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Glacier National Park, Montana

ACUTE KIDNEY INJURY

In this chapter we examine antecedents and outcomes associated with acute kidney injury (AKI) in three nationally representative datasets. The first and largest is the 5 percent Medicare sample, in which we can identify individuals hospitalized with AKI or AKI requiring dialysis. We also use the MarketScan dataset, a compilation of claims submitted voluntarily by large self-insured firms, and the Ingenix i3 dataset, with individuals covered by traditional health insurance. We establish a cohort of patients for each dataset and follow them to identify AKI episodes with and without the need for dialysis.

Available datasets do not commonly contain biochemical data with which to definitively identify an AKI episode. We thus use administrative billing data to identify episodes of AKI alone and those requiring dialysis. This indirect method has a number of limitations, including poor sensitivity and the possibility of a phenomenon described as "code creep." This occurs over a period of time when billing thresholds are changed by physicians and/or hospital coders, and can increase the likelihood of an administrative code for AKI being generated by a less severe episode, potentially skewing analyses that demonstrate temporal changes in AKI incidence. As less severe AKI is identified and coded, the incidence of associated adverse outcomes is also likely to fall.

Figure 6.1 captures this problem by showing the rising incidence of AKI. While in isolation there appears to be an epidemic, it is likely that a proportion of this change is the result of code creep. Superimposed on this figure is the proportion of reported AKI patients requiring dialysis. While the threshold for defining AKI has changed over time, the threshold for when to initiate dialysis has likely remained fairly stable. In contrast to the incidence of AKI, the incidence of AKI requiring dialysis has been declining, further supporting the notion of code creep for AKI diagnoses.

We next examine patient characteristics. The rate of AKI is significantly associated with older age and black/African American race — a disparity rising since 1995. Of note, the difference in AKI incidence between whites and both blacks/African Americans and patients of other races has changed dramatically. There has been a fairly stable use of daily hemodialysis in AKI patients, a slight decrease in the use of continuous hemodialysis, and significant growth in the number of patients whose dialysis modality is unknown, largely a result of changing reimbursement payments.

Data on the causes of hospitalization show that, while AKI remains the primary reported code, use of this code has been declining, and there has been a significant increase in the number of patients with septicemia and concurrent AKI. Again, this is likely due in part to the changing reimbursement for various diagnoses. We also show that increasing age and black/African American race both appear to be significant risk factors for AKI, with or without dialysis.

The next few spreads outline patient outcomes and care patterns after AKI hospitalizations. A significant number (58 percent) of patients with an AKI hospitalization will have a recurrent AKI hospitalization within one year, while numerous

The Utah deserts and plateaus and canyons are not a country of big returns, but a country of spiritual healing, incomparable for contemplation, meditation, solitude, quiet, awe, peace of mind and body. We were born of wilderness, and we respond to it more than we sometimes realize. We depend upon it increasingly for relief from the termite life we have created. Factories, power plants, resorts, we can make anywhere. Wilderness, once we have given it up, is beyond our reconstruction.

WALLACE STEGNER, *Wilderness at the Edge*

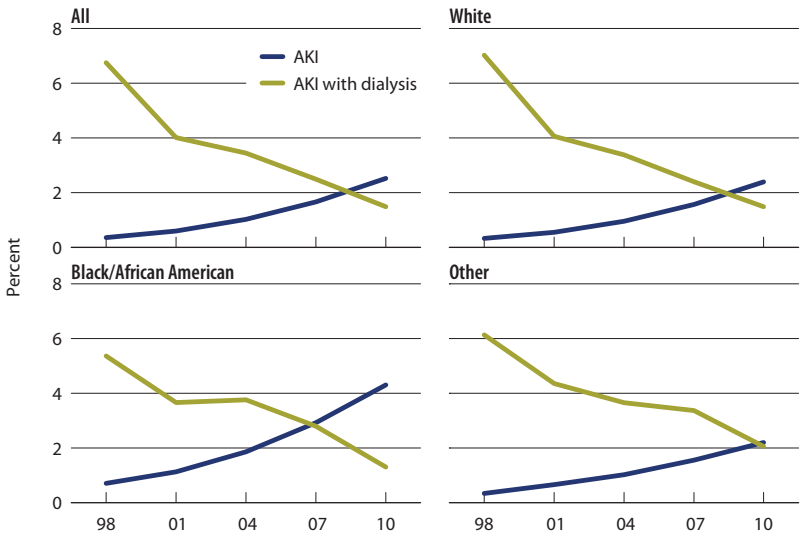
individuals have multiple recurrent AKI hospitalizations. The risk of recurrent hospitalizations is magnified by the presence of CKD at base, but does not appear to be influenced by race. As we have demonstrated in previous ADRs, the risk of either ESRD or death in the year following an AKI hospitalization is quite high, at 5 and 25 percent, respectively, for those with both AKI and CKD (2010 ADR, Volume One, Figure 8.18). Blacks/African Americans are more likely than whites to experience an ESRD event after an AKI episode, but less likely to die.

Renal care after an AKI episode remains poor, with very few patients seeing a nephrologist within one year of their AKI hospitalization. This lack of follow-up holds true even in patients with multiple hospitalizations for AKI. And while serum creatinine testing following an AKI episode occurs in the majority of patients, black/African American patients who do not see a nephrologist are far less likely to be tested than whites.

The use of cardioprotective drugs surrounding an AKI episode varies depending on the class of agents. In general, an AKI episode does not appear to modify the use of beta blockers, calcium channel blockers, or loop diuretics. An AKI episode does result in a decrease in the use of both thiazide diurietcs as well as ACEI/ARB/renin inhibitors; this decrease, however, is transient, and many patients resume these medications within one year of AKI discharge.

Patients who experience an AKI hospitalization have modifications in their reported stage of CKD. Many individuals without CKD prior to their AKI hospitalization are later reclassified as having moderate to advanced CKD. In general, patients appear to have an increase in CKD stage following an AKI hospitalization.
» **Figure 6.1;** see page 145 for analytical methods. *Medicare patients age 66 & older.*

vol 1
6.1 **Hospitalizations for acute kidney injury, with or without dialysis, by race**



In the Medicare, MarketScan, and Ingenix i3 populations with AKI, the proportion of males to females in 2010 was 47 to 53, 60 to 40, and 61 to 39 percent, respectively. By race, 82.7 percent of Medicare AKI patients were white, and 12.6 and 4.7 percent, respectively, were black/African American or individuals of other races » **Figure 6.2;** see page 145 for analytical methods. *Medicare AKI patients age 66 & older, & MarketScan & Ingenix i3 patients AKI age 20–64.*

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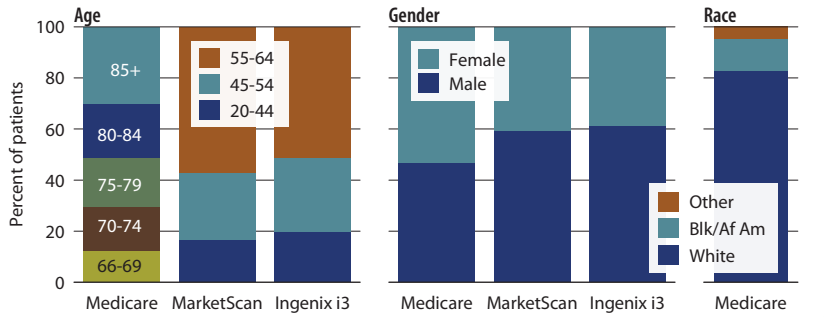
6.2
Characteristics of patients with acute kidney injury, by age, gender, & race, 2010



Acute kidney injury is highly associated with age. Among Medicare patients age 66–69, for example, the rate of AKI in 2010 was 13.6 per 1,000 patient years, and increased to 18.1, 24.9, 34.2, and 46.9, respectively, with increasing ages of 70–74, 75–79, 80–84, and 85 and older. Similar patterns are seen in both the MarketScan and Ingenix i3 populations. » **Figure 6.3;** see page 145 for analytical methods. *Medicare AKI patients age 66 & older, & MarketScan & Ingenix i3 AKI patients age 20–64.*

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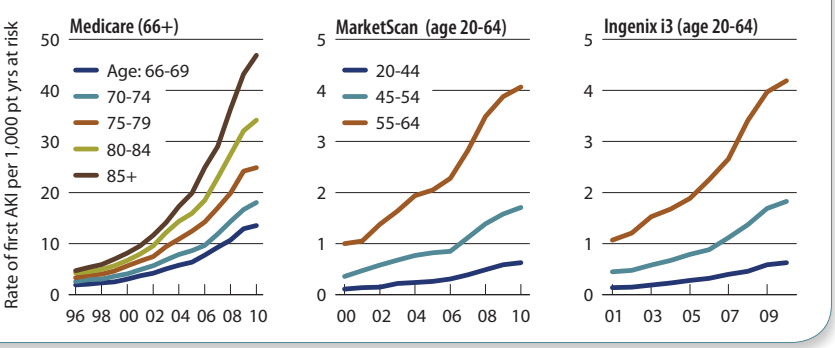
6.3
Rates of first AKI, by age & dataset



The incidence of AKI among Medicare patients age 66 and older varies considerably by race, in 2010 reaching 44.2 per 1,000 patient years in blacks/African Americans compared to 24.3 and 22.5, respectively, in whites and individuals of other races. » **Figure 6.4;** see page 145 for analytical methods. *Medicare AKI patients age 66 & older.*

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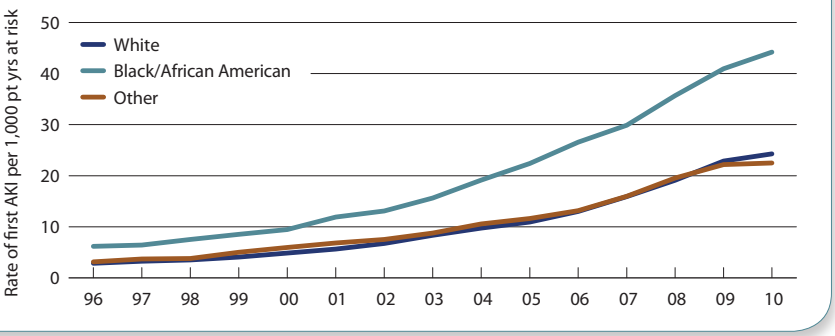
6.4
Rates of AKI in Medicare patients age 66 & older, by race



Among hospitalized patients with AKI who require dialysis, there has been a noticeable increase in the number of patients for whom dialysis type is categorized as unknown, to 40.7 percent in 2010. The type of dialysis received during an AKI hospitalization has historically been obtained from physician claims. Changes in reimbursement protocols have led providers to claim dialysis events independent of dialysis type, making it difficult to determine the mode of dialysis used during the AKI hospitalization.

Acute peritoneal dialysis is now seldom used with AKI, with the percentage of patients falling from 0.33 percent in 1996 to just 0.05 percent in 2010. Use of other modes of dialysis has also fallen, from 8.9 to 5.7 percent for continuous hemodialysis, 62.6 to 49.7 percent for intermittent hemodialysis, and 6.5 to 3.9 percent for daily dialysis. » **Figure 6.5;** see page 145 for analytical methods. *Medicare AKI patients age 66 & older.*

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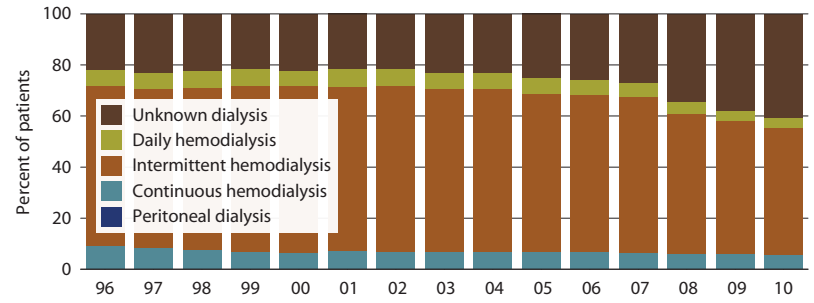
6.5
Type of dialysis in hospitalized Medicare AKI patients age 66 & older who require dialysis



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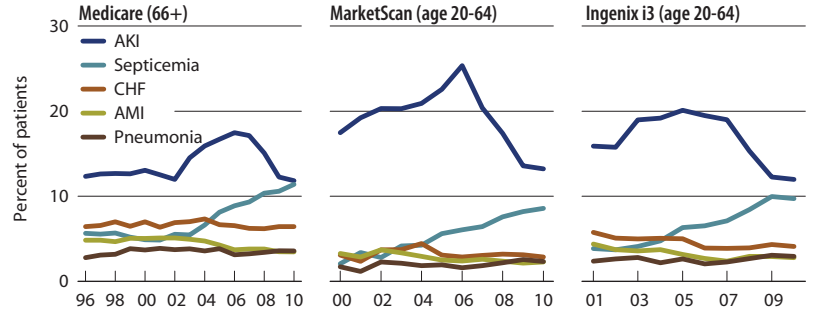
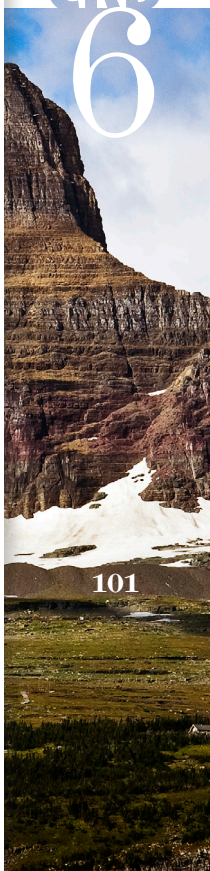
6.6
Primary diagnosis code for patients with AKI, by dataset



While the AKI event itself remains a major reason for AKI hospitalization, the percentage of patients with this diagnosis has been steadily declining overall, falling from a high of 17.5 percent in 2006 to 11.8 percent in 2010 in Medicare patients, from 25.3 to 13.2 percent in the MarketScan population during the same period, and from 20.1 percent in 2005 to 12 percent in 2010 for the Ingenix i3 cohort.

Admissions for septicemia, in contrast, have steadily increased, to 11.4, 8.6, and 9.7 percent, respectively. » **Figure 6.6;** see page 145 for analytical methods. *Medicare AKI patients age 66 & older, & MarketScan & Ingenix i3 patients age 20–64.*



Acute kidney injury is highly associated with age in patients who do not require dialysis, even after adjusting for other factors. The adjusted hazard ratio for an AKI hospitalization increases in a graded manner with each increase in age. Among those age 70–74, for example, the hazard ratio for AKI with no dialysis is 1.3, while in those age 85 and older it reaches 3.7. » **Figure 6.7;** see page 145 for analytical methods. *Medicare patients age 66 & older; adj: gender/race; ref: patients age 66–69, 2010.*

The adjusted hazard ratio for an AKI hospitalization is significantly higher in blacks/African Americans than among their white counterparts: two times higher for AKI alone, and 1.8 times higher for AKI requiring dialysis. Compared to whites, patients of other races have an equivalent risk of an AKI hospitalization alone, but a risk of 1.6 for an AKI hospitalization requiring dialysis. » **Figure 6.8;** see page 145 for analytical methods. *Medicare patients age 66 & older; adj: age, & gender; ref: whites, 2010.*

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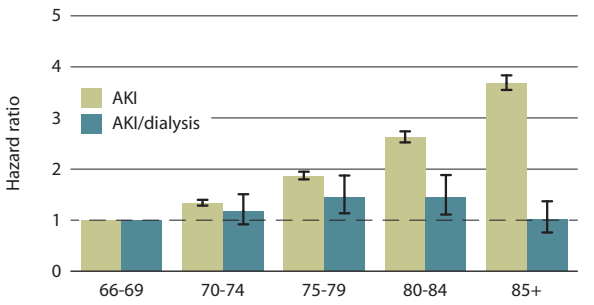
6.7 **Adjusted hazard of an AKI hospitalization in Medicare patients, by age, 2010**



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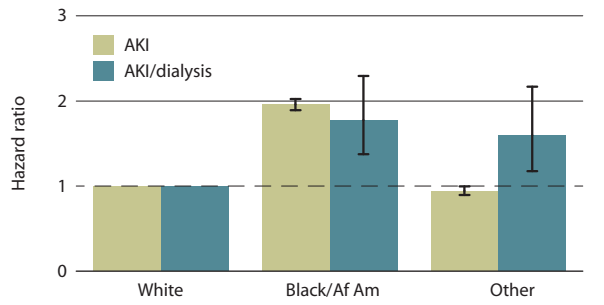
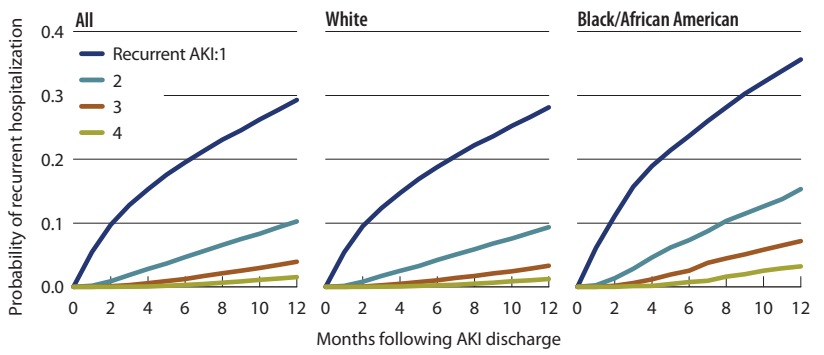
6.8 **Adjusted hazard of an AKI hospitalization in Medicare patients, by race, 2010**



vol 1
6.9 **Probability of a recurrent AKI hospitalization in Medicare patients, by number of recurrent events & race, 2009–2010**



Following discharge after an AKI hospitalization, the probability of one recurrent hospitalization event is 0.29 overall and 0.28 and 0.36, respectively, in whites and blacks/African Americans. The probability of having more than one AKI event is highest in blacks/African Americans compard to whites — at 0.15 versus 0.09 for two events and 0.07 versus 0.03 for three. » **Figure 6.9;** see page 145 for analytical methods. *Medicare AKI patients age 66 & older, 2009–2010.*

In contrast to the association of AKI with increasing age, the incidence of recurrent AKI hospitalization alone or with dialysis does not vary greatly by age. It is apparent, however, that recurrent AKI hospitalization is more common in patients needing dialysis during their hospital stay compared to those who do not, at 33.3 and 28.1 percent overall. This is particularly evident in blacks/African Americans and patients of other races, at 49.4 versus 34.3 percent and 48.6 versus 32.1 percent, respectively. » **Figures 6.10–11;** see page 145 for analytical methods. *Medicare patients age 66 & older; original AKI in 2009, recurrent AKI within one year.*

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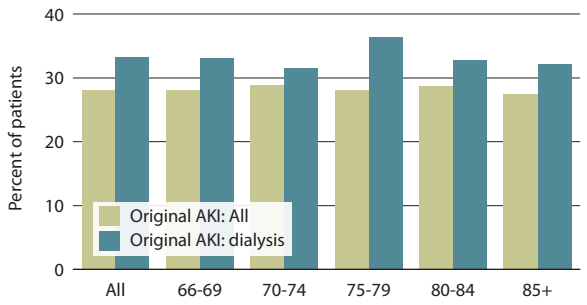
6.10 Patients with a recurrent AKI, by age, 2009–2010



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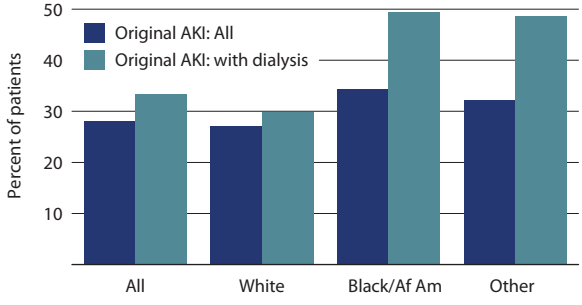
6.11 Patients with a recurrent AKI, by race, 2009–2010



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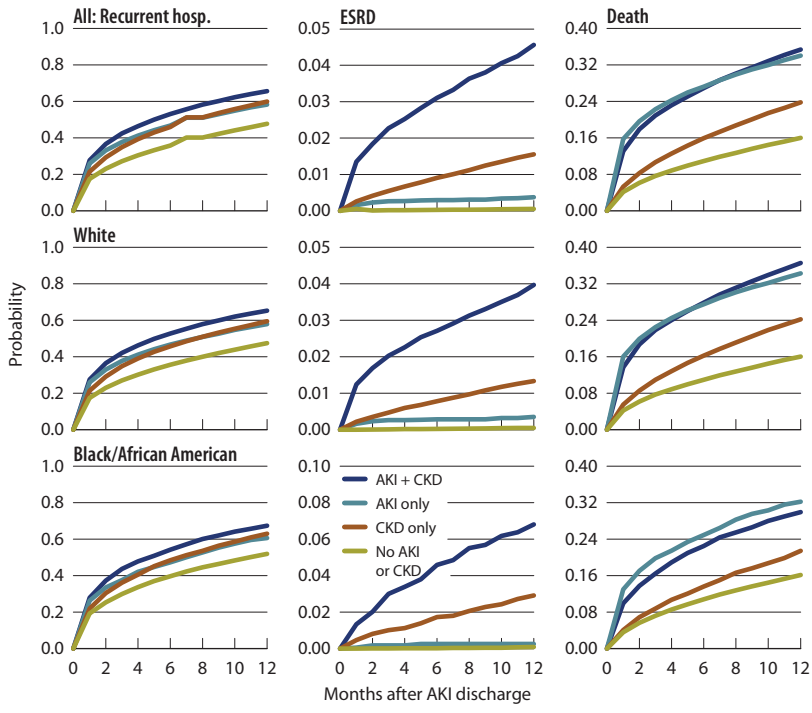
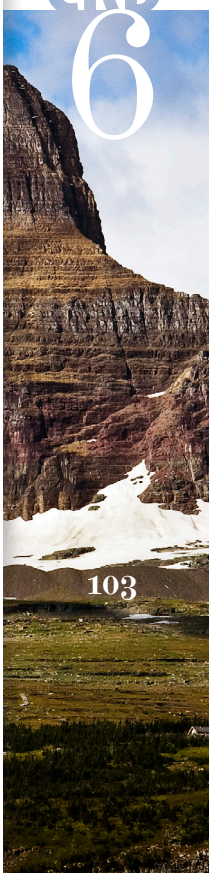
6.12 Probability of a recurrent hospitalization, ESRD, or death following hospitalization for AKI, by race, 2009–2010



Individuals who survive an AKI hospitalization have a greater likelihood of a recurrent hospital admission compared to those with no evidence of kidney disease (AKI or CKD), at 0.58 versus 0.48; the presence of CKD in addition to AKI raises the probability to 0.66.

Those surviving an AKI episode are at risk of developing ESRD, a risk magnified by the presence of CKD prior to AKI. By race, the probability of ESRD is higher in blacks/African Americans than in whites, at 0.07 compared to 0.04 among those with a prior diagnosis of CKD.

In patients who survive the AKI event, the probability of dying within a year is elevated regardless of whether patients have pre-existing CKD, and is slightly higher in whites compared to blacks/African Americans. » **Figure 6.12;** see page 145 for analytical methods. *Medicare patients age 66 & older, 2009–2010.*



Following an AKI hospitalization, 75 percent of patients see a primary physician within three months of discharge, while 38 and 13.2 percent, respectively, see a cardiologist or nephrologist.

Surprisingly, fewer than half of the patients with a recurrent AKI see a primary care physician within three months of their second discharge, while 24.4 percent see a cardiologist and 18.1 and 12.2 percent, respectively, see a nephrologist (any or outpatient).

Outpatient visits to a nephrologist following an initial or recurrent AKI event are more likely in patients with CKD than in those without. » **Figures 6.13–15;** see page 145 for analytical methods. *Medicare AKI patients age 66 & older, 2009–2010.*

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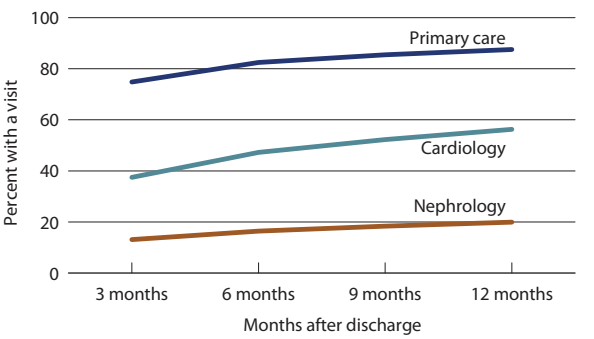
6.13 Outpatient physician visits following initial AKI discharge, 2009–2010



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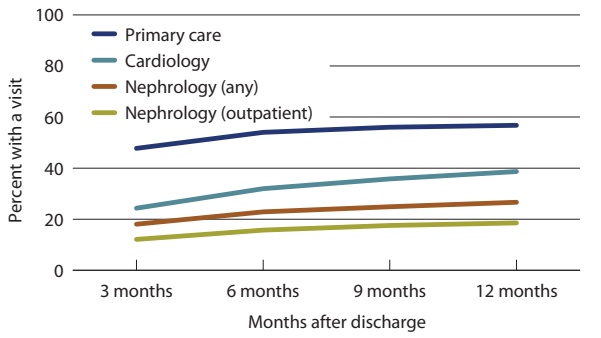
6.14 Physician visits in the year following a recurrent AKI discharge, 2009–2010



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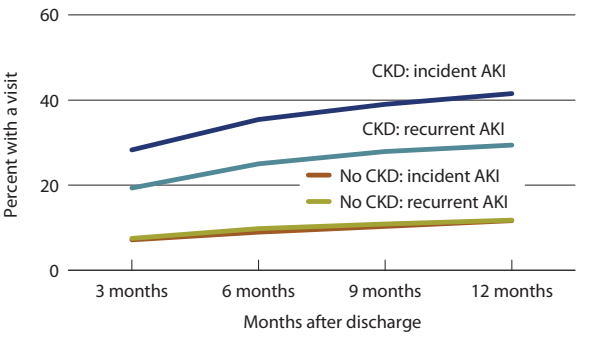
6.15 Outpatient nephrology visits in the year following a recurrent AKI discharge, 2009–2010



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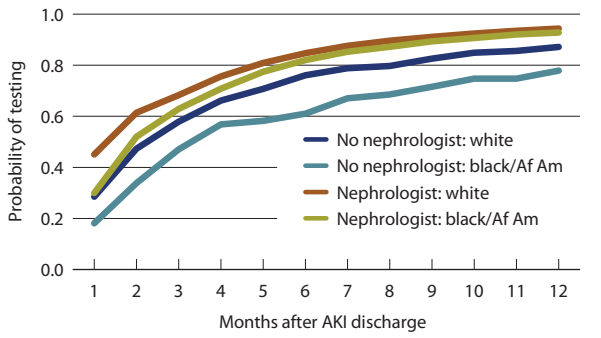
6.16 Probability of serum creatinine testing after hospitalization for acute kidney injury, 2009–2010



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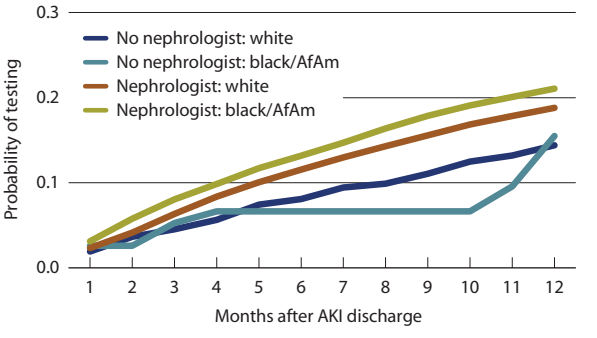
6.17 Probability of urine albumin testing after hospitalization for acute kidney injury, 2009–2010



Among individuals suffering an AKI event, the probability of serum creatinine and urine albumin testing is higher, regardless of race, in those seeing a nephrologist than in those who do not. » **Figures 6.16–17;** see page 145 for analytical methods. *Medicare AKI patients, age 66 & older, 2009.*

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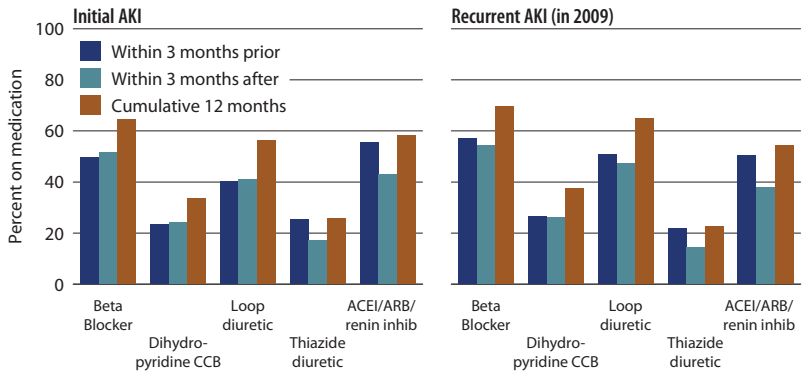
6.18 **Drug therapy prior to & after hospitalization for AKI in patients with Medicare Part D coverage, for initial & recurrent AKI**



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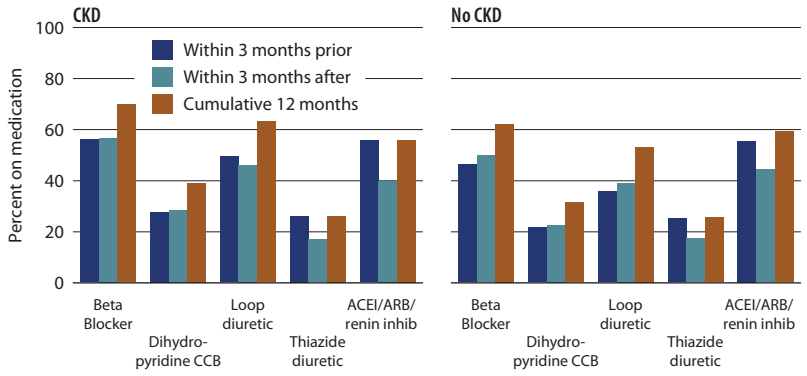
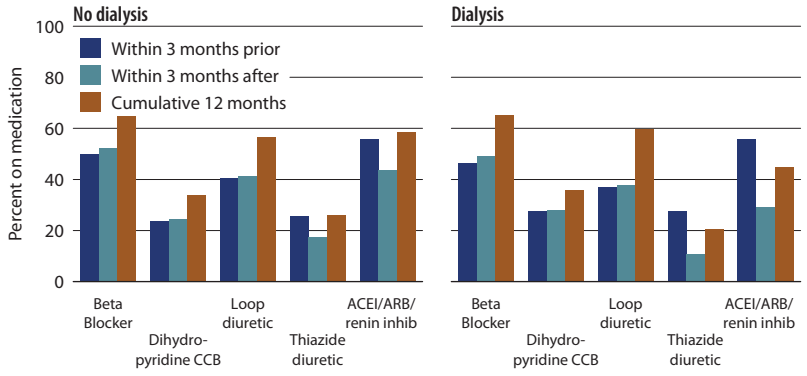
6.19 **Drug therapy prior to & after hospitalization for AKI in patients with Medicare Part D coverage, by CKD status**

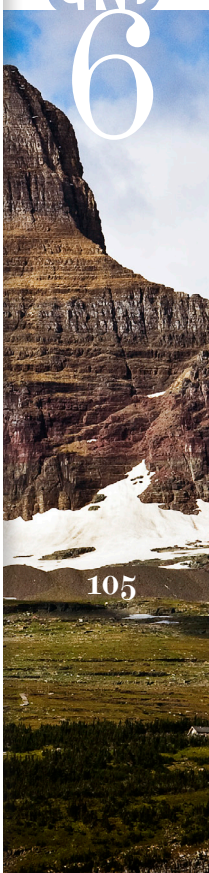


vol 1
6.20 **Drug therapy prior to & after AKI hospitalization in patients with Medicare Part D coverage, with or without dialysis**



When comparing cardiovascular medication use in patients prior to, in the first three months after, and at one year following an AKI or recurrent AKI event, the greatest increases in medication use occur in patients who had dihydropyridine calcium channel blockers, loop diuretics, or beta blockers prescribed within the three months prior to their AKI event. Patients using thiazide diuretics or an ACEI/ARB/renin inhibitor, in contrast, are likely to use less of these medications at three months post-AKI, but generally return to their pre-AKI use levels by twelve months.

The same patterns of medication use persist in AKI patients with or without CKD, and in patients with or without dialysis during their AKI hospital stay. In patients requiring dialysis, for example, the use of thiazide diuretics falls from 28 to 11 percent at month three post-AKI, while use of ACEIs/ARBs/renin inhibitors falls from 56 to 29 percent. » **Figures 6.18–20;** see page 145 for analytical methods. *AKI patients with Part D coverage, 2009. For Figure 6.19, CKD identified as any CKD claim during the three months prior to AKI. Presence of medication represents a Part D claim during 2009, where the timing is based on the service date of the medication in the Part D data. Data on medication "prior to AKI" includes only those patients whose AKI occurs in April or later in the year; "after AKI" includes only those whose AKI occurs in September or earlier in the year, & who survive without developing ESRD for the entire follow-up period (three or 12 months).*



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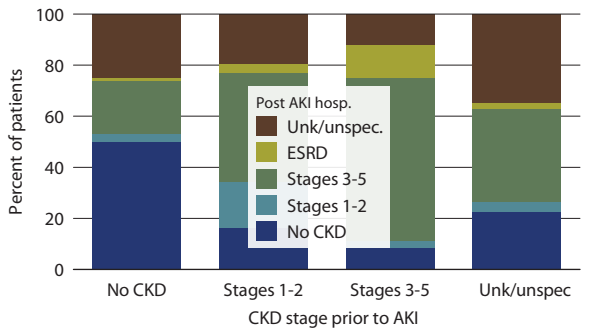
6.21 **Changes to CKD status following hospitalization for AKI in Medicare patients, 2010**



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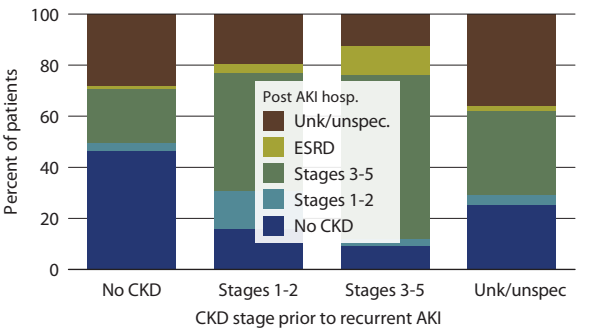
6.22 **Changes to CKD status following a recurrent rehospitalization for AKI in Medicare patients, 2010**



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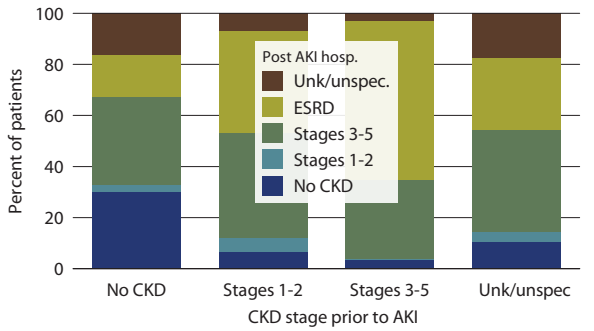
6.23 **Changes to CKD status following a hospitalization for AKI with dialysis in Medicare patients, 2010**



CKD status changes significantly following an AKI hospitalization. Among those with CKD of Stages 1–2 prior to the hospitalization, for example, 43 percent are later classified as having Stage 3–5 CKD. And of those with Stage 3–5 CKD pre-hospitalization, 12.6 percent reach ESRD.

Similar patterns exist in patients with a recurrent AKI hospitalization. Among those with CKD of Stages 1–2 prior to the AKI hospitalization, 46 percent are later classified as having Stage 3–5 CKD, and in patients with Stage 3–5 pre-hospitalization, 11.3 percent reach ESRD.

Among patients with an AKI hospitalization requiring dialysis, of those classified as Stage 1–2 CKD, 41.4 percent are reclassified as having CKD of Stages 3–5 after their hospitalization; among patients with Stage 3–5 CKD pre-hospitalization, 62 percent reach ESRD. » **Figures 6.21–23;** see page 145 for analytical methods. *Medicare AKI patients age 66 & older, 2010. For Figure 6.22, recurrent hospitalization occurred in 2009; for Figure 6.23, data limited to AKI events with dialysis.*

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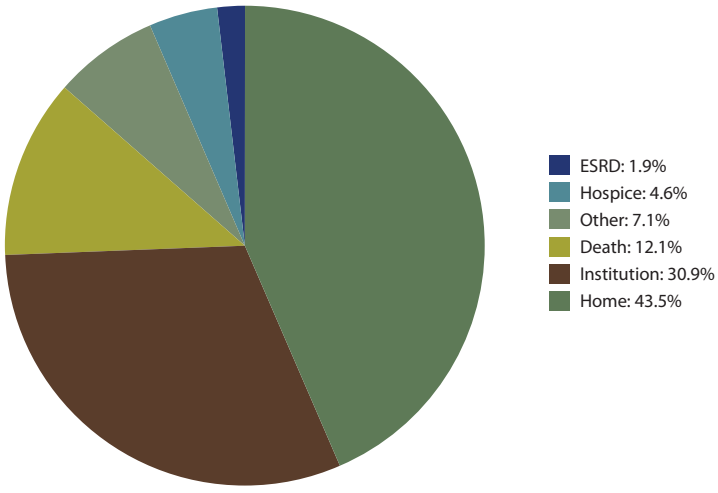
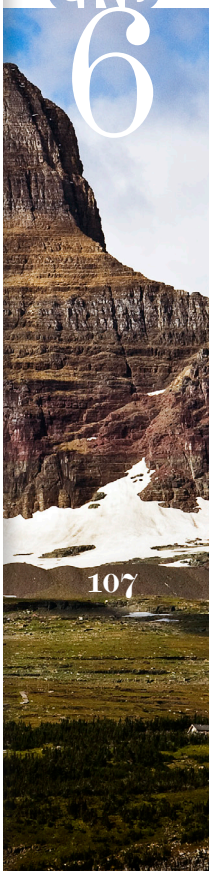
6.24 **Outcomes following an AKI hospitalization, 2010**



Here we demonstrate trajectories for patients once they are discharged from the hospital. Among 2010 AKI patients age 66 and older, approximately 2 percent were enrolled in an ESRD program, while 4.6 and 12.1 percent, respectively, went to hospice or died during their hospitalization. Nearly one-third were institutionalized in a skilled nursing facility, and 44 percent were discharged to their home. » **Figure 6.24;** see page 145 for analytical methods. *Medicare AKI patients age 66 & older, 2010.*



CHARACTERISTICS OF PATIENTS WITH AKI

rates of AKI in Medicare patients age 66 & older, by race (per 1,000 patient years; Figure 6.4)

1996	» white · 2.9	» black/African American · 6.2	» other · 3.1
2000	· 4.9	· 9.5	· 5.9
2005	· 10.9	· 22.4	· 11.6
2010	· 24.3	· 44.2	· 22.5

primary diagnosis for patients with AKI, 2010 (percent; Figure 6.6)

Medicare	» AKI · 11.8	» septicemia · 11.4	» CHF · 6.4	» acute MI · 3.5	» pneumonia · 3.6
MarketScan	· 13.2	· 8.6	· 2.9	· 2.3	· 2.3
Ingenix i3	· 11.9	· 9.7	· 4.1	· 2.8	· 2.9

AKI HOSPITALIZATION

probability of a recurrent AKI hospitalization in Medicare patients, by number of events & race, 2009–2010 (Figure 6.9)

all	» one event · 0.29	» two events · 0.10	» three events · 0.04	» four events · 0.02
white	· 0.28	· 0.09	· 0.03	· 0.01
black/African American	· 0.36	· 0.15	· 0.07	· 0.03

PATIENT CARE & OUTCOMES FOLLOWING AKI HOSPITALIZATION

outpatient physician visits following initial AKI discharge, 2009–2010 (percent; Figure 6.13)

within 3 months	» primary care · 74.9	» cardiology · 37.5	» nephrology · 13.2
within 6 months	· 82.5	· 47.2	· 16.4
within 9 months	· 85.5	· 52.3	· 18.4
within 12 months	· 87.6	· 56.3	· 20.0

physician visits in the year following a recurrent AKI discharge, 2009–2010 (percent; Figure 6.14)

within 3 months	» primary care · 47.8	» cardiology · 24.4	» nephrology (any) · 18.1	» nephrology (OP) · 12.2
within 6 months	· 54.0	· 32.0	· 22.9	· 15.8
within 9 months	· 56.0	· 35.8	· 25.0	· 17.5
within 12 months	· 56.8	· 38.7	· 26.7	· 18.6