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Hospital readmission among new dialysis patients associated with young age and poor functional status

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Abstract

Background/Aims—Over one-third of hospital discharges among dialysis patients are followed by 30-day readmission. The first year after dialysis start is a high-risk time frame. We examined the rate, causes, timing, and predictors of 30-day readmissions among adult, incident dialysis patients.

Methods—Hospital readmissions were assessed day 91 – 15 months after dialysis start using a Mayo Clinic registry linkage to United States Renal Data System claims; January 2001–December 2010.

Results—Among 1,727 patients with ≥1 hospitalization, 532 (31%) had ≥1, and 261 (15%) had ≥2 readmissions. Readmission rate was 1.1% per person-day post-discharge, and the highest rates (2.5% per person-day) occurred ≤5 days after index admission. Overall cumulative readmission rate was 33.8% at 30 days. Common readmission diagnoses included cardiac (22%), vascular (19%), and infection (13%). Similar-cause readmissions to index hospitalization were more

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common during days 0–14 post-discharge than days 15–30 (37.5% vs. 22.9%; P=.004). Younger age at dialysis initiation, inability to transfer/ambulate, serum creatinine ≤5.3 mg/dL, higher number of previous hospitalizations, and longer duration on dialysis were associated with higher readmission rates in multivariable analyses. Patients aged 18–39 were few (8.3%) but comprised 17.7% of "high-readmission" users such that a 30-year-old patient had an 87% chance of being readmitted within 30 days of any hospital discharge, whereas an 80-year-old patient had a 25% chance.

Conclusions—Overall, 30-day readmissions are common within the first year of dialysis start. The first 10-day period after discharge, young patients, and those with poor functional status represent key areas for targeted interventions to reduce readmissions.

Keywords

cardiovascular disease; death; heart failure; hemodialysis; hospitalization; mortality; youth

INTRODUCTION

Hospitalization among hemodialysis (HD) patients remains a significant healthcare burden and detractor of quality of life.[1] Among prevalent HD patients, readmission within 30 days of hospital discharge remains high at 35%. In an effort to impact quality of care in the dialysis facilities, the Centers for Medicare & Medicaid Services (CMS) End-Stage Renal Disease (ESRD) Quality Incentive Program presently includes hospital 30-day readmissions as a clinical measure.[2–4] A standardized readmission ratio is calculated for each outpatient dialysis facility, and those with a higher than expected readmission rate may eventually be subject to a payment reduction from CMS.[2,5]

Individuals new to dialysis represent the most vulnerable group of ESRD patients with increased healthcare utilization.[1,6–11] Among these patients, the first three-month period after dialysis initiation brings substantial life changes and is when hospitalizations are common and mortality risk is highest.[1,7–9,12–16] With approximately 110,000 patients initiating chronic HD yearly, the revolving door of admission and discharge followed by readmission becomes a significant challenge for quality of life optimization after ESRD onset. Early readmissions are concerning in that they may represent premature discharge, suboptimal care during the hospitalization or following discharge during a period of patient vulnerability, and diminished capacity for enacting self-care.[17,18]

Recent studies suggest that differences in readmission rates may be attributable to the patient population served.[19,20] Understanding the factors associated with hospitalization and subsequent readmission, particularly among incident HD patients within individual outpatient ESRD dialysis facilities, may offer important insight, allowing for targeted interventions, care coordination planning, and investment of limited resources in those in most need.

This study examined the rate, causes, timing, and factors associated with unplanned 30-day readmissions, during a one-year period after dialysis start, among incident HD patients from an integrated healthcare network in the Midwest U.S.A. Our goal was to further identify patient profiles comprising an at-risk group for whom smooth transitions of care and care coordination resources may be of most benefit, thereby reducing costs and increasing the overall value of care for incident HD patients.

MATERIALS AND METHODS

Data source and Cohort selection

The Mayo Clinic Health System provides comprehensive, integrated healthcare in an area with 395,000 residents in Southeast Minnesota, Northern Iowa, and Southwest Wisconsin. Mayo Clinic Dialysis Services (MCDS) provides all HD in the Mayo Clinic Health System and is staffed by Mayo Clinic nephrologists who also provide inpatient HD care, as previously described.[7,21] A list of all registered hemodialysis patients treated within MCDS between January 1, 2001 and December 31, 2010 was linked with the USRDS, a national data system that collects, analyzes, and distributes information about ESRD in the United States.[1] The present study inclusion criteria were: 1) linkage to USRDS, 2) first ESRD service between January 1, 2001 and December 31, 2010 according to Centers for Medicare & Medicaid Services medical evidence form (CMS-2728 form), 3) age ≥18 years, 4) Medicare as the primary payer, 5) available outpatient dialysis claims, 6) more than 90 days of follow up after ESRD start (USRDS researcher's guide[1]), 7) at least one hospitalization, and 8) survived hospitalization to discharge. All final cohort patients were incident +90 days. Consent requirement was waived and the Mayo Clinic Institutional Review Board approved this study.

Outcomes, Follow up, and Covariates

The primary outcome was unplanned 30-day readmissions from day 91 through 15 months after dialysis start. 30-day readmissions were further examined for rate, timing of readmission relative to index hospitalization, cause of readmission compared to index hospitalization, and factors relating to high healthcare utilizers for readmissions. Patients were censored at kidney transplantation or death, and were otherwise followed until they had no more claims (lost to follow up) or 15 months from ESRD diagnosis date. Hospitalization and 30-day readmission events were identified through review of administrative billing codes from the USRDS Standard Analytic Files. Readmission within one day of dismissal was counted as one hospitalization event. The time-at-risk for hospital admissions excluded inpatient days. A 30-day readmission was defined as hospital admission within 30 days of index hospitalization discharge. Planned readmissions (such as chemotherapy, pre-scheduled surgery, kidney transplantation, pregnancy/delivery, and rehabilitation) were excluded from analyses. Planned readmissions were identified using the Agency for Healthcare Research and Quality (AHRQ) Clinical Classifications Software (CCS) categories included in the CMS hospital-wide readmission measure used in the Hospital Inpatient Quality Reporting program.[22] Readmission rate was defined as the number of readmissions divided by the number of person-days at risk for readmission, up to 30 days after each hospital discharge. Cutoffs for readmission rate were defined by visual inspection of the distribution. Low and high readmission rates were defined as 0.01–1.00 and >1.00 readmissions per 30 person-days, respectively.

Cause of hospitalization and 30-day readmissions—Primary discharge diagnosis groups were defined according to CCS diagnosis categories.[23,24] Then CCS diagnosis categories were reviewed and combined into the following groups: cardiac, vascular, infection, gastrointestinal, endocrine, pulmonary, surgical, renal, hematology, neurology, other, psychiatry, rheumatology, orthopedic, dermatology, malignancy/oncology, trauma, and women's health. Readmissions were categorized as same-cause or different-cause readmission based on comparisons of primary discharge diagnosis group from index and readmission discharge diagnoses.

Demographics and comorbidities—Baseline demographics, characteristics, and covariates were collected from the CMS-2728, the USRDS Standard Analytic Files, and Mayo Clinic electronic medical records. The severity of co-morbid conditions was calculated and scored according to the Charlson Comorbidity Index using the first 90 days of claims data, CMS-2728 form, and applying an institutional protocol[25] to pull the principal diagnostic codes of the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9) administrative data. Missing baseline data (albumin, creatinine, hemoglobin, and body mass index [BMI]) were supplemented with Mayo Clinic electronic records at time of dialysis start.

Statistical Analyses

Baseline characteristics and covariates were summarized using descriptive statistics. To describe baseline characteristics in the incident cohort, patients were ranked by readmission rate based on the distribution of readmission rates per person. Comparisons between groups were performed using Chi-square and rank sum tests. Cumulative rate of first readmission was estimated using the Kaplan-Meier method. Unadjusted hospital rates were calculated by dividing the total number of events (hospital days, admissions, or 30-day readmissions) by total patient-years at risk. Expert consensus and risk adjustors for the dialysis population from the CMS standardized readmission ratio (sex, age, years on dialysis, diabetes as cause of ESRD, BMI at incidence of ESRD, days hospitalized during index admission, multiple comorbidities)[4] were used to select covariates included in the multivariable models. Frailty models, which are a similar to Cox models but allow for multiple events in the same subject, were used to model readmissions.[26] Time intervals were defined as time from the most recent hospital discharge to the next readmission within 30 days of discharge. Intervals were censored at the earliest of 30 days, transplant or death. Time-dependent covariates were used to represent characteristics that changed at each hospital discharge, e.g., number of previous hospitalizations, number of previous readmissions, and duration of dialysis. Smoothing splines were used to examine potential non-linear effects of the continuous covariates, and two-way interactions between age and the other covariates in the multivariable model were examined. The concordance (c) statistic, which is equivalent to the area under the receiver operating characteristic curve, was used to assess the predictive ability of the multivariable models.[27] *P* values <.05 were considered to be statistically significant. Analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC) and R 3.1.1 (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Study cohort and hospitalizations

Of 4,372 Mayo Clinic Dialysis Services (MCDS) patients linked to the United States Renal Data System (USRDS) – age ≥18 years and ESRD initiation 2001–2010 – we excluded 1,082 (25%) patients with ≤90 days of billing claims. An additional 305 (7%) were excluded due to lack of outpatient dialysis claims, and 1,132 were excluded due to lack of hospitalization during the study period. Another 126 patients were excluded due to death during their first hospitalization. The final study cohort consisted of 1,727 incident patients with at least one hospitalization who were alive at discharge. The unadjusted hospitalization rate was 2.20 per patient per year (PPY), and inpatient stays totaled 16.51 hospital days PPY. Excluding the first 3 months of dialysis, mean time to hospitalization after initiating dialysis was 2.96 (IQR 1.12, 6.12) months (range 0.03–12.0 months)

Baseline characteristics

To describe the study cohort by their readmission utilization patterns, patients were categorized into no (n=1,195), low (n=425), and high (n=107) readmission groups. Groups were based on the distribution of unplanned 30-day readmission rates per person during the study period (day 91 through 15 months after ESRD start), Table 1. Low and high readmission rates were defined as 0.01–1.00 and >1.00 readmissions per 30 person-days, respectively (Figure 1a). Of those with no readmissions, the median age at dialysis initiation was 67 years (Interquartile range [IQR]: 56,76), 59% were male, 58% had diabetes, median Charlson comorbidity score was 6, and diabetes was the most common ESRD cause (37%). Patients in the high readmission group had a higher percentage of patients aged <40 years, first dialysis treatment in the hospital, and higher proportion of patients with hemoglobin <10 g/dL or albumin <3.5 g/dL but lower serum creatinine compared to the other groups at dialysis start.

30-day readmissions

Approximately 31% (n=532) of the study cohort had at least one 30-day readmission from day 91 through 15 months after ESRD start, and 261 (15%) had ≥2 30-day readmissions. There were 1,107 30-day readmissions among these 532 patients with a median time to readmission of 11 days (IQR: 5, 19). The cumulative risk of first readmission was 12% at 14 days and 21% at 30 days from index hospitalization discharge. Accounting for multiple readmissions per patient, the readmission rate was 1.1% per person-day post-discharge corresponding to an overall cumulative readmission rate of 33.8% at 30 days post-discharge. Within the 30-day period following each index hospitalization, the highest readmission rates occurred within the first five days (Figure 1b).

Discharge diagnoses and timing of first readmissions

Cause of hospitalizations and first readmissions was determined by CCS discharge diagnoses. The most common discharge diagnoses for index hospitalization were cardiac (20%), vascular (17%), infectious (13%), gastrointestinal (13%), and endocrine (9%). Similarly, the most common discharge diagnoses for first readmission were cardiac (22%), vascular (19%), infectious (13%), gastrointestinal (12%), and endocrine (8%), Table 2. As expected, these diagnoses categories had the highest proportion of same-cause readmission diagnoses when compared to the preceding index hospitalization (Figure 2a). The frequencies of same-cause and different-cause diagnoses were further examined over time (Figure 2b). Among the first 30-day readmission experienced by patients, same-cause readmissions were more common during days 0–14 post-discharge than during days 15–30 (37.5% vs. 22.9%; P=.004). The highest frequency of same-cause discharge diagnoses between index and readmission was found within the first 5 days of index discharge date. In contrast, beyond 10 days of index discharge and date of readmission, the frequency of same-cause diagnoses was low.

Factors associated with 30-day readmissions

In univariable analysis, younger age at dialysis initiation, non-Caucasian race, inability to ambulate or transfer, serum albumin above 3.5 g/dL, higher number of prior hospitalizations and readmissions, and longer duration of dialysis were associated with readmissions (Table 3). In multivariable analyses, younger age, inability to transfer, serum creatinine ≤5.3 mg/dL, higher number of previous hospitalizations, and longer dialysis duration remained associated with readmissions. The relationship between the frequency of hospitalization and the rate of readmissions is shown in Figure 3. Patients with ≥10 hospitalizations during the study period accounted for 9% of all hospitalizations and, not surprisingly, had the highest rates of readmissions over the study period (5% per person-day; 95% CI, 4%–6%). Among this small group (n=28), the median age at dialysis initiation was 43 years (IQR: 31,60), 64% were female, 68% had diabetes, 50% had congestive heart failure, median Charlson comorbidity score was 6, diabetes was the ESRD cause in 46%, and 14% had inability to ambulate or transfer.

The relationship between age and readmission was also examined. Compared to older age groups, patients aged 18–39 had the highest cumulative 30-day readmission rate (42.5%). Overall, patients aged 18–39 were few (8.3%) but comprised 17.7% of the high-readmission group. As illustrated in Figure 4a, patients 18–29 years of age had the highest rates (41%) of 30-day readmissions. However, for age groups beyond 40 years, the rates of 30-day readmissions were still 25% or greater. The association with age and multiple readmissions is further explored in Figure 4b. Readmission rates per person, which were defined as rate per 30 days of follow-up, are expressed as a percentage, according to age at start of dialysis. The high readmission rate experienced by young incident patients is shown. The difference in risk between young and old is such that a 30-year-old patient has an 87% chance of being readmitted within 30 days of any hospital discharge, whereas an 80-year-old patient has a 25% chance of readmission.

DISCUSSION

In our USRDS-registry matched cohort of incident dialysis patients, hospitalizations and unplanned 30-day readmissions are common within the first year of dialysis start. The first 5 to 10 days following hospital discharge appear to be an at-risk period wherein readmission rates are highest, and readmission and index hospitalization discharge diagnoses are similar.

This suggests that this early period may represent unresolved issues from the prior hospital stay and thus might be a more appropriate surrogate marker for hospital quality or inadequate transitions to outpatient care. Whether dialysis units should be “held accountable” in quality metrics for these early readmissions could be debated. In this study, we identified young patients (aged 18–39 years) as a vulnerable population whose readmission healthcare utilization patterns classify them as “high users” at a rate disproportionate to their prevalence in the entire cohort. Other important factors associated with readmission included a surrogate for debility (inability to ambulate or transfer), lower baseline serum creatinine at the start of dialysis, longer time on dialysis, and a higher number of previous hospitalizations. Taken together, these results help identify critical time periods for early intervention after hospital discharge and a high-risk patient population for potentially cost-effective investment of focused care coordination services.

Our 30-day readmission rate (33.8%) from day 91 through15 months after dialysis start was similar to the 35.2% rate reported by the USRDS[1]. To better improve outcomes, determination of high-risk groups in various settings and patient populations is necessary.[7,28–32] Harel et al[33] conducted a population-based study of HD patients discharging from acute care hospitals (readmission rate 17%) in Ontario, Canada, and found older age, number of hospital admissions in the preceding 6 months, higher Charlson score, and mechanical ventilation therapy during the index hospitalization to associate with readmission. The USRDS annually reports on hospitalizations, and in the 2014 Annual Data Report they identified high-risk patient populations for hospitalizations including whites, African-Americans, and those with diabetes as the primary cause of ESRD. Alarmingly, among prevalent HD patients aged 20–44 years in 2012, 42.9% of hospitalizations were followed by a readmission within 30 days. Similarly, we determined that 42.5% of hospitalizations in young patients (aged 18–39 years) were followed by a readmission. For example, based on our incident cohort findings, a 30-year-old patient had an 87% chance of being readmitted within 30 days of any hospital discharge, whereas an 80-year-old patient had a 25% chance of readmission. These readmissions are prevalent in the young dialysis patient population may represent the culmination of psychosocial interactions or disturbances found in 1) patients dealing with chronic illnesses that were initiated in childhood or 2) patients with abrupt life changes occurring during their anticipated “prime” years.[34,35] Additional studies are needed to examine the factors relating to increased healthcare resource utilization in the young HD patient population.

As value-based payment models are implemented, dialysis providers need to develop financially-viable models and effective transitions of care for this population. Determining how, when, and in whom to invest expensive resources is increasingly important to the individual dialysis facility. While numerous studies on care transitions were performed and later systematically reviewed in the non-ESRD population,[18,36–38] studies examining effective ways to reduce hospitalizations and readmissions in ESRD patients are emerging.[39–42] Examining USRDS data from 2005–2008, Dalrymple et al.[43] found patterns of increased healthcare utilization in for-profit compared to nonprofit dialysis facilities, mostly due to a higher rate of heart failure or volume overload (37% higher) and vascular access complications (15% higher). Erickson et al.[44] determined that one additional provider visit to Medicare dialysis patients in the month following hospital discharge could lead to 31,370 fewer hospitalizations per year and $240 million per year saved. Lopes et al.[17] studied Dialysis Outcomes and Practice Patterns Study data in dialysis facilities in the United States, five European countries, and Japan and found that dialysis facilities with shorter median hospital length of stay as an adopted practice for their patients had a higher likelihood of readmission, particularly in the United States, suggesting that these patients left the hospital before their illness resolved or appropriate care coordination was arranged. We believe our study adds insight regarding: an important subset of patients, the incident dialysis population; the high-risk period of readmission to the hospital; and timing of when similarities exist in the discharge diagnoses for readmission and index hospitalization, each offering opportunities for intervention planning for transition of care.

Our study has limitations. The use of administrative data has the advantage of providing information on large numbers of patients.[45] However, there is potential bias in documentation and billing algorithms employed at individual centers. Moreover, our interpretation of clinical outcomes is limited by lack of detail surrounding the circumstances of hospitalizations (health literacy, functional impairment, language barriers, and level of social support[46]), which may be important factors that predict readmission. As with the majority of USRDS-based studies, by excluding the first 90 days in an incident cohort and restricting to Medicare as the primary payer to get the most complete data for all patients, we lose vital information about the first 3 months after dialysis start wherein hospitalizations are frequent and mortality rates are high.[8,9,13,14] Furthermore, cohort restriction to patients with Medicare as a primary payer limits the generalizability already diminished in our predominantly white population. However, in 2012 the ESRD Medicare population accounted for 82.5% of beneficiaries,[47] and our integrative practice allows for population-based estimates of ESRD for the Midwest population, which has been shown to be reasonably similar to the general US population.[1] Finally, our prolonged study period transitioned through changes in documentation requirements for the CMS 2728 form, which after 2005 provided more detailed data (dialysis access, laboratory tests, debility, health literacy, etc.), and which may have limited the ability to examine other important factors relating to 30-day readmission.

In conclusion, unplanned 30-day readmissions are common, especially within the first year of dialysis initiation, with the highest readmission risk period occurring within the first 5 days and related 30-day readmissions being more likely within the first 10 days post index hospitalization discharge. These findings call into question whether the current 30-day readmission measure is an appropriate surrogate marker of dialysis centers' quality of care for this high-risk population. Readmissions within 5 days of dismissal may more likely reflect hospital quality of care and lack of effective care handoffs at dismissal rather than the care provided by the dialysis unit. Conversely, readmissions unrelated to the index discharge diagnosis become dominant in the latter part of the 30 day interval and may reflect patient characteristics more than hospital quality of care or healthcare system effectiveness. Finally, young patients and those with poor functional status appear to be at highest risk. Our findings support efforts to devise interventional studies in the incident population, which optimize transitions of care and patient education early after hospital dismissal. As a result of these findings, we continue to modify our system-wide quality improvement project to redesign care for hospitalized individuals with ESRD by focusing on education, quality of life, goals of care, and shared decision-making.

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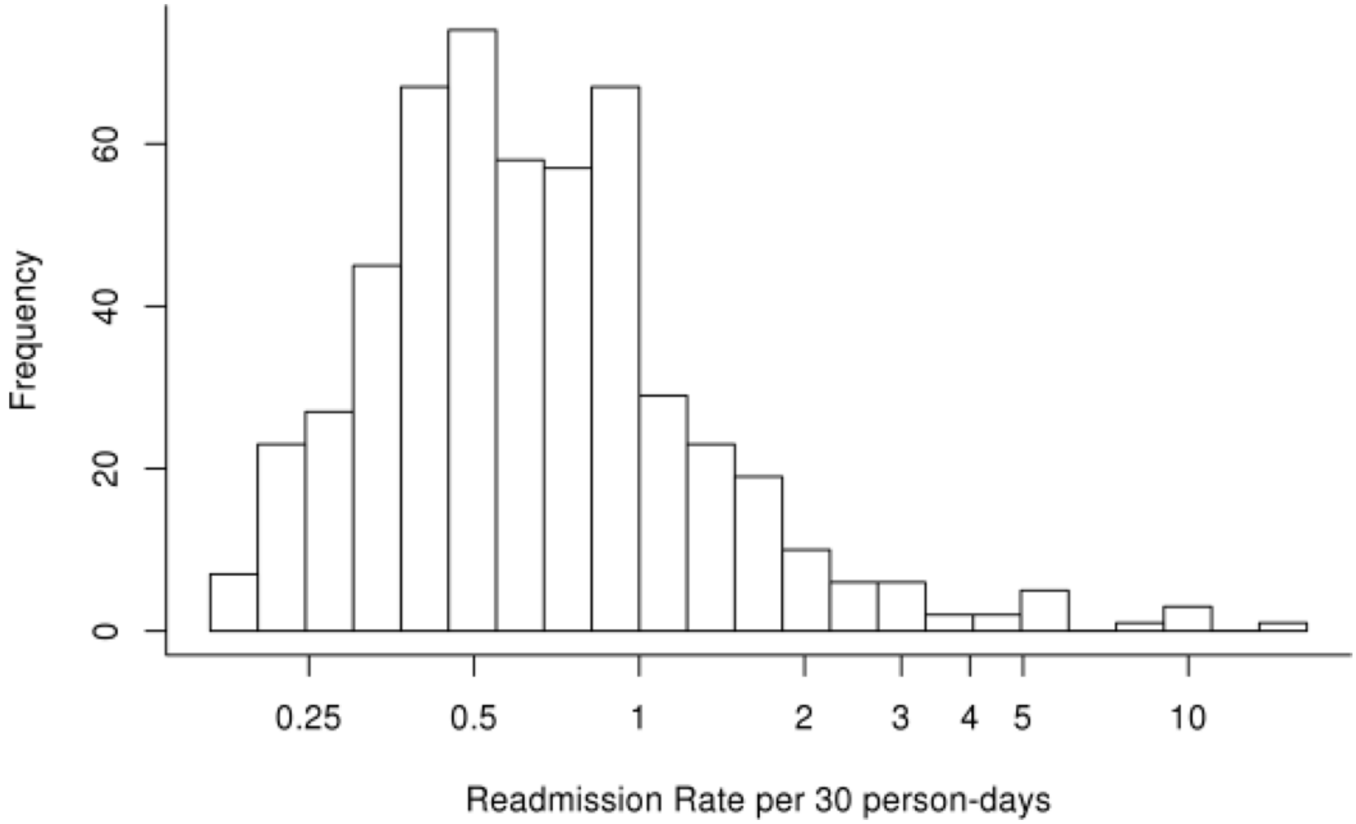

Frequency
0
20
40
60
0.25
0.5
1
2
3
4
5
10
Readmission Rate per 30 person-days

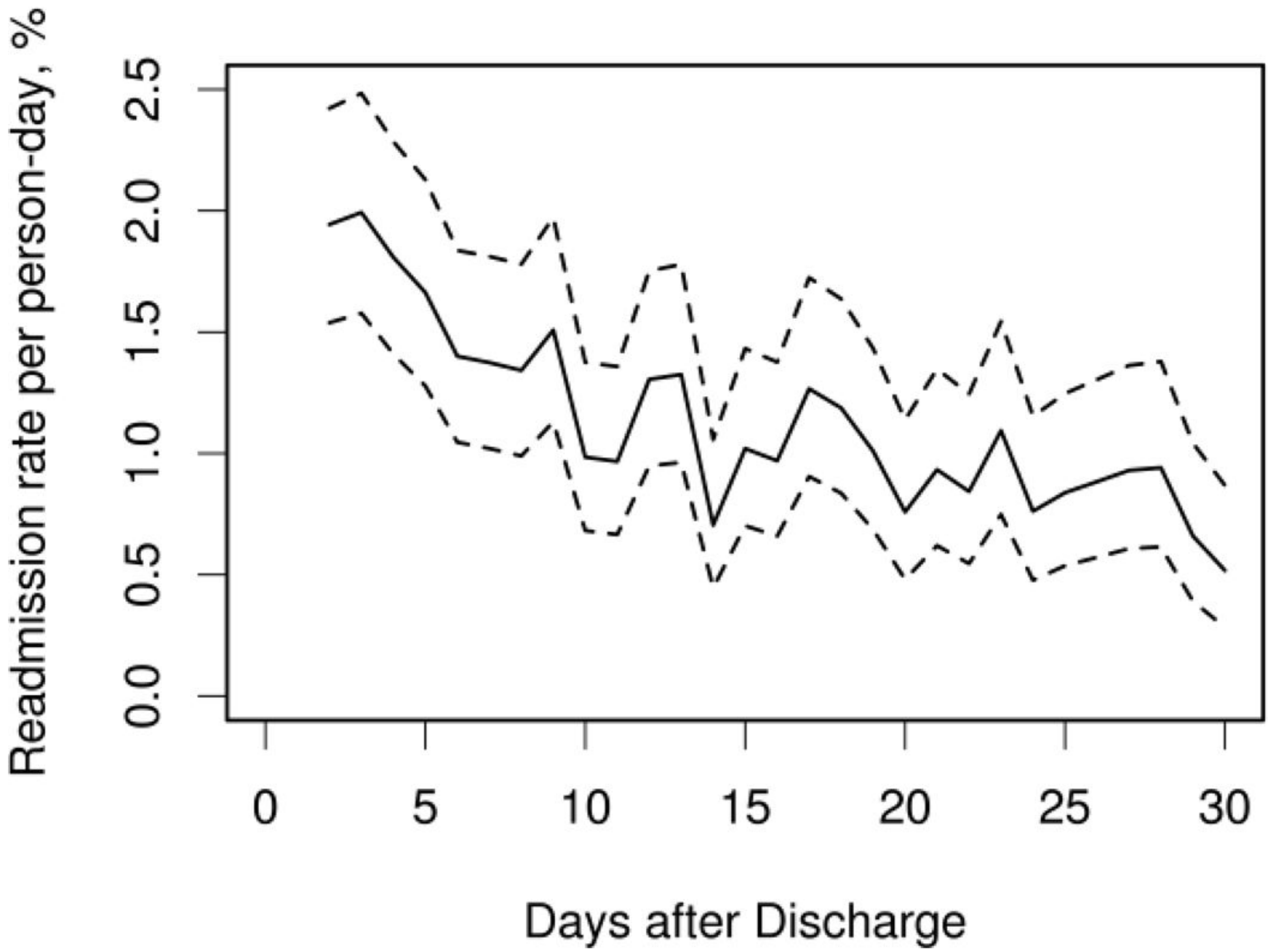
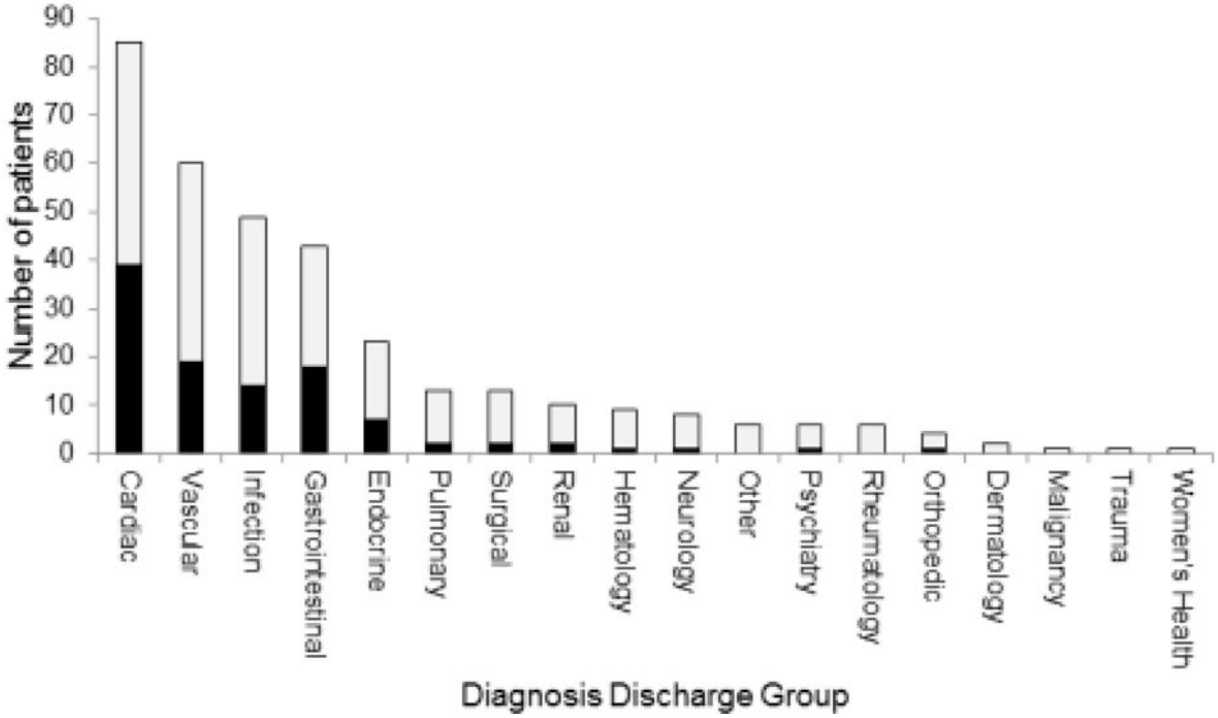


Figure 1.

(a) Distribution of 30-day readmission rates per person for incident hemodialysis patients with at least one 30-day readmission. **(b)** Incident hemodialysis readmission rate per person-day of follow-up according to days within the 30-day period after hospital discharge. Solid line is the readmission rate, expressed as a percentage, and the dashed lines are 95% confidence intervals.

a


90
80
70
60
50
40
30
20
10
0
Number of patients
Cardiac
Vascular
Infection
Gastrointestinal
Endocrine
Pulmonary
Surgical
Renal
Hematology
Neurology
Other
Psychiatry
Rheumatology
Orthopedic
Dermatology
Malignancy
Trauma
Women's Health
Diagnosis Discharge Group

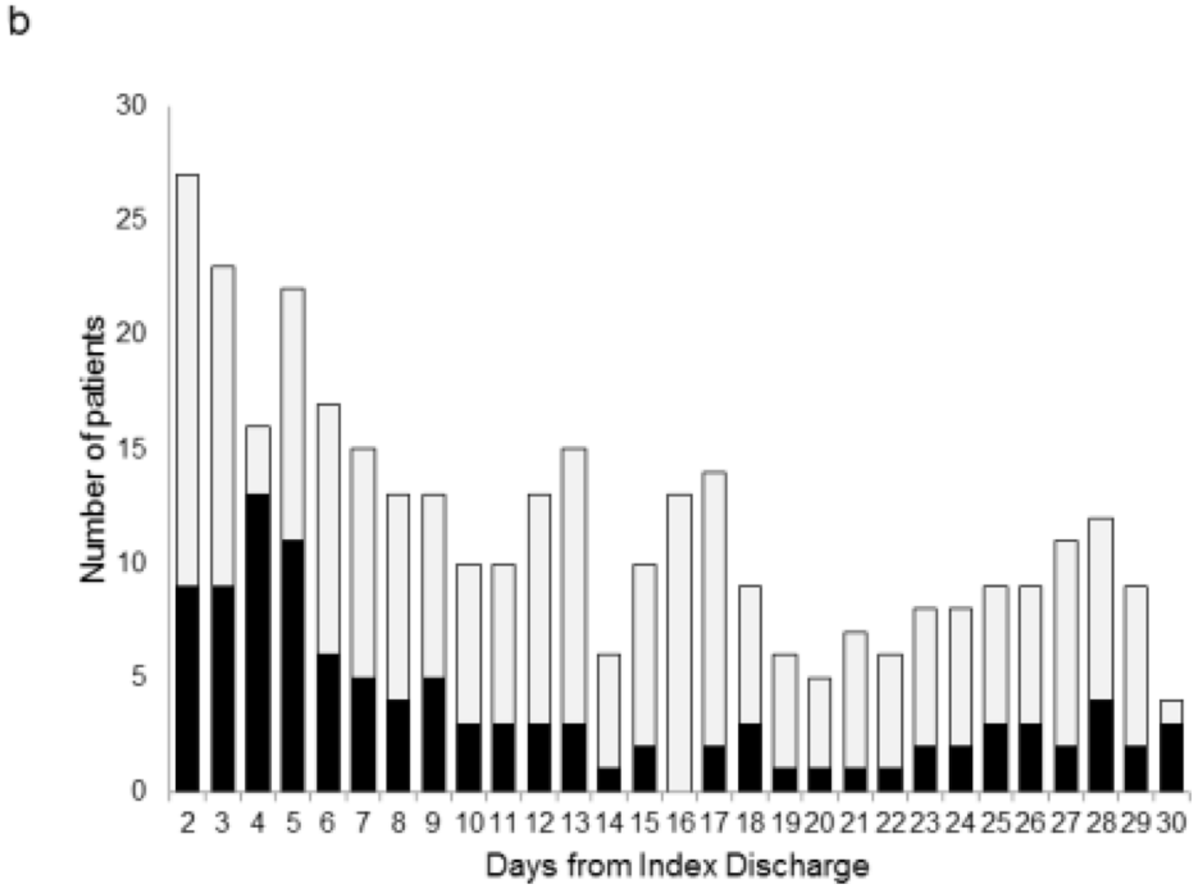
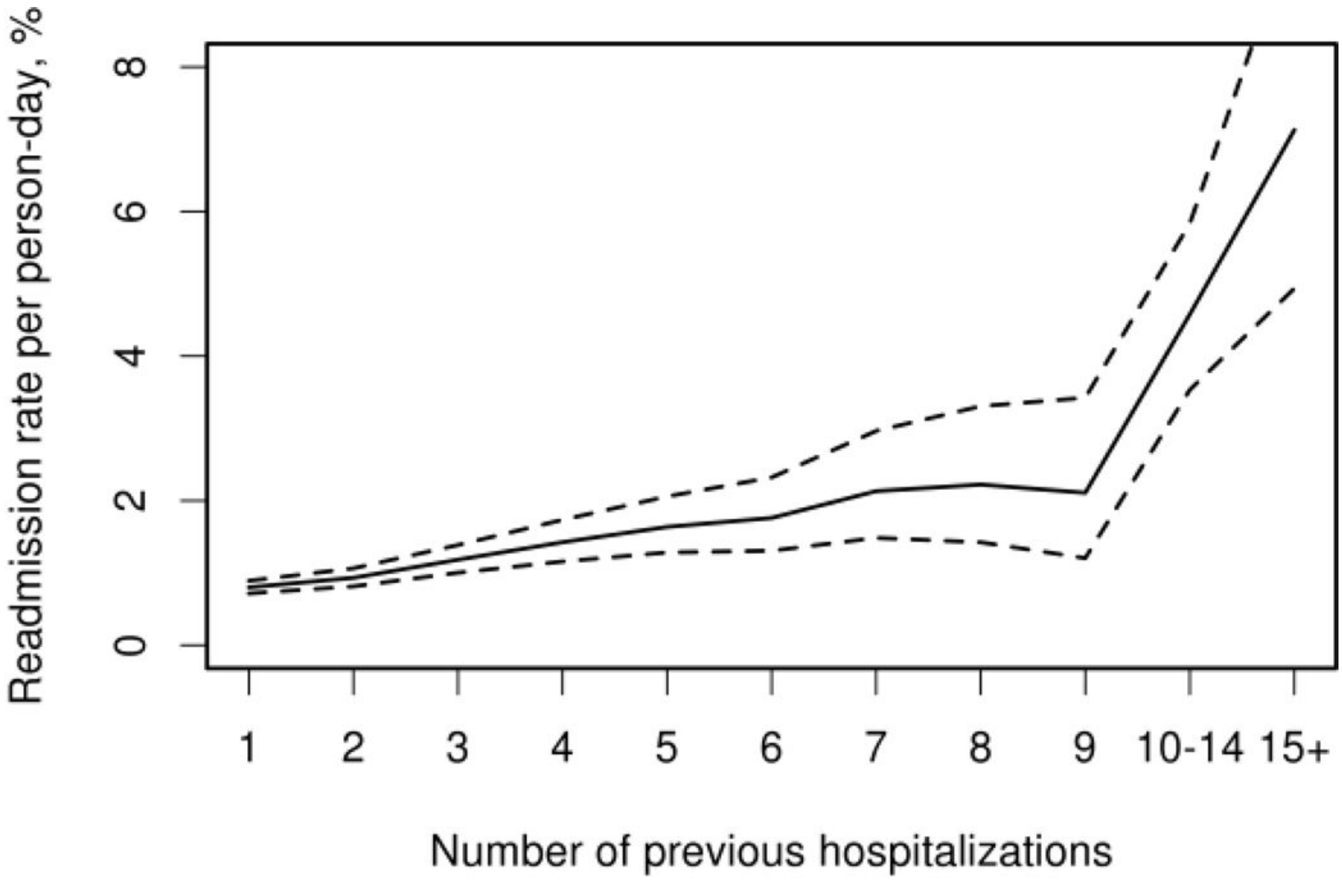


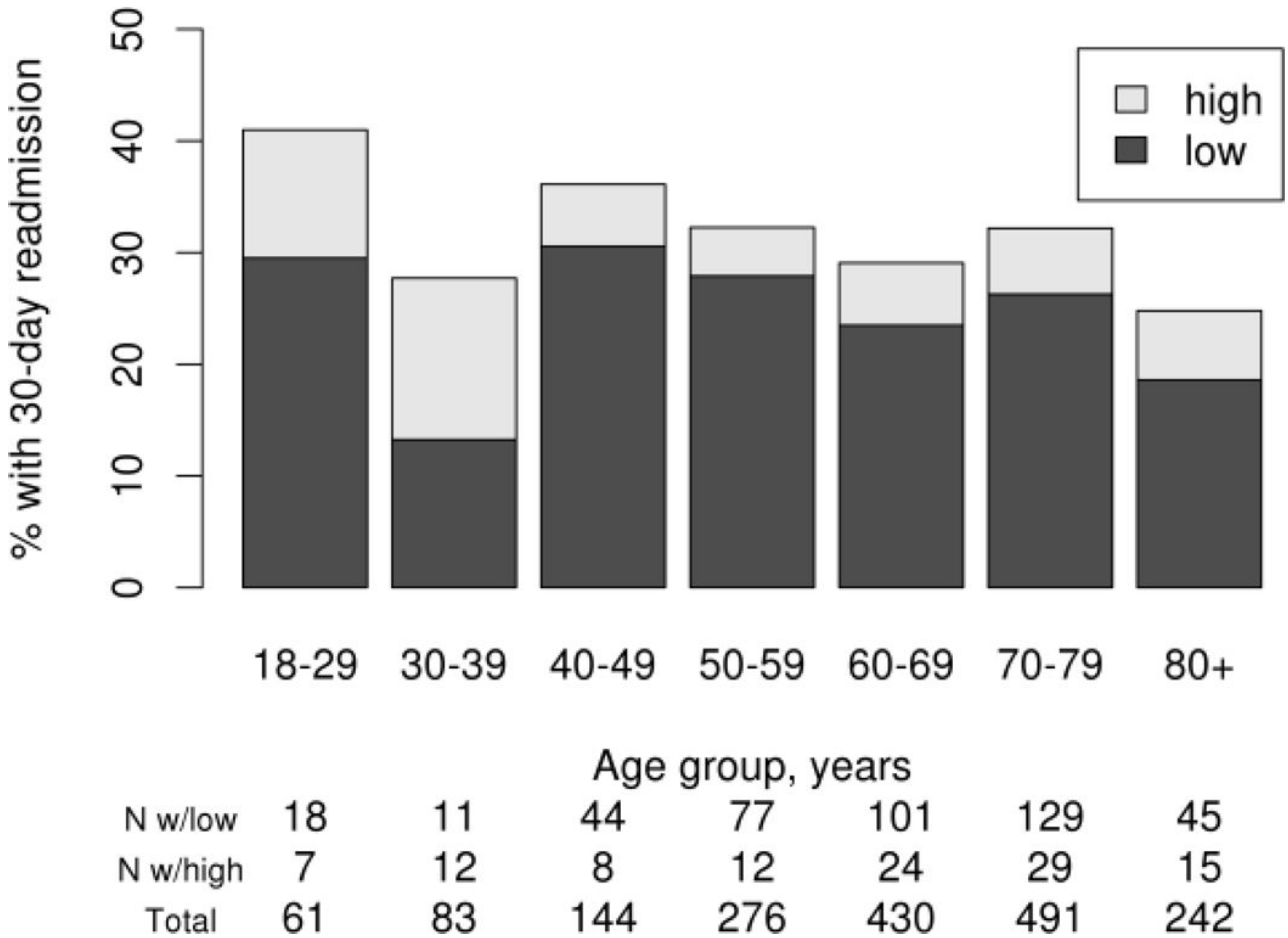
Figure 2.

(a) 30-day readmissions among incident hemodialysis patients classified as same-cause (black bars) or different-cause (white bars) discharge disease groups from the index hospitalization. **(b)** Number of incident hemodialysis patients with first 30-day readmission for the same-cause (black bars) or different-cause (white bars) discharge disease groups by days from index hospitalization to readmission.



	1	2	3	4	5	6	7	8	9	10-14	15+
N readmits	336	222	153	99	73	50	35	24	16	65	34
N patients	1670	962	547	308	197	133	81	56	37	28	7

Figure 3.
Readmission rate per person-day, expressed as a percentage, according to number of previous hospitalizations among incident hemodialysis patients.


% with 30-day readmission
0
10
20
30
40
50
high
low
18-29
30-39
40-49
50-59
60-69
70-79
80+
Age group, years
N w/low 18 11 44 77 101 129 45
N w/high 7 12 8 12 24 29 15
Total 61 83 144 276 430 491 242

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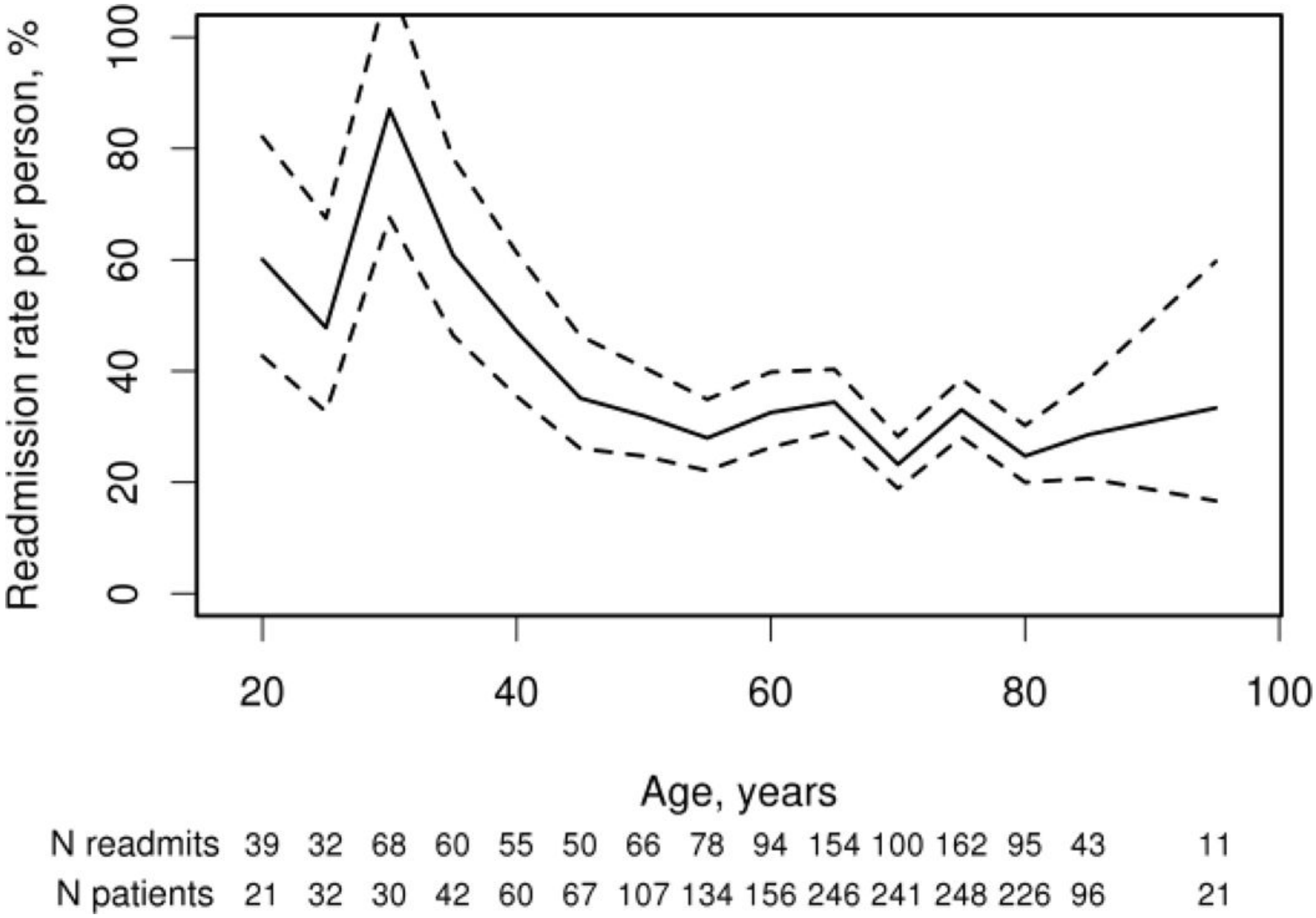

Figure 4.

(a) Percentage of incident hemodialysis patients with at least one 30-day readmission according to low or high readmission rating by age groups. **(b)** Readmission rate per person (defined as rate per 30 days of follow-up), expressed as a percentage, according to age at start of maintenance hemodialysis therapy.

Table 1

Baseline Characteristics and Laboratory Tests of Incident Dialysis Patients Having a Minimum of One Hospitalization Are Compared by Readmission Status/Rate

Characteristic	Readmission Status (%)[*]			*P*-value[†]
	No Readmission N=1195	Low Rate N=425	High Rate N=107	
Median (IQR) age in years at first ESRD service	67.0 (56.0, 76.0)	63.4 (54.0, 75.0)	67.0 (49.0, 75.0)	.12
18≤30	36 (3.0%)	18 (4.2%)	7 (6.5%)	.003
30≤40	60 (5.0%)	11 (2.6%)	12 (11.2%)	
40≤50	92 (7.7%)	44 (10.4%)	8 (7.5%)	
50≤60	187 (15.6%)	77 (18.1%)	12 (11.2%)	
60≤70	305 (25.5%)	101 (23.8%)	24 (22.4%)	
70≤80	333 (27.9%)	129 (30.4%)	29 (27.1%)	
80+	182 (15.2%)	45 (10.6%)	15 (14.0%)	
Sex, male	710 (59.4%)	259 (60.9%)	56 (52.3%)	.269
Race, White	1087 (91.0%)	373 (87.8%)	93 (86.9%)	.096
Body Mass Index	N=1181	N=421	N=107	
Median (IQR)	28.0 (23.9, 33.5)	27.3 (23.9, 33.3)	26.9 (23.2, 31.2)	.14
<18.5	29 (2.5%)	12 (2.9%)	3 (2.8%)	.56
18.5≤30	693 (58.7%)	244 (58.0%)	71 (66.4%)	
30+	459 (38.9%)	165 (39.2%)	33 (30.8%)	
First dialysis in Hospital	656 (54.9%)	262 (61.6%)	68 (63.6%)	.021
Dialysis access used at first outpatient dialysis treatment				.92
Catheter	522 (82.6%)	201 (83.4%)	53 (86.9%)	
Arteriovenous fistula	92 (14.6%)	35 (14.5%)	6 (9.8%)	
Graft	15 (2.4%)	4 (1.7%)	2 (3.3%)	
Other	3 (0.5%)	1 (0.4%)	0 (0.0%)	
Missing	563	184	46	
Primary Reason for ESRD				.54
Diabetes	441 (36.9%)	171 (40.2%)	32 (29.9%)	
Hypertension	265 (22.2%)	82 (19.3%)	24 (22.4%)	
Glomerulonephritis	163 (13.6%)	52 (12.2%)	16 (15.0%)	
Acute tubular necrosis	56 (4.7%)	18 (4.2%)	8 (7.5%)	
Cystic kidney disease	26 (2.2%)	6 (1.4%)	3 (2.8%)	
Other Cause	175 (14.6%)	76 (17.9%)	19 (17.8%)	
Unknown Cause	69 (5.8%)	20 (4.7%)	5 (4.7%)	
Charlson Score Weighted	N=1195	N=425	N=107	
Median (IQR)	6.0 (4.0, 8.0)	7.0 (4.0, 9.0)	6.0 (4.0, 8.0)	.008
Charlson score≥8	382 (32.0%)	167 (39.3%)	38 (35.5%)	.022
Diabetes Diagnosis	697 (58.3%)	266 (62.6%)	65 (60.7%)	.30
Heart Failure	655 (54.8%)	233 (54.8%)	64 (59.8%)	.60
Peripheral Vascular Disease	529 (44.3%)	216 (50.8%)	39 (36.4%)	.011

Characteristic	Readmission Status (%)*			P-value†
	No Readmission N=1195	Low Rate N=425	High Rate N=107	
Inability to ambulate/transfer	31 (2.6%)	20 (4.7%)	4 (3.7%)	.098
Baseline laboratory tests				
Albumin (g/dL)	N=994	N=360	N=107	
Median (IQR)	3.3 (2.8, 3.7)	3.1 (2.7, 3.6)	3.1 (2.7, 3.6)	.005
<3.5	591 (59.5%)	234 (65.0%)	62 (68.1%)	.07
Serum creatinine (mg/dL)	N=1184	N=423	N=106	
Median (IQR)	5.2 (4.0, 7.0)	5.13(3.9, 7.0)	4.6 (3.6, 5.8)	.008
≥5.3	591 (49.9%)	214 (50.6%)	37 (34.9%)	.010
Hemoglobin (g/dL)	N=1145	N=413	N=105	
Median (IQR)	10.1 (9.1, 11.1)	10.1 (9.3, 10.9)	10.1 (9.2, 11.0)	.17
<10	516 (45.1%)	188 (45.5%)	55 (52.4%)	.005

Abbreviations: ESRD, End-Stage Renal Disease; IQR, Interquartile Range

*Low and high readmission rates were defined as 0.01 to 1.00 and >1.00 readmissions per 30 person-days, respectively.

†*P*-values for 3 group comparisons.

Table 2

Primary Discharge Diagnoses of the Top Five Diagnosis Categories for All 30-day Readmissions occurring within the First Year after Dialysis Start.

CCS Major Diagnosis Category*	Descriptive of 30-day Readmission Diagnosis	Frequency
Cardiac		256
	Congestive heart failure; non-hypertensive	85
	Hypertension with complications and secondary hypertension	42
	Coronary atherosclerosis and other heart disease	31
	Nonspecific chest pain	27
	Cardiac dysrhythmias	24
	Acute myocardial infarction	19
	Pulmonary heart disease	8
	Syncope	5
	Pericarditis, endocarditis, myocarditis, cardiomyopathy	5
	Conduction disorders (3), Cardiac arrest and ventricular fibrillation (3), Other and ill-defined heart disease (2), Heart valve disorders (2)	10
Vascular		163
	Complication of device; implant or graft	125
	Other circulatory disease	16
	Peripheral and visceral atherosclerosis	7
	Phlebitis; thrombophlebitis and thromboembolism	7
	Gangrene (7), Aortic and peripheral arterial embolism or thrombosis (1)	8
Infection		156
	Septicemia (except in labor)	50
	Pneumonia (excluding tuberculosis or sexually transmitted disease etiologies)	39
	Urinary tract infections	21
	Skin and subcutaneous tissue infections	20
	Fever of unknown origin	10
	Viral infection (3), Encephalitis (3), Infective arthritis and osteomyelitis (2), Other infections (2), Other upper respiratory infections (1), Shock (1), Unspecified site bacterial infection (1), Mycoses (1), Sexually transmitted infections (not HIV or hepatitis) (2)	16
Gastrointestinal		138
	Intestinal infection	18
	Other liver diseases	18
	Gastrointestinal hemorrhage	18
	Other gastrointestinal disorders	10
	Pancreatic disorders (not diabetes)	9
	Nausea and vomiting	9
	Abdominal pain	8
	Intestinal obstruction without hernia	7

CCS Major Diagnosis Category*	Descriptive of 30-day Readmission Diagnosis	Frequency
	Diverticulosis and diverticulitis	7
	Other disorders of stomach and duodenum	6
	Biliary tract disease	6
	Esophageal disorders (5), Gastritis and duodenitis (5)	10
	Anal and rectal conditions (4), Peritonitis and intestinal abscess (3), Hemorrhoids (2), Noninfectious gastroenteritis (2), Abdominal hernia (1)	12
Endocrine		116
	Diabetes mellitus with complications	64
	Fluid and electrolyte disorders	46
	Other nutritional; endocrine; and metabolic disorders (5), Thyroid disorders (1)	6

*Discharge diagnosis groups are defined by the Agency for Healthcare Research and Quality Clinical Classifications Software (CCS) diagnosis categories.

Table 3

Frailty Models of All Readmissions during the Follow-Up Period

	Univariable Hazard Ratio (95% CI)	*P*-value	Multivariable Hazard Ratio (95% CI)	*P*-value
Age, per 10 years	0.92 (0.88, 0.96)	<.001	0.92 (0.88, 0.96)	<.001
Sex, male	0.92 (0.79, 1.08)	.32	0.94 (0.82, 1.08)	.41
Non-Caucasian	1.29 (1.03, 1.62)	.029	1.18 (0.97, 1.45)	.10
Charlson≥8	1.14 (0.97, 1.35)	.11	1.14 (0.96, 1.35)	.13
Low BMI (<18.5kg/m^2)	1.40 (0.89, 2.22)	.15	1.26 (0.87, 1.82)	.23
High BMI (≥30kg/m^2)	0.93 (0.79, 1.09)	.38	0.90 (0.78, 1.04)	.16
Hospital location of first dialysis	1.12 (0.95, 1.31)	.18	1.04 (0.89, 1.21)	.62
Diabetes as primary cause of ESRD	0.98 (0.84, 1.16)	.84	0.92 (0.79, 1.06)	.24
Diagnosis of diabetes mellitus	1.08 (0.92, 1.27)	.36		
Congestive heart failure	1.05 (0.89, 1.23)	.59	1.08 (0.92, 1.27)	.32
Peripheral vascular disease	1.00 (0.85, 1.17)	.95	0.96 (0.83, 1.12)	.63
Inability to ambulate/transfer	1.52 (1.05, 2.20)	.026	1.37 (1.02, 1.83)	.037
Albumin<3.5g/dL	0.87 (0.76, 0.98)	.026	0.94 (0.84, 1.04)	.23
Hemoglobin<10g/dL	0.95 (0.90, 1.00)	.075	0.96 (0.92, 1.01)	.13
Serum creatinine≥5.3mg/dL	0.88 (0.75, 1.03)	.11	0.86 (0.74, 0.99)	.037
Number of previous hospitalizations	1.15 (1.12, 1.17)	<.001	1.14 (1.11, 1.16)	<.001
Number of previous readmission	1.11 (1.08, 1.14)	<.001		
Duration of dialysis, months	1.34 (1.08, 1.67)	.008	1.39 (1.11, 1.73)	.004
C-statistic			0.661	

Abbreviations: BMI, Body Mass Index; CI, Confidence Interval; ESRD, End-Stage Renal Disease