Chapter 5: Acute Kidney Injury

- In 2014, the percent of Medicare fee-for-service beneficiaries experiencing a hospitalization complicated by AKI was 4.0%, and this appears to have plateaued since 2011 (Figure 5.1). A similar trend was observed in the Clinformatics™ population, among whom 0.3% had an AKI hospitalization in 2014 (Figure 5.2). Unadjusted rates of AKI hospitalization also seem to have plateaued since 2011 in both the Medicare and Clinformatics™ populations (Figure 5.3).
- When examining AKI among patients in the VA system using serum creatinine-based criteria, fewer than 50% of identified cases had an associated diagnosis of AKI during their hospitalization (Table 5.2).
- For Medicare patients aged 66 years and older with an AKI hospitalization in 2012, the cumulative probability of a recurrent AKI hospitalization within one year was 35% (Figure 5.6.a). For Clinformatics™ patients aged 22 years and older, the probability of recurrent AKI hospitalization was 23% (Figure 5.7.a).
- Overall, 16% of Medicare patients and 17% of Clinformatics™ patients had a nephrology visit within 6 months of live discharge from an AKI hospitalization (Figure 5.9).
- Among Medicare patients aged 66 years and older with a first AKI hospitalization, the in-hospital mortality rate in 2013 was 9.0% (or 13.9% when including discharge to hospice). Less than half of all patients were discharged to their home, while 30.4% were discharged to an institution such as a rehabilitation or skilled nursing facility (Figure 5.13).

Introduction

Acute kidney injury (AKI) is now recognized as a major risk factor for the development of chronic kidney disease (CKD). The clearest example of this relationship is seen in cases of severe dialysis-requiring AKI where patients fail to recover renal 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 renal disease burden resulting from AKI, as studies have demonstrated significantly increased long-term risk of CKD and ESRD following AKI, even after initial recovery of renal function. Furthermore, this relationship is bidirectional and 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, in addition to the Medicare 5% sample, we utilized two additional data sources: the 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 Clinformatics™ administrative data do not contain clinical or biochemical data with which to identify an AKI episode using consensus criteria based on changes in serum creatinine or urinary output. In these data sources, episodes of AKI are identified using ICD-9-CM (International Classification of Diseases, Ninth 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 addition, time 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/recognition of AKI) increase the likelihood of administrative coding for AKI. Thus, a rising incidence of AKI may represent a true increase in AKI cases, an increased likelihood to

code for AKI, or a combination of both factors. In addition, a lower threshold for coding for AKI would lead to identification of less severe episodes and an apparent decrease in the rate of associated adverse outcomes. For this chapter, we identified and included all hospitalizations during which a diagnosis of AKI was coded, referring to these as AKI hospitalizations; even if AKI was not the primary diagnosis. In contrast to Medicare and Clinformatics™, VA data contains clinical data that can be used to apply serum creatinine-based criteria to identify episodes of AKI. We present some data from the VA population to illustrate the potential gap between AKI episodes that are identified by administrative coding versus clinical data.

We begin this chapter by exploring trends in hospitalizations complicated by AKI and describing characteristics of these patients, including age, sex, race, and comorbidity status. For this chapter, 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. While coded AKI increased between 2004 and 2011, this trend appears to have leveled off since then in both the Medicare and Clinformatics™ populations. Rates of AKI per 1,000 patient-years at risk increased with increasing age. Patients with diabetes and CKD had higher rates than patients with either comorbidity alone; patients with CKD alone had higher risk of hospitalization than those with diabetes alone.

Next, we explore outcomes and follow-up care after an AKI hospitalization. Among Medicare patients aged 66 years and older, 35% had a recurrent AKI hospitalization by one year, and 47% had a recurrent AKI hospitalization within two years. For Clinformatics™ patients aged 22 years and older, the corresponding proportions were 18% and 26%, respectively. These findings highlight the at-risk nature of this population and support published recommendations for post-AKI follow-up nephrology care. However, in 2013 only 16% of Medicare patients and 17% of Clinformatics™ patients with AKI were seen by a nephrologist within six months of hospital discharge.

As noted above, AKI plays an important role in CKD development and progression. Among Medicare patients without pre-existing CKD who experienced an AKI hospitalization, nearly 30% were reclassified as having some degree of CKD in the subsequent year.

Lastly, we explore patient disposition following an AKI hospitalization. Among patients not admitted from a nursing facility, 48% of Medicare patients suffering an AKI hospitalization returned directly to their homes, while 30% were institutionalized in a skilled nursing facility. By comparison, among hospitalized Medicare patients without an AKI episode, 68% returned home and 23% were institutionalized. These outcomes highlight the significant morbidity associated with AKI.

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 source than in previous years. This has coincided with a decrease in AKI hospitalizations since 2013 and we cannot rule out that this is an artifact of the differing source for the Medicare 5% data files, so caution should be used in drawing conclusions regarding trends. 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.

New this year, we present figures and s from the commercial insurance plan of a large national U.S. health insurance company as included in the Clinformatics™ Data Mart from OptumInsight. These data represent mainly working-age people and their minor dependents, in contrast to the Medicare data. See Table 2.1 in *Volume 1, Chapter 2: Identification and Care of Patients With CKD* for demographic characteristics of the Clinformatics™ population (all ages) and Tables 2.2 (ages 22-64) and 2.3 (all ages) for the prevalence of CKD and related conditions. This

chapter presents results for patients aged 22 and older. Additionally, Table 5.1 of this chapter uses data from all patients hospitalized within a VA hospital during fiscal year 2014 to show AKI 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 identified AKI episodes do not include the KDIGO criteria related to urine output.

Each of these three datasets has interactions between sex and age that are important to keep in mind when looking at differences in AKI by sex, since age is a major risk factor for AKI. Within both Clinformatics™ and the VA, women are younger on average than men. In Clinformatics™, 55% of women are between the ages of 22 and 39, compared to only 18.4 percent 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. On the other hand, women in the Medicare 5% sample are older, on average, than men. Women had a mean age of 76.8 years while the mean age for men was 75.2 years. A higher proportion of women vs. men were aged 85 and older; 20.2% of women compared to 13.3% of men.

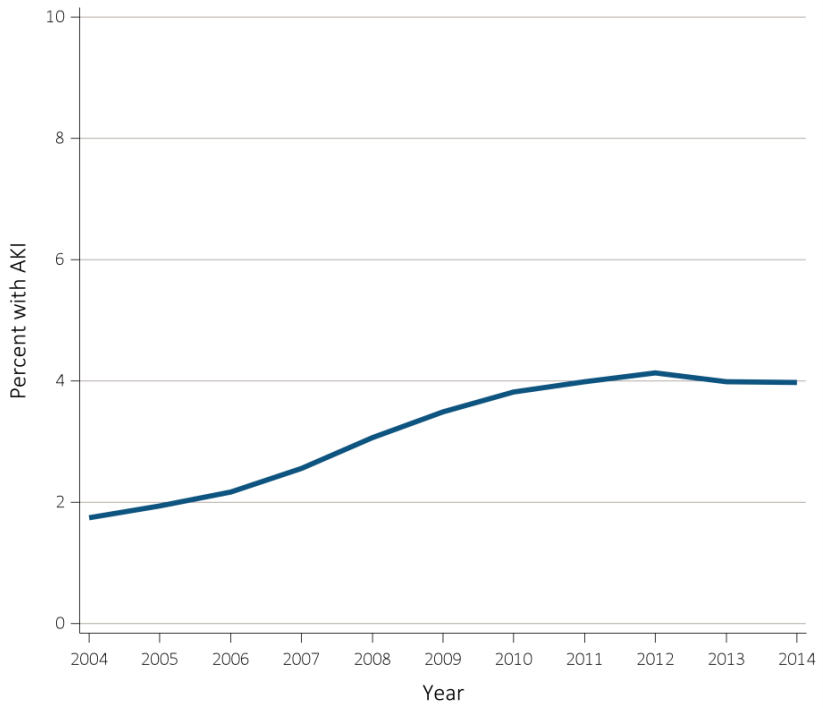
Note that all the figures except Figure 5.13 include all beneficiaries meeting the specified inclusion criteria. In Figure 5.13, those beneficiaries who were admitted from a long-term care facility to the inpatient setting where the AKI hospitalization occurred are excluded. Therefore, the category of institution in this figure includes only those newly admitted following a hospitalization. See the section on Chapter 5 in the *CKD Analytical Methods* chapter for an explanation of analytical methods used to generate the study cohorts, figures, and tables in this chapter.

Characteristics of Patients With Acute Kidney Injury

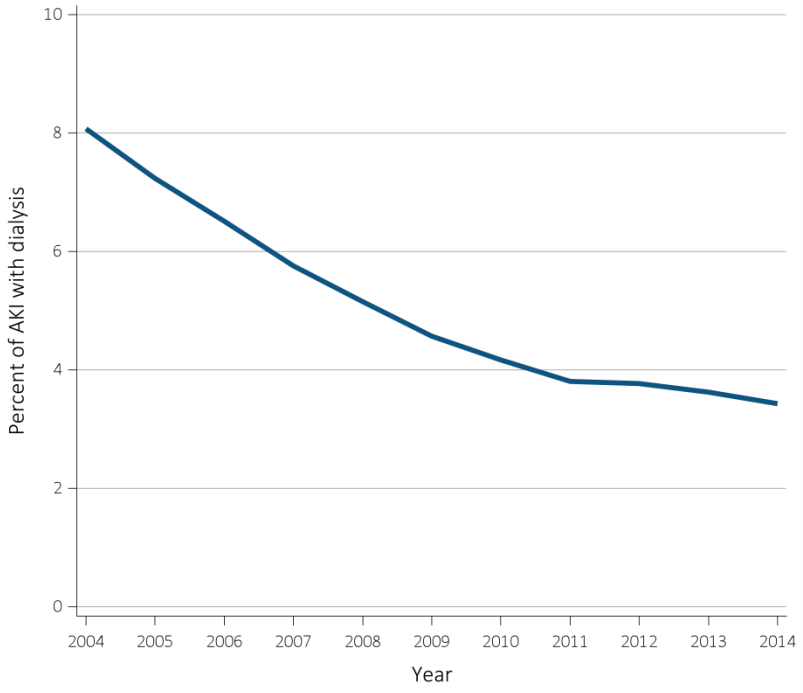
As shown in Figure 5.1, the percentage of patients with an AKI hospitalization (where AKI was one of the diagnoses but not necessarily the admitting diagnosis) in the Medicare fee-for-service population has risen over the past decade but appears to have plateaued around 4.0% since 2011. The proportion of AKI patients requiring dialysis has declined over the same period, but also appears to be leveling off since 2011. Figure 5.2 reveals very similar trends in the Clinformatics™ population, although the percentage of patients with an AKI hospitalization is far lower overall in this younger patient population (0.3% in 2014). Taken together, these findings suggest that an increased likelihood to code for AKI is indeed occurring: 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 fairly 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 that required dialysis, by year, 2004-2014

(a) Percent with an AKI hospitalization



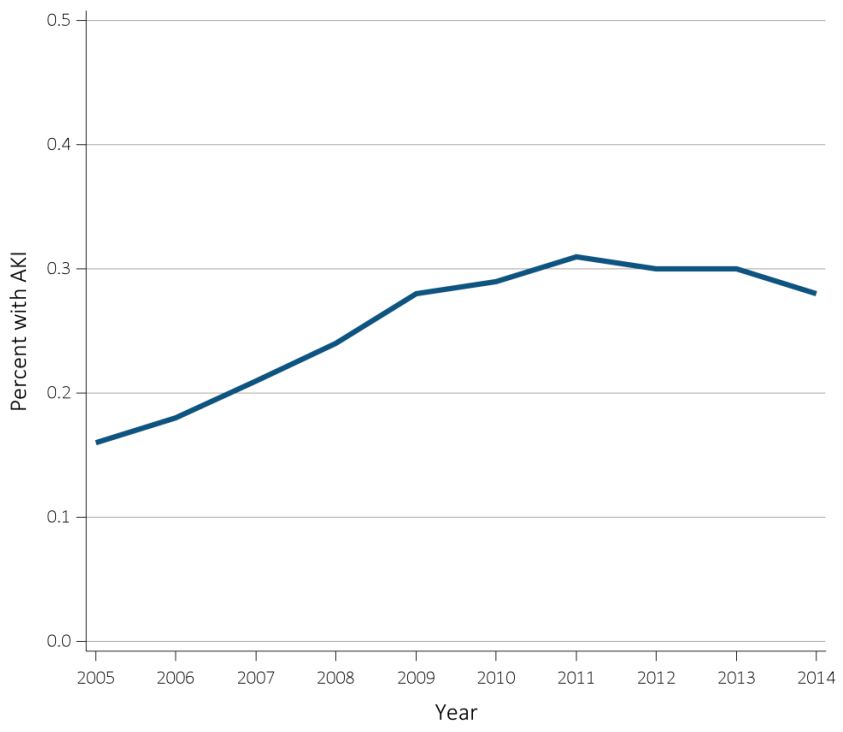
(b) Percent of patients requiring dialysis among those with a first AKI hospitalization



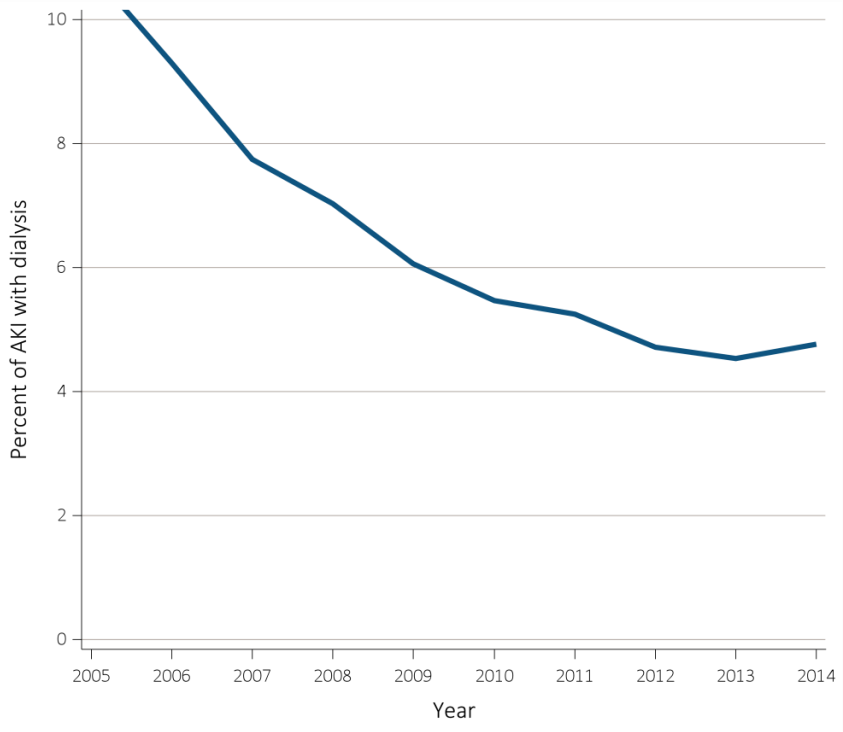
Data Source: Special analyses, Medicare 5% sample. (a) Percent with an AKI hospitalization among all Medicare patients aged 66 and older who had both Medicare Parts A & B, no Medicare Advantage plan, no ESRD by first service date from Medical Evidence form, and were alive on January 1 of year shown. (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 period of the AKI inpatient claim. Abbreviations: AKI, acute kidney injury; ESRD, end-stage renal disease.

vol 1 Figure 5.2 Percent of Clinformatics™ patients aged 22+ (a) with at least one AKI hospitalization, and (b) percent among those with an AKI hospitalization that required dialysis, by year, 2005-2014

(a) Percent with an AKI hospitalization



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



Data Source: Special analyses, Clinformatics™. (a) Percent with an AKI hospitalization among all 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, 2014. (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 period 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 Clinformatics™ patients with AKI in 2014. AKI occurs commonly in older adults, and the incidence rises with age. In the fee-for-service Medicare population, patients aged 80 years and older comprise 54% of all patients with an AKI hospitalization. Diabetes mellitus 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 Clinformatics™ population, about 36% of patients with an AKI hospitalization had either diabetes, CKD, or both.

vol 1 Table 5.1 Characteristics of Medicare and Clinformatics™ patients with at least one hospitalization, by age, sex, race, CKD, DM, and presence of AKI, 2014

	Medicare (aged 66+)						Clinformatics™ (aged 22+)					
	Total		Without AKI		With AKI		Total		Without AKI		With AKI	
	N	%	N	%	N	%	N	%	N	%	N	%
Total	231,894	100.0	178,747	100.0	53,147	100.0	307,333	100.0	287,415	100.0	19,918	100.0
Age												
22-39	—	—	—	—	—	—	132,848	43.2	130,828	45.5	2,020	10.1
40-65	—	—	—	—	—	—	145,567	47.4	132,606	46.1	12,961	65.1
65+	—	—	—	—	—	—	28,918	9.4	23,981	8.3	4,937	24.8
66-69	36,228	15.6	29,906	16.7	6,322	11.9	—	—	—	—	—	—
70-74	45,009	19.4	36,484	20.4	8,525	16.0	—	—	—	—	—	—
75-79	43,280	18.7	33,753	18.9	9,527	17.9	—	—	—	—	—	—
80-84	41,067	17.7	30,863	17.3	10,204	19.2	—	—	—	—	—	—
85+	66,310	28.6	47,741	26.7	18,569	34.9	—	—	—	—	—	—
Sex												
Male	98,054	42.3	72,345	40.5	25,709	48.4	105,505	34.3	92,960	32.3	12,545	63.0
Female	133,840	57.7	106,402	59.5	27,438	51.6	201,828	65.7	194,455	67.7	7,373	37.0
Race												
White	201,739	87.0	157,510	88.1	44,229	83.2	217,342	70.7	202,931	70.6	14,411	72.4
Black/African American	18,668	8.1	12,579	7.0	6,089	11.5	30,300	9.9	27,663	9.6	2,637	13.2
Native American	1,193	0.5	930	0.5	263	0.5	—	—	—	—	—	—
Hispanic	—	—	—	—	—	—	30,723	10.0	29,198	10.2	1,525	7.7
Asian	3,128	1.4	2,262	1.3	866	1.6	13,276	4.3	12,885	4.5	391	2.0
Other	7,166	3.1	5,466	3.1	1,700	3.2	15,692	5.1	14,738	5.1	954	4.8
Pre-existing comorbidities												
No DM or CKD, prior year	137,612	59.3	115,052	64.4	22,560	42.5	272,983	88.8	260,248	90.6	12,735	63.9
DM no CKD, prior year	49,165	21.2	38,030	21.3	11,135	21.0	24,720	8.0	20,937	7.3	3,783	19.0
CKD no DM, prior year	21,423	9.2	13,103	7.3	8,320	15.7	5,194	1.7	3,650	1.3	1,544	7.8
Both CKD & DM, prior year	23,694	10.2	12,562	7.0	11,132	21.0	4,436	1.4	2,580	0.9	1,856	9.3

Data Source: Special analyses, Medicare 5% sample and 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, 2014. 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, 2014. 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 patients with an AKI hospitalization in the VA system. Here, AKI is defined using serum creatinine-based criteria according to the KDIGO guideline (Table A). Similar to the Medicare population, nearly 57% of VA patients with AKI have either diabetes, CKD, or both. Of note, only 49% of patients meeting criteria for AKI were actually given a diagnosis of AKI during their hospital stay. This percentage increased with AKI severity, ranging from 45% of stage 1 AKI hospitalizations to 70% of stage 3 AKI hospitalizations.

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.

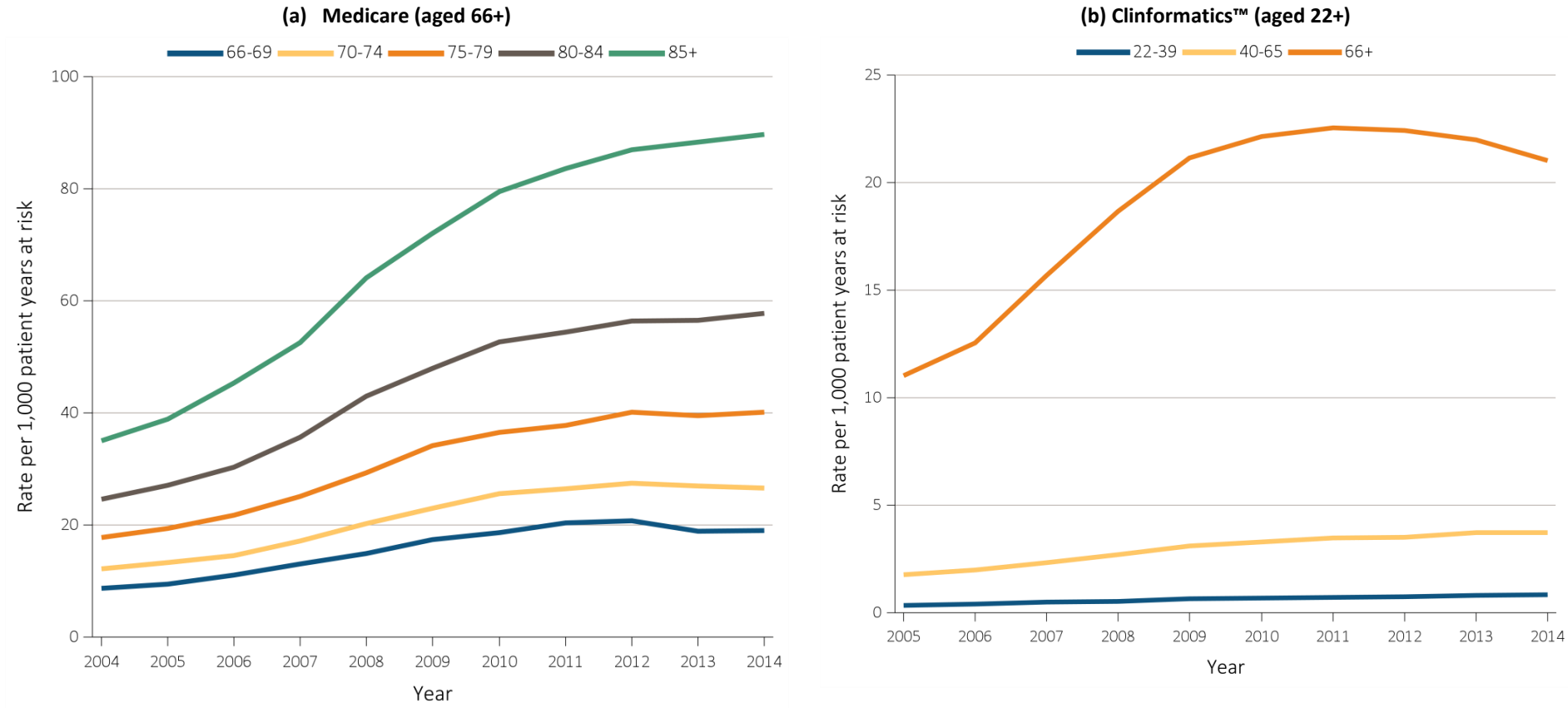
vol 1 Table 5.2 Characteristics of Veterans Affairs patients aged 22+ with at least one hospitalization, by age, sex, race, CKD, DM, presence and stage of AKI, defined by serum creatinine, FY 2014

	Total	No AKI	Any Stage AKI	Stage 1	Stage 2	Stage 3
Total, N	319,969	242,834	77,135	64,566	2,673	9,896
Diagnosis of AKI, %	15.6	5.0	48.8	45.3	53.9	70.0
Age, %						
22-39	3.9	4.8	1.3	1.3	2.0	1.0
40-59	19.0	20.6	14.1	13.5	19.9	16.7
60-65	17.7	17.6	18.0	17.6	22.9	19.5
66-69	19.6	19.5	20.2	20.1	21.0	20.1
70-74	13.2	12.9	14.4	14.5	12.1	13.9
75-79	7.6	7.2	8.8	8.9	7.0	8.3
80-84	7.9	7.3	9.7	9.9	6.8	9.3
85+	10.9	10.1	13.5	14.1	8.2	11.2
Sex, %						
Male	94.3	93.5	96.8	96.8	95.1	97.1
Female	5.7	6.5	3.2	3.2	4.9	2.9
Race, %						
White	69.6	70.4	66.8	68.1	69.3	57.4
Black/African American	19.1	18.0	22.5	21.6	18.6	30.0
Native American	0.6	0.7	0.5	0.5	0.6	0.5
Hispanic	6.1	6.2	5.6	5.3	7.0	6.7
Asian	0.8	0.8	0.8	0.8	0.6	1.2
Other/Not known	3.8	3.8	3.8	3.7	4.0	4.3
Diabetes and CKD, %						
No DM or CKD	58.1	62.8	43.4	44.8	65.5	27.8
DM no CKD	24.7	23.5	28.7	30.5	31.4	16.1
CKD no DM	8.7	7.8	11.8	10.3	1.3	24.6
Both CKD & DM	8.4	6.0	16.2	14.4	1.8	31.5

Data Source: Special analyses, Veterans Affairs data. Patients aged 22 and older with at least one hospitalization in fiscal year 2014. AKI defined by serum creatinine criteria as in KDIGO (2012), see Table A for details. 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; ESRD, end-stage renal disease, FY, federal fiscal year (October 1, 2013 to September 30, 2014).

Rates of AKI are strongly influenced by age, as shown in Figure 5.3. Among fee-for-service Medicare patients in 2014, the rate of AKI for those ages 66-69 is 19.1 per 1,000 patient years, increasing to 26.7, 40.2, 57.8, and 89.7 respectively, for ages 70-74, 75-79, 80-84, and 85 years and older. Between 2003 and 2012, unadjusted rates of AKI increased across all age ranges. Data from 2013 and 2014 show a plateau or slight decrease in AKI rates. In the Medicare population, the overall unadjusted rate of AKI decreased from a peak of 43.0 per 1,000 patient years in 2012 to 41.8 per 1,000 patient years in 2014. Among Clinformatics™ patients, the overall AKI rate peaked at 3.3 per 1,000 patient years in 2011 and was 3.3 per 1,000 patient years in 2014. Among Clinformatics™ patients aged 66 and older, the 2011 rate was 22.5 per 1,000 patient-years and fell to 21.0 per 1,000 patient-years in 2014.

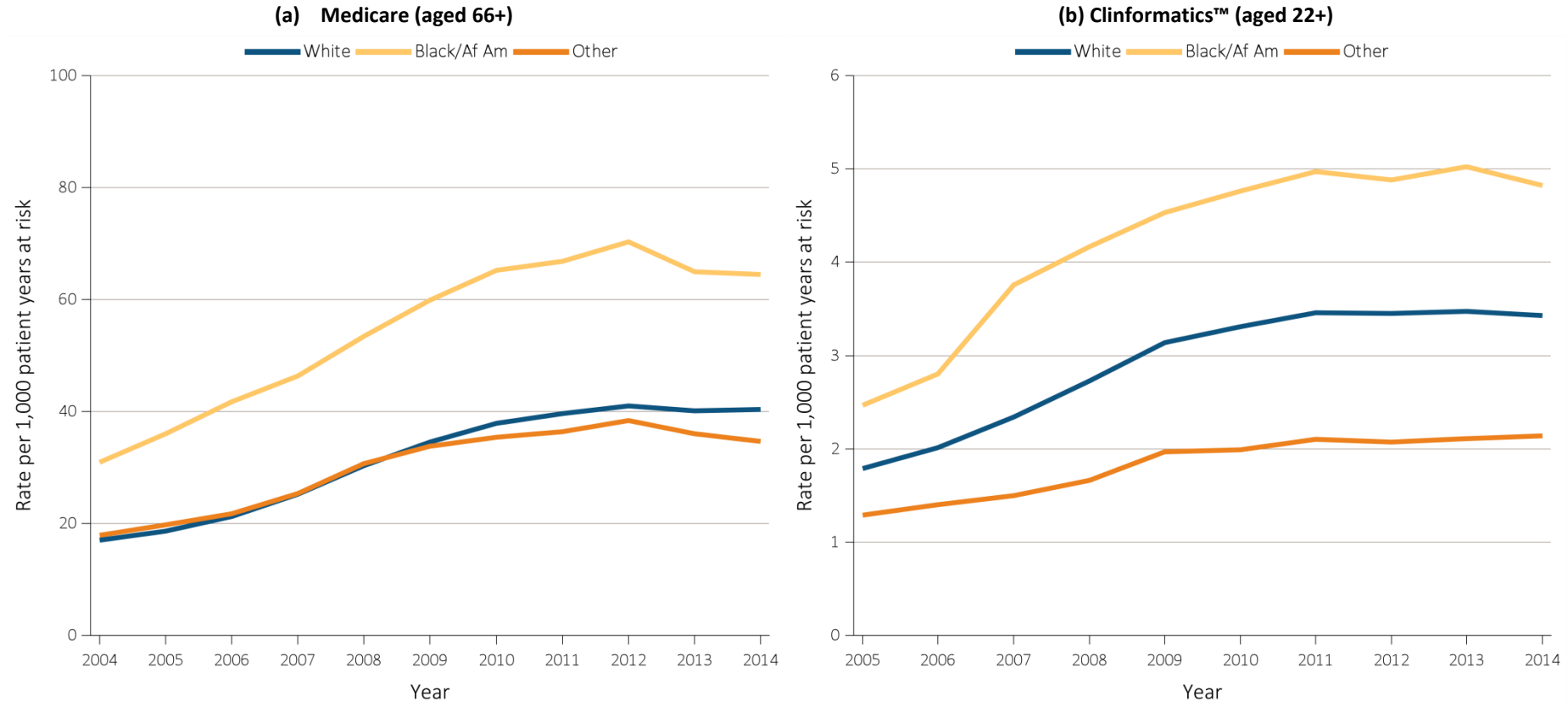
vol 1 Figure 5.3 Unadjusted rates of first hospitalization with AKI, per 1,000 patient-years at risk, by age and year, 2004-2014



Data Source: Special analyses, Medicare 5% sample and 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 Part A & B participation, or switch to Medicare Advantage program. (b) All patient-years at risk for 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. Abbreviation: AKI, acute kidney injury; ESRD, end-stage renal disease.

Figure 5.4 highlights differences in rates of AKI by race. In 2014, among fee-for-service Medicare patients aged 66 and older, the incidence rate was 64.5 per 1,000 patient years at risk in Blacks compared to 40.3 and 34.7, respectively, in Whites and individuals of other races. A similar relationship was observed in the Clinformatics™ population, albeit at much lower rates: 4.8, 3.4, and 2.1 per 1,000 patient years at risk in Blacks, Whites and individuals of other races, respectively. Rates have been flat in the Clinformatics™ population since 2011, while in the Medicare population there has been a slight decrease since 2012. This decrease in AKI rates was noted in all race groups and was most pronounced in Blacks and individuals of other races, who had relative decreases (8.3% and 9.9%) between 2012 and 2014 respectively, compared to a 1.5% decrease among Whites.

vol 1 Figure 5.4 Unadjusted rates of first hospitalization with AKI, per 1,000 patient-years at risk, by race and year, 2004-2014

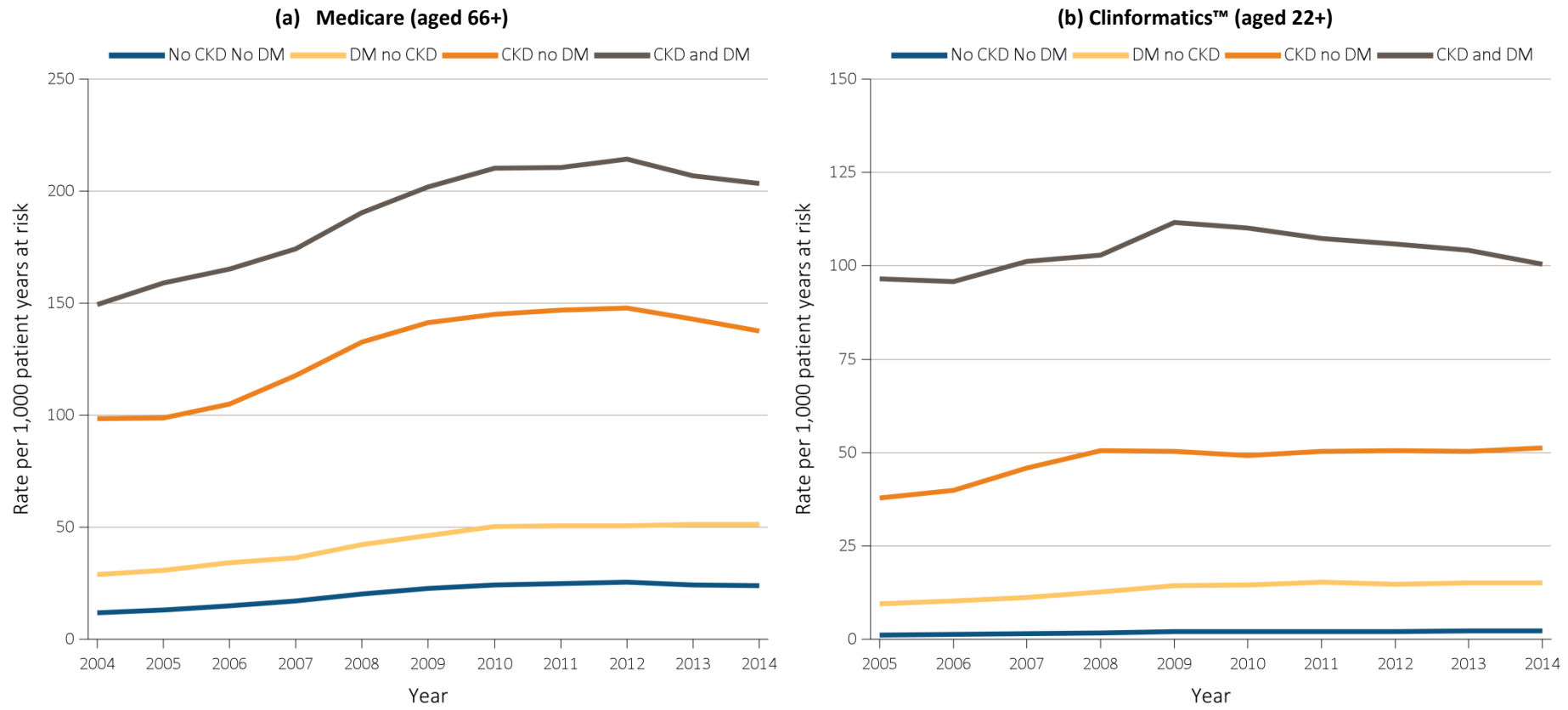


Data Source: Special analyses, Medicare 5% sample and Clinformatics™. (a) All patient-years at risk for Medicare patients aged 66 and older who had both Medicare Parts A & B, no Medicare Advantage plan, no ESRD by first service date from Medical Evidence form, and were alive on January 1 of year shown. Censored at death, ESRD, end of Medicare Part A & B participation, or switch to Medicare Advantage program. (b) All patient-years at risk for 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. 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 vary substantially by underlying comorbidity. In 2014, Medicare patients with diabetes and no known CKD had an AKI incidence rate of 51.2 per 1,000 patient years compared to 24.0 per 1,000 patient years in non-diabetic, non-CKD patients. Non-diabetic patients with CKD experienced an AKI incidence rate of 137.7 per 1,000 patient years, while the rate in patients with both diabetes and CKD was 203.4 per 1,000 patient years. That is, about 20% of Medicare patients with both CKD and diabetes will experience a hospitalization with AKI in a given year.

Similar relationships were seen in the Clinformatics™ population, with patients with both CKD and diabetes experiencing the highest rates of AKI hospitalization at 100.5 per 1,000 patient years. However, the overall rates were much lower, presumably reflecting the younger age range.

vol 1 Figure 5.5 Unadjusted rates of first hospitalization with AKI, per 1,000 patient-years at risk, by CKD, DM, and year, 2004-2014



Data Source: Special analyses, Medicare 5% sample and 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 Part A & B participation, or switch to Medicare Advantage program. (b) All patient-years at risk for 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. Abbreviations: AKI, acute kidney injury; CKD, chronic kidney disease; DM, diabetes mellitus; ESRD, end-stage renal disease.

Hospitalization Associated With Acute Kidney Injury

Figures 5.6 and 5.7 show the probability of a recurrent AKI hospitalization after live discharge following an AKI hospitalization. Among Medicare patients aged 66 and older, in 2012 the overall probability of a recurrent AKI event is 0.35 in the next 12 months and 0.47 by 24 months, as shown in 5.6.a. Among Clinformatics™ patients, these probabilities are 0.18 and 0.26, respectively. In contrast to first episodes, the rate of recurrent AKI is relatively similar across age groups in the fee-for-service Medicare population (5.6.b); however, interpretation of this finding is limited due to the effect of death censoring, which is higher in older age groups.

In both the Medicare and 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 diabetes or CKD is associated with an increased probability for recurrent AKI compared to having neither (Figures 5.6.d and 5.7.d). The highest probability for recurrent AKI is seen in patients with both diabetes and CKD, reaching 0.58 by 24 months among Medicare patients and 0.45 among Clinformatics™ patients. In contrast, Medicare patients with neither comorbidity have a cumulative probability for recurrent AKI hospitalization of 0.31 by 24 months, while their Clinformatics™ counterparts have a probability of 0.22 by 24 months.

vol 1 Figure 5.6 Cumulative probability of a recurrent AKI hospitalization within two years of live discharge from first AKI hospitalization in 2012 for Medicare patients aged 66+, (a) overall, (b) by age, (c) by race, and (d) by CKD and DM

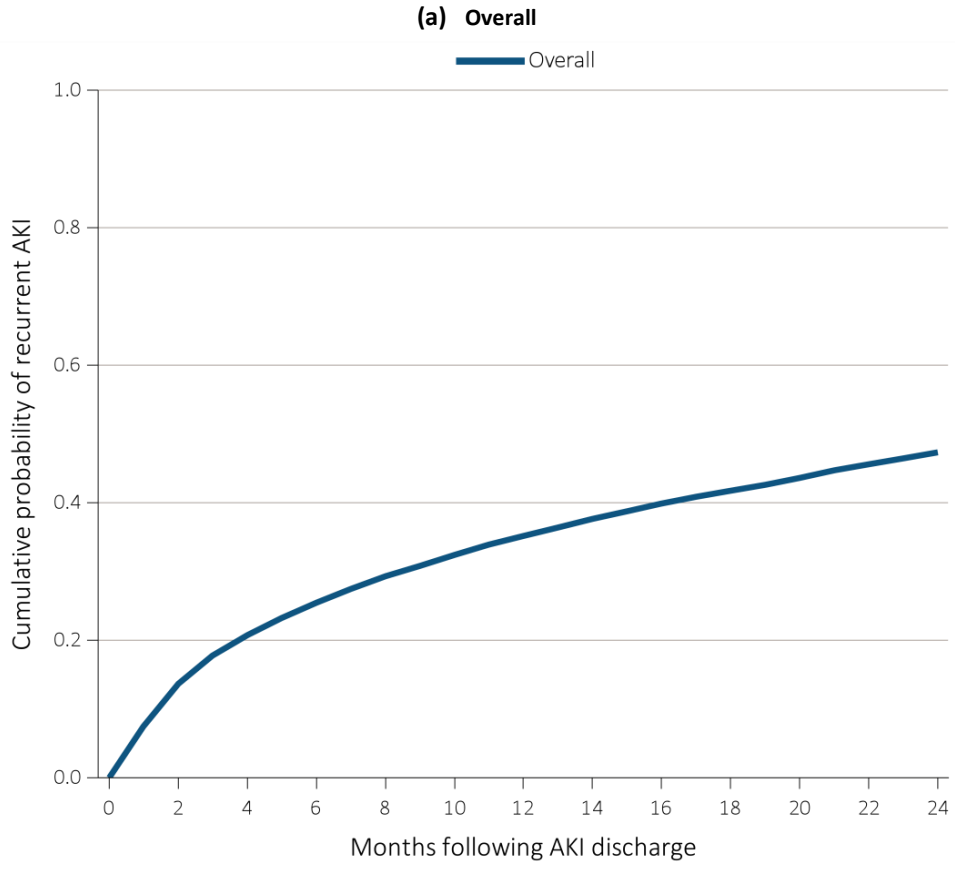


Figure 5.6 continued on next page.

vol 1 Figure 5.6 Cumulative probability of a recurrent AKI hospitalization within two years of live discharge from first AKI hospitalization in 2012 for Medicare patients aged 66+, (a) overall, (b) by age, (c) by race, and (d) by CKD and DM *(continued)*

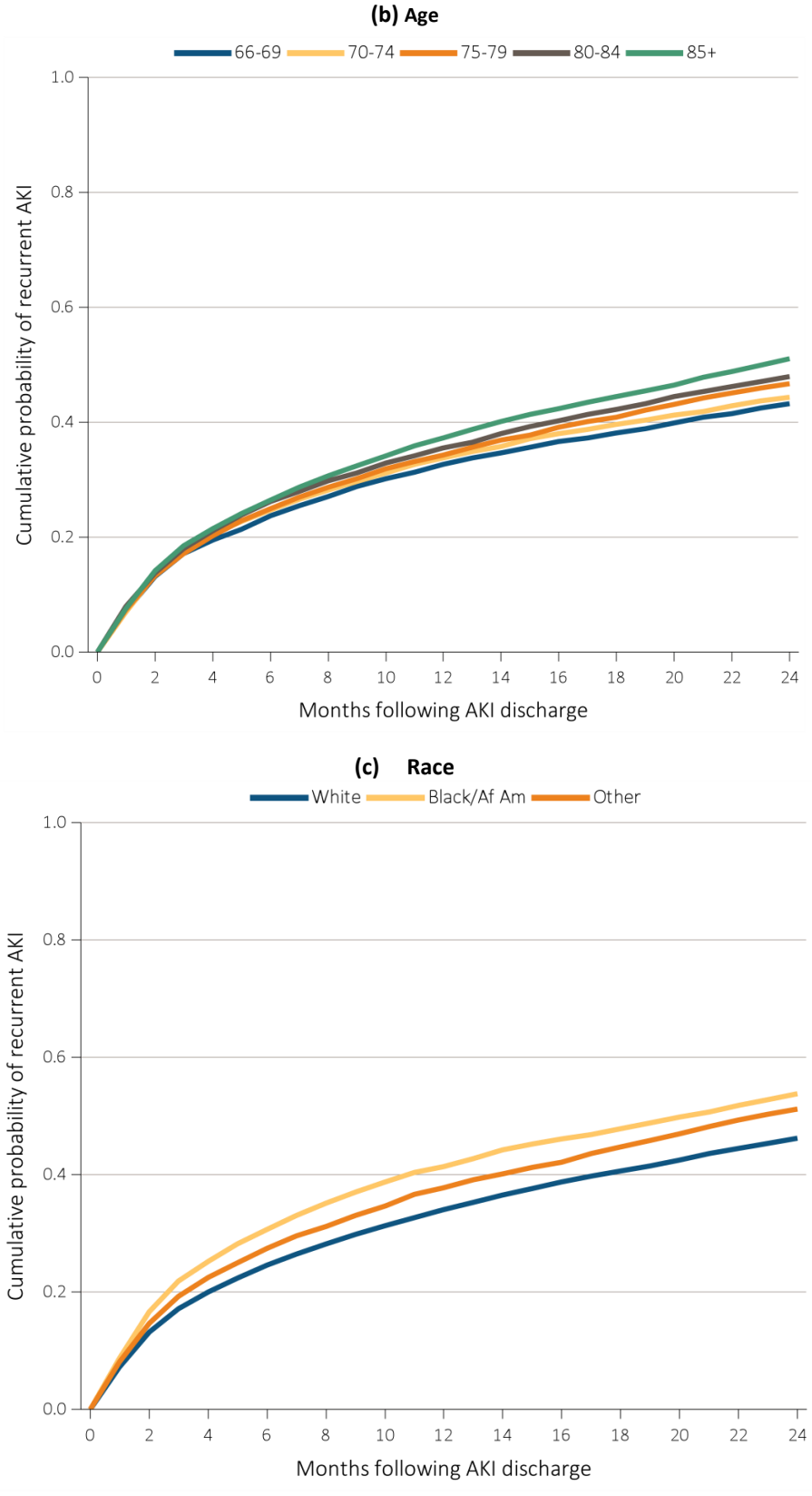
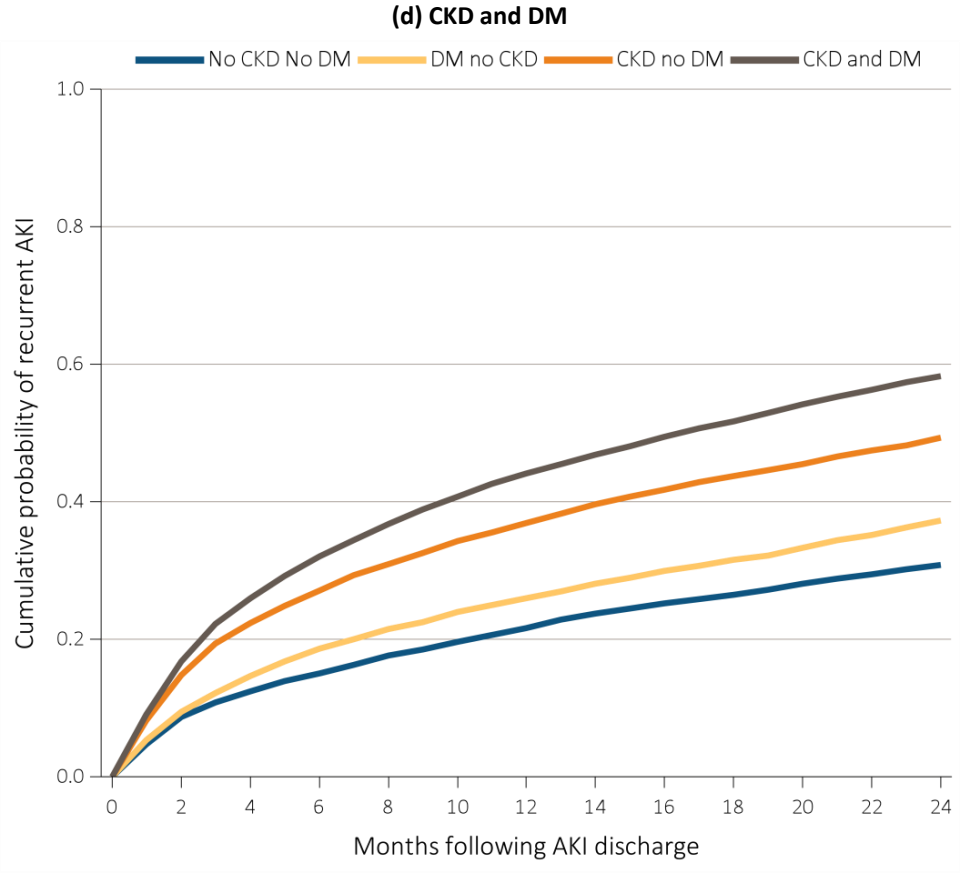


Figure 5.6 continued on next page.

vol 1 Figure 5.6 Cumulative probability of a recurrent AKI hospitalization within two years of live discharge from first AKI hospitalization in 2012 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, 2012. 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 1/1/2012, and were discharged alive from an AKI hospitalization in 2012. Censored at death, ESRD, end of Medicare Part 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 2012 for Clinformatics™ patients aged 22+, (a) overall, (b) by age, (c) by race, and (d) by CKD and DM

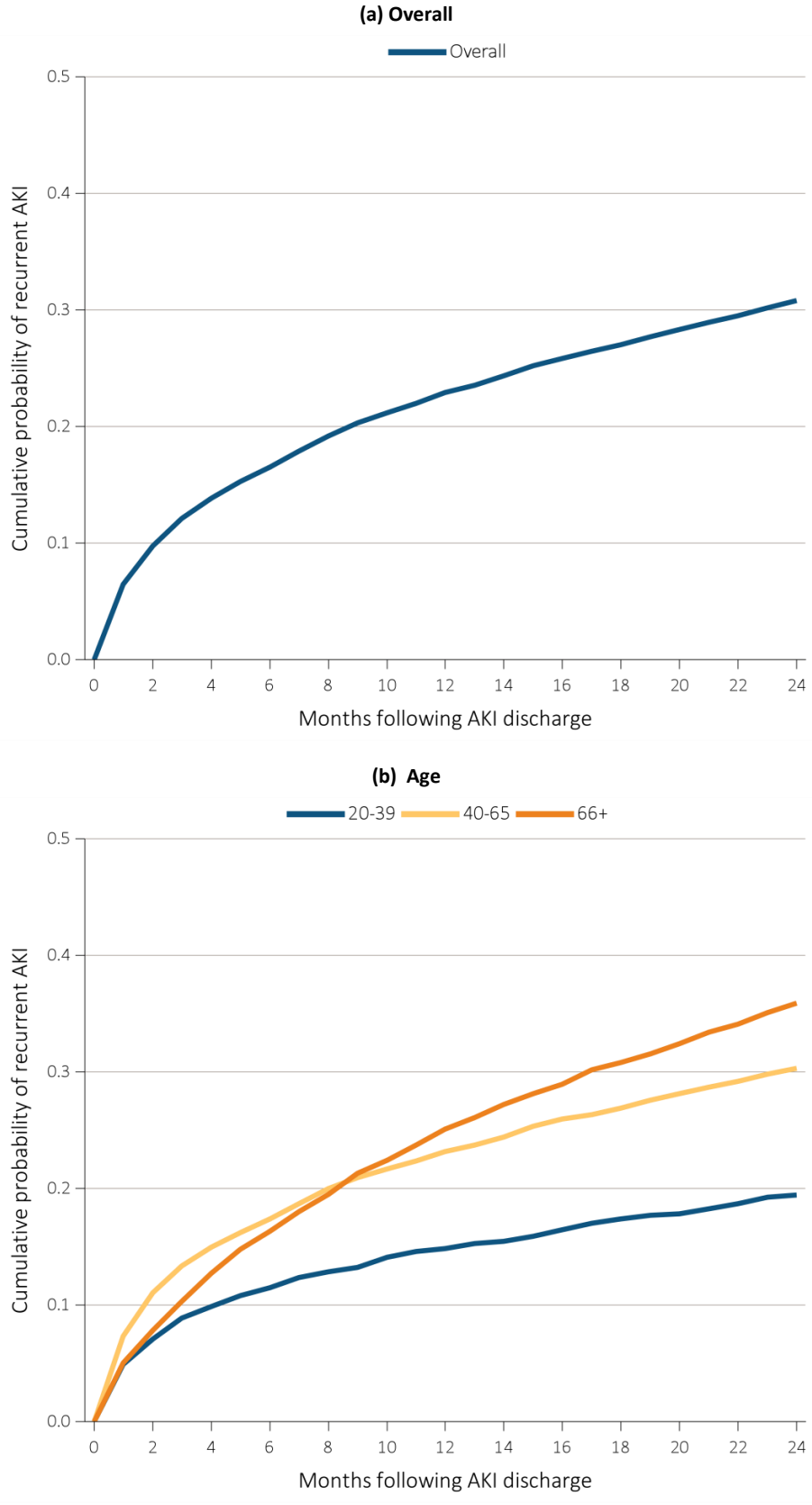
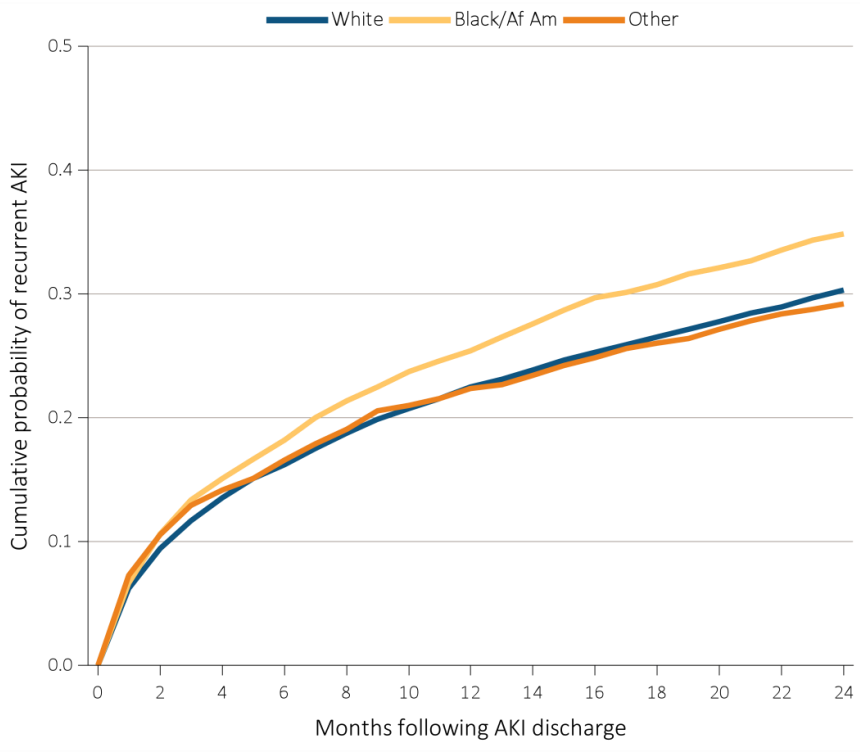


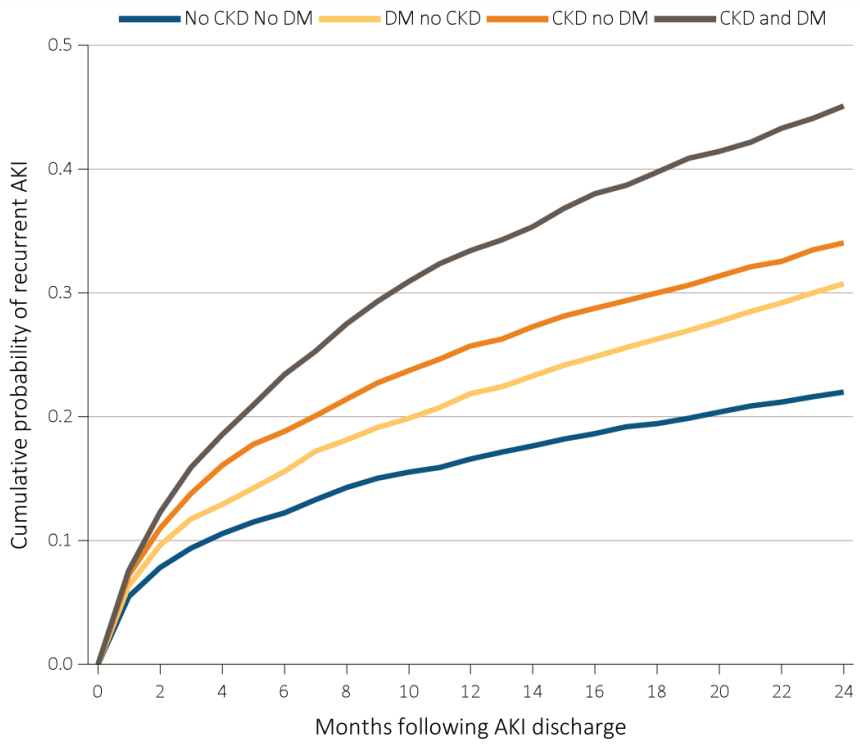
Figure 5.7 continued on next page.

vol 1 Figure 5.7 Cumulative probability of a recurrent AKI hospitalization within two years of live discharge from first AKI hospitalization in 2012 for 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

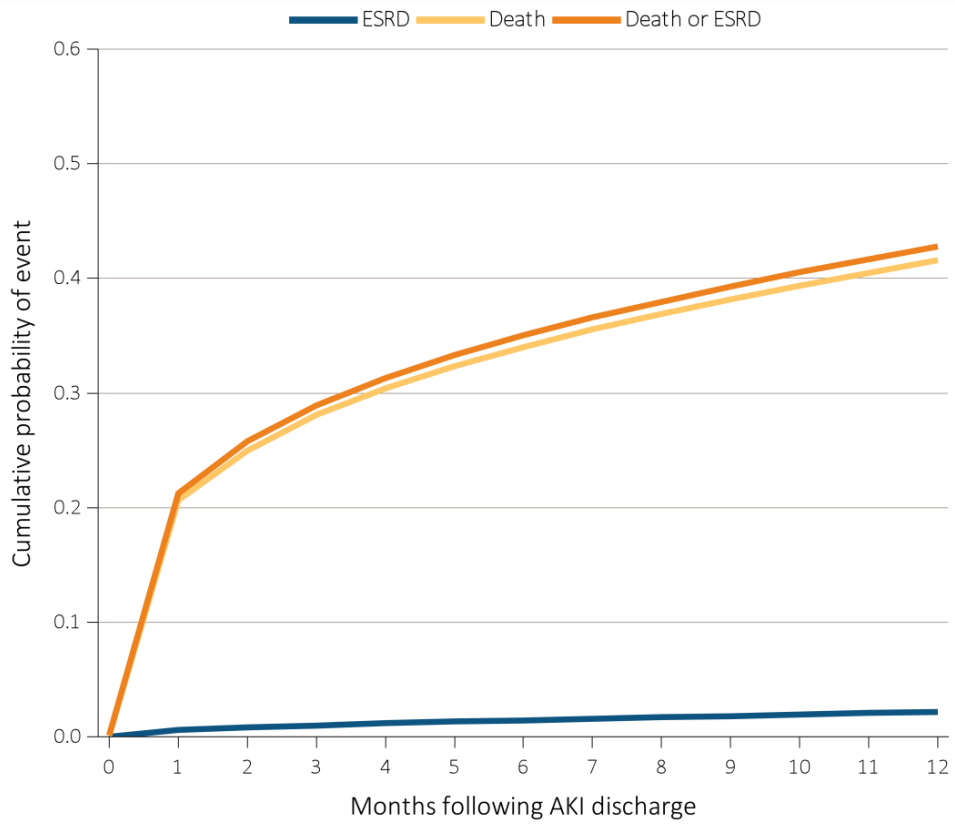


Data Source: Special analyses, Clinformatics™. Age as of January, 2012. Clinformatics™ commercial insurance patients aged 22 and older who were enrolled in the plan, did not have diagnoses of ESRD on January 1, 2012, and were discharged alive from an AKI hospitalization in 2012. Censored at death, ESRD 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 shows that survivors of an AKI hospitalization (those discharged alive) continue to face significant risk for adverse outcomes following discharge. Among survivors of an AKI hospitalization in 2012-2013, the overall probability of developing ESRD in the following year is about 2% in the Medicare fee-for-service population aged 66 and older. In this same time frame, the probability of death is nearly 42%.

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 2012-2013 for Medicare patients aged 66+



Data Source: Special analyses, Medicare 5% sample. 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 2012 or 2013. All models censored at the end of Medicare Part A & B participation, switch to Medicare Advantage program, or 365 days after AKI discharge. Model for ESRD also is censored at death. Model for death is not censored at the start of ESRD. Abbreviations: AKI, acute kidney injury; ESRD, end-stage renal disease.

In 2013, 16% of Medicare patients discharged alive from an AKI hospitalization had outpatient nephrology follow-up within the next six months, while 17% of 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 without diabetes, 19% and 26% were seen by a nephrologist within six months following discharge in the Medicare and Clinformatics™ populations, respectively. For patients with both CKD and diabetes, these proportions rose to 25% and 36%, respectively. In contrast, just 3% of Medicare and 8% of Clinformatics™ AKI patients without diabetes or CKD were seen by a nephrologist by six months following AKI hospitalization.

Trends over the past decade show a slight decrease in post-AKI hospitalization nephrology follow-up in both the Medicare and Clinformatics™ populations. This may once again reflect code creep: milder cases of AKI are being captured by diagnosis, but these may be 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, by CKD, DM, 2004-2013

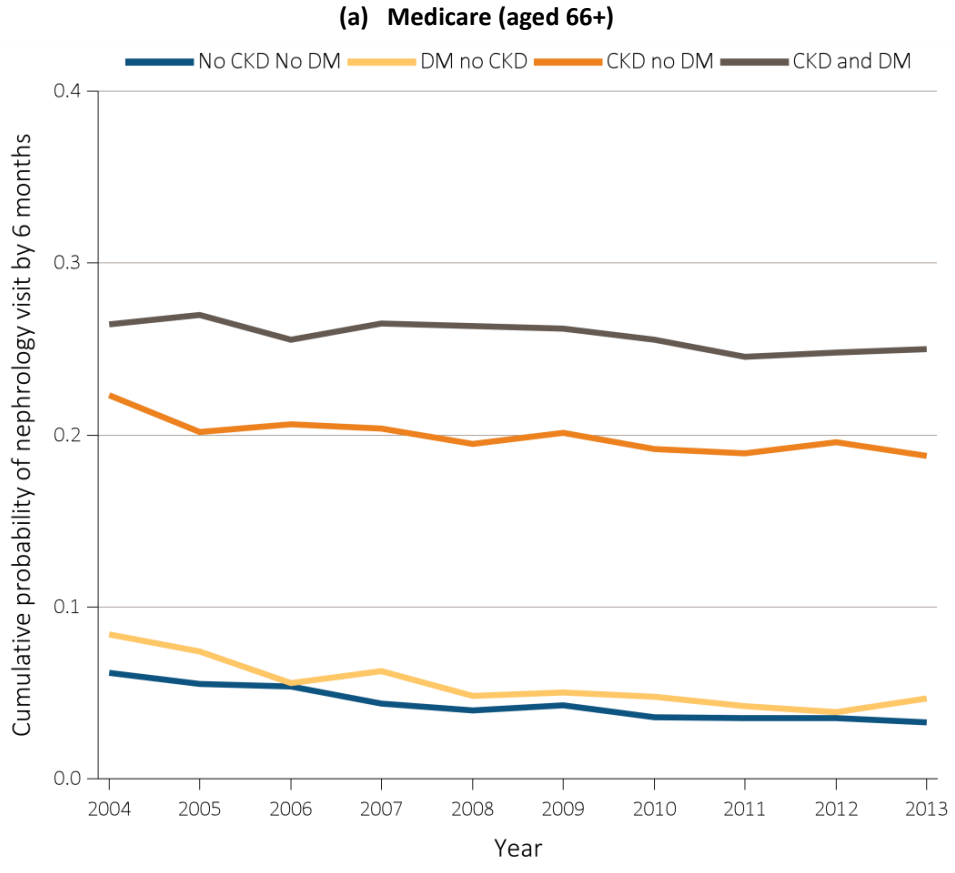
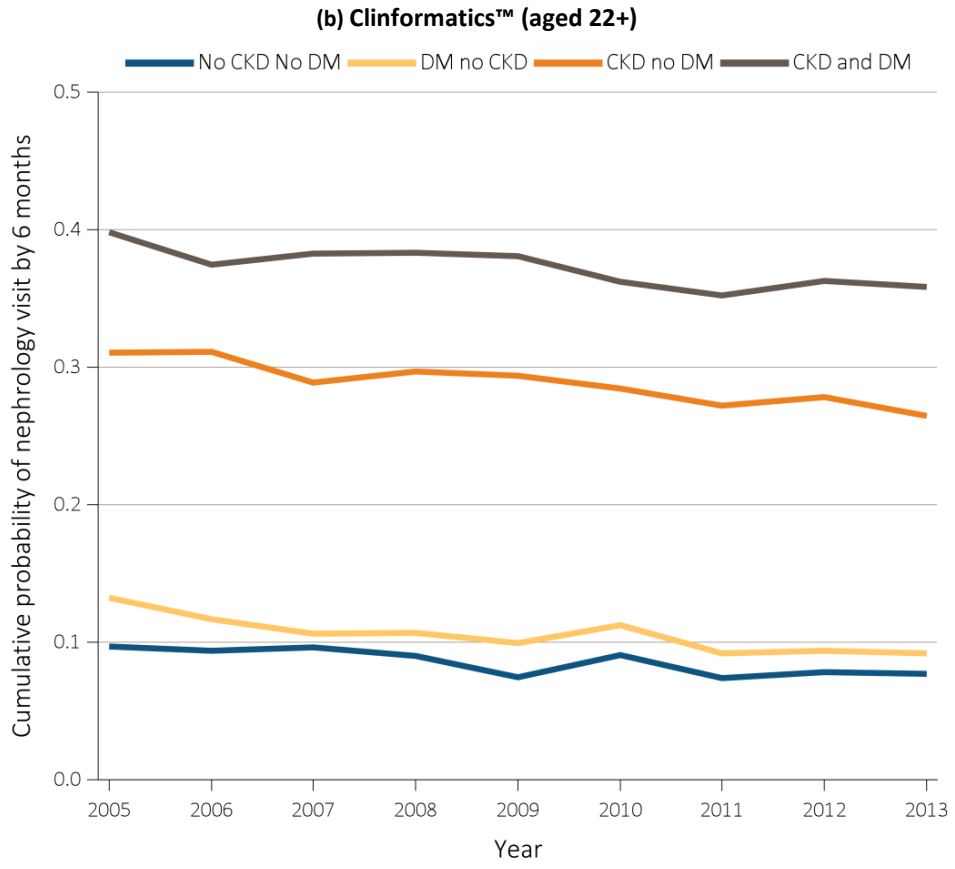


Figure 5.9 continued on next page.

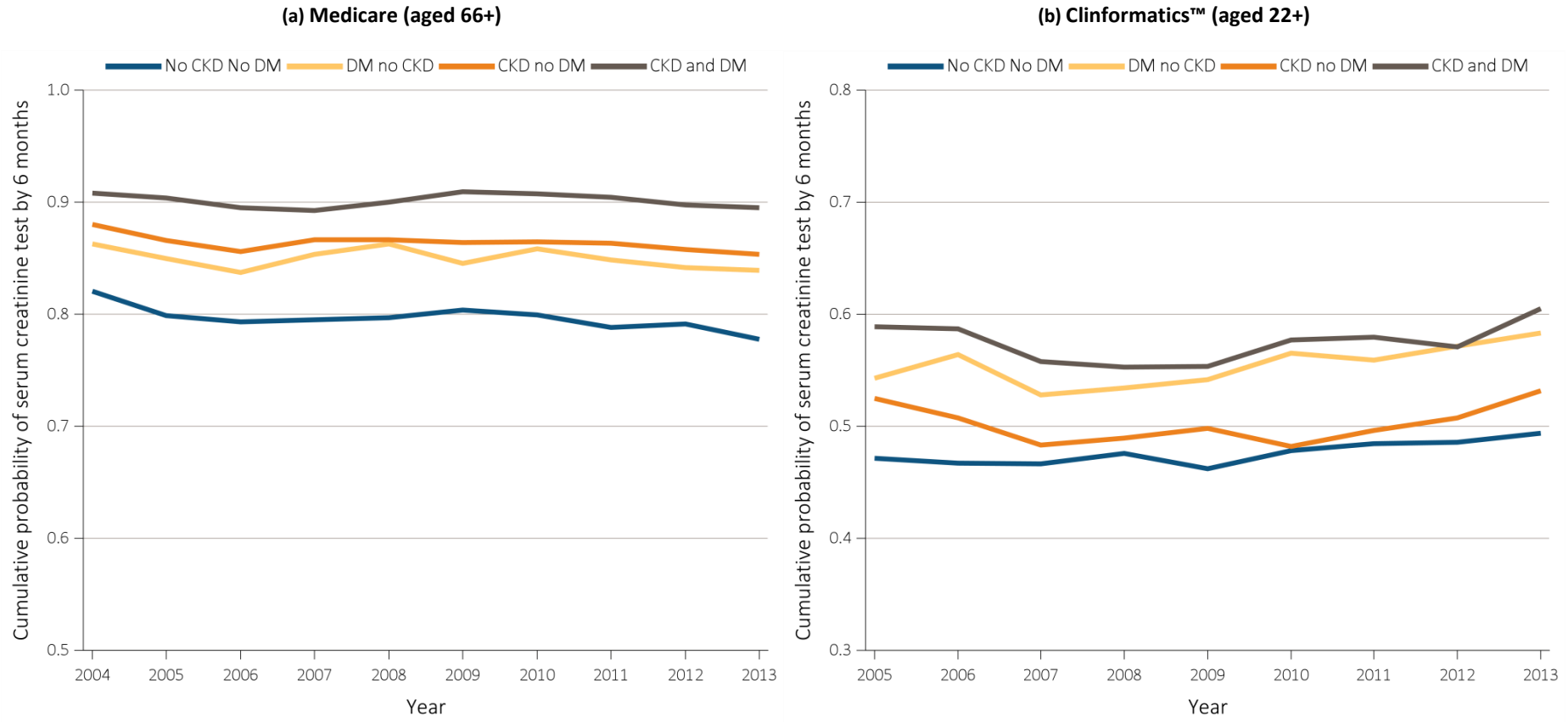
vol 1 Figure 5.9 Cumulative probability of a claim for an outpatient nephrology visit within six months of live discharge from first AKI hospitalization, by CKD, DM, 2004-2013 *(continued)*



Data Source: Special analyses, Medicare 5% sample and 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 Part 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) 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.

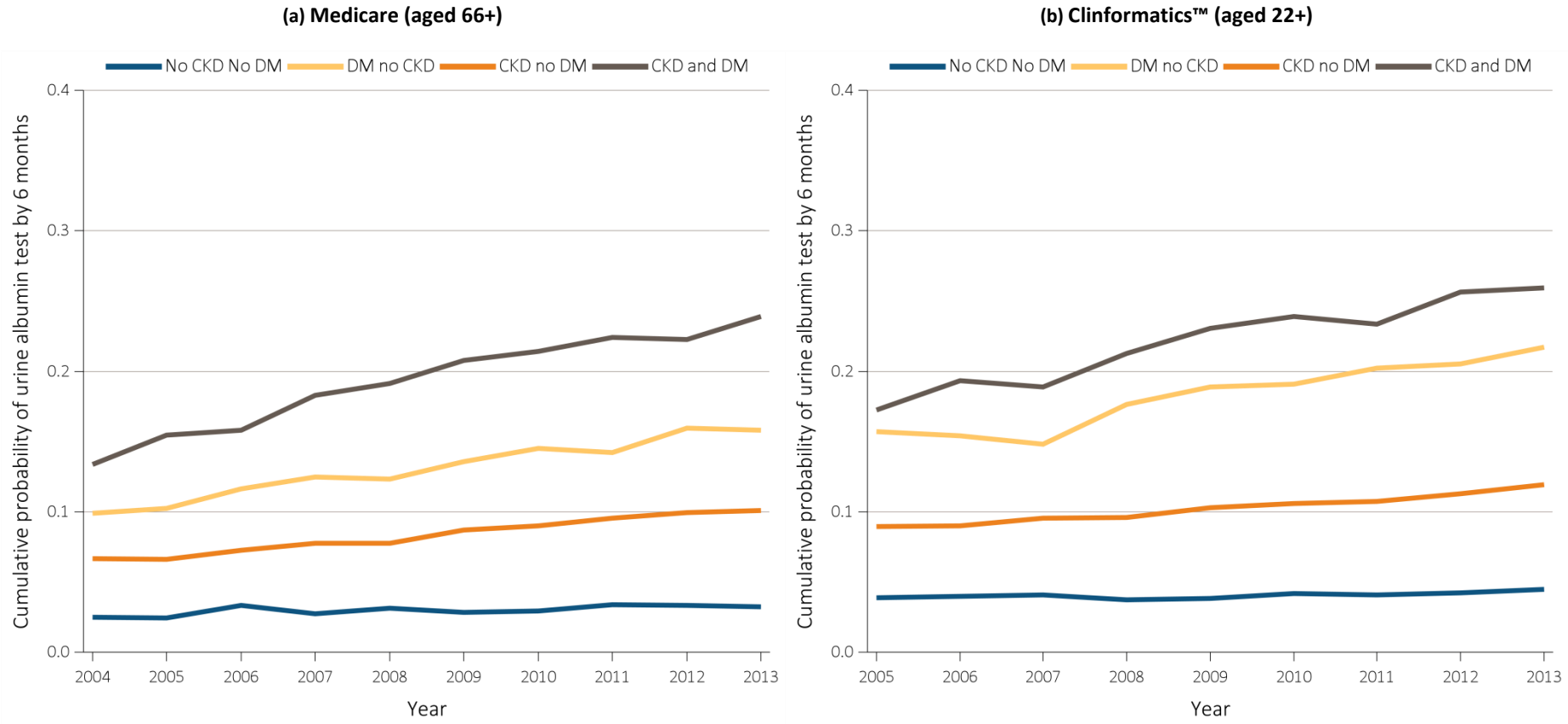
While not all patients with an AKI hospitalization will require formal nephrology follow-up, arguably most (if not all) should have some follow-up biochemical renal assessment. Figures 5.10 and 5.11 show the probability of serum creatinine and urine albumin testing within six months following live discharge from a hospitalization with AKI diagnosis. Of those patients with AKI in 2013, 85% had a follow-up creatinine test billed to Medicare by six months after hospitalization discharge, while 15% had urine albumin testing billed by this point. Among Clinformatics™ patients, 54% had serum creatinine testing and 14% had urine albumin testing. In both the Medicare and Clinformatics™ populations, rates of serum creatinine testing by six months varied by diabetes and CKD status. Among Medicare beneficiaries, this ranged from 78% in patients with neither comorbidity to 89% in patients with both. Greater variation by comorbidity was seen in the probability of urine albumin testing; among Clinformatics™ patients, albumin testing occurred in 4% of patients without pre-existing CKD or diabetes, compared to 26% in patients with both.

vol 1 Figure 5.10 Cumulative probability of a claim for a serum creatinine test within six months of live discharge from first AKI hospitalization by CKD, DM, 2004-2014



Data Source: Special analyses, Medicare 5% sample and 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 in year shown. Censored at death, ESRD, end of Medicare Part A & B participation, or switch to Medicare Advantage program. (b) 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 diagnosis, or plan disenrollment. In both panels, date of first serum creatinine test following AKI discharge is from inpatient and outpatient claims with Healthcare Common Procedure Coding System (HCPCS) codes of 80048, 80050, 80053, 80069, or 82565. Abbreviations: AKI, acute kidney injury; CKD, chronic kidney disease; DM, diabetes mellitus; ESRD, end-stage renal disease.

vol 1 Figure 5.11 Cumulative probability of a claim for an urine albumin test within six months of live discharge from first AKI hospitalizatio n by CKD, DM, 2004-2014



Data Source: Special analyses, Medicare 5% sample and Clinformatics™. (a) Medicare patients aged 66 and older who had both Medicare Parts A and 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 in 2013. Censored at death, ESRD, end of Medicare Part A & B participation, or switch to Medicare Advantage program. (b) 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 diagnosis, or plan disenrollment. In both panels, date of first urine albumin test following AKI discharge is from inpatient and outpatient claims with Healthcare Common Procedure Coding System (HCPCS) codes of 82042, 82043, 82044, or 84156. 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

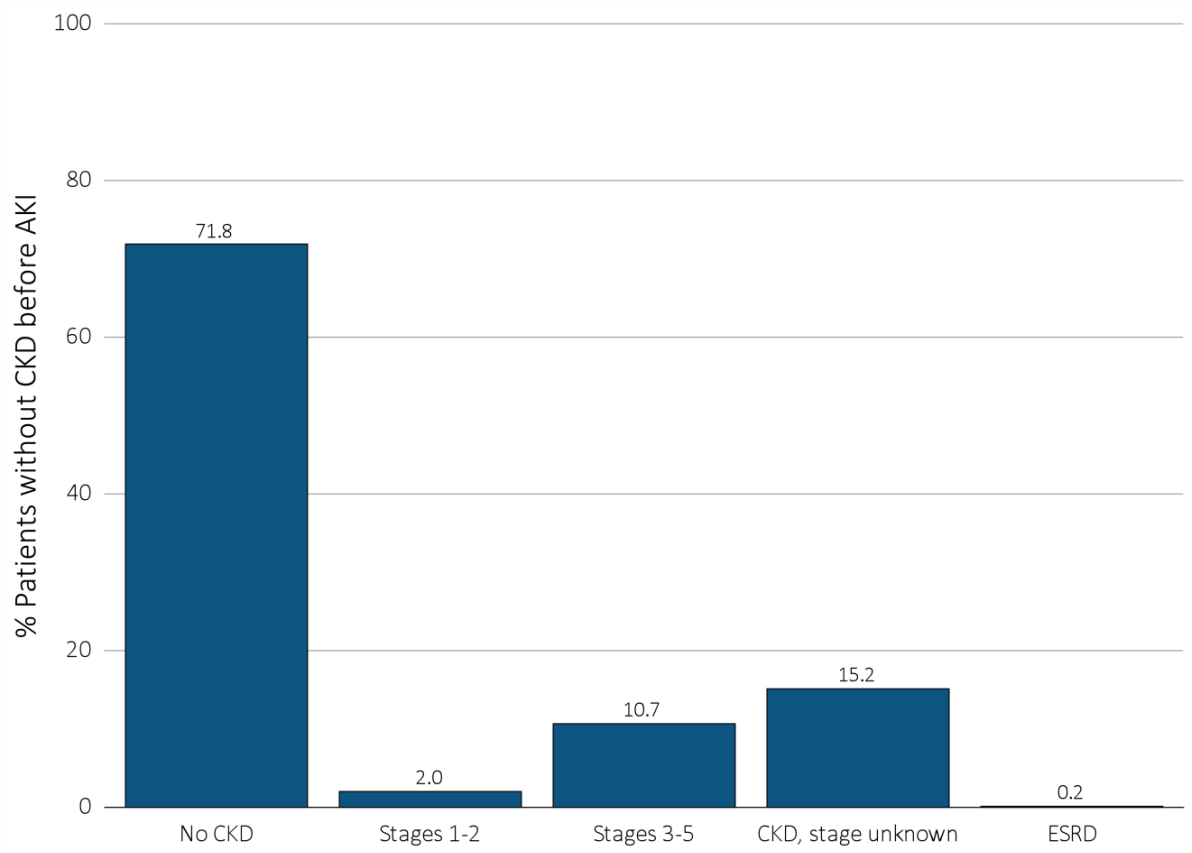
CKD status changes significantly in the year following an AKI hospitalization, as shown in Figure 5.12. Among Medicare patients without baseline CKD, nearly 30% are reclassified as having some degree of CKD, including 0.2% being declared ESRD. Table B shows the ICD-9-CM diagnosis codes used to define stages of chronic kidney disease for Figure 5.12.

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 is 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.

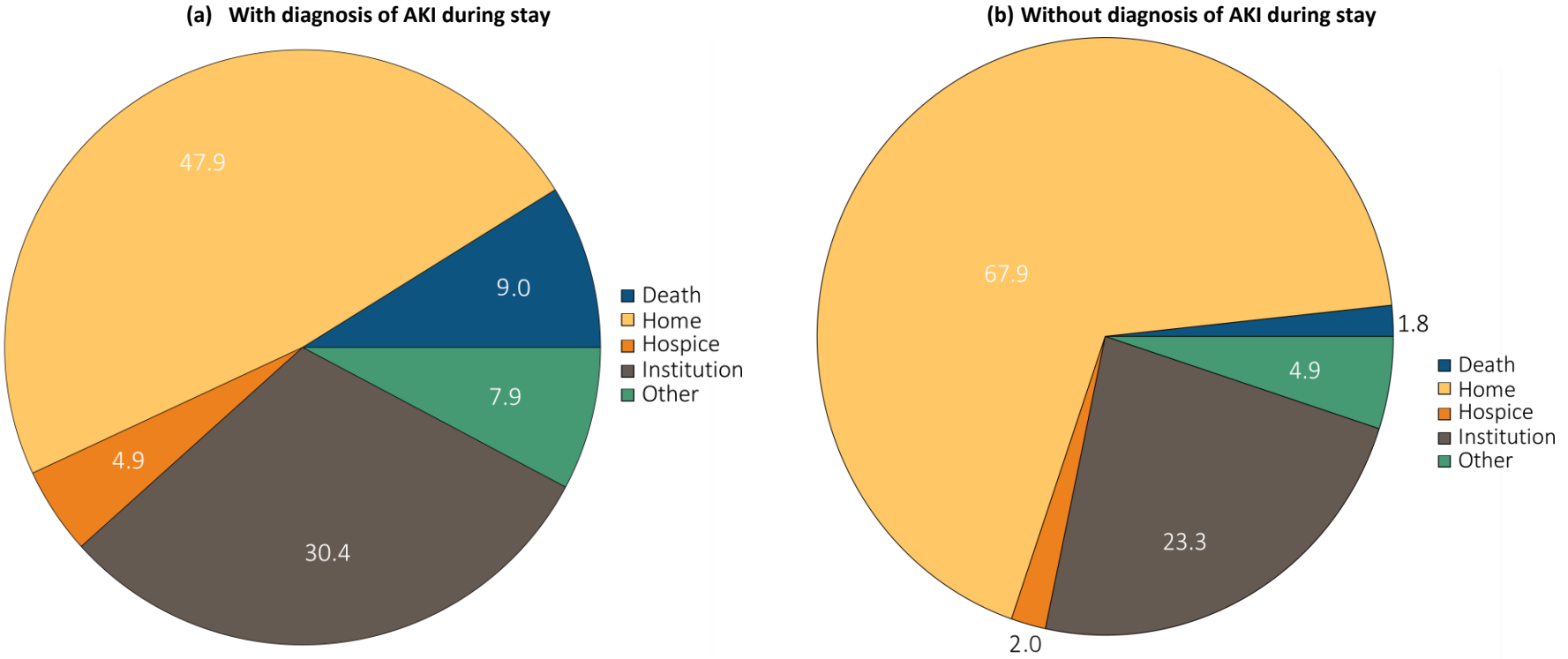
vol 1 Figure 5.12 Renal status one year following discharge from AKI hospitalization in 2012-2013, among surviving Medicare patients aged 66+ without kidney disease prior to AKI hospitalization, by CKD stage and ESRD status



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, were discharged alive from a first AKI hospitalization in 2012 or 2013, 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 5.13, we examine the status and disposition for Medicare AKI patients once they are discharged from the hospital. After excluding patients admitted from a skilled nursing facility (n=1,997, leaving a total of 51,150 AKI discharges), among AKI patients aged 66 and older in 2014, fewer than 48% were discharged directly to their home. Mortality (including discharge to hospice) was 13.9%, while 30.4% of patients were discharged to institutions including short-term skilled nursing facility stays, rehabilitation hospitals, or long-term care facilities. By comparison, among hospitalized Medicare patients without a diagnosis of AKI (excluding those admitted from a skilled nursing facility, n= 3,315, leaving a total of 172,802 discharges), nearly 68% returned home and 23.3% are discharged to institutions.

vol 1 Figure 5.13 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, 2014



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 1/1/2014, had a first hospitalization in 2014, 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.

References

Chawla LS, Eggers PW, Star RA, Kimmel PL. Acute kidney injury and chronic kidney disease as interconnected syndromes. *N Engl J Med* 2014;371:58-66.

Kidney Disease: Improving Global Outcomes (KDIGO) Acute Kidney Injury Workgroup. KDIGO clinical practice guideline for acute kidney injury. *Kidney Int* 2012;2:1-138.

Waikar SS, Wald R, Chertow GM, Curhan GC, Winkelmayer WC, Liangos O, Sosa MA, Jaber BL. Validity of international classification of diseases, ninth revision, clinical modification codes for acute renal failure. *J Am Soc Nephrol* 2006;17:1688–1694.

Grams ME, Waikar SS, MacMahon B, Whelton S, Ballew SH, Coresh J. Performance and limitations of administrative data in the identification of AKI. *Clin J Am Soc Nephrol* 2014;9:682-689.

Notes