinski et al noted a median time from evaluation completion to waitlisting of 414 days and Lee et al noted a median time from dialysis start to transplant evaluation of 24.6 months for PLWH and from evaluation completion to waitlisting was 136, compared with time to listing of 96 days for HIV negative individuals (54,55).

While overall death on dialysis has decreased and reached an all-time low of 18% in 2018 (3), the percentage of those who died in our study was higher than the national average. Interestingly, there were no significant differences in death rates among PLWH and HIV negative individuals. It has been previously reported that PLWH experience a higher rate of death on dialysis compared with HIV negative patients (11,58) though more recent studies have failed to show a significant mortality rate between PLWH and HIV negative dialysis patients (12,59). The etiology of death is unable to be established in this study; whether related to HIV related factors or other co-morbidities, but underscores the high mortality rate for receiving dialysis as the median time to death was less than 2 years after dialysis start.

Factors associated with time to referral and waitlisting

It is recognized that determination of transplant candidacy is a complex and difficult process involving patient characteristics, dialysis as well as transplant center

factors. In this study, increasing age, BMI ≥ 35, being started on hemodialysis, cardiovascular related comorbidities, HIVAN, non-private insurance, being from a non-suburban neighborhood and being at a for-profit dialysis facility were associated with lower referral to kidney transplantation. Though there is no absolute age contraindication to transplantation, persons over the age of 65 are often placed on the deceased donor waiting list (60). Additionally, many institutions do not perform transplantations in morbidly obesity patients (BMI ≥ 35 kg/m_2). It is also not surprising that compared to those started on peritoneal dialysis, hemodialysis patients are less likely to be referred to transplant. Those who are started on peritoneal dialysis are often highly motivated and compliant, signifying that they are likely to be good transplant candidates (61). It was observed that HIVAN was associated with a lower probability of referral, though HIV positive serostatus was not. This could be secondary to HIVAN being a part of the classification of HIV positivity. Additionally, it is possible that the study lacks the power to detect a significance given the trend towards HIV serostatus being associated with a lower referral to transplantation.

One interesting finding is that non-white race and Hispanic ethnicity was associated with a higher probability of referral despite multiple prior studies demonstrating a disparity in access to transplantation in these patient populations. This could be in part due to disparities prior to dialysis start. It was published that in Georgia, compared to blacks, white patients are more likely to be preemptively referred to transplant, thus leaving a predominately black population being started on dialysis (33). These finding stress the need to address disparities that not only occur post-referral, but also prior to start of dialysis.

For profit facilities in this study was associated with a lower probability of being referred. Gander et al recently reported that receiving dialysis at a for-profit facility compared with a nonprofit facility was associated with a lower likelihood of being placed on the deceased donor waiting list and receiving either a deceased donor or living donor kidney transplant (62). It is possible that the observed decreased access to kidney transplantation stems from decreased referrals among for-profit dialysis facilities.

Similar factors were noted as barriers to waitlisting, though factors that seem to pertain more to dialysis facilities such as profit status, type of dialysis facility, size of dialysis facility and number of social workers on staff have less impact on waitlisting, as transplant centers are making the decision on whether or not to list an individual. This could in part explain why HIV positive serostatus was strongly associated with lower probability of waitlisting, though HIV associated nephropathy was not. At the transplant center level, the management of HIV disease is more important that the cause of ESRD. While for referral, diagnosis of HIV associated nephropathy could be a marker for those with more progressive disease, consequently, they are not considered for referral.

Additionally, we see more of an impact on markers of SES such as non-private insurance and coming from a zip that is ≥20% below poverty the poverty level. Part of the transplant evaluation is the consideration of potential candidates having the financial resources to support coverage of the transplant surgery and hospitalization, medications, labs, and medical visits (63). The impact of low SES is greatest among poor blacks. A study found that neighborhood poverty increased, the likelihood of being placed on the waiting list decreased for blacks compared with whites in each poverty

category, and in the poorest neighborhoods, blacks were 57% less likely to be waitlisted than whites (51).

This study noted that being from a non-suburban neighborhood was associated with a lower probability of referral and waitlisting. This was a surprising finding as it has been reported in the literature that urban residents compared with rural residents have improved access to transplantation. Axelrod et al published that compared with urban residents, waitlisting for kidney transplant was lower for residents from rural or small towns (RR = 0.92; 95% CI, 0.90-0.95; P<0.001) and these residents were also less likely to receive a kidney transplant (covariate-adjusted RR = 0.90; 95% CI, 0.88-0.93; P<0.001) (64). Though in ESRD Network 6, distance to a transplant center is not associated with referral or evaluation for kidney transplant (65).

Sensitivity Analysis

In comparing those who are preemptive referred or waitlisted, the collective data implied that these patients are generally healthier, more compliant, have more access to care and are of higher SES. Additionally, in comparing those with a Medicare prescription claim to those who did not, the data suggests that those with a Medicare prescription claim had more access to medical care.

Limitations

The conclusions of our study this limited by a few considerations. First, prescription data only captured those who had a Medicare part D claim for an antiretroviral medication, therefore the HIV-ESRD population is likely underestimated. It

is conceivable that PLWH who have private insurance or did not fill any HIV medications during the study period were misclassified as being HIV negative. In 2016, approximately 81.1% of hemodialysis patients were enrolled in Medicare Part D so it is possible that the majority of the HIV-ESRD population was captured (37). Also, for ease of analytic purposes, this study focused on incident ESRD patients and not prevalent ESRD patients, thus does not encapsulate all of the HIV-ESRD population in Network 6.

The dataset also does not capture HIV-specific clinical information such as CD4 count and HIV viral load, thus it is unknown if referral and waitlisting was impacted by PLWH not meeting the minimal criteria of kidney transplantation (CD4 count >200 and undetectable HIV viral load for > 6 months). Moreover, patient behaviors such as compliance, substance use, or overall social support cannot be assessed. Additionally, medications used for treatment of HIV, such as tenofovir and emtricitabine, are also used for other purposes such as pre-exposure prophylaxis (PREP) for HIV or medical conditions such as treatment of hepatitis B. Because of this, patients taking medications for those purposes may be misclassified as being HIV positive, though this is felt to be highly unlikely given the poor uptake of PREP in the southeast (66) and with tenofovir requiring renal adjustments, it is rarely used for hepatitis patients with ESRD. Lastly, given that this study focused on ESRD Network 6, the generalizability of the findings of this study is limited.

CONCLUSIONS

This pilot study is the first region-level description of PLWH proceeding through the early steps of transplantation. This study illustrated that HIV-ESRD population is predominately young, black males. PLWH and HIV negative individuals are referred and evaluated for kidney transplantation at similar proportions, though PLWH are less likely to achieve waitlisting on the deceased donor organ waiting list. Though the process to transplantation is complex, it was identified that HIV serostatus, BMI ≥ 35 (kg/m2), cardiovascular related co-morbidities, lack of nephrology care prior to dialysis start, poverty, being from a non-suburban neighborhood, and limited full-time social work staff members were barriers to either referral or waitlisting. Barriers specific to the HIV population need to be further elucidated with HIV specific clinical and laboratory data as well as patient behaviors in future studies. Interventions in improving access to kidney transplantation are not only needed at a dialysis facility level, but should also target minimizing patient dropout between transplant evaluation and waitlisting.

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TABLES AND FIGURES

Table 1. Baseline Demographics of PLWH and HIV Negative Persons in ESRD Network 6: 2012 - 2016				
	Entire Cohort (%)	**HIV + (%)**	**HIV – (%)**	***P*-value[a]**
Total Number of Patients	30,221	571 (2)	29,650 (98)	
Age (IQR)	58 (48 - 64)	49 (40 - 56)	58 (48 - 64)	**<0.001**
Sex				
Male	17,006 (56)	396 (69)	16,610 (56)	**<0.001**
Female	13,215 (44)	175 (31)	13,040 (44)	
Race/Ethnicity				
White	12,208 (40)	71 (12)	12,137 (41)	**<0.001**
Black	17,420 (58)	499 (87)	16,921 (57)	
Other	593 (2)	1 (0.2)	592 (2)	
Hispanic	940 (3)	8 (1)	932 (3)	0.058
Primary cause of ESRD[b]				
Diabetic Nephropathy	13,966 (46)	80 (14)	13,886 (47)	**<0.001**
Glomerulopathy	2,096 (7)	33 (6)	2,063 (7)	
Hypertensive Nephrosclerosis	2,664 (9)	24 (4)	2,640 (9)	
HIV Associated Nephropathy	313 (55)	313 (55)	-	
Other	11,182 (37)	121 (21)	11,061 (37)	
Facility % of Incident Patient Clinical and Laboratory Measures				
BMI ≥ 35 (kg/m2)(IQR)	8,416 (28)	65 (11)	8,351 (28)	**<0.001**
Received Pre-ESRD care[c]				
Yes	18,194 (60)	264 (46)	17,930 (60)	**<0.001**
No	8,355 (28)	228 (40)	8,127 (27)	
Unknown	3,670 (12)	79 (14)	3,591 (12)	
Mode of dialysis[c]				
Hemodialysis	27,460 (91)	531 (93)	26,929 (91)	0.196
Peritoneal Dialysis	2,742 (9)	40 (7)	2,2702 (9)	
Co-Morbid Conditions[c]				
Hypertension	26,800 (89)	471 (82)	26,329 (89)	**<0.001**

Congestive Heart Failure	7,992 (26)	75 (13)	7,917 (27)	**<0.001**
Atherosclerotic Heart Disease	2,554 (8)	20 (4)	2,534 (9)	**0.001**
Cerebrovascular Disease	2,694 (9)	24 (4)	2,670 (9)	**0.003**
Peripheral Vascular Disease	2,514 (8)	21 (4)	2,040 (8)	**<0.001**
Chronic obstructive pulmonary disease	2,521 (8)	25 (4)	2,496 (8)	**0.005**
Cancer	1,565 (5)	10 (2)	1,555 (5)	**0.002**
Tobacco use	3,253 (11)	98 (17)	3,155 (11)	**<0.001**
Diabetes				
On Insulin	16,608 (55)	106 (19)	13,503 (46)	**<0.001**
On oral medications	2,893 (10)	24 (4)	2,869 (10)	**<0.001**
Without medications	1,941 (6)	27 (5)	1,914 (6)	**<0.001**
Other Cardiovascular Disease	4,827 (16)	52 (9)	4,775 (16)	**<0.001**
Patient incident year, No. of incident patients, median (IQR)				
Year of Incident ESRD				
2012	6,034 (20)	144 (25)	5,890 (20)	**0.010**
2013	6,042 (20)	111 (19)	5,931 (20)	
2014	5,927 (20)	118 (21)	5,809 (20)	
2015	6,104 (20)	101 (18)	6,017 (20)	
2016	6,114 (20)	97 (17)	6,017 (20)	
Facility % of Incident Patient Socioeconomic Characteristics				
Primary Health Insurance Provider				
Medicare	15,182 (50)	259 (45)	14,923 (50)	**0.019**
Medicaid	8,307 (27)	267 (47)	8,040 (27)	**<0.001**
Private	5,985 (20)	74 (13)	5,911 (20)	**<0.001**
Other Insurance	3,254 (11)	16 (3)	3,238 (11)	**<0.001**
No insurance	4,036 (13)	102 (18)	3,934 (13)	**0.001**
Neighborhood poverty (% of zip code residents below poverty)				
0%-19.9% below poverty	20,264 (67)	312 (55)	19,952 (67)	**<0.001**
≥20% below poverty	9,957 (33)	259 (45)	9,698 (32)	
Median % Black (IQR)	32 (16 - 51)	42 (23 - 66)	32 (16 - 51)	**<0.001**
Median % High School Graduates (IQR)	83 (78 - 88)	83 (78 - 89)	82 (78 - 88)	0.391
Zip code Type[d]				
Urban	4,991 (17)	161 (29)	4,830 (17)	**<0.001**
Suburban	5,547 (19)	131 (23)	5,416 (19)	
Rural	19,016 (64)	271 (48)	18,745 (64)	
Dialysis Facility Characteristics, No. (%)				

Profit status[e]				
For-Profit	25,769 (85)	460 (81)	25,309 (85)	**0.006**
Non-profit	4,404 (15)	110 (19)	4,294 (15)	
Type of Facility[e]				
Free-standing	29,199 (97)	549 (96)	28,650 (97)	0.540
Hospital-based	976 (3)	21 (4)	955 (3)	
Facility size (No. of patients)[e]				
≤ 25	1,179 (4)	18 (3)	1,161 (4)	**0.011**
25-54	5,410 (18)	74 (13)	5,336 (18)	
55-75	6,452 (21)	129 (23)	6,323 (21)	
> 75	17,180 (57)	350 (61)	16,830 (57)	
Social work on full time staff[f]				
0	8, 794 (29)	130 (23)	8,664 (29)	**<0.001**
1	18,727 (62)	348 (61)	18,379 (62)	
2	2,272 (7)	67 (12)	2,205 (7)	
3	129 (0.5)	5 (1)	124 (0.5)	
4	283 (1)	20 (4)	263 (1)	

Abbreviations: BMI: Body Mass Index; ESRD: End-Stage Renal Disease; IQR: Interquartile range; PLWH: Persons living with HIV

[a] P-Values compare PLWH and HIV negative persons.

[b] 8 patients (0.03%) were missing information on primary cause of ESRD.

[c] 6 patients (0.02%) were missing information on Pre-ESRD care; 7 (0.02%) patients were missing information on Mode of dialysis; 4 patients (0.01%) were missing information on Co-morbid conditions.

[d] 407 patients (1.3%) were missing information on Zip code type.

[e] 46 patients (0.2%) were missing information on Profit status; 46 patients (0.2%) were missing information on Type of facility; 52 patients (0.2%) were missing information on Social work staff.

[f] Total number of patients in a facility was obtained from year 2016.

Table 2. Proportions of Referral, Evaluation, Waitlisting and Death in ESRD Network 6: 2012 - 2016

	Entire Cohort (%)	HIV + (%)	HIV – (%)	*P*-value[a]
Total number of patients	30,221	571 (2)	29,650 (98)	
Patient informed of transplant options[b]				
Yes	26,682 (88)	490 (85)	26,192 (88)	**0.049**
Referred to transplant	13,639 (45)	258 (45)	13,381 (45)	0.980
Transplant evaluation initiated	8,049 (26)	143 (25)	7,906 (27)	0.386
Waitlisted[c]	4,589 (15)	56 (10)	4,533 (15)	**0.003**
Median time to referral (in days, IQR)[d]	240 (88 - 634)	331 (118 - 763)	234 (87 - 631)	**0.004**
Median time to evaluation (in days, IQR)[d]	422 (173 - 917)	533 (219 - 1,044)	420 (172 - 912)	**<0.001**
Median time to waitlisting (in days, IQR)[d]	543 (245 - 1,006)	671 (311 - 1,137)	542 (244 - 1,004)	**0.014**
Total died during study period	12,425 (41)	235 (41)	12,190 (41)	0.984
Median time to death (in days, IQR)	590 (229 - 1,069)	571 (293 - 1,046)	591 (227 - 1,069)	0.806

Abbreviations: ESRD: End-Stage Renal Disease; IQR: Interquartile range;
[a] P-Values compare PLWH and HIV negative persons.
[b] 45 patients (0.15%) were missing information on Patient informed of transplant options.
[c] Denominator used for waitlisting was all ESRD patients.
[d] Those who died prior referral, evaluation, or waitlisting were not included in median time calculation.

Table 3. Univariable cox regression model for the relationship between demographic and clinical variables with time to referral and waitlisting: 2012 - 2016[a]

Variable	Time to Referral		Time to Waitlisting	
	HR (95% CI)	*P*-Value	HR (95% CI)	*P*-Value
Patient Related Characteristics				
HIV status				
HIV -	Ref		Ref	
HIV +	0.91 (0.81 - 1.02)	0.105	0.46 (0.32 - 0.63)	**<0.001**
Age	0.97 (0.97 - 0.98)	**<0.001**	0.96 (0.95 - 0.96)	**<0.001**
Sex				
Female	Ref		Ref	
Male	1.12 (1.09 - 1.16)	**<0.001**	1.23 (1.15 - 1.31)	**<0.001**
Race				
White	Ref		Ref	
Black	1.35 (1.30 - 1.40)	**<0.001**	1.14 (1.06 -1.22)	**0.002**
Other	1.45 (1.29 - 1.63)	**<0.001**	1.90 (1.67 - 2.33)	**<0.001**
Hispanic	1.13 (1.03 - 1.24)	**0.008**	1.86 (1.61 - 2.16)	**<0.001**
Primary cause of ESRD				
Diabetic Nephropathy	Ref		Ref	
Hypertensive Nephrosclerosis	1.15 (1.07 - 1.23)	**0.003**	0.95 (0.76 - 1.18)	0.647
Glomerulopathy	1.17 (1.10 - 1.25)	**<0.001**	2.40 (2.15 - 2.68)	**<0.001**
HIV Associated Nephropathy	0.89 (0.75 - 1.05)	0.155	0.52 (0.32 – 0.85)	**0.009**
Other	1.06 (1.02 - 1.10)	**0.002**	1.45 (1.35 - 1.56)	**<0.001**
BMI ≥ 35 (kg/m2)	0.96 (0.93 - 1.00)	**0.049**	0.58 (0.54 - 0.63)	**<0.001**
Received Pre-ESRD care[b]				
No	Ref		Ref	
Yes	1.09 (1.05 - 1.14)	**<0.001**	1.09 (1.02 - 1.18)	**0.018**
Mode of dialysis				
Peritoneal Dialysis	Ref		Ref	
Hemodialysis	0.63 (0.59 - 0.67)	**<0.001**	0.35 (0.32 - 0.38)	**<0.001**
Comorbid Conditions				
Hypertension	1.22 (1.15 - 1.29)	**<0.001**	1.16 (1.04 - 1.29)	**0.010**
Congestive Heart Failure	0.76 (0.73 - 0.79)	**<0.001**	0.39 (0.35 - 0.43)	**<0.001**
Atherosclerotic Heart Disease	0.71 (0.66 - 0.76)	**<0.001**	0.50 (0.38 - 0.53)	**<0.001**
Cerebrovascular Disease	0.65 (0.61 - 0.70)	**<0.001**	0.40 (0.34 - 0.48)	**<0.001**
Peripheral Vascular Disease	0.66 (0.62 - 0.71)	**<0.001**	0.36 (0.30 - 0.43)	**<0.001**
Chronic obstructive pulmonary disease	0.55 (0.51 - 0.59)	**<0.001**	0.13 (0.09 - 0.17)	**<0.001**
Cancer	0.48 (0.44 - 0.53)	**<0.001**	0.38 (0.31 - 0.48)	**<0.001**
Tobacco use	0.81 (0.76 - 0.86)	**<0.001**	0.37 (0.32 - 0.44)	**<0.001**
Diabetes				
On Insulin	0.88 (0.5 - 0.91)	**<0.001**	0.65 (0.60 - 0.69)	**<0.001**
On oral medications	1.01 (0.96 - 1.07)	0.629	0.83 (0.72 - 0.96)	0.053
Without medications	0.95 (0.88 - 1.01)	0.116	0.93 (0.80 - 1.08)	0.116

Patient Socioeconomic Characteristics				
Primary Health Insurance Provider				
Medicaid	0.82 (0.79 - 0.85)	**<0.001**	0.48 (0.44 - 0.53)	**<0.001**
Medicare	0.68 (0.66 - 070)	**<0.001**	0.43 (0.40 - 0.46)	**<0.001**
Employer	1.52 (1.46 - 1.59)	**<0.001**	2.67 (2.49 - 2.86)	**<0.001**
No insurance	1.26 (1.20 - 1.31)	**<0.001**	1.41 (1.29 - 1.53)	**<0.001**
Other Insurance	0.99 (0.94 - 1.05)	0.118	1.09 (0.98 - 1.21)	0.129
Zip code Type				
Suburban	Ref		Ref	
Urban	0.81 (0.77 - 0.86)	**<0.001**	0.67 (0.60 - 0.74)	**<0.001**
Rural	0.79 (0.76 - 0.83)	**<0.001**	0.63 (0.58 - 0.68)	0.192
Neighborhood poverty (% of zip code residents below poverty)				
0%-19.9% below poverty	Ref		Ref	
≥20% below poverty	0.97 (0.94 - 1.00)	0.097	0.73 (0.68 - 0.79)	**<0.001**
Dialysis Facility Characteristics				
Profit status				
Non-profit	Ref		Ref	
For-profit	1.08 (1.03 - 1.13)	**0.003**	1.03 (0.94 - 1.13)	0.573
Type of Facility				
Hospital-Based	Ref		Ref	
Free-standing	1.85 (1.65 - 2.08)	**<0.001**	0.94 (0.79 - 1.13)	0.517
Facility size (No. of patients)				
≤ 25	Ref		Ref	
25-54	1.04 (0.94 - 1.14)	0.477	0.88 (0.74 - 1.04)	0.128
55-75	1.07 (0.98 - 1.18)	0.151	0.77 (0.65 - 0.92)	**0.003**
> 75	1.06 (0.97 - 1.16)	0.211	0.85 (0.72 - 0.99)	**0.041**
Social work on full time staff b				
0	Ref		Ref	
1	0.97 (0.93 - 1.01)	0.109	0.96 (0.89 - 1.04)	0.321
2	1.08 (1.005 - 1.15)	**0.035**	1.04 (0.92 - 1.19)	0.528
3	1.35 (1.10 - 1.65)	**0.003**	1.30 (0.86 - 1.95)	0.212
4	1.79 (1.50 - 2.15)	**<0.001**	2.2 (1.67 - 2.90)	**<0.001**

Abbreviations: BMI: Body Mass Index; ESRD: End-Stage Renal Disease; IQR: Interquartile range

[a] P-Values compare PLWH and HIV negative persons.

[b] 471 patients were excluded from the analysis secondary to missing or invalid data.

Table 4. Adjusted cox regression model for the relationship between demographic and clinical variables with time to referral and waitlisting: 2012 - 2016[a]

	Time to Referral		Time to Waitlisting	
Variable	**Adjusted HR (95% CI)**	***P*-Value**[b]	**Adjusted HR (95% CI)**	***P*-Value**[b]
HIV status				
HIV -	Ref		Ref	
HIV +	0.86 (0.73 - 1.02)	0.086	0.47 (0.29 - 0.75)	0.002
Age	0.98 (0.97 - 0.98)	**<0.001**	0.96 (0.96 - 0.96)	**<0.001**
Sex				
Female	Ref		Ref	
Male	1.09 (1.05 - 1.13)	**<0.001**	1.9 (1.01 - 1.17)	**0.019**
Race				
White	Ref		Ref	
Black	1.27 (1.21 - 1.33)	**<0.001**	1.08 (0.99 -1.17)	**0.083**
Other	1.24 (1.21 - 1.40)	**<0.001**	1.30 (1.07 - 1.60)	**0.009**
Hispanic	1.07 (0.97 - 1.2)	0.172	1.25 (1.07 - 1.48)	**0.007**
Primary cause of ESRD				
Diabetic Nephropathy	Ref		Ref	
Hypertensive Nephrosclerosis	1.02 (0.95 - 1.11)	0.563	0.79 (0.63 - 0.99)	**0.049**
Glomerulopathy	0.92 (0.85 - 1.02)	0.131	1.43 (1.26 - 1.64)	**<0.001**
HIV Associated Nephropathy	0.66 (0.52 - 0.84)	**0.001**	0.52 (0.26 – 1.03)	0.06
Other	0.94 (0.89 - 0.98)	**0.004**	1.07 (0.98 - 1.18)	0.154
BMI ≥ 35 (kg/m2)	0.92 (0.89 - 0.96)	**<0.001**	0.54 (0.49 - 0.59)	**<0.001**
Received Pre-ESRD care				
No	Ref		Ref	
Yes	1.19 (1.14 - 1.24)	**<0.001**	1.23 (1.14 - 1.33)	**<0.001**
Unknown	1.05 (0.99 - 1.12)	0.129	1.00 (0.88 - 1.13)	0.950
Mode of dialysis				
Peritoneal Dialysis	Ref		Ref	
Hemodialysis	0.76 (0.72 - 0.80)	**<0.001**	0.54 (0.49 - 0.59	**<0.001**
Comorbid Conditions				
Hypertension	1.20 (1.13 - 1.27)	**<0.001**	1.24 (1.11 - 1.40)	**0.003**
Congestive Heart Failure	0.90 (0.86 - 0.94)	**<0.001**	0.62 (0.56 - 0.69)	**<0.001**
Atherosclerotic Heart Disease	0.96 (0.89 - 1.028)	0.230	0.90 (0.76 - 1.07)	0.232
Cerebrovascular Disease	0.78 (0.72 - 0.83)	**<0.001**	0.65 (0.55 - 0.77)	**<0.001**
Peripheral Vascular Disease	0.85 (0.78 - 0.91)	**<0.001**	0.69 (0.57 - 0.83)	**0.001**
Chronic obstructive pulmonary disease	0.78 (0.72 - 0.85)	**<0.001**	0.29 (0.21 - 0.39)	**<0.001**
Cancer	0.57 (0.51 - 0.63)	**<0.001**	0.48 (0.38 - 0.60)	**<0.001**
Tobacco use	0.87 (0.82 - 0.93)	**<0.001**	0.42 (0.36 - 0.60)	**<0.001**
Diabetes				
On Insulin	0.94 (0.90 - 0.99)	**0.009**	0.89 (0.81 - 0.98)	**0.014**
On oral medications	1.02 (0.96 - 1.09)	0.417	1.01 (0.89 - 1.15)	0.849
Without medications	0.96 (0.89 - 1.34)	0.265	0.93 (0.80 - 1.08)	0.349
Primary Health Insurance Provider				
Medicaid	0.86 (0.81 - 0.91)	**<0.001**	0.63 (0.56 - 0.71)	**<0.001**
Medicare	0.96 (0.91 - 1.00)	**0.048**	0.85 (0.77 - 0.94)	**0.009**
Employer	1.32 (1.25 - 1.40)	**<0.001**	1.81 (1.61 - 2.03)	**<0.001**
No insurance	0.99 (0.92 - 1.05)	0.994	0.93 (0.81 - 1.06)	**<0.001**

Other Insurance	1.10 (1.03 - 1.18)	**0.001**	1.35 (1.18 - 1.54)	**<0.001**
Zip code Type				
Suburban	Ref		Ref	
Urban	0.82 (0.77 - 0.87)	**<0.001**	0.79 (0.71 - 0.88)	**<0.001**
Rural	0.92 (0.87 - 0.96)	**0.004**	0.85 (0.77 - 0.93)	**0.004**
Neighborhood poverty (% of zip code residents below poverty)				
0%-19.9% below poverty	Ref		Ref	
≥20% below poverty	0.98 (0.94 - 1.03)	0.518	0.87 (0.79 - 0.97)	**0.008**
Median % Black (IQR)	1.001 (1.00 - 1.002)	**0.006**	0.999 (0.998 - 1.001)	0.562
Median % High School Graduates (IQR)	1.005 (1.002 - 1.008)	**0.001**	1.01 (1.01 - 1.02)	**0.002**
Profit status				
Non-profit	Ref		Ref	
For-profit	0.93 (0.87 - 0.98)	**0.011**	0.98 (0.87 - 1.10)	0.672
Type of Facility				
Free-standing	Ref		Ref	
Hospital-Based	1.90 (1.67 - 2.18)	**<0.001**	0.82 (0.65 - 1.02	0.071
Facility size (No. of patients)				
≤ 25	Ref		Ref	
25-54	1.06 (0.95 - 1.17)	0.293	1.03 (0.86 - 1.24)	0.737
55-78	1.08 (0.98 - 1.20)	0.115	0.99 (0.82 - 1.18)	0.883
> 75	0.99 (0.90 - 1.09)	0.848	0.94 (0.79 - 1.12)	0.508
Social work on full time staff b				
0	Ref		Ref	
1	0.96 (0.92 - 1.002)	0.062	0.91 (0.83 - 0.99)	**0.024**
2	1.09 (1.01 - 1.18)	**0.022**	0.91 (0.79 - 1.06)	0.221
3	1.15 (0.91 - 1.45)	0.238	0.89 (0.56 - 1.41)	0.613
4	1.39 (1.15 - 1.69)	**0.009**	1.26 (0.92 - 1.73)	0.157

Abbreviations: BMI: Body Mass Index; ESRD: End-Stage Renal Disease; IQR: Interquartile range;
[a] P-Values compare PLWH and HIV negative persons.
[b] 471 patients were excluded from the analysis secondary to missing or invalid data.

Figure 2. Study cohort flowchart for incident patients with ESRD in ESRD Network 6: 2012-2016

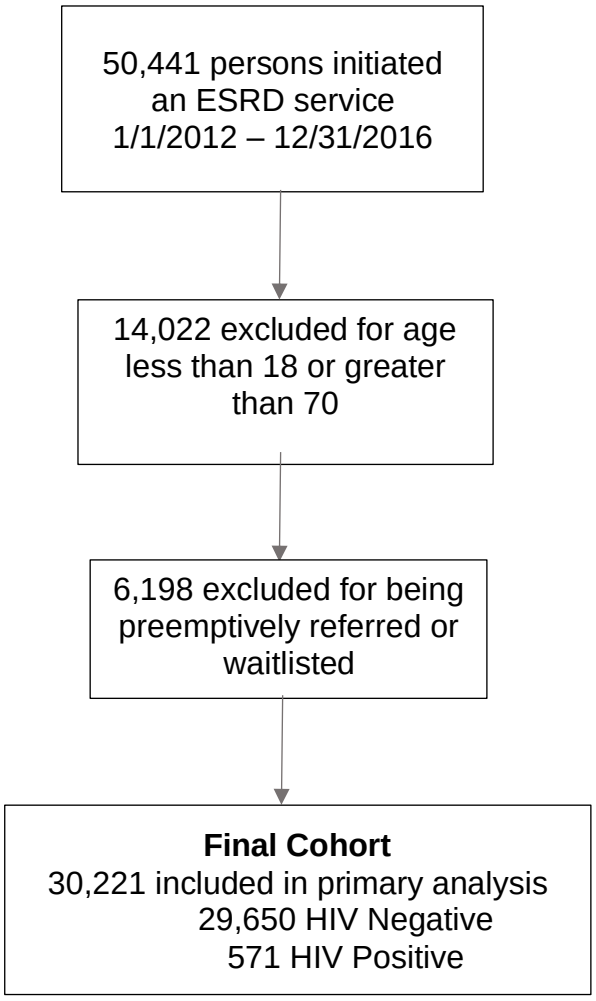
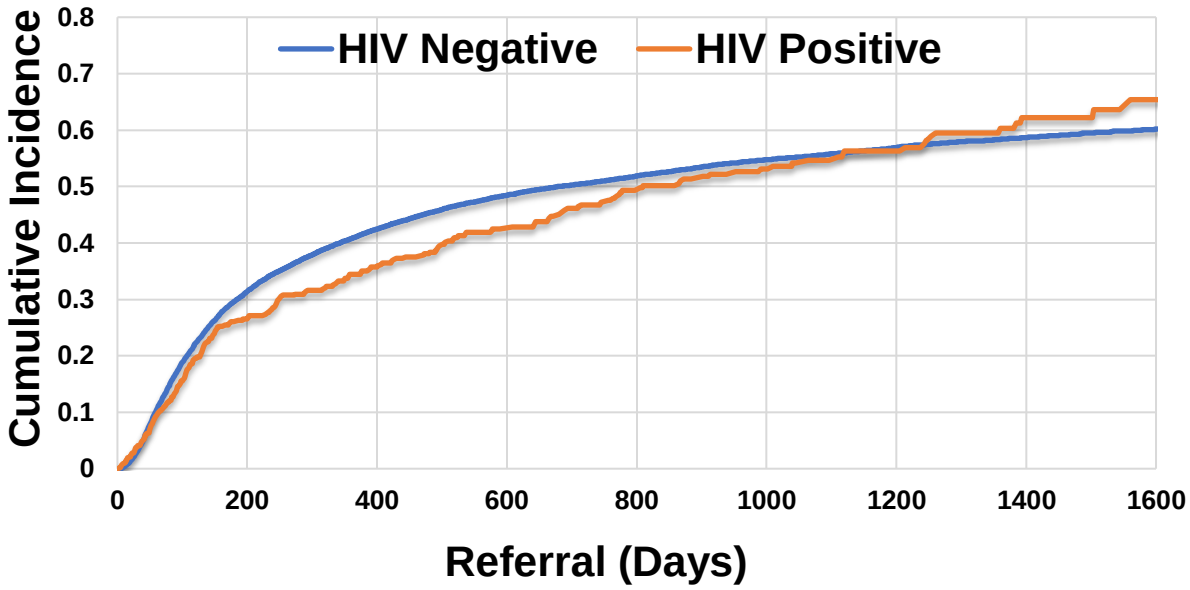


Figure 3. Cumulative Incidence Function of Time to Referral from Dialysis Start: 2012 - 2016



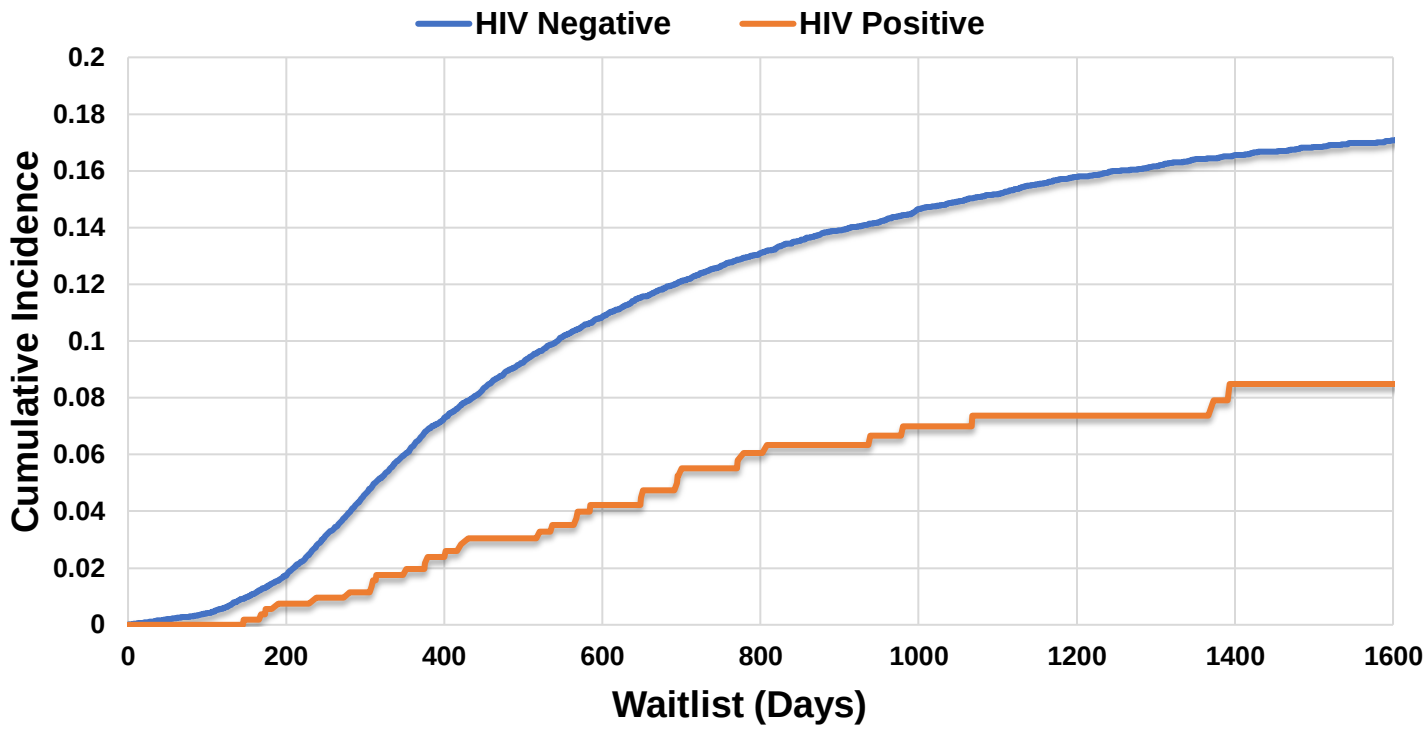
HIV Negative

Cumulative Incidence Estimate at 365 days: 0.41 95% CI (0.405 - 0.412)

HIV Positive

Cumulative Incidence Estimate at 365 days: 0.34 95% CI (0.303 - 0.386)

Figure 4. Cumulative Incidence Function of Time to Waitlisting from Dialysis Start: 2012 - 2016



HIV Negative

Cumulative Incidence Estimate at 730 days: (0.120 - 0.128)

HIV Positive

Cumulative Incidence Estimate at 730 days: 0.06 (0.036 - 0.079)

Supplementary Table 1. List of generic and brand-named antiretroviral medications		
Generic Name	**Brand Name**	**Combination antiretrovirals**
Enfuvirtide	Fuzeon	Triumeq
Maraviroc	Selzentry	Juluca
Ritonavir	Norvir	Stribilid
Cobicistat	Symtuza	Genvoya
Raltegravir	Isentress	Atripla
Dolutegravir	Tivicay	Complera
Elvitegravir	Vitekta	Odefsey
Emtricitabine	Emtriva	Biktarvy
Lamivudine	Epivir	Epzicom
Zidovudine	Retrovir	Trizivir
Didanosine	Videx	Combivir
Tenofovir	Viread	Truvada
Stavudine	Zerit	Prezcobix
Abacavir	Ziagen	Evotaz
Rilpivirine	Edurant	
Etravirine	Intelence	
Delavirdine	Rescriptor	
Efavirenz	Sustiva	
Nevirapine	Viramune	
Tipranavir	Aptivus	
Indinavir	Crixivan	
Saquinavir	Invirase	
Lopinavir	Kaletra	
Fosamprenavir	Lexiva	
Darunavir	Prezista	
Atazanavir	Reyataz	
Nelfinavir	Viracept	
Bictegravir		
Ibalizumab		
Tybost		

Supplementary Table 2. Baseline Demographics of PLHW and HIV Negative Persons in ESRD Network 6 who Medicare claims: 2012 - 2016				
	Entire Cohort (%)	**With Medicare Claim (%)**	**Without Medicare Claim (%)**	***P*-value**
Total Number of Patients	30,221	23,422 (78)	6,799 (22)	
Age (IQR)	58 (48 - 64)	57 (48 - 64)	59 (50 - 65)	**<0.001**
Sex				
Male	17,006 (56)	13,401 (57)	3,605 (53)	**<0.001**
Female	13,215 (44)	10,021 (43)	3,194 (47)	
Race/Ethnicity				
White	12,208 (40)	9,605 (41)	2,603 (38)	**0.003**
Black	17,420 (58)	13, 362 (57)	4,058 (60)	
Other	593 (2)	455 (2)	138 (2)	
Hispanic	940 (3)	716 (3)	224 (3)	0.457
Primary cause of ESRD[a]				
Diabetic Nephropathy	13,966 (46)	10,748 (46)	3,218 (47)	**<0.001**
Glomerulopathy	2,096 (7)	1,686 (7)	410 (6)	
Hypertensive Nephrosclerosis	2,664 (9)	1,990 (9)	674 (10)	
HIV Associated Nephropathy	313 (1)	243 (1)	70 (1)	
Other	11,182 (37)	8,755 (38)	2,427 (36)	
Facility % of Incident Patient Clinical and Laboratory Measures				
BMI ≥ 35 (kg/m2)(IQR)	8,416 (28)	6,541 (28)	1,875 (28)	0.572
Received Pre-ESRD care[b]				
Yes	18,194 (60)	14,219 (61)	3,975 (58)	**0.002**
No	8,355 (28)	6,446 (28)	1,909 (28)	
Unknown	3,670 (12)	2,755 (12)	915 (13)	
Mode of dialysis				
Hemodialysis	27,460 (91)	21,102 (90)	6,358 (94)	**<0.001**
Peritoneal Dialysis	2,742 (9)	2,308 (10)	434 (6)	
Co-Morbid Conditions[c]				
Hypertension	26,800 (89)	20,887 (89)	5,913 (87)	**<0.001**
Congestive Heart Failure	7,992 (26)	5,992 (26)	2,000 (29)	**<0.001**
Atherosclerotic Heart Disease	2,554 (8)	1,946 (8)	608 (9)	0.098
Cerebrovascular Disease (stroke)	2,694 (9)	2,039 (9)	655 (10)	**0.018**
Peripheral Vascular Disease	2,514 (8)	1,884 (8)	630 (9)	**0.001**
Chronic obstructive pulmonary disease	2,521 (8)	1,846 (8)	675 (10)	**<0.001**

Cancer	1,565 (5)	1,565 (5)	430 (6)	**<0.001**
Tobacco use	3,253 (11)	2,444 (10)	809 (12)	**0.006**
Diabetes				
On Insulin	16,608 (55)	10,405 (44)	3,204 (47)	**<0.001**
On oral medications	2,893 (10)	2,256 (10)	637 (9)	0.517
Without medications	1,941 (6)	1,493 (6)	448 (7)	0.524
Other Cardiovascular Disease	4,827 (16)	3,625 (15)	1,202 (18)	**<0.001**
Patient incident year, No. of incident patients, median (IQR)				
Year of Incident ESRD				
2012	6,034 (20)	4,953 (21)	1,081 (16)	**<0.001**
2013	6,042 (20)	4,872 (21)	1,170 (17)	
2014	5,927 (20)	4,566 (19)	1,361 (20)	
2015	6,104 (20)	4,596 (20)	1,508 (22)	
2016	6,114 (20)	4,435 (19)	1,697 (25)	
Facility % of Incident Patient Socioeconomic Characteristics				
Primary Health Insurance Provider				
Medicare	15,182 (50)	12,052 (51)	3,3130 (46)	**<0.001**
Medicaid	8,307 (27)	6,130 (26)	2,177 (32)	**<0.001**
Private	5,985 (20)	5,102 (22)	883 (13)	**<0.001**
Other Insurance	3,254 (11)	2,575 (11)	679 (10)	**0.018**
No insurance	4,036 (13)	3,384 (14)	652 (10)	**<0.001**
Neighborhood poverty (% of zip code residents below poverty)				
0%-19.9% below poverty	20,264 (67)	15,862 (68)	4,402 (65)	**<0.001**
≥20% below poverty	9,957 (33)	7,560 (32)	2,397 (35)	
Median % Black (IQR)	32 (16 - 51)	33 (17 - 53)	32 (16 - 50)	**<0.001**
Median % High School Graduates (IQR)	83 (78 - 88)	83 (78 - 88)	82 (78 - 88)	**0.006**
Zip code Type[d]				
Urban	4,991 (17)	3,748 (16)	1,243 (18)	**<0.001**
Suburban	5,547 (19)	4,273 (19)	1,274 (19)	
Rural	19,016 (64)	14,869 (64)	4,417 (62)	
Dialysis Facility Characteristics, No. (%)				
Profit status[e]				
For-Profit	25,769 (85)	20,031 (86)	5,738 (84)	**0.021**
Non-profit	4,404 (15)	3,343 (14)	1,061 (16)	
Type of Facility				
Free-standing	29,199 (97)	22,585 (97)	6,614 (97)	**0.007**

Hospital-based	976 (3)	791 (3)	185 (3)	
Facility size (No. of patients)				
≤ 25	1,179 (4)	928 (4)	251 (4)	0.471
25-54	5,410 (18)	4,219 (18)	1,191 (18)	
55-75	6,452 (21)	4,971 (21)	1,481 (22)	
> 75	17,180 (57)	13,304 (57)	3,876 (57)	
Social work on full time staff[f]				
0	8, 794 (29)	6,881 (29)	1,913 (28)	0.055
1	18,727 (62)	14,427 (62)	4,300 (63)	
2	2,272 (7)	1,783 (8)	489 (7)	
3	129 (0.5)	124 (1)	36 (1)	
4	283 (1)	154 (1)	61 (1)	

Abbreviations: BMI: Body Mass Index; ESRD: End-Stage Renal Disease; IQR: Interquartile range; PLWH: Persons living with HIV

[a] P-Values compare PLWH and HIV negative persons.

[b] 8 patients (0.03%) were missing information on primary cause of ESRD.

[c] 6 patients (0.02%) were missing information on Pre-ESRD care; 7 (0.02%) patients were missing information on Mode of dialysis; 4 patients (0.01%) were missing information on Co-morbid conditions.

[d] 407 patients (1.3%) were missing information on Zip code type.

[e] 46 patients (0.2%) were missing information on Profit status; 46 patients (0.2%) were missing information on Type of facility; 52 patients (0.2%) were missing information on Social work staff.

[f] Total number of patients in a facility was obtained from year 2016.

Supplementary Table 3. Comparison of people who were preemptively referred and waitlisted to those who were not: 2012 - 2016				
	Entire Cohort (%)	**With Preemptive (%)**	**Without Preemptive (%)**	***P*-value**
Total Number of Patients	36,419	6,198 (17)	30,221 (83)	
Age (IQR)	57 (48 - 64)	55 (45 - 63)	58 (48 - 64)	**<0.001**
Sex				
Male	20,493 (56)	3,487 (56)	17,006 (56)	0.986
Female	15,926 (43)	2,711 (44)	13,215 (44)	
Race/Ethnicity				
White	15,250 (42)	3,042 (49)	12,208 (40)	**<0.001**
Black	20,400 (56)	2,980 (48)	17,420 (58)	
Other	769 (2)	176 (3)	593 (2)	
Hispanic	1,099 (3)	159 (3)	940 (3)	0.060
Primary cause of ESRD[a]				
Diabetic Nephropathy	16,417 (45)	2,451 (40)	13,966 (46)	**<0.001**
Glomerulopathy	2,947 (8)	851 (14)	2,096 (7)	
Hypertensive Nephrosclerosis	3,228 (9)	564 (9)	2,664 (9)	
HIV Associated Nephropathy	330 (1)	17 (0.27)	313 (1)	
Other	13,497 (37)	2,315 (37)	11,182 (37)	
Facility % of Incident Patient Clinical and Laboratory Measures				
BMI ≥ 35 (kg/m2)(IQR)	9,780 (27)	1,364 (22)	8,416 (28)	**<0.001**
Received Pre-ESRD care[b]				
Yes	23,637 (65)	5,5443 (88)	18,194 (60)	**<0.001**
No	8,9691 (24)	336 (5)	8,355 (28)	
Unknown	4,087 (11)	417 (7)	3,670 (12)	
Mode of dialysis				
Hemodialysis	31,180 (87)	3,720 (68)	27,460 (91)	**<0.001**
Peritoneal Dialysis	4,468 (13)	1,726 (32)	2,742 (9)	**<0.001**
Co-Morbid Conditions[c]				
Hypertension	32,380 (89)	5,580 (90)	26,800 (89)	**0.002**
Congestive Heart Failure	8,693 (24)	701 (11)	7,992 (26)	**<0.001**
Atherosclerotic Heart Disease	2,874 (8)	320 (5)	2,554 (9)	**<0.001**
Cerebrovascular Disease (stroke)	2,969 (8)	275 (4)	2,694 (9)	**<0.001**
Peripheral Vascular Disease	2,810 (8)	296 (5)	2,514 (8)	**<0.001**
Chronic obstructive pulmonary disease	2,694 (7)	173 (3)	2,521 (8)	**<0.001**
Cancer	1,764 (5)	199 (3)	1,565 (5)	**<0.001**
Tobacco use	3,541 (10)	288 (5)	3,253 (11)	**<0.001**
Diabetes				
On Insulin	15,899 (44)	2,290 (37)	13,609 (45)	**<0.001**
On oral medications	3,415 (9)	522 (8)	2,893 (10)	**0.005**
Without medications	2,297 (6)	356 (6)	1,941 (6)	**0.045**

Other Cardiovascular Disease	5,435 (15)	608 (10)	4,827 (16)	**<0.001**
Patient incident year, No. of incident patients, median (IQR)				
Year of Incident ESRD				
2012	6,827 (19)	793 (13)	6,034 (20)	**<0.001**
2013	7,152 (20)	1,110 (18)	6,042 (20)	
2014	7,186 (19)	1,259 (20)	5,927 (20)	
2015	7,582 (21)	1,478 (24)	6,104 (20)	
2016	7,672 (21)	1,558 (25)	6,114 (20)	
Facility % of Incident Patient Socioeconomic Characteristics				
Primary Health Insurance Provider				
Medicare	17,921 (49)	2,739 (44)	15,182 (50)	**<0.001**
Medicaid	9,323 (26)	1,016 (16)	8,307 (27)	**<0.001**
Private	8,827 (24)	2,842 (46)	5,985 (20)	**<0.001**
Other Insurance	4,170 (11)	916 (15)	3,254 (11)	**<0.001**
No insurance	4,206 (12)	170 (3)	4,036 (13)	**<0.001**
Neighborhood poverty (% of zip code residents below poverty)				
0%-19.9% below poverty	25,034 (68)	4,770 (77)	20,264 (67)	**<0.001**
≥20% below poverty	11,385 (31)	1,428 (23)	9,957 (33)	**<0.001**
Median % Black (IQR)	31 (15 - 50)	26 (13 - 45)	32 (16 - 51)	**<0.001**
Median % High School Graduates (IQR)	83 (78 - 89)	86 (80 - 91)	83 (78 - 88)	**<0.001**
Zip code Type[d]				
Urban	6,001 (17)	174 (29)	5,827 (16)	**<0.001**
Suburban	6,992 (19)	143 (23)	6,849 (19)	
Rural	22,636 (63)	291 (48)	22,345 (63)	
Dialysis Facility Characteristics, No. (%)				
Profit status[e]				
For-Profit	30,596 (84)	4,827 (78)	25,769 (85)	**<0.001**
Non-profit	5,728 (16)	1,324 (21)	4,404 (15)	
Type of Facility				
Free-standing	34,555 (95)	5,356 (87)	29,199 (97)	**<0.001**
Hospital-based	1,810 (5)	834 (13)	976 (3)	
Facility size (No. of patients)				
≤ 25	2,112 (6)	933 (15)	1,179 (4)	**<0.001**
25-54	6,331 (17)	921 (15)	5,410 (18)	
55-75	7,404 (20)	952 (15)	6,452 (21)	
> 75	20,572 (56)	3,392 (54)	17,180 (57)	
Social work on full time staff[f]				
0	10,888 (30)	2,094 (34)	8,794 (29)	**<0.001**
1	22,081 (61)	3,3354 (54)	18,727 (62)	
2	2,886 (8)	614 (10)	2,272 (8)	
3	209 (1)	49 (1)	160 (1)	
4	290 (1)	75 (1)	215 (1)	

Abbreviations: BMI: Body Mass Index; ESRD: End-Stage Renal Disease; IQR: Interquartile range; PLWH: Persons living with HIV
[a] P-Values compare PLWH and HIV negative persons.
[b] 8 patients (0.03%) were missing information on primary cause of ESRD.
[c] 6 patients (0.02%) were missing information on Pre-ESRD care; 7 (0.02%) patients were missing information on Mode of dialysis; 4 patients (0.01%) were missing information on Co-morbid conditions.
[d] 407 patients (1.3%) were missing information on Zip code type.
[e] 46 patients (0.2%) were missing information on Profit status; 46 patients (0.2%) were missing information on Type of facility; 52 patients (0.2%) were missing information on Social work staff.
[f] Total number of patients in a facility was obtained from year 2016.