Chapter 5: Acute Kidney Injury

- In 2015, 4.3% of Medicare fee-for-service beneficiaries experienced a hospitalization complicated by Acute Kidney Injury (AKI); this appears to have plateaued since 2011 (Figure 5.1). The 2015 Optum Clinformatics™ population showed a similar trend—0.3% had an AKI hospitalization (Figure 5.2).
- Among hospitalized veterans who did not have a prior diagnosis of AKI, 15% met KDIGO guidelines for AKI as defined using serum creatinine-based criteria (Table A). This included 13.4%, 0.5%, and 1.2% of patients with Stage 1, Stage 2, and Stage 3 AKI (Table 5.2).
- In 2013, Medicare patients aged 66 years and older who were hospitalized for AKI had a 35% cumulative probability of a recurrent AKI hospitalization within one year (Figure 5.6.a). For Optum Clinformatics™ patients aged 22 years and older, the probability of recurrent AKI hospitalization was 23% (Figure 5.7.a).
- Among these older Medicare patients, 28% were given an initial diagnosis of CKD in the year following an AKI hospitalization (Figure 5.10.a). In the Optum Clinformatics™ population, 19% of patients with an AKI hospitalization were newly classified as having CKD in the subsequent year (Figure 5.10.b).
- Among Medicare patients aged 66 years and older with a first AKI hospitalization in 2015, the in-hospital mortality rate was 8.7%, or 13.7% when including discharge to hospice. Comparable mortality rates for non-AKI hospitalizations were 2.1% and 4.2%. Less than half of all patients returned to their home on discharge, as compared to two-thirds of non-AKI patients, while 30.6% were discharged to an institution such as a rehabilitation or skilled nursing facility. About one-quarter of non-AKI patients are discharged to rehabilitation or skilled nursing facilities (Figure 5.11).

Introduction

Acute kidney injury (AKI) is now recognized as a major risk factor for the development of chronic kidney disease (CKD). This is obvious in cases of severe, dialysis-requiring AKI where patients fail to recover kidney function. Indeed, acute tubular necrosis without recovery is the primary diagnosis for 2% to 3% of incident end-stage renal disease (ESRD) cases annually. Yet, this represents a small fraction of the kidney disease burden resulting from AKI.

Studies have demonstrated significantly increased long-term risk of CKD and ESRD following AKI, even after initial recovery of function (Heung, 2012). Furthermore, this relationship is bidirectional—CKD patients are at substantially higher risk of suffering an episode of AKI. As a result, AKI is frequently superimposed on CKD, and plays a key role in CKD progression.

This year we again present data from three sources: the Medicare 5% sample, the Optum Clinformatics™ Data Mart dataset (from OptumInsight, representing claims from a large U.S. national health insurance company), and national data from the U.S. Department of Veterans Affairs (VA) health system. Medicare and Optum Clinformatics™ administrative data do not contain clinical or biochemical data with which to identify an AKI episode using the consensus criteria based on changes in serum creatinine or urinary output. In these data sources, episodes of AKI were identified using ICD-9-CM and ICD-10-CM (International Classification of Diseases, Ninth/Tenth Revision, Clinical Modification) diagnosis codes from claims. While this approach carries a high degree of specificity, an important limitation of this indirect method is poor sensitivity, generally <30%, and even lower for less severe cases of AKI. In particular, trends in AKI incidence must be interpreted with caution due to the possibility of "code creep", whereby non-clinical factors such as changing billing thresholds or increased awareness and recognition of AKI increase the likelihood of administrative coding for AKI. Thus, a rising incidence of AKI may represent a true increase

in cases, an increased likelihood to code for AKI, or a combination of both factors. In addition, a lower threshold for coding would lead to identification of less severe episodes and an apparent decrease in the rate of associated adverse outcomes.

In contrast to Medicare and Optum Clinformatics™, VA data contain clinical information to identify episodes of AKI through serum creatinine-based criteria. We present some data from the VA population to illustrate the potential gap between AKI episodes identified by administrative coding versus clinical data.

We begin this chapter by exploring trends in hospitalizations that became complicated by AKI, and describing the characteristics of those patients. We refer to "AKI hospitalizations" as any hospitalization during which there was a diagnosis of AKI; the AKI diagnosis was not necessarily the primary or admitting diagnosis. We focus on hospitalizations because the occurrence of AKI exclusively in the community is uncommon and often unrecognized. Next, we explore the risk of re-hospitalization with recurrent AKI, and describe follow-up care after an episode. We end by examining the impact of AKI on outcomes, including subsequent CKD status and patient disposition after an AKI hospitalization.

Methods

Starting with the 2013 claim year, the USRDS Coordinating Center has received the Medicare 5% sample from the Medicare Chronic Conditions Warehouse, a different data source than in previous years. This has coincided with a subsequent decrease in AKI hospitalizations, and we cannot rule out that this is an artifact of the differing source of the Medicare 5% data files. Conclusions regarding trends should be made in this context.

For the Medicare data, we often present results for those aged 66 and older. This allows a full year of Medicare eligibility (ages 65-66) for us to assess the patient's CKD and diabetes mellitus (DM) status prior to the hospitalization within which AKI occurred.

In contrast to the Medicare data, we also present figures and tables from the commercial insurance plans of a large national U.S. health insurance company, as included in the Optum Clinformatics™ Data Mart from OptumInsight. These data represent mainly working-age people and their minor dependents.

We present results only for patients aged 22 and older. In Volume 1, Chapter 2, *Identification and Care of Patients with CKD* see Table 2.1 for demographic characteristics of the Optum Clinformatics™ population (all ages) and Table 2.2 (ages 22-64) and Table 2.3 (all ages) for the prevalence of CKD and related conditions. Additionally, Table 5.2 of this chapter uses data from all patients hospitalized at a VA hospital during fiscal year 2015, to show AKI as defined by serum creatinine measurements and staged as outlined in the KDIGO clinical practice guideline for AKI (KDIGO, 2012). Note that urine output data was not available, so identification of AKI episodes did not include the KDIGO criteria related to urine output.

Age is a major risk factor for AKI. Each of the included datasets had interactions between sex and age that are important to keep in mind when comparing differences in AKI by sex. Within both Optum Clinformatics™ and the VA, women were younger on average than men. In Optum Clinformatics™, 56% of women were between the ages of 22 and 39, compared to only 19.4% of men. Among VA patients with at least one outpatient visit, 82% of men were aged 60 and older compared to only 46.6% of women. Conversely, women in the Medicare 5% sample were older, on average. Women had a mean age of 77.2 years while for men it was 75.5 years, and a higher proportion of women (20.4%) than men (13.2%) were aged 85 and older.

Note that the analyses for all figures except Figure 5.11 were based on all beneficiaries meeting the specified inclusion criteria. In Figure 5.11, we excluded those beneficiaries who were admitted from a long-term care facility to the inpatient setting where the AKI hospitalization occurred. Therefore, the category of institution in this figure includes only those newly admitted following a hospitalization.

Details of this data are described in the *Data Sources* section of the *CKD Analytical Methods*

chapter. Also see the *CKD Analytical Methods* section of the *CKD Analytical Methods* chapter for an explanation of the analytical methods used to generate the study cohorts, figures, and tables in this chapter. Microsoft Excel and PowerPoint files containing the data and graphics for these figures and tables are available to download from the USRDS website.

Characteristics of Patients with Acute Kidney Injury

The percentage of Medicare fee-for-service patients with an AKI hospitalization has risen over the past decade, but appears to have plateaued near 4.0% since 2011 (Figure 5.1). Of note, the increase was mostly seen in patients who did not require an intensive care unit (ICU) stay during their hospitalization. Over the same period, the proportion of AKI patients requiring inpatient dialysis initially declined, but also appears to have become stable since 2011. Not surprisingly, a higher proportion of patients with an ICU stay had AKI requiring dialysis, compared to patients without an ICU stay. Figure 5.2 reveals very similar trends in the Optum Clinformatics™ population, although the overall percentage of patients with an AKI hospitalization was far lower for these younger patients, at 0.3% in 2015. Taken together, these findings seem to support "code creep": while the threshold for defining (and thus coding for) AKI has decreased over the last 10 years, the threshold for dialysis initiation has likely remained stable.

vol 1 Figure 5.1 Percent of Medicare patients aged 66+ (a) with at least one AKI hospitalization, and (b) percent among those with an AKI hospitalization who required dialysis, and by whether an intensive care unit (ICU) stay was required, 2005-2015

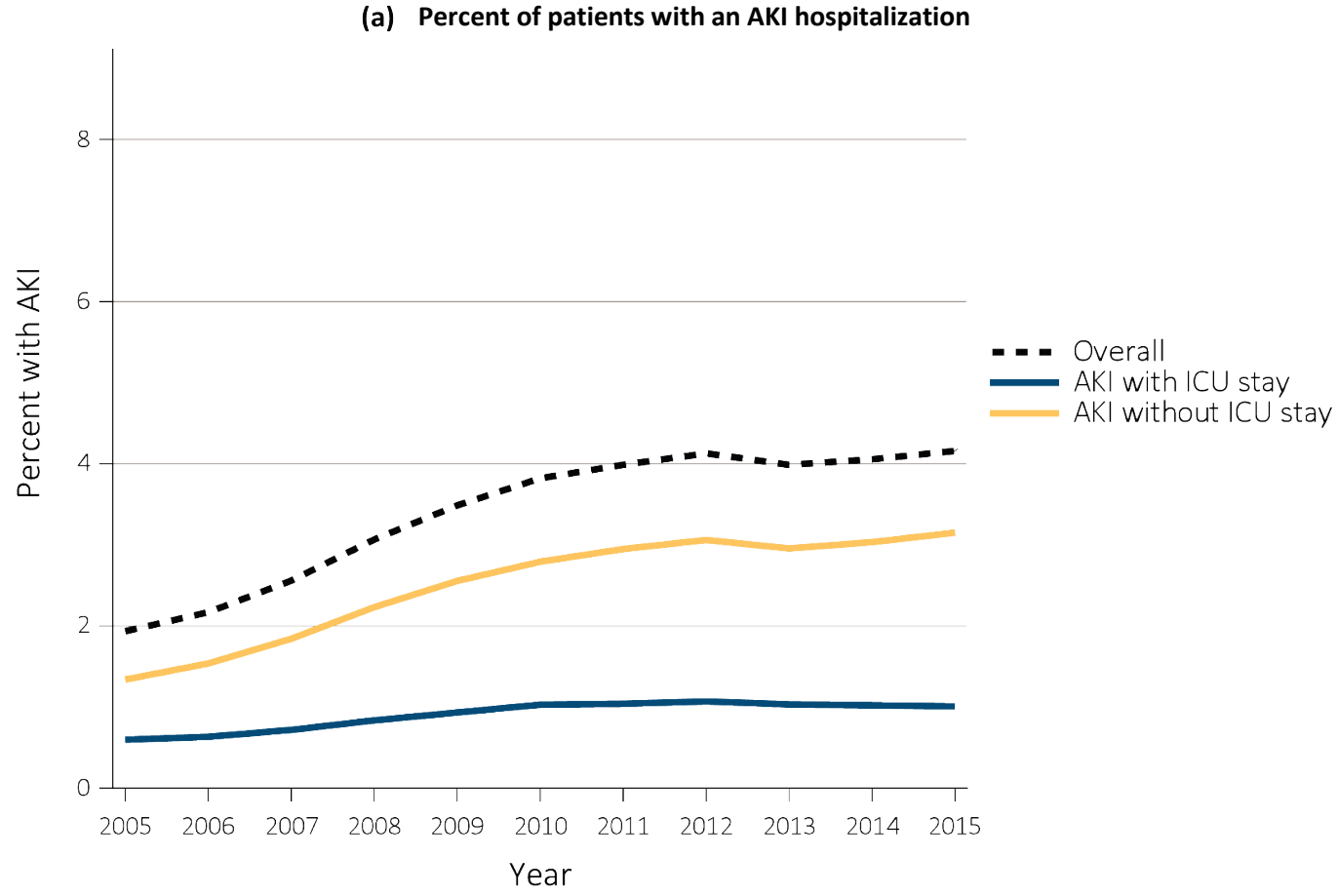
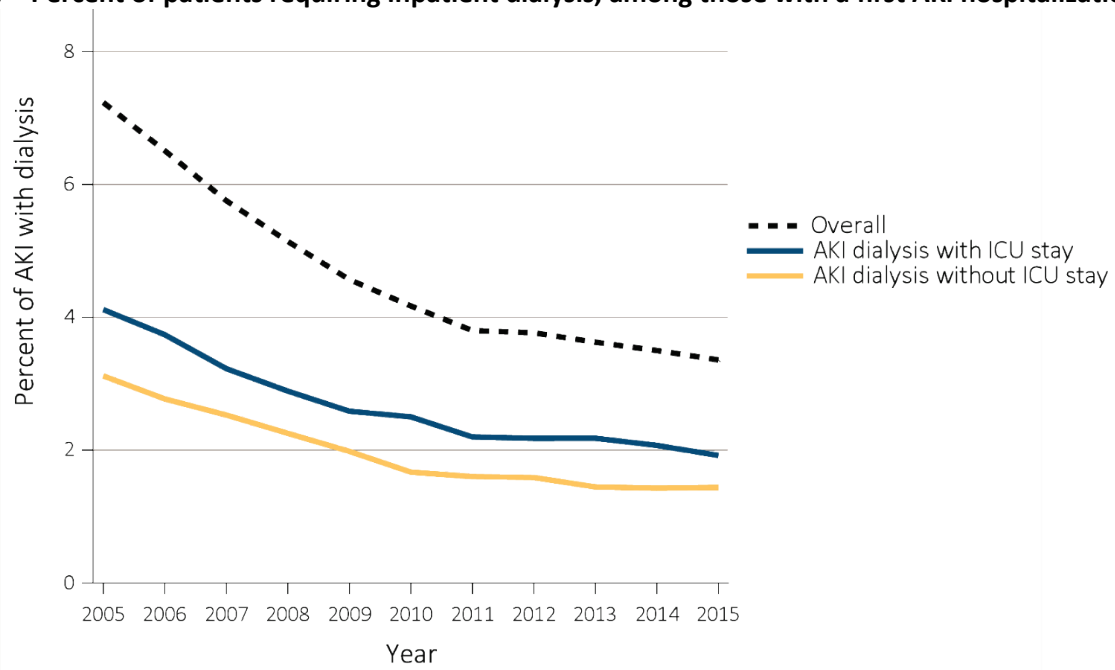


Figure 5.1 continued on next page.

vol 1 Figure 5.1 Percent of Medicare patients aged 66+ (a) with at least one AKI hospitalization, and (b) percent among those with an AKI hospitalization who required dialysis, and by whether an intensive care unit (ICU) stay was required, 2005-2015 *(continued).*

(b) Percent of patients requiring inpatient dialysis, among those with a first AKI hospitalization



Data Source: Special analyses, Medicare 5% sample. (a) Percent with an AKI hospitalization among all Medicare patients aged 66 and older who had both Medicare Parts A & B, no Medicare Advantage plan, no ESRD by first service date from Medical Evidence form, and were alive on January 1 of year shown. (b) Percent of patients receiving dialysis during their first AKI hospitalization among patients with a first AKI hospitalization. Dialysis is identified by a diagnosis or charge for dialysis on the AKI hospitalization inpatient claim or a physician/supplier (Part B) claim for dialysis during the time of the AKI inpatient claim. Abbreviations: AKI, acute kidney injury; ESRD, end-stage renal disease.

vol 1 Figure 5.2 Percent of Optum Clinformatics™ patients aged 22+ (a) with at least one AKI hospitalization, and (b) percent among those with an AKI hospitalization who required dialysis, by year, 2005-2015

(a) Percent of patients with an AKI hospitalization

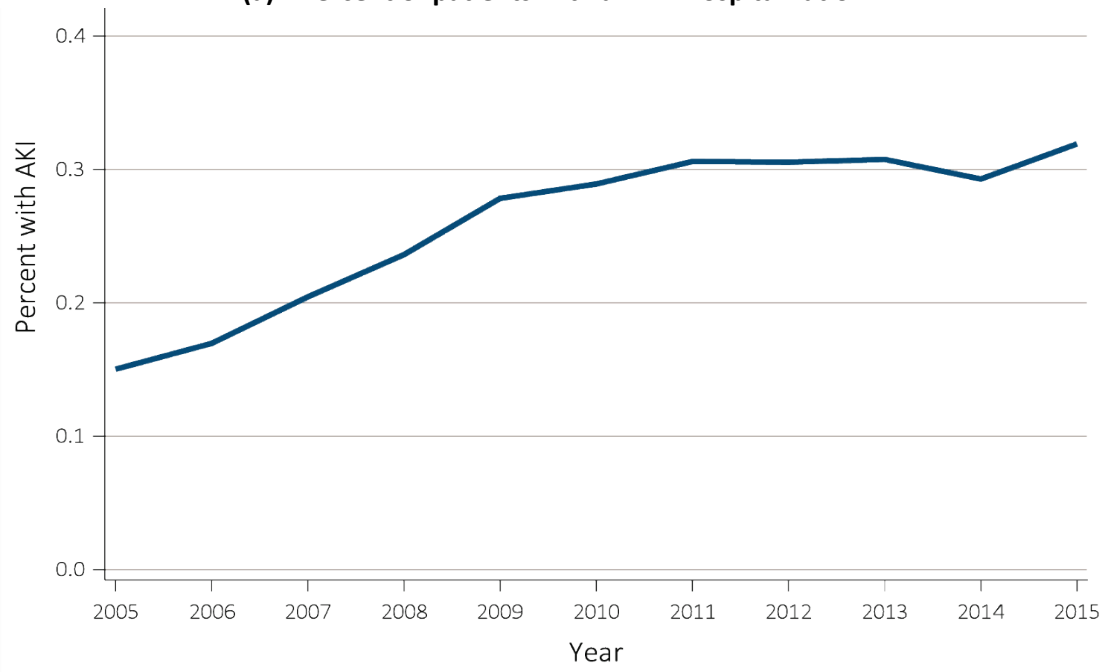
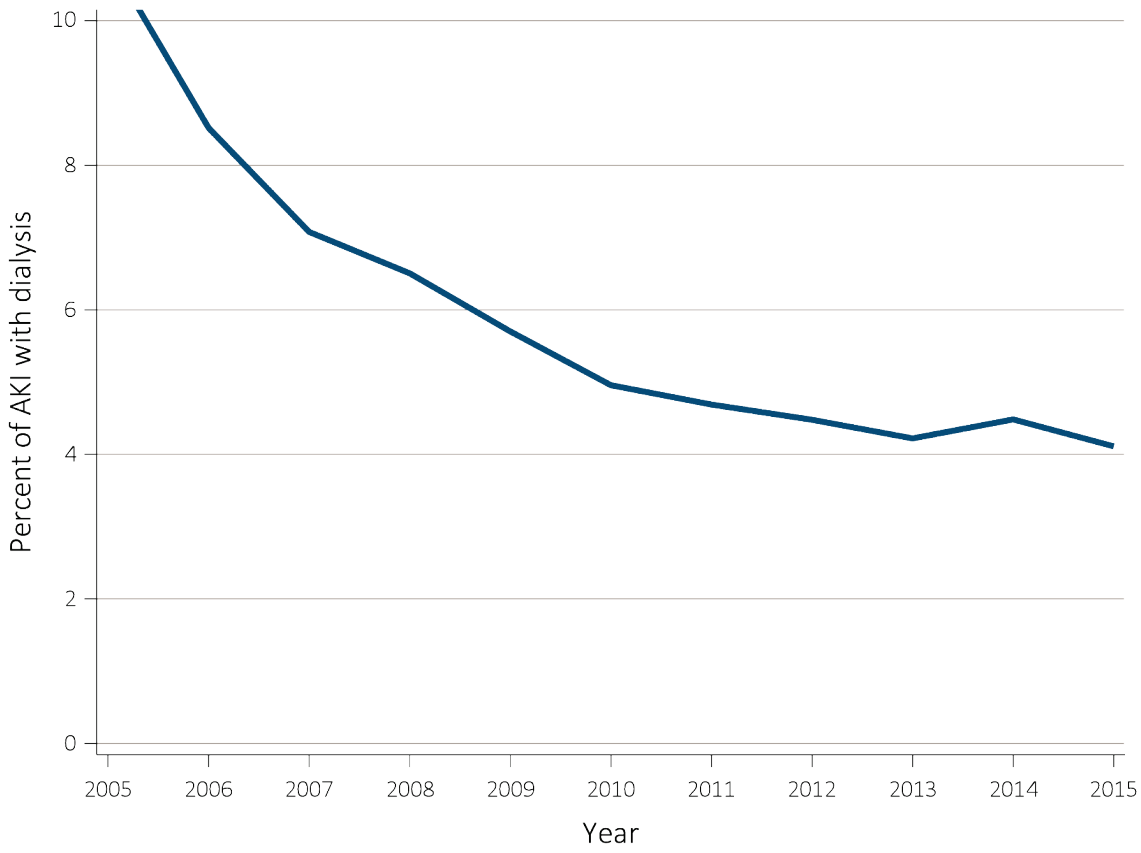


Figure 5.2 continued on next page.

vol 1 Figure 5.2 Percent of Optum Clinformatics™ patients aged 22+ (a) with at least one AKI hospitalization, and (b) percent among those with an AKI hospitalization who required dialysis, by year, 2005-2015 *(continued)*

(b) Percent of patients requiring dialysis, among those with a first AKI hospitalization



Data Source: Special analyses, Optum Clinformatics™. (a) Percent with an AKI hospitalization among all Optum Clinformatics™ commercial insurance patients aged 22 and older who were enrolled in the plan, did not have diagnoses of ESRD, and were alive on January 1, 2015. (b) Percent of patients receiving dialysis during their first AKI hospitalization among patients with a first AKI hospitalization. Dialysis is identified by a diagnosis or charge for dialysis on the AKI hospitalization inpatient (confinement) claim or a medical claim for dialysis during the time of the AKI inpatient claim. Abbreviations: AKI, acute kidney injury; ESRD, end-stage renal disease.

Table 5.1 presents demographic and comorbidity characteristics of Medicare and Optum Clinformatics™ patients with AKI in 2015. AKI occurs commonly in older adults, and the incidence rises with age. In the fee-for-service Medicare population, over half of all patients with an AKI hospitalization were aged 80 or older. In both the Medicare and Clinformatics™ populations, a higher proportion of Black/African American patients had AKI compared to Whites or Asians. Diabetes and pre-existing CKD are recognized as two major risk factors for AKI; at least one of these risk factors was present in nearly 58% of Medicare patients with an AKI hospitalization and 21% of patients had both. Even in the younger Optum Clinformatics™ population, about 34% of patients with an AKI hospitalization had either DM, CKD, or both.

vol 1 Table 5.1 Characteristics of Medicare and Optum Clinformatics™ patients with at least one hospitalization, by age, sex, race, CKD, DM, and presence of AKI, 2015

	Medicare (Age 66+)					Optum Clinformatics™ (Age 22+)				
	Total	No AKI		Any AKI		Total	No AKI		Any AKI	
	N	N	%	N	%	N	N	%	N	%
Total	232,082	176,482	76.0	55,600	24.0	317,719	294,930	92.8	22,789	7.2
Age										
22-39	—	—	—	—	—	137,638	135,283	98.3	2,355	1.7
40-65	—	—	—	—	—	151,583	136,433	90.0	15,150	10.0
65+	—	—	—	—	—	28,498	23,214	81.5	5,284	18.5
66-69	37,398	30,489	81.5	6,909	18.5	—	—	—	—	—
70-74	45,068	35,980	79.8	9,088	20.2	—	—	—	—	—
75-79	42,957	33,078	77.0	9,879	23.0	—	—	—	—	—
80-84	40,215	29,779	74.1	10,436	26.0	—	—	—	—	—
85+	66,444	47,156	71.0	19,288	29.0	—	—	—	—	—
Sex										
Male	98,975	71,850	72.6	27,125	27.4	110,121	95,841	87.0	14,280	13.0
Female	133,107	104,632	78.6	28,475	21.4	207,598	199,089	95.9	8,509	4.1
Race & Ethnicity										
White	202,210	155,688	77.0	46,522	23.0	222,381	206,032	92.6	16,349	7.4
Black/African American	18,353	12,053	65.7	6,300	34.3	32,099	29,071	90.6	3,028	9.4
Native American	1,215	925	76.1	290	23.9	—	—	—	—	—
Hispanic	—	—	—	—	—	34,526	32,532	94.2	1,994	5.8
Asian	3,034	2,247	74.1	787	25.9	13,578	13,127	96.7	451	3.3
Other	7,270	5,569	76.6	1,701	23.4	15,135	14,168	93.6	967	6.4
Pre-existing comorbidities										
No DM or CKD, prior year	137,436	114,016	83.0	23,420	17.0	283,027	267,963	94.7	15,064	5.3
DM no CKD, prior year	47,804	36,483	76.3	11,321	23.7	24,634	20,599	83.6	4,035	16.4
CKD no DM, prior year	22,252	13,258	59.6	8,994	40.4	5,366	3,692	68.8	1,674	31.2
Both CKD & DM, prior year	24,590	12,725	51.8	11,865	48.3	4,692	2,676	57.0	2,016	43.0

Data Source: Special analyses, Medicare 5% sample and Optum Clinformatics™. Medicare patients aged 66 and older who had both Medicare Parts A & B, no Medicare Advantage plan, no ESRD by first service date from Medical Evidence form, and were alive on January 1, 2015. Optum Clinformatics™ commercial insurance patients aged 22 and older who were enrolled in the plan, did not have diagnoses of ESRD, and were alive on January 1, 2015. Abbreviations: AKI, acute kidney injury; CKD, chronic kidney disease; DM, diabetes mellitus; ESRD, end-stage renal disease. —This category does not apply for this dataset.

Table 5.2 presents characteristics of VA patients who had an AKI hospitalization. Here, AKI was defined using serum creatinine-based criteria per the KDIGO guidelines (Table A). For VA patients with diabetes, about 28.2% of them had AKI hospitalization as defined by KDIGO criteria. This percentage increased to 43.7% among CKD patients, and 54.4% among patients with both DM and CKD.

Table A. KDIGO definition and staging of Acute Kidney Injury

Definition of AKI:

An increase in serum creatinine (SCR) by ≥0.3mg/dL (≥26.5 µmol/l) within 48 hours; or an increase in SCR to ≥1.5 times baseline, which is known or presumed to have occurred within the prior 7 days; or urine volume <0.5ml/kg/h for 6 hours.

Stage	Serum creatinine	Urine output
1	1.5–1.9 times baseline OR ≥0.3 mg/dL (≥26.5 µmol/l) increase	<0.5 ml/kg/h for 6-12 hours
2	2.0–2.9 times baseline	<0.5 ml/kg/h for ≥12 hours
3	3.0 times baseline OR increase in SCR to >4.0 mg/dL (≥353.6 µmol/l) OR initiation of renal replacement therapy OR, in patients <18 years, decrease in eGFR to <35 ml/min/1.73m^2	<0.3 ml/kg/h for ≥24 hours OR anuria for ≥12 hours

Adapted from KDIGO (2012). Abbreviations: AKI, acute kidney injury; eGFR, estimated glomerular filtration rate; SCR, serum creatinine.

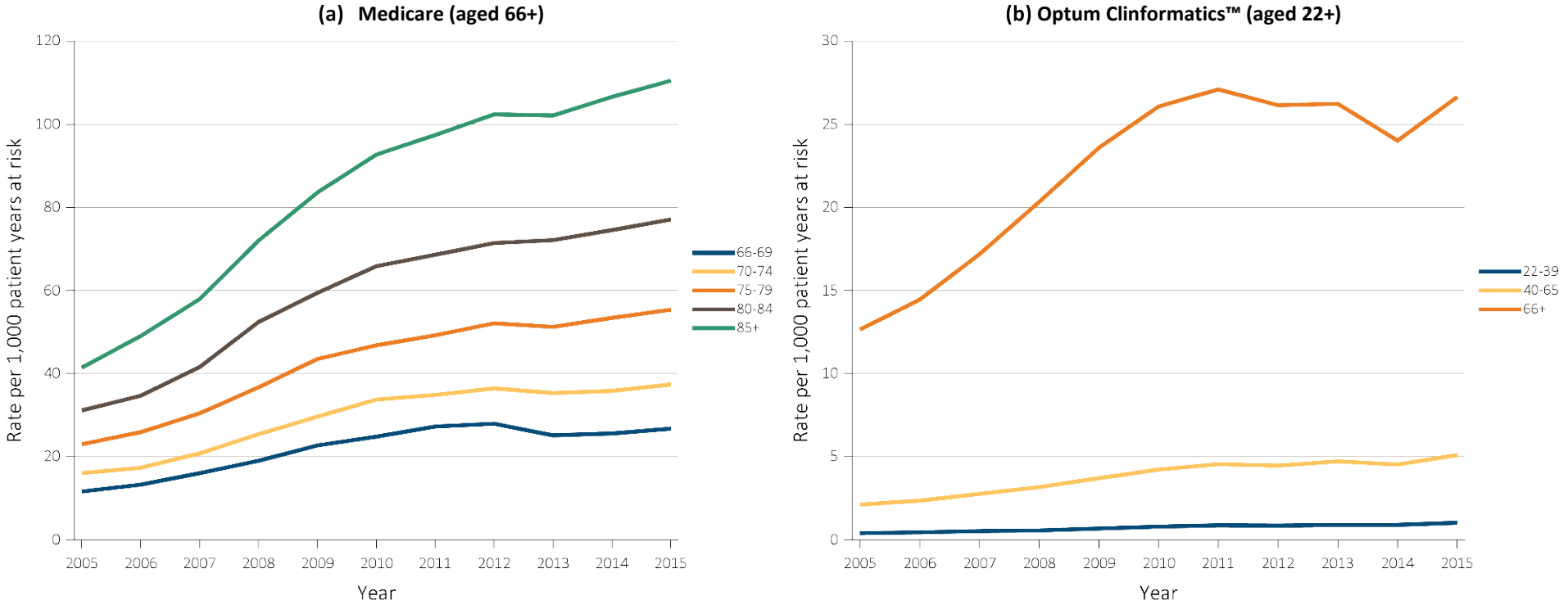
vol 1 Table 5.2 Characteristics of Veterans Affairs patients aged 22+ with at least one hospitalization, by age, sex, race, CKD, DM, presence and stage of AKI, defined by serum creatinine, FY 2015

	Total	No AKI		Any Stage AKI		Stage 1		Stage 2		Stage 3[a]	
	N	N	%	N	%	N	%	N	%	N	%
Total	305,189	227,325	74.5	77,864	25.5	65,343	21.4	2,651	0.9	9,870	3.2
Diagnosis of AKI											
No	254,588	216,356	85.0	38,232	15.0	34,074	13.4	1,212	0.5	2,946	1.2
Yes	50,601	10,969	21.7	39,632	78.3	31,269	61.8	1,439	2.8	6,924	13.7
Age at this inpatient admission											
20-39	12,264	11,198	91.3	1,066	8.7	884	7.2	61	0.5	121	1
40-59	54,613	44,364	81.2	10,249	18.8	8,334	15.3	509	0.9	1,406	2.6
60-65	50,687	37,877	74.7	12,810	25.3	10,485	20.7	551	1.1	1,774	3.5
66-69	56,000	41,230	73.6	14,770	26.4	12,258	21.9	501	0.9	2,011	3.6
70-74	49,322	35,952	72.9	13,370	27.1	11,304	22.9	398	0.8	1,668	3.4
75-79	24,810	17,307	69.8	7,503	30.2	6,395	25.8	187	0.8	921	3.7
80-84	23,262	15,901	68.4	7,361	31.6	6,282	27.0	186	0.8	893	3.8
85+	34,231	23,496	68.6	10,735	31.4	9,401	27.5	258	0.8	1,076	3.1
Sex											
Male	287,706	212,346	73.8	75,360	26.2	63,260	22.0	2,508	0.9	9,592	3.3
Female	17,483	14,979	85.7	2,504	14.3	2,083	11.9	143	0.8	278	1.6
Race/ethnicity											
Non-Hispanic White	209,767	159,271	75.9	50,496	24.1	43,264	20.6	1,761	0.8	5,471	2.6
Non-Hispanic Black	58,349	40,597	69.6	17,752	30.4	14,244	24.4	515	0.9	2,993	5.1
American Indian/Alaska Native	1,598	1,238	77.5	360	22.5	292	18.3	9	0.6	59	3.7
Hispanic	18,730	13,677	73.0	5,053	27.0	4,053	21.6	227	1.2	773	4.1
Asian	2,365	1,792	75.8	573	24.2	461	19.5	17	0.7	95	4
Other/Unknown	14,380	10,750	74.8	3,630	25.2	3,029	21.1	122	0.8	479	3.3
Had CKD before admission											
No	267,428	208,873	78.1	58,555	21.9	50,740	19.0	2,555	1.0	5,260	2
Yes	37,761	18,452	48.9	19,309	51.1	14,603	38.7	96	0.3	4,610	12.2
Had hypertension before admission											
No	118,179	96,638	81.8	21,541	18.2	17,986	15.2	1,021	0.9	2,534	2.1
Yes	187,010	130,687	69.9	56,323	30.1	47,357	25.3	1,630	0.9	7,336	3.9
Had diabetes before admission											
No	201,945	159,424	78.9	42,521	21.1	35,607	17.6	1,785	0.9	5,129	2.5
Yes	103,244	67,901	65.8	35,343	34.2	29,736	28.8	866	0.8	4,741	4.6
Pre-admission CKD and diabetes status											
Neither	180,509	147,353	81.6	33,156	18.4	28,751	15.9	1,728	1.0	2,677	1.5
Diabetes only	79,518	57,072	71.8	22,446	28.2	20,041	25.2	827	1.0	1,578	2
CKD only	21,436	12,071	56.3	9,365	43.7	6,856	32.0	57	0.3	2,452	11.4
Diabetes & CKD	23,726	10,829	45.6	12,897	54.4	9,695	40.9	39	0.2	3,163	13.3

Data Source: Special analyses, Veterans Health Administration data. Patients aged 22 and older with at least one hospitalization in fiscal year 2015. AKI defined by serum creatinine criteria as in KDIGO (2012), see Table A for details. [a] Stage 3 includes those requiring dialysis. Diabetes and CKD determined by ICD-9-CM diagnosis codes. Excludes those with evidence of ESRD prior to admission by diagnosis and procedure codes. Abbreviations: AKI, acute kidney injury; CKD, chronic kidney disease; DM, diabetes mellitus; FY, federal fiscal year (October 1, 2014 to September 30, 2015).

As shown in Figure 5.3, rates of AKI were strongly influenced by age. Among fee-for-service Medicare patients in 2015, the rate of AKI for those aged 66-69 was 26.8 per 1,000 patient years, increasing to 37.4, 55.4, 77.1, and 110.5 for those aged 70-74, 75-79, 80-84, and 85 years and older. Between 2005 and 2012, unadjusted rates of AKI increased for all age groups. Data from 2011 to 2015 showed a plateau or slight decrease in AKI rates for patients less than 80 years; rates continued to rise in older patients. Among Optum Clinformatics™ patients, the overall group AKI rate increased over time, peaking at 4.2 per 1,000 patient years in 2015. For the subgroup aged 66 and older, the 2011 rate was 27.1 per 1,000 patient-years and remained somewhat stable at 26.6 per 1,000 in 2015.

vol 1 Figure 5.3 Unadjusted rates of hospitalization with AKI, per 1,000 patient-years at risk, by age, 2005-2015



Data Source: Special analyses, Medicare 5% sample and Optum Clinformatics™. (a) Age as of January 1 of specified year. All patient-years at risk for Medicare patients aged 66 and older who had both Medicare Parts A & B, no Medicare Advantage plan, no ESRD by first service date from Medical Evidence form, and were alive on January 1 of year shown. Censored at death, ESRD, end of Medicare Parts A & B participation, or switch to Medicare Advantage program. (b) All patient-years at risk for Optum Clinformatics™ commercial insurance patients aged 22 and older who were enrolled in the plan, did not have diagnoses of ESRD, and were alive on January 1 of year shown. Abbreviation: AKI, acute kidney injury; ESRD, end-stage renal disease.

Figure 5.4 highlights differences in AKI rates by race. In 2015, among fee-for-service Medicare patients aged 66 and older, the incidence rate for those of Black race was 90.2 per 1,000 patient-years at risk compared to 53.4 and 43.0, in Whites and individuals of other races. A similar relationship was observed in the Optum Clinformatics™ population, albeit at much lower rates: 6.1, 4.5, and 2.8 per 1,000 patient-years at risk in Blacks, Whites, and individuals of other races.

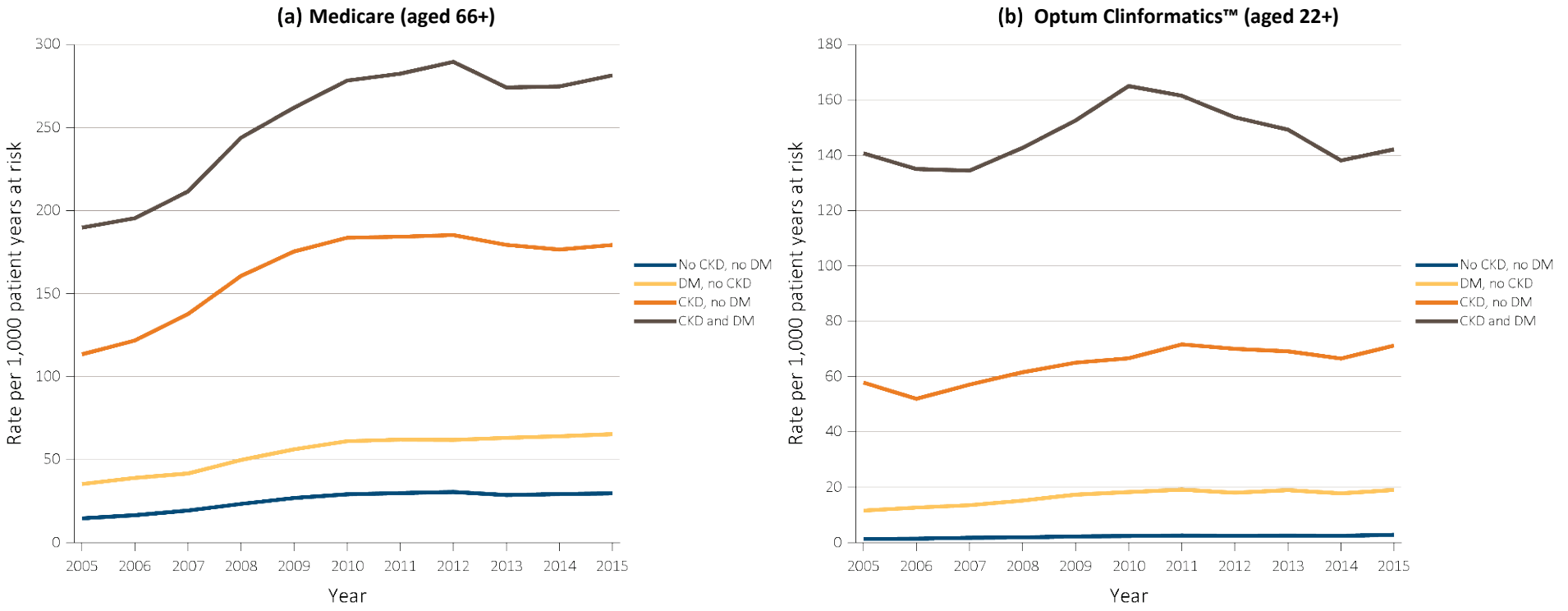
vol 1 Figure 5.4 Unadjusted rates of hospitalization with AKI, per 1,000 patient-years at risk, by race, 2005-2015

Data Source: Special analyses, Medicare 5% sample and Optum Clinformatics™. (a) All patient-years at risk for Medicare patients aged 66 and older who had both Medicare Parts A & B, no Medicare Advantage plan, no ESRD by first service date from Medical Evidence form, and were alive on January 1 of year shown. Censored at death, ESRD, end of Medicare Parts A & B participation, or switch to Medicare Advantage program. (b) All patient-years at risk for Optum Clinformatics™ commercial insurance patients aged 22 and older who were enrolled in the plan, did not have diagnoses of ESRD, and were alive on January 1 of year shown. Abbreviations: Af Am, African American; AKI, acute kidney injury; ESRD, end-stage renal disease.

As shown in Figure 5.5, incidence rates for AKI also varied substantially by underlying comorbidity. In 2015, Medicare patients with DM but no known CKD had an AKI incidence rate of 65.3 per 1,000 patient-years compared to 29.7 per 1,000 patient-years in non-diabetic, non-CKD patients. Non-diabetic patients with CKD experienced an AKI incidence rate of 179.3 per 1,000 patient-years, while the rate in patients with both DM and CKD was 281.4 per 1,000. That is, about 28% of Medicare patients with both CKD and DM experienced a hospitalization with AKI in each year.

The Optum Clinformatics™ population showed similar relationships. Patients with both CKD and DM experienced the highest rates of AKI hospitalization at 142.1 per 1,000 patient-years. However, their overall rates were much lower, presumably reflecting the younger age range in this population.

vol 1 Figure 5.5 Unadjusted rates of hospitalization with AKI, per 1,000 patient-years at risk, by CKD and DM, 2005-2015



Data Source: Special analyses, Medicare 5% sample and Optum Clinformatics™. (a) All patient-years at risk for Medicare patients aged 66 and older who had both Medicare Parts A & B, no Medicare Advantage plan, no ESRD by first service date from Medical Evidence form, and were alive on January 1 of year shown. Censored at death, ESRD, end of Medicare Parts A & B participation, or switch to Medicare Advantage program. (b) All patient-years at risk for Optum Clinformatics™ commercial insurance patients aged 22 and older who were enrolled in the plan, did not have diagnoses of ESRD, and were alive on January 1 of year shown. Abbreviations: AKI, acute kidney injury; CKD, chronic kidney disease; DM, diabetes mellitus; ESRD, end-stage renal disease.

Re-hospitalization Associated with Acute Kidney Injury

Figures 5.6 and 5.7 show the probability of a patient's recurrent AKI hospitalization after their live discharge from an initial AKI hospitalization. Among 2013 Medicare patients aged 66 and older the overall probability of a recurrent AKI event was 0.35 in the next 12 months and 0.48 by 24 months, as shown in Figure 5.6.a. Among Optum Clinformatics™ patients, these probabilities were 0.23 and 0.31. In contrast to first episodes, the rate of recurrent AKI was relatively similar across age groups in the fee-for-service Medicare population (Figure 5.6.b). Interpretation of this finding is limited, however, because of the effect of death censoring, which was higher in older age groups.

In both the Medicare and Optum Clinformatics™ populations, Blacks had a higher probability of recurrent AKI compared to Whites or individuals of other races (Figures 5.6.c and 5.7.c). Similarly, having either DM or CKD was associated with an increased probability for recurrent AKI compared to having neither (see Figures 5.6.d and 5.7.d). The highest probability for recurrent AKI was for patients with both DM and CKD, reaching 0.59 by 24 months among Medicare patients and 0.45 among Optum Clinformatics™ patients. In contrast, Medicare patients with neither comorbidity had a cumulative probability for recurrent AKI hospitalization of 0.30 by 24 months, while their Optum Clinformatics™ counterparts had a probability of 0.21 by 24 months.

Siew et al. (2016) examined recurrent AKI for VA patients in 2003 and 2010 who survived their first AKI hospitalization (n=11,683). Of these, 8.5% had a second AKI episode within 30 days, 14.6% within 90 days, 19.5% within 180 days, and 25.3% with 12 months. AKI was defined according to KDIGO criteria using serum creatinine.

vol 1 Figure 5.6 Cumulative probability of a recurrent AKI hospitalization within two years of live discharge from first AKI hospitalization in 2013 for Medicare patients aged 66+, (a) overall, (b) by age, (c) by race, and (d) by CKD and DM

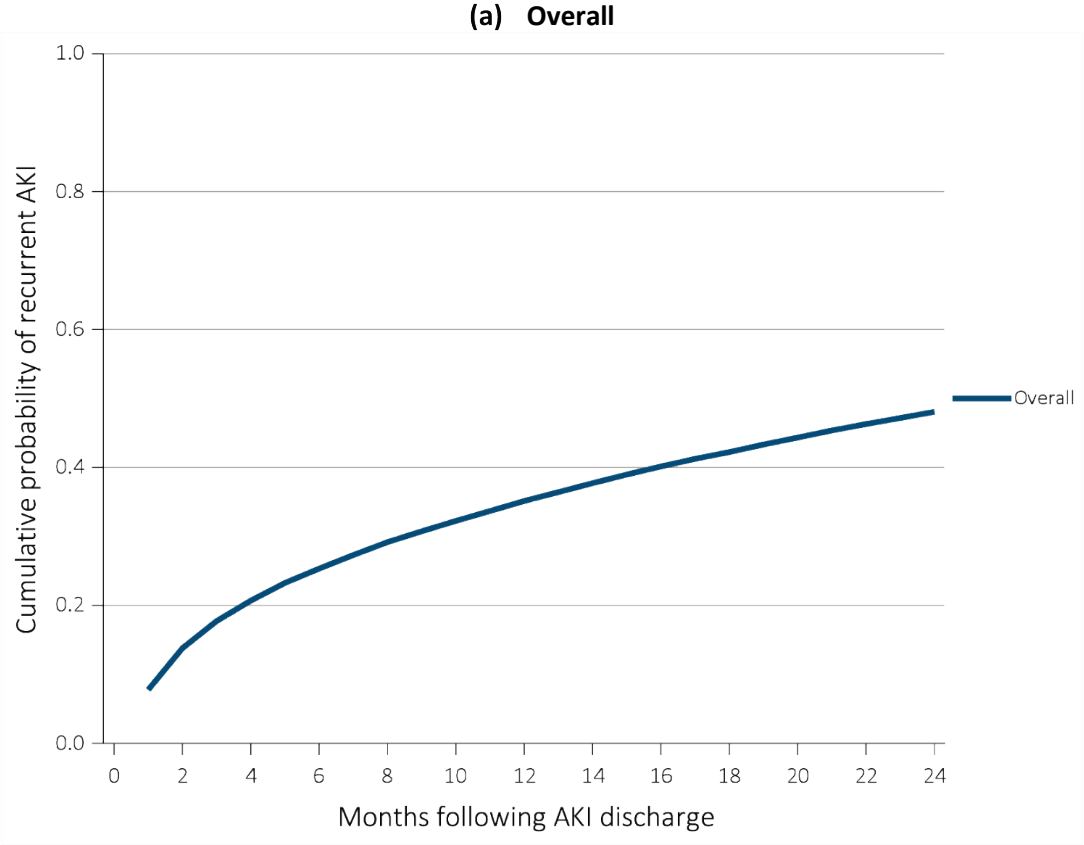
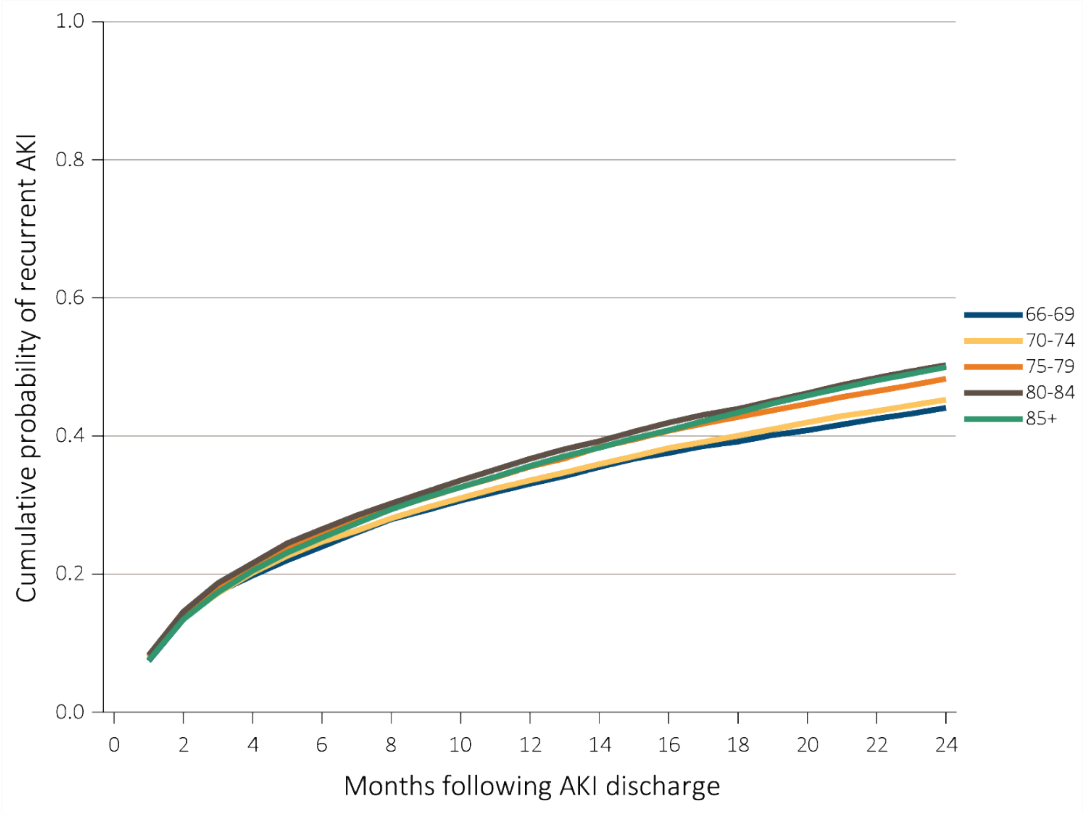


Figure 5.6 continued on next page.

vol 1 Figure 5.6 Cumulative probability of a recurrent AKI hospitalization within two years of live discharge from first AKI hospitalization in 2013 for Medicare patients aged 66+, (a) overall, (b) by age, (c) by race, and (d) by CKD and DM *(continued)*

(b) Age



(c) Race

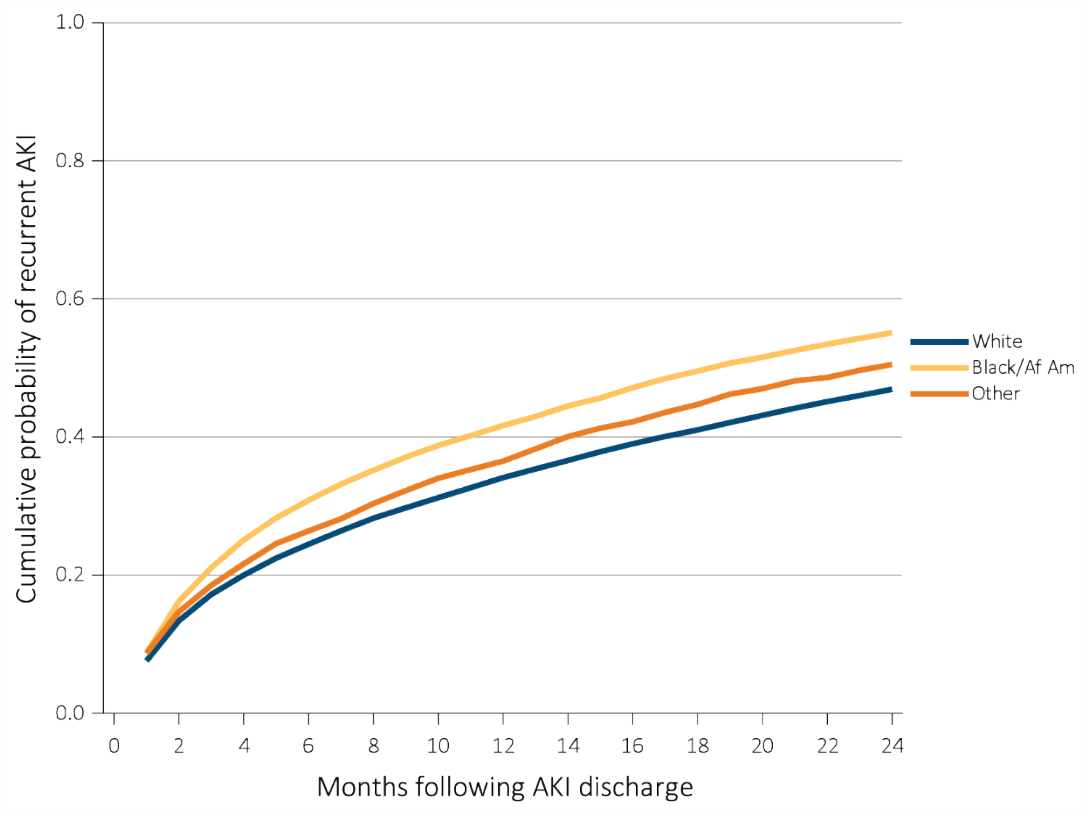
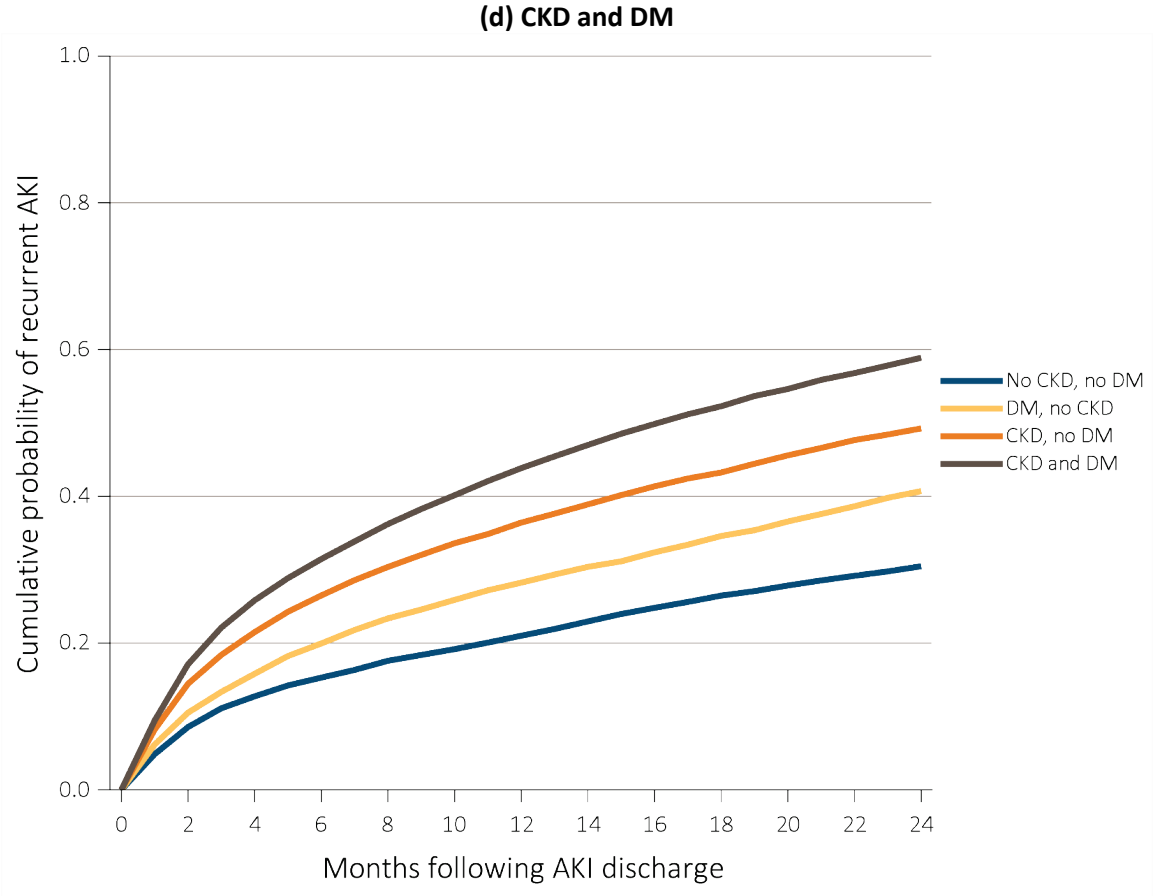


Figure 5.6 continued on next page.

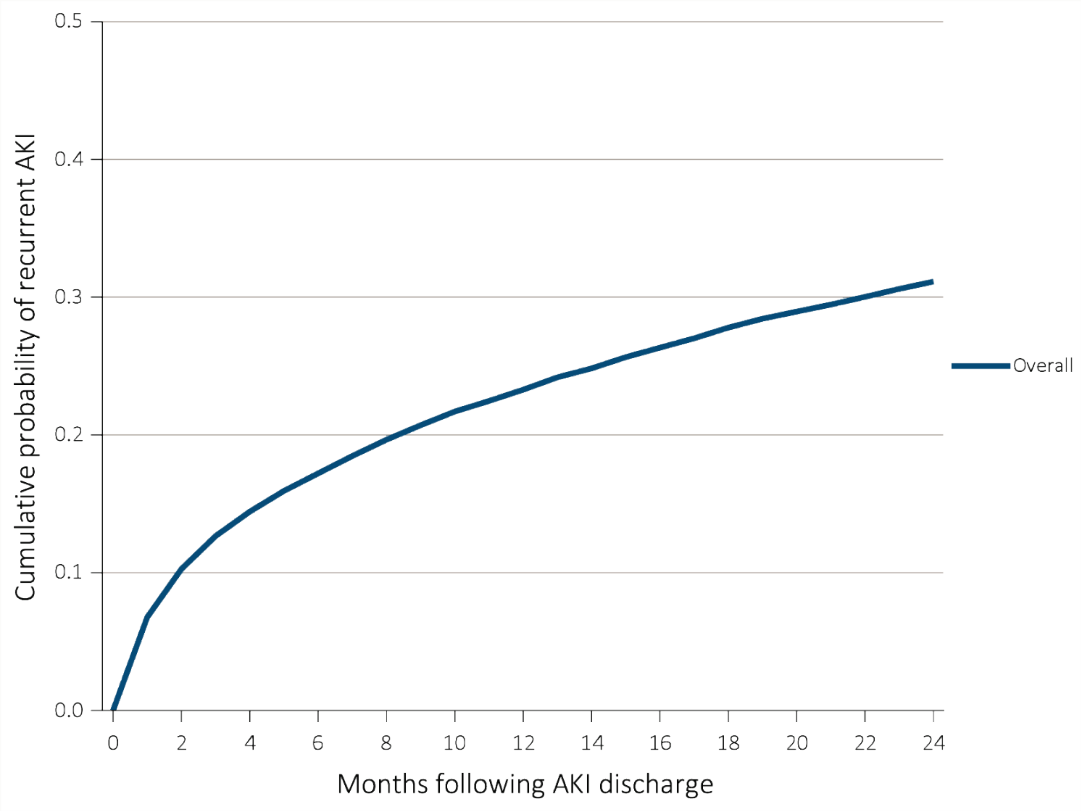
vol 1 Figure 5.6 Cumulative probability of a recurrent AKI hospitalization within two years of live discharge from first AKI hospitalization in 2013 for Medicare patients aged 66+, (a) overall, (b) by age, (c) by race, and (d) by CKD and DM *(continued)*



Data Source: Special analyses, Medicare 5% sample. Age on January 1, 2013. Medicare patients aged 66 and older who had both Medicare Parts A & B, no Medicare Advantage plan, no ESRD by first service date from Medical Evidence form on 1/1/2013, and were discharged alive from an AKI hospitalization in 2013. Censored at death, ESRD, end of Medicare Parts A & B participation, or switch to Medicare Advantage program. Abbreviations: AKI, acute kidney injury; CKD, chronic kidney disease; DM, diabetes mellitus; ESRD, end-stage renal disease.

vol 1 Figure 5.7 Cumulative probability of a recurrent AKI hospitalization within two years of live discharge from first AKI hospitalization in 2013 for Optum Clinformatics™ patients aged 22+, (a) overall, (b) by age, (c) by race, and (d) by CKD and DM

(a) Overall



(b) Age

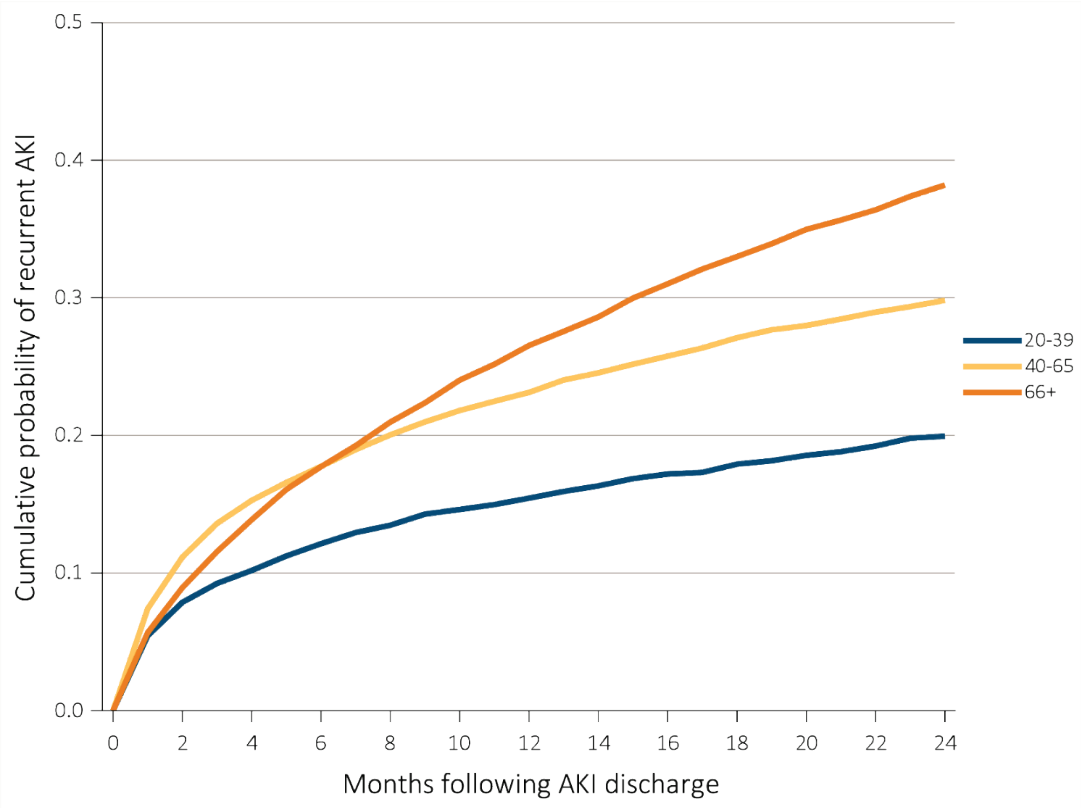
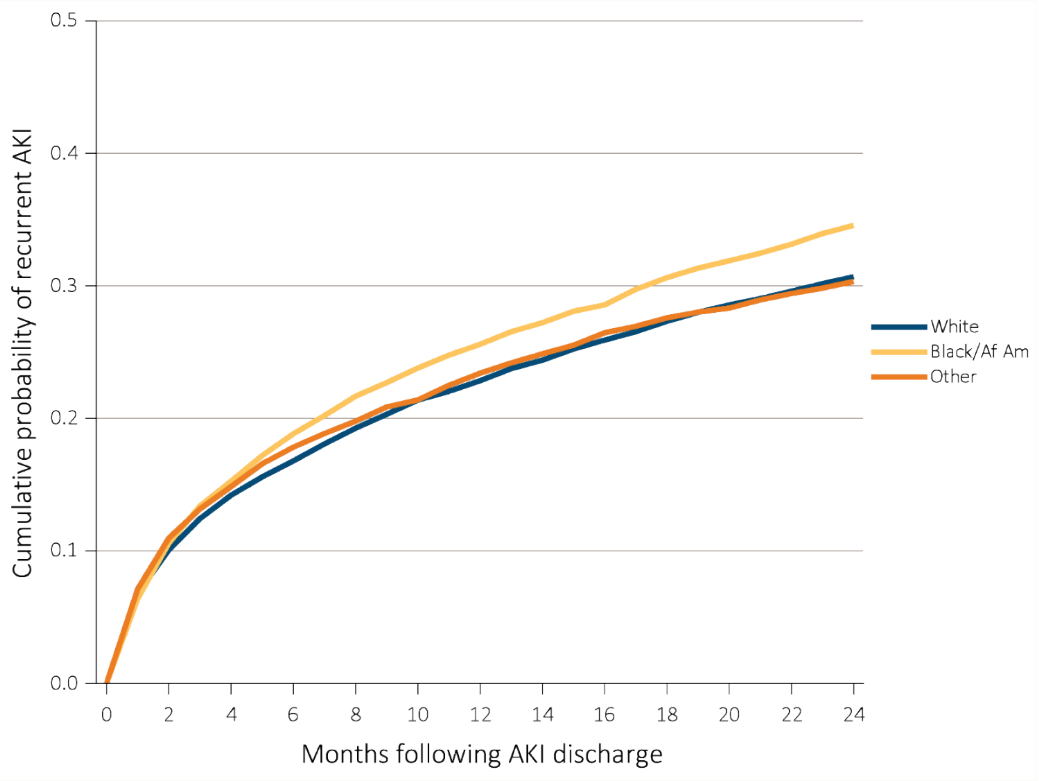


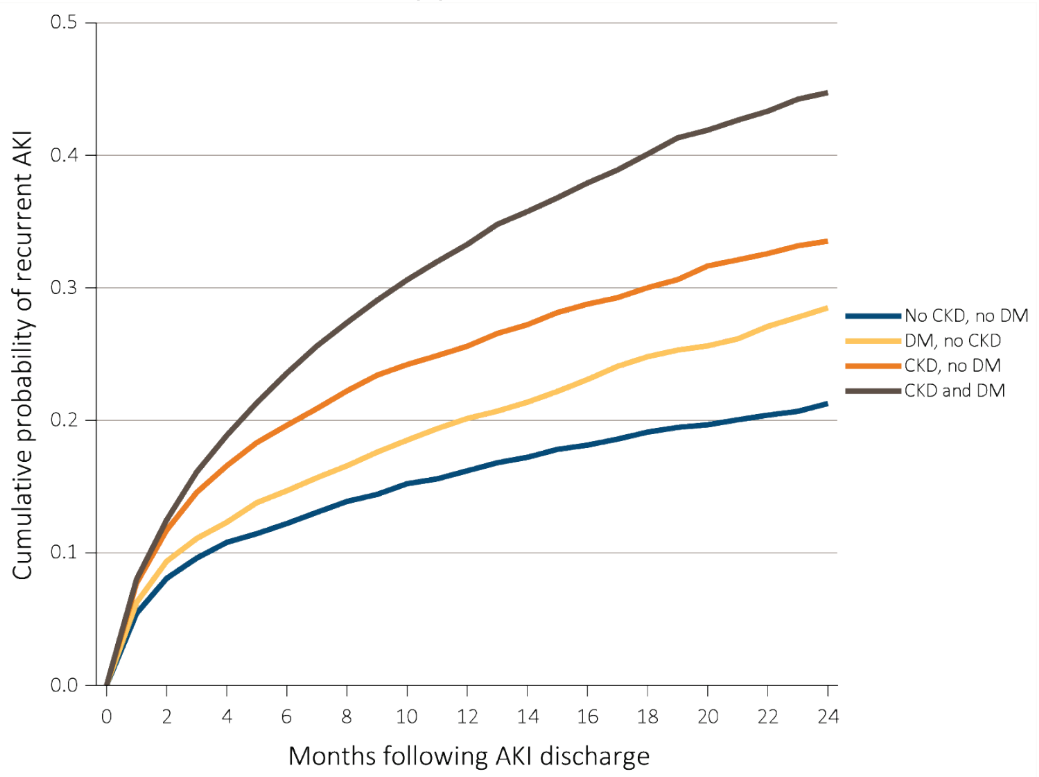
Figure 5.7 continued on next page.

vol 1 Figure 5.7 Cumulative probability of a recurrent AKI hospitalization within two years of live discharge from first AKI hospitalization in 2013 for Optum Clinformatics™ patients aged 22+, (a) overall, (b) by age, (c) by race, and (d) by CKD and DM *(continued)*

(c) Race



(d) CKD and DM

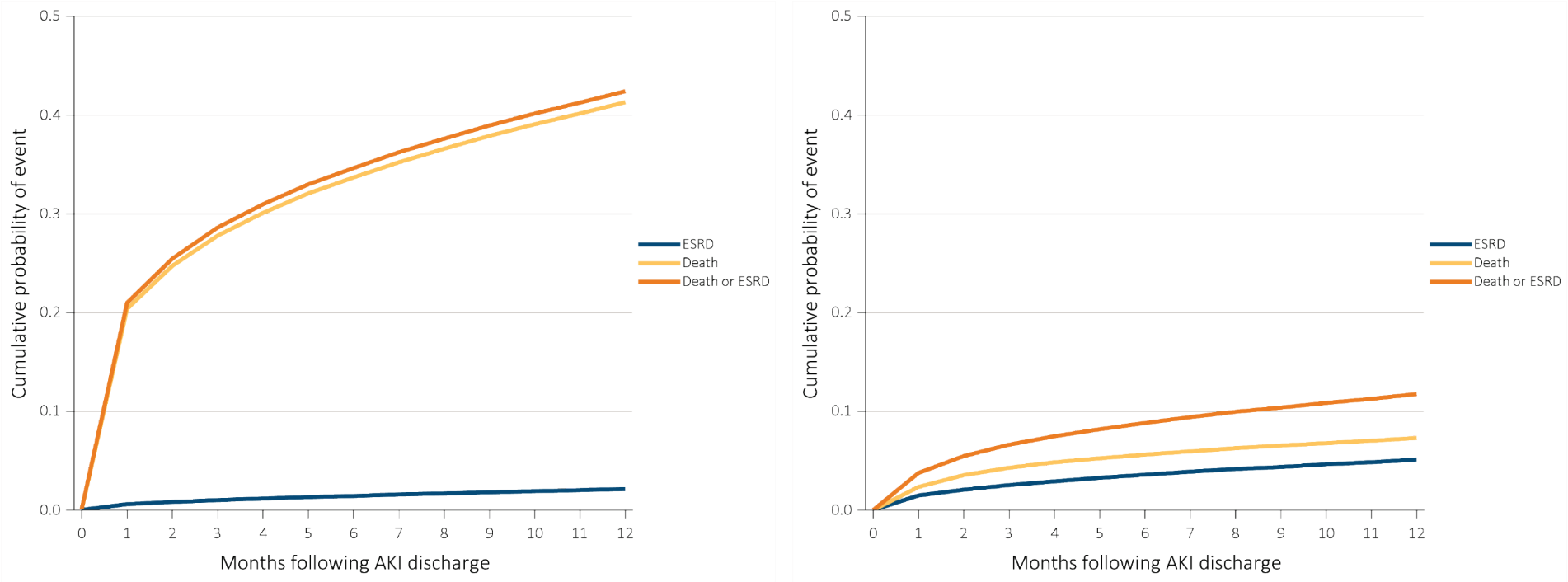


Data Source: Special analyses, Optum Clinformatics™. Age as of January, 2013. Optum Clinformatics™ commercial insurance patients aged 22 and older who were enrolled in the plan, did not have diagnoses of ESRD on January 1, 2013, and were discharged alive from an AKI hospitalization in 2013. Censored at death, ESRD diagnosis, or plan disenrollment. Abbreviations: AKI, acute kidney injury; CKD, chronic kidney disease; DM, diabetes mellitus; ESRD, end-stage renal disease.

Patient Care and Outcomes

Poor short-term outcomes for AKI, including hospital mortality, are well recognized. Figure 5.8 illustrates that survivors of an AKI hospitalization who were discharged alive continued to face significant risk for adverse outcomes. Among survivors of an AKI hospitalization in 2013-2014, the overall probability of developing ESRD in the following year was about 2% in the Medicare fee-for-service population aged 66 and older, and 5% in the Optum Clinformatics™ population. In this same period, the probability of death was 41.3% and 7.3% in the Medicare and Optum Clinformatics™ populations.

vol 1 Figure 5.8 Cumulative probability of death-censored ESRD, death, and the composite of death or ESRD within one year of live discharge from first AKI hospitalization occurring in 2013-2014

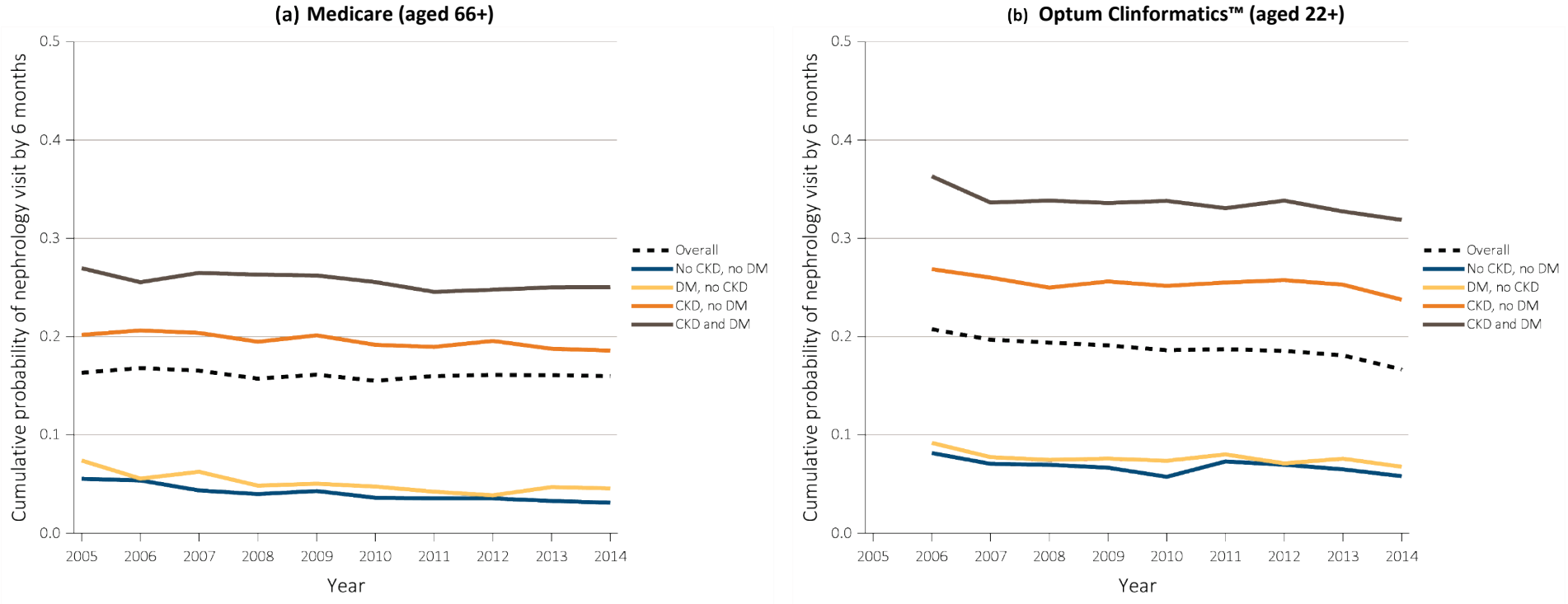


Data Source: Special analyses, Medicare 5% sample. (a) Medicare patients aged 66 and older who had both Medicare Parts A & B, no Medicare Advantage plan, no ESRD by first service date from Medical Evidence form, and were discharged alive from a first AKI hospitalization in 2013 or 2014. (b) All patient-years at risk for Optum Clinformatics™ commercial insurance patients aged 22 and older who were enrolled in the plan, did not have diagnoses of ESRD, and were alive on January of year shown. All models censored at the end of Medicare Parts A & B participation, switch to Medicare Advantage program, or 365 days after AKI discharge. Model for ESRD also was censored at death. Model for death was not censored at the start of ESRD. Abbreviations: AKI, acute kidney injury; ESRD, end-stage renal disease.

In 2014, 16% of Medicare patients discharged alive from an AKI hospitalization had outpatient nephrology follow-up within the next six months, while 17% of Optum Clinformatics™ patients had follow-up over the same period. As shown in Figure 5.9, follow-up rates varied by comorbidity. Among patients with AKI superimposed on pre-existing CKD, but without DM, 19% of Medicare and 24% of Optum Clinformatics™ patients were seen by a nephrologist within six months following discharge. For patients with both CKD and DM, these proportions rose to 25% and 32. In contrast, just 3% of Medicare and 6% of Optum Clinformatics™ AKI patients without DM or CKD were seen by a nephrologist by six months following an AKI hospitalization.

Trends over the past decade showed a slight decrease in post-AKI hospitalization nephrology follow-up for both the Medicare and Optum Clinformatics™ populations. This may once again reflect code creep: the milder cases of AKI captured by diagnosis may have been the least likely to require nephrology referral.

vol 1 Figure 5.9 Cumulative probability of a claim for an outpatient nephrology visit within six months of live discharge from first AKI hospitalization, overall and by CKD, DM, 2005-2014



Data Source: Special analyses, Medicare 5% sample and Optum Clinformatics™. (a) Medicare patients aged 66 and older who had both Medicare Parts A & B, no Medicare Advantage plan, no ESRD by first service date from Medical Evidence form on January 1 of year shown and were discharged alive from a first AKI hospitalization during the year. Censored at death, ESRD, end of Medicare Parts A & B participation, or switch to Medicare Advantage program. Physician visits are from physician/supplier claims with provider specialty codes for nephrology (39) and claim source indicating an outpatient setting. (b) Optum Clinformatics™ commercial insurance patients aged 22 and older who were enrolled in the plan, did not have diagnoses of ESRD, and were discharged alive from an AKI hospitalization in the year shown. Censored at death, ESRD, or plan disenrollment. Provider specialty of "nephrologist" used to identify nephrology visits. Abbreviations: AKI, acute kidney injury; CKD, chronic kidney disease; DM, diabetes mellitus; ESRD, end-stage renal disease.

Changes in CKD Status after Acute Kidney Injury

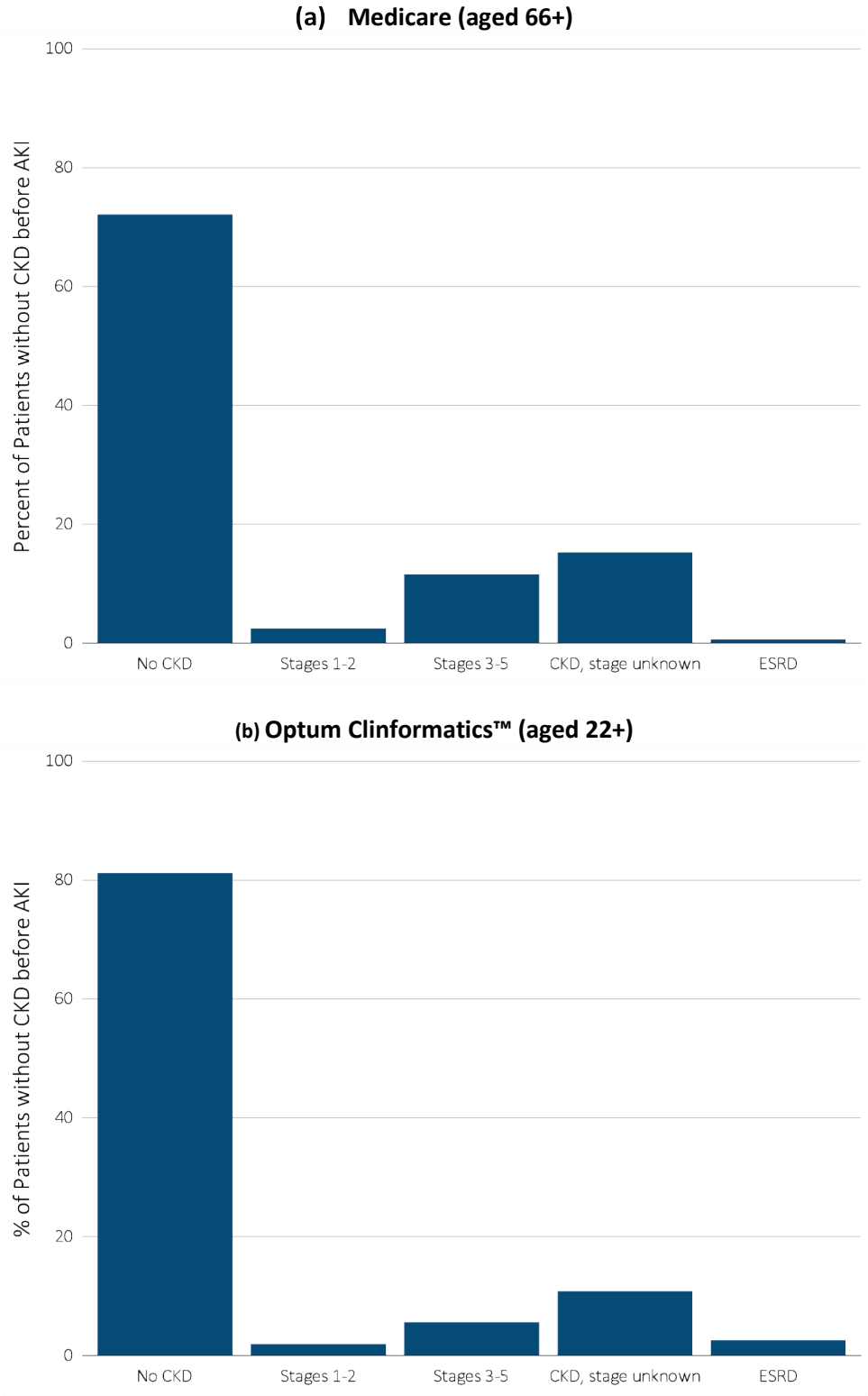
CKD status changed significantly in the year following an AKI hospitalization, as shown in Figure 5.10. Among Medicare patients without baseline CKD, nearly 28% were reclassified as having some degree of CKD, including 0.2% being declared ESRD. In the Optum Clinformatics™ population, about 19% of patients with an AKI hospitalization were newly classified as having CKD in the subsequent year, and 2.2% were given a diagnosis of ESRD. Although the percent of patients with ESRD was markedly higher in the younger Optum Clinformatics™ population as compared to Medicare patients, it is important to note that these were proportions of surviving patients only. Table B shows the ICD-9-CM diagnosis codes used to define stages of CKD for Figure 5.10.

Table B. ICD-9-CM codes for Chronic Kidney Disease (CKD) stages

ICD-9-CM code[a]	Stage
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 (excludes 585.6: Stage 5, requiring chronic dialysis[b])
CKD Stage-unspecified	For these analyses, identified by multiple codes including 585.9, 250.4x, 403.9x & others

[a] For analyses in this chapter, CKD stage estimates require at least one occurrence of a stage-specific code, and the last available CKD stage in a given year was used. [b] In USRDS analyses, patients with ICD-9-CM code 585.6 & with no ESRD 2728 form or other indication of end-stage renal disease (ESRD) are considered to have code 585.5.

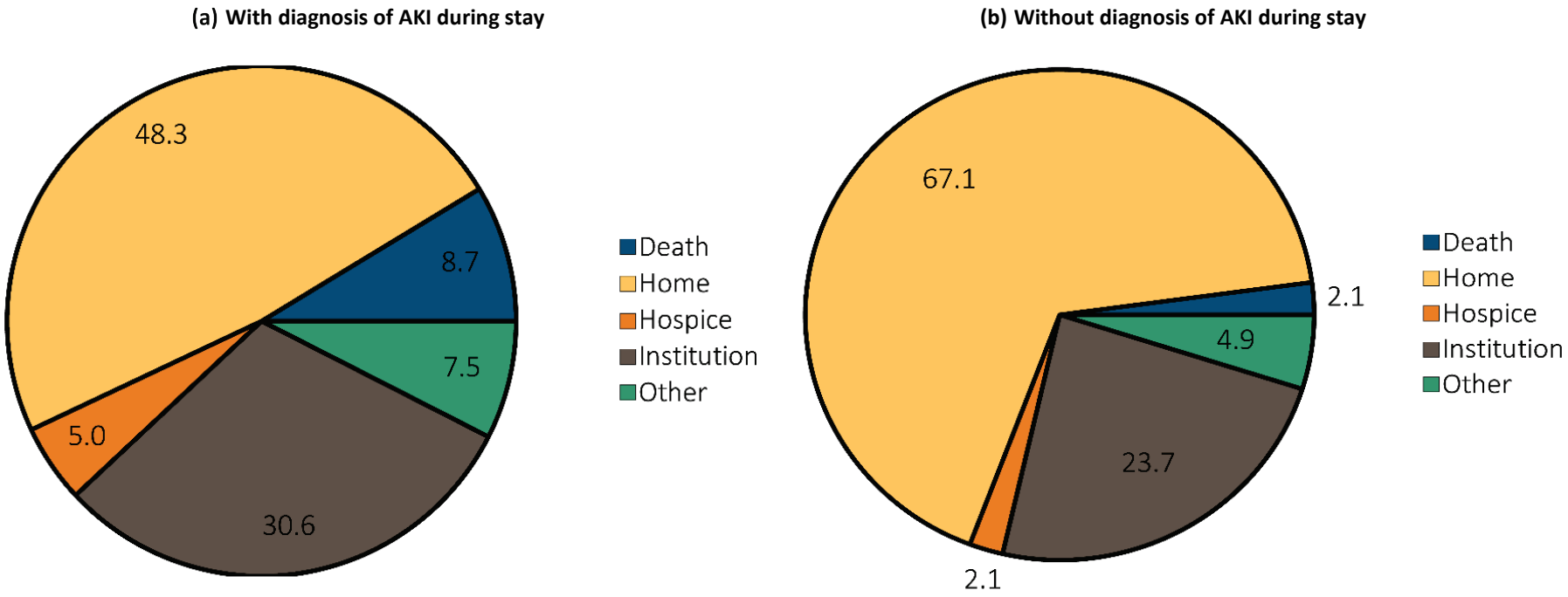
vol 1 Figure 5.10 Renal status one year following discharge from AKI hospitalization in 2013-2014, among surviving patients without kidney disease prior to AKI hospitalization, by CKD stage and ESRD status



Data Source: Special analyses, Medicare 5% sample. (a) Medicare patients aged 66 and older who had both Medicare Parts A & B, no Medicare Advantage plan, did not have ESRD, were discharged alive from a first AKI hospitalization in 2013 or 2014, and did not have any claims with a diagnosis of CKD in the 365 days prior to the AKI. (b) Optum Clinformatics™ commercial insurance patients aged 22 and older who were enrolled in the plan, did not have diagnoses of ESRD, and were discharged alive from an AKI hospitalization in 2013 or 2014, and did not have any claims with a diagnosis of CKD in the 365 days prior to the AKI. Renal status after AKI determined from claims between discharge from AKI hospitalization and 365 days after discharge. Stage determined by 585.x claim closest to 365 days after discharge; ESRD by first service date on Medical Evidence form. Abbreviations: AKI, acute kidney injury; CKD, chronic kidney disease; ESRD, end-stage renal disease.

In Figure 5.11, we examined the status and disposition of 2015 Medicare AKI patients once they were discharged from the hospital. We excluded patients admitted from a skilled nursing facility (SNF; n=1,890), leaving 53,710 AKI discharges. Among AKI patients aged 66 and older about 48% were discharged directly to their home. Mortality (including those discharged to hospice) was 13.7%, while 30.6% of patients were discharged to institutions such as short-term SNFs, rehabilitation hospitals, or long-term care facilities. By comparison, among hospitalized Medicare patients without a diagnosis of AKI (excluding those admitted from a SNF, n= 2,979, leaving 170,626 discharges), 68% returned home and approximately 23% were discharged to institutions.

vol 1 Figure 5.11 Hospital discharge status of first hospitalization for Medicare patients aged 66+ (a) with diagnosis of AKI during stay, and (b) without diagnosis of AKI during stay, 2015



Data Source: Special analyses, Medicare 5% sample. Medicare patients aged 66 and older who had both Medicare Parts A & B, no Medicare Advantage plan, did not have ESRD on 1/1/2015, had a first hospitalization in 2015, and were not admitted to the acute care hospital from a skilled nursing facility. Institution includes short-term skilled nursing facilities, rehabilitation hospitals, and long-term care facilities. Home also includes patients receiving home health care services. Abbreviations: AKI, acute kidney injury; ESRD, end-stage renal disease.

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