Chapter 5: Acute Kidney Injury

- In 2016, 4.4% of Medicare fee-for-service beneficiaries experienced a hospitalization complicated by Acute Kidney Injury (AKI), double the proportion of 2.2% in 2006 (Figure 5.1).
- Risk of AKI increases with age and in the presence of comorbidities such as chronic kidney disease (CKD) and diabetes mellitus (DM). About 1 in 5 hospitalized Medicare patients with both CKD and DM experience a hospitalization with AKI each year (Figure 5.5).
- Among hospitalized veterans aged 22+ years, 25.4% met Kidney Disease: Improving Global Outcomes (KDIGO) guidelines for AKI as defined using serum creatinine-based criteria (Table A). This included 21.4%, 0.8%, and 3.2% of patients with Stage 1, Stage 2, and Stage 3 AKI (Table 5.2). Just over half (52.6%) of patients meeting criteria for AKI were given a diagnosis of AKI.
- In 2014, Medicare patients aged 66+ years who were hospitalized for AKI had a 36% cumulative probability of a recurrent AKI hospitalization within one year (Figure 5.6.a). For Optum Clinformatics™ patients aged 22+ years, the probability of recurrent AKI hospitalization was 23% (Figure 5.7.a).
- Among Medicare patients without a pre-existing diagnosis of CKD, 30.8% were given a new diagnosis of CKD in the year following an AKI hospitalization (Figure 5.10.a). In the Optum Clinformatics™ population, 33.8% of patients with an AKI hospitalization were newly classified as having CKD in the subsequent year (Figure 5.10.b). In contrast, among Medicare patients with a "new" diagnosis of CKD in 2016, 25% had an AKI hospitalization in the preceding year.
- Among Medicare patients aged 66+ years with a first AKI hospitalization in 2016, the in-hospital mortality rate was 8.2%, or 13.2% when including discharge to hospice. Comparable mortality rates for non-AKI hospitalizations were 1.8% and 3.8%. Less than half of all patients returned to their home on discharge, as compared to two-thirds of non-AKI patients, while 30.1% were discharged to an institution such as a rehabilitation or skilled nursing facility (Figure 5.11).

Introduction

Acute kidney injury (AKI) is a common complication among hospitalized patients, and is associated with substantial morbidity and mortality. Among survivors, AKI is recognized as a major risk factor for the development of chronic kidney disease (CKD). Studies have demonstrated significantly increased long-term risk of CKD and ESRD following AKI, even after initial kidney function recovery (Heung, 2012). Furthermore, this relationship is bidirectional—CKD patients are at substantially higher risk for AKI. As a result, AKI is frequently superimposed on CKD, and can contribute significantly to progression of CKD. As such, an examination into the epidemiology and outcomes of AKI is an intrinsic aspect to understanding the landscape of CKD.

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 that are 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 complicated by AKI, and describing the characteristics of those patients. We refer to "AKI hospitalizations" as any hospitalization during which there was a diagnosis (billing code) 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 hospital readmissions 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.

As noted above, for administrative data (Medicare and Optum Clinformatics™) AKI episodes were identified through diagnosis codes from claims. These claims could be from any point during hospitalization and were not limited to the primary diagnosis. AKI episodes are presented both as a proportion (where denominator is either all patients or all hospitalizations), and as a rate (where denominator is patient population at risk). For VA data, AKI was defined using serum creatinine-based criteria (see Table A below), but not urine output criteria.

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.

To supplement the Medicare data, we also present data on patients aged 22+ years 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. For the prevalence of CKD and related conditions among these patients, see Volume 1, Chapter 2, Identification and Care of Patients with CKD, Table 2.1 for demographic characteristics of the Optum Clinformatics™ population (all ages) and Table 2.2 (ages 22-64). Additionally, Table 5.2 of this chapter uses data from all patients hospitalized at a VA hospital during fiscal year 2016, 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 data, women were younger on average than men. In Optum Clinformatics™, 55.6% of women were between the ages of 22 and 39, compared to only 19.8% of men.

Conversely, women in the Medicare 5% sample were older, on average: women had a mean age of 77.1 years while for men it was 75.4 years, and a higher proportion of women (20.4%) than men (13.3%) 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 readmitted 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.

Further details of the data utilized for this chapter are described in the Data Sources 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, see the section on *Chapter 5* within the *CKD Analytical Methods* chapter. Downloadable Microsoft Excel and PowerPoint files containing the data and graphics for these figures and tables are available from the *USRDS website.*

Characteristics of Patients with Acute Kidney Injury

The percentage of Medicare fee-for-service patients with an AKI hospitalization has doubled over the past decade (Figure 5.1.a). However, the rate of AKI with an intensive care unit (ICU) stay has been relatively stable since 2010, and the increase has been in patients who did not require ICU stay during their hospitalization. Over the same period, the proportion of AKI patients requiring inpatient dialysis declined. Not surprisingly, a higher proportion of patients with an ICU stay had AKI requiring dialysis, compared to patients without an ICU stay (Figure 5.1.b). The proportion of patients with an AKI hospitalization who had a nephrology consultation has also fallen over the past decade, from 42.1% in 2006 to 25.2% in 2016 (Figure 5.1.c). Together, these findings seem to support the notion of "code creep", in which there may be greater identification in billing codes of less severe cases of AKI, including those occurring outside the ICU and those that are managed without nephrology input.

Figure 5.2 reveals a similar rising trend of AKI 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 2016.

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 (c) percent of patients with nephrology consultation, among those with a first AKI hospitalization, by whether an intensive care unit (ICU) stay was required, 2006-2016

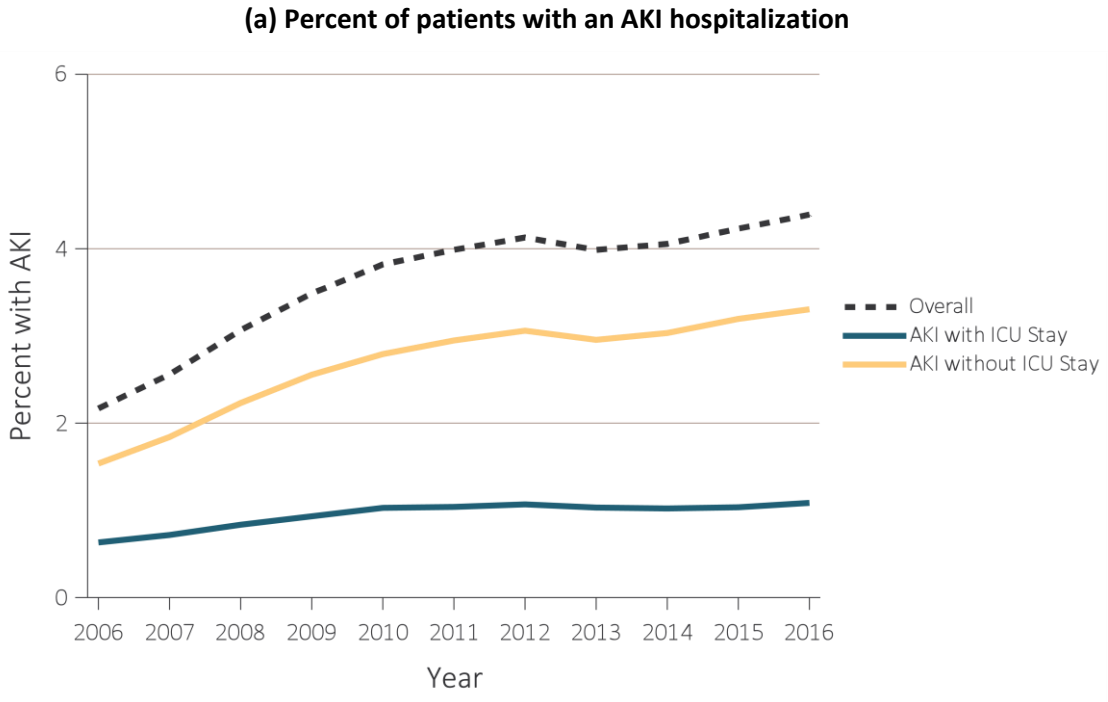
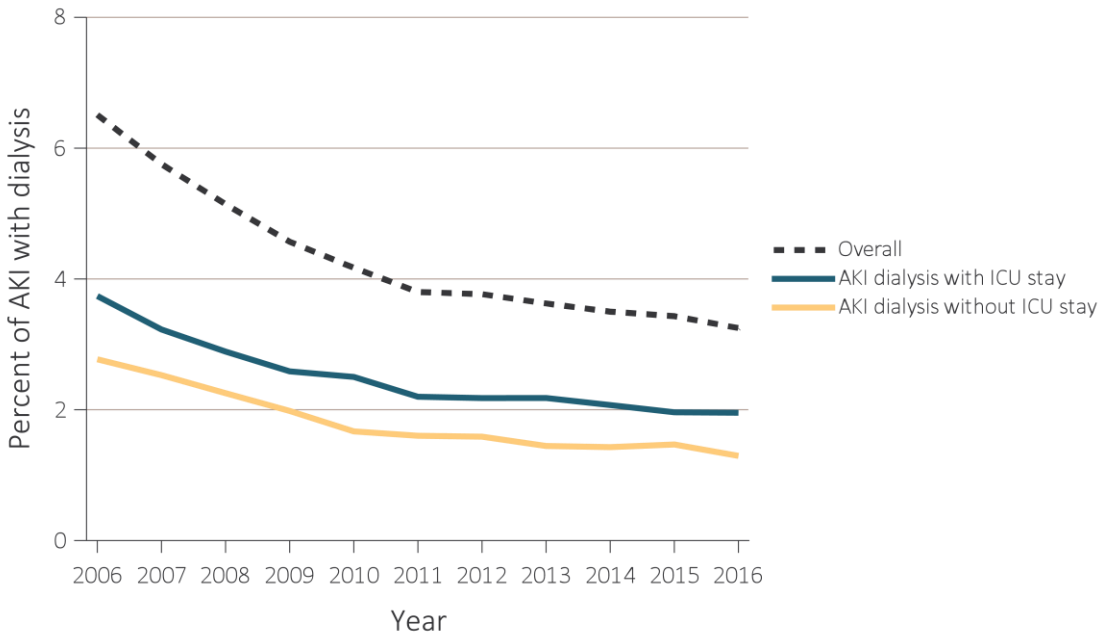


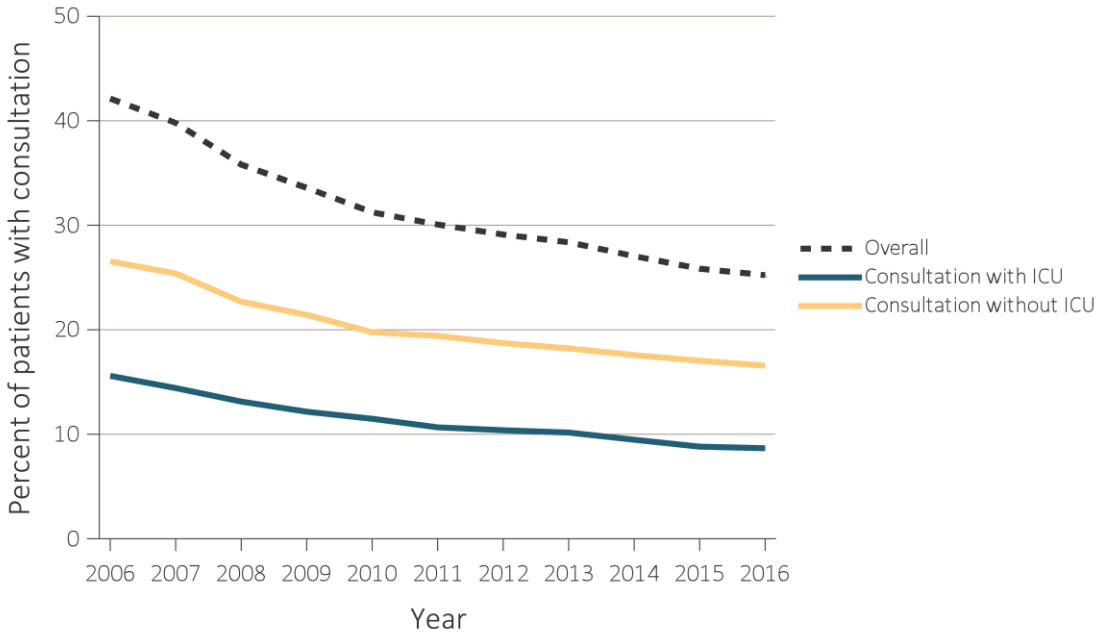
Figure 5.1 continued on next page.

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 (c) percent of patients with nephrology consultation, among those with a first AKI hospitalization, by whether an intensive care unit (ICU) stay was required, 2006-2016 (continued)

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

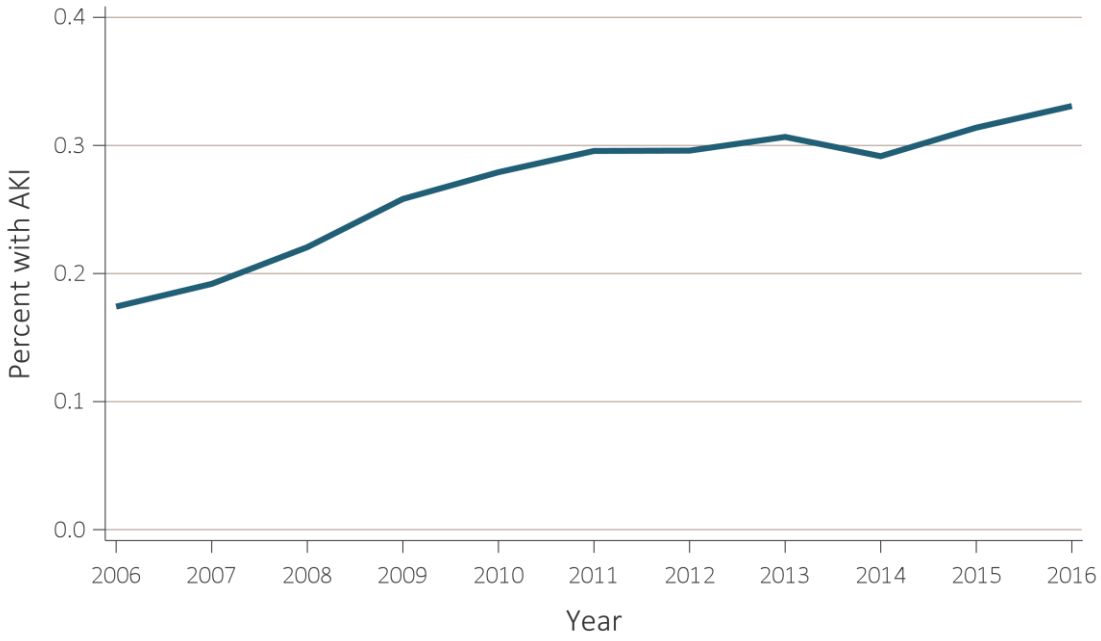


(c) Percent of patients with nephrology consultation, among those with a first AKI hospitalization



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; ICU, intensive care unit.

vol 1 Figure 5.2 Percent of Optum Clinformatics™ patients aged 22+ with at least one AKI hospitalization, by year, 2006-2016



Data Source: Special analyses, Optum Clinformatics™. 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 of year shown. Abbreviations: AKI, acute kidney injury; ESRD, end-stage renal disease.

As shown in Figure 5.3, rates of AKI were strongly influenced by age. Among fee-for-service Medicare patients in 2016, the rate of AKI for those aged 66-69 was 23.0 per 1,000 patient years, increasing to 31.3, 44.2, 62.9, and 95.7 for those aged 70-74, 75-79, 80-84, and 85 years and older. Unadjusted rates of AKI have risen in all age groups over the past decade, although the rate of rise seems to have slowed since 2011 in patients younger than 80 years. The rates of AKI requiring dialysis have remained fairly consistent across all age groups over the past decade. Among Optum Clinformatics™ patients, the overall group AKI rate increased over time, peaking at 3.8 per 1,000 patient years in 2016. For the subgroup aged 66 and older, the 2011 rate was 23.7 per 1,000 patient-years and remained somewhat stable at 21.8 per 1,000 in 2016.

vol 1 Figure 5.3 Unadjusted rates of hospitalization with AKI and AKI requiring dialysis, per 1,000 patient-years at risk, by age, 2006-2016

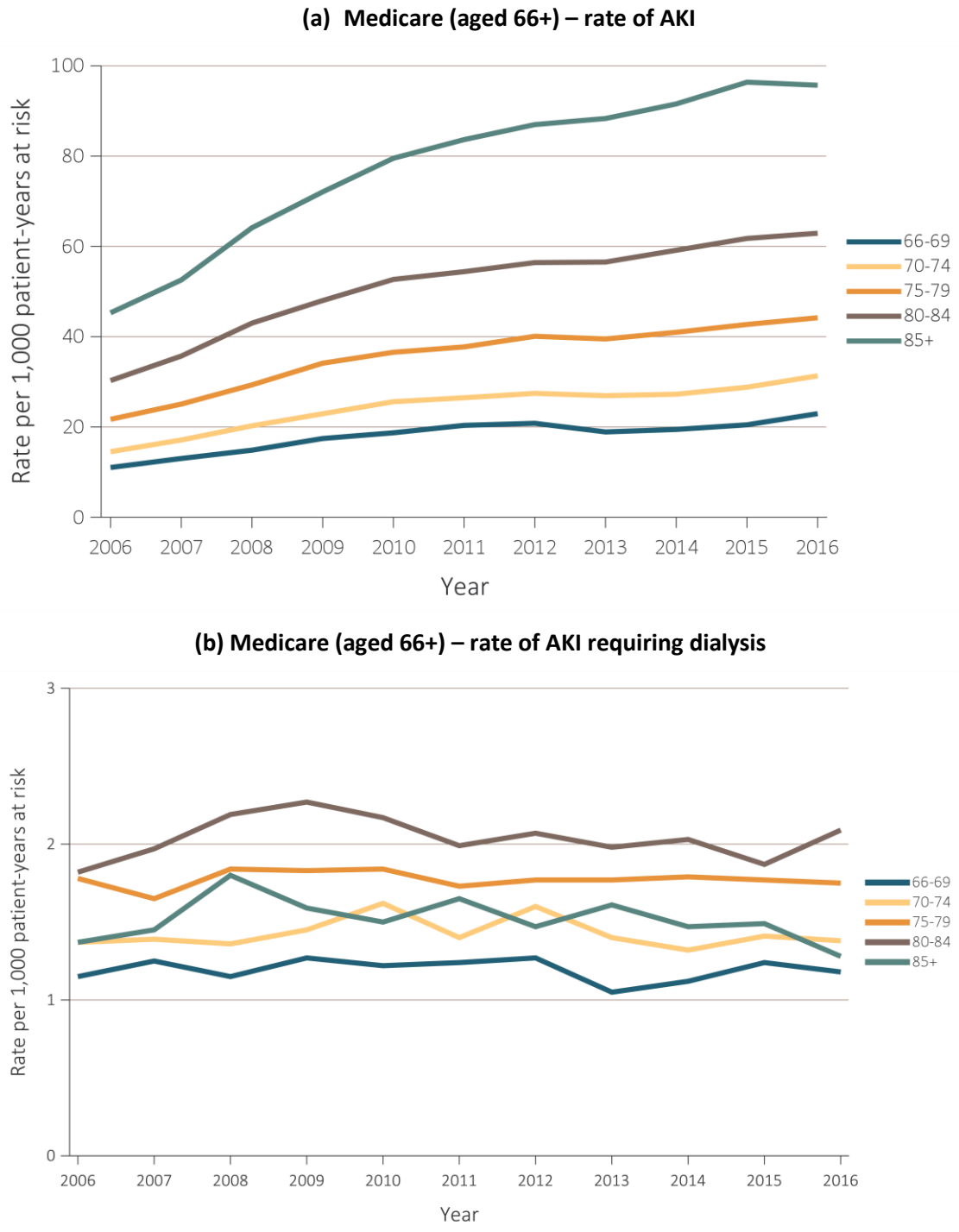
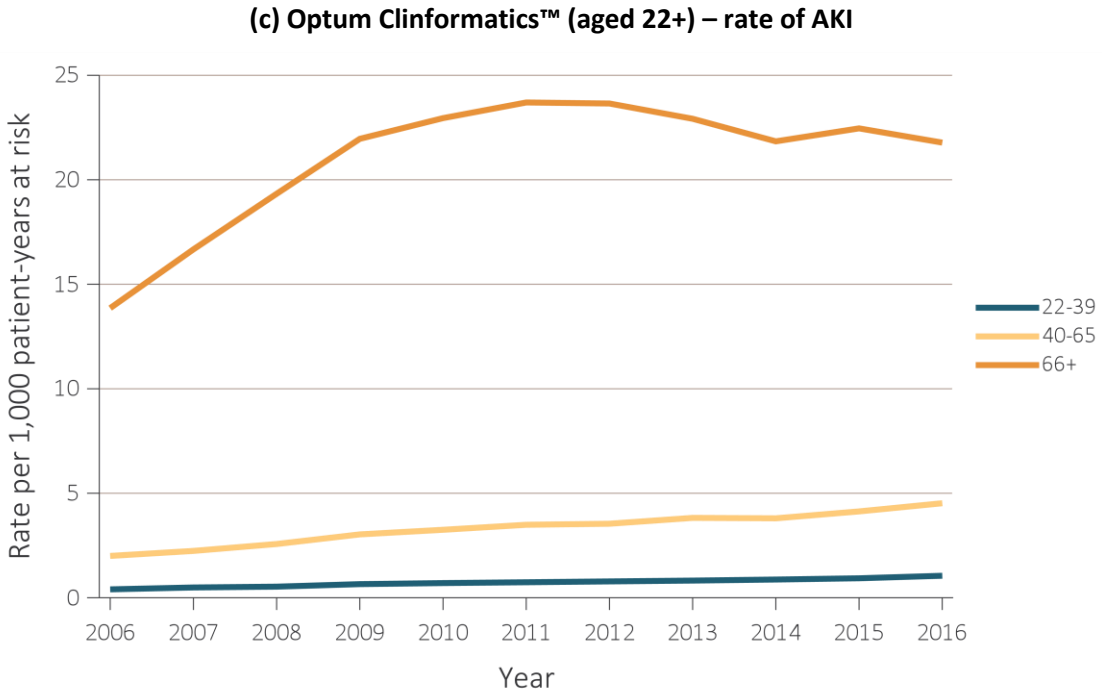


Figure 5.3 continued on next page.

vol 1 Figure 5.3 Unadjusted rates of hospitalization with AKI and AKI requiring dialysis, per 1,000 patient-years at risk, by age, 2006-2016 (continued)



Data Source: Special analyses, Medicare 5% sample and Optum Clinformatics™. (a) and (b) 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. (c) 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 2016, among fee-for-service Medicare patients aged 66 and older, the incidence rate for those of Black race was 71.6 per 1,000 patient-years at risk compared to 44.7 and 35.8, in Whites and individuals of other races. A similar relationship was observed in the Optum Clinformatics™ population, albeit at much lower rates: 5.6, 4.0, and 3.0 per 1,000 patient-years at risk in Blacks, Whites, and individuals of other races. Rates of AKI rose across all race subgroups between 2006 and 2016. However, the rate of AKI requiring dialysis appears to have remained stable.

vol 1 Figure 5.4 Unadjusted rates of hospitalization with AKI, and AKI requiring dialysis, per 1,000 patient-years at risk, by race, 2006-2016

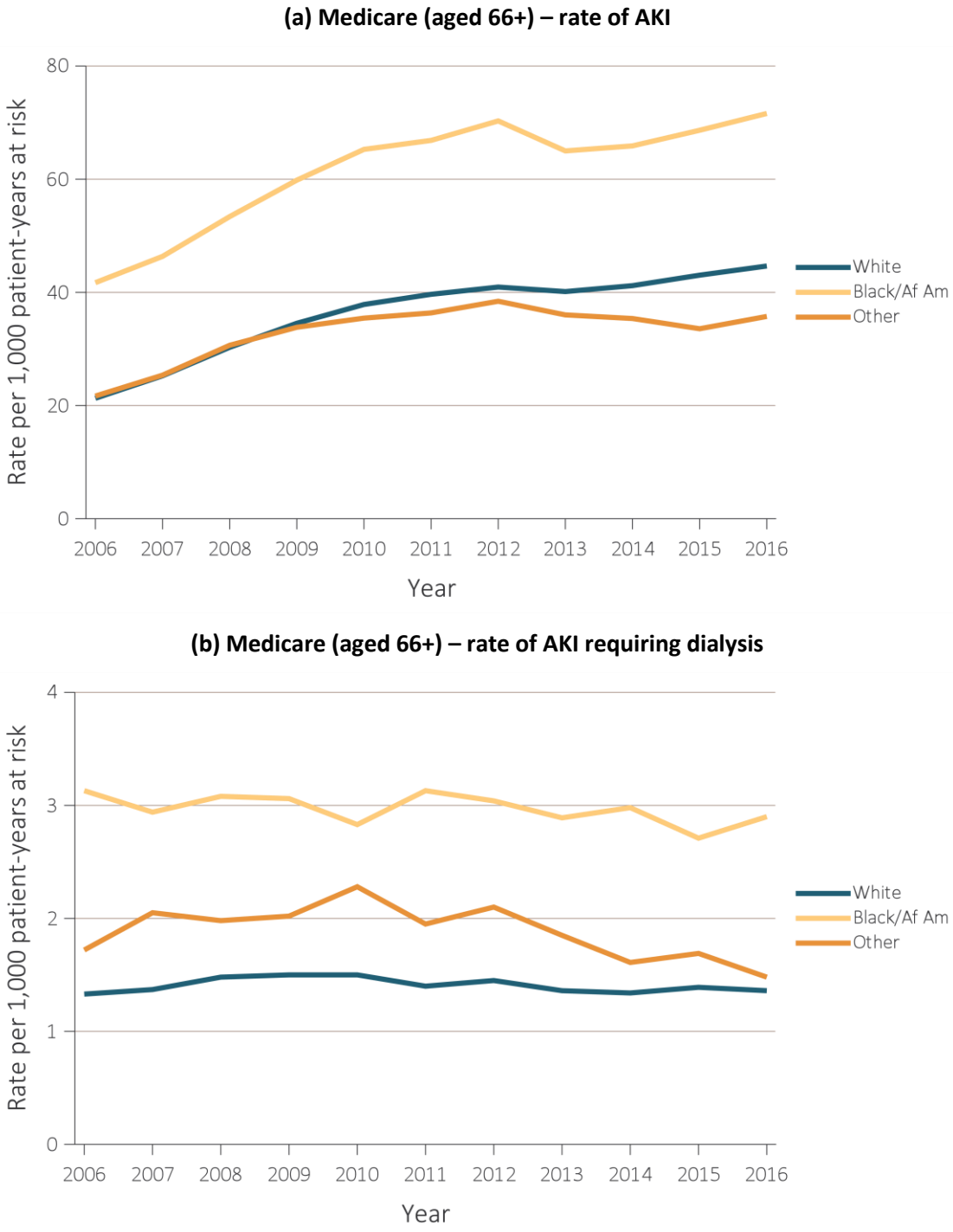
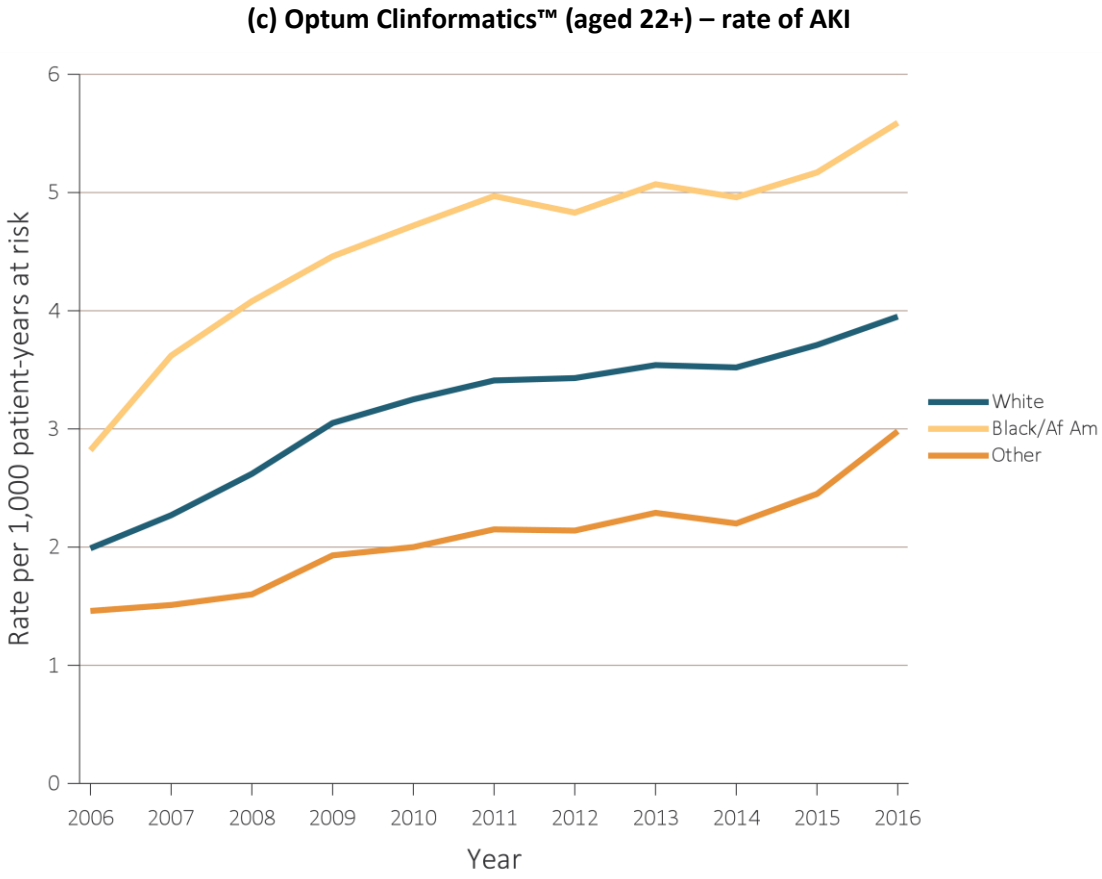


Figure 5.4 continued on next page.

vol 1 Figure 5.4 Unadjusted rates of hospitalization with AKI, and AKI requiring dialysis, per 1,000 patient-years at risk, by race, 2006-2016 (continued)



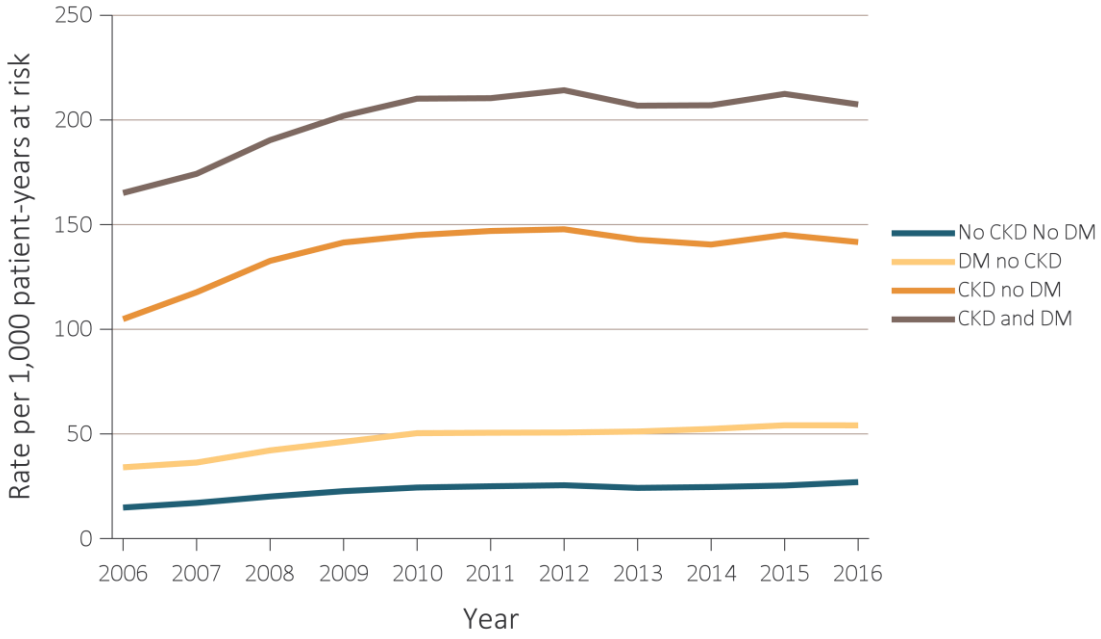
Data Source: Special analyses, Medicare 5% sample and Optum Clinformatics™. (a) and (b) All patient-years at risk for Medicare patients aged 66 and older who had both Medicare Parts A & B, no Medicare Advantage plan, no ESRD by first service date from Medical Evidence form, and were alive on January 1 of year shown. Censored at death, ESRD, end of Medicare Parts A & B participation, or switch to Medicare Advantage program. (c) 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 2016, Medicare patients with DM, but no known CKD, had an AKI incidence rate of 54.1 per 1,000 patient-years, compared to 27.0 per 1,000 patient-years in non-diabetic, non-CKD patients. Non-diabetic patients with CKD experienced an AKI incidence rate of 141.7 per 1,000 patient-years, while the rate in patients with both DM and CKD was 207.4 per 1,000.The overall rate of hospitalization with AKI appears to be stable between 2010 and 2016. However, the rate of AKI requiring dialysis has declined in patients with CKD and those with both CKD and DM.

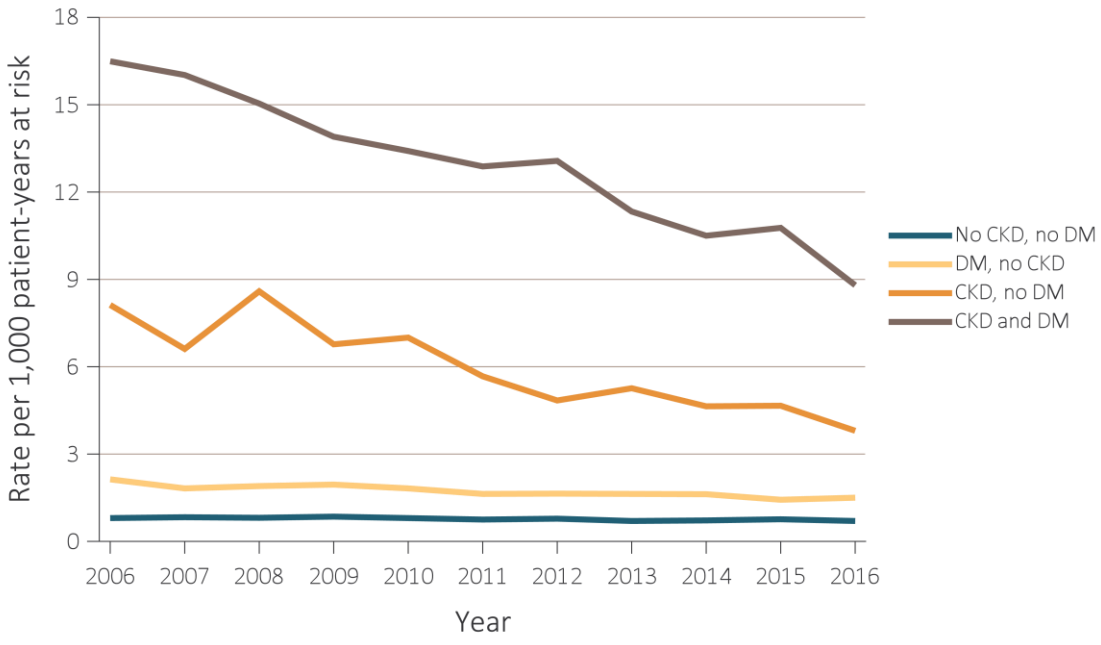
The Optum Clinformatics™ population showed similar relationships. Patients with both CKD and DM experienced the highest rates of AKI hospitalization at 100.9 per 1,000 patient-years. However, their overall rates were much lower than among the Medicare population, presumably reflecting the younger age range in this population.

vol 1 Figure 5.5 Unadjusted rates of hospitalization with AKI, and AKI requiring dialysis, per 1,000 patient-years at risk, by CKD and DM, 2006-2016

(a) Medicare (aged 66+) – rate of AKI



(b) Medicare (aged 66+) – rate of AKI requiring dialysis



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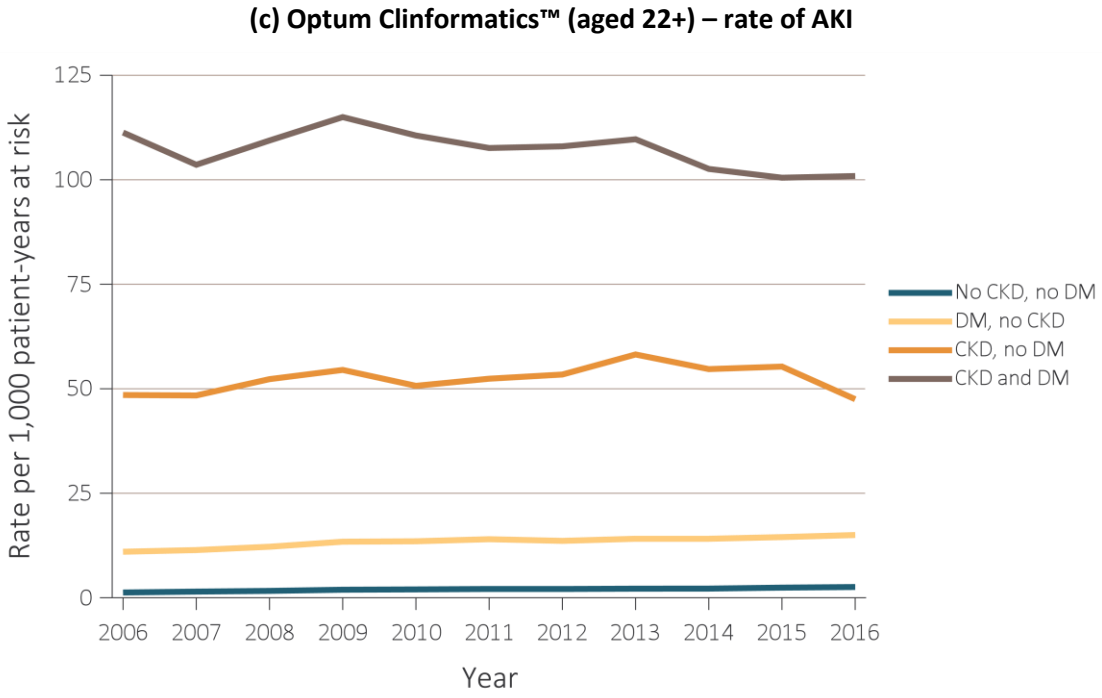
vol 1 Figure 5.5 Unadjusted rates of hospitalization with AKI, and AKI requiring dialysis, per 1,000 patient-years at risk, by CKD and DM, 2006-2016 (continued)



Data Source: Special analyses, Medicare 5% sample and Optum Clinformatics™. (a) and (b) 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. (c) 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.

Table 5.1 presents characteristics of hospitalized Medicare and Optum Clinformatics™ patients in 2016, along with their demographic and comorbidity characteristics by whether or not AKI occurred (defined as an inpatient stay with any diagnosis for AKI during any hospitalization during the year). AKI occurs commonly in older adults, impacting nearly 25% of Medicare patients aged 66 or older who have at least one hospitalization, and the incidence rises with age. Persons over age 80 accounted for 44% of all hospitalizations and 51% of hospitalizations with AKI. Although males appear to be more likely to develop AKI than females, it is important to remember that this does not account for differences in age distribution, although an age adjustment would tend to exacerbate the gender differential. 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 57.2% of Medicare patients with an AKI hospitalization and 23.4% of patients had both. Even in the younger Optum Clinformatics™ population, about 40.2% 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, 2016

	Medicare (Age 66+)					Clinformatics™ (Age 22+)				
	Total	No AKI		Any AKI		Total	No AKI		Any AKI	
	N	N	%	N	%	N	N	%	N	%
Total	238,839	179,641	75.2%	59,198	24.8%	304,907	281,791	92.4	23,116	7.6
Age										
22-39	—	—	—	—	—	129,410	126,921	98.1	2,489	1.9
40-65	—	—	—	—	—	147,949	132,480	89.5	15,469	10.5
65+	—	—	—	—	—	27,548	22,390	81.3	5,158	18.7
66-69	39,652	31,974	80.6	7,678	19.4	—	—	—	—	—
70-74	48,717	38,289	78.6	10,428	21.4	—	—	—	—	—
75-79	44,691	34,005	76.1	10,686	23.9	—	—	—	—	—
80-84	40,775	29,822	73.1	10,953	26.9	—	—	—	—	—
85+	65,004	45,551	70.1	19,453	29.8	—	—	—	—	—
Sex										
Male	103,628	74,289	71.7	29,339	28.3	108,157	93,743	86.7	14,414	13.3
Female	135,211	105,352	77.9	29,859	22.1	196,750	188,048	95.6	8,702	4.4
Race & Ethnicity										
White	207,287	158,061	76.3	49,226	23.8	213,520	197,182	92.3	16,338	7.7
Black/African American	19,096	12,347	64.7	6,749	35.3	30,737	27,564	89.7	3,173	10.3
Native American	1,274	949	74.5	325	25.5	—	—	—	—	—
Hispanic	—	—	—	—	—	33,397	31,240	93.5	2,157	6.5
Asian	3,186	2,264	71.1	922	28.9	12,882	12,422	96.4	460	3.6
Other	7,996	6,020	75.3	1,976	24.7	14,371	13,383	93.1	988	6.9
Pre-existing comorbidities										
No DM or CKD, prior year	141,826	116,465	82.1	25,361	17.9	263,756	249,928	94.8	13,828	5.2
DM no CKD, prior year	43,073	32,816	76.2	10,257	23.8	25,916	21,762	84.0	4,154	16.0
CKD no DM, prior year	23,738	14,001	60.0	9,737	41.0	8,378	6,064	72.4	2,314	27.6
Both CKD & DM, prior year	30,202	16,359	54.2	13,843	45.8	6,857	4,037	58.9	2,820	41.1

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, 2016. 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, 2016. AKI is defined by a diagnosis code anywhere in the hospitalization claim. — Data not available. Abbreviations: AKI, acute kidney injury; CKD, chronic kidney disease; DM, diabetes mellitus; ESRD, end-stage renal disease.

Table 5.2 presents characteristics of hospitalized VA patients who had an AKI hospitalization in fiscal year 2016. Here, AKI was defined using serum creatinine-based criteria per the KDIGO guidelines (Table A). The incidence of AKI generally increased with age, and among race/ethnicity groups the highest proportion of AKI was again observed among non-Hispanic Black patients. For VA patients with diabetes, about 26.0% had an AKI hospitalization as defined by KDIGO criteria. Although this proportion appears similar to that observed in the Medicare population, direct comparison is not possible due to unaccounted for differences in patient characteristics as well as differences in methodology to identify AKI episodes (i.e. clinical vs claims data). The percentage of VA patients with an AKI hospitalization increased to 42.4% among CKD patients, and 53.7% among patients with both DM and CKD. Of note, among VA patients with an AKI hospitalization as defined by KDIGO serum creatinine-based criteria, only 52.6% were given a diagnosis of AKI.

Table A. KDIGO definition and staging of Acute Kidney Injury (AKI)

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; KDIGO, Kidney Disease Improving Global Outcomes; 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 (KDIGO criteria), FY 2016

	Total	No AKI		Any Stage AKI		Stage 1		Stage 2		Stage 3[a]	
	N	N	%	N	%	N	%	N	%	N	%
Total	301,876	225,090	74.6	76,786	25.4	64,601	21.4	2,455	0.8	9,730	3.2
Diagnosis of AKI											
No	249,650	213,229	85.4	36,421	14.6	32,379	13.0	1,045	0.4	2,997	1.2
Yes	52,226	11,861	22.7	40,365	77.3	32,222	61.7	1,410	2.7	6,733	12.9
Age at this inpatient admission											
22-39	12,166	11,106	91.3	1,060	8.7	899	7.4	47	0.4	114	0.9
40-59	51,418	41,857	81.4	9,561	18.6	7,786	15.1	446	0.9	1,329	2.6
60-65	48,075	36,306	75.5	11,769	24.5	9,637	20.0	466	1.0	1,666	3.5
66-69	50,086	36,503	72.9	13,583	27.1	11,163	22.3	482	1.0	1,938	3.9
70-74	57,804	42,384	73.3	15,420	26.7	13,166	22.8	431	0.7	1,823	3.2
75-79	26,928	18,981	70.5	7,947	29.5	6,798	25.2	181	0.7	968	3.6
80-84	21,662	14,712	67.9	6,950	32.1	5,945	27.4	172	0.8	833	3.8
85+	33,737	23,241	68.9	10,496	31.1	9,207	27.3	230	0.7	1,059	3.1
Sex											
Male	284,150	209,947	73.9	74,203	26.1	62,499	22.0	2,308	0.8	9,396	3.3
Female	17,726	15,143	85.4	2,583	14.6	2,102	11.9	147	0.8	334	1.9
Race/ethnicity											
Non-Hispanic White	205,660	156,425	76.1	49,235	23.9	42,388	20.6	1,597	0.8	5,250	2.6
Non-Hispanic Black	59,063	41,142	69.7	17,921	30.3	14,288	24.2	513	0.9	3,120	5.3
American Indian/Alaska Native	1,923	1,490	77.5	433	22.5	354	18.4	17	0.9	62	3.2
Hispanic	17,615	12,824	72.8	4,791	27.2	3,883	22.0	207	1.2	701	4.0
Asian	2,905	2,143	73.8	762	26.2	627	21.6	12	0.4	123	4.2
Other/Unknown	14,710	11,066	75.2	3,644	24.8	3,061	20.8	109	0.7	474	3.2
Had CKD before admission											
No	245,319	196,479	80.1	48,840	19.9	42,320	17.3	2,144	0.9	4,376	1.8
Yes	56,557	28,611	50.6	27,946	49.4	22,281	39.4	311	0.5	5,354	9.5
Had hypertension before admission											
No	108,948	90,340	82.9	18,608	17.1	15,514	14.2	780	0.7	2,314	2.1
Yes	192,928	134,750	69.8	58,178	30.2	49,087	25.4	1,675	0.9	7,416	3.8
Had diabetes before admission											
No	194,998	155,138	79.6	39,860	20.4	33,579	17.2	1,593	0.8	4,688	2.4
Yes	106,878	69,952	65.5	36,926	34.5	31,022	29.0	862	0.8	5,042	4.7
Pre-admission CKD and diabetes status											
Neither	165,385	138,092	83.5	27,293	16.5	23,755	14.4	1,416	0.9	2,122	1.3
Diabetes only	73,997	54,726	74.0	19,271	26.0	17,183	23.2	728	1.0	1,360	1.8
CKD only	29,613	17,046	57.6	12,567	42.4	9,824	33.2	177	0.6	2,566	8.7
Diabetes & CKD	32,881	15,226	46.3	17,655	53.7	13,839	42.1	134	0.4	3,682	11.2

Data Source: Special analyses, Veterans Health Administration data. Patients aged 22 and older with at least one hospitalization in fiscal year 2016. 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, 2015 to September 30, 2016).

Readmission Associated with Acute Kidney Injury

Figures 5.6 and 5.7 show the probability of a patient's recurrent AKI hospitalization after live discharge from an initial AKI hospitalization. Among 2014 Medicare patients aged 66 and older the overall probability of a recurrent AKI event was 0.36 in the next 12 months and 0.49 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 Optum Clinformatics™ patients, who represent a wider range of ages, older patients appeared to have a higher probability for recurrent AKI (Figure 5.7.b).

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 0.38 among Optum Clinformatics™ patients. In contrast, Medicare patients with neither comorbidity had a cumulative probability for recurrent AKI hospitalization of 0.33 by 24 months, while their Optum Clinformatics™ counterparts had a probability of 0.17 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 2014 for Medicare patients aged 66+, (a) overall, (b) by age, (c) by race, and (d) by CKD and DM

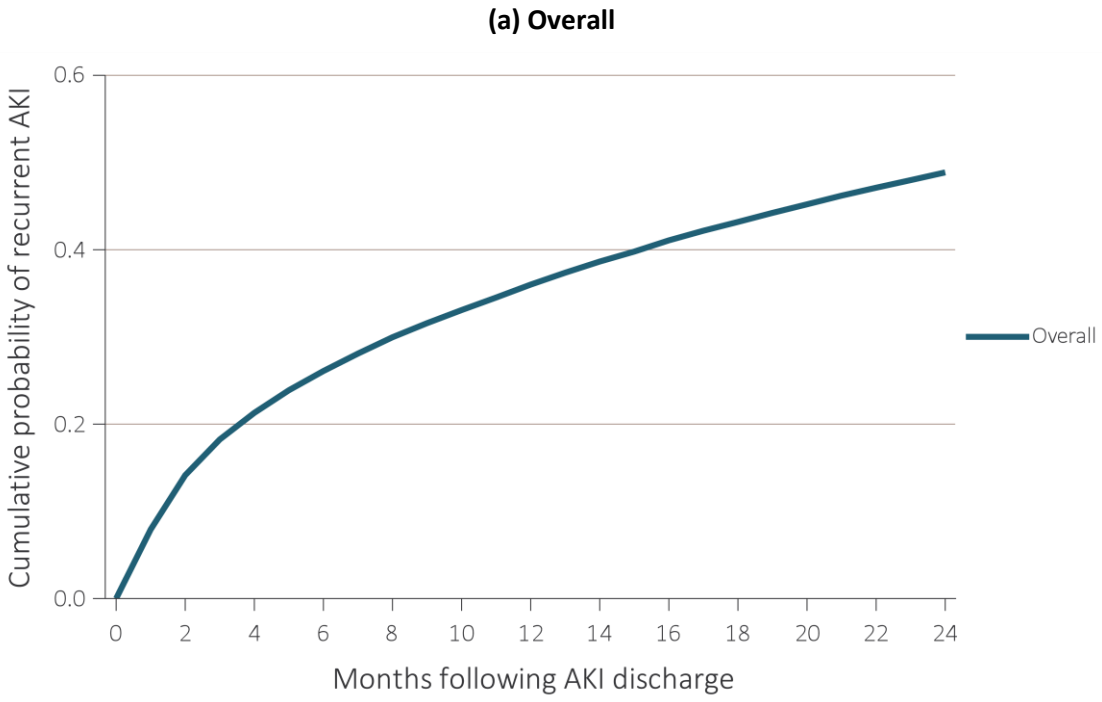
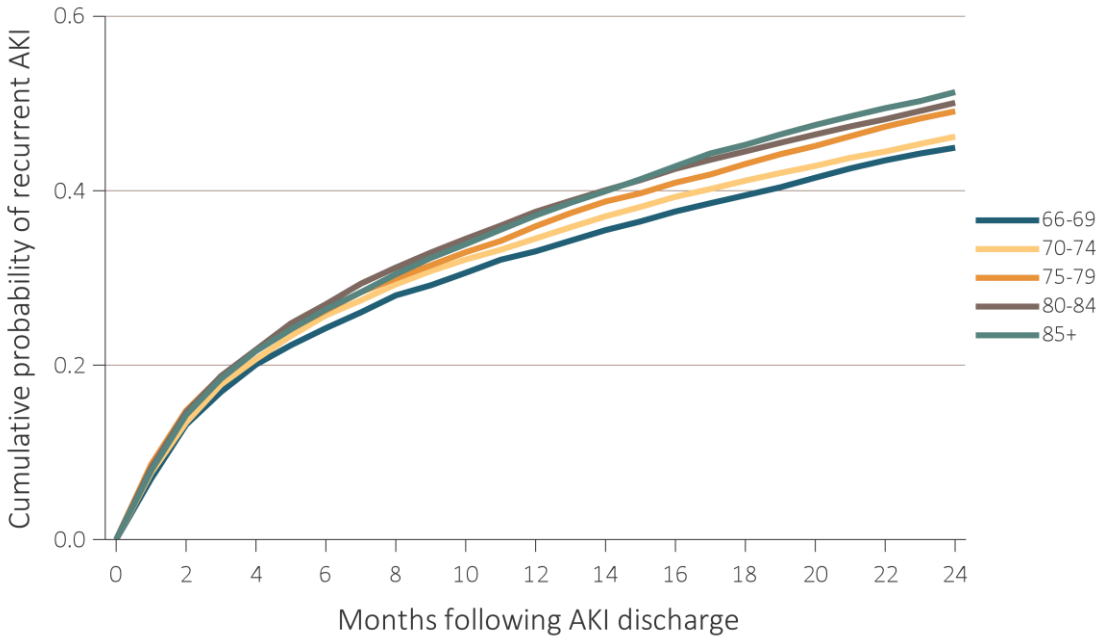


Figure 5.6 continued on next page.

vol 1 Figure 5.6 Cumulative probability of a recurrent AKI hospitalization within two years of live discharge from first AKI hospitalization in 2014 for Medicare patients aged 66+, (a) overall, (b) by age, (c) by race, and (d) by CKD and DM (continued)

(b) Age



(c) Race

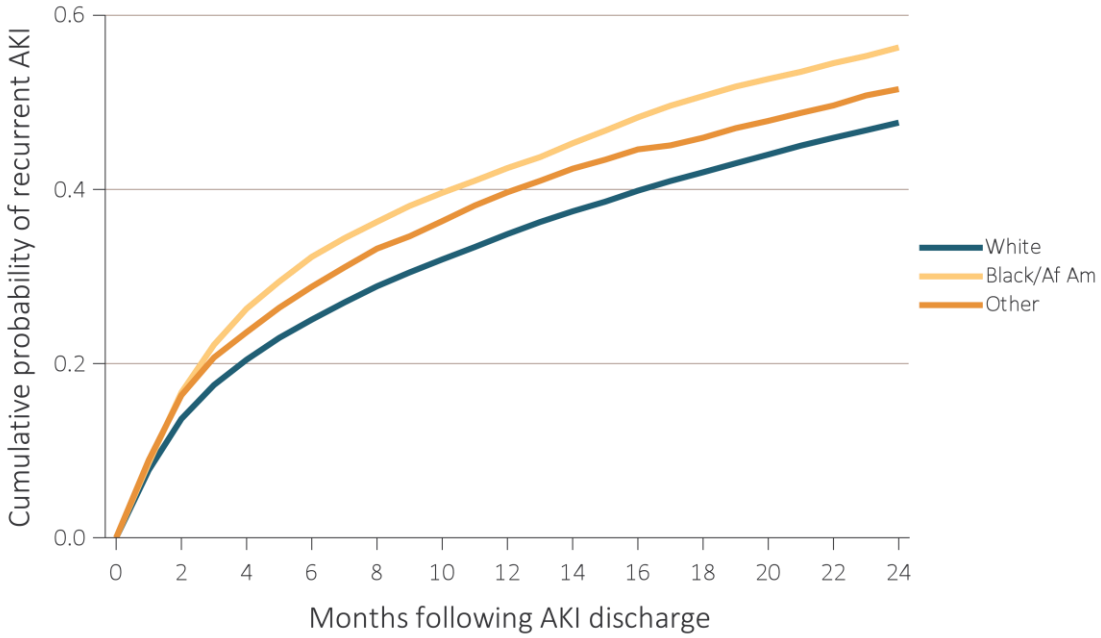
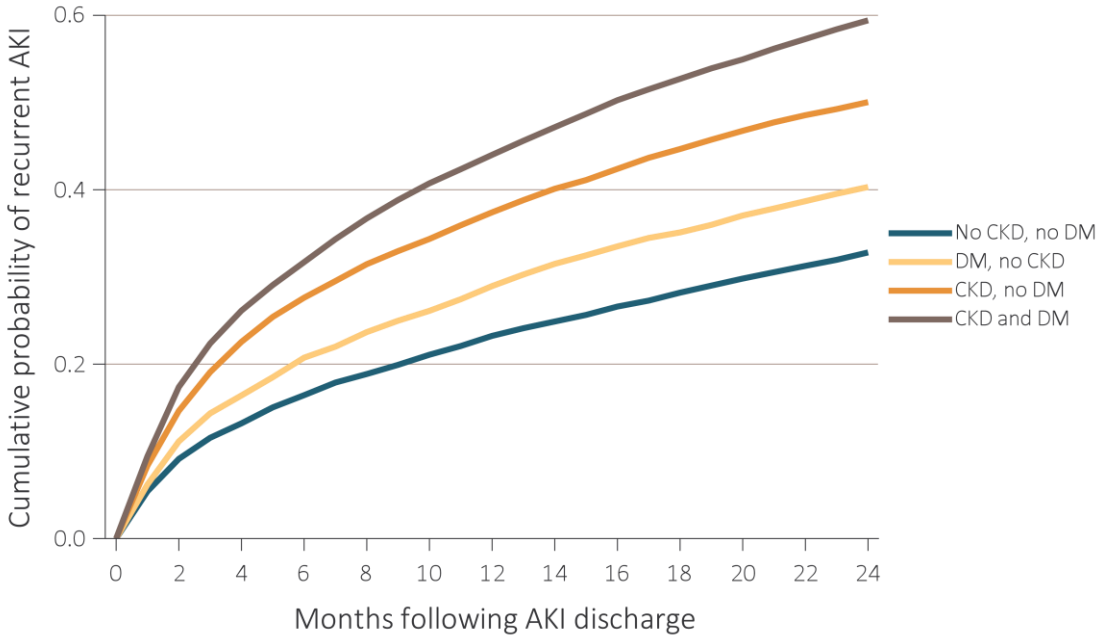


Figure 5.6 continued on next page.

vol 1 Figure 5.6 Cumulative probability of a recurrent AKI hospitalization within two years of live discharge from first AKI hospitalization in 2014 for Medicare patients aged 66+, (a) overall, (b) by age, (c) by race, and (d) by CKD and DM (continued)

(d) CKD and DM



Data Source: Special analyses, Medicare 5% sample. Age on January 1, 2014. 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 1/1/2014, and were discharged alive from an AKI hospitalization in 2014. Censored at death, ESRD, end of Medicare Parts A & B participation, or switch to Medicare Advantage program. Abbreviations: Af/Am, African American; 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 2014 for Optum Clinformatics™ patients aged 22+, (a) overall, (b) by age, (c) by race, and (d) by CKD and DM

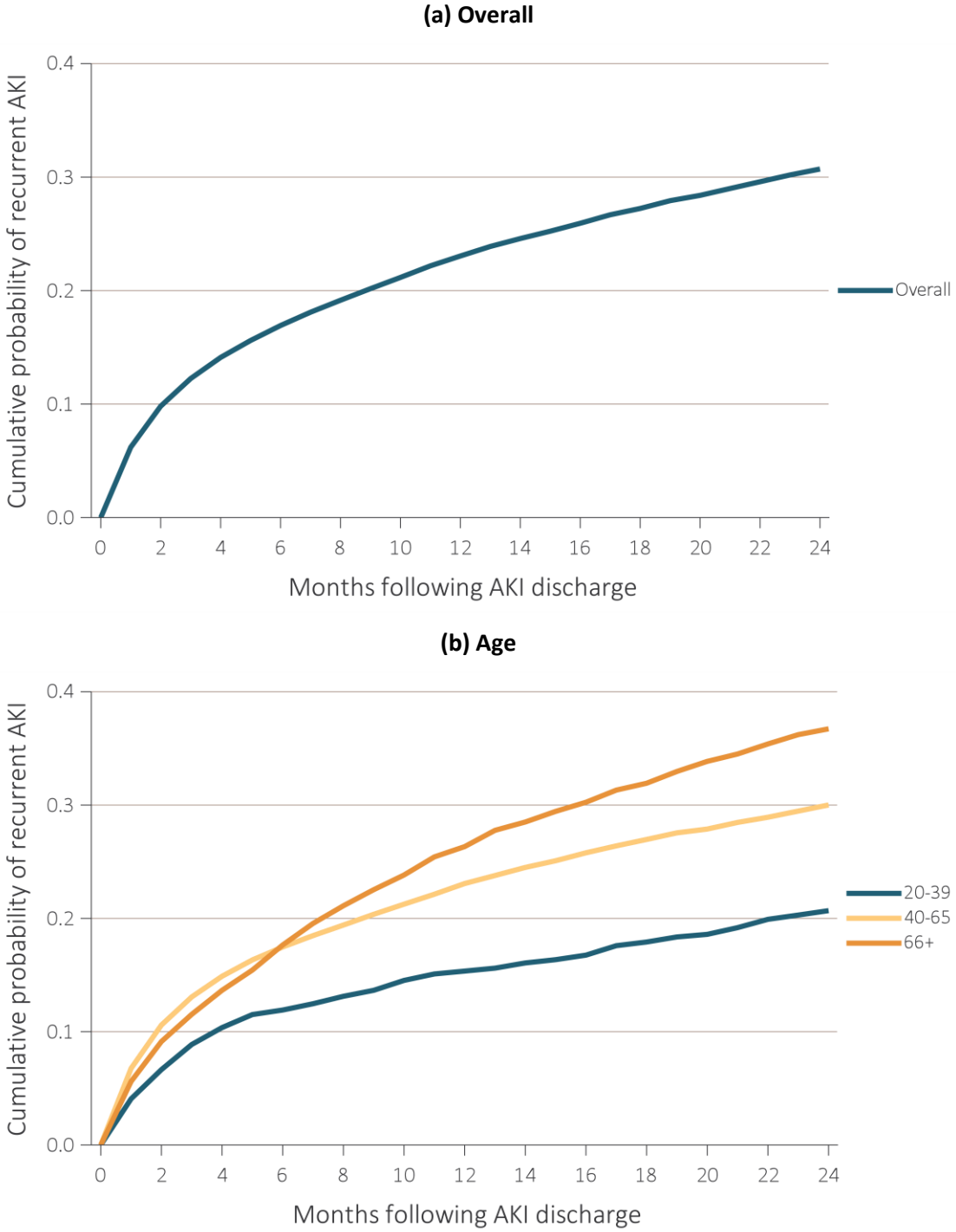
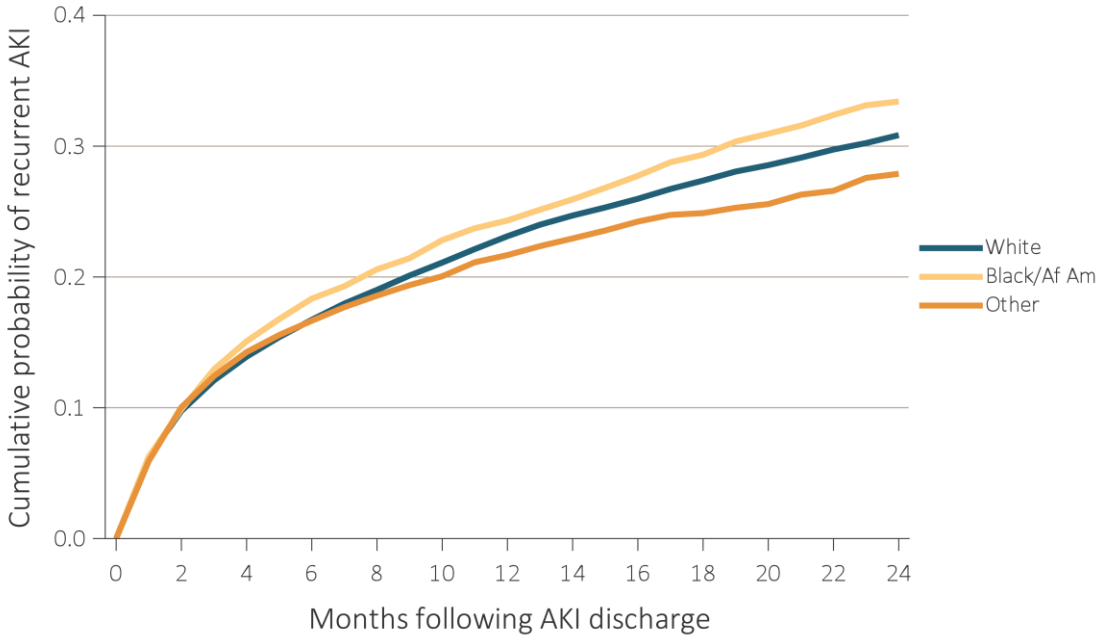


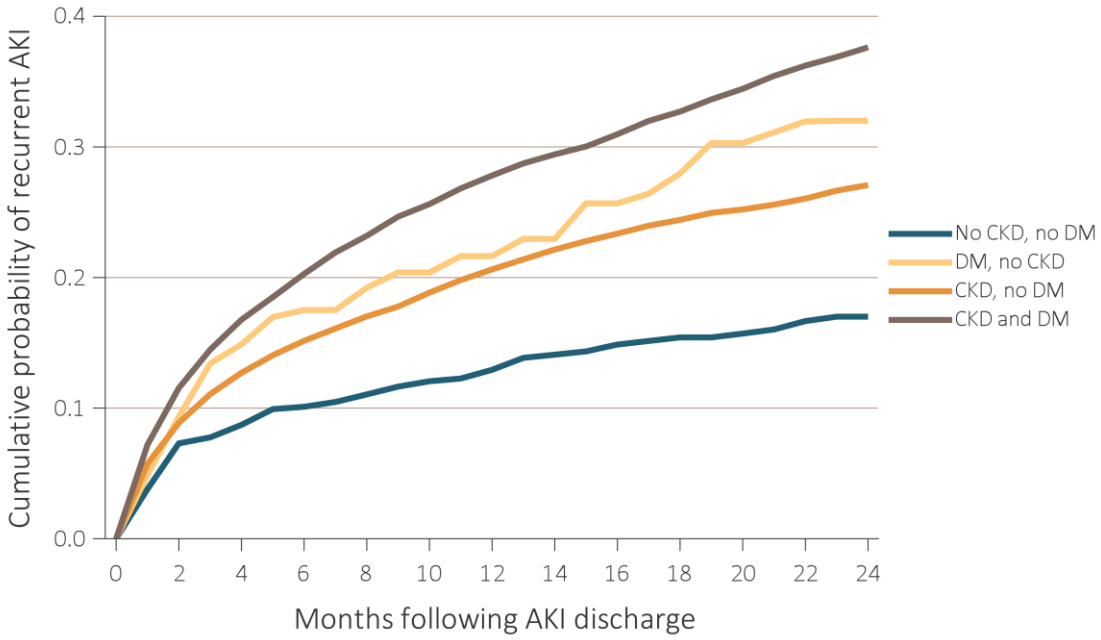
Figure 5.7 continued on next page.

vol 1 Figure 5.7 Cumulative probability of a recurrent AKI hospitalization within two years of live discharge from first AKI hospitalization in 2014 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

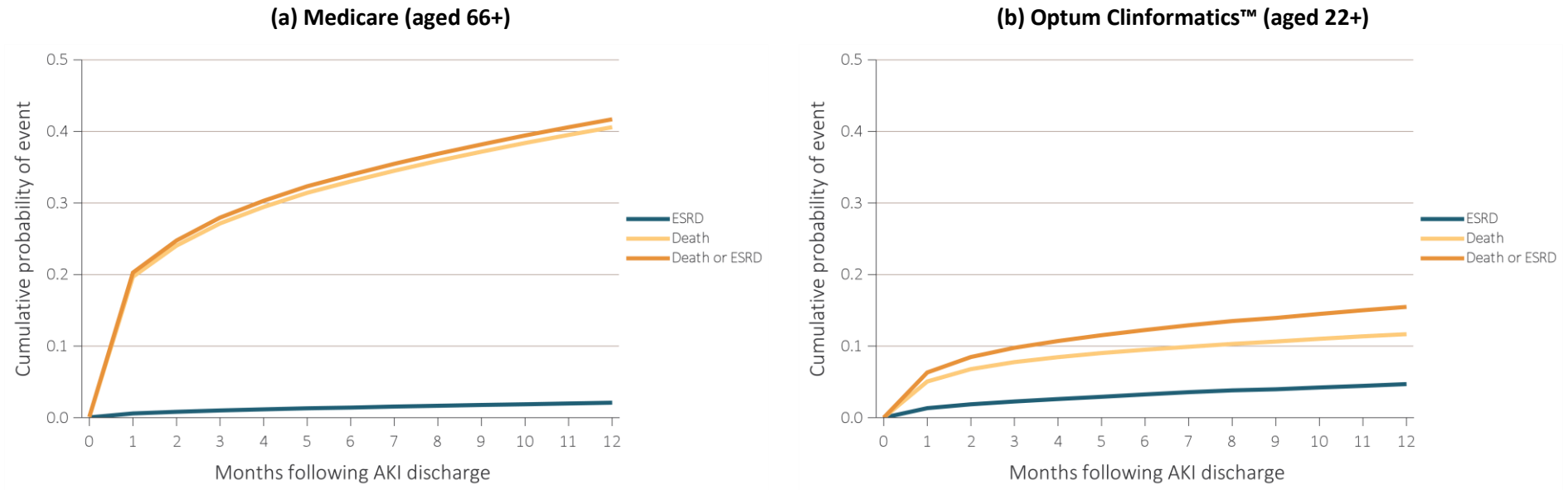


Data Source: Special analyses, Optum Clinformatics™. Age as of January, 2014. Optum Clinformatics™ commercial insurance patients aged 22 and older who were enrolled in the plan, did not have diagnoses of ESRD on January 1, 2014, and were discharged alive from an AKI hospitalization in 2014. Censored at death, ESRD diagnosis, or plan disenrollment. Abbreviations: Af/Am, African American; 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. However, survivors of an AKI hospitalization continue to be at risk for significant adverse outcomes. Figure 5.8 illustrates that, among survivors of an AKI hospitalization in 2014-2015, 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. The seemingly paradoxical higher risk for ESRD in the younger Optum Clinformatics™ population may be due to higher competing risk of death in the Medicare population: in this same period, the probability of death was 40.6% and 11.7% in the Medicare and Optum Clinformatics™ populations, respectively.

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 2014-2015

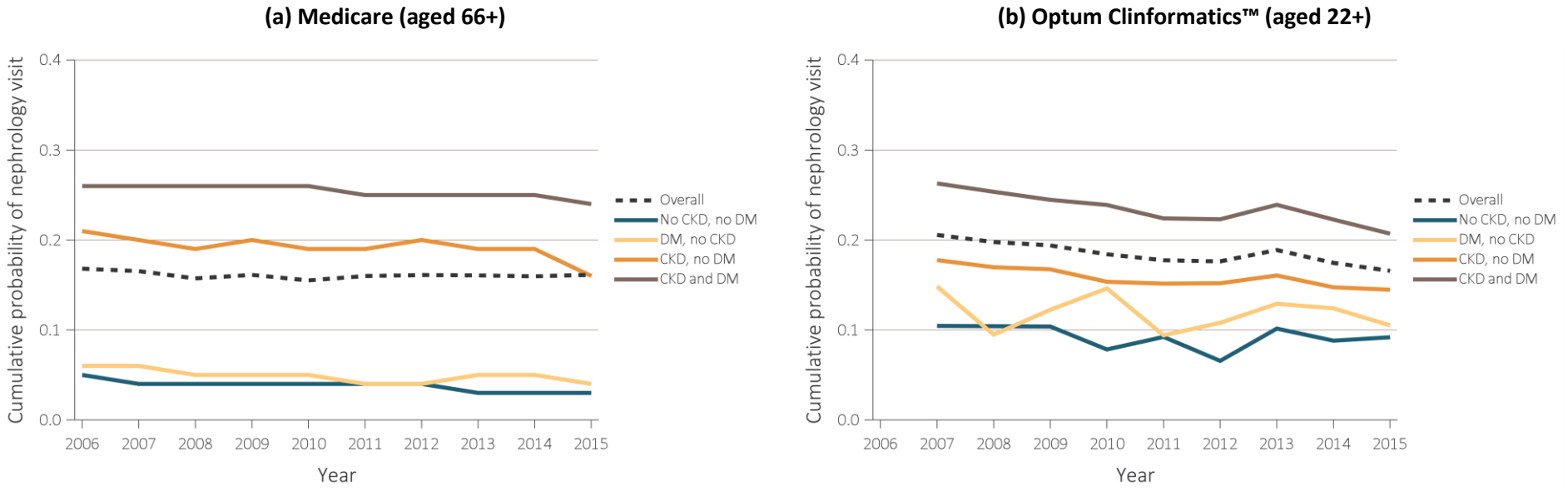


Data Source: Special analyses, Medicare 5% sample. (a) Medicare patients aged 66 and older who had both Medicare Parts A & B, no Medicare Advantage plan, no ESRD by first service date from Medical Evidence form, and were discharged alive from a first AKI hospitalization in 2014 or 2015. (b) All patient-years 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.

Recognizing that AKI can be associated with adverse long-term renal outcomes, including CKD and ESRD, both KDIGO guidelines and HP2020 objectives recommend follow-up renal evaluation after an AKI episode. In 2015, 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, 16% of Medicare and 14% 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 24% and 21%. In contrast, just 3% of Medicare and 9% 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 and DM, 2006-2015



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

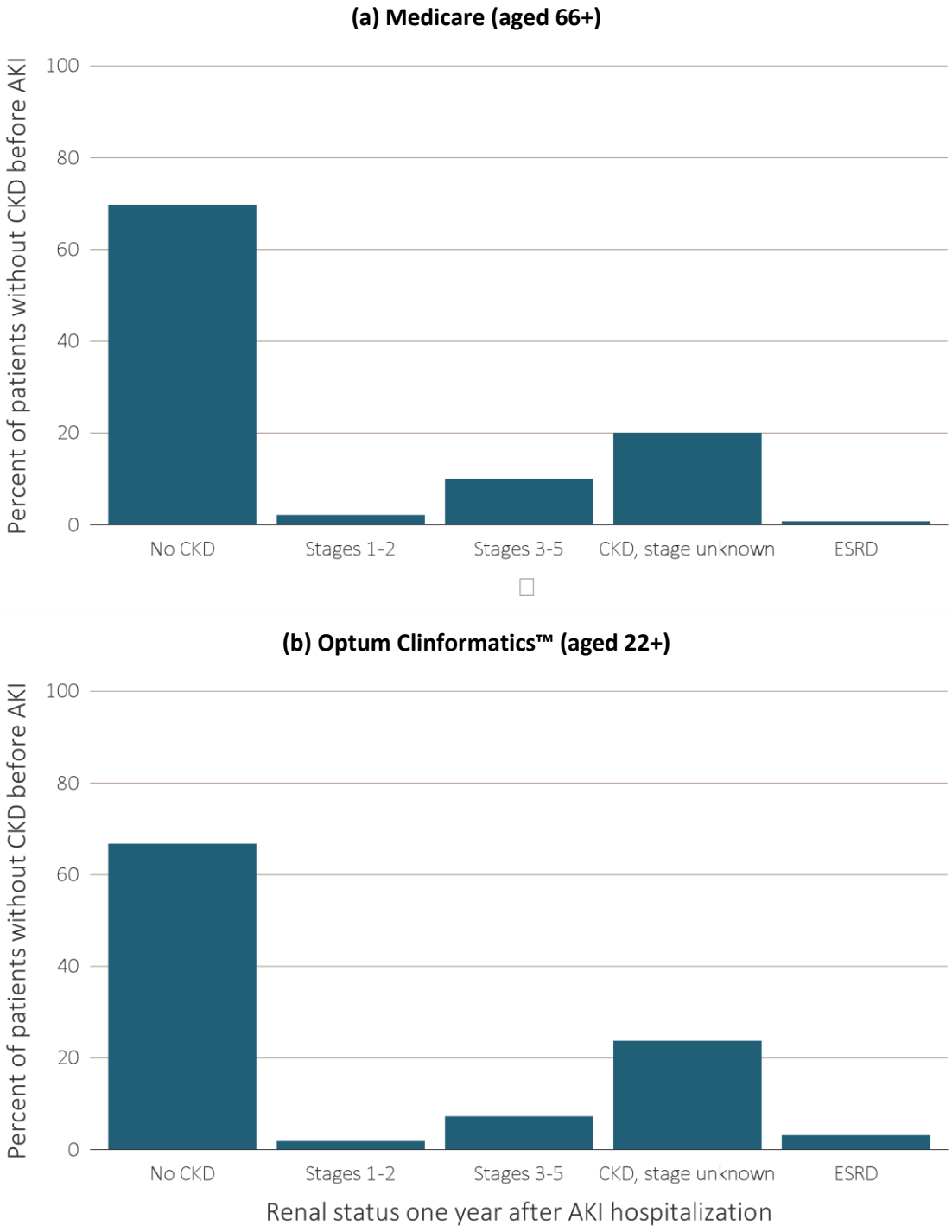
CKD status changed significantly in the year following an AKI hospitalization, as shown in Figure 5.10. Among Medicare patients without baseline CKD, 30.8% were reclassified as having some degree of CKD, including 0.2% being declared ESRD. In the Optum Clinformatics™ population, about 33.8% of patients with an AKI hospitalization were newly classified as having CKD in the subsequent year, and 2.6% 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 and ICD-10-CM codes for Chronic Kidney Disease (CKD) stages

ICD-9-CM code[a]	ICD-10-CM code	Stage
585.1	N18.1	CKD, Stage 1
585.2	N18.2	CKD, Stage 2 (mild)
585.3	N18.3	CKD, Stage 3 (moderate)
585.4	N18.4	CKD, Stage 4 (severe)
585.5	N18.5	CKD, Stage 5 (excludes 585.6/N18.6: Stage 5, requiring chronic dialysis)
CKD stage-unspecified		For these analyses, identified by multiple codes including ICD-9-CM code 585.9, 250.4x, 403.9x & others and ICD-10-CM code N18.9, E11.29, I12.9 & 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 or ICD-10-CM code N18.6 & with no ESRD 2728 form or other indication of end-stage renal disease (ESRD) are considered to have code 585.5/N18.5. ICD-10-CM codes became effective on October 1, 2015.

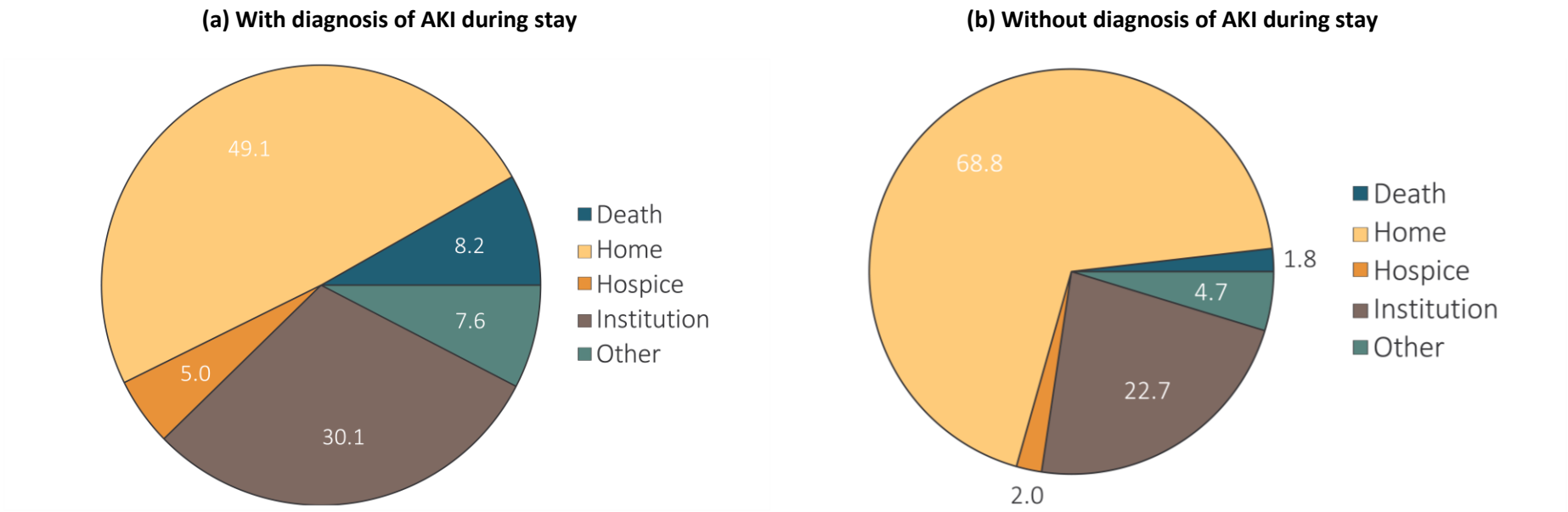
vol 1 Figure 5.10 Renal status one year following discharge from AKI hospitalization in 2014-2015, among surviving patients without kidney disease prior to AKI hospitalization, by CKD stage and ESRD status



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 2014 or 2015, 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 2014 or 2015, 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 2016 Medicare AKI patients once they were discharged from the hospital. We excluded patients admitted from a skilled nursing facility (SNF; n=1,942), leaving 57,256 AKI discharges. Among AKI patients aged 66 and older about 49.1% were discharged directly to their home. Mortality (including those discharged to hospice) was 13.2%, while 30.1% 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= 2,837, leaving 174,193 discharges), 68.8% returned home and approximately 22.7% were discharged to institutions. It is worth noting that, due to data limitations, we cannot fully ascertain and exclude admissions from residential facilities; therefore the high rate of "long-term care facility" in the discharge status could be a reflection of a higher rate of admissions from these facilities.

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, 2016



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 January 1 of 2016, had a first hospitalization in 2016, 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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