chapter EIGHT

acute kidney injury

No star is ever lost we have once seen,
We always may be what we might have been.

Adelaide Ann Procter, "A Legend of Provence"
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. As described in last year’s ADR, 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 8.1 captures this problem by showing the rising incidence of AKI. While in isolation there appears to be an epidemic of AKI, it is likely that a significant proportion of this change is the result of code creep. Superimposed here are data on the proportion of reported AKI requiring dialysis. The threshold for defining AKI has changed over time, but the threshold for when to initiate dialysis has remained fairly stable. In contrast to the incidence of AKI, the incidence of AKI requiring dialysis has been declining.

We next examine patient characteristics. The rate of AKI is significantly associated with older age and African American race — a disparity rising since 1995. 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. We also show that increasing age and African American race both appear to be significant risk factors for AKI, with or without dialysis.

We conclude with two spreads on patient care and outcomes after AKI hospitalization. A number of patients with AKI requiring dialysis see a nephrologist within the first 30 days, but this plateaus by about 180 days, and approximately 40 percent see a nephrologist by the end of the first year. We also present data on serum creatinine and urine protein testing after AKI hospitalization, and on prescription drug therapy prior to and following hospitalization. For AKI patients with or without dialysis, the use of ACEIs/ARBs/renin inhibitors decreases significantly after hospitalization in both African Americans and whites, while statin use increases.

One in two AKI patients is rehospitalized at least once in the first year, a rate influenced by a diagnosis of CKD. There also appears to be a step up in CKD stage following AKI hospitalization. A significant number of patients with CKD of Stages 1–2 prior to AKI appear to progress to Stages 3–5, while a significant number who are Stage 3–5 prior to AKI then progress to ESRD.

The final figure demonstrates a sequence of outcomes following AKI hospitalization. A significant number of patients will progress to ESRD or die during that hospitalization. Of those who survive, 25 percent will be discharged to a skilled nursing facility. In general, few individuals see a nephrologist or receive urine microalbumin testing within the first year.

*Figure 8.1*; see page 171 for analytical methods. *Medicare patients age 66 & older.*
In the Medicare, MarketScan, and Ingenix i3 AKI cohorts, the proportion of males to females is 47 to 53, 58 to 42, and 61 to 32 percent, respectively. By race, 82.9 percent of patients in the Medicare dataset are white, 12.4 percent are African American, and 4.8 percent are individuals of other races. [See Table 1.2; see page 172 for analytical methods. Medicare AKI patients age 66 & older, MarketScan & Ingenix i3 AKI patients age 20–64.]

Acute kidney injury is highly associated with age. Among Medicare patients, the rate of AKI in 2008 for those age 66–69 was 10.3 per 1,000 patient years. This rose to 19.2 in those age 75–79, and to 34.7 in those 85 and older. A similar pattern is seen in both the MarketScan and Ingenix i3 populations. [See Table 1.3; see page 172 for analytical methods. Medicare AKI patients age 66 & older, MarketScan & Ingenix i3 AKI patients age 20–64.]

The incidence of AKI among Medicare patients age 66 and older varies considerably by race. In 2008, the rate per 1,000 patient years was 18.4 in whites, compared to 34.2 in African Americans, and 18.6 among individuals of other races. This disparity has increased significantly over the past 13 years; rates in 1995 were 2.5, 4.9 and 2.4 per 1,000 patient years, respectively. [See Table 1.4; see page 172 for analytical methods. Medicare AKI patients age 66 & older.]
Among hospitalized patients with AKI requiring dialysis, there was a significant increase in 2008 in the number of patients with dialysis categorized as unknown. Dialysis type has typically been obtained from physician claims for dialysis. With changes in reimbursement, however, it is now more profitable for providers to claim an encounter independent of dialysis type, making it difficult to determine the mode used during an AKI hospitalization. Of note, the percentage of individuals undergoing acute peritoneal dialysis therapy has decreased significantly, from 0.5 percent in 1995 to an undetectable number in 2008. *Figure 8.5; see page 172 for analytical methods.* Medicare AKI patients age 66 & older.

The percentage of MarketScan AKI patients using an ACE inhibitor, angiotensin receptor blocker, or renin inhibitor remained constant between 2002 and 2008, at 59–61 percent. Use of these medications in the Ingenix i3 population is slightly lower, but has increased from 42 to 50 percent. Statin use has increased from 36.4 to 42.0 percent among MarketScan patients, and from 23.6 to 37.2 percent for those in the Ingenix i3 database. *Figure 8.6; see page 172 for analytical methods.* MarketScan & Ingenix i3 AKI patients age 20–64.

While the AKI event itself remains the primary reason for AKI hospitalization, the percentage of patients with this diagnosis has been declining, to 15.4, 17.7, and 15.3 percent in the Medicare, MarketScan, and Ingenix i3 datasets, respectively, in 2008. Admissions for septicemia have steadily increased, to 10.6, 7.7 and 8.4 percent. *Figure 8.7; see page 172 for analytical methods.* Medicare AKI patients age 66 & older, & MarketScan & Ingenix i3 AKI patients age 20–64.
Acute kidney injury is highly associated with age, 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 is 1.3, while in those age 85 and older it reaches 3.6. With the exception of these older patients, a similar trend is evident for AKI patients requiring dialysis, with hazard ratios rising from 1.3 among patients 70–74 to 1.7 in those age 80–84. *Figure 8.8; see page 172 for analytical methods. Medicare patients age 66 & older, 2007. Adj: age/gender/race.

The adjusted hazard for an AKI hospitalization is significantly higher in African Americans in the Medicare population than among their white counterparts: 2.1 times higher for AKI alone, and 1.9 times for AKI requiring dialysis. Compared to whites, patients of other races have an equivalent risk of AKI hospitalization alone, but a risk of just 0.6 of AKI requiring dialysis. *Figure 8.9; see page 172 for analytical methods. Medicare patients age 66 & older, 2007. Adj: age/gender/race.

The relationship between older age and an increased adjusted risk of AKI is also present among patients in the two commercial datasets. Compared to that of patients age 20–44, the risk of AKI in the MarketScan population is 7.1 among those age 55–64, and 2.8 for those 45–54; in the Ingenix i3 population the risks are 7.6 and 3.0, respectively. The risk of AKI requiring dialysis also increases with age, though the association is muted. *Figures 8.10–11; see page 172 for analytical methods. MarketScan (8.10) & Ingenix i3 (8.11) patients age 20–64, 2007. Adj: age/gender/race.
Rates of AKI per 1,000 patient years vary widely across the country, and have increased by more than two-fold overall since 2003. In 2008, AKI rates were greatest in the eastern portions of the country, in sections of Nevada and Arizona, and in states along the Gulf Coast, averaging 21.7 per 1,000 patient years in the upper quintile. *Figure B.12; see page 172 for analytical methods. Medicare patients age 66 & older; unadjusted.*
Nearly six in ten patients hospitalized for AKI see a primary care provider within 30 days of discharge. Of those hospitalized with an AKI episode requiring dialysis, however, 35 percent do not see a nephrologist within 30 days, and 23 percent receive no nephrologist care within the first year. + Figure B.15; see page 172 for analytical methods. Medicare AKI patients age 66 & older, 2007.

Twenty-eight percent of African Americans hospitalized for AKI visit a nephrologist within six months of discharge, compared to 24 percent of whites. There is a small difference by race for those whose AKI hospitalization requires dialysis, at 45 percent for African Americans and 47 percent for whites. + Figure B.14; see page 172 for analytical methods. Medicare AKI patients age 66 & older, 2007.

Only 42 percent of white patients who do not see a nephrologist post-AKI, and 38 percent of their African American counterparts, receive serum creatinine testing within the first month after an AKI hospitalization. These rates are only marginally influenced by a nephrologist visit in the same month, rising to 45 and 39 percent. Rates of testing for albuminuria/proteinuria following an AKI episode remain dismal, at less than 20 percent at the end of one year, irrespective of race or nephrologist care. + Figures B.15–16; see page 172 for analytical methods. Medicare AKI patients age 66 & older, 2007.
Individuals who survive an AKI hospitalization have a greater likelihood of a recurrent hospital admission during the next 12 months compared to those with no evidence of kidney disease (AKI or CKD), at 57 versus 47 percent. The presence of CKD in addition to AKI raises this likelihood to 64 percent. Those surviving an AKI episode are also at risk of developing ESRD in the next year, a risk magnified by the presence of CKD prior to AKI. By race, the probability of ESRD is higher in African Americans than in whites, at 7.3 compared to 4.5 percent among those with a prior diagnosis of CKD.

Twenty-eight percent of patients who survive an AKI hospitalization die within one year. The risk of death is elevated regardless of whether or not patients had pre-existing CKD. The percentage of patients using an ARB increases during an AKI hospitalization.

CKD status changes significantly after an AKI hospitalization. Of those with CKD of Stages 1–2 prior to the hospitalization, for example, 46 percent are later classified as having Stage 3–5 CKD. Similarly, of those with Stage 3–5 CKD pre-hospitalization, 21.8 percent are later classified as having ESRD. This pattern is similar when individuals are stratified by race. Among white and African American patients with Stage 1–2 CKD at baseline, 46 and 49 percent, respectively, are reclassified as Stage 3–5 CKD following discharge. And of those with Stage 3–5 CKD at baseline, 20 percent of whites and 30 percent of African American are registered in the ESRD program after hospital discharge.

It is unclear how to interpret data on patients with no CKD at baseline, as they may truly have no CKD, or their CKD may have been unrecognized prior to the AKI hospitalization. + Figure 8.19; see page 172 for analytical methods. Medicare AKI patients age 66 & older, 2007.

Among patients hospitalized for an AKI episode, 26 percent will have an additional AKI hospitalization in the next year, and 8.0 and 2.7 percent, respectively, will have two or three additional AKI hospitalizations in that period. The likelihood of a recurrent hospitalization is higher for African Americans than for whites. + Figure 8.20; see page 172 for analytical methods. Medicare AKI patients age 66 & older, 2007.
Outcomes for patients following an AKI hospitalization can be difficult to conceptualize. Here, in a simplified flow diagram, we demonstrate trajectories for patients once they are discharged from the hospital. Overall, about 3 percent will be enrolled in the ESRD program, while 13 percent will die during the hospitalization. One in four AKI survivors goes to a skilled nursing facility.

It appears that, with the exception of albumin testing, care following an AKI episode is similar among those discharged home and those discharged to a SNF. One-year outcomes of those discharged to a SNF are poor, with 29 percent having a recurrent AKI hospitalization, 50 percent having a recurrent hospitalization for any etiology, and 48 percent dying. *Figure 8.21; see page 172 for analytical methods. Medicare AKI patients, 2007.*
The incidence of AKI varies considerably by race. In 2008, the rate per 1,000 patient years was 18.4 in whites, compared to 34.2 in African Americans, and 18.6 among individuals of other races. Figure 8.4

While the AKI event itself remains the primary reason for AKI hospitalization, the percentage of patients with this diagnosis has been declining, to 15.4, 17.7, and 15.3 percent in the Medicare, MarketScan, and Ingenix i3 datasets, respectively, in 2008. Admissions for septicemia have steadily increased, to 10.6, 7.7 and 8.4 percent. Figure 8.7

AKI is highly associated with age, even after adjusting for other factors. Figure 8.8

The adjusted hazard for an AKI hospitalization is significantly higher in African Americans than in whites: 2.1 times higher for AKI alone, and 1.9 times for AKI requiring dialysis. Figure 8.9

Of those hospitalized with an AKI episode requiring dialysis, 35 percent do not see a nephrologist within 30 days, and 23 percent receive no nephrologist care within the first year. Figure 8.13

Rates of testing for albuminuria/proteinuria following an AKI episode remain dismal, at less than 20 percent at the end of one year, irrespective of race or nephrologist care. Figure 8.16

Twenty-eight percent of patients who survive an AKI hospitalization die within one year. Figure 8.18

Among patients with Stage 3–5 CKD prior to their AKI hospitalization, 21.8 percent are later classified as having ESRD. Figure 8.19