Kenneth Rexroth
"A Letter to William Carlos Williams"

And the beautiful river he saw
Still flows in his veins, as it
does in our veins, and in our eyes;
And flows in time and makes us
part of it and part of him.
Since 2001, the Cardiovascular Special Studies Center (CVSSC) has contributed a chapter to the ADR. This year we return to our exploration of major issues presented earlier. As illustrated by Figure 9.1, the central theme of this year’s chapter is an examination of acute myocardial infarction (AMI), congestive heart failure (CHF), and cardiac arrest (CA) across the spectrum of renal failure. The probabilities of these three endpoints overlap for CKD, dialysis, and transplant patients. For AMI in incident patients, the probability is considerably lower in those with a transplant, while at 18–24 months it is similar for incident dialysis and CKD patients. In the prevalent population, the rate is highest for dialysis, intermediate for CKD, and lowest for transplant. For CHF, the probability is similar for dialysis and CKD patients, both incident and prevalent, while the transplant population has a lower likelihood. In the incident population, at 18 months, AMI and CHF are both comparable in the dialysis and CKD populations—approximately 11–12 percent of incident CKD and dialysis patients develop AMI by this time, and 56 percent develop CHF. The probability of cardiac arrest, in contrast, is lower for CKD patients than for those on dialysis, in whom the probability is strikingly high: 24 percent at three years in both incident and prevalent patients. On the following two pages we provide a broad description of demographics and comorbidities of incident and prevalent Medicare CKD, dialysis, and transplant patients. This fits with our second goal of presenting comparative data on hemodialysis and peritoneal dialysis patients. The next two spreads present data on AMI and CHF in incident and prevalent patients, concentrating on Medicare CKD, hemodialysis, peritoneal dialysis, and renal transplant patients. We describe the relationships of age, gender, race, and diabetic status to the probability of AMI and CHF, and assess the impact of comorbidity as well. We next return to a topic of recurrent interest: cardiac arrest/sudden cardiac death. Implicated as the single largest cause of mortality in dialysis patients—an estimated 27 percent of all-cause mortality in dialysis patients is attributed to arrhythmic mechanisms—this has continued to be a prime area of focus for the CVSSC. Moreover, it is closely linked to AMI and CHF. In the former instance, ischemic heart disease is likely to be an important trigger for cardiovascular death, including arrhythmic death. In CHF, there is clearly a link between cardiomyopathy and cardiac arrest. In the non-renal population, patients with systolic heart failure and low ejection fractions have been targeted for both pharmacologic interventions and interventions involving placement of implantable cardioverter defibrillators (ICDs) for the primary and secondary prevention of sudden cardiac death. In the ESRD population and in Medicare patients with CKD, it is less clear how to identify patients at risk for sudden cardiac death. In ESRD patients in particular, the
frequent occurrence of left ventricular hypertrophy likely predisposes these patients to a heightened vulnerability for arrhythmic death, even patients with preserved left ventricular systolic function. What is clear, however, is that as a group, dialysis patients are at particularly high risk for cardiac arrest. As shown in Figures 9.28 and 9.34, both hemodialysis and peritoneal dialysis patients have a markedly increased probability of cardiac arrest compared to transplant or CKD patients. In the next spread we look at a variety of cardiovascular endpoints in incident and prevalent hemodialysis and peritoneal dialysis patients: AMI, CHF, and cardiac arrest, as well as cerebrovascular disease, coronary revascularization, peripheral vascular disease, all-cause mortality, and any cardiovascular event or death. Although, after the initiation of dialysis, the characteristics of hemodialysis and peritoneal dialysis patients may vary over long-term followup, due to differential rates of selection for renal transplantation the comparison is still pertinent. The CVSSC has recently worked to refine estimates of rates of sudden cardiac death in dialysis patients, and here presents some of our results. Fewer data are available on cause-specific mortality in non-ESRD Medicare patients, and it is plausible that this spread under-estimates the rate of cardiac arrest/sudden cardiac death in non-ESRD patients. Comparative data on cardiac arrest presented here are intended to provide a rough estimate of cardiac arrest event rates in general Medicare CKD patients compared to dialysis patients. In the second part of this spread we present the first data on the use of implantable cardioverter defibrillators (ICDs) from the perspective of the entire U.S. dialysis population. We conclude the chapter with what is partly a reprise from previous ADRs, presenting temporal trends in the rate of cardiac procedure use in incident hemodialysis and peritoneal dialysis patients. There were insufficient data to allow us to examine procedure use in pediatric patients, with the exception of echocardiograms, ECGs, and lipid testing, and because of the small numbers of pediatric dialysis patients, data are aggregated for 1995 to 2001 and do not include time trends. One broad interest of the USRDS has been to evaluate the impact of national practice guidelines over time. The National Kidney Foundation’s K/DOQI practice guideline for the treatment of cardiovascular disease in dialysis patients (Guideline 1.1) recommends the performance of echocardiograms in all dialysis patients (both pediatric and adult) after the attainment of optimal volume status at 30–90 days following dialysis initiation. Repeat echocardiograms are recommended thereafter at 36-month intervals, or sooner if clinically indicated. The rationale relates to both the prognostically important detection of occult cardiomyopathy, and the ability to use evidence-based pharmacologic interventions after diagnosis of cardiomyopathy.
In this spread we provide a snapshot of the distribution of age, gender, race, and diabetic status in relation to comorbid cardiac conditions across the spectrum of renal failure: general Medicare patients age 66 and older with CKD, hemodialysis patients, peritoneal dialysis patients, and renal transplant recipients.

The incident transplant cohort is composed of the youngest individuals, with 59 percent age 44 or younger, compared to only 11 percent of hemodialysis patients (Figure 9.2). In all four groups, those with comorbid cardiac conditions tend to be older. By gender, a relative disproportionate increase in male patients is noted across the CKD and ESRD cohorts and in most patients with comorbid cardiac conditions, particularly AMI; 63 percent of incident transplant patients with a history of AMI, for example, are male.

Reflecting the demographics of the general Medicare population, only 11 percent of CKD patients are black compared to 31 percent of incident hemodialysis patients. In all three ESRD groups, the relative proportion of AMI patients who are black is lower than in the entire population.

Reflecting the important contribution of diabetic status to the development of cardiovascular disease, there is a marked increase...
of diabetes in patients with AMI, CHF, or cardiac arrest. Only 41 percent of the overall incident transplant population, for instance, is diabetic, versus 63 percent of those with a history of AMI.

In the prevalent population, across cohorts, patients with cardiac comorbid conditions are more likely to be older, male, and white (Figure 9.3). Most dramatically, a greater percentage of patients with AMI, CHF, or cardiac arrest also have diabetes.

In both the incident and prevalent CKD and ESRD cohort groups, then, there is an increased association of older age, male gender, white race, and diabetic status in patients with comorbid cardiac conditions. 

All figures "All" category represents the entire CKD, hemodialysis, peritoneal dialysis, or transplant cohort. 

Figure 9.1 ESRD: incident Medicare dialysis patients & first transplant patients with Medicare as primary payer, 2000–2002 combined. General Medicare (5 percent sample): incident CKD patients, age 66 & older, enrolled in Medicare for at least one year, 2000–2002 combined. All patients & those with AMI, CHF, or cardiac arrest (CA) in the followup period. 

Figure 9.2 ESRD: January 1, 2002 point prevalent Medicare dialysis patients. General Medicare (5 percent sample): January 1, 2002 point prevalent patients age 66 & older & enrolled in Medicare for at least one year. All patients & those with AMI, CHF, or cardiac arrest (CA) in the followup period.
cardiovascular special studies
acute myocardial infarction in incident & prevalent patients

9.4 Probability of AMI in incident patients, overall & CKD patients

9.5 Probability of AMI in incident patients, by age & CKD patients

9.6 Probability of AMI in incident patients, by gender & CKD patients

9.7 Probability of AMI in incident patients, by race & CKD patients

9.8 Probability of AMI in incident patients, by diabetic status & CKD patients

9.9 Probability of AMI in incident patients, by comorbidity & CKD patients

9.10 Probability of AMI in prevalent patients, overall prevalent ESRD & CKD patients

9.11 Probability of AMI in prevalent patients, by age prevalent ESRD & CKD patients

9.12 Probability of AMI in prevalent patients, by gender prevalent ESRD & CKD patients

9.13 Probability of AMI in prevalent patients, by race prevalent ESRD & CKD patients

9.14 Probability of AMI in prevalent patients, by diabetic status prevalent ESRD & CKD patients

9.15 Probability of AMI in prevalent patients, by comorbidity prevalent ESRD & CKD patients
All figures are unadjusted for overall probabilities. In figures by age, gender, race, or diabetic status, data by one variable are adjusted for the remaining three; data by comorbidity are adjusted for age, gender, race, or diabetic status. Figures 9.16–21: incident Medicare dialysis & first transplant patients with Medicare as primary payor, age ≥ 20 & older, 2000–2002 combined. General Medicare (5 percent

9.16 Probability of CHF in incident patients, overall & CKD patients

9.17 Probability of CHF in incident patients, by age & CKD patients

9.18 Probability of CHF in incident patients, by gender & CKD patients

9.19 Probability of CHF in incident patients, by race & CKD patients

9.20 Probability of CHF in incident patients, by diabetic status & CKD patients

9.21 Probability of CHF in incident patients, by comorbidity & CKD patients
chapter nine

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All figures unadjusted for overall probabilities. In figures by age, gender, race, & diabetic status, data by one variable are adjusted for the remaining three; data by comorbidity are adjusted for age, gender, race, & diabetic status. 

9.28 Probability of cardiac arrest in incident patients, overall incident ESRD & CKD patients

9.29 Probability of cardiac arrest in incident patients, by age incident ESRD & CKD patients

9.30 Probability of cardiac arrest in incident patients, by gender incident ESRD & CKD patients

9.31 Probability of cardiac arrest in incident patients, by race incident ESRD & CKD patients

9.32 Probability of cardiac arrest in incident patients, by diabetic status incident ESRD & CKD patients

9.33 Probability of cardiac arrest in incident patients, by comorbidity incident ESRD & CKD patients

9.34 Probability of cardiac arrest in prevalent patients, overall incident ESRD & CKD patients

9.35 Probability of cardiac arrest in prevalent patients, by age incident ESRD & CKD patients

9.36 Probability of cardiac arrest in prevalent patients, by gender incident ESRD & CKD patients

9.37 Probability of cardiac arrest in prevalent patients, by race incident ESRD & CKD patients

9.38 Probability of cardiac arrest in prevalent patients, by diabetic status incident ESRD & CKD patients

9.39 Probability of cardiac arrest in prevalent patients, by comorbidity incident ESRD & CKD patients

9.40 Probability of cardiac arrest in prevalent patients, by incident Medicare dialysis & first transplant patients with Medicare as primary payor, age 20 & older, 2000–2002 combined. General Medicare
(5 percent sample): incident CKD patients, age 66 & older, enrolled in Medicare for at least one year, 2000–2002 combined. **Figures 9.34–39** ESRD: January 1, 2002 point prevalent Medicare ESRD patients age 20 & older. General Medicare (5 percent sample): January 1, 2002, point prevalent CKD patients age 66 & older enrolled in Medicare for at least one year.

9.34 **Probability of cardiac arrest in prevalent patients, overall** prevalent ESRD & CKD patients

9.35 **Probability of cardiac arrest in prevalent patients, by age** prevalent ESRD & CKD patients

9.36 **Probability of cardiac arrest in prevalent patients, by gender** prevalent ESRD & CKD patients

9.37 **Probability of cardiac arrest in prevalent patients, by race** prevalent ESRD & CKD patients

9.38 **Probability of cardiac arrest in prevalent patients, by diabetic status** prevalent ESRD & CKD patients

9.39 **Probability of cardiac arrest in prevalent patients, by comorbidity** prevalent ESRD & CKD patients
cardiovascular special studies

9 cardiovascular event rates in HD & PD patients

9.40 Event rates & event-free probabilities, incident patients: acute myocardial infarction

9.41 Event rates & event-free probabilities, incident patients: congestive heart failure

9.42 Event rates & event-free probabilities, incident patients: cardiac arrest

9.43 Event rates & event-free probabilities, incident patients: CVA/TIA

9.44 Event rates & event-free probabilities, incident patients: coronary revascularization

9.45 Event rates & event-free probabilities, incident patients: peripheral vascular disease

9.46 Event rates & event-free probabilities, incident patients: all-cause death

9.47 Event rates & event-free probabilities, incident patients: any CV event or death

PREVALENT PATIENTS

9.48 Event rates & event-free probabilities, prevalent patients: acute myocardial infarction

9.49 Event rates & event-free probabilities, prevalent patients: congestive heart failure

9.50 Event rates & event-free probabilities, prevalent patients: cardiac arrest

9.51 Event rates & event-free probabilities, prevalent patients: CVA/TIA

9.52 Event rates & event-free probabilities, prevalent patients: coronary revascularization

9.53 Event rates & event-free probabilities, prevalent patients: peripheral vascular disease

9.54 Event rates & event-free probabilities, prevalent patients: all-cause death

9.55 Event rates & event-free probabilities, prevalent patients: any CV event or death
Figure 9.56 displays several estimates of the rate of sudden cardiac death. The CVSSC has attempted to refine its estimates of this rate, excluding patients identified as having a cause of death attributed to sepsis, malignancy, hyperkalemia, or withdrawal from dialysis (based on the CMS Death Notification form 2746). As shown here, for the most recent year for which data are available (2004), our best estimate of the rate of sudden cardiac death (after appropriate exclusions) is 6.9 percent per year for the entire U.S. dialysis population. This number should be regarded as a starting point for the design of interventions to reduce the risk of sudden cardiac death in dialysis patients.
In the second part of this spread we present the first data on the use of implantable cardioverter defibrillators (ICDs) in the entire U.S. dialysis population. Herzog et al. (Kidney International 68:818–835) have previously published data on the survival of dialysis patients after cardiac arrest and on the impact of ICDs, also reporting a striking underutilization of defibrillators in cardiac arrest survivors on dialysis. Although the use of ICDs in these patients is a class I indication, only 8 percent of patients in the study received ICDs. Our ADR figures provide further information on the slowly expanding use of defibrillators in a population previously characterized to be at high risk for cardiac arrest and sudden cardiac death. As shown in Figure 9.65, approximately 85 percent of ICDs placed in dialysis patients were for “secondary prevention,” i.e., prevention of sudden cardiac death in cardiac arrest survivors or patients with a history of ventricular tachycardia.

It is likely that there are several explanations for the apparent underutilization of ICDs in dialysis patients, including concerns about overall quality of life, device infection, risk of thrombotic complications interfering with dialysis access, and perhaps a general reluctance to recommend aggressive cardiac intervention in this population—referred to in prior publications as “therapeutic nihilism” or “renalism.”

In Figure 9.56, period prevalent dialysis patients. Adjusted rates adjusted for for age, gender, race, primary diagnosis, & vintage. “Withdrawal”: patients who withdraw from dialysis prior to death. In Figure 9.57, period prevalent dialysis patients, 2002; excludes patients withdrawing from dialysis prior to death. Patients followed from January 1, 2002, or dialysis inception in 2002; probability of SCD & all-cause death calculated during each following three-month interval. In Figure 9.58, period prevalent dialysis patients, 2002, by HSA, unadjusted; excludes patients withdrawing from dialysis prior to death, & those residing in Puerto Rico & the Territories. In Figure 9.59, general Medicare patients, 2002, age 65 & older on January 1, 2002, or at the time of enrollment in 2002, by HSA, unadjusted. Excludes patients residing in Puerto Rico & the Territories. In Figure 9.60, general Medicare patients continuously enrolled in Medicare Parts A & B in 2000, age 65 & older on January 1, 2000; adjusted for age, gender, & race. CKD defined in 2000. In Figure 9.61, general Medicare patients age 66 & older, with first cardiac arrest claim in 2000–2003, & continuously enrolled in Medicare for at least one year; adjusted for age, gender, & race. CKD defined during the one year before cardiac arrest. In Figure 9.62, period prevalent dialysis patients with Medicare as primary payor. In Figures 9.63–66, period prevalent dialysis patients age 20 & older on the date of ICD, with Medicare as primary payor during 1996–2003, & receiving their first ICD treatment after January 1, 1996 (prevalent patients), or after day 90 of ESRD (incident patients). Survival probabilities are unadjusted.
cardiovascular special studies
cardiovascular procedure use in dialysis patients

9.67 Cumulative percent of patients receiving stress tests incident dialysis patients age 20 & older

9.68 Cumulative percent of patients receiving coronary angiography incident dialysis patients age 20 & older

9.69 Cumulative percent of patients receiving coronary angiography/stress tests incident dialysis patients age 20 & older

9.70 Cumulative percent of patients receiving echocardiograms incident dialysis patients
There has been a gradual increase in the use of cardiac procedures in dialysis patients. Figure 9.70, for example, provides interesting benchmark data for assessing the impact of the recent publication of NKF task force guidelines on the treatment of cardiovascular disease in both adult and pediatric patients. For cohort year 2003, 42 percent of adult hemodialysis patients, and 34 percent of those on peritoneal dialysis, received an echocardiogram within a year after dialysis initiation. In the 1995–2001 pediatric cohort, 24 and 18 percent of patients, respectively, received the test within one year. Although, due to the small sample size, the most recent temporal trend data are not available for pediatric patients, their use of echocardiography has been consistently lower.

There has been a gradual increase in the cumulative percent of dialysis patients receiving some type of evaluation for ischemic heart disease. In the most recent (2003) cohort, 23 percent of hemodialysis patients and 24 percent of peritoneal dialysis patients received a coronary angiogram or stress test in the first year after dialysis initiation, an increase from 16 and 17 percent, respectively, in 1995 (Figure 9.69). Despite the presumed burden of ischemic heart disease in dialysis patients, the cumulative percentage receiving coronary revascularization remains low, at less than 5 percent in the first year after initiation for the 2003 cohort (Figure 9.71).

| Figures 9.67–73 | incident Medicare dialysis patients age 20 & older; patients younger than 20 are included as a separate group in Figures 9.70 & 9.72–73. |
### Figures 9.2–3
Cardiovascular morbidity is common across the spectrum of renal failure, particularly diabetic ESRD.

### Figure 9.4
In the incident population, the probability of an AMI is considerably lower in transplant patients than in those on dialysis. **Figure 9.5**

**Acute myocardial infarction**

Older age is linked to probability of AMI in incident patients. **Figure 9.8** The presence of diabetes is associated with greater likelihood of AMI in incident patients. **Figure 9.10** The probability of AMI is similar in prevalent hemodialysis and peritoneal dialysis patients.

### Figure 9.41
At one year, the event-free probability of CHF is lower in hemodialysis than in peritoneal dialysis patients.

### Figure 9.42
After the initiation of dialysis, the rate of cardiac arrest is lower for peritoneal dialysis patients in the first year after initiation of renal replacement therapy. After a year, rates are similar for hemodialysis and peritoneal dialysis patients. **Figure 9.48** In prevalent dialysis patients, the rate of AMI is slightly higher over time for peritoneal dialysis than for hemodialysis patients. **Figure 9.49** At one year, the event-free probability for CHF is lower for hemodialysis patients.

### Figures 9.57 & 9.58
For period prevalent dialysis patients in 2002, the probability of all-cause mortality is 39 percent at two years compared to 14 percent for sudden cardiac death. **Figure 9.60** The three-year probability of cardiac arrest in general Medicare non-CKD patients is 3 percent versus 7 percent for CKD patients. **Figure 9.61** The survival probability after cardiac arrest is higher for general Medicare non-CKD patients: 20 percent versus 8 percent for CKD patients. **Figure 9.62** It is estimated that one out of 370 period prevalent dialysis patients in the U.S. received an ICD in 2003. **Figure 9.63** By gender, male patients are disproportionately represented in ICD use in dialysis patients.

### Figures 9.16 & 9.17 & 9.20
The probability of CHF in incident patients is increased with older age and in diabetic patients. **Figures 9.23 & 9.26** The probability of CHF in prevalent patients is higher in older patients and in those with diabetes.

### Figure 9.28
At three years after dialysis initiation the greatest hazard for cardiac arrest occurs in hemodialysis patients. **Figure 9.32** The largest difference, by diabetic status, in the hazard for cardiac arrest in incident patients occurs in peritoneal dialysis patients.

### ICDs in dialysis patients

### Figures 9.49 & 9.57
Cardiovascular event rates

**Congestive heart failure**

### Cardiac arrest

**Figure 9.16** The probability of CHF is similar for dialysis and Medicare CKD patients, and lower in the transplant population. **Figures 9.17 & 9.20** The probability of CHF in incident patients is increased with older age and in diabetic patients. **Figures 9.23 & 9.26** The probability of CHF in prevalent patients is higher in older patients and in those with diabetes.

### Figures 9.41 & 9.42
At one year, the event-free probability of CHF is lower in hemodialysis than in peritoneal dialysis patients.

### Figures 9.48 & 9.49
In prevalent dialysis patients, the rate of AMI is slightly higher over time for peritoneal dialysis than for hemodialysis patients. **Figure 9.49** At one year, the event-free probability for CHF is lower for hemodialysis patients.

### Figures 9.57 & 9.58
For period prevalent dialysis patients in 2002, the probability of all-cause mortality is 39 percent at two years compared to 14 percent for sudden cardiac death. **Figure 9.60** The three-year probability of cardiac arrest in general Medicare non-CKD patients is 3 percent versus 7 percent for CKD patients. **Figure 9.61** The survival probability after cardiac arrest is higher for general Medicare non-CKD patients: 20 percent versus 8 percent for CKD patients. **Figure 9.62** It is estimated that one out of 370 period prevalent dialysis patients in the U.S. received an ICD in 2003. **Figure 9.63** By gender, male patients are disproportionately represented in ICD use in dialysis patients.

### Cardiovascular procedure use

**General trends show an increase of cardiac procedure use over time in adult and pediatric patients.** **Figure 9.69** In the most recent (2003) cohort, 23 percent of hemodialysis and 24 percent of peritoneal dialysis patients received a coronary angiogram or stress test in the first year after dialysis initiation, an increase from 16 and 17 percent, respectively, in 1995. **Figure 9.73** In 2003, 38 percent of hemodialysis patients and 41 percent of peritoneal dialysis patients received lipid testing in the year after dialysis initiation.