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Variation in Initial Kidney Replacement Therapy for End-Stage Renal Disease Due to Lupus Nephritis in the U.S.

Amy Devlin, MD[1], **Sushrut Waikar, MD, MPH**[2], **Daniel H. Solomon, MD, MPH**[2], **Bing Lu, PhD**[2], **Tamara Shakevich, BS**[2], **Graciela S. Alarcón, MD**[3], **Wolfgang C. Winkelmayer, MD, ScD**[4], and **Karen H. Costenbader, MD, MPH**[2]

[1]Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, MA

[2]Brigham and Women's Hospital, Harvard Medical School, Boston, MA

[3]University of Alabama at Birmingham, Birmingham, AL

[4]Stanford University School of Medicine, Palo Alto, CA

Abstract

Objective—Little is known about patterns of use of initial kidney replacement therapies among patients with LN end-stage renal disease (LN ESRD). We aimed to identify sociodemographic and clinical factors associated with variation in initial kidney replacement therapies among LN ESRD patients.

Methods—Patients with incident LN ESRD (1995–2006) were identified in the US Renal Data System. Age, sex, race, ethnicity, medical insurance, employment status, residential region, clinical factors and comorbidities were considered as potential predictors of ESRD treatment choice -- peritoneal dialysis (PD), hemodialysis (HD) or pre-emptive kidney transplantation -- in age-adjusted and multivariable-adjusted logistic regression analyses.

Results—Of 11,317 individuals with incident LN ESRD, 82.0% initiated HD; 12.2% PD, and 2.8% underwent pre-emptive kidney transplantation. Receiving initial PD was significantly associated with earlier calendar year, female sex, higher albumin and hemoglobin, and lower serum creatinine levels. African Americans (vs. Whites), Medicaid beneficiaries and those with no health insurance (vs. private insurance), and those unemployed (vs. employed) had significantly reduced PD initiation. Comorbidities including congestive heart failure, peripheral vascular disease and inability to ambulate were also associated with decreased PD. Many sociodemographic and clinical factors favoring PD were associated with pre-emptive kidney transplant (vs. dialysis) as well.

Conclusion—Few patients with LN ESRD receive initial PD or pre-emptive kidney transplantation. Race, ethnicity, employment and medical insurance type are strongly associated with initial kidney replacement therapy choice. Future studies need to investigate the appropriateness of sociodemographic and clinical variation and the comparative effectiveness of kidney replacement therapies for LN ESRD.

Corresponding author: Karen H. Costenbader, MD, MPH, Section of Clinical Sciences, Division of Rheumatology, Immunology and Allergy, Brigham and Women's Hospital, PBB-B3, 75 Francis Street, Boston, MA, USA, Telephone: (617) 732-5158, Fax: (617)731-9032, Kcostenbader@Partners.org.

Disclaimer: Data for these analyses were provided by United States Renal Data System (USRDS), but the analysis and conclusions are those of the authors and do not represent the USRDS or National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK).

Keywords

peritoneal dialysis; hemodialysis; kidney transplantation; survival; lupus; nephritis; end-stage renal disease; chronic kidney disease; systemic lupus erythematosus; African American; Hispanic; race; women

Introduction

Despite advancements in therapies for SLE over the past two decades, the annual incidence of LN related end-stage renal disease (ESRD) has not declined[1–3]. Approximately 20% of lupus nephritis (LN) patients advance to ESRD over a 10 year period [4–6]. As they approach ESRD, patients and their providers must choose among kidney replacement options, including hemodialysis (HD), peritoneal dialysis (PD) or pre-emptive kidney transplantation. Although HD and PD have been offered to ESRD patients for several decades, little is known about factors that influence the choice of initial dialysis modality, particularly for LN ESRD patients. Immunosuppressant use, underlying SLE disease activity, pre-existing comorbid illness, and availability of dialysis services and transplantation certainly all deserve consideration as this decision is made.

While kidney transplantation is the best long-term option for patients with ESRD, the vast majority of LN ESRD patients initiate dialysis first, due to both the imbalance of supply and demand of donor organs[10] and the desire to delay transplantation following lupus disease activity[11]. In recent years, fewer than 3% of U.S. LN ESRD patients received a pre-emptive kidney transplant without initial dialysis[3]. It remains unclear whether long-term outcomes among LN ESRD patients differ according to the kidney replacement option chosen, in particular the two dialysis modalities[6–8]. Although there is a paucity of prospective data comparing infection rates among LN ESRD patients receiving HD compared to PD, a few studies have suggested an increased risk for peritonitis and higher mortality rates among SLE patients receiving PD[7, 9, 10]. Past studies of the influence of dialysis modality upon SLE disease activity have also yielded inconsistent results[7–13]. Pre-dialysis comorbidities, especially cardiovascular conditions, have been associated with increased mortality rates among LN ESRD PD patients in particular [9]. LN ESRD patients appear to do well after kidney transplant, however, with low SLE activity and rates of recurrent lupus nephritis[14–17]. In addition to clinical factors, geographic access to dialysis and transplantation may influence patient selection of kidney replacement therapy for LN ESRD, although this has never been studied.

In the present study, we investigated clinical and sociodemographic determinants of the choice of initial kidney replacement therapy among LN ESRD patients in the U.S. from 1995–2006.

Methods

Data Sources

The US Renal Data System (USRDS) is the registry of patients with ESRD in the U.S. The USRDS database includes all ESRD patients in the U.S who receive any kidney replacement therapy as dialysis or kidney transplantation[13]. For each new patient at enrollment, the attending nephrologist is required to complete the Medical Evidence Report form (CMS-2728). The date of first service is derived from the earliest of start dates reported on the medical evidence form, for chronic kidney failure: the date of kidney transplant as reported on a CMS or Organ Procurement Transplant Network transplant, the Medical

Evidence Report, a hospital inpatient claim, or the date of the first Medicare dialysis claim[13].

Study Population

As previously described[3], we identified all individuals aged 18 to 100 years with SLE (International Classification of Diseases, Ninth revision, ICD-9 code 710.0) identified as the cause of ESRD at enrollment in the USRDS from January 1, 1995 to December 31, 2006. From the USRDS, we obtained information concerning patient demographics, including age, sex, race (white, African American, Asian/Pacific Islander, or Native American), Hispanic ethnicity, and U.S. state or U.S. islands (including Puerto Rico, U.S. Virgin Islands, American Samoa and Guam) at the time of initiation of ESRD treatment. The following data for each patient at ESRD onset were recorded: body mass index (BMI), serum creatinine, hemoglobin and albumin, type of medical insurance prior to ESRD (Medicare, Medicaid, Department of Veteran's Affairs, Employer group, or none), current employment status (employed/unemployed). Comorbid diabetes mellitus, hypertension, malignancy, congestive heart failure, cerebrovascular disease, coronary artery disease, chronic obstructive pulmonary disease, peripheral arterial disease, as well as current cigarette smoking, current drug abuse, and inability to ambulate or to transfer, as documented on the medical evidence forms were also included.

The outcomes of study were the specific types of initial kidney replacement therapy: HD, PD, or pre-emptive kidney transplant. Patients with missing data concerning type of initial kidney replacement therapy were excluded from all analyses. Data were obtained from the USRDS through a data use agreement and data are shown in accordance with USRDS reporting policies (cell sizes below 11 have been suppressed).

Statistical Analysis

We examined the clinical and sociodemographic characteristics of U.S. patients with ESRD due to LN according to the type of initial kidney replacement therapy they received: HD, PD or pre-emptive kidney transplantation at ESRD onset. In univariable analyses, t-tests for continuous variables and Chi-squared or Fisher's exact tests for categorical variables were used to examine the distributions of these variables according to the two outcomes: initial PD (vs. HD) and pre-emptive transplantation (vs. any dialysis). Separate age-adjusted, and then multivariable, logistic regression models were used to identify those variables that were significantly associated with receiving either initial PD (vs. HD) or pre-emptive transplantation (vs. any dialysis and compared to HD only) among the sociodemographic and clinical variables. As the relationships between clinical laboratory values and outcomes were not linear, we employed tertile cut-offs for the serum values, and clinically-accepted cut-offs for BMI. In the multivariable models we tested for potential interactions among the variables, in particular for modification of associations of race and ethnicity by other variables. All the p values were calculated with two-sided significance level of 0.05. Data analyses were performed using SAS 9.2 (SAS Institute, Inc, Cary, North Carolina). The Partners' Healthcare Institutional Review Board reviewed this study protocol and granted it a waiver as human subjects' exempt research.

Results

We identified 11,317 individuals with complete data concerning intial kidney replacement therapy for ESRD due to LN between January 1, 1995 and December 31, 2006. (Table 1) The majority of patients, 82.0%, used HD at the onset of ESRD, while 12.2% used PD and 2.8% had a pre-emptive kidney transplant. From 1995 to 2006, there was a steady and significant decline in the proportion of incident LN ESRD patients begun on PD (from 16.8

% to 9.7%), with corresponding increase in those started on HD. Compared to patients started on HD (mean age 41.2, SD 15.1 years), patients started on PD were of comparable age (mean age 41.0, SD 13.1 years), although the age range was slightly different with a higher proportion in the 30–50 year age group. Patients who were initiated on PD had slightly higher serum albumin and hemoglobin levels. Fewer individuals starting on PD than on HD had serum creatinine levels above 8.4 mg/dl and fewer had BMIs greater than 25 kg/m^2. Those who received initial PD were more likely to be women, and of Asian or White race, than those initiating HD. A higher proportion of initial PD compared to HD patients also had private medical insurance, with correspondingly lower proportions of individuals with Medicaid, Medicare or no medical insurance. More initial PD than HD patients were employed at ESRD onset and there was some variation in geographic distribution, with a lower proportion of the initial PD than HD patients living in the South and more in the West. There were no significant differences in cigarette smoking, cancer, coronary artery disease or chronic obstructive pulmonary disease, but hypertension was more common and diabetes mellitus, congestive heart failure, peripheral vascular disease, cerebrovascular disease, current drug abuse and inability to ambulate were all less common among those initially starting PD than HD.

In age-adjusted analyses (Table 2), the likelihood of receiving initial PD (vs. HD) was significantly higher in earlier calendar years, for those with higher serum albumin and hemoglobin levels, for women compared to men, for Whites compared to African Americans, for those with private compared to any other type of insurance, and for those who were employed compared to those unemployed. Hispanic ethnicity was not associated with receiving PD vs. HD, and there was no strong geographic variation except for increased PD use in Puerto Rico and the U.S. Islands. While cigarette smoking and BMI were not associated with likelihood of receiving initial PD, comorbidity with diabetes mellitus, congestive heart failure, peripheral vascular disease, cerebrovascular disease and inability to ambulate decreased the likelihood of PD, and having hypertension increased it.

Many of these associations continued to be observed even after multivariable adjustment (Table 2). Age at ESRD onset of < 50 years, earlier calendar year during the period of study, female sex, White compared to African American race, having private medical insurance vs. Medicaid, and being employed were all independently associated with significantly higher odds of receiving PD compared to HD. Higher serum albumin and serum hemoglobin levels at ESRD onset were also associated with increased odds of receiving initial PD, as was the presence of hypertension. Comorbidity with congestive heart failure, peripheral vascular disease and inability to ambulate were associated with decreased likelihood of PD. We did not detect interactions between race and U.S. region in determining risk of receiving initial PD.

Only 313 individuals received a pre-emptive kidney transplant without preceding dialysis (Table 1), but the proportion grew over successive calendar years (from 1.7% to 3.7%). The age distribution of the pre-emptive transplant patients was more concentrated between ages 30 and 50 than that of the dialysis patients. These patients also had significantly higher serum albumin and hemoglobin levels, and lower serum creatinine levels at USRDS enrollment. While their BMIs and sex distributions were similar to those of the dialysis patients, the proportions of African Americans and Hispanics, those with Medicaid or no health insurance, those unemployed and those living in the U.S. South, were much lower than for dialysis patients. The proportions of patients with diabetes, coronary artery disease, congestive heart failure, chronic obstructive pulmonary disease and inability to ambulate were significantly lower among those undergoing pre-emptive kidney transplantation vs. dialysis.

Age-adjusted analyses of receiving a pre-emptive kidney transplant (vs. any dialysis) at ESRD onset are shown in Table 3. Odds of receiving a pre-emptive transplant were highest among those with serum albumin >3.2 mg/dl, hemoglobin > 10.0 mg/dl and creatinine < 6. mg/dl. Males and females were equally likely to receive transplants, but odds of receiving a transplant were significantly lower among both African Americans and Asians compared to Whites. Age-adjusted odds of a pre-emptive transplant were significantly lower for those with non-private health insurance and for those who were unemployed. Significant regional variation in the odds of receiving a pre-emptive kidney transplant was observed, with the lowest odds in the Southern states.

In age-adjusted models, those who had diabetes mellitus, coronary artery disease and congestive heart failure and chronic obstructive pulmonary disease had decreased odds of receiving a pre-emptive kidney transplant. BMI and hypertension were not significant predictors of receiving a pre-emptive kidney transplant and were not included in final multivariable models. Current drug abuse, inability to ambulate or inability to transfer to bed were not included as covariables in the age-adjusted or multivariable models as too few subjects had these comorbidities.

After multivariable adjustment, those over age 50 and Hispanics had significantly reduced odds of receiving pre-emptive kidney transplants. Comorbidity with diabetes mellitus, cigarette smoking and coronary artery disease were no longer significantly associated with odds of transplant. The significant predictors of receiving a pre-emptive transplant compared to HD were identical to those of receiving a pre-emptive transplant compared to *any* dialysis with very similar levels of significance (data not shown). We did not detect significant interactions between race and region in determining odds of receiving a pre-emptive kidney transplant.

Discussion

Employing nationwide data from 1995–2006, we have found substantial sociodemographic variation in the choice of initial kidney replacement therapy for incident LN ESRD patients. Only a small minority of patients, less than 3% overall, proceeded directly to kidney transplantation without first receiving some form of dialysis. HD was the predominant initial dialysis modality throughout this period and its usage has grown over time. PD was used more commonly among female patients, among Whites vs. African Americans, those with private insurance vs. Medicaid, and those who were employed. Patients who received PD appeared to be in significantly better general health than those who received HD, with higher serum levels of hemoglobin and albumin at ESRD onset. The presence of hypertension at ESRD onset was significantly associated with increased odds of receiving initial PD. Hypertension has been associated with better outcomes among ESRD patients in past studies, and lower blood pressure may be an indicator of frailty and poor nutritional status in this population[18]. Additionally, it may be that hypertension was more reliably coded by physicians who are apt to start patients on PD. The small group of patients who underwent pre-emptive kidney transplantation at ESRD onset was even more highly selected. Compared to dialysis patients, they were significantly younger, with better laboratory values, significantly more White, more non-Hispanic, fewer in the U.S. South, more employed, and more with private medical insurance.

HD and PD have distinct advantages and disadvantages. PD is a more flexible option with less disruption required during peak work hours[19]. After adjusting for ethnicity, age, distance from treatment center, treatment length and employment status, studies of patient quality of life have found that PD patients to be more satisfied and happier than their otherwise similar HD counterparts [20, 21]. In a large survey of practicing nephrologists it was

felt by the majority that both PD and home HD were underutilized, and respondent physicians felt that 26–39% of ESRD patients could be successfully placed on PD[22]. There is also clear economic advantage to PD compared to HD. According to USRDS annual data reporting, Medicare spends approximately $18,000 less annually for a PD patient than for a HD patient[23]. However, the large degree of patient autonomy required entails good patient-provider communication and adherence with home PD regimens and ESRD medications.

Previous studies comparing PD vs. HD mortality among *all-cause* ESRD patients are inconclusive. Several studies have suggested early survival advantages in PD vs. HD patient populations within the first 1–2 years of ESRD onset, although similar long-term survival rates[24,25]. Other research has shown significantly higher death rates in PD vs. HD patients soon after dialysis initiation, especially in elderly diabetics[26]. Several prior small studies have suggested an increased risk of peritonitis and other infectious complications among immunosuppressed LN ESRD patients receiving PD. In 1996, Andrews and colleagues reported that immunosuppressed patients undergoing PD had three times as many hospitalizations and more than double the number of peritonitis episodes as non-immunosuppressed PD patients[27]. Subsequently in a small study involving 23 LN ESRD undergoing PD compared to non-LN PD controls, Huang and colleagues reported a much higher rate of peritonitis and overall mortality among the LN patients, in particular in association with corticosteroid use[7]. A 2005 study reported higher rates of peritonitis, non-catheter related infections, and mortality among a small group of LN PD patients compared to non-diabetic, non-LN PD patients[10]. While the current study elucidates important clinical determinants and sociodemographic patterns among LN patients choosing HD or PD, we cannot comment on the safety or efficacy of these dialysis modalities, and further study of the comparative effectiveness of these therapies for LN ESRD is warranted.

The effects of dialysis modality upon SLE disease activity, morbidity and mortality are not known: existing observational data comparing outcomes are sparse, conflicting and difficult to interpret as a healthier, more advantaged patient population may be selected for PD[7–13]. One small study reported a higher increase from baseline in SLE activity scores in patients undergoing PD compared to HD, but no differences in survival rates[28]. Pre-transplant use of PD compared with HD has been associated with better allograft survival among LN ESRD transplant recipients[29] and lower risk of risk of developing post-transplant bacteremia[30].

Lupus patients with recurrent infections, malignancies, or other pre-existing comorbidities may be poor candidates for PD or pre-emptive transplantation due to increased complication rates[7, 9, 10]. A recent survival analysis of LN ESRD undergoing PD revealed that pre-dialysis SLE activity scores had limited prognostic value but preexisting comorbidities, especially cardiovascular conditions, were associated with significantly higher mortality rates among SLE PD patients[9]. For the current study, data were not available concerning prior infections and we were not able to calculate complete Charlson comorbity scores. We did find that comorbidities including diabetes mellitus, congestive heart failure, chronic obstructive pulmonary disease, peripheral vascular disease, and inability to ambulate were associated with decreased odds of receiving either PD or pre-emptive kidney transplant.

Limited geographic access to PD services and a national transition to predominant care provision by chain-affiliated dialysis facilities are likely responsible for increasing the proportion of all U.S. ESRD patients started on HD in the past two decades[19, 23]. From 1995 to 1999, the proportion of dialysis facilities in the U.S. offering PD services was 56%, which declined to 47% by 2003[31]. In a large cohort study, PD availability was greater in metropolitan cities and the Northeast but more limited in the South, Midwest and rural areas[20]. PD access was also more limited in hospital referral regions with higher proportions of African American, Asian and Hispanic ESRD patients. Survey data suggest that recent

nephrology fellows have markedly less familiarity, exposure and training with PD compared to HD, which likely influences how they will counsel patients concerning dialysis options[19, 25]. Understanding the sociodemographic predictors of initial dialysis modality among LN ESRD patients is increasingly relevant, however, as the Centers for Medicare and Medicaid Services (CMS) ESRD 2011 Prospective Payment System Program has recently replaced the current adjusted composite payment system, effectively providing strong incentives to increase utilization of home dialysis modalities including PD[32–36].

While the number of pre-emptive kidney transplantations performed for LN ESRD has gradually increased, there are still few performed annually and recipients remain younger, more White, and overall healthier patients with private medical insurance. SLE disease activity and risk of recurrence may be one clinically important reason to postpone kidney transplantation. A traditional recommendation has been for LN patients to undergo at least 3–6 months of dialysis prior to renal transplantation with the goal of ensuring quiescent lupus[37]. In recent national data, the highest risks of recurrent LN after kidney transplantation were among African-Americans, women, and patients younger than 33 years old[17]. However, the absolute risks were low and the prevalence of recurrent nephritis after transplant for all LN ESRD patients was only 2.44% from 1987–2006. The increasing rate of pre-emptive kidney transplantation suggests that clinical practice may be changing with respect to the requirement of a period of time on dialysis to allow disease activity to subside before transplantation. While we have data on some clinical parameters at ESRD onset, no data concerning SLE disease duration, activity or organ damage are available for these patients and this is recognized as a limitation in our study.

Geographic access to transplant organs likely affects pre-emptive kidney transplantation rates. Lower rates of wait-listing for and receipt of kidney transplants among all-cause ESRD patients in the U.S. South have been demonstrated in past studies[38]. We found significant regional variation in the odds of receiving a pre-emptive kidney transplant for LN ESRD, with substantially lower likelihood in the U.S. South. In addition to regional differences, discrepancies in ESRD dialysis management and transplant referral practices exist among academic medical centers, community hospitals and private clinic settings. Patients living in rural areas with less access to academic centers have lower rates of kidney transplant wait-listing and transplantation[39]. Nephrology referrals tend to be delayed in rural areas where patients are being managed in smaller clinics and community hospitals. Late specialist referrals have been associated with tardy dialysis initiation, increased morbidity, worse long term survival rates and reduced rates of kidney transplantation among ESRD patients[26, 40, 41]. Unfortunately, the type of referring center, academic or community hospital, is not specified in the USRDS.

Another limitation of this study is the use of data reported by the attending nephrologist and staff on the USRDS Medical Evidence Report at the onset of ESRD for many baseline variables. Consistent completion of this form is expected as it is a U.S. government document establishing the onset of ESRD and qualification for Medicare insurance coverage, but missing data do exist for some of the baseline characteristics and some underreporting of comorbidities is known to occur[42]. The validity of the USRDS CMS Medical Evidence Report for the diagnoses of glomerulonephritis has recently been studied in a subpopulation of patients with renal biopsy results enrolled in the Glomerular Disease Collaborative Network[43]. The positive predictive value of a diagnosis of SLE was perfect, 100%, and the false positive rate was thus zero. However, the sensitivity of this diagnosis was low, only 27%, and many patients that were documented as having more general glomerulonephritis, were found to have LN on their renal biopsies. This implies that the cases included here do have true LN, although a substantial number of other cases were not included. Agreement between the form and biopsy results improved substantially after 1995,

when the form was revised[43], and only cases since 1995 were included in our analyses. Additionally, in the Glomerular Diseases Collaborative Network population agreement for individual disease diagnoses did not differ by sex, race, location of the nephrologist, or whether the biopsy was performed before or after the form was completed[43], suggesting that the population of LN ESRD patients not included in our study is similar to that included.

In addition to SLE disease activity, which may vary by race, ethnicity, age and sex, other pre-existing co-morbidities, financial and social circumstances are considered by patients and their providers in selecting the most suitable initial dialysis option. Our study was unable to account for cultural beliefs, educational background, and language barriers. These factors have been shown to influence decision-making concerning dialysis management and kidney transplantation[44–46]. The USRDS unfortunately also does not include data on marital status or other social support.

There are no other large observational studies of initial kidney replacement therapy type among patients with ESRD due to LN. Moroni and colleagues have observed that in their own clinical practice the initial selection of PD versus HD tended to be more common for younger, healthier and ambulatory LN ESRD patients[8, 47], and we have confirmed this in a much larger national cohort from a different country. We found that after adjustment for clinical and sociodemographic variables, African American compared to White race was associated with a 25% reduction in the odds of receiving initial PD compared to HD and a 79% reduction in the odds of receiving a pre-emptive kidney transplant. Exactly how complex decisions about kidney replacement therapy are made for and with LN ESRD patients is not known. Lupus disease severity likely differs among racial and ethnic groups, potentially influencing both the incidence of ESRD, choices of kidney replacement therapy, referral for transplantation[48] and ultimately outcomes from LN ESRD. Rheumatologists and primary care physicians may be unaware of the factors involved in the decision-making, and providers may make unfounded assumptions about patients' attitudes, preferences or adherence to care[49].

The current study provides data about the enormous sociodemographic variation that exists in the selection of kidney replacement modalities for LN ESRD patients in the U.S. The next step will be to evaluate the appropriateness of this variation and the comparative effectiveness of these therapies for LN ESRD patients. In future analyses, we intend to pursue these important and related avenues of research.

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Significance and Innovation

1. This is the first and only large observational study of initial kidney replacement therapy among patients with ESRD due to LN, with over 11,000 patients throughout the U.S. from 1995–2006.
2. Understanding the sociodemographic predictors of initial dialysis modality among LN ESRD patients is increasingly relevant as, in 2011 the Centers for Medicare and Medicaid Services (CMS) ESRD payment system has changed, effectively providing strong incentives to increase utilization of home dialysis modalities including PD.
3. These findings will lead to investigations of the appropriateness of this variation and the comparative effectiveness of these therapies for LN ESRD patients.

Table 1

Initial Type of Kidney Replacement Therapy among Individuals with new onset ESRD due to LN in U.S., 1995–2006

	Hemodialysis, 9,622 (85.0%)	Peritoneal Dialysis, 1,382 (12.2%)	p*	Pre-emptive kidney transplant, 313 (2.8%)	p**
Incidence year	**N (column %)**	**N (column %)**		**N (column %)**	
1995–1997	1922 (20.0)	397 (28.7)	**<0.001**	41 (13.1)	**<0.001**
1998–2000	2411 (25.1)	341 (24.7)		73 (23.3)	
2001–2003	2529 (26.3)	336 (24.3)		82 (26.2)	
2004–2006	2760 (28.7)	308 (22.3)		117 (37.4)	
Age Group, years					
18– 29	2612 (27.1)	307 (22.2)	**<0.001**	47 (15.0)	**<0.001**
30 – 39	2392 (24.9)	395 (28.9)		81 (25.9)	
40 – 49	2111 (21.9)	354 (25.6)		112 (35.8)	
>=50	2507 (26.1)	326 (23.6)		73 (23.3)	
Serum Albumin, mg/dl					
≤ 2.5	2618 (27.2)	160 (11.6)	**<0.001**	-	**<0.001**
2.6 – 3.2	2430 (25.3)	277 (20.0)		29 (9.3)	
≥ 3.3	2251 (23.4)	629 (45.5)		218 (69.7)	
Hemoglobin, mg/dl					
≤ 8.5	3024 (31.4)	296 (21.4)	**<0.001**	16 (5.1)	**<0.001**
8.6 – 10.0	2883 (30.0)	376 (27.2)		-	
≥ 10.1	2644 (27.5)	526 (38.1)		188 (60.1)	
Serum Creatinine, mg/dl					
≤ 6.0	3142 (32.7)	415 (30.0)	**0.001**	186 (59.4)	**<0.001**
6.1 – 8.4	3035 (31.5)	501 (36.3)		84 (26.8)	
≥ 8.5	3304 (34.3)	438 (31.7)		33 (10.5)	
BMI, kg/m2					
underweight, < 18.5	987 (10.3)	163 (11.8)	**<0.001**	25 (8.0)	0.294
normal weight, 18.5 – 25	4058 (43.2)	563 (40.7)		145 (46.3)	
overweight/obese, > 25	4257 (44.2)	575 (41.6)		134 (42.8)	
Sex					

	Hemodialysis, 9,622 (85.0%)	Peritoneal Dialysis, 1,382 (12.2%)	p*	Pre-emptive kidney transplant, 313 (2.8%)	p**
Female	7822 (81.3)	1183 (85.6)	**<0.001**	251 (80.2)	0.458
Male	1800 (18.7)	199 (14.4)		62 (19.8)	
Race					
White	4000 (41.6)	699 (50.6)	**<0.001**	251 (80.2)	**<0.001**
Black	4894 (50.9)	554 (40.1)		41 (13.1)	
Asian	467 (4.9)	97 (7.0)		17 (5.4)	
Native American	95 (1.0)	15 (1.1)		-	
Ethnicity					
Hispanic	1567 (16.3)	240 (17.4)	0.311	37 (11.8)	**0.030**
Non- Hispanic	8055 (83.7)	1142 (82.6)		276 (88.2)	
Medical Insurance					
Private	3640 (37.8)	703 (50.9)	**0.001**	221 (70.6)	**<0.001**
Medicaid	2311 (24.0)	199 (14.4)		18 (5.8)	
Medicare	2512 (26.1)	342 (24.8)		59 (18.9)	
No insurance	1035 (10.8)	109 (7.9)		-	
Employment at onset ESRD					
Employed	1912 (19.9)	448 (32.4)	**<0.001**	152 (48.6)	**<0.001**
Unemployed	7710 (80.1)	934 (67.6)		161 (51.4)	
Region of Residence*					
Northeast	1571 (16.3)	231 (16.7)	**0.004**	66 (21.1)	**<0.001**
Midwest	1789 (18.6)	256 (18.5)		87 (27.8)	
South	4262 (44.3)	558 (40.4)		76 (24.3)	
West	1899 (19.7)	312 (25.6)		83 (26.5)	
Puerto Rico and U.S. Islands	89 (0.9)	24 (1.7)		-	
Cigarette Smoking					
Current smoking	380 (4.0)	57 (4.1)	0.755	-	0.065
Not smoking	9242 (96.1)	1325 (95.9)		307 (98.1)	
Diabetes Mellitus					
No	8891 (92.4)	1303 (94.3)	**0.012**	305 (97.4)	**0.001**

	Hemodialysis, 9,622 (85.0%)	Peritoneal Dialysis, 1,382 (12.2%)	p*	Pre-emptive kidney transplant, 313 (2.8%)	p**
Yes	731 (7.6)	79 (5.7)		8 (2.6)	
Hypertension					
No	2528 (25.2)	299 (21.6)	**0.004**	88 (28.1)	0.179
Yes	7194 (74.8)	1083 (78.4)		225 (71.9)	
Coronary Artery Disease					
No	9054 (94.1)	1304 (94.4)	0.702	303 (96.8)	**0.046**
Yes	568 (5.9)	78 (5.6)		-	
Congestive Heart Failure					
No	8012 (83.3)	1258 (91.0)	**<0.001**	307 (98.1)	**<0.001**
Yes	1610 (16.7)	124 (9.0)		-	
Chronic Obstructive Pulmonary Disease					
No	9394 (97.6)	1360 (98.4)	0.070	312 (99.7)	**0.021**
Yes	228 (2.4)	22 (1.6)		-	
Peripheral Vascular Disease					
No	9280 (96.5)	1357 (98.2)	**<0.001**	308 (98.4)	0.089
Yes	342 (3.6)	25 (1.8)		-	
Cerebrovascular Disease					
No	9109 (94.7)	1333 (96.5)	**0.005**	301 (96.2)	0.311
Yes	513 (5.3)	49 (3.6)		12 (3.8)	
Cancer					
No	9479 (98.5)	1358 (98.2)	0.476	311 (99.4)	0.206
Yes	143 (1.5)	24 (1.7)		-	
Current Drug Abuse					
No	9543 (99.2)	1380 (99.9)	**0.006**	313 (100.0)	0.128
Yes	79 (0.8)	-		-	
Inability to Ambulate					
No	9397 (97.7)	1372 (99.3)	**<0.001**	313 (100.0)	**0.009**
Yes	225 (2.3)	-		-	
Inability to Transfer from Bed					

	Hemodialysis, 9,622 (85.0%)	Peritoneal Dialysis, 1,382 (12.2%)	p*	Pre-emptive kidney transplant, 313 (2.8%)	p**
No	9536 (99.1)	1376 (99.6)	0.079	313 (100.0)	0.104
Yes	86 (0.9)	-		-	

t-tests for continuous variables and Fisher's exact or Chi-squared tests for categorical variables

* comparison of PD to HD

** comparison of pre-emptive transplantation to any dialysis Missing data for PD vs. HD: albumin 2639, hemoglobin 1255, BMI 401, creatinine 169, race 183, medical insurance 153, region of residence 13.

Missing data for pre-emptive transplantation vs. dialysis: albumin 2700, hemoglobin 1301, BMI 410, serum creatinine 179, race 183, medical insurance 161, region of residence 13. All cell sizes under 11 are not shown according to USRDS policy.

Table 2

Age-Adjusted and Multivariable-Adjusted Odds Ratios for Receiving Initial Peritoneal Dialysis (vs. Hemodialysis) at LN ESRD Onset

	Age-adjusted OR (95% CI)	p	Multivariable- adjusted** OR (95% CI)	p***
Calendar year (per year increase)	0.94 (0.92, 0.95)	**<0.001**	0.93 (0.91, 0.95)	**<0.001**
Age group* (years)				
18–29	0.71 (0.61, 0.84)	**<0.001**	0.84 (0.71, 0.99)	**0.047**
30–39	1.0 (ref.)		1.0 (ref.)	
40–49	1.02 (0.87, 1.19)	0.846	0.93 (0.79, 1.1)	0.414
>=50	0.79 (0.67, 0.92)	**0.003**	0.73 (0.61, 0.87)	**<0.001**
Serum Albumin (mg/dl)				
≤ 2.5	0.53 (0.44, 0.65)	**<0.001**	0.57 (0.47, 0.71)	**<0.001**
2.6 – 3.2	1.0 (ref.)		1.0 (ref.)	
≥ 3.3	2.44 (2.09, 2.84)	**<0.001**	2.14 (1.83, 2.50)	**<0.001**
Hemoglobin (mg/dl)				
≤ 8.5	0.75 (0.66, 0.88)	**<0.001**	0.79 (0.67, 0.94)	**0.007**
8.6 – 10.0	1.0 (ref.)		1.0 (ref.)	
≥ 10.0	1.31 (1.09, 1.59)	**<0.001**	1.41 (1.21, 1.63)	**<0.001**
Serum Creatinine (mg/dl)				
≤ 6.0	0.81 (0.71, 0.93)	**0.003**	0.98 (0.84, 1.13)	0.757
6.1 – 8.4	1.0 (ref.)		1.0 (ref.)	
≥ 8.5	0.80 (0.70, 0.92)	**0.001**	0.79 (0.68, 0.91)	**0.001**
BMI (kg/m2)				
underweight, < 18.5	1.19 (0.99, 1.44)	0.068	1.15 (0.95, 1.41)	0.160
normal weight, 18.5 – 25	1.0 (ref.)		1.0 (ref.)	
overweight/obese, > 25	0.97 (0.85, 1.09)	0.581	0.98 (0.86, 1.12)	0.811
Sex				
Female	1.0 (ref.)		1.0 (ref.)	
Male	0.74 (0.63, 0.86)	**<0.001**	0.68 (0.58, 0.81)	**<0.001**
Race				
White	1.0 (ref.)		1.0 (ref.)	
Black	0.63 (0.56, 0.71)	**<0.001**	0.75 (0.65, 0.87)	**<0.001**
Asian	1.18 (0.93, 1.49)	0.171	1.18 (0.91, 1.54)	0.212
Native American	0.92 (0.53, 1.59)	0.755	1.22 (0.69, 2.17)	0.496
Ethnicity				
Non-Hispanic	1.0 (ref.)		1.0 (ref.)	
Hispanic	1.10 (0.95, 1.28)	0.213	1.01 (0.83, 1.21)	0.961
Medical Insurance				
Private	1.0 (ref.)		1.0 (ref.)	
Medicaid	0.45 (0.38, 0.54)	**<0.001**	0.61 (0.51, 0.73)	**<0.001**

	Age-adjusted OR (95% CI)	p	Multivariable- adjusted** OR (95% CI)	p***
Medicare	0.73 (0.64, 0.84)	**<0.001**	0.88 (0.75, 1.03)	0.102
No insurance	0.55 (0.44, 0.68)	**<0.001**	0.79 (0.63, 0.99)	**0.041**
Region of Residence				
Northeast	1.0 (ref.)		1.0 (ref.)	
Midwest	0.98 (0.81,1.18)	0.798	1.00 (0.82, 1.22)	0.994
South	0.90 (0.76, 1.06)	0.189	0.98 (0.82, 1.17)	0.811
West	1.12 (0.93, 1.35)	0.217	0.94 (0.77, 1.15)	0.551
Puerto Rico and U.S. Islands	1.86 (1.16, 2.99)	**0.010**	2.08 (1.24, 3.49)	**0.005**
Employment at onset ESRD				
Employed	1.0 (ref.)		1.0 (ref.)	
Unemployed	0.52 (0.45, 0.58)	**<0.001**	0.64 (0.56, 0.74)	**<0.001**
Cigarette Smoking				
No	1.0 (ref.)		1.0 (ref.)	
Yes	1.02 (0.77, 1.36)	0.892	1.20 (0.89,1.63)	0.239
Diabetes Mellitus				
No	1.0 (ref.)		1.0 (ref.)	
Yes	0.73 (0.58, 0.93)	**0.012**	0.95 (0.74, 1.22)	0.685
Hypertension				
No	1.0 (ref.)		1.0 (ref.)	
Yes	1.22 (1.06, 1.39)	**0.005**	1.43 (1.23, 1.65)	**<0.001**
Coronary Artery Disease				
No	1.0 (ref.)		1.0 (ref.)	
Yes	0.97 (0.76, 1.25)	0.818	1.14 (0.87, 1.49)	0.344
Congestive Heart Failure				
No	1.0 (ref.)		1.0 (ref.)	
Yes	0.49 (0.40, 0.59)	**<0.001**	0.58 (0.47, 0.71)	**<0.001**
Chronic Obstructive Pulmonary Disease				
No	1.0 (ref.)		1.0 (ref.)	
Yes	0.69 (0.44, 1.07)	0.097	0.77 (0.48, 1.23)	0.270
Peripheral Vascular Disease				
No	1.0 (ref.)		1.0 (ref.)	
Yes	0.51 (0.34, 0.77)	**0.001**	0.64 (0.42, 0.98)	**0.040**
Cerebrovascular Disease				
No	1.0 (ref.)		1.0 (ref.)	
Yes	0.65 (0.48, 0.88)	**0.005**	0.74 (0.54, 1.02)	0.063
Cancer*				
No	1.0 (ref.)		1.0 (ref.)	
Yes	1.18 (0.76, 1.83)	0.462	1.19 (0.75, 1.88)	0.461
Current Drug Abuse				

	Age-adjusted OR (95% CI)	p	Multivariable- adjusted** OR (95% CI)	p***
No	1.0 (ref.)		1.0 (ref.)	
Yes	0.17 (0.04, 0.68)	**0.013**	0.33 (0.08, 1.35)	0.123
Inability to Ambulate				
No	1.0 (ref.)		1.0 (ref.)	
Yes	0.30 (0.16, 0.58)	<**0.001**	0.40 (0.18, 0.91)	**0.030**
Inability to Transfer from Bed				
No	1.0 (ref.)		1.0 (ref.)	
Yes	0.50 (0.22, 1.14)	0.097	1.63 (0.54, 4.89)	0.385

OR (95%CI): odds ratio with 95% profile likelihood confidence intervals

* age alone in age-adjusted model

** adjusting for all variables listed in table

*** Wald chi square test for multivariable model

Table 3

Age-Adjusted and Multivariable-Adjusted Odds Ratios for Receiving Pre-emptive Kidney Transplantation (vs. Dialysis) at LN ESRD Onset

	Age-adjusted OR (95% CI)	p	Multivariable- adjusted** OR (95% CI)	p***
Calendar year (per year increase)	1.08 (1.05, 1.12)	**<0.001**	1.04 (1.00, 1.08)	0.063
Age group* (years)				
18–29	0.55 (0.39, 0.80)	**<0.001**	0.76 (0.51, 1.12)	0.164
30–39	1.0 (ref.)		1.0 (ref.)	
40–49	1.56 (1.17, 2.09)	**0.003**	1.08 (0.77, 1.49)	0.667
>=50	0.89 (0.64, 1.22)	0.462	0.61 (0.42, 0.89)	**0.010**
Serum Albumin (mg/dl)				
≤ 2.5	0.17 (0.07, 0.45)	**<0.001**	0.17 (0.07, 0.45)	**<0.001**
2.6 – 3.2	1.0 (ref.)		1.0 (ref.)	
≥ 3.3	6.88 (4.65, 10.17)	**<0.001**	4.66 (3.09, 7.03)	**<0.001**
Hemoglobin (mg/dl)				
≤ 8.5	0.25 (0.15, 0.44)	**<0.001**	0.40 (0.22, 0.70)	**0.001**
8.6 – 10.0	1.0 (ref.)		1.0 (ref.)	
≥ 10.1	3.03 (2.27, 4.05)	**<0.001**	1.76 (1.28, 2.41)	**<0.001**
Serum Creatinine (mg/dl)				
≤ 6.0	2.26 (1.74, 2.94)	**<0.001**	2.51 (1.87, 3.37)	**<0.001**
6.1 – 8.4	1.0 (ref.)		1.0 (ref.)	
≥ 8.5	0.37 (0.25, 0.55)	**<0.001**	0.46 (0.30, 0.71)	**<0.001**
BMI (kg/m^2)				
underweight, < 18.5	0.68 (0.45, 1.05)	0.083	0.92 (0.57, 1.47)	0.726
normal weight, 18.5 – 25	1.0 (ref.)		1.0 (ref.)	
overweight/obese, > 25	0.86 (0.68, 1.09)	0.213	0.94 (0.72, 1.23)	0.655
Sex				
Female	1.0 (ref.)		1.0 (ref.)	
Male	1.13 (0.86, 1.51)	0.384	1.07 (0.78, 1.47)	0.684
Race				
White	1.0 (ref.)		1.0 (ref.)	
Black	0.14 (0.10, 0.19)	**<0.001**	0.21 (0.15, 0.31)	**<0.001**
Asian	0.57 (0.35, 0.95)	**0.031**	0.44 (0.26, 0.77)	**0.004**
Native American	0.72 (0.26, 1.98)	0.524	0.69 (0.22, 2.14)	0.518
Ethnicity				
Non- Hispanic	1.0 (ref.)		1.0 (ref.)	
Hispanic	0.73 (0.52, 1.04)	0.078	0.51 (0.34, 0.76)	**0.001**
Medical Insurance				
Private	1.0 (ref.)		1.0 (ref.)	
Medicaid	0.16 (0.10, 0.25)	**<0.001**	0.35 (0.21, 0.60)	**<0.001**

	Age-adjusted OR (95% CI)	p	Multivariable- adjusted** OR (95% CI)	p***
Medicare	0.42 (0.31, 0.56)	**<0.001**	0.56 (0.40, 0.78)	**<0.001**
No insurance	0.13 (0.06, 0.28)	**<0.001**	0.28 (0.13, 0.62)	**0.002**
Employment at onset ESRD				
Employed	1.0 (ref.)		1.0 (ref.)	
Unemployed	0.28 (0.22, 0.35)	**<0.001**	0.57 (0.43, 0.75)	**<0.001**
Region of Residence				
Northeast	1.0 (ref.)		1.0 (ref.)	
Midwest	1.16 (0.84, 1.61)	0.365	1.09 (0.75, 1.58)	0.656
South	0.44 (0.32, 0.62)	**<0.001**	0.62 (0.43, 0.91)	**0.013**
West	1.04 (0.75, 1.45)	0.803	0.79 (0.54, 1.15)	0.209
Puerto Rico and U.S. Islands	0.25 (0.03, 1.81)	0.170	0.57 (0.07, 4.42)	0.590
Cigarette Smoking				
No	1.0 (ref.)		1.0 (ref.)	
Yes	0.44 (0.19, 0.99)	**0.046**	0.62 (0.26, 1.47)	0.277
Diabetes Mellitus				
No	1.0 (ref.)		1.0 (ref.)	
Yes	0.31 (0.15, 0.62)	**0.001**	0.57 (0.27, 1.19)	0.134
Hypertension				
No	1.0 (ref.)		1.0 (ref.)	
Yes	0.82 (0.64, 1.06)	0.123	0.97 (0.73, 1.29)	0.817
Coronary Artery Disease				
No	1.0 (ref.)		1.0 (ref.)	
Yes	0.49 (0.26, 0.93)	**0.030**	0.53 (0.27, 1.05)	0.070
Congestive Heart Failure				
No	1.0 (ref.)		1.0 (ref.)	
Yes	0.10 (0.05, 0.23)	**<0.001**	0.20 (0.09, 0.46)	**<0.001**
Chronic Obstructive Pulmonary Disease				
No	1.0 (ref.)		1.0 (ref.)	
Yes	0.13 (0.02, 0.95)	**0.045**	0.22 (0.03, 1.64)	0.140
Peripheral Vascular Disease				
No	1.0 (ref.)		1.0 (ref.)	
Yes	0.46 (0.19, 1.13)	0.089	0.85 (0.32, 2.23)	0.737
Cerebrovascular Disease				
No	1.0 (ref.)		1.0 (ref.)	
Yes	0.72 (0.40, 1.29)	0.273	0.94 (0.50, 1.76)	0.846
Cancer				
No	1.0 (ref.)		1.0 (ref.)	
Yes	0.38 (0.09, 1.55)	0.179	0.29 (0.07, 1.22)	0.091

OR (95%CI): odds ratio with 95% profile likelihood confidence intervals

* age alone in model

** adjusting for all variables listed in table

*** Wald chi square test for multivariable model comparing transplant to dialysis