Risks of Subsequent Hospitalization and Death in Patients with Kidney Disease

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Summary

Background and objectives Rates of hospitalization are known to be high in patients with kidney disease. However, ongoing risks of subsequent hospitalization and mortality are uncertain. The primary objective was to evaluate patients with kidney disease for long-term risks of subsequent hospitalization, including admissions resulting in death.

Design, setting, participants, & measurements Patients hospitalized in Washington State between April of 2006 and December of 2008 who survived to discharge (n=676,343) were classified by International Classification of Disease codes into CKD (n=27,870), dialysis (n=6131), kidney transplant (n=1100), and reference (n=641,242) cohorts. Cox proportional hazard models controlling for age, sex, payer, comorbidity, previous hospitalization, primary diagnosis category, and length of stay were conducted for time to event analyses.

Results Compared with the reference cohort, risks for subsequent hospitalization were increased in the CKD (hazard ratio=1.20, 99% confidence interval=1.18–1.23, $P<0.001$), dialysis (hazard ratio=1.76, 99% confidence interval=1.69–1.83, $P<0.001$), and kidney transplant (hazard ratio=1.85, 99% confidence interval=1.68–2.03, $P<0.001$) cohorts, with a mean follow-up time of 29 months. Similarly, risks for fatal hospitalization were increased for patients in the CKD (hazard ratio=1.41, 99% confidence interval=1.34–1.49, $P<0.001$), dialysis (hazard ratio=3.04, 99% confidence interval=2.78–3.31, $P<0.001$), and kidney transplant (hazard ratio=2.25, 99% confidence interval=1.67–3.03, $P<0.001$) cohorts. Risks for hospitalization and fatal hospitalization increased in a graded manner by CKD stage.

Conclusions Risks of subsequent hospitalization, including admission resulting in death, among patients with kidney disease were substantially increased in a large statewide population. Patients with kidney disease should be a focus of efforts to reduce hospitalizations and mortality.

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Introduction

CKD is a well established predictor of all-cause and cardiovascular mortality (1,2), hospitalization (2), and disability (3–6). Within the Medicare and dually enrolled Medicare–Medicaid population, persons with CKD have increased rates of hospitalization, particularly for heart failure and infections compared with persons without CKD (5). Additionally, the average length of stay is longer for patients hospitalized with a diagnosis of CKD than for any other disease category (7). Moreover, care for people with kidney disease requires disproportionately large healthcare resources. For example, CKD is present in 8–10% of Medicare beneficiaries, but it is associated with 27–35% of expenditures (7,8).

Prognostic information about patients with kidney disease has been obtained from study cohorts primarily dominated by single-payer systems. The United States Renal Data System, drawing information from Medicare and employer group health plans, provides the most comprehensive assessment of 1-year morbidity and mortality for patients across stages of CKD (9). However, longer-term data from large multipayer populations are necessary to more fully elucidate the impact of kidney disease on health outcomes. The primary objective of this study was to determine the longitudinal risks of hospitalization, including admissions resulting in death, among a full-spectrum of patients with kidney disease who were discharged from acute care hospitals in Washington State.

Materials and Methods

Study Design

Data on hospitalizations were obtained from the Washington State Comprehensive Hospital Abstract Reporting System (CHARS). The CHARS database contains information on discharges from all payers for hospitals in Washington State. The current study used the CHARS revisit file, which permitted a patient-level analysis of hospitalizations.

This longitudinal cohort study included 676,343 adult persons (aged 19+ years) hospitalized in the state of Washington from April of 2006 to December of 2008. Hospitalizations of women at baseline admission for

prenatal care, labor and delivery, and maternity care were excluded. An index hospitalization was identified as the earliest hospitalization for each patient in the study period. Patients were followed a minimum of 12 months and up to 45 months after index hospitalization discharge. The study period for which data were analyzed ended on December 31, 2009.

Definitions

Demographic characteristics were based on index hospitalization data. Four cohorts were identified using International Classification of Disease 9th Edition Clinical Modification (ICD9-CM) diagnostic codes. The CKD cohort was defined by the presence of any ICD9-CM diagnosis code during the index hospitalization of 585 (CKD): 585.1 (CKD stage 1), 585.2 (CKD stage 2, mild), 585.3 (CKD stage 3, moderate), 585.4 (CKD stage 4, severe), 585.5 (CKD stage 5), or 585.9 (CKD unspecified). The dialysis cohort was defined by the presence of any ICD9-CM diagnosis code during the index hospitalization of 585.6 (ESRD, typically treated by dialysis). The kidney transplant cohort was defined by the presence of any ICD9-CM diagnosis code during the index hospitalization of V42.0 (organ or tissue replaced by transplant—kidney). The reference cohort was defined by all other hospitalized patients not in the CKD, dialysis, or kidney transplant cohorts. In the United States, ICD9 codes for staging of CKD were first implemented in October of 2005. Enrollment of study participants was started 6 months later to allow for adoption of CKD staging diagnoses.

Classification of hospitalizations was based on the primary ICD9-CM diagnosis code of the index hospitalization (the first hospitalization in the study period from April of 2006 to 2008). Health insurance payers of record on the index hospitalization were used to classify patients as private pay (commercial, health maintenance organization, and self-pay) and public pay (Medicare, Medicaid, and dual-enrolled Medicare–Medicaid). To control for varying entry points of illness into the study, the number of previous hospitalizations within the past 12 months was calculated for each subject enrolled within the first year of the study. By study definition, subjects who entered the study after the first year did not have previous hospitalizations in the previous 12 months. Comorbidity variables based on the index and previous hospitalizations (past 12 months) were determined by a set of 30 comprehensive definitions using the Elixhauser method (10).

Statistical Analyses

Two primary outcomes were prespecified: (*1*) time to subsequent hospitalization and (*2*) time to subsequent hospitalization resulting in death. Cox proportional hazard models controlling for age, sex, payer, comorbidity (Elixhauser method) (10), 12-month previous hospitalization, categorization of index hospitalization primary diagnoses, and length of stay were also conducted for time to event analyses. In each analysis, kidney disease cohorts were compared with the reference group of hospitalized patients without kidney disease. Survival functions were developed using fully adjusted statistical models. Hazard ratios and 99% confidence intervals were calculated for each cohort for each study outcome. Internal validation of main study findings was completed using split-file validation and sensitivity analyses to examine the interaction between kidney disease cohorts and predictors of adverse health outcomes such as hypertension and diabetes.

Given the large number of patients in this dataset and to minimize the chance of a type I error, a 99% confidence interval for the main analyses was chosen *a priori*. Therefore, $P<0.01$ was required to deem a result statistically significant. SPSS Version 18.0 (IBM, Chicago, IL) was used for all statistical analyses.

Results

Almost one-half of the total population (n=676,343) included in this study had public source payers at index hospitalization: 37.1% (n=251,100) by Medicare, 8.1% (n=55,039) by Medicaid, and 3.7% (n=24,779) by dual-enrolled Medicare–Medicaid. Private source payers at index hospitalization included 45.1% (n=304,758) commercial/health maintenance organizations and 6.0% (n=40,667) self-pay. The average age of all study subjects at index hospitalization was 60±18 years (mean ± SD). The reference cohort included 94.8% (n=641,242) of the study population. The CKD cohort included 4.1% (n=27,870) of the study population. Dialysis and kidney transplant cohorts included 0.9% (n=6131) and 0.2% (n=1100) of the study population, respectively.

Patients in the CKD cohort were older than the reference cohort (Table 1). Patients in the dialysis and reference groups had similar ages, whereas patients in the kidney transplant cohort were younger. Males were more common in the CKD, dialysis, and kidney transplant cohorts. Diabetes and hypertension were present in a higher percentage of patients in the CKD, dialysis, and kidney transplant cohorts compared with the reference group. Public source payers (Medicare, Medicaid, or dual-enrolled Medicare–Medicaid) were listed as payers for the majority of index hospitalizations for patients in the CKD (75.2%), dialysis (79.0%), and kidney transplant (63.5%) cohorts. Public source health insurance was listed as the payer for less than one-half (47.5%) of index hospitalizations in the reference cohort.

Within the first year after index hospitalization, patients in the reference cohort were subsequently hospitalized at an annual rate of 510 hospitalizations per 1000 patients. Although 4.1% of the study population included patients in the CKD cohort, they accounted for 7.1% of subsequent hospitalizations, resulting in an annual rate of 923 hospitalizations per 1000 patients. Patients in the dialysis cohort comprised less than 1% of the sample but accounted for 2.5% of subsequent hospitalizations, resulting in an annual rate of 1469 hospitalizations per 1000 patients. Similarly, although less than 0.2% of the study population included patients in the kidney transplant cohort, they accounted for 0.3% of subsequent hospitalizations, resulting in an annual rate of 1076 hospitalizations per 1000 patients. Additionally, patients in the CKD, dialysis, and kidney transplant cohorts were more likely than patients in the reference cohort to experience a subsequent hospitalization (Figure 1 and Table 2). In all kidney disease cohorts, mean time to

Table 1. Characteristics of patients hospitalized in Washington State from 2006 (second quarter) to 2008 (*n*=676,343)

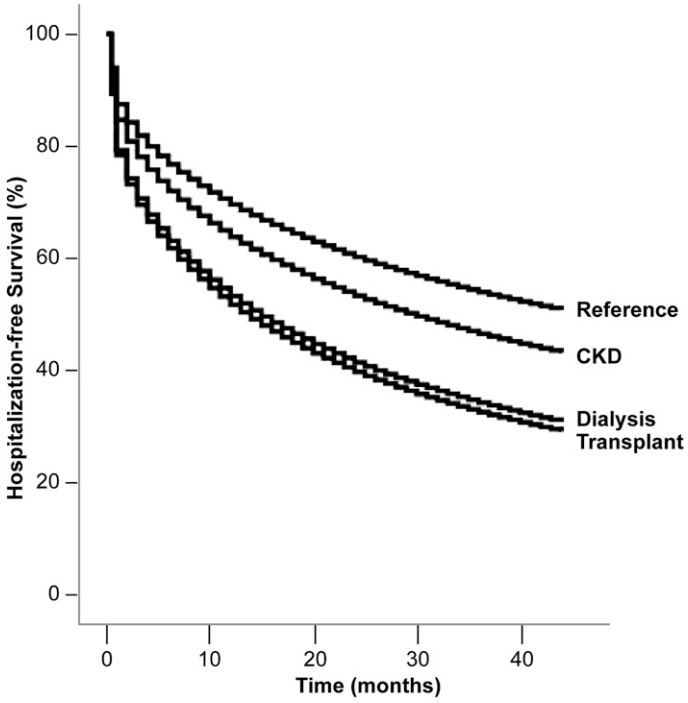
Index Hospitalization	Reference (*n*=641,242)		CKD (*n*=27,870)		Dialysis (*n*=6131)		Transplant (*n*=1100)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Age (yr)	59	18	75	14	62	16	54	13
	Median	IQR	Median	IQR	Median	IQR	Median	IQR
Length of stay (d)	3	1–4	3	2–6	4	2–7	3	2–5
	n	Percent	*n*	Percent	*n*	Percent	*n*	Percent
Diabetes	107,194	16.7	10,883	39.0	2869	46.8	447	40.6
Hypertension	279,009	43.5	20,008	71.8	4823	78.7	793	72.1
Sex								
male	294,853	46.0	15,098	54.2	3460	56.4	588	53.5
female	346,389	54.0	12,772	45.8	2671	43.6	512	46.5
Primary payer								
Medicare	228,952	35.7	18,120	65.0	3494	57.0	534	48.5
Medicaid	53,090	8.3	1384	5.0	504	8.2	61	5.5
dual enrolled	22,379	3.5	1448	5.2	848	13.8	104	9.5
commercial/HMO	296,837	46.3	6321	22.7	1205	19.7	395	35.9
self-pay	39,984	6.2	597	2.1	80	1.3	6	0.5
Top five primary diagnostic categories (ICD9-CM)	*n*	Percent	*n*	Percent	*n*	Percent	*n*	Percent
circulatory diseases (390–459)	113,592	17.7	8984	32.2	1645	26.8	176	16.0
musculoskeletal diseases (710–739)	84,188	13.1	1347	4.8	149	2.4	76	6.9
digestive diseases (520–579)	82,803	12.9	2565	9.2	409	6.7	125	11.4
injury and poisoning (800–999)	72,971	11.4	2186	7.8	1076	17.6	80	7.3
neoplasm (140–239)	55,563	8.7	989	3.5	123	2.0	48	4.4

CKD cohort defined by CKD not treated by hemodialysis, peritoneal dialysis, or kidney transplant. Dialysis cohort includes hemodialysis and peritoneal dialysis. IQR, interquartile range; HMO, Health Maintenance Organization; ICD9-CM, International Classification of Diseases Ninth Revision Clinical Modification.

repeat admission was shorter compared with the reference cohort. Patients in the CKD, dialysis, and kidney transplant cohorts were also at increased risk of subsequent hospitalizations resulting in death (Figure 2 and Table 3). Compared with the reference cohort, increased risks for fatal hospitalization were observed for every group with kidney disease. Although 4.1% of the study population included patients in the CKD cohort, they accounted for 10.8% of fatal hospitalizations. Patients in the dialysis cohort comprised less than 1% of the sample but accounted for more than 3.8% of fatal hospitalizations. Similarly, although less than 0.2% of the study population included patients in the kidney transplant cohort, they accounted for 0.3% of fatal hospitalizations. Risks for hospitalization, both fatal and nonfatal, increased progressively with CKD stage (Table 4). Overall, study subjects were followed a mean of 29±10 months. The follow-up time periods for each of the four study cohorts were similar, with the reference group followed for 29±10 months, the CKD group followed for 27±11 months, the dialysis group followed for 29±12 months, and the kidney transplant group followed for 30±10 months.

The most common classification of primary diagnoses for index hospitalization among all cohorts was circulatory diseases. Among patients in the CKD group, heart failure, ischemic heart disease, and acute renal failure were the three most frequent primary diagnoses for subsequent hospitalization (Table 5). Procedural complications, primarily related to vascular access or peritoneal catheters for dialysis patients and postoperative management for kidney transplant patients, were the most common primary diagnoses for subsequent hospitalizations in the dialysis and kidney transplant cohorts. Heart failure and diabetes in the dialysis cohort and sepsis and pneumonia in patients with kidney transplants were the next two most frequent causes for subsequent admission. By comparison, the three most frequent primary diagnostic categories for subsequent hospitalization among patients in the reference cohort were ischemic heart disease, osteoarthritis, and pneumonia.

To internally validate the main study findings, a split-file analysis showed similar results between randomly assigned derivation and validation cohorts. Sensitivity analyses found no statistical interactions that influenced increased risk for study outcomes between kidney disease cohorts and diagnoses of diabetes or hypertension. When these cohorts were analyzed for patients with and without diagnoses of diabetes or hypertension, risks of hospitalization or fatal hospitalization were fairly similar (Supplemental Tables 1 and 2).



Number at Risk

Reference	641242	463004	318034	181067	60604
CKD	27870	15523	9698	5001	1200
Dialysis	6131	2676	1650	911	313
Transplant	1100	600	384	196	73

Figure 1. | **Hospitalization-free survival.** Dialysis cohort includes patients treated by either hemodialysis or peritoneal dialysis. Plots shown for a fully adjusted Cox proportional hazards model (*N*=676,343). Fully adjusted model controls for age; sex; index hospitalization primary diagnosis, length of stay, and primary payer; 12-month count of previous hospitalizations; and Elixhauser comorbidity variables.

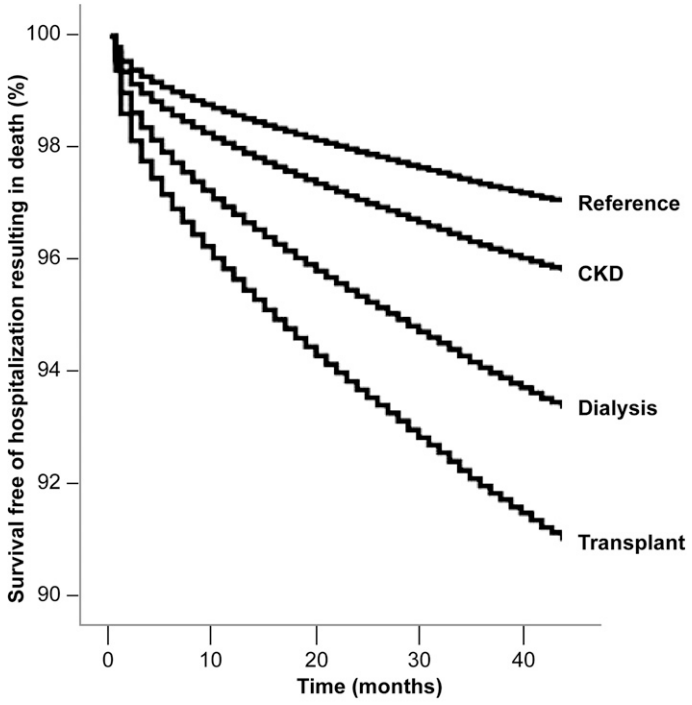
Table 2. Risk of subsequent hospitalization among patients surviving their index hospital admission in Washington State from 2006 (second quarter) to 2008 in a fully adjusted Cox proportional hazards model (*n*=676,343)

	Subsequent Hospitalization								
	Hazard Ratio	99% CI	*P*	Time to First Hospitalization (Months)		Full Study First Hospitalizations		Within First Month First Hospitalization	
				Median	IQR	*n*	Percent	*n*	Percent
Cohort									
CKD	1.20	1.18–1.23	<0.001	4	1–11	17,095	61.3	5773	20.7
dialysis	1.76	1.69–1.83	<0.001	3	1–8	4453	72.6	1560	25.4
kidney transplant	1.85	1.68–2.03	<0.001	4	1–12	736	66.9	212	19.3
reference	1.00			5	1–13	268,808	41.9	84,745	13.2
All cohorts				5	1–13	291,092	43.0	92,290	13.6

Fully adjusted model controlling for age; sex; index hospitalization primary diagnosis, length of stay, and primary payer; 12-month count of previous hospitalizations; and Elixhauser comorbidity variables. CKD cohort defined by CKD not treated with hemodialysis, peritoneal dialysis, or kidney transplant. Dialysis cohort includes hemodialysis and peritoneal dialysis. CI, confidence interval; IQR, interquartile range.

Discussion

Patients with kidney disease were among the highest risk group for subsequent hospitalization, including admissions resulting in death, in more than 650,000 patients covered by multiple payers in Washington State followed over an average of 29 months. The risks of subsequent hospital



Number at Risk

Reference	641242	629473	497232	320952	122857
CKD	27870	26358	20737	12948	3568
Dialysis	6131	5633	4659	3252	1472
Transplant	1100	1073	892	608	269

Figure 2. | **Survival free of hospitalization resulting in death.** Dialysis cohort includes patients treated by either hemodialysis or peritoneal dialysis. Plots shown for a fully adjusted Cox proportional hazards model (*N*=676,343). Fully adjusted model controls for age; sex; index hospitalization primary diagnosis, length of stay, and primary payer; 12-month count of previous hospitalizations; and Elixhauser comorbidity variables.

Table 3. Risk of fatal hospitalization among patients surviving their index hospital admission in Washington State from 2006 (second quarter) to 2008 in a fully adjusted Cox proportional hazards model (*n*=676,343)

	Fatal Hospitalization								
	Hazard Ratio	99% CI	*P*	Time to Fatal Hospitalization (Months)		Full Study Fatal Hospitalization		Within First Month Fatal Hospitalization	
				Median	IQR	*n*	Percent	*n*	Percent
Cohort									
CKD	1.41	1.34–1.49	<0.001	9	2–18	2857	10.3	518	1.9
dialysis	3.04	2.78–3.31	<0.001	10	3–20	1004	16.4	145	2.4
kidney transplant	2.25	1.67–3.03	<0.001	14	5–27	76	6.9	6	0.5
reference	1.00			9	2–19	22,432	3.5	4437	0.7
All cohorts				9	2–19	26,369	3.9	5106	0.8

Fully adjusted model controlling for age; sex; index hospitalization primary diagnosis, length of stay, and primary payer; 12-month count of previous hospitalizations; and Elixhauser comorbidity variables.
CKD cohort defined by CKD not treated with hemodialysis, peritoneal dialysis, or kidney transplant. Dialysis cohort includes hemodialysis and peritoneal dialysis. CI, confidence interval; IQR, interquartile range.

Table 4. Risk of study outcomes among patients surviving their index hospital admission in Washington State from 2006 (second quarter) to 2008 by CKD stage in a fully adjusted Cox proportional hazards model (*n*=27,870)

	Hazard Ratio	99% CI	*P*	Time to First Hospitalization (Months)		Full Study First Hospitalization		Within First Month First Hospitalization	
				Median	IQR	*N*	Percent	*n*	Percent
Subsequent hospitalization									
CKD stage unspecified	1.20	1.17–1.22	<0.001	4	1–11	13,731	61.8	4672	21.0
CKD stage 1 and 2	1.11	0.99–1.24	0.02	5	1–12	534	57.8	157	17.0
CKD stage 3	1.12	1.15–1.20	<0.001	4	1–11	1578	55.9	519	18.4
CKD stage 4	1.40	1.29–1.52	<0.001	3	1–8	944	64.4	325	22.2
CKD stage 5	1.77	1.53–2.04	<0.001	3	1–9	328	71.1	108	23.4
reference	1.00			5	1–13	268,808	41.9	84,745	13.2
total CKD	1.20	1.18–1.23	<0.001	4	1–11	17,098	61.3	5781	20.7
Fatal hospitalization									
CKD stage unspecified	1.41	1.53–1.49	<0.001	9	3–18	2,322	10.5	416	1.9
CKD stage 1 and 2	1.00	0.72–1.34	0.98	13	4–23	63	6.8	8	0.9
CKD stage 3	1.26	1.06–1.49	<0.001	8	2–17	233	8.3	49	1.7
CKD stage 4	1.87	1.54–2.27	<0.001	6	2–16	181	12.3	35	2.4
CKD stage 5	2.45	1.76–3.42	<0.001	8	3–15	61	13.2	10	2.2
reference	1.00			9	2–19	22,432	3.5	4437	0.7
total CKD	1.41	1.34–1.49	<0.001	9	2–18	2860	10.3	518	1.9

The CKD cohort did not include patients treated by hemodialysis, peritoneal dialysis, or kidney transplant. Fully adjusted model controlling for age; sex; index hospitalization primary diagnosis, length of stay, and primary payer; 12-month count of previous hospitalizations; and Elixhauser comorbidity variables. CI, confidence interval; IQR, interquartile range.

Table 5. Primary diagnoses for subsequent hospitalization among patients surviving their index hospital admission in Washington State from 2006 (second quarter) to 2008 (*n*=676,343)

Cohort	Hospitalizations	Rank	ICD9-CM	Top Three Primary Diagnoses	*n*	Percent
CKD	17,095	1	428	Heart failure	1604	9.4
CKD	17,095	2	410–414	Ischemic heart disease	1157	6.8
CKD	17,095	3	584	Acute renal failure	996	5.8
Dialysis	4453	1	996	Procedural complications[a]	653	14.7
Dialysis	4453	2	428	Heart failure	225	5.1
Dialysis	4453	3	250	Diabetes	221	5.0
Kidney transplant	736	1	996	Postoperative complications	89	12.1
Kidney transplant	736	2	038	Sepsis	43	5.8
Kidney transplant	736	3	480–488	Pneumonia	38	5.2
Reference	268,808	1	410–414	Ischemic heart disease	15,021	5.6
Reference	268,808	2	715	Osteoarthritis	11,807	4.4
Reference	268,808	3	480–488	Pneumonia	8943	3.3

[a]Complications related to procedures for vascular access and peritoneal catheters among patients treated by dialysis.

admission and fatal hospitalization increased in a graded manner by severity of CKD.

The present study is unique in its long-term assessment of ongoing risks for hospital admission, complete scope of diagnoses, and large sample size including all healthcare payers. Risks for subsequent hospitalization, including those risks resulting in death, were clearly increased among the full spectrum of patients with kidney disease. The previous state of knowledge mostly concerned shorter-term risks for discreet hospitalization. For example, rates of hospital admission and inpatient mortality for an acute myocardial infarction or heart failure were reported to be increased in patients with kidney disease and amplified in advanced CKD stages (11–15). Similarly, patients admitted with a diagnosis of stroke or pneumonia also had increased risk of in-hospital mortality by CKD stages (16,17). Compared with Medicare beneficiaries with other chronic illnesses (cancer, chronic obstructive pulmonary disease, depression, diabetes, and heart

failure), patients with CKD have more comorbidities, the highest annual number of inpatient stays, and the greatest number of hospital days (7). Furthermore, prior studies typically included patients covered by single payers. A key observation of the current study is that notable differences in outcomes were observed by payer. Compared with those patients with private sources of health insurance, patients with public health insurance (Medicare, Medicaid, or dual-enrolled Medicare–Medicaid) were associated with increased risk of overall and fatal hospitalizations.

Reasons for increased risk of hospitalization and death among patients with kidney disease are complex. In the present study, heart failure and ischemic heart disease were the top two reasons for hospitalization in patients with CKD, but risk of acute renal failure (acute kidney injury) was nearly as great. These observations point to the need for study of strategies to prevent hospital admission focused on high-risk complications. In addition to improved cardiovascular prevention and management, strategies to reduce risk of acute kidney injury, such as avoidance of nephrotoxin exposure, volume depletion, and/or hypotension, could be assessed to reduce hospitalizations in patients with CKD. Better tactics to manage dialysis access and postoperative transplant complications are opportunities to reduce readmissions in dialysis and kidney transplant patient groups. Diabetes care and infection prevention are other essential areas for focus to reduce repeat hospital admissions in patients treated by dialysis or kidney transplant.

Systems issues are also crucial to understanding why patients are repeatedly admitted to the hospital. For example, medication discrepancies during hospital discharge are common. Among patients treated by dialysis transitioning from the hospital to an outpatient setting, erroneous medication information transfer occurred in 79%, with an average of three discrepancies (18). Importantly, patients with medication discrepancies are more likely to be readmitted (19). In addition, established practices for kidney disease management are vastly underused (20–23). A recent survey of internal medicine residents found deficits in almost every domain of knowledge about CKD complications and management (24). Moreover, when patients with kidney disease are admitted to the hospital, they are less likely to receive evidence-based therapies and often experience adverse drug events, both of which lead to poor outcomes (25).

This study has limitations to be considered. First, the data were derived from an administrative dataset. Potentially important covariates, namely disease severity and other clinical variables (*e.g.*, measures of kidney function) were not available. Second, the index hospitalization was constrained to the study timeframe and did not necessarily reflect an actual first hospitalization. However, the large sample size and internal validation mitigate these limitations and increase confidence in the findings. Additionally, controlling for multiple comorbidities and sensitivity analyses for effects of diabetes or hypertension did not negate the impact of kidney disease on risks of subsequent or fatal hospitalizations. Third, diagnosis codes may not correctly classify all patients into proper cohorts. However, patients with kidney disease who may be misclassified into the reference cohort would bias study results to the null. Therefore, the true magnitude of risk is likely under-represented. Fourth, another limitation imposed by the use of administrative data is lack of detail for specific clinical outcomes. For example, CHARS data do not include causes or occurrences of death outside of the hospital. However, statewide hospital records were examined and followed for up to 45 months. Furthermore, patients from multiple payer sources were included, which makes the population more generalizable than studies limited to a single payer. Fifth, although statewide data were used, racial and ethnic characteristics of Washington State may not be globally representative. Findings of this study should be validated elsewhere to draw broader conclusions. Overall, these limitations are characteristic of the limitations encountered when analyzing administrative datasets. Nonetheless, such analyses offer a compelling design for evaluating prognostic information because of the longitudinal, population-based data that can be sufficiently powered and validated.

In conclusion, patients with kidney disease had long-term risks of subsequent hospitalization and admission resulting in death that were substantially increased in a large statewide population followed for an average of 29 months. These risks extended in a graded fashion across the spectrum of patients with kidney disease from CKD to ESRD treated by dialysis or kidney transplant. Because of such profound risks, patients with kidney disease should be a primary focus of efforts designed to improve care and lessen the complications leading to hospital admissions and death.

Disclosures

None.

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Supplementary Table 1

Sensitivity analysis of fully-adjusted risks for subsequent hospitalization in patients with and without a diagnosis of diabetes at the index hospitalization (n=676,343).

Subsequent Hospitalization

	Without Diabetes			With Diabetes		
Index Hospitalization	**HR**	**99% CI**	**p**	**HR**	**99% CI**	**p**
Cohort:						
CKD	1.20	1.17-1.23	<0.001	1.21	1.16-1.25	<0.001
Dialysis	1.79	1.71-1.87	<0.001	1.65	1.51-1.79	<0.001
Kidney transplant	1.90	1.70-2.12	<0.001	1.63	1.35-1.97	<0.001
Reference	1.00			1.00		

Fatal Hospitalization

	Without Diabetes			With Diabetes		
Index Hospitalization	**HR**	**99% CI**	**p**	**HR**	**99% CI**	**p**
Cohort:						
CKD	1.38	1.29-1.47	<0.001	1.49	1.35-1.64	<0.001
Dialysis	3.08	2.79-3.40	<0.001	2.84	2.38-3.39	<0.001
Kidney transplant	2.19	1.52-3.14	<0.001	2.36	1.40-3.96	<0.001
Reference	1.00			1.00		

Fully adjusted model controlling for age; gender; index hospitalization primary diagnosis, length of stay, and primary payer; 12 month count of previous hospitalizations; Elixhauser comorbidity variables.

CKD cohort defined by CKD not treated with hemodialysis, peritoneal dialysis or kidney transplant. Dialysis cohort includes hemodialysis and peritoneal dialysis.Diabetes defined by ICD9 diagnosis codes of 250.00 through 250.33, 648.00, 648.01, 648.02, 648.03, 648.04 or 249.00 through 249.31.
Source: Healthcare Cost and Utilization Project, Comorbidity Software, Version 3.6
(www.hcup-us.ahrq.gov/toolssoftware/comorbidity/comorbidity.jsp#download)

Supplementary Table 2
Sensitivity analysis of fully-adjusted risks for subsequent hospitalization for patients with and without a diagnosis of hypertension at the time of the index hospitalization (n=676,343).

Subsequent Hospitalization

	Without Hypertension			With Hypertension		
	HR	**99% CI**	**p**	**HR**	**99% CI**	**p**
Cohort:						
CKD	1.18	1.15-1.21	<0.001	1.22	1.12-1.31	<0.001
Dialysis	1.72	1.65-1.80	<0.001	1.63	1.33-2.00	<0.001
Kidney transplant	1.90	1.66-2.18	<0.001	1.69	1.44-1.98	<0.001
Reference	1.00			1.00		

Fatal Hospitalization

	Without Hypertension			With Hypertension		
	HR	**99% CI**	**p**	**HR**	**99% CI**	**p**
Cohort:						
CKD	1.38	1.29-1.48	<0.001	1.48	1.36-1.61	<0.001
Dialysis	3.05	2.78-3.36	<0.001	2.73	2.15-3.57	<0.001
Kidney transplant	2.30	1.53-3.47	<0.001	2.22	1.44-3.42	<0.001
Reference	1.00			1.00		

Fully adjusted model controlling for age; gender; index hospitalization primary diagnosis, length of stay, and primary payer; 12 month count of previous hospitalizations; Elixhauser comorbidity variables.

CKD cohort defined by CKD not treated with hemodialysis, peritoneal dialysis or kidney transplant. Dialysis cohort includes hemodialysis and peritoneal dialysis. Hypertension defined by ICD9 diagnosis codes of 401.1, 401.9, 642.00, 642.01, 642.02, 642.03 or 642.04.
Source: Healthcare Cost and Utilization Project, Comorbidity Software, Version 3.6
(www.hcup-us.ahrq.gov/toolssoftware/comorbidity/comorbidity.jsp#download)