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Survival Analysis of Infections in Dialysis Patients by Patient Characteristics and Modality

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ABSTRACT
SURVIVAL ANALYSIS OF INFECTIONS IN DIALYSIS PATIENTS BY PATIENT CHARACTERISTICS AND MODALITY
BY
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INTRODUCTION:
Although infections are a growing concern for patients undergoing dialysis (Karkar 2018), little current research has been done on the characteristics of dialysis patients who get an infection.

AIM:
The objective of this study is to investigate the patient characteristics associated with dialysis-related infections. Our secondary aim is to determine if these associations are modified by dialysis modality.

METHODS:
For this study, we linked data from the United States Renal Data System (USRDS) with Kaiser Permanente Georgia databases. To compare the covariates with the outcome variable of dialysis-related infection, we used a Bivariable Cox hazard ratio model. Descriptive baseline data are presented as mean±SD or median and interquartile range (IQR), as suitable. Baseline characteristics in peritoneal dialysis (PD) and hemodialysis (HD) patients were compared by comparison testing, Kruskal-Wallis test, or chi-square proportion test.

RESULTS:
Our cohort of 2305 dialysis patients were 59.7% male, 40.4%% female, 70.5% black and had an average age of 54.70±15.20. Among the total population of dialysis patients, bacteremia infections (13.02%) was the highest followed by medical device-related infections (12.69%). Bivariate analysis, using Cox's Proportional Hazards Model, identified that the risk of infection while undergoing peritoneal dialysis (HR, 1.244; 95% CI, 1. 076-1.440) is greater than undergoing hemodialysis. When adding demographic variables to the model, the risk factors for contracting an infection are age (HR, 1.023; 95% CI, 1.018-1.027) and gender (HR, 1.194; 95% CI, 1.055-1.352).

DISCUSSION:
In this cohort, the risk factors identified for contracting an infection were peritoneal dialysis, age, and gender. This tells us that patients with these characteristics should exercise caution when undergoing dialysis and be informed of current infection control practices and the differences between modality options.

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by

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APPROVAL PAGE

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Author's Statement Page

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Introduction

The prevalence of end stage renal disease (ESRD) continues to increase in the US and there is an estimated >2 million patients on dialysis worldwide, but that number is predicted to double by 2030 [1]. There were 124,675 newly reported cases of ESRD in 2016 and 726,331 prevalent cases in the US [2]. The number of prevalent ESRD cases has continuously increased by approximately 20,000 a year. As of 2016, 87.3% of incident patients began renal replacement therapy via hemodialysis, 9.7% started with peritoneal dialysis, and 2.8% received a preemptive kidney transplant. 63.1% of prevalent ESRD patients were undergoing hemodialysis while 7.0% were undergoing peritoneal dialysis treatment [3].

The choice between the two main modalities of dialysis, peritoneal or hemodialysis, can have a profound impact on the patient's life [4]. The choice between the hemodialysis and peritoneal dialysis is made by the patient and doctor after considering multiple patient factors such as age, comorbidities, and the patient's personal preference [4]. Patients typically perceive that home dialysis gives more freedom and flexibility, better well-being, and strengthens relationship either through at home peritoneal dialysis or at home hemodialysis [1]. While it has been shown that the overall mortality rate is similar between peritoneal and hemodialysis [5], the modality is a strong predictor of the type of infection and the difference in risk during the first 90 days of dialysis [6]. Infection is the second leading cause of death among dialysis patients and the first cause of hospitalization [7]. Decreased immune defense in patients with established renal failure causes a risk of infection with all dialysis treatments [8]. It has been shown that hemodialysis has twice the risk for hospitalization for septicemia while peritoneal

dialysis has a higher death rate for septicemia [6]. ESRD patients are more susceptible to viral infections than the over-all population [25].

ESRD patients experience a moderately high occurrence of hospitalization, however, the frequency of hospital admission has declined over the past decade [25]. Although, studies have shown that the rates for hospitalization for cardiovascular disease and infection rise with increasing CKD stage [9]. In 2016, for patients undergoing either hemodialysis or peritoneal dialysis, infection-related hospitalization was 3.6 PPY and 4.7 PPY respectively [25]. There has been a decline in hospitalizations due to infection from 2007-2016 and this improvement is likely from better infection control practices among dialysis patients [25]. It has been found that hospitalization rates for hemodialysis patients were the highest during the first year of dialysis, but markedly decreased throughout the first three years of hemodialysis [25]. In contrast, peritoneal dialysis patients experienced increasing hospitalization rates over the years of dialysis [25]. Kidney disease is one of the top 10 leading causes of early death in the United States [25]. Hemodialysis patients have a reported mortality that was highest in month two but then declined, whereas mortality for peritoneal dialysis patients was initially moderately low but increased marginally over the course of the year [25].

Starting dialysis is typically considered when symptoms or signs that can be credited to kidney failure, inability to control volume status or blood pressure, and a progressive decline in nutritional status refractory to interventions, are present [7]. When deciding between the two dialysis modalities, the patient should be well-informed on the advantages and disadvantages of both options. Frequency and severity of infections, as well as the risk of hospitalization due to infection, can impact the choice after considering other patient characteristics such as

comorbidities or other conditions that lead to a greater risk of infection [10]. Although infections are a growing concern for patients undergoing dialysis [7], little research has been done on infections not requiring hospitalization in dialysis patients. The objective of this study is to investigate the patient's characteristics associated with dialysis-related infections. Our secondary aim is to determine if these associations are modified by dialysis modality.

Literature Review

2.1 Peritoneal Dialysis

Peritoneal dialysis (PD) is one of the top choices of renal replacement therapy and it is predominantly done at home [11]. PD is a treatment that uses dialysate to clean fluid and waste from blood using the peritoneum as a filter. However, it is contraindicated if the peritoneal cavity is destroyed, the membrane is not functional, or catheter access is impossible [1]. Multiple studies have shown that patients undergoing PD therapy were typically younger, white, and male [12]. As of 2007, per-person costs for PD patients were almost $20,000 lower than that of hemodialysis patients [5]. Peritoneal dialysis is frequently more cost-effective than hemodialysis in industrialized countries [1], however, it was reported that in 2019, the prevalence of peritoneal dialysis use was only 10.1% [2]. The incident number of patients undergoing PD peaked in the mid-1990s, declined for over a decade, and then started increasing again in 2008 [26]. The prevalent PD population increased by 92.5% from 2000 to 2017 (USRDS). There are various reasons why fewer patients choose PD as a therapy including socioeconomic disadvantages. Poverty, housing instability, lack of storage space, low health literacy, and possible provider biases around patients' ability to learn how to use PD are factors that affect PD home dialysis use [13]. Peritoneal dialysis-related infections is a substantial cause

for modality change, the removal of the peritoneal dialysis catheter, loss of peritoneal dialysis function, and death [8]. Peritoneal dialysis has been shown to have an association with an increased risk of infections of the peritoneum, subcutaneous tunnel and catheter exit sites [8]. The overall rate of peritoneal dialysis-related infections was found to be 0.24-1.66 episodes/patient/year which exceeds the quality standards of <0.67 episodes/patient/year [8]. The leading complication of peritoneal dialysis is peritonitis, however, less than 4% of peritonitis cases result in death [8].

2.2 Hemodialysis

Hemodialysis (HD) is the most common choice of renal replacement therapy and it is primarily done in dialysis facilities. Home HD makes up only 2% of the population [13]. The purpose of hemodialysis is to reestablish the intracellular and extracellular fluid environment that is a hallmark of normal kidney function [14]. This is done by transporting solutes, like urea, from the blood into the dialysate and also by the transportation of solutes, like bicarbonate, from the dialysate into the blood [14]. An incision, usually on the arm, is made to access the patients' blood vessels and a dialysis machine filters the blood through an artificial kidney. In HD facilities, arteriovenous fistulas and grafts make up the majority of vascular accesses, however 19% of the prevalent HD population uses central venous catheters [15]. HD is contraindicated if there is an lack of possible vascular access or prohibitive cardiovascular instability [7]. Death within the first 90 days of dialysis disproportionately affects patients who are undergoing in-center hemodialysis, which is likely due to the fact that patients with acute kidney injury complicating chronic kidney failure or patients with poorer health status are more likely to choose in-center hemodialysis as their modality [7]. Among HD patients, the first cause

of hospitalization and the second cause for mortality is infection [7]. Hemodialysis when compared with peritoneal dialysis as an initial modality, doubles the risk for a septicemia caused hospitalization [6]. Bloodstream infections are one of the most common infections in HD patients, and in 2014, 29,516 bloodstreams infections were reported in outpatient HD centers [16]. Frequent and continued exposure to contaminants in hemodialysis facilities make HD patients more susceptible to healthcare-associated infections [7]. Infected patients, contaminated water, equipment, and environmental surfaces are some of the sources of infection [7].

2.3 Infections

Bloodstream Infections

Bloodstream infections can be found in both hemodialysis patients or peritoneal dialysis patients but are more frequent in patients undergoing hemodialysis. In particular, bloodstream infections are disproportionately high in HD patients with central venous catheters and opposed to HD patients with permanent accesses [17]. In the United States, 75% of bloodstream infections in patients on HD are related to vascular access [16], and 70% of those are associated with central venous catheters specifically [15]. The most common pathogens that have been found in studies of bloodstream infections of HD patients were staphylococci and other gram-positive cocci [18]. In order to combat the growing number of bloodstream infections in the dialysis population, CDC has published a list of interventions to prevent bloodstream infections. These interventions include: reducing catheter prevalence, use of chlorhexidine as an antiseptic for

the catheter site, disinfecting the catheter hub, using antimicrobial ointment at the catheter exit site, observing staff performance of catheter and vascular access care, educating staff and patients on infection control [16] [24]. Reducing bloodstream infections in HD patients would also result in economic savings, about $300 million annually if measures were taken for all HD patients in the United States [17].

Peritonitis

Peritonitis is an inflammation of the peritoneum that is usually caused by a bacterial infection. Peritonitis is also associated with changes in peritoneal transport and peritoneal inflammation that leads to hyperemia [8]. Peritonitis can be associated with severe pain that leads to hospitalization or catheter loss [8]. Peritonitis, while found in both HD and PD patients, is a common yet serious complication of PD [19]. Estimates have shown that for every 0.5-per-year increase in peritonitis rate, 18% of the case resulted in the removal of the PD catheter and 3.5% resulted in death while the overall risk of death increased by 4% [8]. Peritonitis is the main cause or contributing cause of death to 16% of PD patients, although only 5% of peritonitis episodes lead to death [19]. It is possible to achieve low rates of peritonitis if careful attention is paid to the cause of peritonitis protocols designed to reduce the rate of infection are followed [8]. Worldwide, the most common etiological organisms that cause PD-associated peritonitis are gram-positive cocci like *Staphylococcus epidermidis* and *Staphylococcus aureus* [8].

Sepsis and Septicemia

Sepsis is a dysregulated immune response that leads to acute organ dysfunction and septicemia is defined as having bacteria in your bloodstream that leads to sepsis [20]. Septicemia, while being a narrower definition of sepsis, is often used interchangeably with sepsis along with a variety other versions terms like severe sepsis and sepsis syndrome [21]. Induced by infection, sepsis is a disorder of pathologic, biochemical, and physiologic irregularities [21]. In 2011, sepsis accounted for more than $20 billion, or 5.2%, of the United States hospital costs, making this a major public health issue [21]. One study showed that the unadjusted incidence of severe sepsis was 145.4 per 1,000 in patients who were undergoing maintenance dialysis in comparison to 3.5 per 1,000 in the general population [22]. HD when compared to PD as a preliminary modality, doubles the risk for hospitalization due to septicemia, although, the recorded death for septicemia is higher in PD patients [6]. During a seven-year period, it was shown that 11.7% of HD patients and 9.4% of HD had at least one occurrence of septicemia [6]. Mortality rates are higher in those with severe sepsis and it was found to be an independent predictor of death among those on maintenance dialysis [22]. The true incidence of sepsis is unknown, and this is possibly contributed to the lack of a clear definition of septicemia [21]. Septicemia sometimes gets confused with peritonitis and bacteremia by those who are entering codes [6].

Bacteremia

Bacteremia is defined as having the presence of bacteria in the blood, and although it sometimes used interchangeably or incorrectly coded with sepsis, they are two different terms [6]. It has been shown in many studies that HD patients have higher rates of bacteremia than PD patients [12]. However, a 2018 study found that 11% of PD patients with peritonitis, also had bacteremia complications that caused serious systemic disorder. These patients also had longer hospital stays and greater disease severity [23]. In the first 3 months of dialysis, the risk for bacteremia and death are particularly high for HD patients [6]. One study found that 40% of all bacteremia cases during their observation period occurred in the first 90 days from starting HD and this is likely related to the use of HD catheters as an initial access which are widely known to increase the risk of bacteremia [6]. The annual number of catheter-related bacteremia cases is anticipated to be between 67,500 and 150,00 [24]. *Staphylococcus aureus* has been found to be the most common gram-positive organism that causes bacteremia while *Escherichia coli* was found to be the most common of the gram-negative organisms [25].

Medical device-related Infections

Common causes of infection in both HD and PD patients are related to the medical devices used in dialysis, such as catheters. PD is linked with a high risk of infection of the peritoneum, subcutaneous tunnel, and

catheter exit site, like exit site infection and tunnel infection. Most catheter related problems in PD patients are from peritonitis (61%) and exit site infection and tunnel infection (23%). One study showed that catheter-related peritonitis occurred in about 20% of PD patients and exist sit infection was the cause for catheter removal in over one-fifth of the cases [8]. Using HD catheters has been shown numerous times to be an independent predictor of death in HD patients [6]. In elderly patients, 15.1% percent of those with an HD catheter die in the first 90 days when compare with 6.7% with a fistula, making the hazard ratio of death with a HD catheter 2.15 [6]. Central venous catheters in HD patients are notorious for causing infections. A great deal of bloodstream infections is related to vascular access, and 70% of those are related specifically to central venous catheters. Most of the vascular accesses in HD facilities are made up arteriovenous fistulas and grafts but 19% of the prevalent HD population uses central venous catheters [15]. The Centers for Medicare and Medicaid Services have started a Fistula First initiative to try to move HD patients away from using central venous catheters in an effort to prevent the associated infections [17]. The Centers for Disease Control and Prevention (CDC) has also recommended a set of “Core Interventions for Bloodstream Infection Prevention” that specifically address infection control measures for central venous catheters [15][24].

Methods

3.1 Study Population and Data Sources

For this study, we linked data from the United States Renal Data System (USRDS) with Kaiser Permanente Georgia databases. The USRDS collects and distributes information about end-stage renal disease (ESRD) and chronic kidney disease (CKD) in the United States. Kaiser Permanente is an integrated managed care consortium and a not-for-profit health plan located in eight regions of the United States.

Patients initiating long-term hemodialysis or peritoneal dialysis care between January 1, 2010-Decemeber 31, 2017 and identified in both the Kaiser Permanente Georgia database and USRDS data sources were included in the cohort. Adults (age≥18) who were members of Kaiser Permanente Georgia health plan on their dialysis start date and matched with a USRDS record, were included in the study. Patients who received a kidney transplant before dialysis initiation, started dialysis prior to becoming a member with Kaiser Permanente Georgia, had unknown gender or unknown race were excluded from the cohort. This exclusion criteria was created to focus on patients whose first initiated ESRD therapy was dialysis and to avoid confounding a possible impact of one therapy on another. Codes and categories were modeled after USRDS methods which allows for comparisons between populations.

3.2 Outcomes

Our outcome of interest was dialysis-related infections after the start of dialysis. Infections were classified as bloodstream infections, bacteremia, septicemia, peritonitis, and dialysis-related infections, and defined using International Classification of Diseases (ICD), 9th or 10th Revision codes. We used the index infection from the linked USRDS and Kaiser Permanente

Georgia data in the survival analysis. Time to infection was defined as the start of dialysis to the date of dialysis-related infection. Patients were followed from the beginning of dialysis until death, kidney transplant, disenrolled from the health plan, or the end of the study period (December 31, 2017).

3.3 Covariates

Covariates were measured at dialysis initiation and included demographic variables, body mass index, smoking, comorbidities, and laboratory data. The included demographic variables are as follows: age at the start of dialysis, gender, race (Black, White, Asian, Native Hawaiian or other Pacific Islander, American Indian or Alaskan Native, other. Comorbidities (listed in Table 2) were identified through ICD codes (from linked USRDS and Kaiser Permanente data) at any time before or during dialysis duration. The eGFR was calculated using the four-variable Modification of Diet in Renal Disease equation.

3.4 Statistical Analyses

Descriptive baseline data are presented as mean$\pm$SD or median and interquartile range (IQR), as suitable. Baseline characteristics in PD and HD patients were compared by comparison testing, Kruskal-Wallis test, or chi-square proportion test.

SAS 9.4 was used to compare the covariates with the outcome variable of dialysis-related infection, we used a Bivariable Cox hazard ratio model. Also using a bivariate hazard ratio model, we compared the covariates to modality and demographics; modality, demographics, and comorbidities.

Results

Our cohort of 2305 dialysis patients were 59.7% male, 40.4%% female, 70.5% black and had an average age of 54.70±15.20. The total population of dialysis patients had an average BMI of 29.49±7.66 and 3.12% were smokers. The population of dialysis patients diagnosed with diabetes and hypertension was 42.08% and 83.12% respectively. 81.65% (n=1882) of dialysis patients started on hemodialysis while 18.35% (n=423) started on peritoneal dialysis. Compared to peritoneal dialysis patients, the average age for hemodialysis patients was older (56.18 ±15.19 vs. 50.37±14.22), and there was a higher percentage of diabetes (35.88% vs 6.20%; p-value=<0.0001), cardiovascular disease (25.81% vs. 3.30%); p-value=<0.0001), cerebrovascular disease (4.90% vs. 0.48%; p-value=0.0051), and chronic obstructive pulmonary disease (2.65% vs. 0.04%; p-value=0.0006). Laboratory data showed the average albumin, eGFR, and hemoglobin levels for the cohort of dialysis patients were 2.93±3.03, 9.02 ±4.13, and 9.99±4.37, respectively. Table 1 shows our populations demographics by modality and table 2 shows our populations comorbidities by modality.

Table 2 shows that among hemodialysis patients, the percentage of bacteremia infections (14.93%) was the highest, where in peritoneal dialysis patients, the percentage of peritonitis infections (24.11%) was the highest. Among the total population of dialysis patients, bacteremia infections (13.02%) was the highest followed by medical device-related infections (12.69%).

Bivariate analysis, using Cox's Proportional Hazards Model, identified that the risk of infection while undergoing peritoneal dialysis (HR, 1.244; 95% CI, 1. 076-1.440) is greater than

undergoing hemodialysis (Table 4). When adding demographic variables to the model, the risk factors for contracting an infection are age (HR, 1.023; 95% CI, 1.018-1.027) and gender (HR, 1.194; 95% CI, 1.055-1.352). After adding patient comorbidities to the model with demographic variables, the risk factors then become BMI (HR, 1.006; 95% CI, 0.996-1.016) cardiovascular disease (HR, 1.114; 95% CI, 0.914-1.357), cerebrovascular disease(HR, 1.298; 95% CI, 0.947-1.780), COPD (HR, 1.247; 95% CI, 0.770-2.018), diabetes (HR, 1.169; 95% CI, 0.995-1.374), hypertension (HR, 1.201; 95% CI, 0.619-1.441), and eGFR (HR, 1.032; 95% CI, 1.011-1.052).

Also using a Cox's Proportional Hazards Model, the following risk factors were identified for contracting an infection while on hemodialysis by demographics: age (HR, 1.020; 95% CI, 1.015-1.025) and gender (HR, 1.143; 95% CI, 0.992-1.316) (Table 5). After adding patient comorbidities to the model with demographic variables, the risk factors then become BMI (HR, 1.002; 95% CI, 0.991-1.014) cardiovascular disease (HR, 1.135; 95% CI, 0.913-1.412), cerebrovascular disease (HR, 1.184; 95% CI, 0.839-1.672), COPD (HR, 1.207; 95% CI, 0.732-1.989), diabetes (HR, 1.289; 95% CI, 1.068-1.556), hypertension (HR, 1.169; 95% CI, 0.913-1.496), and eGFR (HR, 1.031; 95% CI, 1.008-1.055).

The following risk factors for contracting an infection while on peritoneal dialysis by demographics were found using a Cox's Proportional Hazard Model: age (HR,1.035; 95% CI, 1.025-1.045), gender (HR, 1.450; 95% CI, 1.118-1.880), African-American race (HR, 1.445; 95% CI, 1.077-1.940) (Table 6). After adding patient comorbidities to the model with demographic variables, the risk factors then become age (HR, 1.028; 95% CI, 1.014-1.041), gender (HR, 1.386; 95% CI, 1.023-1.877), African-American race (HR, 1.241; 95% CI, 0.862-1.788), BMI (HR, 1.017; 95% CI, 0.994-1.041), smoking (HR, 1.025; 95% CI, 0.375-2.799), diabetes (HR, 0.999; 95% CI,

0.709-1.406), hypertension (HR, 1.184; 95% CI, 0.723-1.940), and eGFR (HR, 1.032; 95% CI, 0.986-1.080).

Discussion

The objective of this study was to investigate the patient characteristics associated with dialysis-related infections and to determine if these associations are modified by dialysis modality. The study revealed that peritoneal dialysis, age, and gender are associated with dialysis-related infections. It has been widely debated whether PD or HD patients are at a greater risk for infections, but the consensus is that there is a higher risk of infection for PD patients. We also found this to be true with PD patients being 1.244 times more likely to get an infection than hemodialysis patients. Analysis showed that with every one-year increase in age, risk of infection while on dialysis increases 1.024 times.

Our analysis showed that women are 1.194 times more likely to get an infection while on dialysis than men. This finding is also consistent with the literature, particularly those who included genitourinary infections in their studies [12]. Although we did not include genitourinary infections in our analysis, these can lead to more serious infections like sepsis and bloodstream infections. This tells us that patients with these characteristics should exercise caution when undergoing dialysis and be informed of current infection control practices. As most studies have found, we showed that bacteremia was the most common infection among HD patients and peritonitis was the most common among peritoneal dialysis. This is mainly because of the type of catheters used in HD and PD.

We found that black patients undergoing peritoneal dialysis are 1.445 times more likely to get an infection on PD than whites, while there was no increased risk of infection for black

patients on HD. This contradicts Aslam et al. who found that there were similar infection rates for both modalities but is consistent with most literature, though most of this literature is older. This difference could be because they had a smaller population of black patients whereas we had a large population of black patients in our cohort.

4.1 Strengths

This study has numerous strengths. Our greatest strength is that by combing the two datasets, USRDS was able to provide a better follow-up on dialysis modality where Kaiser Permanente Georgia was able to provide an overall follow-up with patient medical history. One strength of this study is that we were able to capture patients in the first 90 days of dialysis by using Kaiser Permanente data. This is significant because the rate of bacteremia in HD patients has been found to be much higher during the first 90 days of dialysis than the total time at risk [6] We were also able to catch minor infections that did not result in hospitalization which has not been widely studied. Another strength is that our southeastern population has a high percentage of minority patients with an average age of 55, where most studies have an older population with a smaller minority population, making our population more generalizable. Lastly, this research is current and analyzes a variety of infections. Most literature on this topic is older.

4.2 Limitations

This study has several limitations. First, our study population includes only patients from Kaiser Permanente Georgia who are on dialysis and have health insurance, which reduces the generalizability. Second, there is enrollment bias because our inclusion criteria was that patients had to be enrolled with Kaiser Permanente Georgia while on dialysis. Lastly, we relied

solely on ICD codes to diagnose infections as our population size was too large to verify diagnoses through chart review. However, the ICD codes should be an accurate reflection of the infections in this population.

Conclusion

The prevalence of end stage renal disease continues to increase in the US and the difficult choice between modalities can have a profound effect on the patient's life. We found that the risk and types of infections varies between the two modalities with bacteremia being the most common infection in HD patients and peritonitis being the most common infection in PD patients. The findings from this analysis do not emphasize one modality over the other but rather provide more current information about risk factors associated with infections in dialysis patients so healthcare providers and patients can make informed medical decisions that best suit the patient's circumstances. Further research should be focused on infection control protocol and guidelines to reduce the number of dialysis-related infections.

Table 1: Characteristics of total population, hemodialysis, and peritoneal dialysis patients.

Characteristics	Total (N=2305)	Hemodialysis N=1882 (81.65)	Peritoneal dialysis N=423 (18.35)	P Value
	N (%)	N (%)	N (%)	
Age, year, Mean (SD)	54.7±15.20	56.18±15.19	50.37±14.22	
Gender (%)				0.5587
Male	1375(59.65)	1128(48.94)	754(32.71)	
Female	930(10.35)	247(10.72)	176(7.64)	
Race (%)				0.0714
Black	1624(70.46)	1347(58.44)	277(12.02)	
White	613(26.59)	483(20.95)	130(5.64)	
Asian	44(1.91)	33(1.43)	11(0.48)	
Native Hawaiian or Other Pacific Islander	8(0.35)	7(0.30)	1(0.04)	
American Indian or Alaskan Native	5(0.22)	5(0.22)	0	
Other	11(0.48)	7(0.30)	4(0.17)	

P-values were calculated from comparison testing; Chi-square test was used for categorical variables; Kruskal-Wallis test was used for continuous non-parametric variables

Table 2: Comorbidities and laboratory data of total population, hemodialysis, and peritoneal dialysis patients.

Characteristics	Total (N=2305)	Hemodialysis N=1882(81.65)	Peritoneal dialysis N=423(18.35)	P Value
	N (%)	N (%)	N (%)	
Comorbidities (%)				
Cardiovascular disease	671(29.11)	595(25.81)	76(3.30)	<.0001
Cerebrovascular disease	124(5.38)	113(4.90)	11(0.48)	0.0051
COPD	62(2.69)	61(2.65)	1(0.04)	0.0006
Diabetes	970(42.08)	827(35.88)	143(6.20)	<.0001
Hypertension	1916(83.12)	1560(67.68)	356(15.44)	0.5285
Malignancy	85(3.69)	74(3.21)	11(0.48)	0.1892
PVD	102(4.43)	90(3.90)	12(0.52)	0.0788
BMI (kg/m^2), **Mean (SD)**	29.49±7.66	29.74±7.95	28.97±6.55	<.0001
Smoking (%)	72(3.12)	60(2.60)	12(0.52)	0.7075
Laboratory data, Mean (SD)				
Albumin (g/dl)	2.93±3.03	2.89±1.09	3.24±1.15	<.0001
eGFR (ml/min per 1.73 $m^{2)}$	9.02±4.13	9.01±4.19	8.72±3.49	<.0001
Hemoglobin (g/dl)	9.99±4.37	9.82±4.72	10.53±2.52	<.0001

Abbreviations: BMI, body mass index; COPD, chronic obstructive pulmonary disease; PVD, peripheral vascular disease
p-values were calculated from comparison testing; Chi-square test was used for categorical variables; Kruskal-Wallis test was used for continuous non-parametric variables

Table 3: Type of infection in total population, hemodialysis, and peritoneal dialysis patients.				
Variables	**Hemodialysis, *n*(%)**	**Peritoneal Dialysis, *n*(%)**	**Missing*, *n*(%)**	**Total, *n*(%)**
	N=793(42.13)	**N=235(55.55)**	**26(26.26)**	**N=1054(43.84)**
Bloodstream infections	33(1.75)	13(3.07)	1(1.01)	47(1.96)
Bacteremia	281(14.93)	24(5.67)	8(8.08)	313(13.02)
Septicemia	205(10.89)	24(5.67)	9(9.09)	238(9.90)
Peritonitis	47(2.50)	102(24.11)	2(2.02)	151(6.28)
Medical Device-related infections	227(12.06)	72(17.02)	6(6.06)	305(12.69)
ICD Codes: a993, T80.2; b790.7, R78.81; c003.1, 022.3, 038, 054.5, 112.5, 785.52, 995.91, A40, A41.0, A26.7, A32.7, A42.7, B37.7, R57.2, O85; d567, K65.0; e996.6, T82.7, T85.7; *Missing=unknown modality				

Table 4: Hazard ratio and 95% confidence interval for demographics of total population of dialysis patients with an infection by characteristics.			
Characteristics	Model 1: Crude Model	Model 2: Modality+demographics	Model 3: Model 2+comorbidities
	Hazard Ratio (95% CI)	Hazard Ratio (95% CI)	Hazard Ratio (95% CI)
Dialysis Modality (HD vs. PD)			
HD	1.00 (ref)	1.00 (ref)	1.00 (ref)
PD	1.244(1.076-1.440)	1.455(1.252-1.691)	1.672(1.396-2.002)
Age, year, Mean (SD)		1.023(1.018-1.027)	1.015(1.010-1.021)
Sex			
Male		1.00 (ref)	1.00 (ref)
Female		1.194(1.055-1.352)	1.171(1.011-1.357)
Race			
White		1.00 (ref)	1.00 (ref)
Black		.998(0.867-1.148)	0.930(0.784-1.104)
Asian		1.050(0.643-1.715)	1.133(0.640-2.006)
Native Hawaiian or Other Pacific Islander		1.424(0.530-3.822)	1.006(0.247-4.103)
American Indian or Alaskan Native		0.372(0.052-2.652)	0.000(0.000-1.68E89)*
Other		0.514(0.191-1.382)	0.812(0.300-2.200)
BMI (kg/m^2), **Mean (SD)**			1.006(0.996-1.016)
Smoking (%)			0.712(0.425-1.194)
Comorbidities (%)			
Cardiovascular disease			1.114(0.914-1.357)
Cerebrovascular disease			1.298(0.947-1.780)
COPD			1.247(0.770-2.018)
Diabetes			1.169(0.995-1.374)
Hypertension			1.201(0.964-1.495)
Malignancy			0.945(0.619-1.441)
PVD			0.961(0.644-1.434)
Laboratory data, Mean (SD)			
Albumin (g/dl)			0.900(0.846-0.958)
eGFR (ml/min per 1.73 $m^{2)}$			1.032(1.011-1.052)
Hemoglobin (g/dl)			0.983(.950-1.016)
Abbreviations: BMI, mody mass index; COPD, chronic obstructive pulmonary disease; PVD, peripheral vascular disease; *No information			

Table 5: Hazard ratio and 95% confidence interval for demographics of hemodialysis patients with an infection by characteristics.		
Characteristics (Hemodialysis)	Model 1: Modality+demographics	Model 2: Model 1+comorbidities
	Hazard Ratio (95% CI)	Hazard Ratio (95% CI)
Age, year, Mean (SD)	1.020(1.015-1.025)	1.011(1.005-1.018)
Sex		
Male	1.00 (ref)	1.00 (ref)
Female	1.143(0.992-1.316)	1.109(0.936-1.314)
Race		
White	1.00 (ref)	1.00 (ref)
Black	0.882(0.752-1.034)	0.836(0.686-1.018)
Asian	0.854(0.477-1.529)	0.896(0.435-1.847)
Native Hawaiian or Other Pacific Islander	1.641(0.609-4.422)	0.941(0.230-3.851)
American Indian or Alaskan Native	0.362(0.501-2.581)	0.000(0.000-1.61E196)
Other	0.206(0.029-1.470)	0.294(0.041-2.120)
BMI (kg/m2), **Mean (SD)**		1.002(0.991-1.014)
Smoking (%)		0.648(0.354-1.187)
Comorbidities (%)		
Cardiovascular disease		1.135(0.913-1.412)
Cerebrovascular disease		1.184(0.839-1.672)
COPD		1.207(0.732-1.989)
Diabetes		1.289(1.068-1.556)
Hypertension		1.169(0.913-1.496)
Malignancy		1.093(0.685-1.743)
PVD		0.942(0.611-1.452)
Laboratory data, Mean (SD)		
Albumin (g/dl)		0.901(0.839-0.968)
eGFR (ml/min per 1.73 m2)		1.031(1.008-1.055)
Hemoglobin (g/dl)		0.987(0.945-1.030)
Abbreviations: BMI, body mass index; COPD chronic obstructive pulmonary disease; PVD, peripheral vascular disease		

Table 6: Hazard ratio and 95% confidence interval for demographics of peritoneal dialysis patients with an infection by characteristics.		
Characteristics (Peritoneal dialysis)	Model 1: Modality+demographics	Model 2: Model 1+comorbidities
	Hazard Ratio (95% CI)	Hazard Ratio (95% CI)
Age, year, Mean (SD)	1.035(1.025-1.045)	1.028(1.014-1.041)
Sex		
Male	1.00 (ref)	1.00 (ref)
Female	1.450(1.118-1.880)	1.386(1.023-1.877)
Race		
White	1.00 (ref)	1.00 (ref)
Black	1.445(1.077-1.940)	1.241(0.862-1.788)
Asian	2.246(0.896-5.629)	2.490(0.931-6.663)
Native Hawaiian or Other Pacific Islander	0.000(0.000-6.18E298)*	0*
American Indian or Alaskan Native	None on PD	None on PD
Other	1.054(0.329-3.373)	1.544(0.454-5.257)
BMI (kg/m_2), **Mean (SD)**		1.017(0.994-1.041)
Smoking (%)		1.025(0.375-2.799)
Comorbidities (%)		
Cardiovascular disease		0.988(0.611-1.595)
Cerebrovascular disease		1.922(0.830-4.454)
COPD		3.149(0.408-24.276)
Diabetes		0.999(0.709-1.406)
Hypertension		1.184(0.723-1.940)
Malignancy		0.681(0.235-1.973)
PVD		1.276(0.426-3.820)
Laboratory data, Mean (SD)		
Albumin (g/dl)		0.876(0.766-1.001)
eGFR (ml/min per 1.73 m_2)		1.032(0.986-1.080)
Hemoglobin (g/dl)		0.975(0.916-1.037)
Abbreviations: BMI, body mass index; COPD, chronic obstructive pulmonary disorder; PVD, peripheral vascular disease; *No information		

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