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Outcomes of Infection-Related Hospitalization in Medicare Beneficiaries Receiving In-Center Hemodialysis

Lorien S. Dalrymple, M.D., M.P.H.[1], **Yi Mu, M.S.**[2], **Patrick S. Romano, M.D., M.P.H.**[1], **Danh V. Nguyen, Ph.D.**[3], **Glenn M. Chertow, M.D., M.P.H.**[4], **Cynthia Delgado, M.D.**[5], **Barbara Grimes, Ph.D.**[6], **George A. Kaysen, M.D., Ph.D.**[1], and **Kirsten L. Johansen, M.D.**[5,7]

[1]Department of Medicine, University of California Davis, CA

[2]Department of Public Health Sciences, University of California Davis, CA

[3]Department of Medicine, University of California Irvine, CA

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

[5]San Francisco Department of Veterans Affairs Medical Center, CA

[6]Department of Epidemiology and Biostatistics, University of California San Francisco, CA

[7]Departments of Medicine, Epidemiology and Biostatistics, University of California San Francisco, CA

Abstract

Corresponding Author: Lorien S. Dalrymple, M.D., M.P.H., Division of Nephrology, 4150 V Street, Suite 3500, Sacramento, CA 95817, TEL: (916) 734-3774; FAX: (916) 734-7920, Lorien.Dalrymple@ucdmc.ucdavis.edu.

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Supplementary Material

Table S1: *ICD-9-CM* diagnosis codes.

Table S2: Baseline characteristics of patients with and without infection during follow-up.

Table S3: Baseline characteristics associated with 30-d readmission or death prior to readmission.

Note: The supplementary material accompanying this article (doi:_____) is available at www.ajkd.org

Descriptive Text for Online Delivery of Supplementary Material

Supplementary Table S1 (PDF)

ICD-9-CM diagnosis codes.

Supplementary Table S2 (PDF)

Baseline characteristics of patients with and without infection during follow-up.

Supplementary Table S3 (PDF)

Baseline characteristics associated with 30-d readmission or death prior to readmission.

Background—Infection is a common cause of hospitalization in adults receiving hemodialysis. Limited data are available on downstream events resulting from or following these hospitalizations.

Study Design—Retrospective cohort study using the US Renal Data System.

Setting & Participants—Medicare beneficiaries initiating in-center hemodialysis 2005 – 2008.

Factors—Demographics, dual Medicare/Medicaid eligibility, body mass index, comorbid conditions, initial vascular access type, nephrology care prior to dialysis initiation, residence in a care facility, tobacco use, biochemical measures, and type of infection.

Outcomes—30-day hospital readmission or death following first infection-related hospitalization.

Results—60,270 Medicare beneficiaries had at least one hospitalization for infection. Of those who survived the initial hospitalization, 15,113 (27%) were readmitted and survived the 30 days following hospital discharge, 1,624 (3%) were readmitted to the hospital and then died within 30-days of discharge, and 2,425 (4%) died without hospital readmission. Complications related to dialysis access, sepsis, and heart failure accounted for 12%, 9%, and 7% of hospital readmissions, respectively. Factors associated with higher odds of 30-day readmission or death without readmission included non-Hispanic ethnicity, lower serum albumin, inability to ambulate or transfer, limited nephrology care prior to dialysis, and specific types of infection. In comparison, older age, select comorbidities, and institutionalization had stronger associations with death without readmission than with readmission.

Limitations—Findings limited to Medicare beneficiaries receiving in-center hemodialysis.

Conclusions—Hospitalizations for infection among patients receiving in-center hemodialysis are associated with exceptionally high rates of 30-day hospital readmission and death without readmission.

INDEX WORDS

infection; infection-related hospitalization; hospital readmission; transitions of care; survival; mortality; hemodialysis; end-stage renal disease (ESRD); Medicare beneficiaries; discharge diagnosis; dialysis access; sepsis

Infection accounts for nearly one-fourth of hospitalizations in patients receiving hemodialysis.[1] Despite the recognition that infection is a common complication of end-stage renal disease (ESRD)[1–4] few studies have examined consequences of these hospitalizations. Among Hemodialysis (HEMO) Study participants, 58% of infection-related hospitalizations were complicated by hospitalization for 7 or more days, intensive care unit (ICU) care, or death.[5] Furthermore, among patients on hemodialysis in the United States hospitalized for an infection in 2011, approximately one-third were readmitted within 30 days,[1] highlighting the high risk of readmission following hospitalization for an infection in this population.

Factors that portend poor outcomes among adults on hemodialysis hospitalized for infection and the leading causes of readmission or death are not well described. Examining risk factors for, and outcomes following, infection-related hospitalization could aid in the

identification of effective interventions to reduce associated risks. In the current study, we examine outcomes following hospitalization for infection among Medicare beneficiaries receiving in-center hemodialysis, with a focus on factors associated with 30-day readmission and death without readmission.

METHODS

Study Cohort and Data Collection

We assembled data from the US Renal Data System (USRDS) on Medicare part A and B beneficiaries who initiated dialysis from January 1, 2005 through June 30, 2008, survived the first 90 days of dialysis, and were receiving in-center hemodialysis at a free-standing dialysis facility with known profit status on day 91.[6] We retrieved baseline data on age; sex; race; ethnicity; co-morbidities including diabetes, heart failure, hypertension, chronic obstructive pulmonary disease (COPD), coronary artery disease, peripheral vascular disease, cerebrovascular disease (cerebrovascular accident or transient ischemic attack (CVA/TIA), cancer and amputation; tobacco use; vascular access type; and Quételet's (body mass) index (BMI) at dialysis initiation, nephrology care and biochemical studies (serum creatinine, albumin and hemoglobin concentrations) prior to dialysis initiation, and residence in a care facility (nursing home, assisted living or other) at dialysis initiation (Centers for Medicare & Medicaid Services [CMS] Form 2728). We ascertained dual Medicare/Medicaid eligibility from the USRDS. We classified region as Northeast, South, Midwest or West based on the ESRD network.

Infection-Related Hospitalization

We focused on the first infection-related hospitalization after day 90 of dialysis. Medicare beneficiaries were observed for an infection-related hospitalization until the time of transplantation, recovery of kidney function, change in dialysis modality, loss to follow-up, death or study end. We limited our study to infection-related hospitalizations with discharge dates at least 30 days prior to December 31, 2009, to allow for complete assessment of 30-day outcomes. We included hospitalizations for which the date of admission was the same as the date of discharge and we combined hospitalizations with overlapping dates of admission and discharge into a single hospitalization, with discharge diagnoses selected from the hospital record with the earliest start date or longest length of stay (8% of all hospitalizations in our cohort). This approach minimizes the likelihood of counting admissions/transfers directly to inpatient rehabilitation facilities or other acute inpatient facilities as hospital readmissions, as the latter hospitalizations would have been combined into a single hospitalization record.

Infection-related hospitalization was ascertained by identifying hospitalizations with a *principal* discharge diagnosis of selected *International Classification of Diseases, 9th revision, Clinical Modification* (*ICD-9-CM*) codes (Table S1, available as online supplementary material).[7–9] We limited our examination to those infection-related diagnoses outlined in the supplemental material. We generally excluded the following types of infection: those commonly only found in infants or children, hepatitis B and C virus, HIV, cholecystitis associated with cholelithiasis/choledocholithiasis, infections specified as

chronic (e.g., chronic osteomyelitis or amputation infection [chronic]), sexually transmitted diseases (e.g., chlamydia, gonorrhea, syphilis, pelvic inflammatory disease), pregnancy-related infections, or those that could not be classified into an organ system or an organ system of interest. Furthermore, we excluded rare parasitic or protozoal diseases and limited our ascertainment of tuberculosis-related diagnoses to select pulmonary infections (e.g., pulmonary, lung, bronchus). The types of selected infections were broadly classified into mutually exclusive categories: 1) blood stream infections or sepsis (i.e., bacteremia, candidemia, viremia, or sepsis); 2) pulmonary; 3) genitourinary; 4) gastrointestinal, peritonitis, or hepatobiliary; 5) skin and soft tissue; 6) bone and joint; 7) cardiovascular; 8) central nervous system; 9) dialysis access (including peritoneal dialysis access) or central venous catheters; or 10) device, procedure, or surgery-related (not related to dialysis access). Due to the small number of cardiovascular and central nervous system infections, these were subsequently combined into one category.

For the first infection-related hospitalization, we also collected data on the hospital length of stay (LOS), whether ICU or coronary care unit (CCU) care was required (identified using USRDS hospitalization data), and the use of invasive mechanical ventilation (identified using procedure codes 96.70, 96.71, 96.72). To ascertain whether an adult received care in an ICU or CCU or required mechanical ventilation, all hospital records were examined prior to combining the overlapping hospital records.

Outcomes of Infection-Related Hospitalization

We examined 30-day outcomes after the first infection-related hospitalization among patients who survived the index hospitalization. If patients underwent transplantation (n=35) or were lost to follow-up (n=1) within 30 days following the index hospitalization, they were not included in the examination of outcomes. The primary outcomes of interest were readmission or death without readmission within 30 days of hospital discharge. For descriptive purposes, we also examined death following hospital readmission *and* within 30 days of discharge (death either during the hospital readmission or following discharge from the readmission hospitalization). Similar to examination of the index hospitalization, we included hospitalizations where the date of admission was the same as the date of discharge and hospitalizations with overlapping dates of admissions and dates of discharge were combined into a single hospitalization. Principal causes of readmission were examined and grouped based on 3-digit *ICD-9-CM* codes. Causes of death were classified based on the ESRD Death Notification Form (Form CMS-2746-U3).

Statistical Analyses

We examined and summarized baseline characteristics of the cohort using the Kruskal-Wallis test for continuous variables and the Chi-square test for categorical variables. To examine factors associated with 30-day hospital readmission or death, we used multinomial logistic regression with the following outcomes: readmission, death without readmission, or neither within 30 days of discharge (referent outcome category). To focus on the first clinical event after discharge, we classified patients who were readmitted and then died as readmission in the multinomial logistic regression model. We elected *a priori* to examine sequential multinomial models, the first limited to patient characteristics, the second

additionally accounting for the type of infection, and the third further accounting for processes of care during the first hospitalization. In our first model, we included baseline demographics, dual Medicare/Medicaid eligibility, BMI, comorbid conditions, initial vascular access type, nephrology care prior to dialysis initiation, residence in a care facility at dialysis initiation, tobacco use, estimated glomerular filtration rate (based on the 4-variable Modification of Diet in Renal Disease Study equation),[10] and serum albumin. In our second model, we further included the type of infection, combining select types into larger categories to account for small numbers. In our third model, we additionally included LOS (as quartiles), ICU/CCU care or mechanical ventilation during the index hospitalization. Of those with at least one infection-related hospitalization, the percent with missing data for select data elements was as follows: 24%, albumin; 0.3%, eGFR; 0.3%, initial vascular access type; and 1.3%, BMI. Inference under missing data was based on multiple imputation,[11] with 10 imputed datasets; individual point and variance estimates were obtained from fitting multinomial logistic regression to each of the 10 imputed datasets and the results were combined to provide valid inferences that properly account for the uncertainty due to the missing data elements.

All data were analyzed using SAS 9.2 (SAS Institute Inc). Our study did not involve human subjects as defined by the University of California Davis Institutional Review Board.

RESULTS

Our initial cohort included a total of 140,665 Medicare beneficiaries on in-center hemodialysis. Of these, 60,270 developed at least one infection-related hospitalization during follow-up. Patients observed to have at least one infection were followed up for a median of 204 (interquartile range [IQR], 72–449) days whereas those not observed to have an infection during our study timeframe were followed for a median of 586 (IQR, 215–928) days. The time to first infection-related hospitalization differed by initial vascular access type with a median time to infection of 187 (IQR, 67–422) days for those with a dialysis catheter as compared to 329 (IQR, 139–598) days in those using an arteriovenous fistula at the dialysis initiation. Patients who had at least one infection-related hospitalization had a mean age of 65.5 years, 52% were male, 65% were white, 83% initiated dialysis with a catheter, and 9% were residing in a nursing home at dialysis initiation (Table S2). As expected, differences were observed between patients who did and did not have an infection during follow-up (Table S2). Baseline patient characteristics differed by the type of infection-related hospitalization (Table 1).

The leading causes of hospitalization for infection were dialysis access or central venous catheter-related infections (30%), blood stream infections or sepsis (24%), and pulmonary infections (22%) whereas cardiovascular (<1%) and central nervous system (<1%) infections were relatively rare. For the first infection-related hospitalization, the median length of hospital stay was 6 (IQR, 3–10) days, 22,581 (37%) required ICU- or CCU-level care, 3,267 (5%) required mechanical ventilation, and 5,238 (9%) died. In-hospital mortality differed by type of infection and ranged from 2% to 22% depending on the type of infection (Table 2). Of all deaths during the index hospitalization, 60% were observed in adults with an admission for blood stream infection or sepsis and 17% were observed in adults with an

admission for hemodialysis access-related infections. The observed 30-day mortality was highest for blood stream infections or sepsis and cardiovascular or central nervous system infections (Table 2).

Of those who survived the initial hospitalization and were available for 30-day follow-up (n=54,996), 2,425 (4%) died without hospital readmission, 1,624 (3%) were readmitted to the hospital and then died within 30-days of discharge, and 15,113 (27%) were readmitted and survived the 30 days following hospital discharge. Readmission differed by the type of infection(range,28%–42%; Table 2).

The overall median time to 30-day readmission was 12 (IQR, 6–21) days. Based on principal diagnoses categorized at the three-digit *ICD-9-CM* level, 15% of readmissions were associated with “Complications Peculiar to Certain Specified Procedures” (which includes infection and inflammation due to a vascular device, implant or graft and complications related to renal dialysis devices, implants or grafts). The ten leading causes of readmission are shown in Table 3. Within each of these broad categories, the median time to readmission ranged from 11 to 14 days. We further examined cause-specific readmission using the three leading 4-digit and 5-digit *ICD-9-CM* sub-classifications within each 3-digit category (Table 3).

Among patients who survived the initial hospitalization and died within 30 days of discharge, 2,425 (4%) died without hospital readmission and the median time to death among these patients was 6 (IQR, 2–13) days. Overall, 21% had no listed cause of death in the USRDS. Among patients with a defined cause of death, the leading causes were similar between those who died before as compared to after hospital readmission (Table 4), but discontinuation of dialysis/uremia was more common in the former (22%) than in the latter (10%).

In multivariable multinomial logistic models, we first examined baseline characteristics associated with readmission or death within 30 days of discharge among patients who survived the initial hospitalization, classifying patients as having: readmission, death without readmission, or neither within 30-days of discharge (Table S3). Further accounting for the type of infection did not substantively change associations between baseline characteristics and the risk of 30-day readmission or death (Table 5). Non-Hispanic ethnicity, lower serum albumin concentrations, lower BMI, inability to ambulate or transfer and the absence of nephrology care prior to dialysis were strongly associated with readmission and death without readmission whereas older age, white race, several comorbid conditions, and residence in a skilled nursing facility were more strongly associated with death without readmission. Patients in the South, Midwest and West had lower odds of hospital readmission and higher odds of death without readmission than patients living in the Northeast (Table 5). Blood stream infections or sepsis and cardiovascular or CNS infections were associated with the highest odds of death. Cardiovascular or CNS infections were associated with the highest odds of 30-day readmission (Table 5).

In the final model, we additionally examined associations among the LOS, mechanical ventilation, or the need for ICU or CCU care and the risk of adverse outcomes. Care in the

ICU or CCU was associated with 22% (95% confidence interval [CI], 17%–27%) higher odds of readmission and 64% (95% CI, 49%–80%) higher odds of death. Mechanical ventilation was associated with higher odds of readmission (odds ratio [OR], 1.18; 95 % CI, 1.04–1.33) and 2.5-fold higher odds of death (OR, 2.59; 95% CI, 2.17–3.08). Longer LOS was associated with higher odds of readmission. As compared with a hospital LOS of 0–3 days, LOS of 4–6, 7–10, or ≥ 11 days was associated with 8% (95% CI, 3%–14%), 35 % (95% CI, 28%–43%), and 77 % (95% CI, 67%–87%) higher odds of readmission, respectively. Hospital LOS 7 days or greater was associated with a higher odds of death as compared with a hospital LOS of 0–3 days. Specifically, hospital LOS of 7–10 or ≥ 11 days was associated with 42% (95% CI, 24–64%) and 122% (95% CI, 95%–154%) higher odds of death, respectively, whereas a hospital LOS of 4–6 days was not (OR, 0.95; 95% CI, 0.83–1.10). The inclusion of aspects of the hospitalization (ICU care, mechanical ventilation, LOS) generally lowered associations between types of infection and odds of readmission or death without readmission.

DISCUSSION

In this study of Medicare beneficiaries initiating in-center hemodialysis, we found that 43% had at least one hospitalization for infection during follow-up—highlighting the burden of infection in this population. Of patients who survived the initial hospitalization, 30% were readmitted within 30 days. Complications related to vascular access, sepsis, and heart failure were leading causes of hospital readmission but other important causes included diabetic complications, *Clostridium difficile* colitis, and fluid and electrolyte abnormalities. The associations between baseline patient characteristics and outcomes were generally stronger for odds of death without readmission as compared with odds of readmission, suggesting that clinical characteristics may better predict death than readmission. Specific types of infection portended particularly high risks of adverse 30-day outcomes.

The time to readmission warrants special consideration. For example, 25% of patients readmitted for heart failure or disorders of fluid, electrolytes or acid-base balance were readmitted within 7 days, but one-half of these readmissions occurred approximately 14 days after discharge, suggesting multiple potential interfaces with the outpatient dialysis facility. This is a notable observation as these conditions can often be corrected by optimizing outpatient dialysis. One could speculate that some events might have been prevented by modifying the target (“estimated dry”) weight and/or dialysate prescription in patients who may have lost weight or modified their dietary intake during and in the wake of an infection.

Of all patients hospitalized for infection who survived the initial hospitalization, 4% died without readmission and 3% were readmitted to the hospital and then died within 30-days of discharge. Among patients who died without readmission the leading cause of death was withdrawal of dialysis or uremia whereas among those who were readmitted to the hospital and then died within 30 days, withdrawal of dialysis was the second leading cause of death. These findings suggest that serious infection and the associated consequences contribute to some patients’ decisions to stop dialysis.

Although greater attention has been focused on infection in adults on dialysis as reflected by participation of dialysis facilities in the Centers for Disease Control and Prevention (CDC) National Healthcare Safety Network dialysis event reporting[12] and the Centers for Disease Control Dialysis Bloodstream Infection Collaborative,[13] surprisingly, few studies have examined consequences of infection-related hospitalizations. The USRDS 2013 Annual Data Report (ADR) provides the most recent context. Among *prevalent* patients on hemodialysis in 2011 hospitalized for an infection, 34% were readmitted within 30 days (31% survived and 3% died after readmission) whereas 4.5% were not readmitted and died.[1] Among patients who survived the index hospitalization, 11% were readmitted for infection not related to vascular access, 2.1 % for infection related to vascular access, 6.4% for cardiovascular causes, and 14.3% for other causes within 30 days of discharge.[1] Differences in how causes of readmission were classified limit direct comparison; however, our findings and those reported in the USRDS ADR highlight that the majority of readmissions are not specifically for infection. As compared with findings reported in the USRDS ADR, our study focuses on incident patients receiving in-center hemodialysis, comprehensively examines factors associated with outcomes of infection-related hospitalization, and provides more detailed information on the causes and timing of readmission or death.

Among HEMO Study participants, Allon *et al.* found that infection-related hospitalizations resulted in death in nearly one in seven participants, a higher rate than we find here.[5] Potential explanations for this difference include the following: 1) HEMO participants were enrolled between 1995 and 2000 (care of adults with infection may have improved since that time); 2) HEMO participants had been on dialysis an average of 3.9 years; and 3) differences in the distribution of the types of infection.[5] The observed proportion of deaths in our cohort was similar to those reported in the USRDS ADR in 2013,[1] despite comparing an incident to a prevalent population. Among prevalent patients on hemodialysis, infection-related hospitalizations may not have substantively worse 30-day outcomes when compared with other leading causes of hospitalization, such as cardiovascular disease. Among prevalent patients on hemodialysis in 2011 who had a cardiovascular-related hospitalization, 37% were readmitted (34% survived and 3% died) and 3% died without readmission within 30-days.[1]

The post-hospitalization period is a uniquely high risk period for patients on dialysis. The unadjusted overall hospitalization rate among patients on hemodialysis is 1.88 hospitalizations per patient-year[1] and is equivalent to 16 hospitalizations per 100 person-months. Our findings suggest that a hospitalization rate of 30% is substantially higher than one would expect in a 30-day period. Similarly, a death rate of 223.8 per 1,000 patient-years (prevalent hemodialysis patients in 2005, from day 90, and vintage < 2 years),[1] is equivalent to 1.90 deaths per 100 person-months. Our observed overall mortality of 7% is higher than would expect in an average 30-day period. Our findings can also be contrasted with Medicare fee-for-service beneficiaries. Among Medicare fee-for-service beneficiaries hospitalized for a medical condition in 2003–2004, 21% were readmitted and 4% died without readmission within 30 days of discharge.[14]

In addition to furthering our understanding of the clinical consequences of infection-related hospitalization among adults receiving in-center hemodialysis, our findings can contribute to

the ongoing debate as to whether hospital readmission should be considered an indicator of quality of care.[15] This is a timely question given the Centers for Medicare and Medicaid Services implementation of the "national dry run" of the Standardized Readmission Ratio for dialysis facilities in March 2014.[16] For example, hospital readmissions for heart failure, fluid, electrolyte and acid-base balance accounted for approximately 10% of hospital readmissions, therefore, dialysis-facility interventions addressing these specific clinical areas could contribute to a lowering of hospital readmission but a number of other interventions or strategies would likely be necessary to substantively lower hospital readmissions. Arguably, in certain cases, readmission is necessary to optimize long-term outcomes whereas other readmissions may result from poorly coordinated or insufficient outpatient care. Distinguishing preventable from necessary hospital readmissions, and identifying the role of the dialysis facility in preventing hospital readmission, will be essential in order to develop and implement successful payment and other policies aimed to improve quality of care.

Our study has important strengths. First, we examined clinically important and highly relevant outcomes of infection-related hospitalization—a largely understudied area of research. Second, we comprehensively examined the causes of readmission and death, identifying potential areas where targeted intervention may be helpful, especially with respect to preventing readmissions. Third, we were able to examine associations between risk factors and both key outcomes, furthering our understanding of how certain characteristics predispose to hospital readmission or death without readmission.

We should also note important limitations of our study. First, our findings are limited to Medicare beneficiaries who survived the first 90 days of dialysis and were receiving in-center hemodialysis in free-standing dialysis facilities. Second, we focused on hospitalizations for infection using the principal discharge diagnosis, so our findings are limited to those hospitalizations for infection and do not address the consequences of hospitalizations for other reasons that were complicated by infection. Third, changes in *ICD-9-CM* coding during our study period may have led to under-ascertainment of infections related to central lines as we excluded the diagnosis code 999.3 and only included the more specific diagnosis code 999.31, which was introduced in October 2007. However, this change is unlikely to have led to substantial under-ascertainment of these infections as diagnosis code 996.62 was more frequently reported than 999.3 or 999.31 for our study period. In addition, we relied on the CMS Medical Evidence Form for co-morbidities, and we did not capture co-morbidities that accumulated over time on dialysis. Last, our findings only apply to the types of infection examined in our cohort. We excluded specific types of infections and limited the organ systems/sites of infection under study.

In summary, our findings highlight the significant clinical consequences of hospitalizations for infection in patients receiving in-center hemodialysis. Our findings identify areas where outpatient dialysis facilities, nephrologists, and other care providers can focus their efforts and develop interventions that address improved transitions of care from the hospital to the outpatient dialysis facility.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Baseline Patient Characteristics by Type of Infection-Related Hospitalization

	Dialysis Access or CVC (n=18254)	Bloodstream or Sepsis (n=14327)	Pulmonary (n=13132)	All Other Types (n=14557)
Age (y)	62.2 ± 15.8	67.8 ± 13.6	67.5 ± 14.2	65.7 ± 14.4
BMI (kg/m2)*	29.4 ± 8.6	28.7 ± 8.1	27.9 ± 7.8	29.7 ± 8.6
$eGFR_{MDRD}$ (ml/min/1.73 m2)*	11.0 ± 5.7	11.9 ± 6.2	11.3 ± 5.7	11.3 ± 5.5
Male sex	9629 (53)	7497 (52)	7063 (54)	6946 (48)
Race				
White	10705 (59)	9353 (65)	9100 (69)	9926 (68)
Black	6734 (37)	4314 (30)	3441 (26)	4069 (28)
Asian	404 (2)	360 (3)	310 (2)	236 (2)
Pacific Islander	109 (0.6)	101 (0.7)	75 (0.6)	87 (0.6)
American Indian or Alaskan Native	223 (1)	150 (1)	167 (1)	173 (1)
Multi-Racial or Other**	79 (0.4)	49 (0.3)	39 (0.3)	66 (0.5)
Hispanic	2720 (15)	1756 (12)	1576 (12)	1917 (13)
Diabetes	11373 (62)	9383 (65)	7658 (58)	9753 (67)
ASHD	3954 (22)	3722 (26)	3365 (26)	3681 (25)
Cerebrovascular Disease	2104 (12)	1927 (13)	1476 (11)	1652 (11)
Peripheral Vascular Disease	2942 (16)	2683 (19)	2196 (17)	2564 (18)
Congestive Heart Failure	6696 (37)	6076 (42)	5252 (40)	5681 (39)
Amputation	791 (4)	655 (5)	384 (3)	640 (4)
Hypertension	16096 (88)	12389 (86)	11667 (89)	12775 (88)
Cancer	1116 (6)	1183 (8)	1115 (8)	1061 (7)
COPD	1674 (9)	1655 (12)	1967 (15)	1419 (10)
Initial Access Type				
AVF	991 (5)	1465 (10)	1931 (15)	1896 (13)
Graft	708 (4)	667 (5)	637 (5)	711 (5)
Catheter	16267 (89)	11967 (84)	10358 (79)	11718 (80)
Other	228 (1)	183 (1)	165 (1)	183 (1)
Missing	60 (0.3)	45 (0.3)	41 (0.3)	49 (0.3)
Inability to Ambulate or Transfer	1560 (9)	1762 (12)	879 (7)	1281 (9)
Institutionalization				
None	16516 (90)	12416 (87)	12119 (92)	13224 (91)
Nursing home	1503 (8)	1710 (12)	856 (7)	1147 (8)
Assisted living	143 (0.8)	120 (0.8)	116 (0.9)	122 (0.8)
Other	92 (0.5)	81 (0.6)	41 (0.3)	64 (0.4)
Prior Nephrology Care				
<6 mo	1672 (9)	1406 (10)	1477 (11)	1529 (11)

	Dialysis Access or CVC (n=18254)	Bloodstream or Sepsis (n=14327)	Pulmonary (n=13132)	All Other Types (n=14557)
6–12 mo	4166 (23)	3346 (23)	3294 (25)	3595 (25)
> 12 mo	3424 (19)	2851 (20)	3057 (23)	3419 (23)
None	6557 (36)	4719 (33)	3770 (29)	4199 (29)
Unknown	2435 (13)	2005 (14)	1534 (12)	1815 (12)
Albumin				
< 2.5 g/dL	3054 (17)	2336 (16)	1857 (14)	2121 (15)
2.5 – < 3.0 g/dL	3288 (18)	2546 (18)	2203 (17)	2583 (18)
3.0 – < 3.5 g/dL	3659 (20)	3025 (21)	2839 (22)	3115 (21)
3.5 – < 4.0 g/dL	2697 (15)	2129 (15)	2303 (18)	2369 (16)
≥ 4 g/dL	1122 (6)	811 (6)	902 (7)	970 (7)
Missing	4434 (24)	3480 (24)	3028 (23)	3399 (23)
Current tobacco use	1233 (7)	829 (6)	1008 (8)	842 (6)
Region				
Northeast	2830 (16)	2312 (16)	2086 (16)	2566 (18)
South	8831 (48)	6372 (44)	5637 (43)	6402 (44)
Midwest	4019 (22)	3268 (23)	3299 (25)	3452 (24)
West	2574 (14)	2375 (17)	2110 (16)	2137 (15)

Note: P<0.001 for all. Values for categorical variables are given as number (percentage); values for continuous variables are given as mean ± standard deviation.

* Baseline values prior to multiple imputation;

** Unknown race classified as other

BMI, body mass index; CVC, central venous catheter; $eGFR_{MDRD}$ estimated glomerular filtration rate calculated with 4-variable Modification of Diet in Renal Disease Study equation; ASHD atherosclerotic heart disease; COPD chronic obstructive pulmonary disease; AVF arteriovenous fistula

Table 2

Types and Outcomes of Infection-Related Hospitalization

	No. of Infection Hospitalizations	In-Hospital Mortality	30-d Hospital Readmission	30-d Death without Readmission	30-d Hospital Readmission or Death	Overall 30-d Mortality*
Dialysis Access or CVC	18254	903 (5)	4865 (28)	473 (3)	5338 (31)	815 (5)
Blood Stream Infection or Sepsis	14327	3,163 (22)	3784 (34)	1070 (10)	4854 (43)	1607 (14)
Pulmonary	13132	608 (5)	3645 (29)	403 (3)	4048 (32)	752 (6)
Genitourinary	3742	84 (2)	1109 (30)	129 (4)	1238 (34)	240 (7)
GI, Peritoneal, or Hepatobiliary	3731	133 (4)	1198 (33)	109 (3)	1307 (36)	203 (6)
Skin and Soft Tissue	3474	90 (3)	1013 (30)	94 (3)	1107 (33)	187 (6)
Surgery or Procedure-Related	1889	100 (5)	577 (32)	77 (4)	654 (37)	120 (7)
Bone and Joint	1053	51 (5)	309 (31)	33 (3)	342 (34)	56 (6)
Cardiovascular or CNS	668	106 (16)	237 (42)	37 (7)	274 (49)	69 (12)
TOTAL	60,270	5,238 (9)	16,737 (30)	2,425 (4)	19,162 (35)	4,049 (7)

Note: Values are given as number or number (row percentage). 30-day outcomes are among those who survive index hospitalization and are available for ascertainment of outcomes (n=54,996).

CNS, central nervous system; CVC, central venous catheter; GI, gastrointestinal

* Includes those who are and are not readmitted prior to death within 30-days of discharge

Table 3

Leading Causes and Timing of 30-Day Hospital Readmission

	No.	Time to readmission (d)
Complications Peculiar to Certain Specified Procedures (996)	2469 (15)	13 [6–22]
Infection and inflammatory reaction due to internal prosthetic device, implant, and graft, due to other vascular device, implant or graft (996.62)	1367	
Other complications of internal prosthetic device, implant, and graft due to renal dialysis device, implant and graft (996.73)	714	
Mechanical complication of other vascular device, implant and graft (996.1)	161	
Septicemia (038)	1557 (9)	11 [5–20]
Unspecified septicemia (038.9)	954	
MSSA Septicemia (038.11)	179	
Streptococcal septicemia (038.0)	85	
Heart Failure (428)	1166 (7)	14 [7–22]
Congestive heart failure, unspecified (428.0)	900	
Acute on chronic systolic heart failure (428.23)	70	
Acute on chronic diastolic heart failure (428.33)	55	
Diabetes Mellitus (250)	789 (5)	12 [6–20]
Diabetes with other specified manifestations, type II or unspecified type, not stated as uncontrolled (250.80)	227	
Diabetes with peripheral circulatory disorders, type II or unspecified type, not stated as uncontrolled (250.70)	107	
Diabetes with neurological manifestations, type II or unspecified type, not stated as uncontrolled (250.60)	88	
Pneumonia, organism unspecified (486)	654 (4)	12 [6–21]
Hypertensive Chronic Kidney Disease (403)	620 (4)	14 [6–22]
Hypertensive CKD, unspecified, with CKD stage 5 or ESRD (403.91)	525	
Hypertensive CKD, malignant, with CKD stage 5 or ESRD (403.01)	79	
Hypertensive CKD, unspecified, with CKD stages 1–4 or unspecified (403.90)	11	
Disorders of Fluid, Electrolyte, and Acid-Base Balance (276)	469 (2.8)	13 [7–21]
Fluid overload (276.6)	179	
Hyperkalemia (276.7)	176	
Dehydration (276.51)	70	
Intestinal Infections Due to Other Organisms (008)	397 (2.4)	14 [7–21]
Clostridium difficile (008.45)	364	
Other organisms, NEC (008.8) or Bacteria, Other (008.49)	31	
Other Diseases of the Lung (518)	365 (2.2)	12 [6–19]
Acute respiratory failure (518.81)	277	
Acute edema of lung, unspecified (518.4)	35	
Acute and chronic respiratory failure (518.84)	35	
General Symptoms (780)	351 (2.1)	11 [6–19]
Pyrexia unknown origin (780.6)	98	

	No.	Time to readmission (d)
Other convulsions (780.39)	59	
Syncope and collapse (780.2)	55	
Other Causes	7900	

Note: Values are given as number, number (percentage), or median [interquartile range]. The table includes details on the 10 leading causes of readmission classified at the 3 digit *International Classification of Diseases, Ninth Revision, Clinical Modification*, level and the three most frequent 4th or 5th digit classifications within each 3 digit classification.

MSSA methicillin sensitive *Staphylococcus aureus*; CKD chronic kidney disease; ESRD end-stage renal disease; NEC not elsewhere classified

Table 4

Causes of Death within 30 Days of Hospital Discharge

	All Death within 30 d of Discharge (n=4049)	Without Hospital Readmission (n=2425)	With Hospital Readmission Before Death (n=1624)
Cardiac Arrest, Cause Unknown	800 (20)	481 (20)	319 (20)
Withdrawal from Dialysis/Uremia	684 (17)	525 (22)	159 (10)
Septicemia, Other	236 (6)	98 (4)	138 (8)
Other Identified Cause of Death	183 (5)	99 (4)	84 (5)
Congestive Heart Failure	155 (4)	92 (4)	63 (4)
Myocardial Infarction, Acute	126 (3)	59 (2)	67 (4)
Other*	1865 (46)	1071 (44)	794 (49)

Note: Values are given as number (percentage).

*Other includes all other possible causes of death

Table 5

Associations between Baseline Characteristics, Type of Infection and 30-Day Outcomes in Multivariable Multinomial Model

	Hospital Readmission	Death without Readmission
Type of Infection		
Dialysis Access or CVC	0.91 (0.84, 0.99)	1.01 (0.82, 1.23)
Blood Stream Infection or Sepsis	1.32 (1.22, 1.44)	3.62 (2.99, 4.38)
Pulmonary	0.97 (0.89, 1.05)	0.99 (0.80, 1.21)
Genitourinary	1.00 (reference)	1.00 (reference)
GI, Peritoneal, or Hepatobiliary	1.20 (1.09, 1.33)	1.08 (0.83, 1.41)
Surgery or Procedure-Related	1.16 (1.03, 1.32)	1.62 (1.21, 2.18)
Skin, Soft Tissue, Bone or Joint	1.03 (0.94, 1.14)	1.06 (0.82, 1.37)
Cardiovascular or CNS	1.87 (1.55, 2.26)	3.47 (2.34, 5.13)
Age category		
18 – 44 y	1.04 (0.97, 1.11)	0.49 (0.36, 0.65)
45 – 64 y	1.00 (reference)	1.00 (reference)
65 – 74 y	1.06 (1.01, 1.12)	1.84 (1.61, 2.11)
75 – 84 y	1.10 (1.04, 1.17)	3.02 (2.65, 3.45)
≥ 85 y	1.08 (0.99, 1.17)	3.80 (3.20, 4.50)
Male sex	0.92 (0.88, 0.95)	0.94 (0.86, 1.03)
Race		
White	1.00 (reference)	1.00 (reference)
Black	1.02 (0.98, 1.07)	0.68 (0.61, 0.76)
Asian	0.81 (0.71, 0.93)	0.53 (0.38, 0.74)
Other	0.84 (0.74, 0.96)	0.44 (0.29, 0.68)
Hispanic Ethnicity	0.87 (0.82, 0.92)	0.59 (0.50, 0.69)
Medicare/Medicaid Dual Eligibility	1.11 (1.07, 1.16)	0.96 (0.87, 1.06)
Region		
Northeast	1.00 (reference)	1.00 (reference)
South	0.89 (0.84, 0.94)	1.42 (1.24, 1.61)
Midwest	0.93 (0.88, 0.99)	1.32 (1.15, 1.52)
West	0.85 (0.79, 0.91)	1.22 (1.03, 1.43)
eGFRMDRD, per 5-ml/min/1.73m2 higher	1.06 (1.05, 1.08)	1.08 (1.04, 1.12)
Albumin category		
< 2.5 g/dL	1.16 (1.08, 1.24)	1.20 (1.02, 1.41)
2.5 – <3.0 g/dL	1.12 (1.05, 1.20)	1.16 (1.00, 1.34)
3.0 – <3.5 g/dL	1.10 (1.03, 1.16)	1.13 (0.98, 1.29)
3.5 – <4.0 g/dL	1.00 (reference)	1.00 (reference)
≥ 4 g/dL	0.98 (0.90, 1.07)	1.03 (0.85, 1.24)

	Hospital Readmission	Death without Readmission
Initial Vascular Access Type		
AVF	1.00 (reference)	1.00 (referene)
Graft	1.11 (1.00, 1.24)	0.91 (0.70, 1.17)
Dialysis Catheter	1.11 (1.04, 1.19)	1.16 (0.99, 1.35)
Other	1.13 (0.95, 1.35)	1.06 (0.70, 1.60)
BMI category		
< 18.5 kg/m2	1.13 (1.02, 1.24)	1.49 (1.22, 1.82)
18.5 – <25 kg/m2	1.07 (1.02, 1.12)	1.14 (1.03, 1.28)
25 – <30 kg/m2	1.00 (reference)	1.00 (reference)
≥ 30 kg/m2	0.90 (0.86, 0.94)	0.89 (0.79, 1.00)
Diabetes Mellitus	1.05 (1.01, 1.09)	1.03 (0.94, 1.13)
Atherosclerotic Heart Disease	1.01 (0.97, 1.06)	0.98 (0.88, 1.08)
Cerebrovascular Disease	0.97 (0.92, 1.03)	1.04 (0.92, 1.18)
Peripheral Vascular Disease	1.05 (1.00, 1.11)	1.17 (1.04, 1.31)
Heart Failure	1.08 (1.03, 1.12)	1.24 (1.13, 1.36)
History of Amputation	1.01 (0.92, 1.11)	0.99 (0.80, 1.25)
Hypertension	0.93 (0.88, 0.98)	0.89 (0.78, 1.01)
Cancer	1.11 (1.03, 1.19)	1.17 (1.02, 1.35)
COPD	1.15 (1.08, 1.22)	0.98 (0.86, 1.12)
Inability to Ambulate or Transfer	1.12 (1.04, 1.20)	1.24(1.08, 1.43)
Current Tobacco Use	1.04 (0.97, 1.13)	0.95 (0.77, 1.17)
Institutionalization		
None	1.00 (reference)	1.00 (reference)
Assisted Living	0.95 (0.77, 1.17)	1.19 (0.81, 1.74)
Nursing Home	1.02 (0.94, 1.10)	1.34 (1.17, 1.54)
Other	0.85 (0.64, 1.13)	1.31 (0.77, 2.23)
Nephrology Care Prior to Dialysis		
>12 mo	1.00 (reference)	1.00 (reference)
6–12 mo	1.12 (1.06, 1.18)	1.14 (1.01, 1.30)
< 6 mo	1.13 (1.05, 1.21)	1.15 (0.98, 1.35)
None	1.15 (1.09, 1.21)	1.18 (1.04, 1.34)
Unknown	1.22 (1.14, 1.30)	1.13 (0.97, 1.32)

Note: Values are given as odds ratio (95% confidence interval).

CVC central venous catheter; GI gastrointestinal; CNS central nervous system; eGFRMDRD, estimated glomerular filtration rate calculated with 4-variable Modification of Diet in Renal Disease Study equation; AVF arteriovenous fistula; COPD chronic obstructive pulmonary disease