Chapter Eight
Acute kidney injury

Why it is first the blow rather than the movement caused by it; the blow has performed its function before the object has started on its course.

Leonardo da Vinci
This year we present an entire chapter dedicated to acute kidney injury (AKI). It can be difficult to identify episodes of AKI, since available datasets do not commonly contain biochemical data. As an alternative, we have chosen to use administrative billing data in order to identify episodes of both AKI alone and AKI requiring dialysis. Use of this indirect identification method has a number of limitations, some of which include poor sensitivity and the possibility of a phenomenon described as “code creep,” which can occur over a period of time when billing thresholds for AKI episodes are changed by physicians and hospital coders. These changing thresholds can increase the likelihood of an administrative code for AKI being generated by a less severe episode of AKI, potentially skewing analyses designed to demonstrate temporal changes in the incidence of AKI. Despite these limitations, we have attempted to identify antecedents and outcomes associated with AKI in three large, nationally representative datasets. The first and largest of these is the 5 percent Medicare sample, which we use to identify the percentage of individuals hospitalized with AKI or AKI requiring dialysis in different cohort years. We also utilize the MarketScan database, a compilation of claims submitted voluntarily by large, self-insured firms, and the Ingenix i3 dataset, which includes individuals covered by traditional health insurance. Using a point prevalent method, we establish a cohort of individuals for each dataset, and follow them forward to identify AKI from the diagnosis codes generated within each year. Figure 8.1 demonstrates a significant increase in overall AKI episodes over time. The incidence of AKI requiring dialysis, in contrast, has remained relatively stable, suggesting either the possibility of code creep or a greater awareness of AKI. In the next spread we use the Medicare, MarketScan, and Ingenix i3 datasets to compare patient characteristics, medications, and the primary cause of hospitalization in individuals with hospital-diagnosed AKI, as well as the type of dialysis modality used in those with AKI who require dialysis. The most common reason for hospitalization is the actual episode of AKI itself, accounting for 20–23 percent of all hospitalizations—a number fairly stable over time. The percentage of patients undergoing continuous renal replacement therapy (CRRT) has increased slightly, while the percentage on intermittent hemodialysis has fallen slightly. And since 1995, the use of peritoneal dialysis as an acute therapy has become quite uncommon. The next spread describes rates of AKI in point prevalent patients with and without CKD, by dataset. Overall, the rate of AKI is greater with increased age, among African Americans, and in men, and in the Medicare cohort is nearly seven-fold higher in those with a diagnosis of CKD than in those without. Figures 8.10–11 describe geographic variations in rates of AKI by HSA and state. For reasons that are unclear, there appears to be a marked variation in the diagnosis of AKI across the country, a phenomenon we will explore in future ADRs. In the following spread we describe the type of care delivered during a hospitalization for AKI and after AKI discharge. Overall, the majority of individuals with...
AKI — with or without dialysis — see a primary care provider shortly after their hospitalization. In those who require dialysis, 38.2 percent see a nephrologist in the first 30 days following AKI discharge. Approximately 90–95 percent of discharged AKI patients have their serum creatinine tested by the end of one year, while only 14–24 percent undergo urine protein testing. Use of angiotensin converting enzymes (ACE-Is) and angiotensin receptor blockers (ARBs) decreases following hospitalization for AKI, as does the use of statins, but to a much lesser degree. It is unknown whether these changes are temporary and reversed once the AKI episode is fully resolved. We will further explore this issue in future ADRs. Chronic kidney disease (CKD) is a risk multiplier in AKI patients, as exhibited by end-stage renal disease (ESRD) rates of 32.8 per 1,000 patient years in AKI patients with CKD compared to 4.4 and 16.4, respectively, in those with AKI or CKD only; rates of death are 200.7, 164.9, and 132.2 per 1,000 patient years, respectively. The hazard ratio of ESRD is 85 in patients with AKI and CKD, compared to 11.7 and 44.5, respectively, in patients with AKI or CKD only; hazard ratios of death are 3.1, 2.5, and 2.3. In conclusion, we show that the incidence of AKI is increasing, particularly among the very elderly, and varies considerably across the country. Individuals with an AKI episode are likely to have their ACE-I/ARB treatment stopped and are unlikely to see a nephrologist after discharge from their AKI hospitalization, even if the AKI episode requires dialysis. And outcomes after an AKI episode are poor, an association strongly modified by underlying CKD.

Figure 8.1; see page 149 for analytical methods. Prevalent Medicare patients age 66 & older.
n the Medicare, MarketScan, and Ingenix i3 AKI cohorts, the proportion of males to females is 47 to 53, 60 to 40, and 58 to 42 percent, respectively. By race, 82.8 percent of Medicare AKI patients are white, and 12.6 and 4.5 percent are African American or of other races. Prevalent Medicare AKI patients age 66 & older, & MarketScan & Ingenix i3 AKI patients age 20–64, 2007.

Overall, the incidence of AKI in all three cohorts has increased over the past five years. Among Medicare patients, the largest increase appears to be in those age 85 and older. Males and females with AKI are equally represented in the Medicare database, but men account for 58–60 percent of AKI patients in the MarketScan and Ingenix i3 populations. In all databases the percentage of individuals requiring dialysis has decreased significantly over time, while the percentage of MarketScan patients using either ACE-I/ARBs or statins prior to their AKI episode appears to be falling. The most common reason for hospitalization is the AKI episode itself, followed by cardiac etiologies and infections. Prevalent Medicare AKI patients age 66 & older, & MarketScan & Ingenix i3 AKI patients age 20–64.
In 2007, intermittent hemodialysis was the preferred type of therapy for hospitalized AKI patients requiring dialysis, at 70.8 percent; continuous hemodialysis was used in 5.9 percent of patients. The percentage of hospitalized AKI patients who received contrast in the two weeks prior to their hospitalization increased from 2.9 in 1995 to 6.2 in 2007. Of patients in the Medicare database with AKI, 82.8, 12.6, and 4.5 percent are white, African American, and of other races, respectively. In 2007, 28.9 percent of hospitalized MarketScan AKI patients used ACE-Is/ARBs and 18.9 percent used statins, compared to 41.5 and 24.8 percent, respectively, of Ingenix i3 patients. \(\text{Figures 8.3–6; see page 149 for analytical methods. Prevalent Medicare AKI patients age 66 & older (8.3–5); prevalent MarketScan & Ingenix i3 AKI patients age 20–64 (8.6).}\)
Acute kidney injury (AKI) is highly associated with age. In the Medicare database, the rate of AKI in 2007 was 8.9 per 1,000 patient years for patients age 66–69, compared to 11.3, 16.2, 21.8, and 27.6, respectively, in those age 70–74, 75–79, 80–84, and 85 and older. By race, AKI hospitalization rates were 15.1 per 1,000 patient years in whites and 28.6 and 15.0, respectively, in African Americans and individuals of other races. The rate of AKI in EGHP patients appears to be relatively constant and, in all populations, males are more likely to have an AKI compared to females.

The presence of CKD highly modifies the rate of AKI. In Medicare patients, for example, the presence of CKD increases the incidence of AKI by nearly seven-fold overall, with similar patterns seen in the employer group health plan population as well, but to a much higher degree. **Figures 8.7–9; see page 149 for analytical methods.** January 1 point prevalent Medicare patients age 66 & older, & MarketScan & Ingenix i3 patients age 20–64, 2007 (8.7); prevalent Medicare patients age 66 & older, & MarketScan & Ingenix i3 patients age 20–64, 2006 (8.8–9).
Rates of acute kidney injury vary widely across the country. By HSA, AKI appears to be most common in the eastern part of the country, with an average incidence of 19.9 per 1,000 patient years in the upper quintile — nearly a two-fold difference over the lower quintile. Using state-level data, there is a nine-fold difference in the incidence of AKI with dialysis between the upper and lower quintiles. The source of this variation is unclear, and we will further investigate this issue in future ADRs. Figure 8.10–11: Geographic variations in unadjusted rates of AKI with dialysis (per 1,000 patient years), by state: no entry period, 2007.
Most AKI patients are seen by their primary care provider following an AKI episode. At 30 days after AKI discharge, 74.5 percent have seen their primary physician compared to 11.9 and 29.5 percent, respectively, who see a nephrologist or cardiologist. Surprisingly, just over one-third of AKI patients who require dialysis see a nephrologist within 30 days of discharge; this increases to 48.6 percent within one year of discharge.

When compared to all AKI patients, patients who require dialysis are nearly three times more likely to have at least one visit to a nephrologist in the month following AKI discharge. At six months, 5.1 percent of AKI patients not requiring dialysis have seen a nephrologist at least once, compared to 8.5 percent of those whose AKI hospitalization required dialysis.

In general, the majority of patients receive creatinine testing shortly after their AKI episode. At three months after AKI discharge, for example, 67–77 percent have had at least one serum creatinine test; this rises to 90–96 percent one year after discharge. Testing for urine protein, in contrast, is relatively uncommon after an AKI episode, occurring in 14–24 percent of patients in the year following AKI discharge. The rate of proteinuria testing does not appear to be influenced by whether a patient sees a nephrologist post-discharge.

Individuals with an episode of AKI, with or without dialysis, are more likely to have their ACE-I/ARBs and statins discontinued during their hospitalization than following discharge.
The probability of a diabetic AKI patient having an A1c test after AKI discharge is higher in those requiring dialysis, at 0.61 compared to 0.49 in those not needing dialysis. Patients requiring dialysis are less likely to receive an eye exam, at 0.22 versus 0.33, while the likelihood of an influenza vaccination is similar for each, at 0.20 and 0.22. (Figure 8.18; see page 150 for analytical methods. Prevalent Ingenix is AKI patients, age 20–64, 2006.)
he odds of an in-hospital death during an AKI hospitalization are 41 percent higher in Medicare patients age 80 and older than in those age 66–70. Females have a slight survival advantage compared to males, while patients of other races are 13 percent more likely to die than white patients. Patients with diabetes are 24 percent more likely to reach ESRD after AKI discharge than those with no diabetes, and the hazard of ESRD in patients with CKD is nearly four times that of non-CKD patients. The hazard of death following discharge for AKI is two times higher in Medicare patients age 80 and older compared to those age 66–70. As with in-hospital death, females are less likely to die after AKI discharge, and the hazard of death is 17 percent higher in CKD patients compared to those with no CKD. Tables 8.d–g; see page 150 for analytical methods. Patients with AKI hospitalizations; Medicare age 66 & older, MarketScan & Ingenix i3 age 20–64. Events in Table 8.d are during 2006–2007; events in Tables 8.e–g are during 2005–2006. Confidence intervals for these tables can be found in the Chapter Eight Excel file on our website.
Compared to those for patients age 66–70, the odds of an in-hospital death for Medicare AKI patients who require dialysis are 26 percent higher in those age 80 and older, and 18 and 20 percent higher, respectively, in those age 76–80 and 71–75. Medicare patients of other races are 25 percent more likely to die than whites. The hazard of death following AKI discharge is nearly twice as high in patients age 80 and older compared to their younger counterparts age 66–70. African Americans are 11 percent more likely to die than are whites, and patients with CKD are 20 percent more likely to die after discharge than those with no CKD. The odds of ESRD after discharge are highest in the youngest patients, and are 14 percent greater in males than in females. Patients with hypertension are 21 percent more likely to reach ESRD than non-hypertensive patients, and the hazard of ESRD is 2.5 times greater in patients with CKD than in those without. Tables 8.h–k; see page 151 for analytical methods.
In 2007, **INTERMITTENT HEMODIALYSIS** was the preferred type of therapy for hospitalized AKI patients requiring dialysis, at 71%. • 8.3

In 2007, 29% of hospitalized MarketScan AKI patients used **ACE-Is/ARBs** & 19% used statins. • 8.6

In egHP patients, the presence of **CKD** increases the incidence of **AKI** by more than ten-fold, irrespective of age. • 8.8

AKI appears to be most common in the **EASTERN** part of the country. • 8.10

Most AKI patients are seen by their **PRIMARY CARE PROVIDER** following an AKI episode. • 8.12

Testing for **URINE PROTEIN** is relatively **UNCOMMON** after an AKI episode. • 8.13

The probability of **ESRD OR DEATH** after hospital discharge is **HIGHER** in patients hospitalized for AKI than in those hospitalized for other reasons. • 8.19

The odds of an **IN-HOSPITAL DEATH** during an AKI hospitalization are 41% higher in Medicare patients age 80 & older compared to those age 66–70. • 8.d

Patients with **DIABETES** are 24% **MORE LIKELY** to reach **ESRD** after AKI discharge than those with no diabetes. • 8.d

Of patients requiring dialysis during an AKI hospitalization, **AFRICAN AMERICANS** are 11% more likely to die after discharge than are whites. • 8.i

**Summary**