2014 USRDS Annual Data Report
Volume 1: Chronic Kidney Disease

CKD in the United States: An Overview of the USRDS Annual Data Report, Volume 1

Introduction

Chronic kidney disease (CKD) has received significant attention over the last decade, primarily since the consensus definition and staging classification of CKD was first published by the National Kidney Foundation Kidney Disease Outcomes Quality Initiative (NKF KDOQI, 2002).

Federal agencies have also done much to raise awareness of CKD as a significant public health problem. Since 1988, NIH has sponsored the United States Renal Data System (USRDS), publishing a comprehensive Annual Data Report (ADR). The ADR first included a chapter addressing CKD in 2002, and expanded this to an annual, multi-chapter CKD volume in 2008. In 2002, the National Institutes of Health launched a National Kidney Disease Education Program (NKDEP; NIDDK, 2002). NKDEP provides information for patients and providers regarding the detection and care of people with CKD.

The Centers for Disease Control and Prevention (CDC) now support a CKD initiative (CDC, 2014a) with the CKD Surveillance Program as its major component; since 2007 this project has reported on many aspects of this important chronic condition (CDC, 2007).

A nexus between the common non-communicable diseases (NCDs), such as diabetes mellitus (DM), hypertension (HTN), obesity, and CKD is well recognized. Over the last decade, the relationship between acute kidney injury (AKI) and CKD has received greater attention (Chawla et al., 2014). During the 2011 High-Level Meeting of the United Nations (UN) General Assembly on Prevention and Control of NCDs, it was recognized that, similar to other chronic NCDs, renal diseases "...pose a major health burden for many countries and that these diseases share common risk factors and can benefit from common responses to non-communicable diseases" (UN, 2011). The Meeting concluded, however, that CKD could be addressed as a complication of the four main NCDs highlighted by the World Health Organization—cardiovascular disease (CVD), cancer, chronic lung diseases and DM. At present, the national NCD public health programs of many countries do not specifically include CKD as a public health priority. It is imperative that CKD be recognized as an NCD in its own right, and directly addressed in national programs to combat NCDs around the world; CKD is common, associated with high morbidity, mortality, and cost, yet readily identifiable by simple testing of blood and urine. Timely recognition and treatment has the potential to delay progression of disease and reduce complications.

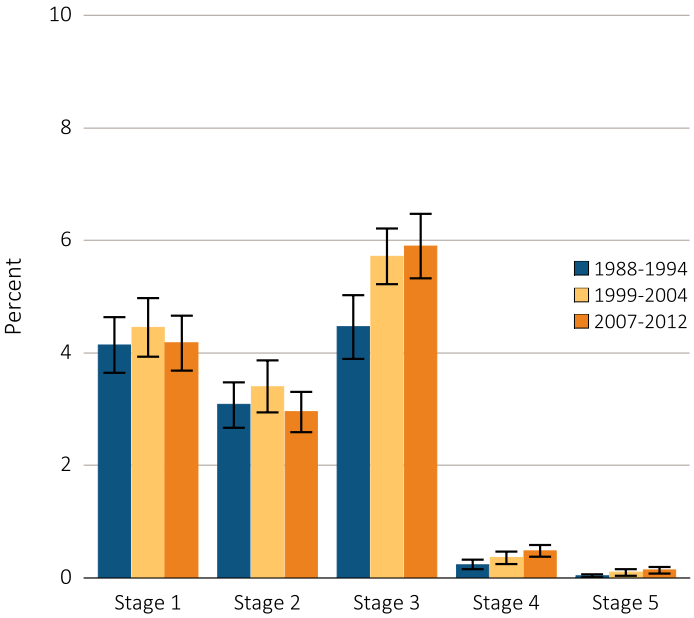
While the number of new patients with end-stage renal disease (ESRD) appears to be stabilizing in the United States (U.S.), the need to further reduce both the incidence and prevalence of this devastating complication of kidney disease cannot be overemphasized. The key to success is undoubtedly in the realm of prevention of both CKD and AKI. Large observational studies have shown that even mild to moderate reductions in kidney function and small quantities of albumin in the urine are associated with high rates of all-cause mortality and cardiovascular mortality in particular (CKD Prognosis Consortium, 2010; Astor et al., 2011). CKD has therefore been appropriately recognized as a cardiovascular risk equivalent (Sarnak et al., 2003).

The 2014 USRDS Annual Data Report provides a detailed overview of key aspects of CKD in the U.S. As in previous years, we include in Volume 1 a chapter on Acute Kidney Injury. A chapter discussing prescription medication use through the Medicare Part D benefit, as well as comparisons to employer-sponsored health insurance populations throughout the Volume are not included in this year's ADR because of unavailability of the relevant data. These topics will return in the 2015 edition.

Chapter 1: CKD in the General Population

As for many other conditions, the National Health and Nutrition Examination Survey (NHANES) has been a valuable resource for estimation of the prevalence of CKD in the U.S. Chapter 1 uses these data to describe CKD in the U.S. general (non-institutionalized) population of people aged 20 or older. We find that CKD is more common than DM in the U.S.; an estimated 13.6 percent of adults have CKD, compared to 12.3 percent with DM (CDC, 2014b). This may well be an overestimate of CKD prevalence, as it is based on the single point estimates of serum creatinine and urine albumin available in the NHANES survey, while the consensus clinical definition of CKD requires the demonstration of persistent abnormality over at least a three month period. However, for public health surveillance of CKD, a single measurement in stable, ambulatory individuals is a satisfactory compromise, as implementation of two or more measurements would not be practical in a national study such as NHANES. As shown in Figure i.1, the overall prevalence of CKD increased from 1988-1994 to 1999-2004 (12 percent to 14 percent), but has since remained relatively stable. The largest increase has occurred in patients with Stage 3 CKD, from 4.5 percent to 6.0 percent over the three time periods.

vol 1 Figure i.1 Prevalence of CKD by stage among NHANES participants, 1988-2012



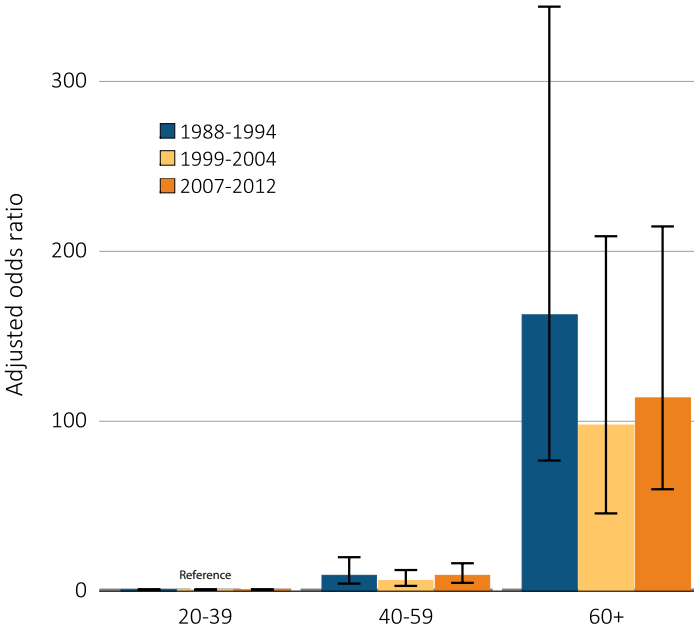
Data Source: National Health and Nutrition Examination Survey (NHANES), 1988–1994, 1999-2004 & 2005–2012 participants age 20 & older. Whisker lines indicate 95% confidence intervals. Abbreviations: CKD, chronic kidney disease. This graphic also appears as Figure 1.1.

Stages of CKD – KDOQI 2002 Definitions	
Stage 1:	eGFR ≥ 90 ml/min/1.73m² and ACR ≥ 30 mg/g
Stage 2:	eGFR 60-89 ml/min/1.73m² and ACR ≥ 30 mg/g
Stage 3:	eGFR 30-59 ml/min/1.73m²
Stage 4:	eGFR 15-29 ml/min/1.73m²
Stage 5:	eGFR < 15 ml/min/1.73m²

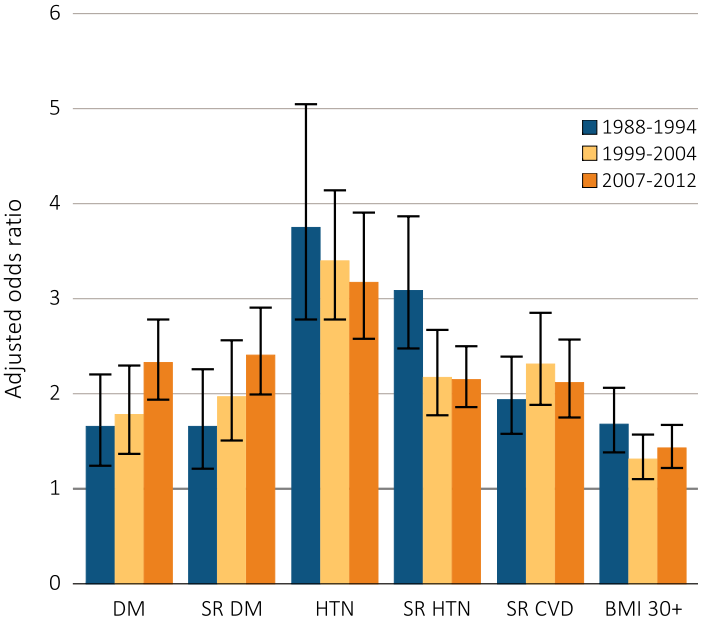
The aging kidney and age as a risk factor for CKD have emerged as important themes in recent years. Figure i.2 shows that age may indeed be the strongest risk factor for the presence of CKD of those available in the NHANES. This has practical implications for screening, prevention, risk stratification and treatment. Other important and clinically relevant risk factors that should prompt screening for the presence of CKD include the presence of DM, HTN, CVD, obesity, or metabolic syndrome, a family history of ESRD or CKD, and a history of AKI.

vol 1 Figure i.2 Adjusted odds ratios of eGFR <60 ml/min/1.73m2 in NHANES participants by age & other risk factors, 1998-2012

(a) Age category



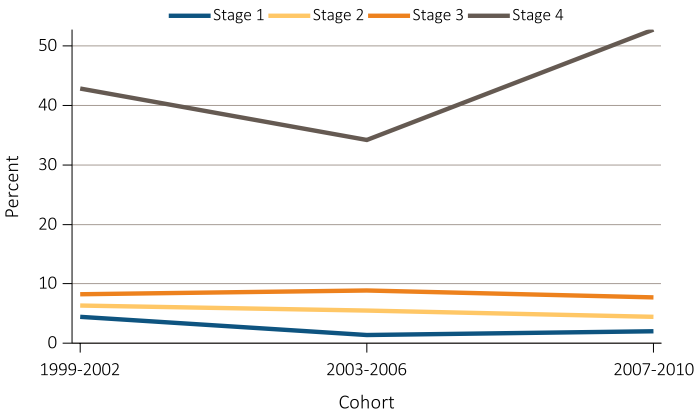
(b) CKD risk factor



Data Source: National Health and Nutrition Examination Survey (NHANES), 1988–1994, 1999-2004 & 2007–2012 participants age 20 & older; single-sample estimates of eGFR & ACR. Adj: age, sex, & race; eGFR calculated using the CKD-EPI equation. Whisker lines indicate 95% confidence intervals. Abbreviations: BMI, body mass index; CKD, chronic kidney disease; CVD, cardiovascular disease; DM, diabetes mellitus; HTN, hypertension; SR, self-report. This graphic also appears as Figure 1.9.

CKD is a notoriously silent disease, and patient awareness remains very low at less than 10 percent for those with Stages 1-3 CKD (see Figure i.3). Not surprisingly, awareness is higher among those with Stage 4 CKD, by which time patients often experience overt symptoms.

vol 1 Figure i.3 NHANES participants with CKD aware of their kidney disease, 1999-2010

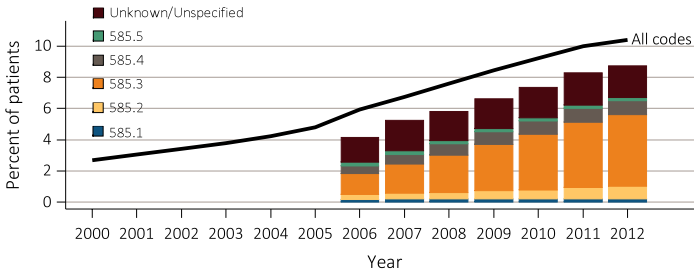


Data Source: National Health and Nutrition Examination Survey (NHANES), 1988–1994, 1999-2004 & 2007–2012 participants age 20 & older. Abbreviations: CKD, chronic kidney disease. This graphic also appears as Figure 1.11.

Chapter 2: Identification and Care of Patients with CKD

While the NHANES continues to serve as a rich source of information for estimating the prevalence of CKD and analyzing risk factors, it does not contain health system derived data, such as claims data from Medicare or other health plans or health systems. Chapter 2 presents findings from the five percent Medicare sample for age-eligible Medicare enrollees (aged 65 or older), which is a very high-risk population for development of CKD and other comorbid conditions. Data for adults aged 20 or older can be found in the accompanying reference tables for this volume. The prevalence of recognized CKD in the Medicare population aged 65 years or older continues to rise over time, peaking at 10.4 percent in the most recent data available in 2012, as shown in Figure i.4. Unfortunately, this represents an underestimate of the true prevalence of CKD in enrollees using Medicare-reimbursed health care services, but has high specificity, identifying the individuals most likely to have an accurate diagnosis.

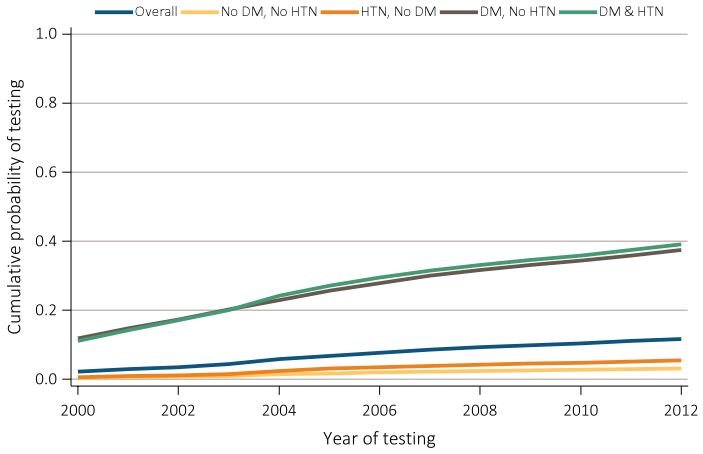
vol 1 Figure i.4 Trends in CKD prevalence, overall and by CKD stage, among Medicare patients age 65+, 2000-2012



Data Source: Medicare 5 percent sample. This graphic also appears as Figure 2.1.

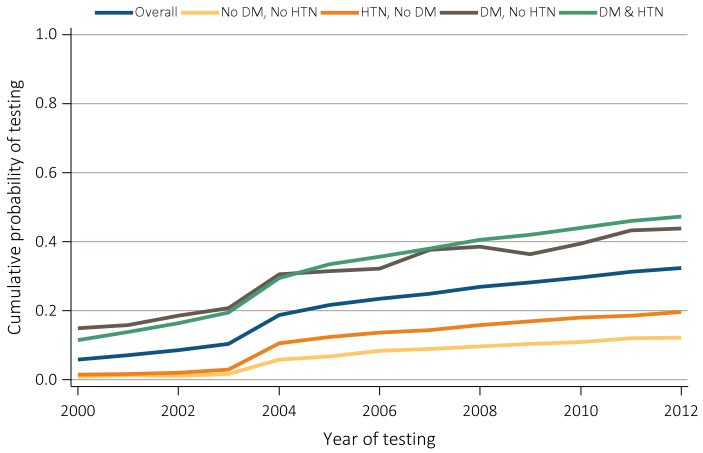
The recent Kidney Disease: Improving Global Outcomes (KDIGO) guidelines on CKD evaluation and management emphasize the importance of assessing the presence of albuminuria in addition to estimated glomerular filtration rate (eGFR) for risk stratification (KDIGO, 2013). Rates of urine albumin testing in the Medicare population have increased slowly over time in both those with and without CKD, as shown in Figures i.5 and i.6. However, rates of such testing remain very low among non-diabetic patients, who because of other health factors are at high risk for kidney disease.

vol 1 Figure i.5 Unadjusted cumulative probability for urine albumin testing, among Medicare patients age 65+ without a diagnosis of CKD, 2000-2012



Data Source: Medicare patients from the 5 percent sample, age 65 or older with Part A & B coverage in the prior year. Tests tracked during each year. Abbreviations: CKD, chronic kidney disease; DM, diabetes mellitus; HTN, hypertension. This graphic is adapted from Figure 2.3.

vol 1 Figure i.6 Unadjusted cumulative probability of urine albumin testing, among Medicare patients age 65+ with a diagnosis of CKD, 2000-2012



Data Source: Medicare patients from the 5 percent sample, age 65 or older with Part A & B coverage in the prior year. Tests tracked during each year. Abbreviations: CKD, chronic kidney disease; DM, diabetes mellitus; HTN, hypertension. This graphic is adapted from Figure 2.4.

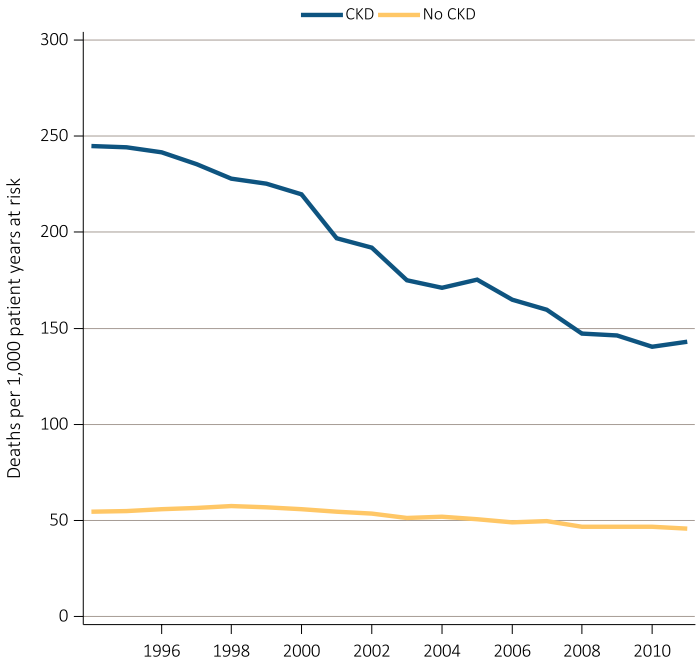
Care of CKD patients after diagnosis is challenging to assess. In the Medicare CKD population aged 65 and older, it appears that 91 percent see a primary care physician within a year of diagnosis, while 62 percent visit a cardiologist; only 31 percent, however, see a nephrologist. When restricted to patients with CKD of Stages 3–5 (based on diagnosis codes), this rate reaches 55 percent.

Chapter 3: Morbidity and Mortality in Patients with CKD

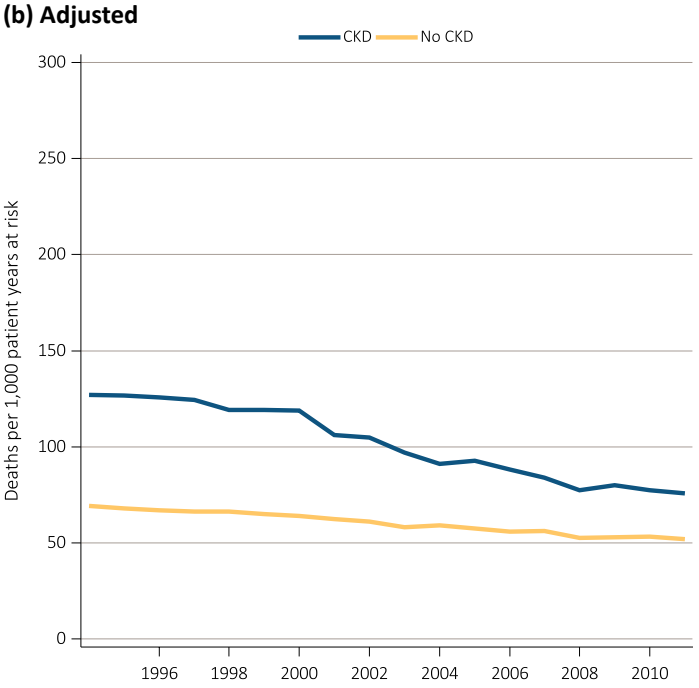
Chapter 3 examines hospitalization and mortality for CKD patients as compared to other Medicare patients. Adjusted mortality rates are higher for Medicare patients with CKD than those without, and rates increase with CKD stage, a finding consistent with studies using biochemical measures to define CKD (serum creatinine with validated equations to eGFR, as in Matsushita et al., 2010). Figure i.7 shows the declining trends in adjusted and unadjusted mortality rates for Medicare patients. The co-occurrences of DM and CVD with CKD multiply a patient's risk of death, as shown in Figure i.8.

vol 1 Figure i.7 Unadjusted and adjusted all-cause mortality rates (per 1,000 patient years at risk) for Medicare patients aged 66 and older, by CKD status and year, 1995-2012

(a) Unadjusted

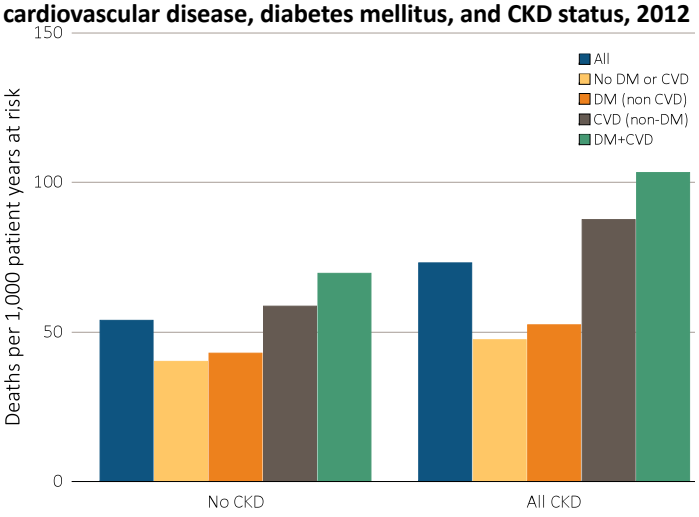


(b) Adjusted



Data source: Medicare 5 percent sample. January 1 point prevalent Medicare patients age 66 and older. Adj: age/sex/race/prior year hospitalization/comorbidities. Ref: 2012 patients. Abbreviations: CKD, chronic kidney disease. This graphic also appears as Figure 3.1.

vol 1 Figure i.8 Adjusted mortality rates (per 1,000 patient years at risk) in Medicare patients aged 66 and older, by cardiovascular disease, diabetes mellitus, and CKD status, 2012

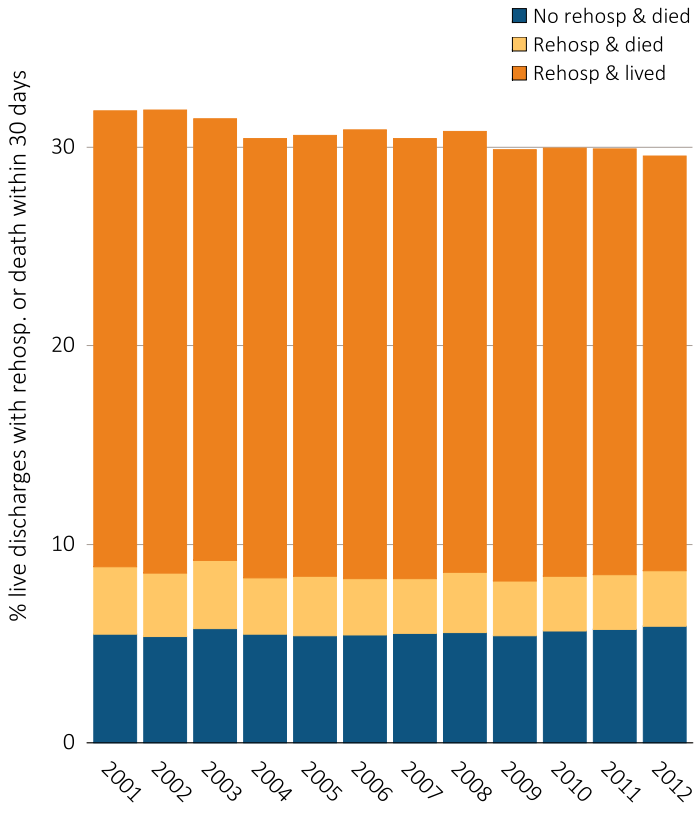


Data source: Medicare 5 percent sample. January 1, 2012 point prevalent patients age 66 and older. Adj: age/sex/race/prior year hospitalization/comorbidities. Ref: all patients, 2012. Abbreviations: CKD, chronic kidney disease; CVD, cardiovascular disease; DM, diabetes mellitus. This graphic also appears as Figure 3.4.

One consistent finding regarding hospitalization in the CKD population is an increasing rate of both overall and cause-specific admissions with advancing stages of CKD. When data are adjusted for age, race, sex, prior year hospitalization, and several comorbidities, CKD patients are hospitalized at a rate of 0.40 admissions per patient year overall—0.35 for Stages 1-2, 0.40 for Stage 3, and 0.55 for Stages 4-5 (0.39 where stage is not specified). The USRDS has observed for more than a decade that rates of hospitalization for cardiovascular disease and infection also rise with CKD stage (Go et al., 2004). In general, hospitalizations in CKD patients also increase in the presence of underlying comorbidities, such as DM and CVD.

Hospital readmissions are a key quality indicator for the Medicare program. In an attempt to lower the rate of readmission, the Medicare Hospital Readmission Reduction Program was instituted as part of the Patient Protection and Affordable Care Act, reducing Medicare payments to hospitals with excess readmissions (CMS, 2010). Rates of rehospitalization for CKD patients are higher than those for patients without diagnosed CKD. In 2012, 24 percent of patients with CKD were readmitted within 30 days, compared to 17 percent of those without CKD. As shown in Figure i.9, these rates have not changed significantly in the past decade, which is of major concern.

vol 1 Figure i.9 Adjusted percentage readmitted to the hospital within 30 days of discharge, among Medicare CKD patients aged 66 and older, discharged alive from an all-cause index hospitalization between January 1 and December 1, by year, 2001-2012



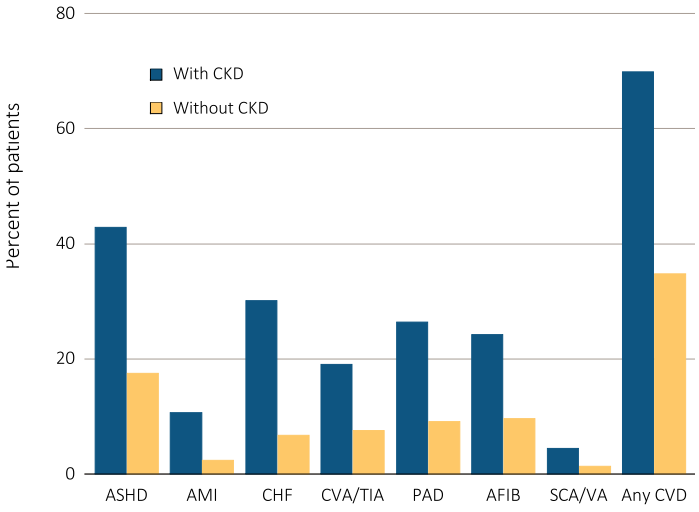
Data source: Medicare 5 percent sample. January 1 of each reported year point prevalent, Medicare patients age 66 and older with CKD (defined during the prior year) discharged alive from an all-cause index hospitalization between January 1 and December 1 of the reported year. Adj: age/sex/race. Ref: 2012. Abbreviations: CKD, chronic kidney disease; Rehosp, rehospitalized. This graphic also appears as Figure 3.14.

Rates of hospitalization, and of rehospitalization within 30 days, are progressively higher with advancing CKD. The issue of rehospitalization has received more attention for patients in the general population than for those with CKD, despite the fact that the rate for CKD patients is almost 40 percent higher. The rate accelerates as patients approach ESRD, reaching 43 percent in the month prior to ESRD initiation (USRDS, 2013). These data show the substantial burden of disease and needed care in the CKD population, burdens also illustrated through the data on mortality and CVD in CKD patients.

Chapter 4: Cardiovascular Disease in Patients with CKD

Chapter 4 explores cardiovascular disease as an important comorbidity for patients with CKD. CKD patients are at high-risk for CVD, and the presence of CKD often complicates CVD treatment and prognosis. This year we continue to examine Medicare data with respect to the interaction of CKD and CVD. Figure i.10 shows that the prevalence of any cardiovascular disease defined using Medicare claims is twice as high for those with CKD compared to those without (69.8 percent versus 34.8 percent).

vol 1 Figure i.10 Cardiovascular disease in patients with or without CKD, 2012



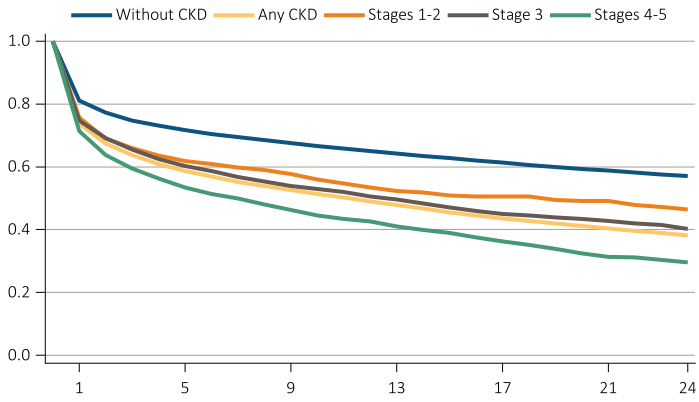
Data Source: Medicare 5 percent sample. Patients age 66 and older, alive, without end-stage renal disease, and residing in the U.S. on 12/31/2012 with fee-for-service coverage for the entire calendar year. Abbreviations: AFIB, atrial fibrillation; AMI, acute myocardial infarction; ASHD, atherosclerotic heart disease; CHF, congestive heart failure; CKD, chronic kidney disease; CVA/TIA, cerebrovascular accident/transient ischemic attack; CVD, cardiovascular disease; PAD, peripheral arterial disease; SCA/VA, sudden cardiac arrest and ventricular arrhythmias. This graphic also appears as Figure 4.1.

It is of note that atherosclerotic heart disease (ASHD) is the most frequent CVD linked to CKD; its prevalence in CKD patients aged 66 years and older exceeded 40 percent in 2012. This data also shows that the proportion of CVD patients undergoing cardiovascular procedures was higher among those with CKD that those without. This is gratifying to note, and suggests that 'therapeutic nihilism' toward those with CKD might well be on the decline. However, this issue will require further examination.

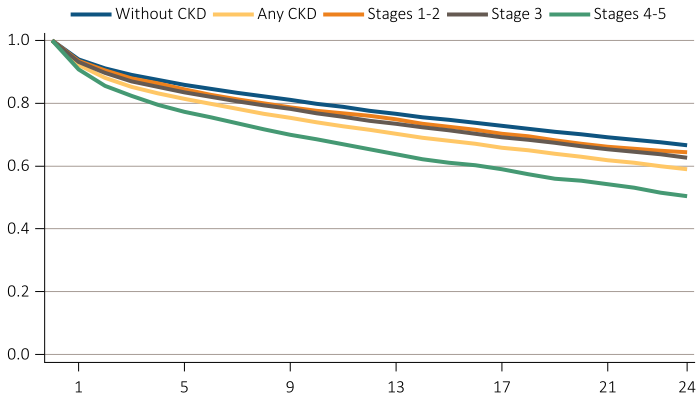
The presence of CKD worsens the short- and long-term prognosis for CVD and many interventions, as shown in Figure i.11.

vol 1 Figure i.11 Survival of patients with a cardiovascular diagnosis or procedure, by CKD status, 2010-2012

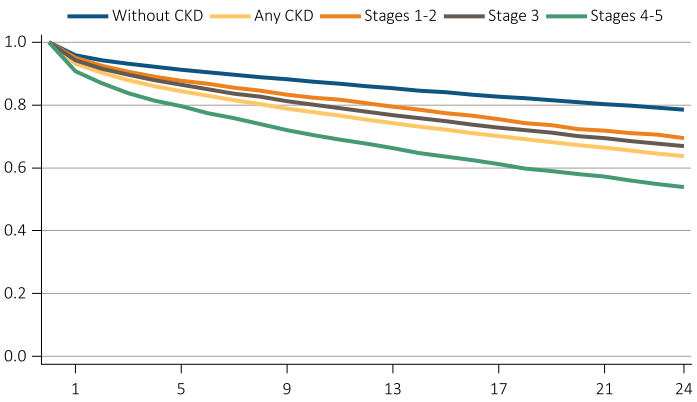
(a) AMI



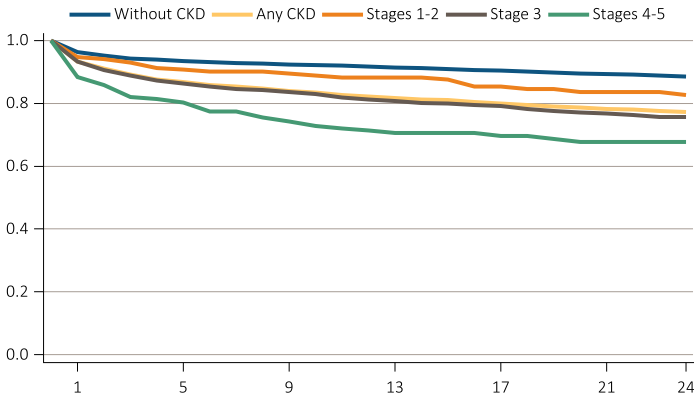
(b) CHF



(c) CVA/TIA



(d) CABG

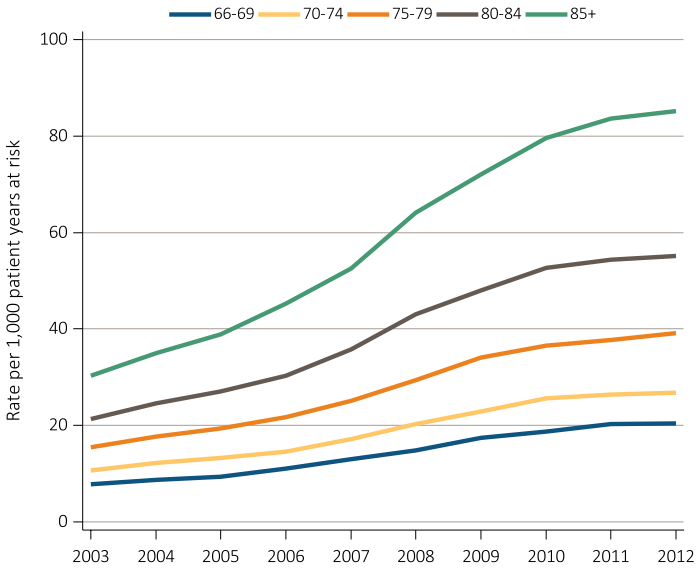


Data Source: Medicare 5 percent sample. Patients age 66 and older, alive, without end-stage renal disease, and residing in the U.S. on 12/31/2012 with fee-for-service coverage for the entire calendar year. Abbreviations: AMI, acute myocardial infarction; CABG, coronary artery bypass grafting; CHF, congestive heart failure; CKD, chronic kidney disease; CVA/TIA, cerebrovascular accident/transient ischemic attack. This graphic is adapted from Figure 4.2.

Chapter 5: Acute Kidney Injury

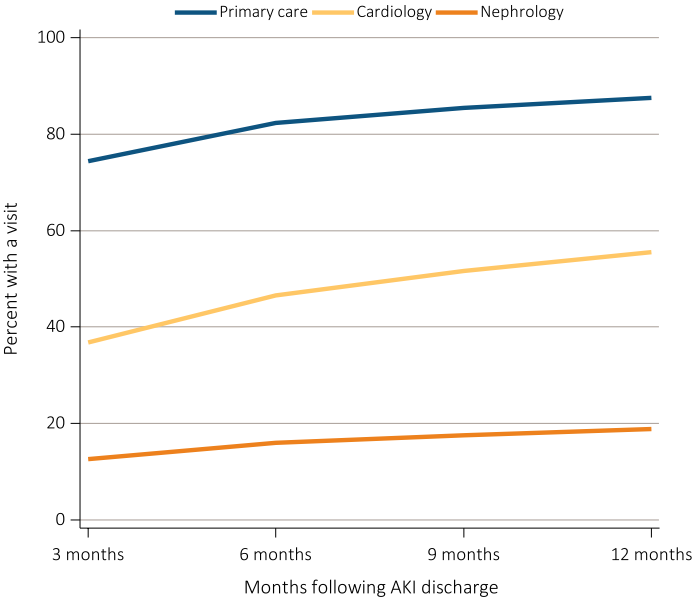
This year we continue to highlight AKI data in Chapter 5. Over the past decade, there has been a rising incidence in AKI hospitalizations among Medicare patients. The incident rate of AKI increases with age, as shown in Figure i.12. The probability of having a follow-up visit with a nephrologist within one year of an AKI hospitalization remains less than 20 percent, as shown in Figure i.13, while follow-up with serum creatinine testing after an AKI hospitalization is generally high (exceeding 90 percent by 12 months, as shown in Figure i.14).

vol 1 Figure i.12 Unadjusted rates of first hospitalization with AKI for Medicare patients aged 66+ by age and year, 2003-2012



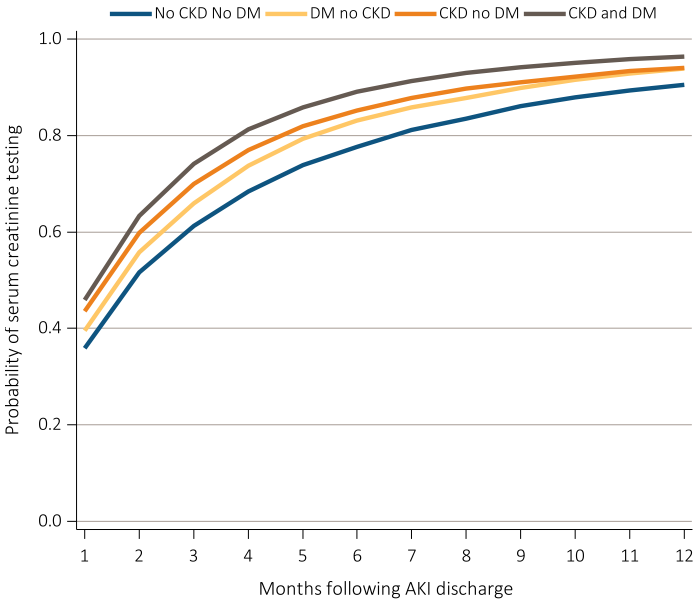
Data Source: Medicare 5 percent sample. Age as of January 1 of specified year. All patient-years at risk for Medicare patients aged 66 or older who had both Medicare Parts A & B, no Medicare Advantage plan (Part C/HMO), no ESRD by first service date from Medical Evidence form, and were alive on January 1 of year shown. Censored at death, ESRD, end of Medicare Parts A & B participation, or switch to Medicare Advantage program. Abbreviations: AKI, acute kidney injury. This graphic also appears as Figure 5.2.

vol 1 Figure i.13 Outpatient physician visits within one year of live discharge from first AKI hospitalization in 2011 for Medicare patients aged 66+ by physician specialty and time



Data Source: Medicare 5 percent sample. Medicare patients aged 66 and older who had both Medicare Parts A & B, no Medicare Advantage plan (Part C/HMO), no ESRD by first service date from Medical Evidence form on 1/1/2011, and were discharged alive from a first AKI hospitalization in 2011. For each time point, the denominator is all patients alive, without ESRD, not in a Medicare Advantage plan and with Medicare Parts A & B. Physician visits are from physician/supplier claims with provider specialty codes for primary care (01, 08-family practice, 11-internal medicine), cardiology (06), and nephrology (39) and claim source indicating an outpatient setting. Abbreviations: AKI, acute kidney injury. This graphic also appears as Figure 5.9.

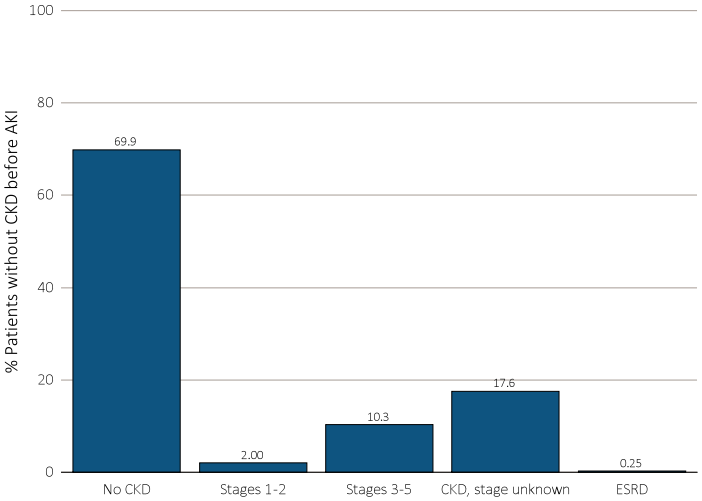
vol 1 Figure i.14 Cumulative probability of a claim for a serum creatinine test within one year of live discharge from first AKI hospitalization in 2011 for Medicare patients aged 66+, by CKD, DM and time



Data Source: Medicare 5 percent sample. Medicare patients aged 66 and older who had both Medicare Parts A & B, no Medicare Advantage plan (Part C/HMO), no ESRD by first service date from Medical Evidence form on 1/1/2011, and were discharged alive from a first AKI hospitalization in 2011. 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. Censored at death, ESRD, end of Medicare Parts A & B participation, or switch to Medicare Advantage program. Abbreviations: AKI, acute kidney injury; CKD, chronic kidney disease; DM, diabetes mellitus; This graphic also appears as Figure 5.11.

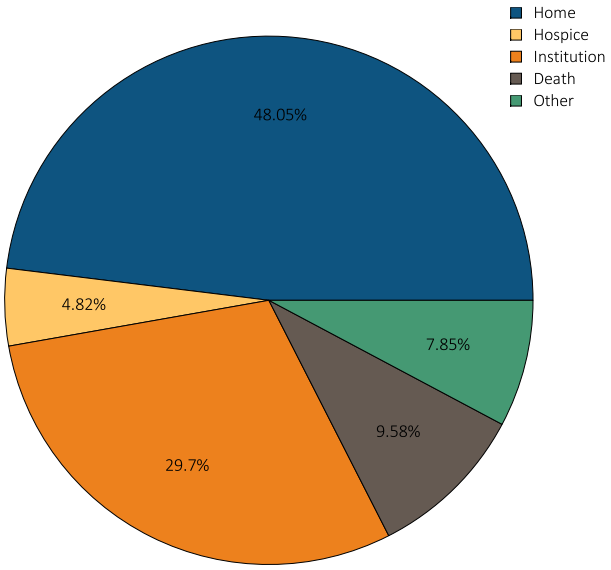
AKI is associated with decline in both renal and functional status. Specifically, nearly 30 percent of patients without claims for CKD in the year before an AKI hospitalization have claims for CKD in the 365 days following their AKI discharge, as presented in Figure i.15. Figure i.16 shows the discharge status from the AKI hospitalization claim for patients with AKI. Approximately 30 percent of patients that were not admitted from a long-term care facility are discharged to an institution (e.g., short and long-term nursing facilities, rehabilitation hospitals) rather than to home.

vol 1 Figure i.15 Renal status one year following discharge from AKI hospitalization in 2010-2011, among surviving Medicare patients aged 66+ without kidney disease prior to AKI hospitalization, by CKD stage and ESRD status



Data Source: Medicare 5 percent sample. Medicare patients aged 66 and older who had both Medicare Parts A & B, no Medicare Advantage plan (Part C/HMO), did not have ESRD, were discharged alive from a first AKI hospitalization in 2010 or 2011, 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 I. This graphic also appears as Figure 5.13.

vol 1 Figure i.16 Hospital discharge status of first AKI hospitalization for Medicare patients aged 66+, 2012



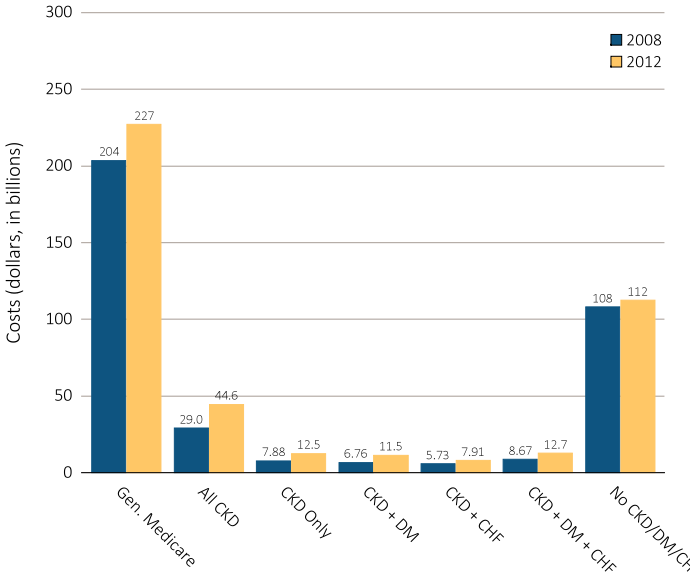
Data Source: Medicare 5 percent sample. Medicare patients aged 66 or older who had both Medicare Parts A & B, no Medicare Advantage plan (Part C/HMO), did not have ESRD on 1/1/2012 and had a first AKI hospitalization in 2012. Institution includes short-term skilled nursing facilities, rehabilitation hospitals, and long-term care facilities. Home also includes patients receiving home health care services. Excludes patients admitted to the acute care hospital from a skilled nursing facility. Abbreviation: AKI, acute kidney injury. This graphic also appears as Figure 5.14.

Chapter 6: Costs of CKD

Chapter 6 contrasts the expenditures of the Medicare program on health care services for enrollees overall, with spending for those with CKD, DM, and CHF. Determining the financial impact of CKD on the health care system is challenging on several levels. First, the considerable under-recognition of CKD reduces the estimated CKD-related total expenditures. Furthermore, the costs of managing CKD are influenced by its interactions with CVD, DM, stroke, infections and other comorbidities. Thus, it is not possible to attribute health care expenditures to mutually exclusive diagnostic categories. In this ADR, we present only Medicare Parts A and B cost data (estimated from the five percent Medicare sample). The costs associated with the recognized CKD population are considerable, and increase with worsening CKD stage; this is consistent with the rising burden of CVD and other chronic diseases with advancing CKD.

Figure i.17 displays 2008-2012 global cost comparisons between the general Medicare population and patients with recognized CKD, or comorbid CKD with DM and/or CHF. More detailed analyses presented in Chapter 6 of this volume illustrate the disproportionate extent of Medicare expenditures when the sizes of these cohorts are considered.

vol 1 Figure i.17 Overall Medicare Parts A and B costs for fee-for-service patients aged 65 and older, by CKD, DM, CHF, and year, 2008 and 2012



Data source: Medicare 5 percent sample. Abbreviations: CKD, chronic kidney disease; CHF, congestive heart failure, DM, diabetes mellitus. This graphic also appears as Figure 6.1.

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Chapter 1: CKD in the General Population

Introduction

In this chapter we provide single-sample, cross-sectional estimates of kidney function through data downloaded in 2014 from the National Health and Nutrition Examination Survey (NHANES) database, a valuable source of information for assessing disease prevalence and at-risk subsets in a representative sample of non-institutionalized U.S. adults. Note that there was no data collection in NHANES during 1995-1998.

The biochemical data available in NHANES are used to evaluate kidney function, usually by estimating glomerular filtration rate (eGFR) and urinary albumin excretion. As with assessment of prevalence of other diseases in this national survey, kidney function is estimated at a single point in time. In clinical practice, defining chronic kidney disease (CKD) would typically require multiple assessments of kidney function and urine protein over weeks or months. Due to the fact that repeated measures of kidney function were only conducted in a voluntary subset of the 1988–1994 NHANES participants, we are forced to rely on a single, cross-sectional sample to estimate the prevalence of CKD in the U.S. adult population, and to determine CKD trends over time. Thus, estimates of CKD reported in this chapter will be higher than would be the case if measures of eGFR and urine albumin/creatinine ratio (ACR) were repeated over time to fulfill the persistence criterion in the clinical definition of CKD.

Other chapters in this volume identify presence of CKD and its related stages based on ICD-9-CM (International Classification of Diseases, 9th revision, clinical modification) diagnosis codes. Because the NHANES database does not contain diagnostic information, we must use alternate definitions. For this Annual Data Report, we developed criteria underlying the definition of CKD based upon the KDIGO 2012 Clinical Practice Guideline for the Evaluation and Management of Chronic Kidney Disease (KDIGO, 2012). First, we evaluate kidney function by eGFR; individuals with eGFR <60 ml/min/1.73m^2 are considered to have reduced kidney function (eGFR was calculated using the CKD-EPI creatinine equation [Levey et al., 2009]). Secondly, we use the ACR to assess urinary albumin excretion and consider three categories of measurements: <30 mg/g, 30-300 mg/g (microalbuminuria), and >300 mg/g (macroalbuminuria). Lastly, we consider a measure composed of both eGFR and ACR, and classify individuals to have CKD if they have either an eGFR <60 ml/min/1.73m^2 or ACR ≥30 mg/g. Staging of kidney disease follows the Kidney Disease Outcomes and Quality Improvement (KDOQI) CKD guidelines (NKF, 2002).

The chapter begins with an examination of the prevalence of CKD in the U.S. among individuals age 20 or older. We also evaluate the population distributions of eGFR and ACR over time, and the cross-tabulations of the two measures in the 2007-2012 samples, based on the KDIGO categorization. Next, we assess the burden of CKD and interactions with interrelated conditions of public health relevance—diabetes mellitus (DM), hypertension (HTN), self-reported cardiovascular disease (SR CVD), and obesity—by comparing prevalence estimates based on eGFR to those based on ACR. Table 1.1 displays the importance of CKD as a non-communicable disease, and shows that a large proportion of individuals with kidney disease also suffer from DM, SR CVD, or has all three conditions.

Stages of CKD - KDOQI 2002 definitions

Stage 1:	eGFR ≥ 90 ml/min/1.73m^2 and ACR ≥ 30 mg/g
Stage 2:	eGFR 60-89 ml/min/1.73m^2 and ACR ≥ 30 mg/g
Stage 3:	eGFR 15-29 ml/min/1.73m^2
Stage 4:	eGFR 15-29 ml/min/1.73m^2
Stage 5:	eGFR < 15 ml/min/1.73m^2

vol 1 **Table 1.1 Distribution of NHANES participants with diabetes, cardiovascular disease, & single sample markers of CKD, 2007-2012**

	Percent of NHANES population	
No DM, CVD, or CKD	76.5	.
DM only	5.0	.
CVD only	3.9	.
DM & CVD	1.0	.
All CKD	13.6	.
CKD only	.	8.0
DM & CKD	.	2.4
CVD & CKD	.	1.7
DM & CVD & CKD	.	1.5
Total	**100.00**	**13.6**

Data Source: National Health and Nutrition Examination Survey (NHANES), 1988–1994, 1999-2004 & 2005–2012 participants age 20 & older. Note: Cardiovascular disease designation is based on self-report of any CVD condition (see CKD Analytical Methods chapter for detail); CKD is defined as eGFR <60 or ACR ≥30. Abbreviations: ACR, urine albumin/creatinine ratio; CKD, chronic kidney disease; CVD, cardiovascular disease; DM, diabetes mellitus; eGFR, estimated glomerular filtration rate; . not applicable.

Through exploring the implications of kidney function and related comorbidities of DM, HTN, and SR CVD in the general population, this chapter sets the stage for Chapter 2 (Vol. 1, *Identification and Care of Patients with Chronic Kidney Disease*). There we discuss CKD as recognized in the health care system by using Medicare claims data, providing extensive information on morbidity, interventions, and costs.

We conclude this chapter by examining awareness, treatment, and control of major risk factors for CKD, and illustrating the impact of hypertension, total cholesterol, uric acid, smoking, and glycemic control within populations of subjects with eGFR <60 or ACR ≥30. It will be important to determine whether changes in the awareness, treatment, and control of major risk factors translate into reduced rates of cardiovascular events, death, and progression of CKD to end-stage renal disease.

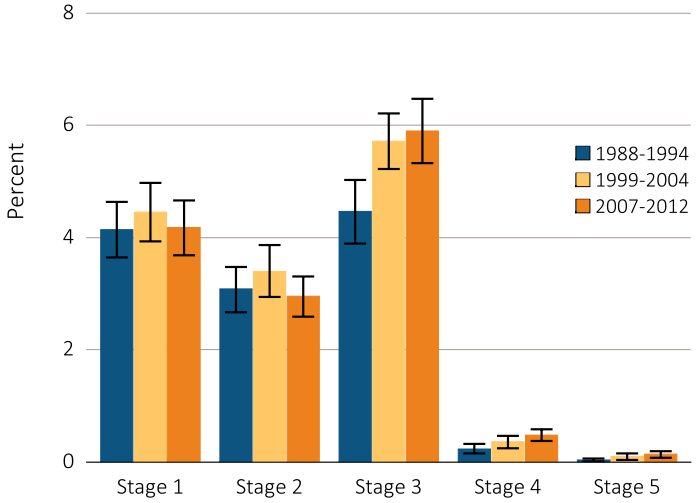
Analytical Methods

See the CKD Analytical Methods chapter for an explanation of analytical methods used to generate the figures and tables in this chapter.

Prevalence of CKD

The overall prevalence of CKD increased from 1988-1994 to 1999-2004 (12 percent to 14 percent) but has since remained stable. Figure 1.1 shows that the largest increase occurred in Stage 3 CKD, which rose from 4.5 percent to 6.0 percent over the three time periods. Stages 1 and 2 increased from 1988-1994 to 1999-2004, but then reverted to 1998-1994 levels in the most recent years.

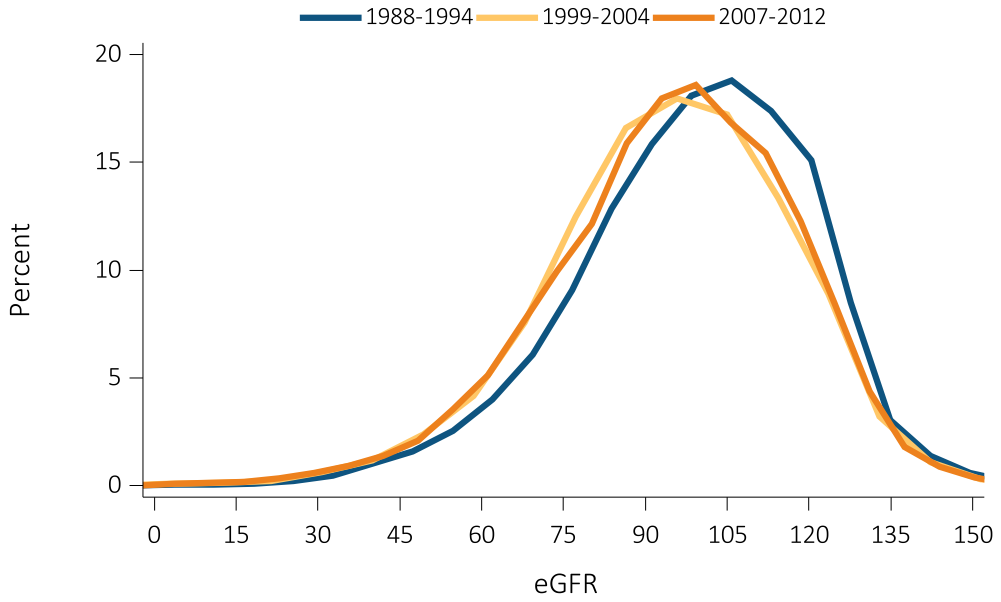
vol 1 **Figure 1.1 Prevalence of CKD by stage among NHANES participants, 1988-2012**



Data Source: National Health and Nutrition Examination Survey (NHANES), 1988–1994, 1999-2004 & 2005–2012 participants age 20 & older. Whisker lines indicate 95% confidence intervals. Abbreviations: CKD, chronic kidney disease.

Figure 1.2 illustrates density distributions of eGFR in 1988–1994, 1999-2004 and 2007-2012. Overall, a population shift towards lower eGFR levels was observed from the 1988-1994 baseline, with most of the leftward shift confined to eGFR levels between 50 and 130 ml/min/1.73 m^2. Figure 1.3, with corresponding findings for ACR, shows little change in the distribution patterns over the three eras.

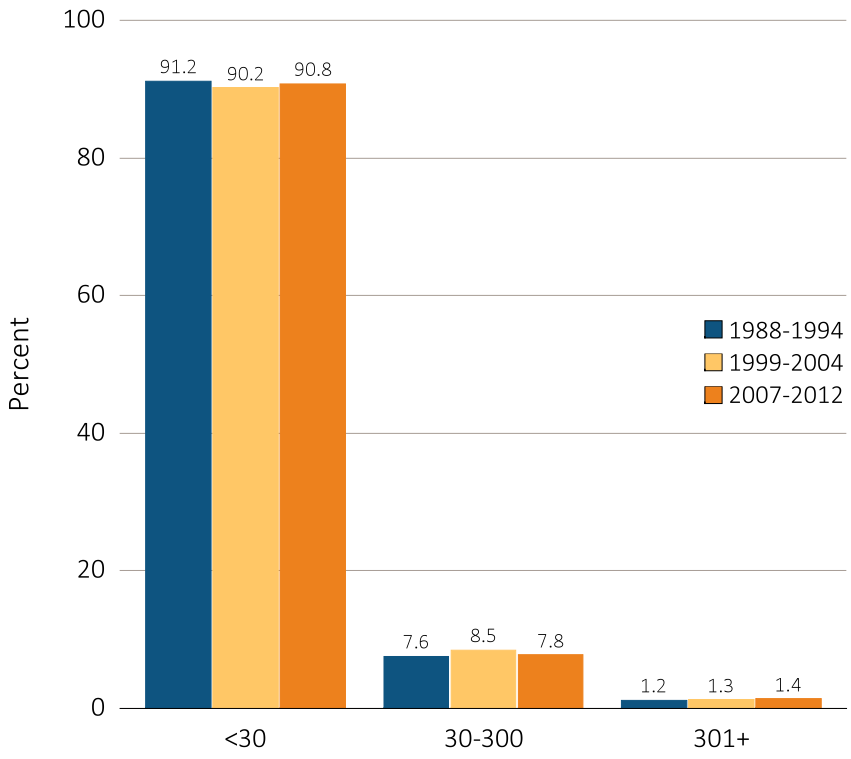
vol 1 Figure 1.2 eGFR distribution curves among NHANES participants, 1988-2012



Data Source: National Health and Nutrition Examination Survey (NHANES), 1988–1994, 1999-2004 & 2005–2012 participants age 20 & older. Single-sample estimates of eGFR & ACR; eGFR calculated using the CKD-EPI equation. Abbreviations: ACR, urine albumin/creatinine ratio; eGFR, estimated glomerular filtration rate.

Albuminuria increases as kidney function decreases. For example, in the 2007 to 2012 NHANES sample, 6.5 percent of persons with normal (>90 eGFR) kidney function had some evidence of albuminuria. This rate increases rapidly as kidney function declines, to 9.4 percent for eGFR 60-90, 22.2 percent for 45-59, and 46.7 percent for 30-44. For persons with very poor kidney function (eGFR <30), over half have evidence of micro or macroalbuminuria (Table 1.2). Over these time periods there was also an increase in the percent of individuals in the higher risk KDIGO categories, increasing from 12 percent of 1988-1994 participants to approximately 14 percent for both 1999-2004 and 2007-2012 participants.

vol 1 Figure 1.3 Urine albumin/creatinine ratio distribution of NHANES participants, 1988-2012



Data Source: National Health and Nutrition Examination Survey (NHANES), 1988–1994, 1999-2004 & 2005–2012 participants age 20 & older. Single-sample estimates of eGFR & ACR; eGFR calculated using the CKD-EPI equation. Abbreviations: ACR, urine albumin/creatinine ratio; eGFR, estimated glomerular filtration rate.

vol 1 **Table 1.2 Percentage of NHANES participants within the KDIGO 2012 prognosis of CKD by GFR and albuminuria categories, 1998-2012**

NHANES III (1988-1994)

Low risk =	*88.0%*
Moderately increased risk =	*9.0%*
High risk =	*2.1%*
Very high risk =	*0.9%*

				Albuminuria categories			
				A1	A2	A3	
				Normal to mildly increased	Moderately increased	Severely increased	
				<30 mg/g <3 mg/mmol	30-300 mg/g 3-30 mg/mmol	>300 mg/g >30 mg/mmol	**Total**
GFR categories (ml/min/1.73 m^2)	G1	Normal to high	≥ 90	64.8	3.8	0.4	**69.0**
	G2	Mildly decreased	60-89	23.2	2.7	0.4	**26.3**
	G3a	Mildly to moderately decreased	45-59	2.5	0.7	0.2	**3.4**
	G3b	Moderately to severely decreased	30-44	0.6	0.4	0.1	**1.1**
	G4	Severely decreased	15-29	0.1	0.1	0.1	**0.3**
	G5	Kidney failure	< 15	0.002	0.01	0.03	**0.04**
		Total		**91.2**	**7.7**	**1.2**	**100**

NHANES (1999-2004)

Low risk =	*85.9%*
Moderately increased risk =	*10.5%*
High risk =	*2.3%*
Very high risk =	*1.3%*

				Albuminuria categories			
				A1	A2	A3	
				Normal to mildly increased	Moderately increased	Severely increased	
				<30 mg/g <3 mg/mmol	30-300 mg/g 3-30 mg/mmol	>300 mg/g >30 mg/mmol	**Total**
GFR categories (ml/min/1.73 m^2)	G1	Normal to high	≥ 90	55.3	4.1	0.4	**59.8**
	G2	Mildly decreased	60-89	30.6	3.1	0.3	**34.0**
	G3a	Mildly to moderately decreased	45-59	3.3	0.8	0.2	**4.3**
	G3b	Moderately to severely decreased	30-44	0.8	0.4	0.2	**1.4**
	G4	Severely decreased	15-29	0.1	0.1	0.1	**0.3**
	G5	Kidney failure	< 15	0.03	0.03	0.05	**0.1**
		Total		**90.1**	**8.5**	**1.3**	**100**

NHANES (2007-2012)

Low risk =	*86.2%*
Moderately increased risk =	*9.8%*
High risk =	*2.3%*
Very high risk =	*1.7%*

				Albuminuria categories			
				A1	A2	A3	
				Normal to mildly increased	Moderately increased	Severely increased	
				<30 mg/g <3 mg/mmol	30-300 mg/g 3-30 mg/mmol	>300 mg/g >30 mg/mmol	**Total**
GFR categories (ml/min/1.73 m^2)	G1	Normal to high	≥ 90	57.4	3.8	0.2	**61.4**
	G2	Mildly decreased	60-89	28.8	2.5	0.5	**31.8**
	G3a	Mildly to moderately decreased	45-59	3.5	0.8	0.2	**4.5**
	G3b	Moderately to severely decreased	30-44	0.8	0.6	0.1	**1.5**
	G4	Severely decreased	15-29	0.2	0.2	0.1	**0.5**
	G5	Kidney failure	< 15	0.02	0.05	0.07	**0.1**
		Total		**90.7**	**8.0**	**1.2**	**100**

Data source: National Health and Nutrition Examination Survey (NHANES), 1988-1994, 1999-2004 & 2007-2012 participants age 20 and older. Single-sample estimates of eGFR and ACR; eGFR calculated using the CKD-EPI equation. Abbreviations: ACR, urine albumin/creatinine ratio; CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate; GFR, glomerular filtration rate; KDIGO, Kidney Disease: Improving Global Outcomes CKD Work Group.

Comorbidity and Risk Factors

Many studies have shown that older age, diabetes mellitus, hypertension, cardiovascular disease and higher body mass index (BMI) are associated with CKD. Data showing the percentage of adult NHANES participants with either a spot eGFR <60 ml/min/1.73 m² or a spot ACR ≥30 mg/g confirms higher estimated prevalence in the presence of each of these risk factors (Table 1.3).

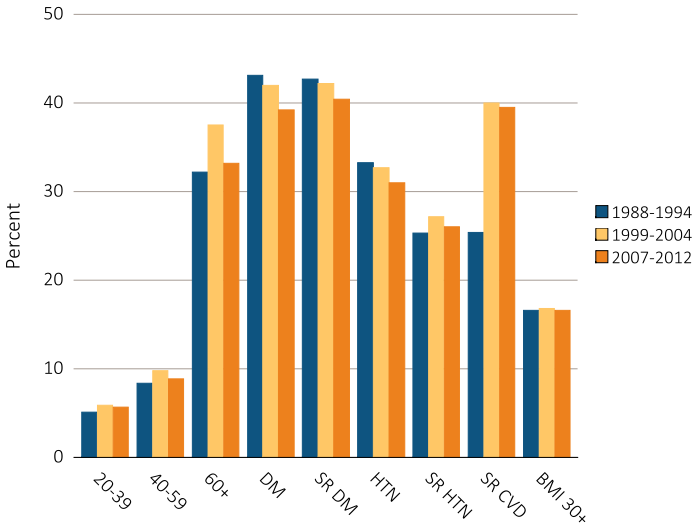
Estimates of GFR less than 60 ml/min/1.73 m² and ACR ≥30 mg/g for adult NHANES participants are shown in Table 1.3. For the presence of either eGFR <60 or ACR ≥30, prevalence estimates rose from 12.0 to 14.0 and then decreased to 13.6 percent. The largest relative increase (1.6-fold) was seen in those with SR CVD, where estimates rose from 25.4 percent in 1988-1994 to 40.0 percent in 1999-2004 and 39.5 percent in 2007-2012. The prevalence of eGFR <60 rose from 4.9 to 6.2 and then to 6.5 percent over the three periods, with the largest relative increase (1.5-fold) in those aged 40–59 (from 1988-1994 to 1999-2004). Prevalence for ACR ≥30 first rose from 8.8 to 9.8, then declined to 9.2 percent across the three periods; this changed from 16.6 to 23.0, and then to 23.8 percent for those with SR CVD.

vol 1 **Table 1.3 Prevalence (%) of CKD in NHANES population within age, sex, race/ethnicity, & risk-factor categories, 1998-2012**

	All CKD			eGFR <60			ACR ≥30		
	1988-1994	1999-2004	2007-2012	1988-1994	1999-2004	2007-2012	1988-1994	1999-2004	2007-2012
20-39	5.1	5.9	5.7	0.1	0.3	0.2	5.0	5.8	5.5
40-59	8.4	9.8	8.9	1.3	2.0	2.3	7.5	8.4	7.2
60+	32.2	37.5	33.2	19.1	25.1	22.7	18.0	20.1	17.7
Male	10.2	12.3	12.1	4.1	5.0	5.4	7.4	9.2	8.7
Female	14.2	15.7	15.1	5.6	7.2	7.6	10.2	10.3	9.6
Non-Hispanic White	12.3	14.0	13.9	5.5	7.0	7.6	8.2	8.9	8.4
Non-Hispanic Black/Af Am	14.5	14.9	15.9	4.1	5.0	6.2	12.7	12.4	12.3
Other	10.5	13.5	11.7	2.2	3.4	3.1	9.2	11.7	10.1
Diabetes	43.1	42.0	39.2	15.6	17.0	19.6	36.3	33.3	28.6
Self-reported diabetes	42.7	42.2	40.4	16.4	18.5	21.1	35.9	32.6	29.3
Hypertension	33.3	32.7	31.0	15.3	17.1	17.1	23.4	21.3	19.8
Self-reported hypertension	25.3	27.2	26.0	12.9	15.8	15.2	17.1	16.4	16.2
Self-reported cardiovascular disease	25.4	40.0	39.5	14.5	27.3	26.8	16.6	23.0	23.8
Obesity (BMI 30+)	16.6	16.8	16.6	6.2	6.4	7.3	12.3	12.6	11.5
All	12.0	14.0	13.6	4.9	6.2	6.5	8.8	9.8	9.2

Data source: National Health and Nutrition Examination Survey (NHANES), 1988-1994, 1999-2004 & 2007-2012 participants age 20 & older. Single-sample estimates of eGFR & ACR; eGFR calculated using the CKD-EPI equation. Diabetes defined as HbA1c >7 percent, self-reported (SR), or currently taking glucose-lowering medications. Hypertension defined as BP ≥130/≥80 for those with diabetes or CKD, otherwise BP ≥140/≥90, or taking medication for hypertension. Values in Figure 1.12 cannot be directly compared to those in Table 1.3 due to different Survey cohorts. The table represents NHANES participants who are classified as hypertensive (measured/treated) but some of those are at target blood pressure. Abbreviations: ACR, urine albumin/creatinine ratio; BMI, body mass index; BP, blood pressure, CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate.

vol 1 Figure 1.4 NHANES participants with CKD, by age & risk factor, 1998-2012

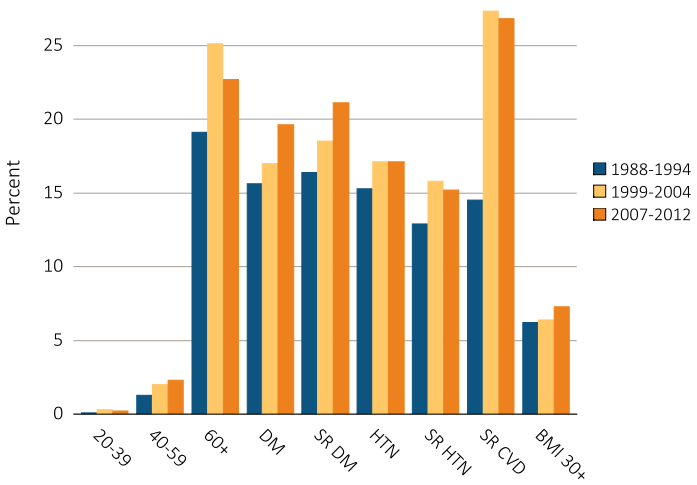


Data Source: National Health and Nutrition Examination Survey (NHANES), 1988–1994, 1999-2004 & 2007–2012 participants age 20 & older. Single-sample estimates of eGFR & ACR; eGFR calculated using the CKD-EPI equation. Diabetes defined as HbA1c >7 percent, self-reported, or currently taking glucose-lowering medications. Hypertension defined as BP ≥130/≥80 for those with diabetes or CKD, otherwise BP ≥140/≥90, or taking medication for hypertension. Abbreviations: ACR, urine albumin/creatinine ratio; BMI, body mass index; CKD, chronic kidney disease; CVD, cardiovascular disease; DM, diabetes mellitus; eGFR, estimated glomerular filtration rate; HTN, hypertension; SR, self-reported.

Figure 1.5 shows that CKD defined by eGFR <60 was much more prevalent in individuals aged 60 and older. Low eGFR reached up to 25 percent in this cohort of the 1999-2004 participants, compared to 0.3 percent in individuals aged 20 to 39 years and 2.0 percent in individuals aged 40 to 59 years. The prevalence of low eGFR also rose in all other comorbid categories after the years 1988-1994, especially in SR CVD; some of the increase may be due to a change in data collection for this variable after the 1988-1994 cohort. While differences in categorization for SR CVD may explain some of the disparities in prevalence estimates for markers of CKD, these substantial differences have yet to be adequately explained.

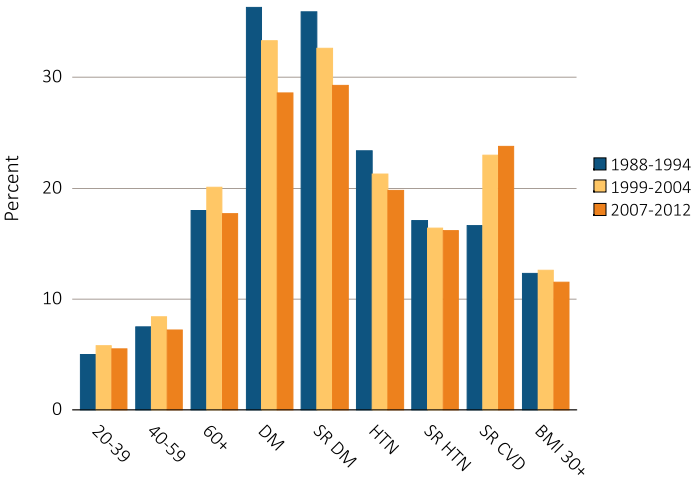
The prevalence of ACR ≥30 mg/g has decreased over the three time periods among individuals with DM, self-reported DM, HTN, self-reported HTN, and high BMI (Figure 1.6). Prevalence also increased in the older age groups, but less markedly than for eGFR <60.

vol 1 Figure 1.5 NHANES participants with eGFR <60 ml/min/1.73 m^2, by age & risk factor, 1998-2012



Data Source: National Health and Nutrition Examination Survey (NHANES), 1988–1994, 1999-2004 & 2007–2012 participants age 20 & older. Single-sample estimates of eGFR & ACR; eGFR calculated using the CKD-EPI equation. Diabetes defined as HbA1c >7 percent, self-reported (SR), or currently taking glucose-lowering medications. Hypertension defined as BP ≥130/≥80 for those with diabetes or CKD, otherwise BP ≥140/≥90, or taking medication for hypertension. Abbreviations: ACR, urine albumin/creatinine ratio; BMI, body mass index; CVD, cardiovascular disease; DM, diabetes mellitus; eGFR, estimated glomerular filtration rate; HTN, hypertension; SR, self-reported.

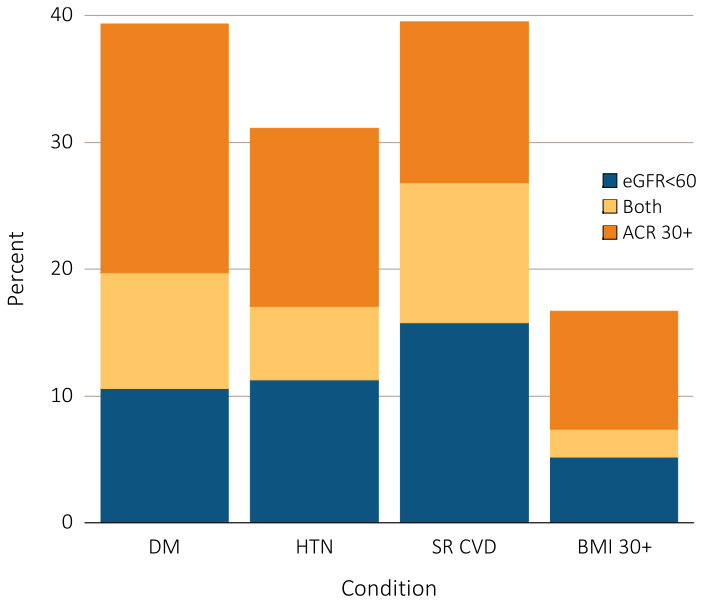
vol 1 Figure 1.6 NHANES participants with urine albumin/creatinine ratio ≥30 mg/g, by age & risk factor, 1998-2012



Data source: National Health and Nutrition Examination Survey (NHANES), 1988–1994, 1999-2004 & 2007–2012 participants age 20 & older. Single-sample estimates of eGFR & ACR; eGFR calculated using the CKD-EPI equation. Diabetes defined as HbA1c >7 percent, self-reported (SR), or currently taking glucose-lowering medications. Hypertension defined as BP ≥130/≥80 for those with diabetes or CKD, otherwise BP ≥140/≥90, or taking medication for hypertension. Abbreviations: ACR, urine albumin/creatinine ratio; BMI, body mass index; CKD, chronic kidney disease; CVD, cardiovascular disease; DM, diabetes mellitus; eGFR, estimated glomerular filtration rate; HTN, hypertension; SR, self-report.

In Figure 1.7 we present the occurrence of eGFR <60 ml/min/1.73 m² and ACR ≥30 mg/g among adult NHANES 2007–2012 participants with diabetes mellitus, hypertension, SR CVD, and body mass index ≥30 kg/m2. eGFR <60 was most prevalent in those with SR CVD, at 26.8 percent, followed by those with diabetes mellitus, hypertension, and high body mass index, at 20.3, 17.2 and 7.4 percent, respectively. ACR ≥30 was most common in those with diabetes mellitus, at 29.3 percent, followed by those with SR CVD, hypertension, and high body mass index, at 19.8, 13.7, and 11.5 percent. The presence of both eGFR <60 and ACR ≥30 was most common with SR CVD, at 15.8 percent, followed by diabetes mellitus, hypertension, and high body mass index, at 9.7, 5.8, and 2.2 percent.

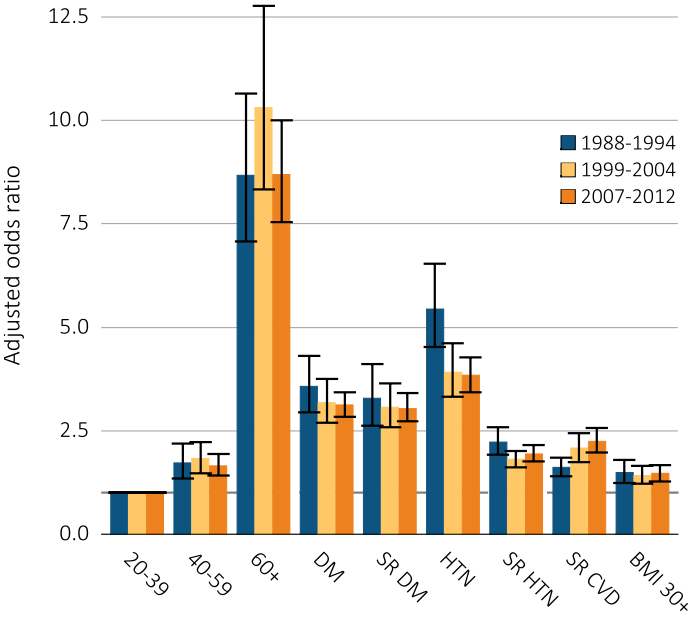
vol 1 Figure 1.7 Distribution of markers of CKD in NHANES participants with diabetes, hypertension, self-reported cardiovascular disease, & obesity, 2007–2012



Data Source: National Health and Nutrition Examination Survey (NHANES), 2007–2012 participants age 20 & older. Single-sample estimates of eGFR & ACR; eGFR calculated using the CKD-EPI equation. Abbreviations: ACR, urine albumin/creatinine ratio; BMI, body mass index; CKD, chronic kidney disease; SR CVD, self-reported cardiovascular disease; eGFR, estimated glomerular filtration rate; HTN, hypertension.

The increase in the odds of eGFR <60 ml/min/1.73 m2, ACR ≥ 30 mg/g, and either eGFR <60 or ACR ≥30 for each of the comorbid conditions are shown in Figures 1.8-1.10 (adjusted for age, sex, and race).

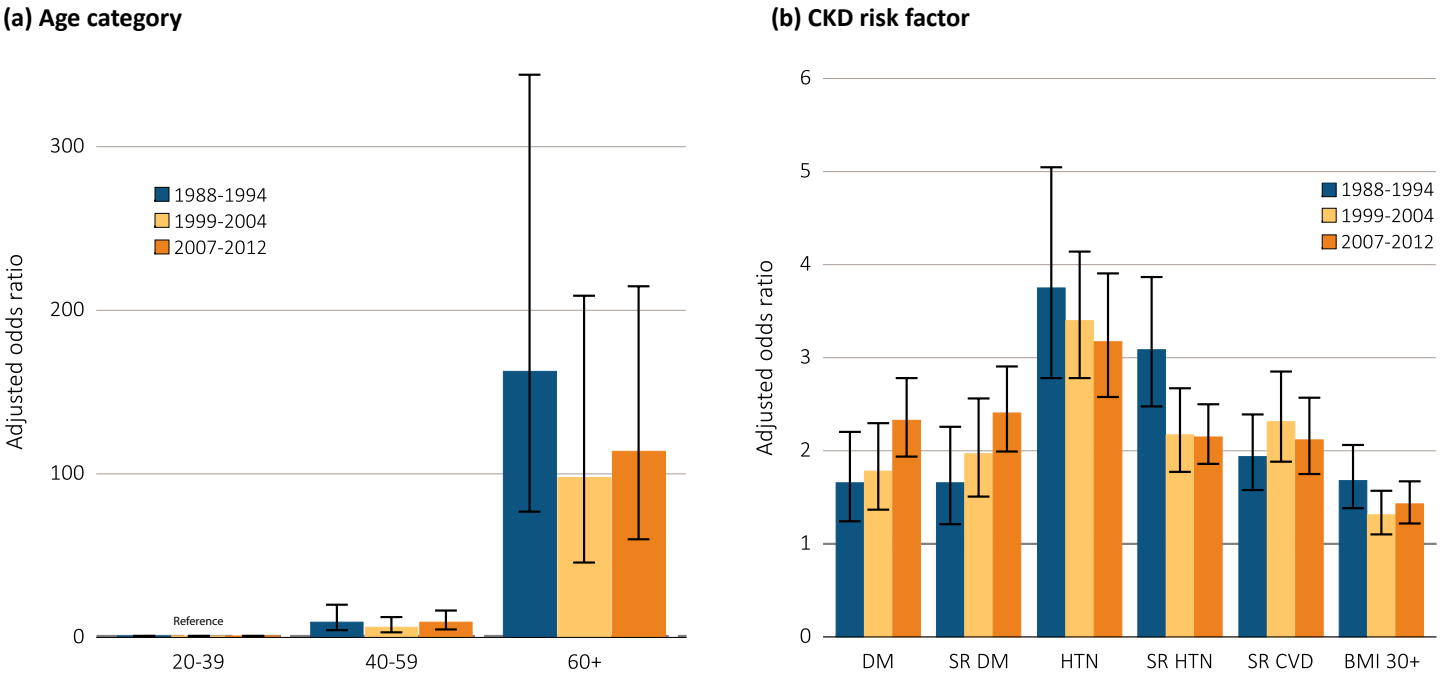
vol 1 Figure 1.8 Adjusted odds ratios of CKD in NHANES participants by risk factor, 1998-2012



Data Source: National Health and Nutrition Examination Survey (NHANES), 1988–1994, 1999-2004 & 2007–2012 participants age 20 & older; single-sample estimates of eGFR & ACR. Adj: age, sex, & race; eGFR calculated using the CKD-EPI equation. Whisker lines indicate 95% confidence intervals. Abbreviations: ACR, urine albumin/creatinine ratio; BMI, body mass index; CKD, chronic kidney disease; CVD, cardiovascular disease; DM, diabetes mellitus; eGFR, estimated glomerular filtration rate; HTN, hypertension; SR, self-report.

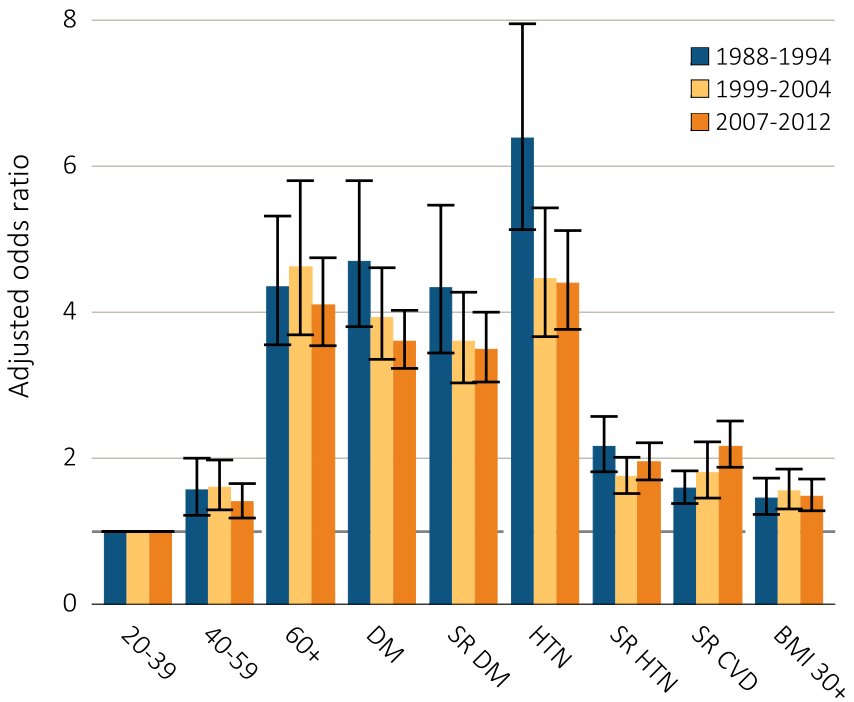
Adjusted odds ratios for eGFR <60 ml/min/1.73 m² or ACR ≥30 mg/g (Figure 1.8) were lower in NHANES 1999-2004 and 2007–2012 participants than in 1988–1994, for each risk factor except SR CVD, where adjusted odds ratios rose from 1.61 to 2.25. For eGFR <60 alone (Figure 1.9), adjusted odds ratios followed a similar pattern, except for diabetes and self-reported diabetes, where the odds increased from 1.66 to approximately 2.35 in both groups. Also, eGFR <60 showed a very strong association with age, with adjusted odds ratios in the 100 range. For ACR ≥30 alone (Figure 1.10), a substantial decline in the adjusted odds ratio is seen among those in both diabetes mellitus (from 4.70 to 3.60) and hypertension categories (from 6.37 to 4.40), while a substantial increase in the adjusted odds ratio is seen for SR CVD (from 1.59 to 2.17).

vol 1 Figure 1.9 Adjusted odds ratios of eGFR <60 ml/min/1.73m2 in NHANES participants by age & risk factor, 1998-2012



Data Source: National Health and Nutrition Examination Survey (NHANES), 1988–1994, 1999-2004 & 2007–2012 participants age 20 & older; single-sample estimates of eGFR & ACR. Adj: age, sex, & race; eGFR calculated using the CKD-EPI equation. Whisker lines indicate 95% confidence intervals. Abbreviations: ACR, urine albumin/creatinine ratio; BMI, body mass index; CKD, chronic kidney disease; CVD, cardiovascular disease; DM, diabetes mellitus; eGFR, estimated glomerular filtration rate; HTN, hypertension; SR, self-report.

vol 1 Figure 1.10 Adjusted odds ratios of urine albumin/creatinine ratio ≥30 mg/g in NHANES participants by age & risk factor, 1998-2012



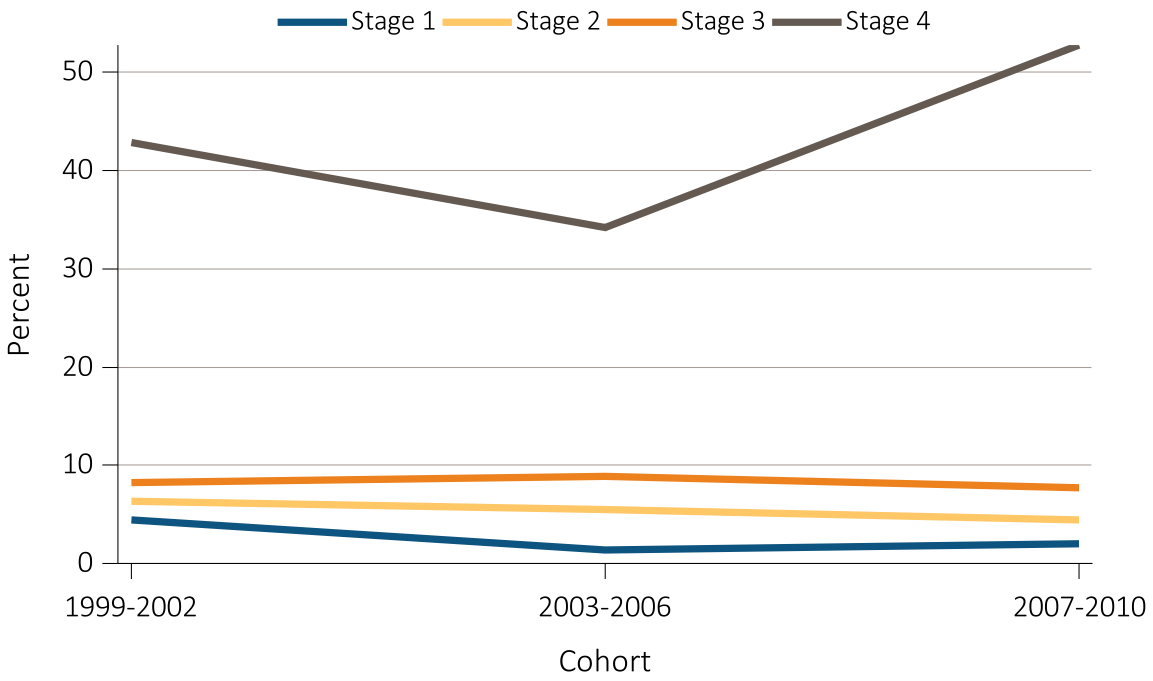
Data Source: National Health and Nutrition Examination Survey (NHANES), 1988–1994, 1999-2004 & 2007–2012 participants age 20 & older; single-sample estimates of eGFR & ACR. Adjusted: age, sex, & race; eGFR calculated using the CKD-EPI equation. Whisker lines indicate 95% confidence intervals. Abbreviations: ACR, urine albumin/creatinine ratio; BMI, body mass index; CKD, chronic kidney disease; CVD, cardiovascular disease; DM, diabetes mellitus; eGFR, estimated glomerular filtration rate; HTN, hypertension; SR, self-report.

Awareness, Treatment, and Control

Among the individuals that are classified as having CKD by laboratory measurements, the percent of those individuals being aware of their kidney disease has remained low over the years 1999-2010 (Figure 1.11), with improvement between the years 2003-2006 and 2007-2010, among Stage 4 individuals. Note that 4-year cohorts are examined in this graphic, the awareness variable was not included in the in the years 1988-1994 and is not available for 2011-2012 sampling of NHANES. Awareness is not presented for Stage 5 CKD due to very small sample size.

Table 1.4 presents awareness, treatment, and control of hypertension, hyperlipidemia, and diabetes mellitus in NHANES 1988–1994, 1999-2004 and 2007–2012 adult participants with eGFR <60 ml/min/1.73 m^2 or ACR ≥30 mg/g. While the prevalence of hypertension among CKD patients was similar in the three periods, at 70 versus 74 percent, the proportion of participants unaware of their hypertension rose from 36 percent to 51 percent in the first two survey time frames and then declined to 24 percent by the third survey period. The proportion of individuals who were aware, treated, and disease-controlled rose steadily from approximately 12 percent in the early cohorts to 27 percent in the 2007-2012 cohort. In the subgroup with diabetes mellitus, glycemic control improved firmly from 31 to 39 and then to 45 percent over the three survey periods.

vol 1 **Figure 1.11 NHANES participants with CKD aware of their kidney disease, 1999-2010**



Data Source: National Health and Nutrition Examination Survey (NHANES), 1988–1994, 1999-2004 & 2007–2012 participants age 20 & older. Abbreviations: CKD, chronic kidney disease.

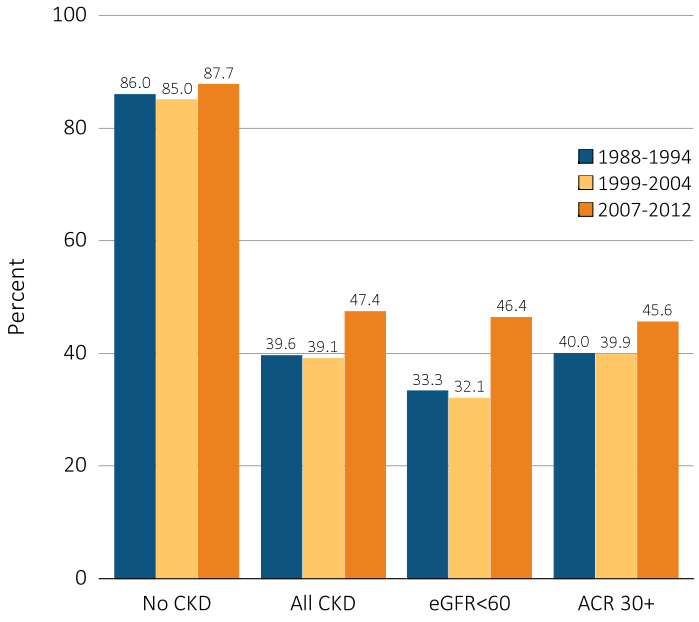
vol 1 Table 1.4 Awareness, treatment, & measures of control of risk factors (% of NHANES participants), 1998-2012

	All CKD			eGFR <60 ml/min/1.73m^2			ACR ≥30		
	1988-1994	1999-2004	2007-2012	1988-1994	1999-2004	2007-2012	1988-1994	1999-2004	2007-2012
Hypertension, by current hypertensive status[a]									
Non-hypertensive status	30.7	26.5	26.0	18.4	14.3	15.9	32.0	30.4	29.1
Hypertensive (measured/treated)	69.3	73.5	74.0	81.6	85.7	84.1	68.0	69.6	70.9
Control of hypertension among hypertensive patients[b]									
Unaware	33.4	50.6	22.5	22.8	44.2	16.4	36.0	54.7	25.1
Aware, not treated	14.7	6.3	6.5	12.1	4.2	2.8	15.7	7.1	8.7
Aware, treated, uncontrolled	39.2	31.5	43.9	47.8	36.4	46.6	38.4	30.2	44.8
Aware, treated, controlled	12.7	11.5	27.2	17.3	15.2	34.2	9.9	8.0	21.4
Total cholesterol[c]									
<200 (desirable)	35.1	46.6	58.7	27.2	45.6	62.1	38.2	47.5	58.2
200–239 (borderline high)	33.5	32.6	26.4	32.7	33.7	23.5	32.8	31.9	27.3
240+ (high)	31.4	20.8	14.9	40.0	20.7	13.4	29.0	20.6	14.5
Uric Acid									
Normal	69.6	69.2	69.2	54.4	55.2	55.1	73.9	74.0	75.4
High	30.4	30.8	30.8	45.6	44.8	44.9	26.1	26.0	24.6
Smoking									
Current	22.2	16.9	14.6	11.9	7.8	8.2	27.0	21.3	17.6
Former	35.2	32.3	32.6	43.2	39.4	40.1	31.5	29.1	29.7
Never	42.6	50.7	52.8	44.9	52.8	51.6	41.5	49.6	52.6
Control of diabetes among patients with diabetes[d]									
Glycohemoglobin <7% (controlled)	31.5	39.2	45.3	37.1	50.9	55.0	29.6	33.6	37.9
Glycohemoglobin 7% or higher (uncontrolled)	68.5	60.8	55.7	62.9	49.1	45.0	70.4	66.4	62.1

Data Source: National Health and Nutrition Examination Survey (NHANES), 1988–1994, 1999-2004 & 2007–2012 participants age 20 & older. Single-sample estimates of eGFR & ACR; eGFR calculated using the CKD-EPI equation. Abbreviations: ACR, urine albumin/creatinine ratio; CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate. [a]. Hypertension defined as blood pressure ≥130/≥80 for those with CKD and diabetes; otherwise ≥140/≥90, or self- reported treatment for hypertension. [b]. Awareness and treatment are self-reported. Control defined as <130/<80 for those with CKD and diabetes; otherwise <140/<90. [c]. Total cholesterol classified according to Adult Treatment Panel III blood cholesterol guidelines (ATP III). [d]. Glycohemoglobin classified according to American Diabetes Association guidelines.

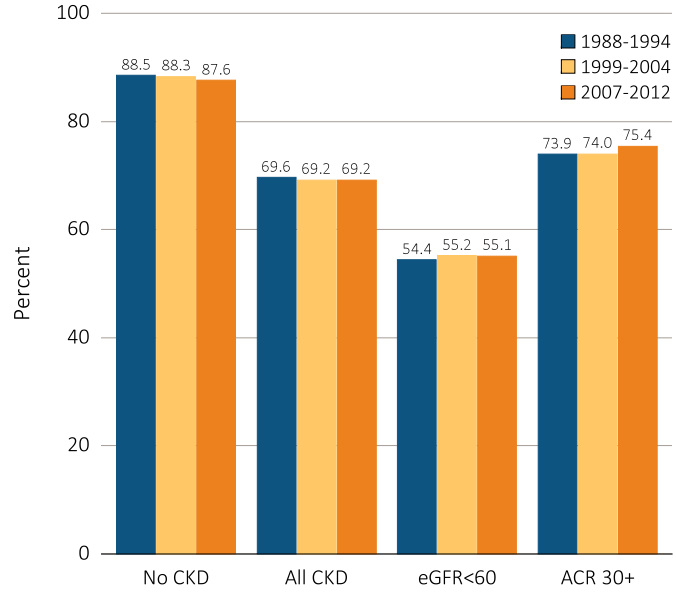
As illustrated by Figures 1.12-1.15, over the periods of 1988–1994, 1999-2004 and 2007–2012, improvements in the management of hypertension, smoking, and hyperglycemia among diabetic participants were present, regardless of whether eGFR or ACR was used for subgroup definition.

vol 1 Figure 1.12 NHANES participants at target blood pressure, 1998-2012



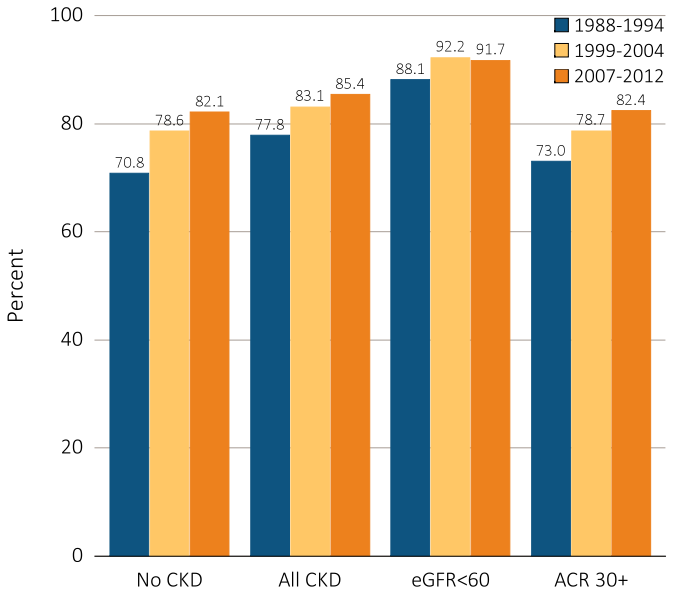
Data Source: National Health and Nutrition Examination Survey (NHANES), 1988–1994, 1999-2004 & 2007–2012 participants age 20 & older. Single-sample estimates of eGFR & ACR; eGFR calculated using the CKD-EPI equation. Figure represents all hypertensives plus those hypertensive participants that are at target blood pressure, probably due to medication. Abbreviations: ACR, urine albumin/creatinine ratio; CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate.

vol 1 Figure 1.13 NHANES participants within uric acid normal range, 1998-2012



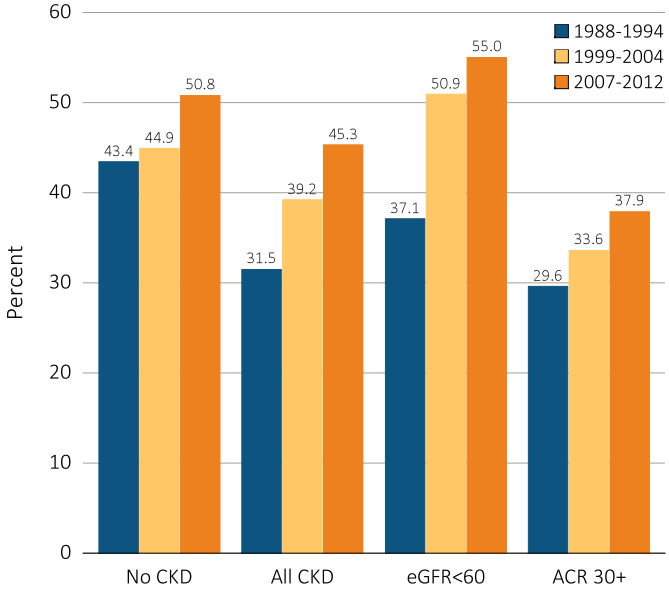
Data Source: National Health and Nutrition Examination Survey (NHANES), 1988–1994, 1999-2004 & 2007–2012 participants age 20 & older. Single-sample estimates of eGFR & ACR; eGFR calculated using the CKD-EPI equation. Abbreviations: ACR, urine albumin/creatinine ratio; CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate.

vol 1 Figure 1.14 NHANES participants not currently smoking, 1998-2012



Data Source: National Health and Nutrition Examination Survey (NHANES), 1988–1994, 1999-2004 & 2007–2012 participants age 20 & older. Single-sample estimates of eGFR & ACR; eGFR calculated using the CKD-EPI equation. Abbreviations: ACR, urine albumin/creatinine ratio; CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate.

vol 1 Figure 1.15 Diabetic NHANES participants with glycohemoglobin <7%, 1998-2012



Data Source: National Health and Nutrition Examination Survey (NHANES),1988–1994, 1999-2004 & 2007–2012 participants age 20 & older. Single-sample estimates of eGFR & ACR; eGFR calculated using the CKD-EPI equation. Abbreviations: ACR, urine albumin/creatinine ratio; CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate.

References

Levey AS, Stevens LA, Schmid CH, Zhang YL, Castro AF, Feldman HI, Kusek JW, Eggers P, Van Lente F, Greene T, Coresh J. A new equation to estimate glomerular filtration rate. *Annals of Internal Medicine* 2009;150(9):604-612.

National Kidney Foundation. K/DOQI Clinical Practice Guidelines for Chronic Kidney Disease: Evaluation, Classification, and Stratification. *American Journal of Kidney Diseases* 2002 Feb;39(2 Suppl 1):S1-266.

Chapter 2: Identification and Care of Patients With Chronic Kidney Disease

Introduction

The examination of care in patients with chronic kidney disease (CKD) is a significant challenge, as most large datasets lack the biochemical data (serum creatinine and urine protein) required to definitively identify the disease. A random survey sample such as the National Health and Nutrition Examination Survey (NHANES) dataset contains the necessary biochemical information, as shown in Chapter 1, to estimate the true prevalence of CKD in the population. However, the cross-sectional nature of the NHANES study and relatively small sample of patients (compared to large administrative datasets) limits the evaluation of long-term outcomes, adverse events, and quality of care delivered to patients with CKD as well as the ability to conduct analyses on subsets of patients.

Analyses of USRDS data for this chapter utilize the general Medicare 5 percent sample, with an average of 1.2 million individuals each year, to assess the recognized CKD population. Analyses were restricted to patients age 65 and older given that age is the main criterion for Medicare eligibility. The term "recognized CKD" is used because patients are identified based on the presence of a relevant diagnosis code in the Medicare billing claims, meaning that either a provider or billing coder in the health care system recognized the presence of CKD and submitted a claim. As such, any observed trends may not necessarily relate to a true change in disease prevalence, but rather could represent changes in awareness or recognition of CKD, or of billing practices in general.

Prevalence of Recognized CKD and Odds of a CKD Diagnosis Code

The mean age of the period prevalent Medicare population age 65 and older is 75.9 overall, and 77.9 for those with CKD. Recognized CKD in the Medicare population is 10 percent and is more common among persons with hypertension (HTN) and diabetes mellitus (DM), at 16 percent and 21 percent, respectively. These data illustrate the importance of screening and detection programs to target those with DM and HTN, populations in need of testing for evidence of kidney disease.

The definition of the total recognized CKD population includes a variety of ICD-9-CM diagnosis codes, some of which are sub-codes under related comorbidities such as DM (250.4x) and HTN (403.9x), and some of which are more kidney disease specific, such as glomerular disease (583.x). In 2005, new stage-specific CKD codes (585.x) were introduced, providing an opportunity to track trends in the severity of CKD over time. Since their introduction, the CKD stage-specific codes have represented the majority of CKD diagnosis codes utilized, and overall there is evidence of a growing recognition of CKD over time. We include here a brief description of the CKD-related ICD-9-CM codes.

Table A. ICD-9-CM Codes

585.1	Chronic kidney disease, Stage 1
585.2	Chronic kidney disease, Stage 2 (mild)
585.3	Chronic kidney disease, Stage 3 (moderate)
585.4	Chronic kidney disease, Stage 4 (severe)
585.5	Chronic kidney disease, Stage 5 (excludes 585.6: Stage 5, requiring chronic dialysis[a])

CKD unspecified identified by multiple codes including 585.9, 250.4x, 403.9xm & others. CKD stage estimates are from a single measurement. For clinical case definition, abnormalities should be present ≥ 3 months.
[a] 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. See the CKD Analytical Methods chapter for details.

Laboratory Testing of Patients With and Without CKD

Assessing the care of patients at high risk for kidney disease has long been a focus of the USRDS, and is now part of the Healthy People 2020 goals developed by the Department of Health and Human Services (see the *Healthy People 2020* chapter in Volume 2). Urine testing for albumin in patients with DM has been recommended for some time by the American Diabetes Association. The 2012 Kidney Disease Improving Global Outcomes (KDIGO) guidelines on CKD evaluation and management recommend risk stratification of CKD patients using both the urine albumin/creatinine ratio and the estimated glomerular filtration rate, emphasizing that both tests are needed to fully assess kidney disease and its associated risks of death and progression to end-stage renal disease (ESRD) (Matsushita et al., 2010; *Kidney Disease: Improving Global Outcomes* (KDIGO) CKD Work Group, 2012). Analysis of Medicare data from 2012 shows that urine albumin testing has increased over time, but the proportion of patients with recognized CKD who were tested still remains low. Among patients with recognized CKD, 43 percent with DM alone, and 20 percent with HTN alone, received a urine albumin test; for patients with both DM and HTN, the proportion tested was still under 50 percent. By contrast, serum creatinine testing was used in 90 percent of patients. However, because the serum creatinine test is usually part of a panel of tests, its use may not indicate an active assessment of kidney function. Because urine albumin testing must be ordered separately, it may represent true intent to assess kidney disease. It will be of interest to note whether additional uptake of urine albumin testing will occur in future years, possibly in response to the 2012 KDIGO guidelines.

Visits With a Physician After CKD Diagnosis

Data on physician care show that patients are far more likely to visit a primary care physician or cardiologist than a nephrologist after a CKD diagnosis. This may relate in part to the fact that most guidelines (including KDIGO) only suggest referral to nephrology for advanced CKD (eGFR <30 or Stage 4 CKD) unless there are other concerns, such as rapid progression of disease. It is also unclear whether the U.S. nephrology workforce is large enough to handle management of the very large population of patients with earlier stages of CKD. Regardless of the possible reasons, less than one-third of all patients with a CKD claim in 2011 were seen by a nephrologist over the subsequent year. Among those with more advanced CKD (Stage 3 or higher), in contrast, 40–56 percent visited a nephrologist. Whether the involvement of a nephrologist, and at what stage of CKD, improves outcomes, is a matter of ongoing interest.

Analytical Methods

See the *CKD Analytical Methods* chapter for an explanation of analytical methods used to generate the figures and tables in this chapter.

Prevalence of Recognized CKD

Table 2.1 provides the prevalence of coded CKD, DM, and often related cardiovascular comorbid conditions among patients in the Medicare population. Over one-third of the Medicare population has at least one of the comorbid conditions, and over 10 percent have two or more comorbid conditions.

vol 1 **Table 2.1 Prevalence of coded DM, CKD, CHF & CVA among Medicare patients age 65+, 2012**

	Medicare 5% Sample	Distribution
All	1,230,285	100.0%
Total CHF	112,316	9.1
Total DM	299,052	24.3
Total CKD	127,941	10.4
Total CVA	107,026	8.7
DM & CHF	21,429	1.7
DM & CKD	33,392	2.7
DM & CVA	20,143	1.6
CHF & CKD	12,829	1.0
CHF & CVA	8,471	0.7
CKD & CVA	7,312	0.6
CHF & DM & CVA	5,818	0.5
CKD & DM & CVA	6,626	0.5
CKD & CHF & CVA	4,329	0.4
DM & CHF & CKD	15,273	1.2
DM & CHF & CKD & CVA	6,148	0.5
No DM, CKD, CHF & CVA	770,062	62.6

Data Source: Medicare 5 percent sample. Period prevalent patients, 2012, without ESRD, age 65 and older (Medicare). Abbreviations: CHF, congestive heart failure; CKD, chronic kidney disease; CVA, cerebrovascular accident; DM, diabetes mellitus.

Table 2.2 presents descriptive data on patients age 65 and older in the Medicare 5 percent sample. The high prevalence of comorbid conditions in the overall sample reflects the older age of these patients. For example, 61 percent and 24 percent have diagnoses of HTN and DM, respectively. Among patients with CKD, rates of comorbidity are even higher, with nearly half having a diagnosis of DM and over 90 percent having a diagnosis of HTN.

vol 1 **Table 2.2 Characteristics of all patients, characteristics of CKD patients among Medicare patients age 65+, 2012**

	Overall		Patients with CKD	
	N	Distribution of Characteristics (%)	N	Distribution of Characteristics (%)
All	1,230,285	100.0	127,941	100.0
65-74	654,860	53.2	47,139	36.8
75-84	403,494	32.8	51,577	40.3
85+	171,931	13.9	29,225	22.8
Male	522,684	42.5	60,194	47.0
Female	707,601	57.5	67,747	52.9
White	1,064,647	86.5	106,359	83.1
Black/ African Am	93,195	7.6	14,091	11.1
Native Am	4,916	0.4	536	0.4
Asian	22,961	1.9	2,568	2.1
Other	40,193	3.3	4,114	3.2
Unknown	4,373	0.4	273	0.2
DM	299,050	24.3	61,439	48.1
HTN	751,550	61.1	118,129	92.3
CHF	112,316	9.1	38,579	30.1
Cancer	127,979	10.4	22,712	17.7

Data Source: Medicare 5 percent sample. Period prevalent patients, 2012, without ESRD, age 65 and older (Medicare). Abbreviations: African Am, African American; CKD, chronic kidney disease; CHF, congestive heart failure; DM, diabetes mellitus; HTN, hypertension; Native Am, Native American.

Prevalence and Odds of a CKD Diagnosis Code

Table 2.3 presents the prevalence and adjusted odds ratio of recognized CKD in the Medicare population. Of Medicare patients age 65 and older, 10 percent have a coded diagnosis of CKD. The prevalence of CKD increases with age, from 7.2 percent at ages 65–74 to 17.0 percent at age 85 and older. Males have slightly higher prevalence than females. The prevalence among Black/African Americans (15 percent) is roughly 50 percent higher than Whites, Native Americans, and other races (approximately 10 percent); the prevalence in Asians is 11 percent. The results from the adjusted analyses confirm greater odds of recognized CKD in older patients, Blacks, and those with comorbidities such as DM, HTN, and cardiovascular disease (CVD).

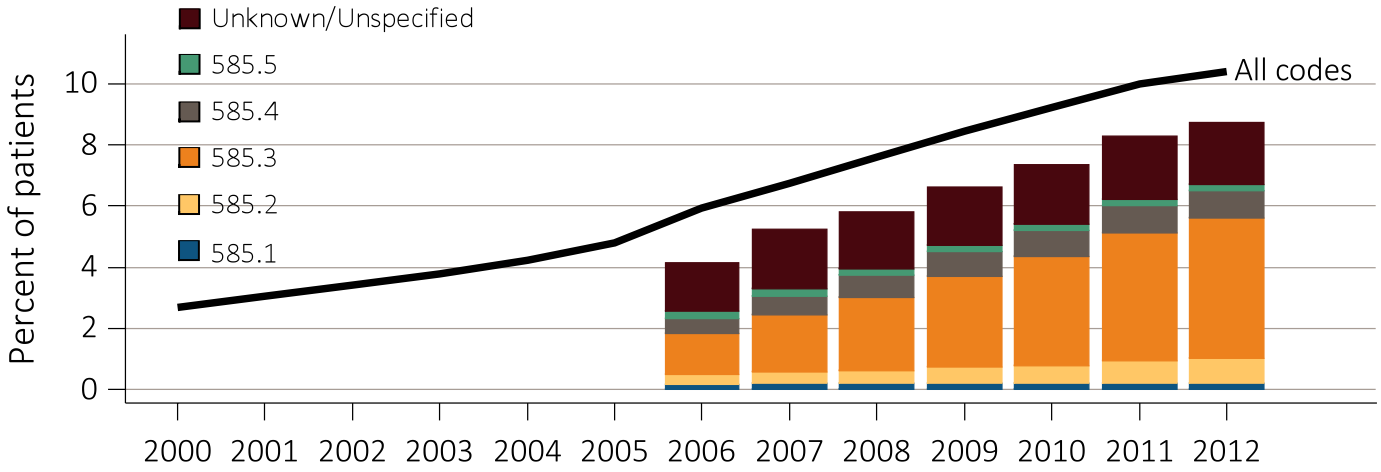
vol 1 **Table 2.3 Prevalence of CKD, and adjusted odds ratios of CKD among Medicare patients age 65+, 2012**

	Prevalence of CKD (% of overall)	Adjusted Odds Ratios of CKD
Overall	10.4	[a]
65-74	7.2	Ref.
75-84	12.8	1.4
85+	17.0	1.8
Male	11.5	Ref.
Female	9.6	0.8
White	9.9	Ref.
Black/African Am	15.1	1.4
Native Am	10.9	1.1
Asian	11.2	1.1
Other/Unknown	10.2	0.9
DM	20.5	2.1
HTN	15.7	3.7
CVD	18.4	2.3

Data Source: Medicare 5 percent sample. Period prevalent patients, 2012, without ESRD, age 65 and older (Medicare). Adjustments included are age, sex, race, and comorbidities. CVD is defined as either one of the following comorbidities being true: cerebrovascular accident, peripheral vascular disease, atherosclerotic heart disease, congestive heart failure, dysrhythmia or other cardiac comorbidities. [a] Not applicable. Abbreviations: African Am, African American; CKD, chronic kidney disease; DM, diabetes mellitus; HTN, hypertension; CVD, cardiovascular disease; Native Am, Native American.

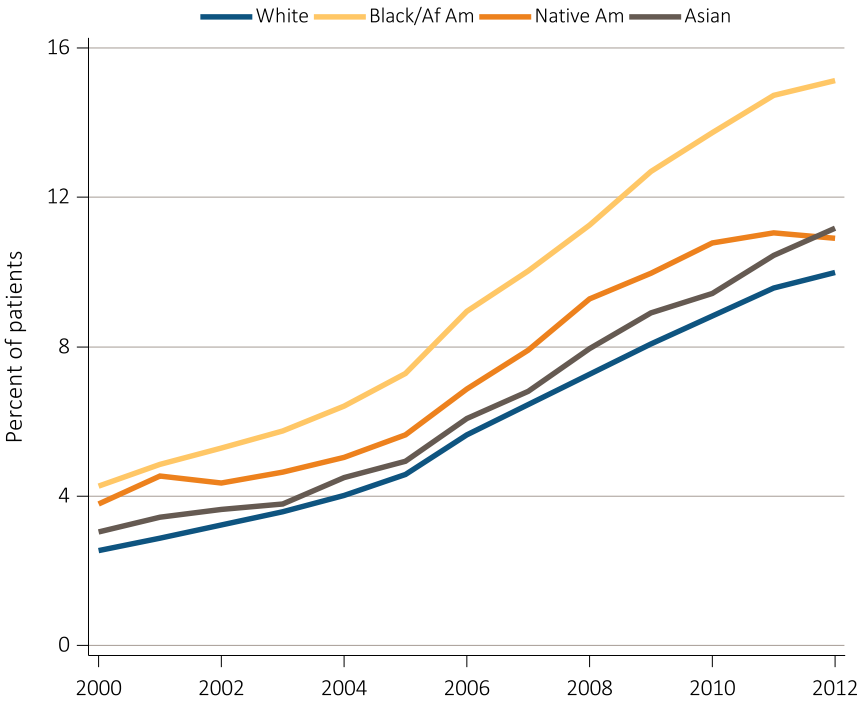
Figure 2.1 shows the temporal trend in prevalence of recognized CKD overall and by CKD stage-specific code, and Figure 2.2 shows the prevalence stratified by race, among Medicare patients age 65 and older. The prevalence of recognized CKD has risen each year, and is 3.8 times higher in 2012 than in 2000. Likewise, CKD prevalence has risen each year in each race group, with the exception of a recent leveling off among Native Americans.

vol 1 Figure 2.1 Temporal trends in CKD prevalence, overall and by CKD stage, among Medicare patients age 65+, 2000-2012



*Data Source: Medicare 5 percent sample. Medicare 5 percent sample. See **Table A** at the beginning of this chapter for a description of ICD-9-CM codes and CKD stages. Abbreviation: CKD, chronic kidney disease.*

vol 1 Figure 2.2 Temporal trends in CKD prevalence by race among Medicare patients age 65+, 2000-2012



Data Source: Medicare 5 percent sample. Abbreviations: Af Am, African American; CKD, chronic kidney disease; Native Am, Native American.

Table 2.4 compares the prevalence of CKD in the NHANES and Medicare populations among patients age 65 and older, according to demographic characteristics and comorbid conditions. In both datasets, there is a higher prevalence of CKD in older age groups, among Black/African American patients, and among patients with CVD compared to patients with HTN or DM (but no diagnosed CVD). However, the absolute prevalence of CKD is substantially lower in Medicare versus NHANES, reflecting the capture of "recognized CKD" in Medicare data versus the systematic evaluation of kidney function by study design in NHANES.

vol 1 **Table 2.4 Percent of patients with CKD by demographic characteristics, among patients overall and with DM, HTN, or CVD, in NHANES (2011-2012) and Medicare (2012) datasets**

	Overall		DM (No HTN)		HTN (No DM)		Any CVD	
	NHANES	Medicare	NHANES	Medicare	NHANES	Medicare	NHANES[a]	Medicare[b]
65-74	26.4	7.2	7.5	9.3	31.4	12.4	40.9	21.1
75-79	50.4	12.8	*	12.6	45.4	17.7	66.7	25.8
80+	65.2	17.0	*	15.3	67.2	24.0	80.5	29.8
White	38.3	9.9	24.9	11.3	44.5	17.3	55.6	24.5
Black/African Am	49.9	15.1	*	11.9	46.6	21.4	68.3	35.2
Native Am	-	10.9	-	9.9	-	16.3	-	27.5
Asian	-	11.2	-	12.7	-	16.9	-	29.4
Other/Unk	42.4	10.2	18.3	11.5	47.0	15.5	70.1	27.2
Male	37.9	11.5	29.5	12.4	41.7	19.8	44.3	26.8
Female	41.3	9.6	20.7	10.2	47.2	15.9	75.9	24.3
All	39.7	10.4	26.6	11.3	44.9	17.5	58.5	25.4

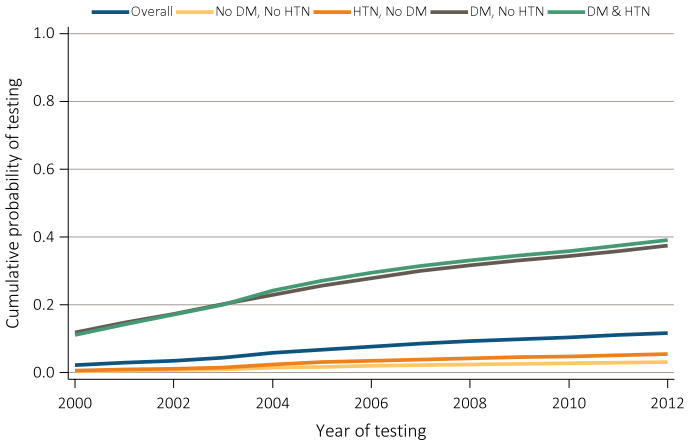
*Data Source: Medicare patients from the 5 percent sample, age 65 and older alive and eligible for all of 2012 and NHANES 2011-2012 participants, age 65 and older. CKD claims as well as other diseases identified in 2012. [a] CVD defined as any of the self-report diseases: angina, myocardial infarction, stroke, coronary heart disease, or congestive heart failure. [b] CVD defined as either one of the following comorbidities: cerebrovascular accident, peripheral vascular disease, atherosclerotic heart disease, congestive heart failure, dysrhythmia or other cardiac comorbidities. * Values for cells with 10 or fewer patients are suppressed. - No available data. Abbreviations: African Am, African American; CKD, chronic kidney disease; CVD, cardiovascular disease; DM, diabetes mellitus; HTN, hypertension; Native Am, Native American; Unk, Unknown.*

Laboratory Testing of Patients With and Without CKD

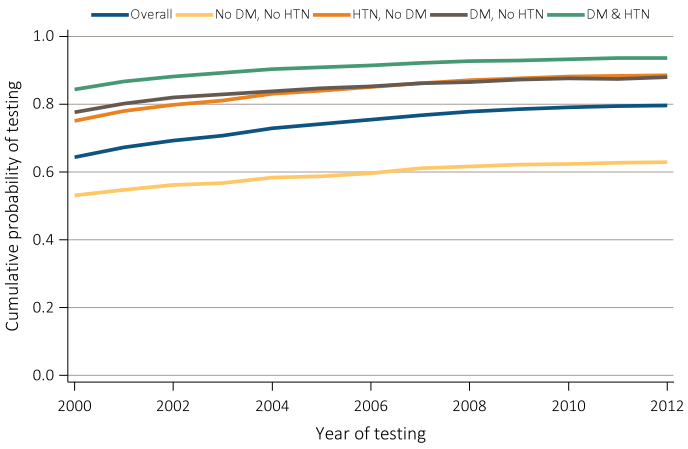
Individuals at risk for CKD should be screened periodically for kidney disease, and those with CKD should be monitored for progression of disease. Urine albumin and creatinine tests are valuable laboratory markers to detect signs of kidney damage, as well as to evaluate for progressive decline in kidney function. As shown in Figure 2.3, 79 percent of Medicare patients without diagnosed CKD received serum creatinine testing in 2012, while only 11 percent received a urine albumin test (which must be ordered separately from serum creatinine and other standard blood tests). Thirty-seven percent of patients with DM alone had urine albumin testing, compared to 5 percent in patients with HTN alone. Having both DM and HTN greatly increases the likelihood of developing CKD: 93 percent of patients with both conditions had serum creatinine testing in 2012, while 39 percent had urine albumin testing. Because urine albumin testing must be ordered separately from standard blood tests, it may represent true intent to assess kidney disease. There has been a steady rise in use of urine albumin testing over time, particularly in those with DM. As shown in Figure 2.4, among patients with a diagnosis of CKD, patterns of testing were similar, though at somewhat higher rates than among patients without CKD. For example, in 2012, in patients with a diagnosis of CKD, 47 percent had urine albumin testing and 96 percent had serum creatinine testing among patients who also had both DM and HTN.

vol 1 Figure 2.3 Unadjusted cumulative probability for urine albumin & serum creatinine testing, among Medicare patients age 65+ WITHOUT a diagnosis of CKD, 2000-2012

(a) Urine albumin



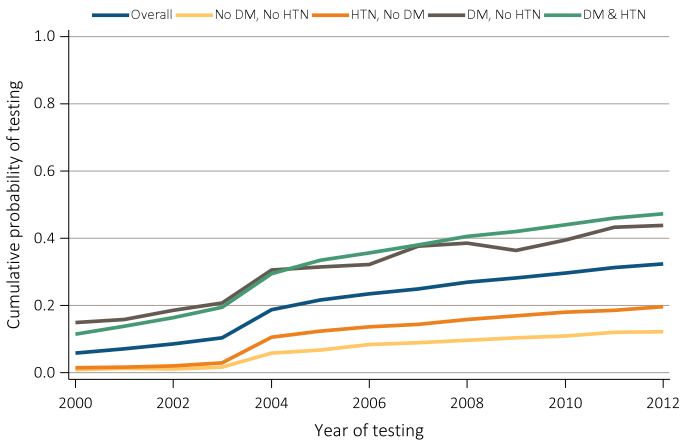
(b) Serum creatinine



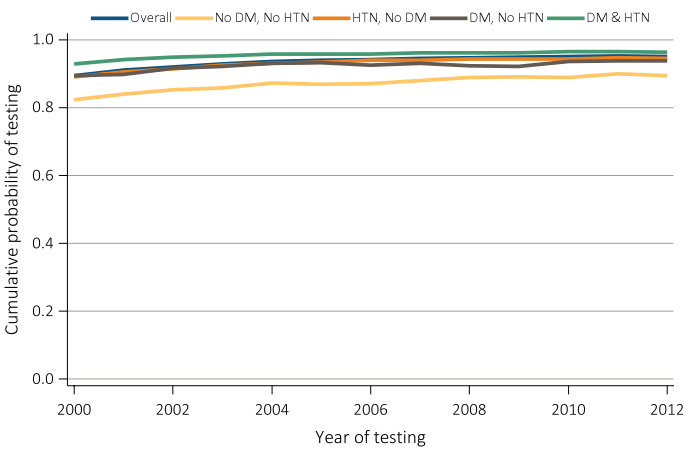
Data Source: Medicare patients from the 5 percent sample, age 65 and older with Part A & B coverage in the prior year. Tests tracked during each year. Abbreviations: CKD, chronic kidney disease DM, diabetes mellitus; HTN, hypertension.

vol 1 Figure 2.4 Unadjusted cumulative probability of urine albumin & serum creatinine testing, among Medicare patients age 65+ WITH a diagnosis of CKD, 2000-2012

(a) Urine albumin



(b) Serum creatinine

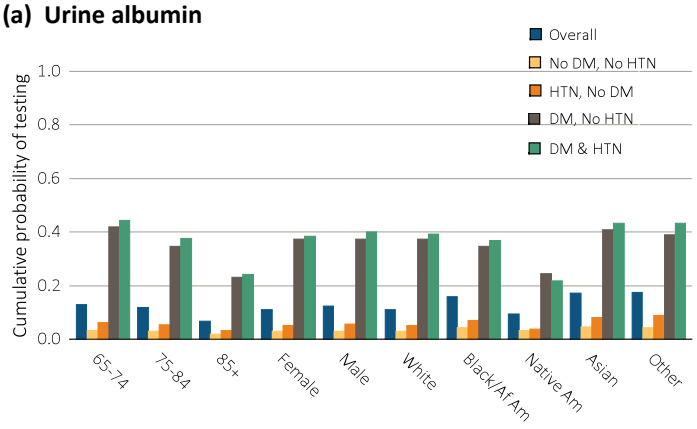


Data Source: Medicare patients from the 5 percent sample, age 65 and older with Part A & B coverage in the prior year. Tests tracked during each year. Abbreviations: CKD, chronic kidney disease DM, diabetes mellitus; HTN, hypertension.

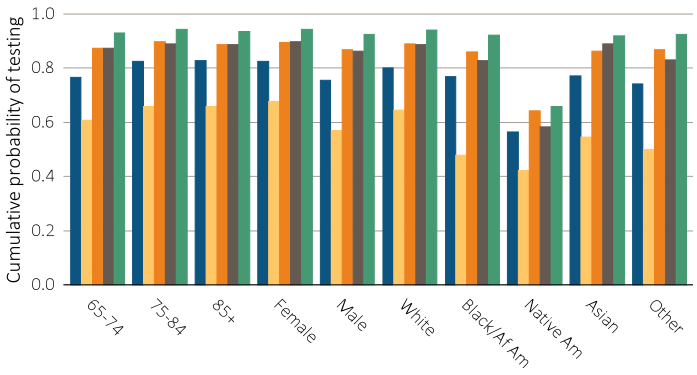
Figure 2.5 shows the adjusted cumulative probability of urine albumin (a) & serum creatinine (b) testing by demographic characteristics, among Medicare (age 65 and older) patients without a diagnosis of CKD. Generally, the cumulative probability of serum creatinine testing was about 2-3 times higher than urine albumin testing. Patients with HTN and no DM have a much higher probability of serum creatinine testing than urine albumin testing (~0.85 vs. ~0.05, across all demographics).

vol 1 Figure 2.5 Adjusted cumulative probability of urine albumin (a) & serum creatinine (b) testing by demographic characteristics, among Medicare patients age 65+ WITHOUT a diagnosis of CKD, 2000-2012

(a) Urine albumin



(b) Serum creatinine

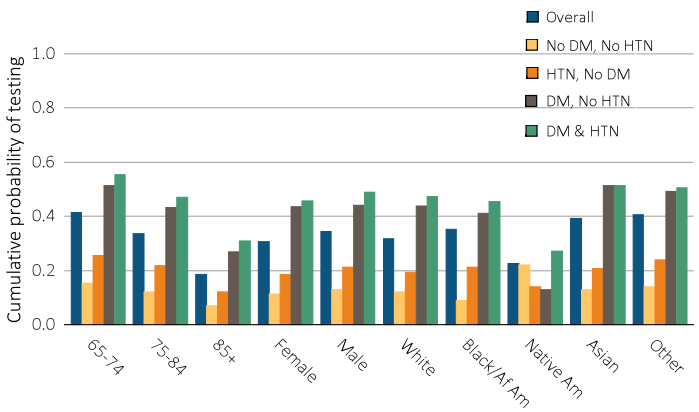


Data Source: Medicare 5 percent sample. Models are adjusted for age, race, and sex. Abbreviations: Af Am, African American; CKD, chronic kidney disease; CVD, cardiovascular disease; DM, diabetes mellitus; HTN, hypertension; Native Am, Native American; HTN, hypertension.

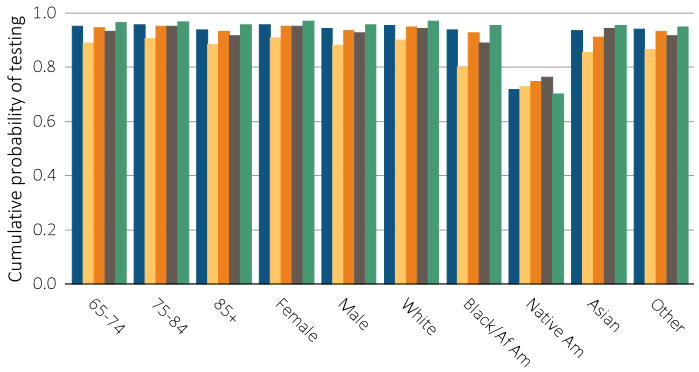
Figure 2.6 shows the adjusted cumulative probability of urine albumin (a) & serum creatinine (b) testing by demographic characteristics, among Medicare (age 65 and older) patients with a diagnosis of CKD. These trends are similar to those in Figure 2.5, with cumulative probability of serum creatinine testing about 2-3 times higher than urine albumin testing. Patients with HTN and no DM have a much higher probability of serum creatinine testing than urine albumin testing (~0.9 vs. ~0.2, across all demographics).

vol 1 Figure 2.6 Adjusted cumulative probability of urine albumin (a) & serum creatinine (b) testing by demographic characteristics, among Medicare patients age 65+ WITH a diagnosis of CKD, 2000-2012

(a) Urine albumin



(b) Serum creatinine



Data Source: Medicare 5 percent sample. Models are adjusted for age, race and sex. Abbreviations: CKD, chronic kidney disease; DM, diabetes mellitus; HTN, hypertension.

Figures 2.5 and 2.6 demonstrate lower rates of urine albumin testing with older age, among patients with and without recognized CKD. Serum creatinine testing appears uniformly high, regardless of CKD status, presence of other comorbidities, or demographics, with the possible exception of Native Americans. This again may relate to the fact that serum creatinine is usually included with standard panels of routinely ordered blood tests.

Visits With a Physician After CKD Diagnosis

As indicated in Table 2.5, the probability of at least one primary care visit over the next year, among Medicare (age 65 and older) patients was 0.91, and 0.62 for at least one cardiologist visit over the next year. These probabilities varied little across demographic categories or CKD diagnostic category. By contrast, among patients with any CKD diagnosis the probability of at least one nephrologist visit over

the next year was 0.31. With more advanced CKD (diagnosis code 585.3 or higher), this probability increased nearly two-fold to 0.55. Notably, CKD patients age 85 and older were as likely to have a cardiologist visit as younger patients, but they were much less likely to have a nephrologist visit than younger patients.

vol 1 **Table 2.5 Cumulative probability of a physician visit at month 12 after CKD diagnosis in 2011 among Medicare patients age 65+**

	Any CKD Diagnosis			CKD Diagnosis Code of 585.3 or Higher		
	Primary Care	Cardi-ologist	Nephrol-ogist	Primary Care	Cardiol-ogist	Nephrol-ogist
65-74	0.88	0.54	0.31	0.89	0.55	0.56
75-84	0.90	0.61	0.29	0.90	0.62	0.51
85+	0.90	0.60	0.22	0.91	0.61	0.39
Male	0.90	0.55	0.27	0.91	0.56	0.48
Female	0.88	0.62	0.29	0.89	0.64	0.52
White	0.89	0.59	0.28	0.90	0.60	0.49
Black/ African Am	0.89	0.56	0.33	0.89	0.57	0.55
Other	0.88	0.54	0.29	0.88	0.55	0.49
Overall	0.91	0.62	0.31	0.92	0.64	0.55

Data Source: Medicare 5 percent sample. Patients alive & eligible all of 2011. CKD diagnosis is at date of first CKD claim in 2011; claims for physician visits were searched during the 12 months following that date. CKD diagnosis code of 585.3 or higher represents CKD Stages 3-5. Abbreviations: African Am, African American; CKD, chronic kidney disease.

References

Matsushita K, van der Velde M, Astor BC et al. *Association of estimated glomerular filtration rate and albuminuria with all-cause and cardiovascular mortality in general population cohorts: a collaborative meta-analysis. Lancet* 2010;375:2073–2081

Kidney Disease: Improving Global Outcomes (KDIGO) CKD Work Group. KDIGO 2012 clinical practice guideline for the evaluation and management of chronic kidney disease. *Kidney Int Suppl* 2013;3(1):1–150

Chapter 3: Morbidity and Mortality

Introduction

In this chapter we evaluate the morbidity and mortality of chronic kidney disease (CKD) patients continuously enrolled in Medicare. Each year's analysis sample is limited to patients aged 66 and older; employing a one-year entry period allows us to identify CKD and other medical conditions using ICD-9-CM (International Classification of Diseases, 9th revision, clinical modification) diagnosis codes from Medicare claims. Hospitalizations, services, and deaths are then reported for the following calendar year. For example, the rates reported for 2012 are based on events in 2012 for patients with and without CKD in 2011. We present results on mortality, then focus on hospitalizations, and end with an examination of patient re-admission to the hospital within 30 days of discharge from their first hospitalization of the calendar year (referred to as the index hospitalization).

Adjusted mortality rates are higher for Medicare patients with CKD than those without, and rates increase with CKD stage, a finding consistent with studies using biochemical measures to define CKD (serum creatinine with validated equations to estimate glomerular filtration rate; Matsushita et al., 2010). The co-occurrences of diabetes mellitus (DM) and cardiovascular disease (CVD) with CKD multiplies a patient's risk of death. This is clinically significant as cardiovascular risk factors are relatively undertreated in U.S. patients with CKD; we illustrate this through data on the disease awareness, treatment, and control of risk factors in the population-level National Health and Nutrition Examination Survey (NHANES) cohort shown in Chapter 1, CKD in the General Population. Clearly, early detection and active treatment are important considerations in reducing morbidity and mortality in the CKD population.

One consistent finding regarding hospitalization in the CKD population is an increasing rate of both overall and cause-specific admissions with advancing stages of CKD. When data are adjusted for age, race, sex, prior year hospitalization, and several comorbidities, CKD patients are hospitalized at a rate of 0.40 admissions per patient year overall—0.35 for Stages 1-2, 0.40 for Stage 3, and 0.55 for Stages 4-5 (0.39 where stage is not specified). We have observed for more than a decade that rates of hospitalization for cardiovascular disease and infection also rise with CKD stage (Go et al., 2004). In general, hospitalizations in CKD patients also increase in the presence of underlying comorbidities, such as diabetes and cardiovascular disease.

Hospital readmissions are a key quality indicator for the Medicare program. In an attempt to lower the rate of readmission, the Medicare Hospital Readmission Reduction Program was instituted as part of the Patient Protection and Affordable Care Act, (CMS, 2010) reducing Medicare payments to hospitals with excess readmissions. Rates of rehospitalization for CKD patients are higher than those for patients without diagnosed CKD. In 2012, 24 percent of patients with CKD were readmitted within 30 days, compared to 17 percent of those without CKD. These rates have not changed significantly in the past decade, which is of major concern.

In Chapter 2, Identification and Care of Patients with Chronic Kidney Disease, we document the increasing recognition of CKD through analysis of diagnosis codes from Medicare claims. Chapter 1 reports the smaller increases in CKD prevalence in the general population as found in the NHANES. This population-based survey identifies CKD through single time point, estimates of glomerular filtration rates and albuminuria. The ascertainment of CKD cases through claims data has increased in recent years, likely resulting in decreased estimates of average disease severity as influenced by the early disease stage of those identified most recently. We adjust for co-morbid conditions, over time, but such adjustments are limited to the measures available from claims. Thus, changes in mortality and hospitalization rates should be viewed with some caution.

Analytical Methods

See the CKD Analytical Methods chapter for an explanation of analytical methods used to generate the figures and tables in this chapter.

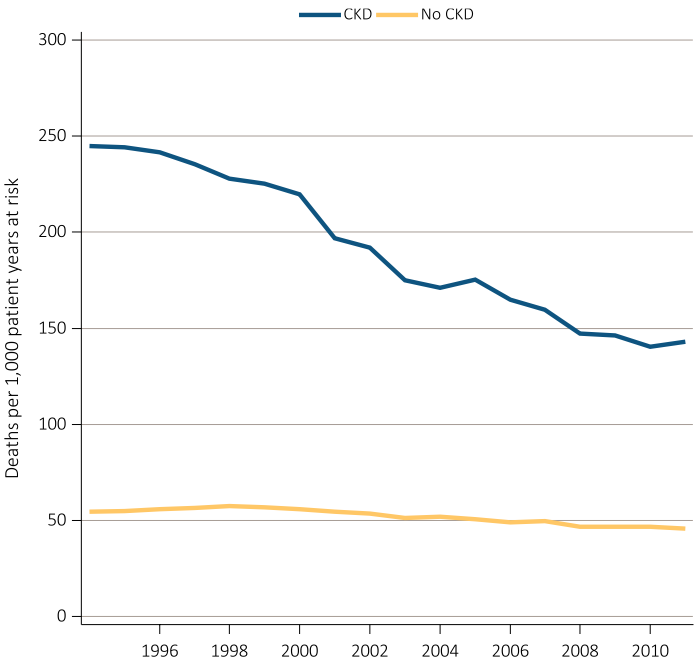
Mortality Rates

Figure 3.1(a) presents the unadjusted mortality rates for Medicare patients age 66 and older, with and without CKD, over time. Unadjusted mortality in CKD patients has decreased by 42 percent since 1995, from 245 deaths per 1,000 patient years to 143 deaths in 2012. For those without CKD, the unadjusted rate decreased from 55 deaths per 1,000 patient years in 1995 to 46 deaths per 1,000 patient years in 2012, a reduction of 16 percent.

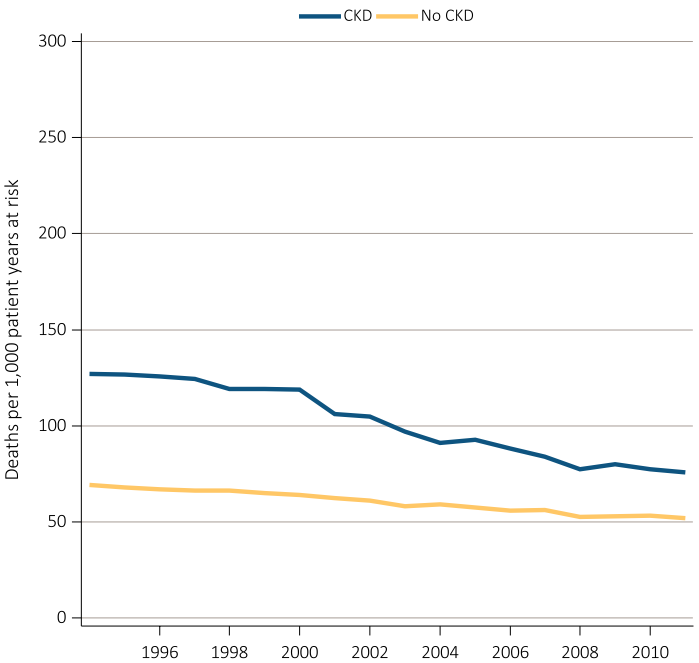
Adjusted mortality rates are shown in Figure 3.1(b). When adjusted for age, race, sex and health status (prior year hospitalization and comorbid conditions), the 2012 mortality rate for CKD patients is reduced considerably, to 76 deaths per 1,000 patient years at risk. Among those without CKD, adjustment for these factors results in a slightly higher mortality rate of 52 deaths per 1,000 patient years, as compared to the unadjusted rate of 46. One major contributor to the discrepancy between adjusted and unadjusted death rates is the relative age difference between those with CKD and those without. In 2012, the mean age of patients with CKD was 79.1 years, compared to 76.0 years for those without, and 76.3 years for the sample as a whole.

vol 1 **Figure 3.1 Unadjusted and adjusted all-cause mortality rates (per 1,000 patient years at risk) for Medicare patients aged 66 and older, by CKD status and year, 1995-2012**

(a) Unadjusted



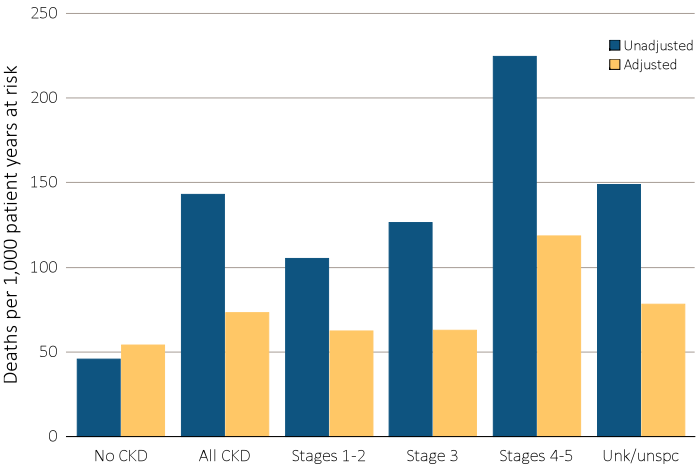
(b) Adjusted



Data source: Medicare 5 percent sample. January 1 of each reported year point prevalent Medicare patients age 66 and older. Adj: age/sex/race/ prior year hospitalization/comorbidities. Ref: 2012 patients. Abbreviations: CKD, chronic kidney disease.

As expected, unadjusted mortality rates increase with progressing stage of CKD, as shown in Figure 3.2, from 105 deaths per 1,000 patient years for those in Stages 1 and 2, to 127 for Stage 3, and 225 for Stages 4 and 5 (without ESRD; stages identified by the ICD-9-CM codes, see Table A). Those without an identified CKD stage or with a diagnosis code other than the 585 code series had an unadjusted mortality rate between that of Stage 3 and Stages 4-5, at 149 deaths per 1,000 patient years at risk. After adjustment, death rates were similar for Stages 1-2 and Stage 3, at 62 and 63 deaths per 1,000 patient years, respectively. Those with unspecified CKD stage had slightly higher death rates at 78 per 1,000 patient years. The adjusted rate for Stages 4-5 in 2012 was 119 deaths per 1,000 patient years at risk.

vol 1 Figure 3.2 Unadjusted and adjusted all-cause mortality rates (per 1,000 patient years at risk) for Medicare patients aged 66 and older by CKD status and stage, 2012



Data source: Medicare 5 percent sample. January 1, 2012 point prevalent Medicare patients age 66 and older. Adj: age/sex/race/prior year hospitalization/comorbidities. Ref: all patients, 2012. See Table A for CKD stage definitions. Abbreviations: CKD, chronic kidney disease; Unk/unspc, CKD stage unidentified.

Table A. ICD-9-CM Codes

585.1	Chronic kidney disease, Stage 1
585.2	Chronic kidney disease, Stage 2 (mild)
585.3	Chronic kidney disease, Stage 3 (moderate)
585.4	Chronic kidney disease, Stage 4 (severe)
585.5	Chronic kidney disease, Stage 5 (excludes 585.6: Stage 5, requiring chronic dialysis[a])

CKD unspecified identified by multiple codes including 585.9, 250.4x, 403.9x & others. CKD stage estimates are from a single measurement. For clinical case definition, abnormalities should be present ≥ 3 months. a In USRDS analyses, patients with ICD-9-CM code 585.6 and no end-stage renal disease (ESRD) Medical Evidence form (CMS 2728) or other indication of ESRD are considered to have code 585.5; see the CKD Analytical Methods chapter for details.

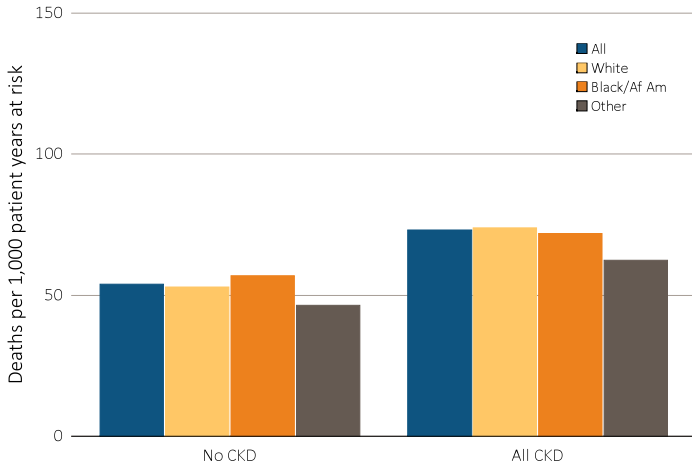
Table 3.1 lists mortality rates for several demographic subgroups of patients. Adjusted for patient demographics and co-morbid conditions, mortality among CKD patients (73.2/1000) is 36 percent greater than for the non CKD population (54.0/1000). As expected, all mortality rates increase somewhat dramatically with age. When adjusted for sex, race, prior year hospitalization and comorbidities, death rates increase 4.5 times, from 36 per 1,000 patient years for CKD patients aged 66-69, to 162 for CKD patients aged 85 and older. This same pattern is seen for unadjusted rates and among patients without CKD. Mortality is higher for men than women regardless of CKD status. Whites with CKD have higher mortality rates, both adjusted and unadjusted, than other race groups, although the adjusted rates for Blacks/African Americans and Whites are very similar. Among patients without CKD, Blacks/African Americans have slightly higher death rates, when adjusted for age, sex, prior year hospitalization, and comorbidities (see Figure 3.3).

vol 1 Table 3.1 Unadjusted and adjusted mortality rates (per 1,000 patient years at risk) in Medicare patients, by age, sex, race, and CKD status, 2012

	Unadjusted		Adjusted	
	No CKD	**All CKD**	**No CKD**	**All CKD**
All	45.7	143.0	54.0	73.2
66–69	15.3	69.1	22.8	35.8
70–74	21.4	78.2	27.8	40.1
75–84	44.6	125.5	47.5	66.4
85+	138.3	261.7	129.9	161.9
Male	46.4	149.4	58.5	77.4
Female	45.2	137.3	49.4	71.0
White	46.3	146.5	53.0	73.8
Black/Af Am	45.9	130.6	56.9	71.9
Other	35.5	113.4	46.3	62.4

Data source: Medicare 5 percent sample. January 1, 2012 point prevalent patients age 66 and older. Adj: age/sex/race/prior year hospitalization/comorbidities. Ref: all patients, 2012. Abbreviations: Af Am, African American; CKD, chronic kidney disease.

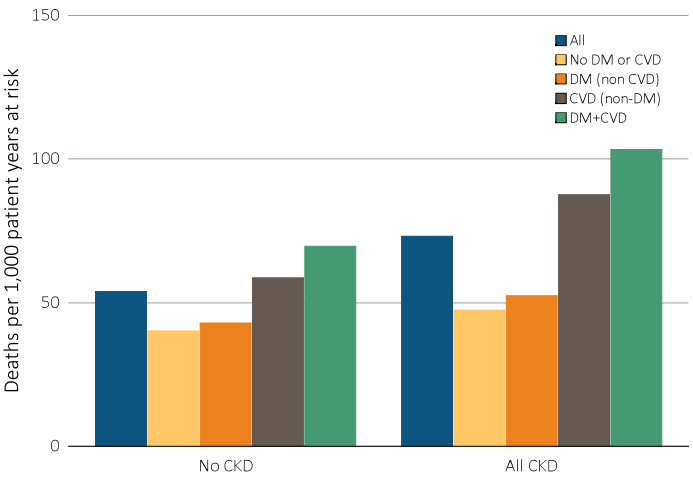
vol 1 Figure 3.3 Adjusted mortality rates (per 1,000 patient years at risk) in Medicare patients aged 66 and older, by race and CKD status, 2012



Data source: Medicare 5 percent sample. January 1, 2012 point prevalent patients age 66 and older. Adj: age/sex/race/prior year hospitalization/ comorbidities. Ref: all patients, 2012. Abbreviations: Af Am, African American; CKD, chronic kidney disease.

Adjusted rates of mortality generally increase with patient health complexity. Figure 3.4 shows mortality rates by the presence of two common comorbidities of CKD – diabetes mellitus (DM) and cardiovascular disease (CVD). Focusing on patients with CKD, in 2012 those without DM or CVD had an adjusted mortality rate of 47 deaths per 1,000 patient years at risk, while those with both diabetes mellitus and cardiovascular disease had double the mortality rate, at 103 deaths per 1,000 patient years.

vol 1 Figure 3.4 Adjusted mortality rates (per 1,000 patient years at risk) in Medicare patients aged 66 and older, by cardiovascular disease, diabetes mellitus, and CKD status, 2012



Data source: Medicare 5 percent sample. January 1, 2012 point prevalent patients age 66 and older. Adj: age/sex/race/prior year hospitalization/ comorbidities. Ref: all patients, 2012. Abbreviations: CKD, chronic kidney disease; CVD, cardiovascular disease; DM, diabetes mellitus.

Hospitalization Rates

Table 3.2 shows 2012 all-cause hospitalization rates for older Medicare patients by whether they had identified CKD during 2011. The unadjusted rate for those with CKD was 749 hospitalizations per 1,000 patient years at risk, compared to an unadjusted rate of 282 for patients without CKD. Across demographic characteristics, the unadjusted hospitalization rate for patients with CKD is 2.5 to three times the corresponding rate for patients without CKD. Once adjustment is made for age, race, sex, prior year hospitalization, and comorbidities, the hospitalization rate for patients with CKD (404 per 1,000 patient years at risk) was 37 percent greater than for those without CKD (294 per 1,000). Similar to mortality rates, the adjusted hospitalization rate increases with age for all patients. In contrast to mortality findings, women with CKD had higher adjusted hospitalization rates than did men, while there was little difference by sex among patients without CKD.

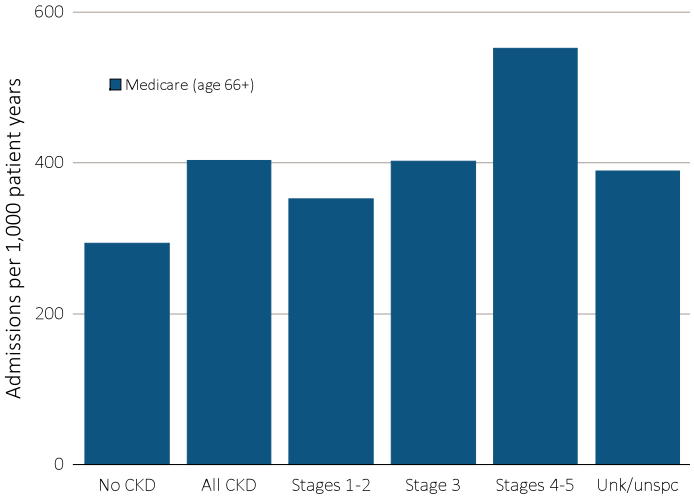
vol 1 Table 3.2 Unadjusted and adjusted all-cause hospitalization rates (per 1,000 patient years at risk) for Medicare patients aged 66 and older, by CKD status, 2012

	Unadjusted		Adjusted	
	No CKD	All CKD	No CKD	All CKD
All	282	749	294	404
66–69	183	639	232	345
70–74	221	665	245	351
75–84	315	754	305	412
85+	467	868	425	505
Male	276	744	297	396
Female	287	753	292	410
White	283	738	293	405
Black/Af Am	313	855	329	433
Other	227	695	255	367

Data source: Medicare 5 percent sample. January 1, 2012 point prevalent patients age 66 and older. Adj: age/sex/race/prior year hospitalization/comorbidities. Ref: all patients, 2012. Abbreviations: Af Am, African American; CKD, chronic kidney disease.

Figure 3.5 shows the adjusted, all-cause hospitalization rates by stage of CKD. Even with adjustment for demographic and clinical factors, the rates of hospitalization increase with each progressive stage of CKD. Patients in Stage 1 or 2 had a 2012 hospitalization rate of 356 admissions per 1,000 patient years, increasing to 406 for patients in Stage 3 and 539 for Stages 4 and 5. Patients with diagnoses that do not specify stage of CKD had rates similar to those with Stage 3 CKD.

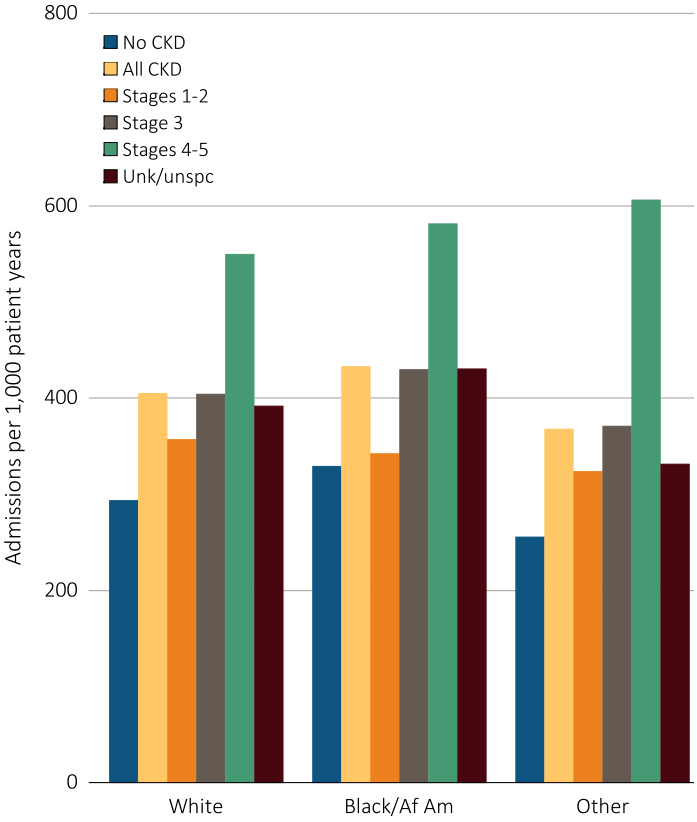
vol 1 Figure 3.5 Adjusted all-cause hospitalization rates (per 1,000 patient years at risk) for Medicare patients aged 66 and older by CKD status and stage, 2012



Data source: Medicare 5 percent sample. January 1, 2012 point prevalent Medicare patients, age 66 and older. Adj: age/sex/race/prior year hospitalization/comorbidity. Ref: all patients, 2012. See Table A for CKD stage definitions. Abbreviations: CKD, chronic kidney disease; Unk/unspc, CKD stage unidentified.

In 2012, hospitalization rates were slightly higher for Blacks/African Americans as compared to Whites, while those for patients of other races were the lowest of the three groups (see Figure 3.6). For patients with Stage 1 or 2 CKD, the hospitalization rates were similar by race, with Whites having the highest rate—324/1000 for other races, 342 for Blacks/African Americans, and 357 for Whites. Rates for Stage 3 were 371/1000 for other races, 404 for Whites, and 429 for Blacks/African Americans. However, among patients with Stage 4 or 5 CKD (not ESRD), those of other race had the highest hospitalization rate at 606 admissions per 1,000 patient years, compared to 549 for Whites and 581 for Blacks/African Americans. Again, patients without stage specified by their CKD diagnosis code had rates similar to Stage 3 CKD patients.

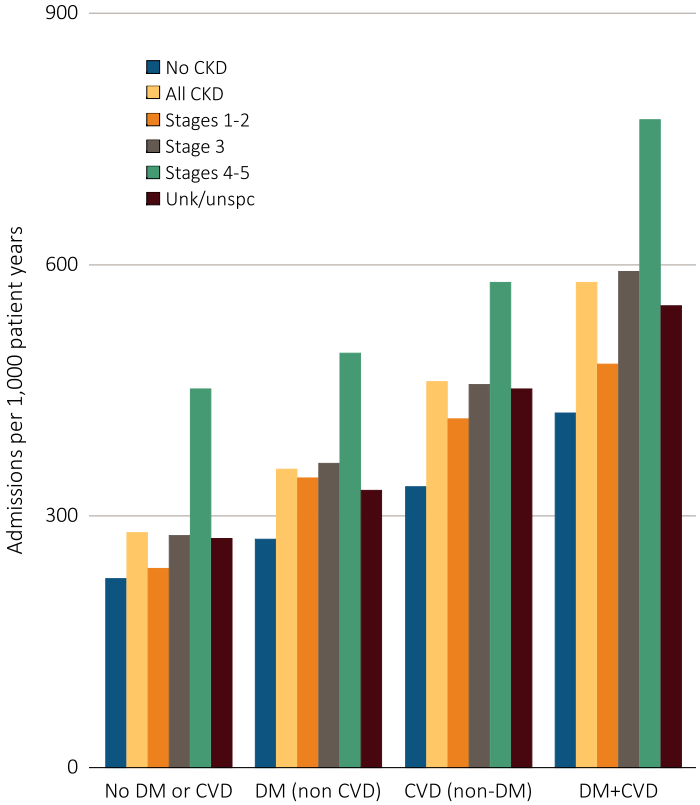
vol 1 Figure 3.6 Adjusted all-cause hospitalization rates (per 1,000 patient years at risk) in Medicare patients aged 66 and older, by race, CKD status, and stage, 2012



Data source: Medicare 5 percent sample. January 1, 2012 point prevalent Medicare patients, age 66 and older. Adj: age/sex/race/prior year hospitalization/comorbidity; rates by one factor are adjusted for the others. Ref: all patients, 2012. See Table A for CKD stage definitions. Abbreviations: Af Am, African American; CKD, chronic kidney disease; Unk/unspc, CKD stage unidentified.

Adjusted rates of hospitalization for all causes increased with the presence of diabetes mellitus and cardiovascular disease, for patients both with and without CKD (see Figure 3.7). In 2012, admissions per 1,000 patient years increased from 280 for CKD patients without DM or CVD, to 356 for CKD patients with only diabetes mellitus and 460 for those with only cardiovascular disease, to a high of 579 for CKD patients with both comorbidities. This additional comorbidity burden is most striking for patients with Stage 4 or 5 CKD; patients with both DM and CVD in addition to their late-stage CKD had an all-cause hospitalization rate of 773 admissions per 1,000 patient years, compared to only 451 for late-stage CKD patients without diabetes mellitus or cardiovascular disease.

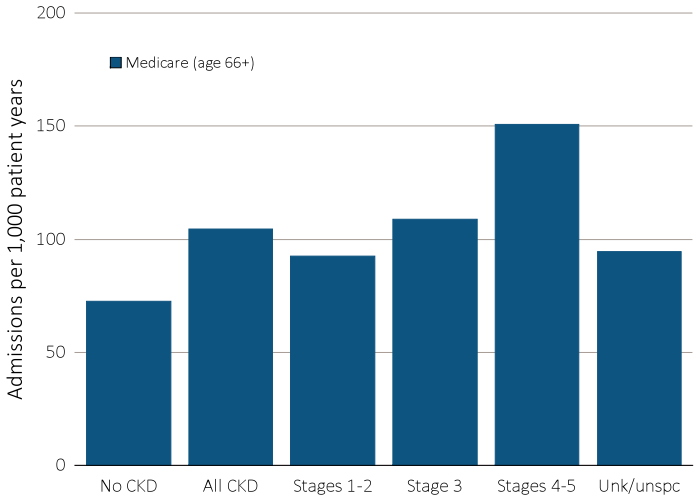
vol 1 Figure 3.7 Adjusted all-cause hospitalization rates (per 1,000 patient years at risk) in Medicare patients aged 66 and older, by cardiovascular disease, diabetes mellitus, CKD status, and stage, 2012



Data source: Medicare 5 percent sample. January 1, 2012 point prevalent Medicare patients, age 66 and older. Adj: age/sex/race/prior year hospitalization/comorbidity; rates by one factor are adjusted for the others. Ref: all patients, 2012. See Table A for CKD stage definitions. Abbreviations: CKD, chronic kidney disease; CVD, cardiovascular disease; DM, diabetes mellitus; Unk/unspc, CKD stage unidentified.

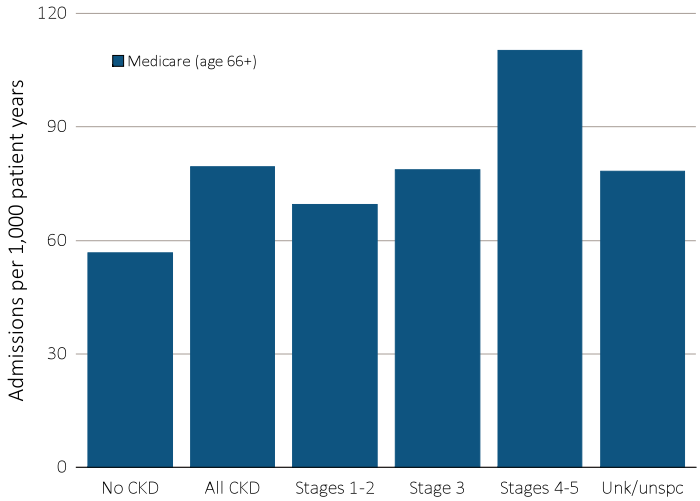
We present in Figures 3.8 through 3.10 hospitalization rates specific to CVD (23 percent), infection (19 percent), and all other cause categories (58 percent). Figure 3.8 shows the adjusted hospitalization rates for admissions with a primary diagnosis indicating CVD. The pattern of increase by stage of CKD for CVD hospitalizations is similar to that of all-cause hospitalizations. Among those with CKD, rates increase from 91 cardiovascular admissions per 1,000 patient years for those in Stages 1 and 2, to 107 for Stage 3, and 142 for Stages 4 and 5. This pattern also holds for hospitalization with a primary diagnosis code indicating infection, with rates increasing from 72 infection-related admissions per 1,000 patient years for CKD Stages 1 and 2, to 81 for Stage 3, and 112 for Stages 4 and 5 (see Figure 3.9).

vol 1 Figure 3.8 Adjusted rates of hospitalization for cardiovascular disease (per 1,000 patient years at risk) in Medicare patients aged 66 and older, by CKD status and stage, 2012



Data source: Medicare 5 percent sample. January 1, 2012 point prevalent Medicare patients, age 66 and older. Adj: age/sex/race/prior year hospitalization/comorbidity; rates by one factor are adjusted for the others. Ref: all patients, 2012. See Table A for CKD stage definitions. Abbreviations: CKD, chronic kidney disease; Unk/unspc, CKD stage unidentified.

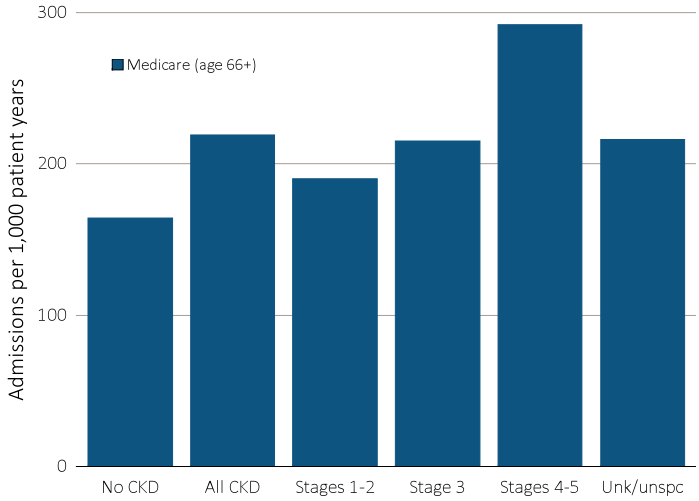
vol 1 Figure 3.9 Adjusted rates of hospitalization for infection (per 1,000 patient years at risk) in Medicare patients aged 66 and older, by CKD status and stage, 2012



Data source: Medicare 5 percent sample. January 1, 2012 point prevalent Medicare patients, age 66 and older. Adj: age/sex/race/prior year hospitalization/comorbidity; rates by one factor are adjusted for the others. Ref: all patients, 2012. See Table A for CKD stage definitions. Abbreviations: CKD, chronic kidney disease; Unk/unspc, CKD stage unidentified.

The majority of hospitalizations were for conditions other than those related to CVD or infection. Again, the pattern showed a similar CKD stage-related increase from 192 admissions per 1,000 for Stages 1-2, to 216 for Stage 3, and 284 for Stages 4 and 5, as shown in Figure 3.10.

vol 1 Figure 3.10 Adjusted rates of hospitalization for causes other than cardiovascular disease or infection (per 1,000 patient years at risk) in Medicare patients aged 66 and older, by CKD status and stage, 2012

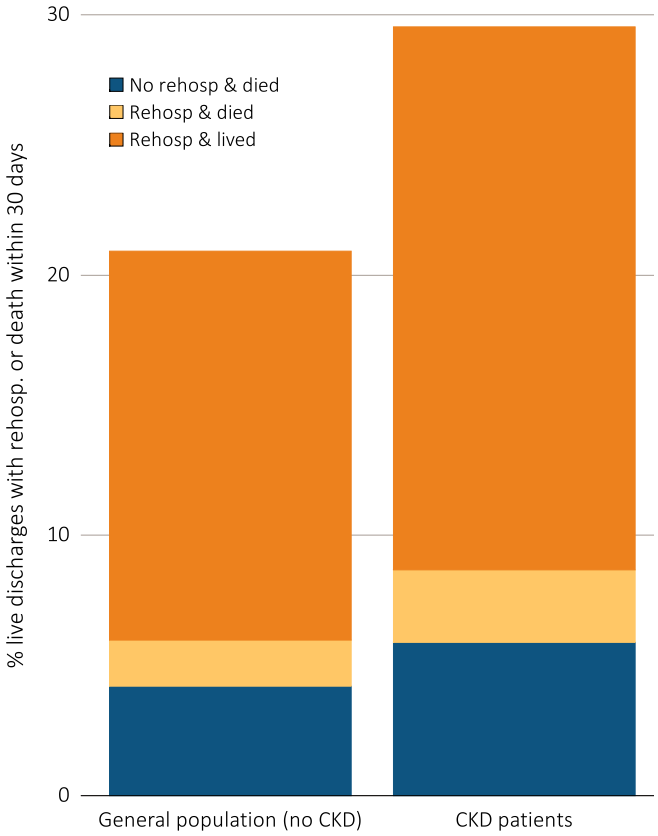


Data source: Medicare 5 percent sample. January 1, 2012 point prevalent Medicare patients, age 66 and older. Adj: age/sex/race/prior year hospitalization/comorbidity; rates by one factor are adjusted for the others. Ref: all patients, 2012. See Table A for CKD stage definitions. Abbreviations: CKD, chronic kidney disease; Unk/unspc, CKD stage unidentified.

Rehospitalization

In 2012, the proportion of Medicare patients aged 66 and older who were re-admitted to the hospital within 30 days of discharge from a first, all-cause (index) hospitalization was 16.7 percent for those without CKD, and 23.7 percent for those with CKD (see Figure 3.11 and Table 3.3). Ten percent of the non-CKD patients that had been rehospitalized within 30 days had also died, representing 1.8 percent of the patients without CKD that were discharged alive from a first all-cause hospitalization. Eleven percent of the patients with CKD that were rehospitalized had also died within 30 days of the initial discharge, or 2.8 percent of the live discharges. Among patients discharged alive from their first hospitalization and not rehospitalized within 30 days, 4.2 percent of those without CKD had died within 30 days, as had 5.9 percent of those with CKD.

vol 1 Figure 3.11 Unadjusted percentage readmitted to the hospital within 30 days of discharge, among Medicare patients aged 66 and older, discharged alive from an all-cause index hospitalization between January 1 and December 1, by CKD status, 2012



Data source: Medicare 5 percent sample. January 1, 2012 point prevalent, Medicare patients age 66 and older, discharged alive from an all-cause index hospitalization between January 1, 2012, and December 1, 2012, unadjusted. Abbreviations: CKD, chronic kidney disease; Rehosp, rehospitalized.

All-cause rehospitalization within 30 days of live discharge from a first hospitalization is lower for those without CKD, but similar across the stages of CKD, rising slightly from 23 percent in Stages 1-2, to 24 percent in Stage 3 and 25 percent in Stages 4-5 (see Table 3.3). However, the proportion of patients that died within 30 days increases with the stage of CKD from 7.6 percent (Stages 1-2), to 8.1 percent (Stage 3), and 10.6 percent (Stages 4-5).

vol 1 Table 3.3 Unadjusted percentage readmitted to the hospital within 30 days of discharge, among Medicare patients aged 66 and older, discharged alive from an all-cause index hospitalization between January 1 and December 1, by CKD status and stage, 2012

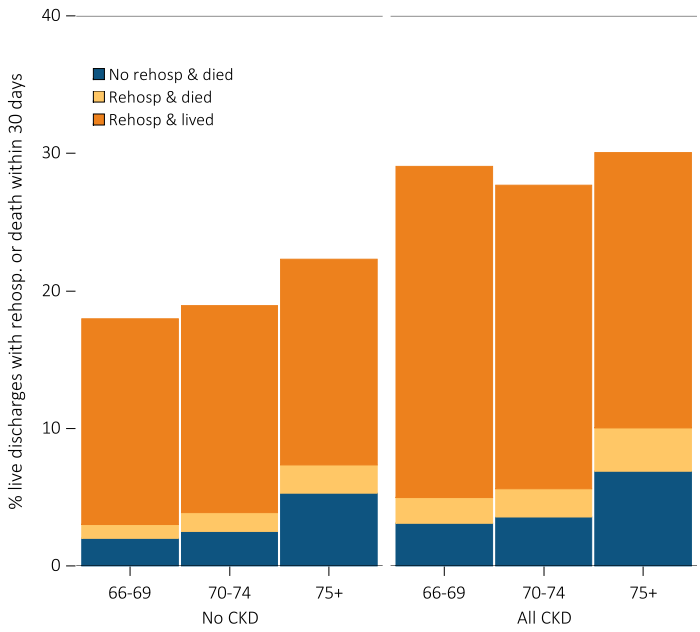
	No CKD	All CKD	Stages 1-2	Stage 3	Stages 4-5	Unk/unspc
All	16.7	23.7	23.2	23.8	25.3	23.0
66-69	16.0	25.9	23.9	25.4	28.5	26.2
70-74	16.4	24.1	23.6	23.7	24.4	24.5
75-84	17.0	24.1	23.8	24.3	26.1	23.3
85+	17.0	21.8	21.5	22.7	23.4	20.2
Male	17.6	24.3	23.6	24.5	26.1	23.5
Female	16.1	23.1	22.8	23.3	24.6	22.5
White	16.5	23.2	22.8	23.3	24.6	22.7
Black/Af Am	18.7	26.2	26.4	26.4	26.8	25.7
Other	17.2	24.8	21.4	26.6	30.0	21.1
No rehospitalization & died	4.2	5.9	5.1	5.4	7.2	6.1
Rehospitalization & died	1.8	2.8	2.5	2.7	3.4	2.7
Rehospitalization & lived	15.0	20.9	20.7	21.1	21.9	20.3

Data source: Medicare 5 percent sample. January 1, 2012 point prevalent, Medicare patients age 66 and older, discharged alive from an all-cause index hospitalization between January 1, 2012, and December 1, 2012; unadjusted. See Table A for CKD stage definitions. Abbreviations: Af Am, African American; CKD, chronic kidney disease; Unk/unspc, CKD stage unidentified.

Figure 3.12 presents the percentages of Medicare patients that are re-hospitalized or die within 30 days of discharge from an all-cause, index hospitalization. As seen in Table 3.3, rates of rehospitalization for patients with CKD decrease with age across all stages of CKD, while those for patients without CKD are similar across all age groups. This is likely due to the competing risk of interim death. For patients without CKD, the proportion either returning to the hospital or dying within 30 days increases with age, but there is no clear relationship for patients with CKD. However, comparison of those who died without rehospitalization with those who were rehospitalized and later died shows that overall percent of CKD patients dying within 30 of discharge does increase with age.

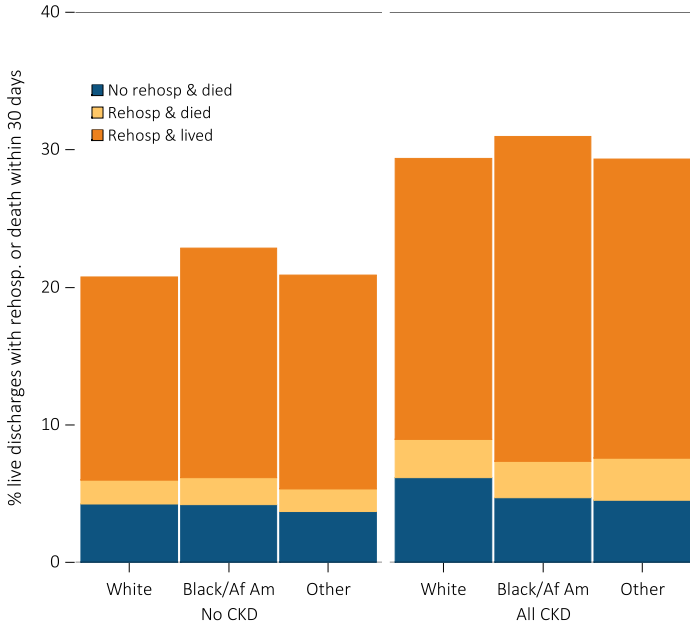
As shown in Figure 3.13, for both patients with and without CKD, Blacks/African Americans experience more re-admission or death within 30 days of discharge from an all-cause index hospitalization. This is primarily influenced by rehospitalization where the patient did not die within 30 days. For those without CKD, Blacks/African Americans and Whites have similar rates of patient death, either with or without rehospitalization, while deaths for those of other races are slightly lower. For CKD patients, however, White patients experience a higher rate of death within 30 days of discharge without having been re-hospitalized than do Blacks/African Americans and those of other races.

vol 1 Figure 3.12 Unadjusted percentage readmitted to the hospital within 30 days of discharge, among Medicare patients aged 66 and older, discharged alive from an all-cause index hospitalization between January 1 and December 1, by age and CKD status, 2012



Data source: Medicare 5 percent sample. January 1, 2012 point prevalent, Medicare patients age 66 and older, discharged alive from an all-cause index hospitalization between January 1, 2012, and December 1, 2012; unadjusted. Abbreviations: CKD, chronic kidney disease; Rehosp, rehospitalized.

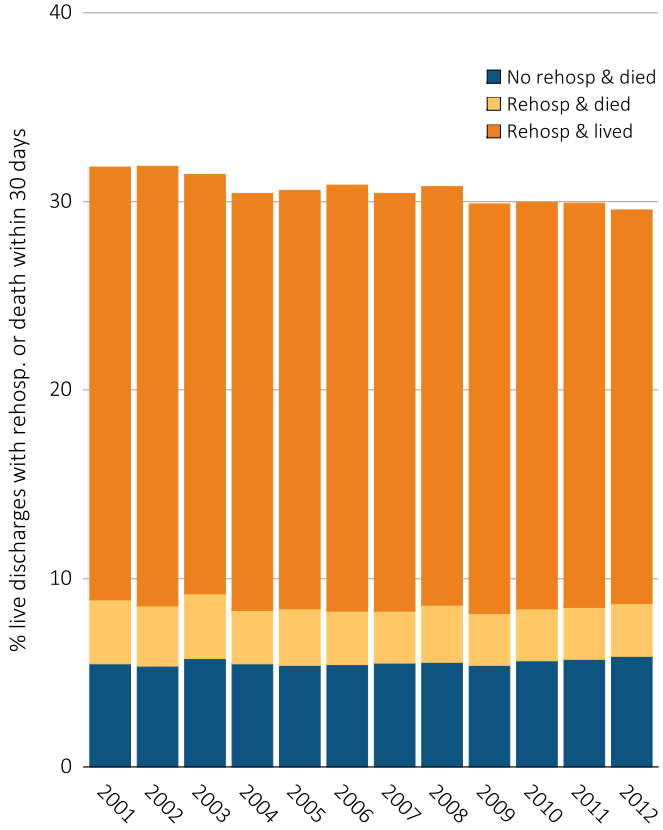
vol 1 Figure 3.13 Unadjusted percentage readmitted to the hospital within 30 days of discharge, among Medicare patients aged 66 and older, discharged alive from an all-cause index hospitalization between January 1 and December 1, by race and CKD status, 2012



Data Source: Medicare 5 percent sample. January 1, 2012 point prevalent, Medicare patients age 66 and older, discharged alive from an all-cause index hospitalization between January 1, 2012, and December 1, 2012; unadjusted. Abbreviations: Af Am, African American; CKD, chronic kidney disease; Rehosp, rehospitalized.

Figure 3.14 presents rates of CKD patient re-hospitalization or death, over time. The combined outcomes have decreased slightly over the last 12 years, from 31.8 percent in 2001 to 29.5 percent in 2012. Much of this slight reduction occurred in the group that had been rehospitalized, but was still alive at 30 days following discharge, a rate that decreased from 23.0 percent in 2001 to 20.9 percent in 2012.

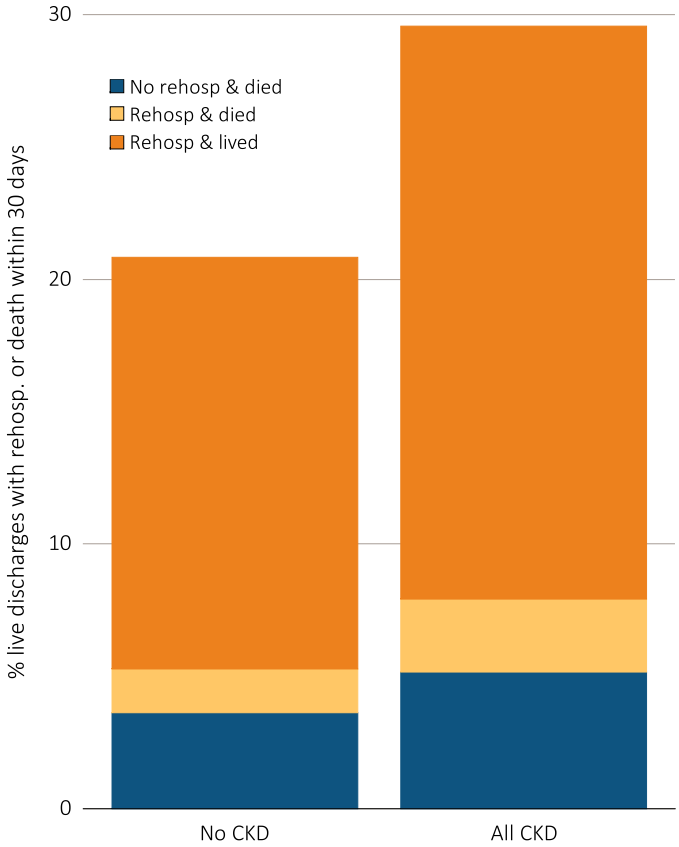
vol 1 Figure 3.14 Adjusted percentage readmitted to the hospital within 30 days of discharge, among Medicare CKD patients aged 66 and older, discharged alive from an all-cause index hospitalization between January 1 and December 1, by year, 2001-2012



Data source: Medicare 5 percent sample. January 1 of each reported year point prevalent, Medicare patients age 66 and older with CKD (defined during the prior year) discharged alive from an all-cause index hospitalization between January 1 and December 1 of the reported year. Adj: age/sex/race. Ref: 2012. Abbreviations: CKD, chronic kidney disease; Rehosp, rehospitalized.

Figure 3.15 shows the death and rehospitalization percentages for Medicare patients (66 and older) that were discharged alive from a cardiovascular index hospitalization. The magnitude and pattern of these percentages are similar to those for all-cause index hospitalizations.

vol 1 Figure 3.15 Unadjusted percentage readmitted to the hospital within 30 days of discharge, among Medicare patients aged 66 and older, discharged alive from a cardiovascular-related index hospitalization between January 1 and December 1, by CKD status, 2012



Data Source: Medicare 5 percent sample. January 1, 2012 point prevalent, Medicare patients age 66 and older discharged alive from a cardiovascular-related index hospitalization between January 1, 2012, and December 1, 2012; unadjusted. Abbreviations: CKD, chronic kidney disease; Rehosp, rehospitalized.

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Centers for Medicare and Medicaid Services (CMS). Readmissions Reduction Act 2010. Retrieved September 29, 2014 from http://cms.gov/Medicare/Medicare-Fee-for-Service-Payment/AcuteInpatientPPS/Readmissions-Reduction-Program.html/.

Go AS, Chertow GM, Fan D, McCulloch CE, Hsu C. Chronic kidney disease and the risks of death, cardiovascular events, and hospitalization. *New England Journal of Medicine* 2004;351(13):1296-1305.

Matsushita K, van der Velde M, Astor BC, Woodward M, Levey AS, de Jong PE, Coresh J, Gansevoort RT. Association of estimated glomerular filtration rate and albuminuria with all-cause and cardiovascular mortality in general population cohorts: a collaborative meta-analysis. *Lancet* 2010;375(9731):2073–81.

Chapter 4: Cardiovascular Disease in Patients With CKD

Introduction

Cardiovascular disease is an important comorbidity for patients with chronic kidney disease (CKD). CKD patients are at high-risk for cardiovascular disease, and the presence of CKD often complicates its treatment and prognosis. In this chapter, we review recent trends in the prevalence and outcomes of cardiovascular disease in CKD patients and compare these to outcomes of cardiovascular disease in patients without CKD, focusing on the high-risk, elderly Medicare population.

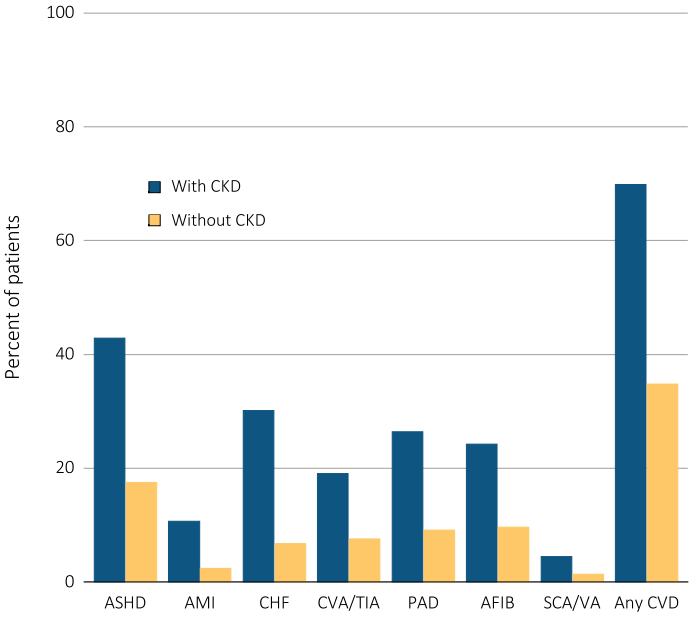
Analytical Methods

See the *CKD Analytical Methods* chapter for an explanation of analytical methods used to generate the figures and tables in this chapter.

Cardiovascular Disease Prevalence and Outcomes in CKD

As shown in Figure 4.1, elderly CKD patients have a greater burden of cardiovascular disease than do their non-CKD counterparts for a wide range of conditions. Stable atherosclerotic heart disease (ASHD), acute myocardial infarction (AMI), congestive heart failure (CHF), stroke (cerebrovascular accident/transient ischemic attack, CVA/TIA), peripheral arterial disease (PAD), atrial fibrillation (AFIB), sudden cardiac arrest and ventricular arrhythmias (SCA/VA) are all more common in CKD patients aged 66 and older when compared with those without CKD. Indeed, the prevalence of any cardiovascular disease is double in CKD patients (69.8 percent versus 34.8 percent).

vol 1 Figure 4.1 Cardiovascular disease in patients with or without CKD, 2012



Data Source: Medicare 5 percent sample. Patients age 66 and older, alive, without end-stage renal disease, and residing in the U.S. on 12/31/2012 with fee-for-service coverage for the entire calendar year. Abbreviations: AFIB, atrial fibrillation; AMI, acute myocardial infarction; ASHD, atherosclerotic heart disease; CHF, congestive heart failure; CKD, chronic kidney disease; CVA/TIA, cerebrovascular accident/transient ischemic attack; CVD, cardiovascular disease; PAD, peripheral arterial disease; SCA/VA, sudden cardiac arrest and ventricular arrhythmias.

The prevalence of these conditions also generally increases with age and presence of CKD (Table 4.1). The relationship with race/ethnicity and sex is less straightforward. Major procedures utilized for the treatment of cardiovascular disease are more common among CKD patients, including percutaneous coronary intervention (PCI), coronary artery bypass grafting (CABG), and the placement of implantable cardioverter defibrillators (ICD) and cardiac resynchronization (CRT) devices.

vol 1 Table 4.1 Prevalence of cardiovascular comorbidities & procedures (percent), by CKD status, age, race & sex, 2012

Cardiovascular Comorbidities[a]

	Overall	66-69	70-74	75-84	85+	White	Black / Af Am	Other	Male	Female
Atherosclerotic heart disease (ASHD)										
Without CKD	17.4	11.6	15.4	20.6	23.1	17.9	14.2	14.7	23.2	13.3
Any CKD	42.9	35.2	39.5	44.8	46.1	43.9	36.4	40.1	50.2	36.3
Acute myocardial infarction (AMI)										
Without CKD	2.4	1.7	2.1	2.7	3.3	2.5	1.9	1.6	3.1	1.9
Any CKD	10.6	9.7	9.7	10.6	11.8	11.0	8.9	8.1	12.6	8.9
Congestive heart failure (CHF)										
Without CKD	6.7	3.3	4.5	7.6	14.0	6.7	8.1	5.4	6.9	6.6
Any CKD	30.1	22.2	24.3	29.4	39.5	30.1	32.3	26.4	30.2	30.1
Cerebrovascular accident/transient ischemic attack (CVA-TIA)										
Without CKD	7.5	4.3	5.9	9.1	12.1	7.5	8.5	6.4	7.5	7.6
Any CKD	19.1	14.7	16.2	20.0	21.9	18.9	21.4	17.8	19.0	19.2
Peripheral artery disease (PAD)										
Without CKD	9.1	4.6	6.4	10.5	17.9	9.2	10.1	7.1	9.2	9.1
Any CKD	26.4	19.5	22.4	26.8	32.0	26.6	26.2	22.9	27.3	25.6
Atrial fibrillation (AFIB)										
Without CKD	9.6	4.3	6.6	11.9	18.0	10.3	4.8	5.3	10.8	8.7
Any CKD	24.2	14.1	18.2	25.0	32.3	26.0	14.6	16.1	26.5	22.1
Cardiac arrest and ventricular arrhythmias (SCA/VA)										
Without CKD	1.3	0.9	1.2	1.6	1.6	1.4	1.1	0.8	1.9	0.9
Any CKD	4.5	4.0	4.5	4.8	4.3	4.6	4.5	2.9	6.2	3.0

Cardiovascular Procedures[b]

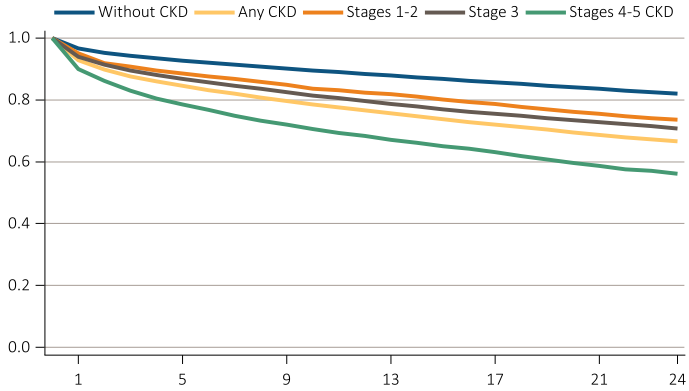
Revascularization - percutaneous coronary interventions (PCI)										
Without CKD	4.2	6.2	5.1	3.9	2.1	4.3	3.5	3.8	4.7	3.6
Any CKD	5.3	7.8	6.7	5.5	3.3	5.4	4.7	4.8	5.9	4.6
Revascularization - coronary artery bypass graft (CABG)										
Without CKD	1.1	1.7	1.4	1.1	0.3	1.2	0.8	0.9	1.4	0.8
Any CKD	1.8	2.9	2.8	1.9	0.6	1.9	1.3	1.3	2.2	1.2
Implantable cardioverter defibrillators & cardiac resynchronization therapy with defibrillator (ICD/CRT-D)										
Without CKD	0.8	1.4	1.1	0.9	0.3	0.8	0.5	0.8	1.3	0.4
Any CKD	1.2	2.0	1.8	1.5	0.5	1.3	0.9	1.2	1.9	0.6

Data Source: Medicare 5 percent sample. Patients age 66 and older, alive, without end-stage renal disease, and residing in the U.S. on 12/31/2012 with fee-for-service coverage for the entire calendar year. Abbreviations: AFIB, atrial fibrillation; AMI, acute myocardial infarction; ASHD, atherosclerotic heart disease; Af Am, African American; CABG, coronary artery bypass grafting; CHF, congestive heart failure; CKD, chronic kidney disease; CVA/TIA, cerebrovascular accident/transient ischemic attack; CVD, cardiovascular disease; ICD/CRT-D, implantable cardioverter defibrillators/cardiac resynchronization therapy with defibrillator devices; PAD, peripheral arterial disease; PCI, percutaneous coronary interventions; SCA/VA, sudden cardiac arrest and ventricular arrhythmias. [a] The denominators for all cardiovascular comorbidities are Medicare enrollees age 66+. [b] The denominators for PCI and CABG are Medicare enrollees age 66+ with ASHD. The denominator for ICD/CRT-D is Medicare enrollees age 66+ with CHF.

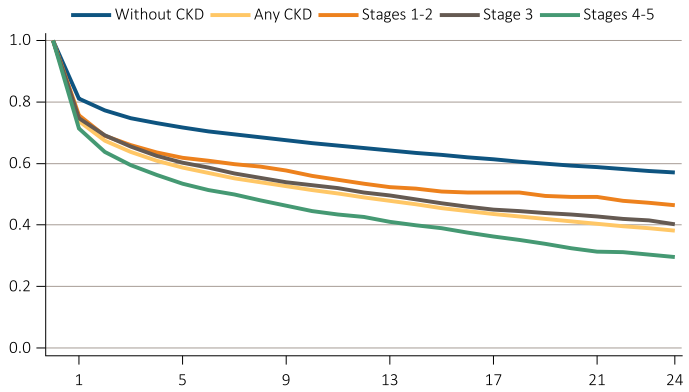
The presence of CKD also worsens the short- and long-term prognosis for many of these common cardiovascular diseases. Figures 4.2a through 4.2j illustrate survival in patients with cardiovascular disease stratified by the presence of CKD and its severity. In general, CKD patients have worse survival across all of the conditions reported, with late stages of CKD associated with the worst outcomes. This pattern also is true in patients who undergo common major procedures for the treatment of cardiovascular diseases. For example, the two-year survival of non-CKD AMI patients is 57 percent, compared to 46 percent for CKD Stage 1-2 patients and 30 percent for CKD Stage 4-5 patients.

vol 1 Figure 4.2 Survival of patients with a cardiovascular diagnosis or procedure, by CKD status, 2010-2012

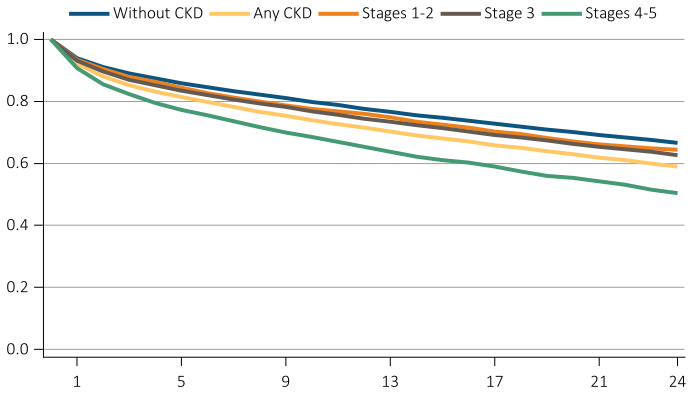
(a) ASHD



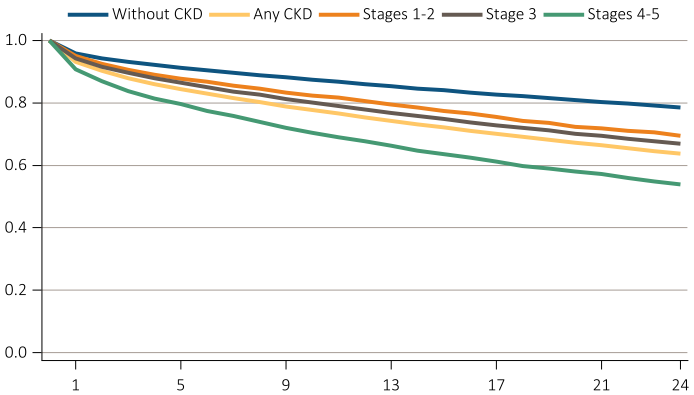
(b) AMI



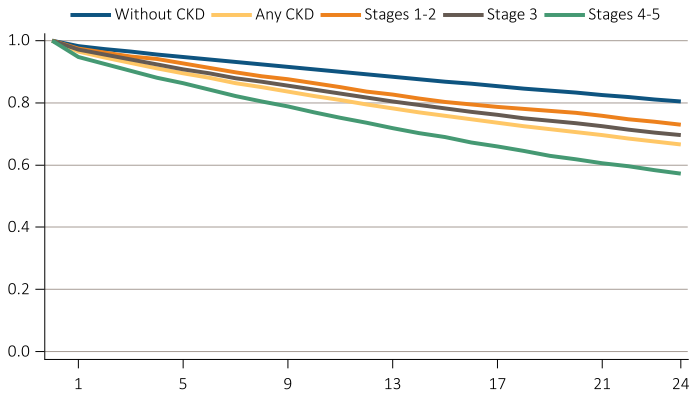
(c) CHF



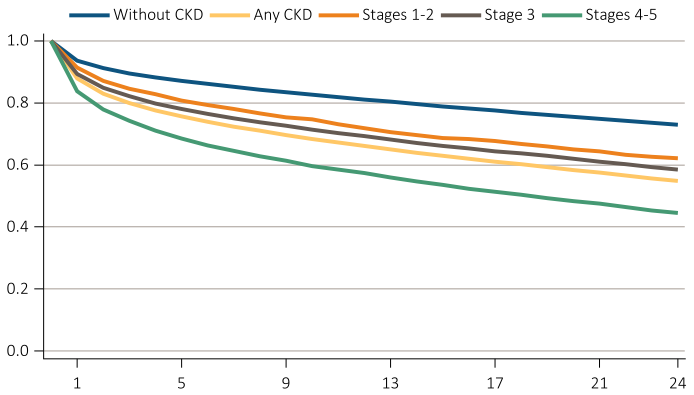
(d) CVA / TIA



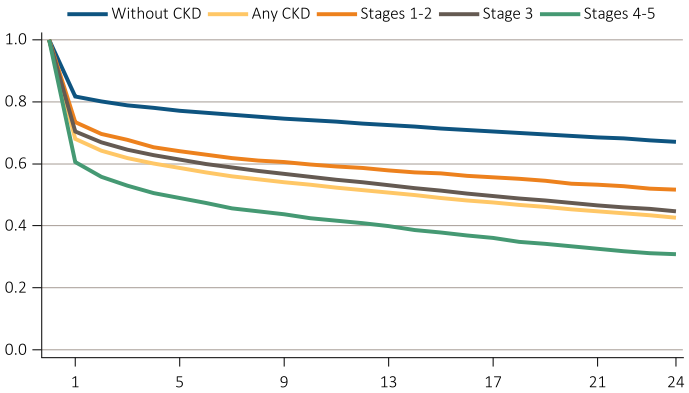
(e) PAD



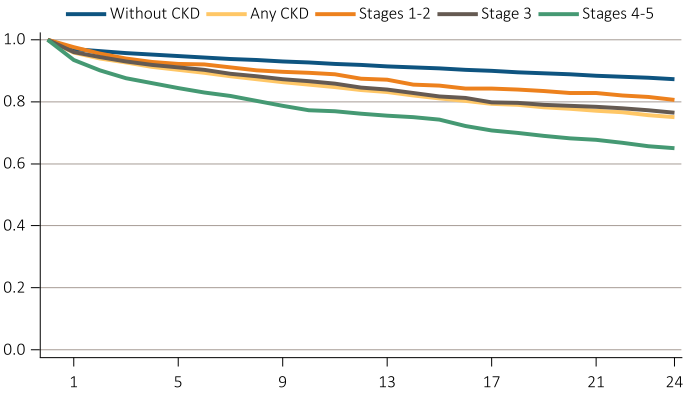
(f) AFIB



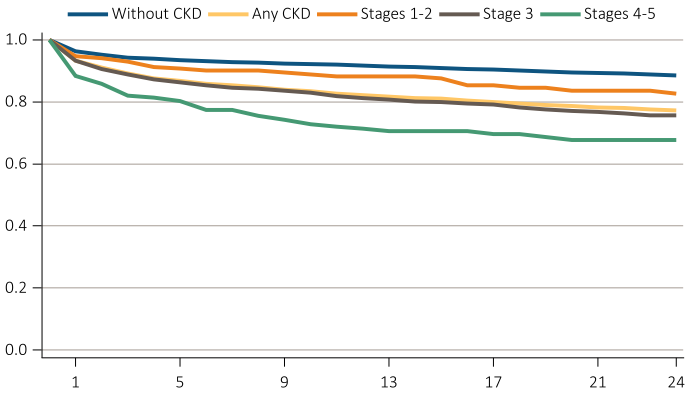
(g) SCA / VA



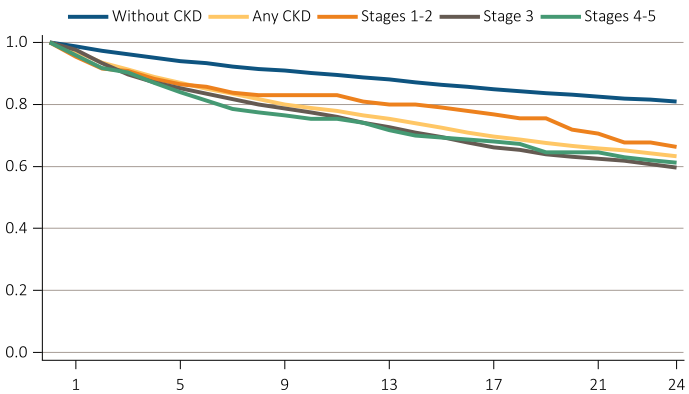
(h) PCI



(i) CABG



(j) ICD / CRT / D



Data Source: Medicare 5 percent sample. Patients age 66 and older, alive, without end-stage renal disease, and residing in the U.S. on 12/31/2012 with fee-for-service coverage for the entire calendar year. Abbreviations: AFIB, atrial fibrillation; AMI, acute myocardial infarction; ASHD, atherosclerotic heart disease; CABG, coronary artery bypass grafting; CHF, congestive heart failure; CKD, chronic kidney disease; CVA/TIA, cerebrovascular accident/transient ischemic attack; CVD, cardiovascular disease; ICD/CRT-D, implantable cardioverter defibrillators/cardiac resynchronization therapy with defibrillator devices; PAD, peripheral arterial disease; PCI, percutaneous coronary interventions; SCA/VA, sudden cardiac arrest and ventricular arrhythmias.

Congestive Heart Failure and Chronic Kidney Disease

Congestive heart failure (CHF) is the most frequent cardiovascular disease that has been linked to CKD, with its prevalence in CKD patients aged 66 and older exceeding 40 percent in 2012. Given its importance in this population, key characteristics of CHF in CKD patients are further examined in Table 4.2 after stratifying CHF based on systolic dysfunction (i.e., heart failure with decreased ejection fraction), diastolic dysfunction (i.e., heart failure with preserved ejection fraction), or unspecified. For ease of reporting and because of consistency of clinical approaches, systolic CHF includes patients with systolic dysfunction regardless of the presence of concomitant diastolic dysfunction. Patients with isolated diastolic CHF are treated separately since long-term risk assessments and treatments vary for this group.

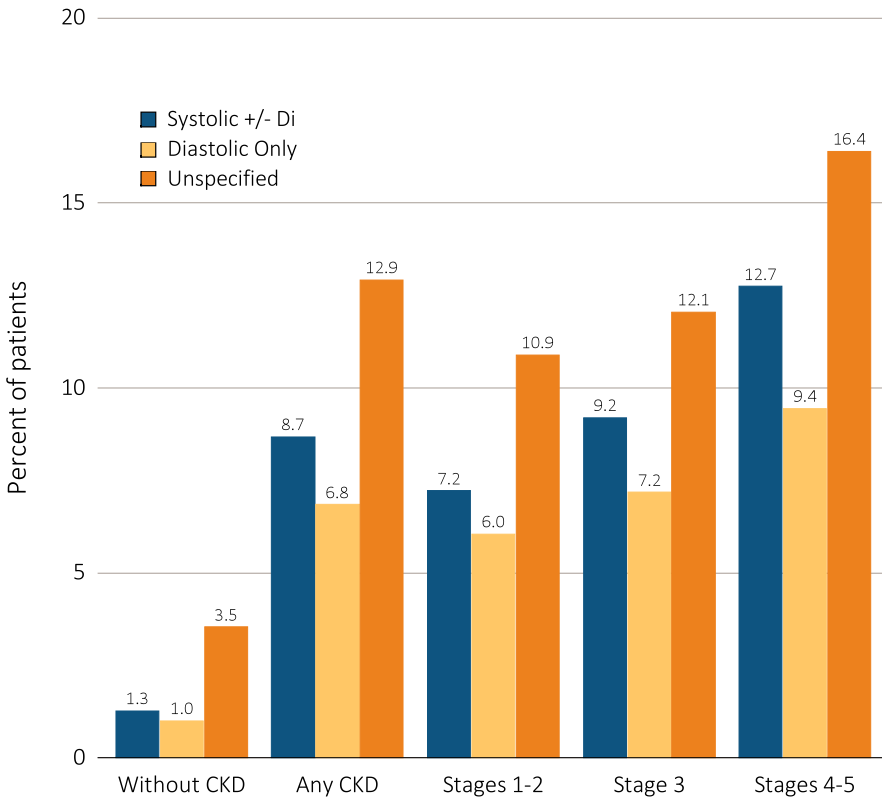
vol 1 **Table 4.2 Characteristics of patients with heart failure, by CKD status, 2012**

	Systolic +/- Diastolic heart failure		Diastolic only heart failure		Heart failure, unspecified	
	Without CKD	Any CKD	Without CKD	Any CKD	Without CKD	Any CKD
Age:						
66-69	13.9	10.2	10.2	9.4	10.5	9.0
70-74	18.2	16.9	15.2	14.0	15.7	14.9
75-84	39.6	40.5	39.0	39.1	37.2	38.8
85+	28.3	32.4	35.7	37.4	36.6	37.3
Male	52.7	56.3	31.1	35.3	39.0	45.4
Female	47.3	43.7	68.9	64.7	61.0	54.6
White	88.0	84.1	87.7	84.1	86.0	82.4
Black/African American	7.7	11.2	8.3	11.4	9.2	12.1
Other race	4.3	4.7	4.1	4.5	4.8	5.5
Non-diabetes	61.4	43.6	61.7	42.9	62.0	45.3
Diabetes	38.6	56.4	38.3	57.1	38.0	54.7

Data Source: Medicare 5 percent sample. Patients age 66 and older, alive, without end-stage renal disease, and residing in the U.S. on 12/31/2012 with fee-for-service coverage for the entire calendar year. Abbreviation: CKD, chronic kidney disease.

In general, the distribution of age and sex show similar patterns among patients with CHF and CKD when compared with those with CHF without CKD. However, the proportion of Black/African Americans and diabetic patients was higher among patients with CHF and CKD. These patterns were consistent regardless of whether systolic, diastolic, or unspecified CHF was identified. The relative proportion of patients with systolic CHF is slightly higher than diastolic CHF in CKD patients, and increases with greater severity of CKD (e.g., Stages 1-2 vs. Stage 3 vs. Stages 4-5), although the vast majority of patients have unspecified CHF in all instances (Figure 4.3).

vol 1 Figure 4.3 Heart failure in patients with or without CKD, 2012



Data Source: Medicare 5 percent sample. Patients age 66 and older, alive, without end-stage renal disease, and residing in the U.S. on 12/31/2012 with fee-for-service coverage for the entire calendar year. Abbreviation: CKD, chronic kidney disease.

Tables 4.3a and 4.3b show the complex relationship and interplay between CKD and CHF due to common risk factors as well as patho-physiological dependencies related to management of volume status. For example, the presence of CHF is an important risk factor for all-cause death in the Medicare population with CKD with a risk-adjusted odds ratio of 2.6 (Table 4.3a). Conversely, we also found that CKD was an important risk factor for all-cause death in the Medicare population with CHF with a risk-adjusted odds ratio of 1.5 (Table 4.3b).

vol 1 Table 4.3 Adjusted hazard ratio of all-cause death (a) associated with the presence of CHF in patients with CKD, and (b) associated with the presence of CKD in patients with CHF, 2011-2012

(a)

		Hazard ratio	Confidence Interval	p-value
Age:	66-69	reference		
	70-74	1.25	1.18 - 1.33	<.0001
	75-84	1.83	1.74 - 1.93	<.0001
	85+	3.63	3.44 - 3.82	<.0001
Male		reference		
Female		0.83	0.81 - 0.85	<.0001
White		reference		
Black/African American		0.95	0.92 - 0.99	0.0223
Other race		0.82	0.77 - 0.87	<.0001
CHF	Yes vs. No	2.57	2.50 - 2.63	<.0001
Diabetes	Yes vs. No	1.08	1.06 - 1.11	<.0001
Hypertension	Yes vs. No	0.88	0.83 - 0.92	<.0001

(b)

		Hazard ratio	Confidence Interval	p-value
Age:	66-69	reference		
	70-74	1.18	1.11 - 1.25	<.0001
	75-84	1.74	1.66 - 1.83	<.0001
	85+	3.30	3.14 - 3.47	<.0001
Male		reference		
Female		0.87	0.85 - 0.89	<.0001
White		reference		
Black/African American		0.89	0.85 - 0.92	<.0001
Other race		0.76	0.72 - 0.81	<.0001
CKD	Yes vs. No	1.52	1.49 - 1.56	<.0001
Diabetes	Yes vs. No	1.09	1.07 - 1.12	<.0001
Hypertension	Yes vs. No	0.91	0.88 - 0.94	<.0001

Data Source: Medicare 5 percent sample. Patients age 66 and older, alive, without end-stage renal disease, and residing in the U.S. on 12/31/2012 with fee-for-service coverage for the entire calendar year. Abbreviations: CKD, chronic kidney disease; CHF, congestive heart failure.

Chapter 5: Acute Kidney Injury

Introduction

In recent years, acute kidney injury (AKI) has gained increasing recognition as a major risk factor for the development of chronic kidney disease (CKD). The clearest example of this relationship comes 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 percent 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 greater risk of suffering an episode of AKI. As a result, AKI is frequently superimposed on CKD and therefore plays a key role in CKD progression.

In this chapter, we examine antecedents and outcomes associated with AKI using the Medicare five percent sample. As is typical of administrative datasets, Medicare data does 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. Instead, episodes of AKI, including those requiring dialysis, are identified based on billing claims alone. An important limitation of this indirect method is poor sensitivity, particularly 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 or 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.

As shown in Figure 5.1, the percent of patients with an AKI hospitalization in the Medicare population appears to be rising, now reaching 4 percent annually compared to 1.5 percent a decade ago. Conversely, the proportion of these patients requiring dialysis has declined over the same time frame. Together, these findings suggest that code creep 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.

Unadjusted AKI incidence rates have also been rising. AKI rates are significantly associated with aging, ranging from 20.4 per 1,000 patient years in patients aged 66-69 to 85.2 per 1,000 patient years among patients older than 85 years. Although the temporal rising trend is seen in every age range, the rate of increase appears to be more pronounced with older ages. AKI rates also remain significantly associated with Black/African American race — a disparity rising over the past decade. AKI rates are also higher among patients with diabetes mellitus (DM), pre-existing CKD or both.

Next, we examine outcomes following an AKI hospitalization. An episode of AKI is associated with an increased risk for future episodes of AKI; slightly more than one third of Medicare patients with an AKI hospitalization had another AKI event in the next 24 months. As with first episodes of AKI, Black/African American patients were at higher risk to suffer a recurrent AKI episode than White patients, and recurrent AKI was also more likely in patients with diabetes, CKD or both when compared to those without either comorbidity.

Follow-up medical visits after an initial AKI hospitalization vary by physician specialty. While nearly 75 percent of AKI patients will be seen by a primary care physician within three months of AKI hospitalization, less than 13 percent will have been seen by a nephrologist. This percentage increases over

time, but remains less than 20 percent by one year. Not surprisingly, nephrology visits are more likely in AKI patients with underlying CKD, in whom 28.8 percent are seen by one year. Follow-up serum creatinine testing occurs in the majority of patients, with about 70 percent of patients tested within three months of hospitalization and 85 percent tested by six months.

As noted above, AKI plays an important role in CKD progression, and patients who experienced an AKI hospitalization had modifications in their reported stage of CKD. Nearly 30 percent of individuals without CKD prior to their AKI hospitalization are reclassified as having some degree of CKD in the subsequent year.

Lastly, we explore patient disposition following an AKI hospitalization. Less than half of patients suffering an AKI hospitalization return to their homes, while nearly 30 percent are institutionalized in a skilled nursing facility. These outcomes highlight the significant morbidity associated with AKI.

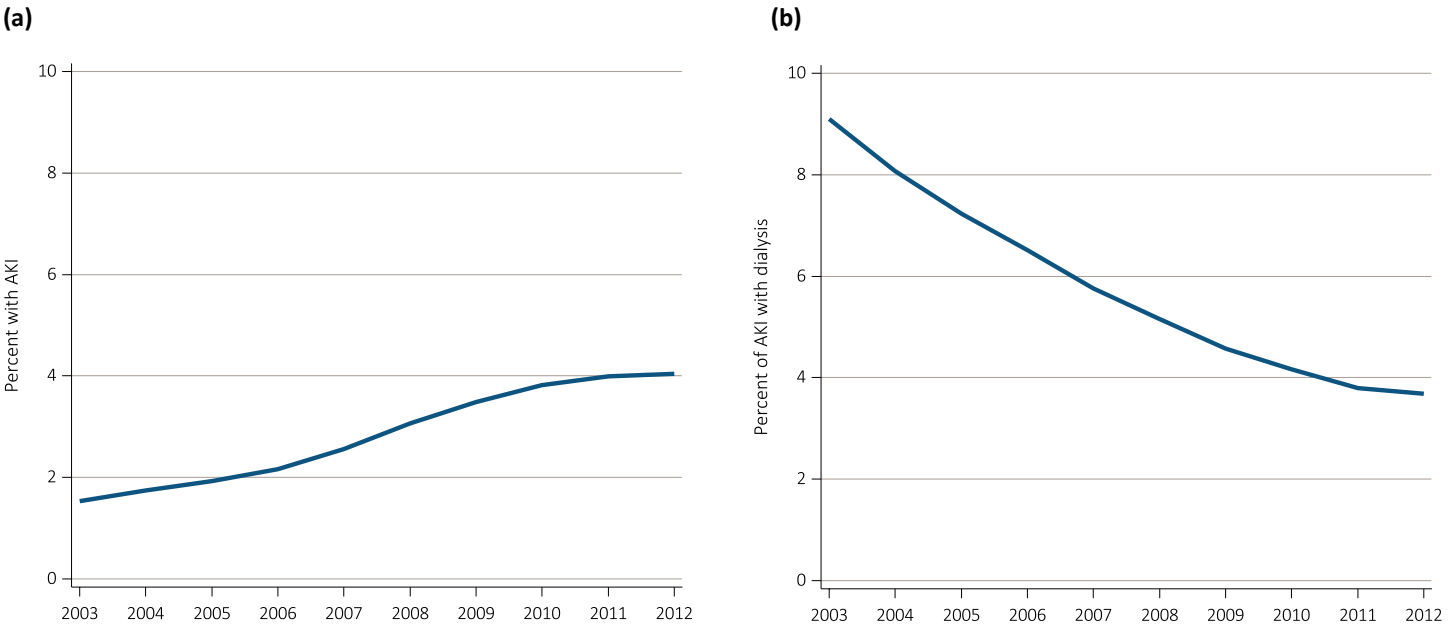
Analytical Methods

For this year's Annual Data Report (ADR), there have been some methodological changes from previous years. First, to define a hospitalization as an AKI hospitalization, the ICD-9-CM (International Classification of Diseases, 9th revision, clinical modification) diagnosis code for AKI must be on the inpatient claim for the hospital stay, even if the patient received dialysis during the stay. This definition of AKI has been validated in published studies (Waikar et al., 2006). In previous ADRs, a hospital stay with dialysis for a person that did not have an ESRD Medical Evidence form (CMS 2728) was considered AKI even if the diagnosis of AKI was not present.

Also in this year's ADR, the analytic sample for the whole chapter contains patients who were alive, did not have ESRD (as indicated by the first service date on the ESRD Medical Evidence form), were not enrolled in a Medicare Advantage plan (Part C/HMO), and had Parts A and B coverage on January 1 of the calendar year. In previous ADRs, the figures corresponding to Figures 5.1-5.3 and Table 5.1 of this year's ADR used a subsample of this main analytic sample consisting of patients who were alive without ESRD or enrollment in a Medicare managed care plan for the entire calendar year. Removing this survival requirement provides a more comprehensive view of AKI in the Medicare population and increases the number of patients with AKI in 2008 from 23,862 to 39,633 and in 2011 from 32,211 to 51,436.

See the *CKD Analytical Methods* chapter for a more detailed explanation of the analytical methods used to generate the figures and table in this chapter.

vol 1 Figure 5.1 Percent of Medicare patients aged 66+, (a) with at least one AKI hospitalization, and (b) with an AKI hospitalization that had dialysis by year, 2003-2012



Data Source: Medicare 5 percent sample. 5.1a: Percent with an AKI hospitalization among all Medicare patients aged 66 and older who had both Medicare Parts A & B, no Medicare Advantage plan (Part C/HMO), no ESRD by first service date from Medical Evidence form, and were alive on January 1 of year shown. 5.1b: 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. Abbreviation: AKI, acute kidney injury.

Characteristics of Patients With Acute Kidney Injury

Acute kidney injury occurs most commonly in older adults. In the Medicare population, patients aged 80 years and older comprise nearly 55 percent of all patients with an AKI hospitalization as shown in Table 5.1. In 2012, males continue to make up a slight majority of AKI cases, a steady trend observed since 2003. Diabetes mellitus and pre-existing CKD are recognized as two major risk factors for AKI; one or both of these risk factors was present in 56.6 percent of Medicare patients with an AKI hospitalization.

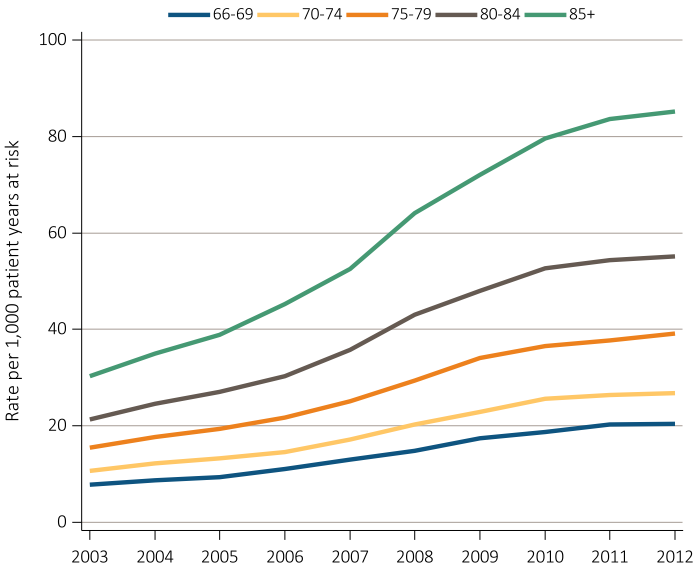
Rates of AKI are strongly influenced by age, as shown in Figure 5.2. Among Medicare patients ages 66-69, for example, the rate of AKI in 2012 was 20.4 per 1,000 patient years, increasing to 26.8, 39.2, 55.1, and 85.2 respectively, for ages 70-74, 75-79, 80-84, and 85 and older. Rates of AKI have risen over time across all age ranges.

vol 1 **Table 5.1 Characteristics of Medicare patients aged 66+ with at least one AKI hospitalization: age, sex, race, CKD, DM by year, 2003-2012**

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Age										
66-69	10.6	10.5	10.3	10.6	10.6	10.3	10.9	10.8	11.3	11.3
70-74	16.5	16.3	16.0	15.3	15.4	15.5	15.4	15.6	15.6	15.8
75-79	21.8	21.3	21.0	20.2	19.4	18.5	18.6	18.0	17.7	18.0
80-84	22.5	22.9	22.9	22.3	22.4	22.4	21.5	21.3	20.7	19.9
85+	28.6	29.0	29.9	31.6	32.1	33.4	33.7	34.3	34.7	34.9
Sex										
Female	47.9	48.0	47.7	48.1	47.8	47.8	47.8	47.5	47.7	48.2
Male	52.1	52.0	52.3	51.9	52.2	52.2	52.2	52.5	52.3	51.9
Race										
White	82.9	82.6	81.7	82.0	82.8	83.2	83.2	83.1	83.1	82.7
Black/African American	12.7	13.0	13.7	13.5	12.5	12.0	12.0	12.1	12.0	12.2
Native Am	0.4	0.3	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5
Asian	1.0	1.3	1.2	1.2	1.2	1.4	1.4	1.4	1.5	1.5
Other	3.0	2.9	3.1	2.9	3.0	3.0	3.0	3.0	2.9	3.1
Pre-existing comorbidities										
No DM or CKD prior year	55.0	53.3	52.2	51.2	49.4	48.2	47.2	46.0	44.5	43.4
DM no CKD prior year	24.6	25.2	25.1	25.1	23.1	23.0	22.5	22.5	22.0	21.1
CKD no DM prior year	8.8	9.5	9.5	10.0	12.1	12.8	13.5	13.9	14.8	15.3
Both CKD & DM prior year	11.7	12.0	13.2	13.7	15.4	16.0	16.8	17.7	18.7	20.2

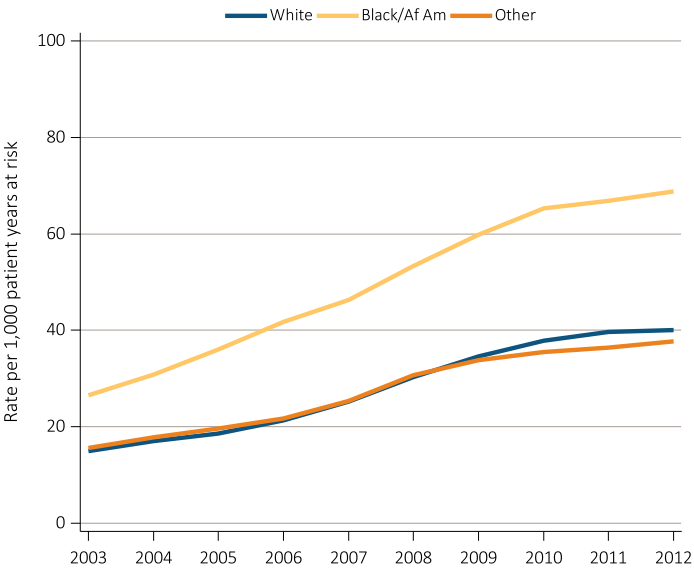
Data Source: Medicare 5 percent sample. Medicare patients aged 66 and older who had both Medicare Parts A & B, no Medicare Advantage plan (Part C/HMO), no ESRD by first service date from Medical Evidence form, and were alive on January 1 of year shown. Abbreviations: AKI, acute kidney injury; CKD, chronic kidney disease; DM, diabetes mellitus.

vol 1 Figure 5.2 Unadjusted rates of first hospitalization with AKI for Medicare patients aged 66+ by age and year, 2003-2012



Data Source: Medicare 5 percent sample. 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 (Part C/HMO), 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 Parts A & B participation, or switch to Medicare Advantage program. Abbreviation: AKI, acute kidney injury.

vol 1 Figure 5.3 Unadjusted rates of first hospitalization with AKI for Medicare patients aged 66+ by race and year, 2003-2012

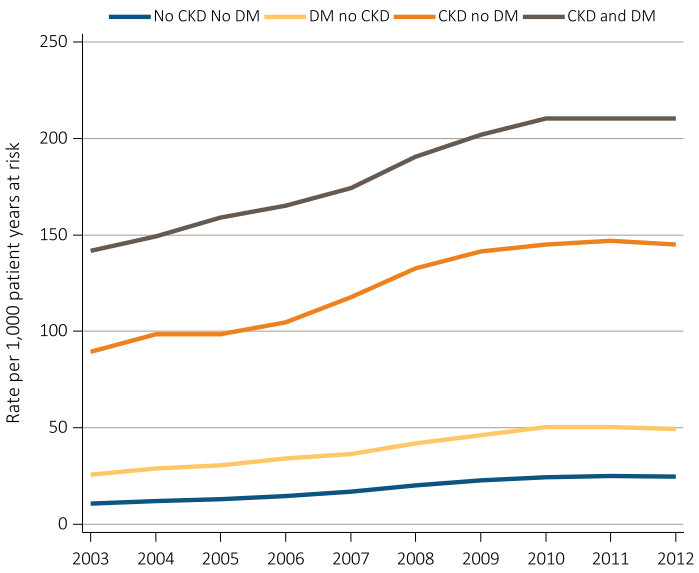


Data Source: Medicare 5 percent sample. All patient-years at risk for Medicare patients aged 66 or older who had both Medicare Parts A & B, no Medicare Advantage plan (Part C/HMO), no ESRD by first service date from Medical Evidence form, and were alive on January 1 of year shown. Censored at death, ESRD, end of Medicare Parts A & B participation, or switch to Medicare Advantage program. Abbreviations: Af Am, African American; AKI, acute kidney injury.

Rates of AKI in Medicare patients age 66 and older vary considerably by race, as shown in Figure 5.3. In 2012, the incidence rate reached 68.8 per 1,000 patient years at risk in Blacks/African Americans compared to 40.1 and 37.7, respectively, in Whites and individuals of other races. While this relationship has been observed since 2003, the gap has steadily widened reflecting a higher rate of increase in Blacks/African Americans.

The incidence rates for AKI, shown in Figure 5.4, also vary substantially by underlying comorbidity. In 2012, Medicare patients with DM and no known CKD had an AKI incidence rate of 49.5 per 1,000 patient years compared to 24.8 per 1,000 patient years in non-diabetic, non-CKD patients. Non-diabetic patients with CKD experienced an AKI incidence rate of 145.0 per 1,000 patient years, while the rate in patients with both diabetes and CKD was 210.3 per 1,000 patient years.

vol 1 Figure 5.4 Unadjusted rates of first hospitalization with AKI for Medicare patients aged 66+ by CKD, DM, and year, 2003-2012

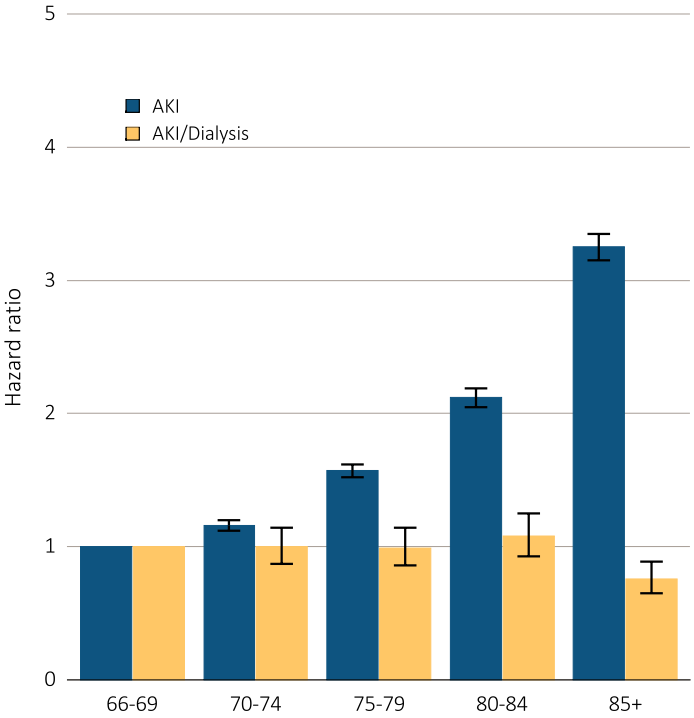


Data Source: Medicare 5 percent sample. All patient-years at risk for Medicare patients aged 66 and older who had both Medicare Parts A & B, no Medicare Advantage plan (Part C/HMO), no ESRD by first service date from Medical Evidence form, and were alive on January 1 of year shown. Censored at death, ESRD, end of Medicare Parts A & B participation, or switch to Medicare Advantage program. Abbreviations: AKI, acute kidney injury; CKD, chronic kidney disease; DM, diabetes mellitus.

Hospitalization for Acute Kidney Injury

As indicated in Figure 5.5, the adjusted hazard for an AKI hospitalization is highly associated with age and increases in a graded manner with increasing age group. There is no trend by age in the hazard of dialysis-associated AKI hospitalization. Since dialysis is a treatment choice of physicians and patients, the relationship with age is more complicated, perhaps reflecting different thresholds to initiate dialysis in patients in the oldest age groups.

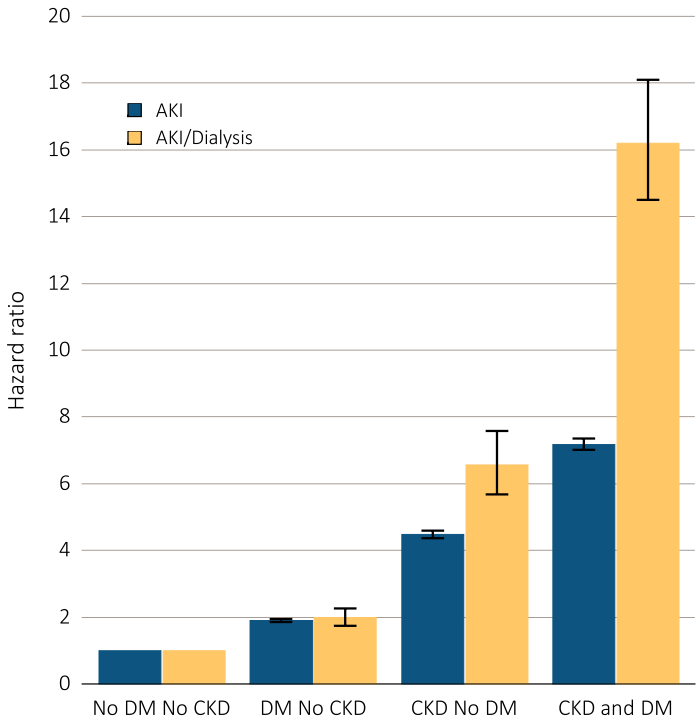
vol 1 Figure 5.5 Adjusted hazard of a first AKI hospitalization in Medicare patients aged 66+, overall and dialysis-requiring, by age, 2012



Data Source: Medicare 5 percent sample. Medicare patients aged 66 or older who had both Medicare Parts A & B, no Medicare Advantage plan (Part C/HMO), no ESRD by first service date from Medical Evidence form, and were alive on 1/1/2012. Dialysis is identified by a diagnosis or charge for dialysis on the AKI inpatient claim or a physician/supplier (Part B) claim for dialysis during the time period of the AKI inpatient claim. Models each include age, race, sex, DM and CKD status in prior year. Censored at death, ESRD, end of Medicare Parts A & B participation, or switch to Medicare Advantage program. Error bars represent 95% confidence interval of estimates. Abbreviation: AKI, acute kidney injury.

As shown in Figure 5.6, when examining baseline conditions, it is apparent that DM and CKD influence AKI risk both independently and synergistically. Compared to patients with neither comorbidity, patients with both DM and CKD had an adjusted hazard ratio of 7.18 for an episode of AKI. Having either DM or CKD alone conferred a hazard ratio of 1.90 and 4.48 respectively. The hazard ratios were even more pronounced for AKI requiring dialysis.

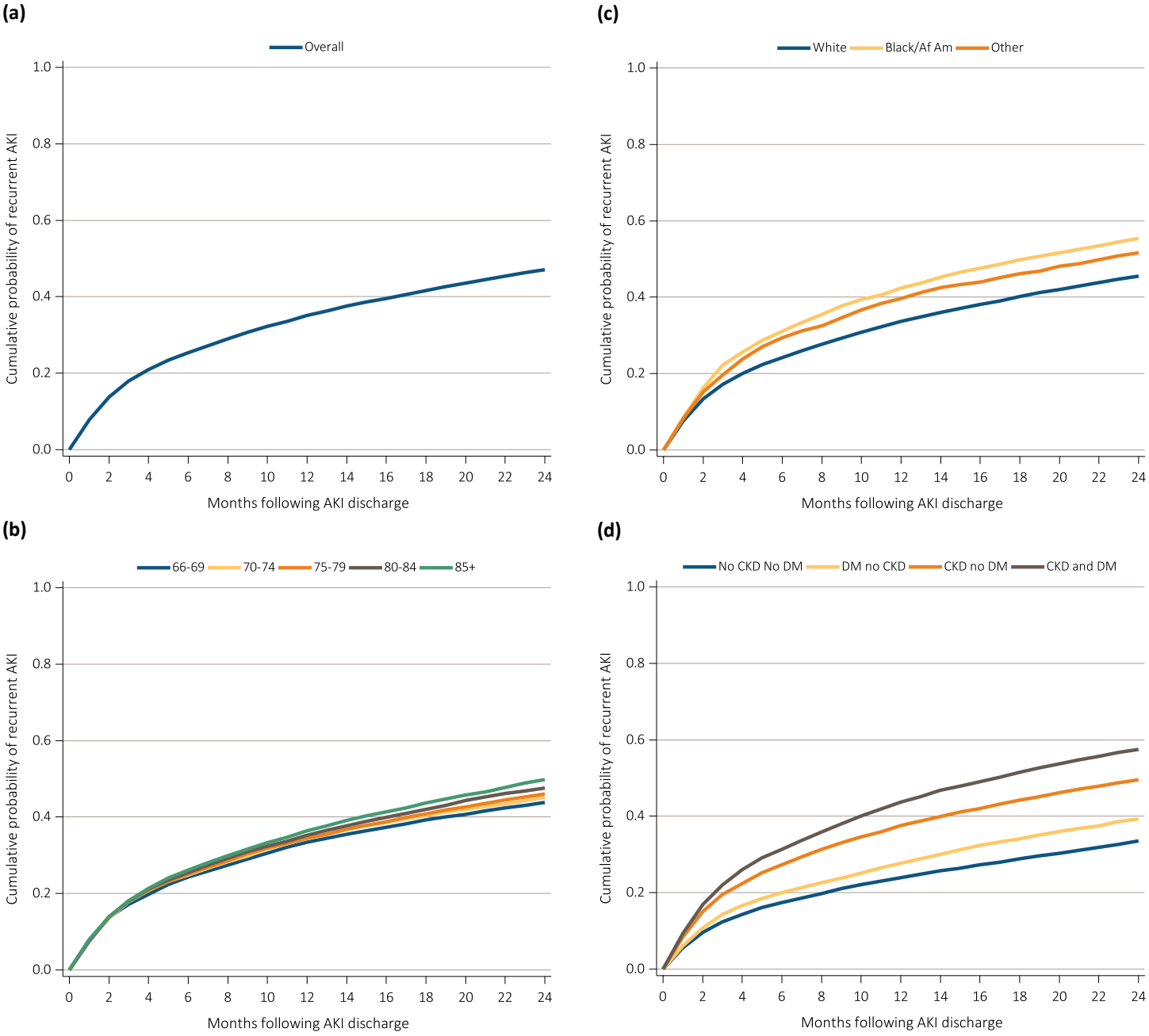
vol 1 Figure 5.6 Adjusted hazard of an AKI hospitalization in Medicare patients by DM & CKD status, 2012



Data Source: Medicare 5 percent sample. Medicare patients aged 66 and older who had both Medicare Parts A & B, no Medicare Advantage plan (Part C/HMO), no ESRD by first service date from Medical Evidence form, and were alive on 1/1/2012. Dialysis is identified by a diagnosis or charge for dialysis on the AKI inpatient claim or a physician/supplier (Part B) claim for dialysis during the time period of the AKI inpatient claim. Models each include age, race, sex, DM and CKD status in prior year. Censored at death, ESRD, end of Medicare Parts A & B participation, or switch to Medicare Advantage program. Error bars represent 95% confidence interval of estimates. Abbreviations: AKI, acute kidney injury; CKD, chronic kidney disease; DM, diabetes mellitus.

Following an AKI hospitalization, 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 Figure 5.7a. In contrast to first episodes, the rate of recurrent AKI is relatively similar across age groups in the Medicare population (5.7b); however, interpretation of this finding is limited by the effects of death censoring, which will be higher in older age groups. Blacks/African Americans are more likely to have a recurrent AKI hospitalization than other races, with a probability of 0.55 at 24 months (5.7c). Similarly, having either DM or CKD is associated with an increased probability for recurrent AKI compared to having neither (5.7d). The highest probability for recurrent AKI is seen in patients with both diabetes and CKD, in whom the probability reaches 0.58 by 24 months.

vol 1 Figure 5.7 Cumulative probability of a recurrent AKI hospitalization within two years of live discharge from first AKI hospitalization in 2010 for Medicare patients aged 66+, (a) overall, (b) by age, (c) by race, and (d) by CKD and DM

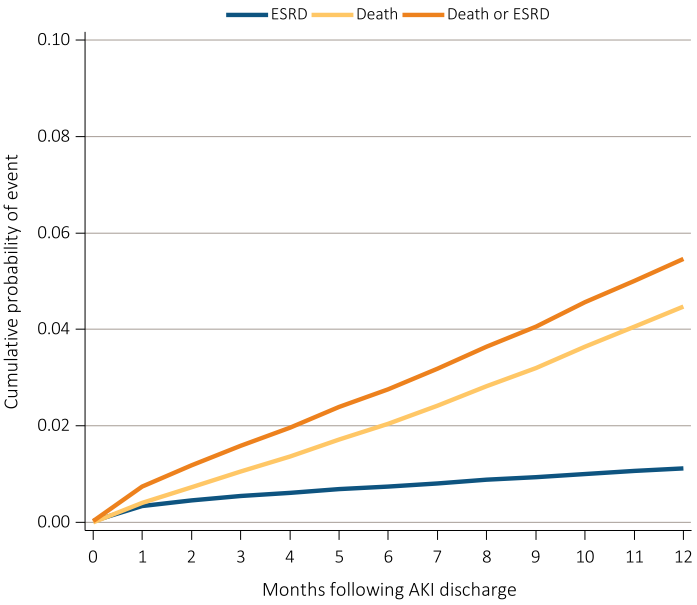


Data Source: Medicare 5 percent sample. Age on January 1, 2010. Medicare patients aged 66 and older who had both Medicare Parts A & B, no Medicare Advantage plan (Part C/HMO), no ESRD by first service date from Medical Evidence form on 1/1/2010 and were discharged alive from an AKI hospitalization in 2010. Censored at death, ESRD, end of Medicare Parts A & B participation, or switch to Medicare Advantage program. Abbreviations: AKI, acute kidney injury; CKD, chronic kidney disease; DM, diabetes mellitus.

Patient Care and Outcomes

Figure 5.8 shows that among survivors of an AKI hospitalization, the overall probability of developing ESRD in the following year is slightly higher than 2 percent in the Medicare population aged 66 and older. In this same time frame, the probability of death is nearly 43 percent.

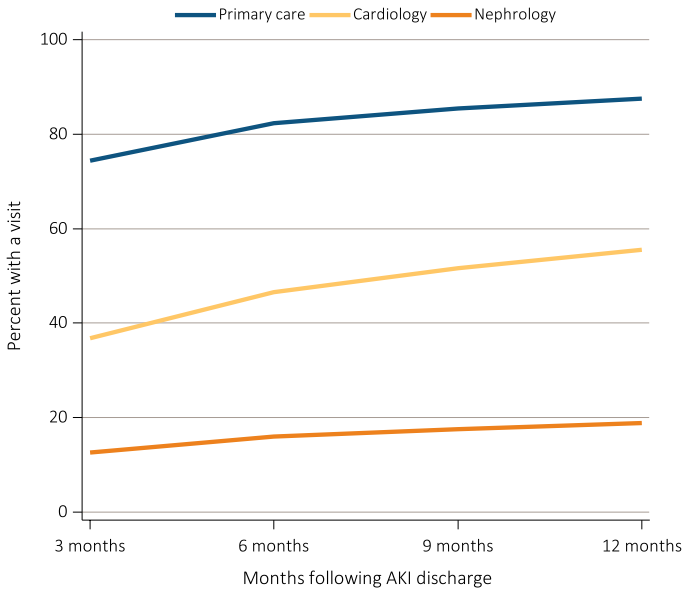
vol 1 Figure 5.8 Cumulative probability of death-censored ESRD, death, and the composite of death or ESRD within one year of live discharge from first AKI hospitalization occurring in 2010-2011 for Medicare patients aged 66+



Data Source: Medicare 5 percent sample. Medicare patients aged 66 or older who had both Medicare Parts A & B, no Medicare Advantage plan (Part C/HMO), no ESRD by first service date from Medical Evidence form, and were discharged alive from a first AKI hospitalization in 2010 or 2011. All models censored at the end of Medicare Parts 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 by diagnosis code; ESRD, end-stage renal disease.

Following an initial AKI hospitalization, 74.4 percent of patients see a primary physician within three months of discharge, while 36.8 and 12.7 percent, respectively, see a cardiologist or nephrologist, as illustrated in Figure 5.9. Follow-up increases with time, but the percent of patients seen by a nephrologist at 12 months following an AKI hospitalization remained only 18.8 percent.

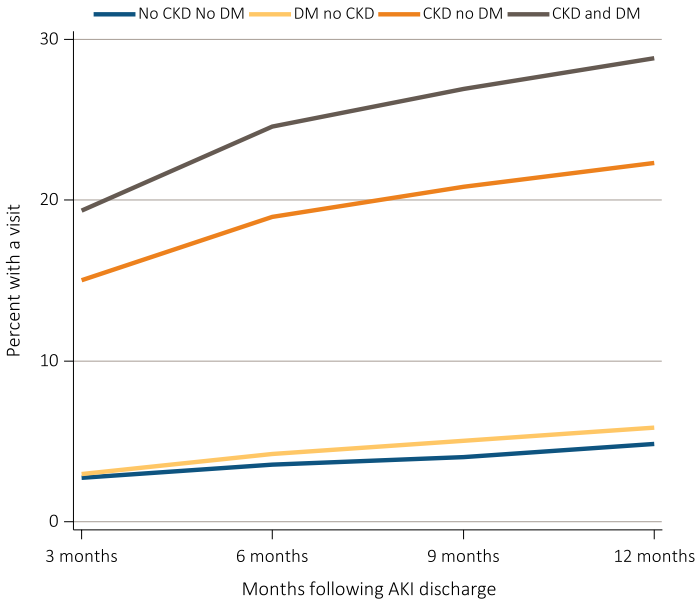
vol 1 Figure 5.9 Outpatient physician visits within one year of live discharge from first AKI hospitalization in 2011 for Medicare patients aged 66+ by physician specialty and time



Data Source: Medicare 5 percent sample. Medicare patients aged 66 and older who had both Medicare Parts A & B, no Medicare Advantage plan (Part C/HMO), no ESRD by first service date from Medical Evidence form on 1/1/2011, and were discharged alive from a first AKI hospitalization in 2011. For each time point, the denominator is all patients alive, without ESRD, not in a Medicare Advantage plan and with Medicare Parts A & B. Physician visits are from physician/supplier claims with provider specialty codes for primary care (01, 08-family practice, 11-internal medicine), cardiology (06), and nephrology (39) and claim source indicating an outpatient setting. Abbreviation: AKI, acute kidney injury.

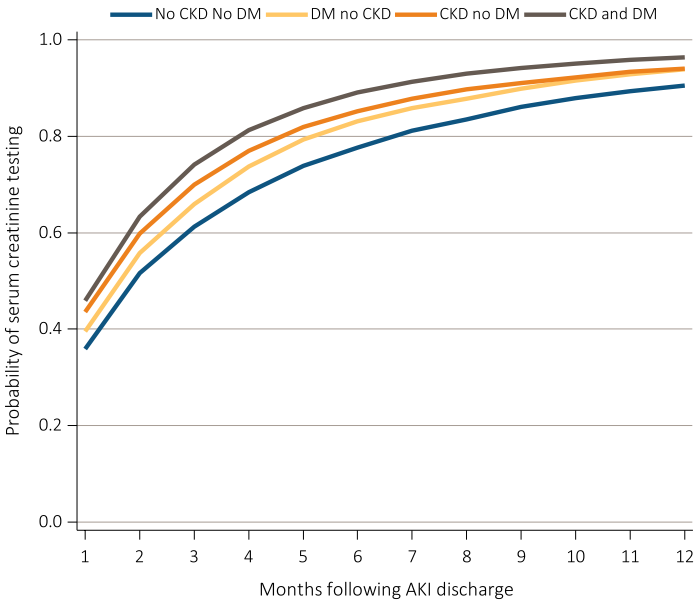
Figure 5.10 shows that compared to the overall AKI cohort, patients with AKI superimposed on CKD were more likely to have a nephrologist visit following an AKI hospitalization. At three months, 15.0 percent of AKI on CKD patients had seen a nephrologist, and this rose to nearly 22.3 percent by 12 months. In contrast, just 4.9 percent of AKI patients without either diabetes or CKD were seen by a nephrologist by 12 months following AKI hospitalization.

vol 1 Figure 5.10 Outpatient nephrology visits within one year of live discharge from first AKI hospitalization in 2011 for Medicare patients aged 66+ by CKD, DM, and time



Data Source: Medicare 5 percent sample. Medicare patients aged 66 and older who had both Medicare Parts A & B, no Medicare Advantage plan (Part C/HMO), no ESRD by first service date from Medical Evidence form on 1/1/2011, and were discharged alive from a first AKI hospitalization in 2011. For each time point, the denominator is all patients alive, without ESRD, not in a Medicare Advantage plan and with Medicare Parts A & B. Physician visits are from physician/supplier claims with provider specialty codes for nephrology (39) and claim source indicating an outpatient setting. Abbreviations: AKI, acute kidney injury; CKD, chronic kidney disease; DM, diabetes mellitus.

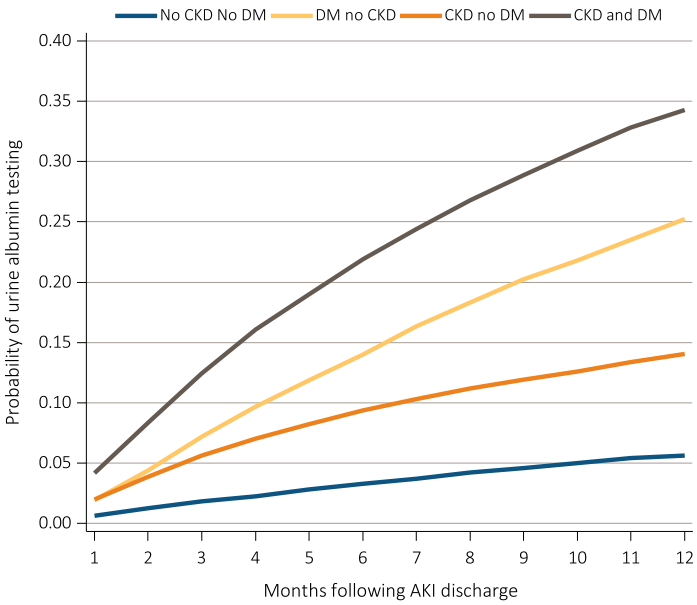
vol 1 Figure 5.11 Cumulative probability of a claim for a serum creatinine test within one year of live discharge from first AKI hospitalization in 2011 for Medicare patients aged 66+ by CKD, DM, and time



Data Source: Medicare 5 percent sample. Medicare patients aged 66 and older who had both Medicare Parts A & B, no Medicare Advantage plan (Part C/HMO), no ESRD by first service date from Medical Evidence form on 1/1/2011, and were discharged alive from a first AKI hospitalization in 2011. 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. Censored at death, ESRD, end of Medicare Parts A & B participation, or switch to Medicare Advantage program. Abbreviations: AKI, acute kidney injury; CKD, chronic kidney disease; DM, diabetes mellitus.

Among individuals suffering an in-hospital AKI event, the probability of serum creatinine and urine albumin testing increased with time following index hospitalization discharge, as shown in Figures 5.11 and 5.12. While 85 percent of AKI patients had a follow-up creatinine by 6 months after hospitalization, only 13 percent of patients had urine albumin testing by this point. Rates of serum creatinine testing were relatively similar regardless of diabetes or CKD status. However, compared to patients without these comorbidities, the probability of urine albumin testing was higher in patients with CKD (14 percent by 12 months), diabetes (25 percent by 12 months), or both (34 percent by 12 months).

vol 1 Figure 5.12 Cumulative probability of a claim for an urine albumin test within one year of live discharge from first AKI hospitalization in 2011 for Medicare patients aged 66+ by CKD, DM, and time



Data Source: Medicare 5 percent sample. Medicare patients aged 66 and older who had both Medicare Parts A and B, no Medicare Advantage plan (Part C/HMO), no ESRD by first service date from Medical Evidence form on 1/1/2011, and were discharged alive from a first AKI hospitalization in 2011. 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. Censored at death, ESRD, end of Medicare Parts A & B participation, or switch to Medicare Advantage program. Abbreviations: AKI, acute kidney injury; CKD, chronic kidney disease; DM, diabetes mellitus.

Changes in CKD Status After Acute Kidney Injury

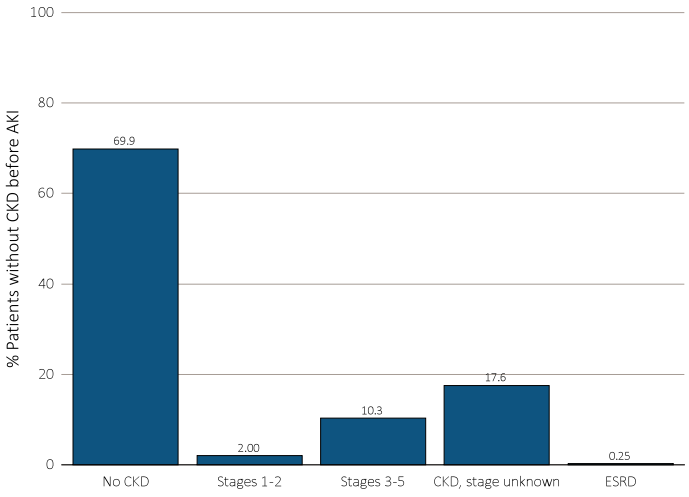
CKD status changes significantly in the year following an AKI hospitalization, as shown in Figure 5.13. Among patients without baseline CKD, nearly 30 percent are reclassified as having some degree of CKD, including 0.25 percent being declared ESRD.

Table A. ICD-9-CM Codes

585.1	Chronic kidney disease, Stage 1
585.2	Chronic kidney disease, Stage 2 (mild)
585.3	Chronic kidney disease, Stage 3 (moderate)
585.4	Chronic kidney disease, Stage 4 (severe)
585.5	Chronic kidney disease, Stage 5 (excludes 585.6: Stage 5, requiring chronic dialysis[a])

CKD unspecified identified by multiple codes including 585.9, 250.4x, 403.9xm & others. CKD stage estimates are from a single measurement. For clinical case definition, abnormalities should be present ≥ 3 months.
[a] 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. See the CKD Analytical Methods chapter for details.

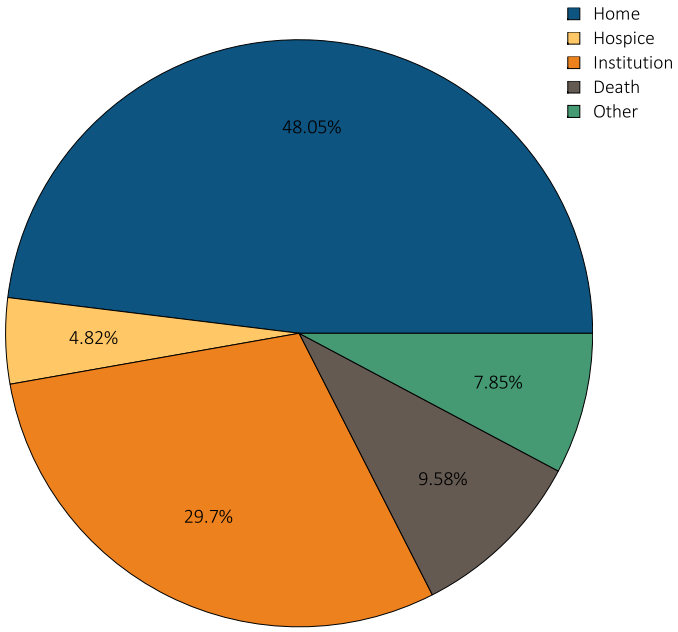
Figure 5.13 Renal status one year following discharge from AKI hospitalization in 2010-2011, among surviving Medicare patients aged 66+ without kidney disease prior to AKI hospitalization, by CKD stage and ESRD status



Data Source: Medicare 5 percent sample. Medicare patients aged 66 and older who had both Medicare Parts A & B, no Medicare Advantage plan (Part C/HMO), did not have ESRD, were discharged alive from a first AKI hospitalization in 2010 or 2011, 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.

In Figure 5.14, we examine the status and disposition for AKI patients once they are discharged from the hospital. Among AKI patients age 66 and older in 2012, fewer than 50 percent were discharged to their home. Mortality (including discharge to hospice) was 14.4 percent, while 29.7 percent of patients discharged to institutions including short-term skilled nursing facility stays, rehabilitation hospitals or long-term care facilities.

vol 1 **Figure 5.14 Hospital discharge status of first AKI hospitalization for Medicare patients aged 66+, 2012**



Data Source: Medicare 5 percent sample. Medicare patients aged 66 or older who had both Medicare Parts A & B, no Medicare Advantage plan (Part C/HMO), did not have ESRD on 1/1/2012 and had a first AKI hospitalization in 2012. Institution includes short-term skilled nursing facilities, rehabilitation hospitals, and long-term care facilities. Home also includes patients receiving home health care services. Excludes patients admitted to the acute care hospital from a skilled nursing facility. Abbreviation: AKI, acute kidney injury.

References

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.

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.

Chapter 6: Medicare Expenditures for CKD

Introduction

Determining the economic impact of chronic kidney disease (CKD) on the health care system is challenging on several levels. There is, for instance, considerable under-recognition of CKD (as noted in Vol. 1, Chapters 1, 2, and 3), that reduces estimated CKD total expenditures. A biochemical measure of renal function would create the most definitive criterion, but health plan datasets, including Medicare, rarely contain this information on a reliable or large scale. Definition of a CKD cohort based on ICD-9-CM (International Classification of Diseases, 9th revision, clinical modification) diagnosis codes, however, may selectively represent only the more advanced, and thus most expensive cases. This bias tends to result in an over-estimate of per capita CKD costs.[1] In addition, the costs of CKD are influenced by its interactive nature and resulting association with cardiovascular disease, diabetes mellitus (DM), stroke, and infectious complications. Thus, it is not possible to attribute health care expenditures to mutually exclusive diagnostic categories.

To calculate costs related to CKD, we employ the method first discussed in the 2011 USRDS Annual Data Report (ADR), and continued in the 2012 and 2013 ADRs. This method utilizes diagnosis codes to create a point prevalent CKD cohort from patients classified as having CKD on January 1 of each given year. As described in the 2013 ADR, this cost-calculation method does not include "new" CKD patients, who in the 2009 and 2010 ADR accounted for a disproportionate percentage of overall costs, resulting from a possible association with high rates of acute kidney injury (AKI). How to best integrate costs of AKI patients into CKD cost calculations is a continuing area of research due to the potential for transition from AKI to CKD.

For this year, we present only Medicare Parts A and B cost data[2] (using the 5 percent Medicare sample). We first examine CKD costs in relation to patients' CKD stage, race, and concurrent disease, focusing on DM and congestive heart failure (CHF). DM and CHF, in addition to CKD, represent the highest chronic disease population-level expenditures in the Medicare population, and thus are analyzed as coexisting diseases. CHF, for example, affects nine percent of patients in the fee-for-service Medicare population, but accounts for nearly 22 percent of expenditures. More than 34 percent of overall expenditures go toward the 24 percent of patients with DM. And patients with recognized CKD, who represent 10 percent of the point prevalent population, account for 20 percent of total expenditures. People with diagnoses of DM, CKD, and/or CHF thus account for one-third of the Medicare population and one-half of programmatic costs (see Table 6.1).

We next present data on overall Medicare costs and those related to CKD with and without DM and CHF, allowing for comparison of trends. CKD with comorbidities contributes significant cost stress to the Medicare system, accounting for large proportions of Medicare spending on DM and CHF. CKD patients with DM account for 31.3 percent of Medicare spending on DM, while CKD with CHF accounts for greater than 41.3 percent of Medicare CHF spending.

Lastly, we present costs in different Medicare populations, including CKD patients with concurrent DM and CHF, comparing 2008 and 2012 expenditures. Although costs in all categories have grown, the rate of growth differs across groups. These data further illustrate the importance of prevention of comorbidities in cost-reduction efforts.

Analytical Methods

See the CKD Analytical Methods chapter for an explanation of analytical methods used to generate the figures and tables in this chapter.

[1] "Costs" in this chapter refer to Medicare expenditures rather than true economic costs.

[2] Limitation based on unavailability of data.

vol 1 **Table 6.1 Point prevalent distribution of Medicare fee-for-service patients aged 65+ and total annual costs of Medicare Parts A and B services, by DM, CHF, and/or CKD, 2012**

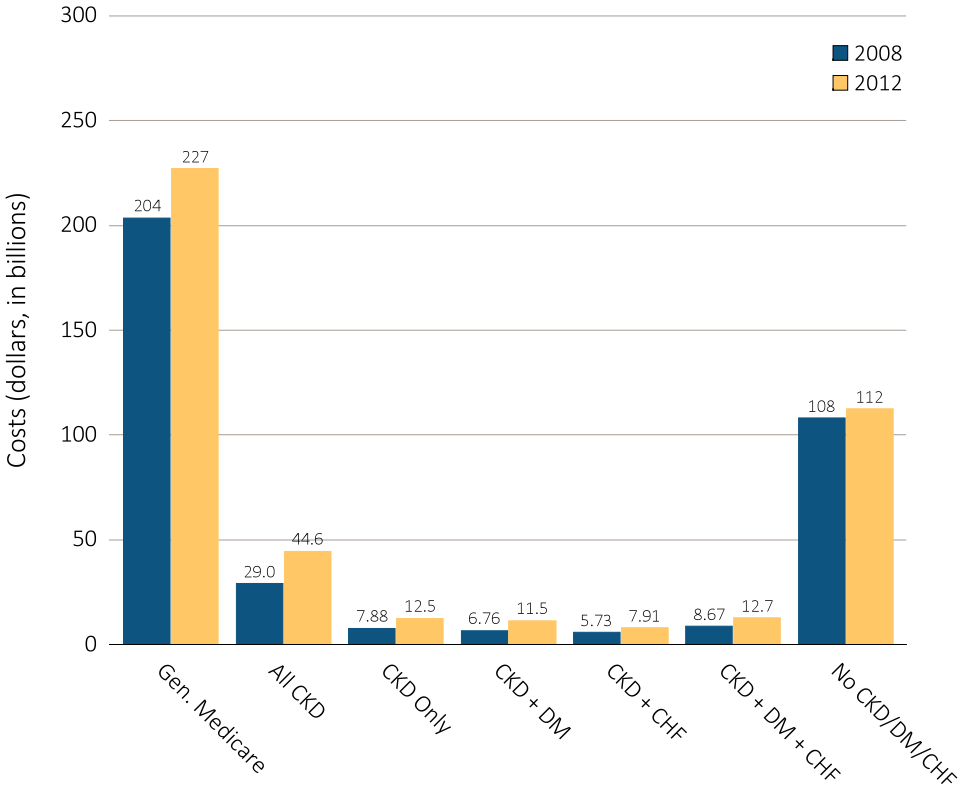
	U.S. Medicare population	Costs (millions, U.S. $)	PPPY (U.S. $)	Population (%)	Costs (%)
All	24,818,540	$227,107	$9,806	100.0	100.0
With CHF or CKD or DM	8,295,460	$114,649	$15,048	33.4	50.5
CKD only (- DM & CHF)	931,880	$12,463	$14,469	3.8	5.5
DM only (- CHF & CKD)	4,265,980	$40,811	$10,182	17.2	18.0
CHF only (- DM & CKD)	977,660	$16,924	$19,215	3.9	7.5
CKD & DM only (- CHF)	762,740	$11,535	$16,492	3.1	5.1
CKD & CHF only (- DM)	340,140	$7,910	$27,810	1.4	3.5
DM & CHF only (- CKD)	580,740	$12,332	$23,768	2.3	5.4
CKD & CHF & DM	436,320	$12,674	$34,631	1.8	5.6
No CKD or DM or CHF	16,523,080	$112,459	$7,236	66.6	49.5
All CKD (+/- DM & CHF)	2,471,080	$44,581	$20,162	10.0	19.6
All DM (+/- CKD & CHF)	6,045,780	$77,352	$13,832	24.4	34.1
All CHF (+/- DM & CKD)	2,334,860	$49,840	$24,312	9.4	21.9
CKD & DM (+/- CHF)	1,199,060	$24,209	$22,723	4.8	10.7
CKD & CHF (+/- DM)	776,460	$20,584	$31,648	3.1	9.1
DM & CHF (+/- CKD)	1,017,060	$25,006	$28,261	4.1	11.0

Data Source: Medicare 5 percent sample. Abbreviations: CKD, chronic kidney disease; CHF, congestive heart failure; DM, diabetes mellitus; PPPY, per patient per year costs.

Costs of CKD

Among the general Medicare population aged 65 and older, total costs for Parts A and B rose 11.5 percent to $227.1 billion between 2008 and 2012, while such costs rose 53.6 percent to $44.6 billion among the CKD patients (Figure 6.1). Costs for these patients with CKD now represent 19.6 percent of all Medicare Parts A and B spending. Although there was a universal rise in expenditure for all covered groups, certain patient populations with comorbid conditions in addition to CKD experienced higher rates of growth. Costs for patients with CKD and DM rose 70.2 percent between 2008 and 2012, while similar costs for patients without CKD, DM, or CHF increased by only 4.1 percent.

vol 1 **Figure 6.1 Overall Medicare Parts A and B costs for fee-for-service patients aged 65 and older, by CKD, DM, CHF, and year, 2008 and 2012**



Data source: Medicare 5 percent sample. Abbreviations: CKD, chronic kidney disease; CHF, congestive heart failure, DM, diabetes mellitus.

vol 1 **Table 6.2 Overall per person per year costs for Medicare Parts A and B services for CKD patients, by CKD stage, age, sex, race, and year, 2009 and 2012**

	2009					2012				
	Any CKD	Stages 1-2	Stage 3	Stages 4-5	Unk/ unspc	Any CKD	Stages 1-2	Stage 3	Stages 4-5	Unk/ unspc
All	$20,555	$18,290	$19,262	$25,456	$20,657	$20,162	$17,969	$19,392	$25,623	$20,100
Population	1,653,828	140,329	531,543	188,477	793,479	2,211,129	209,487	936,011	225,867	839,765
Age:										
66-69	$18,623	$16,002	$17,101	$26,268	$18,700	$18,364	$16,876	$16,955	$26,641	$18,482
70-74	$18,545	$15,441	$17,643	$24,903	$18,489	$18,023	$15,682	$17,155	$24,502	$18,186
75-80	$19,730	$17,341	$18,448	$24,220	$20,063	$19,509	$16,643	$18,907	$24,496	$19,698
70-84	$21,791	$21,277	$20,589	$24,719	$21,939	$20,851	$18,594	$20,258	$25,564	$20,668
85+	$23,100	$21,901	$21,864	$27,023	$22,925	$22,836	$22,222	$22,238	$26,614	$22,387
Male	$20,317	$17,741	$19,222	$26,272	$20,198	$20,346	$18,072	$19,837	$26,020	$20,055
Female	$20,774	$18,839	$19,302	$24,770	$21,068	$20,000	$17,873	$18,993	$25,304	$20,138
White	$20,172	$18,052	$19,005	$24,737	$20,281	$19,935	$18,016	$19,260	$24,914	$19,855
Black/Af Am	$22,664	$20,360	$20,590	$29,155	$22,600	$22,322	$18,631	$20,803	$29,014	$23,015
Other race	$22,455	$17,385	$20,921	$27,122	$23,123	$19,320	$16,195	$18,551	$27,813	$18,477

Data source: Medicare 5 percent sample. Abbreviations: Af Am, African American; CKD, chronic kidney disease; Unk/unspc, CKD stage unknown.

Table A. ICD-9-CM Codes

585.1	Chronic kidney disease, Stage 1
585.2	Chronic kidney disease, Stage 2 (mild)
585.3	Chronic kidney disease, Stage 3 (moderate)
585.4	Chronic kidney disease, Stage 4 (severe)
585.5	Chronic kidney disease, Stage 5 (excludes 585.6: Stage 5, requiring chronic dialysis[a])

CKD unspecified identified by multiple codes including 585.9, 250.4x, 403.9xm & others. CKD stage estimates are from a single measurement. For clinical case definition, abnormalities should be present ≥ 3 months.
[a] In USRDS analyses, patients with ICD-9-CM code 585.6 and no end-stage renal disease (ESRD) Medical Evidence form (CMS 2728) or other indication of ESRD are considered to have code 585.5; see CKD Analytical Methods chapter for details.

Table 6.2 shows overall per person per year (PPPY) costs of Parts A and B services for patients with CKD (but not end-stage renal disease [ESRD]) by stage of CKD (see Table A for definitions). In 2012, PPPY costs reached $20,162 for Medicare CKD patients aged 65 and older, a 2.0 percent decrease compared to 2011 ($20,564). Costs for patients with Stages 4-5 CKD ($25,623) were 42.6 percent greater than costs for patients with Stages 1-2 CKD ($17,969).

n Table 6.3, PPPY costs are shown for patients with both CKD and DM. Among 2012 Medicare patients with these two conditions, PPPY costs for Blacks/ African Americans were $24,696, 8.9 percent greater than the $22,494 incurred by Whites. This represents an increase in the percentage difference in PPPY costs between Blacks/African Americans and Whites of 1.2 percentage points as compared to 2011, when PPPY for Blacks/African Americans was 7.7 percent greater than Whites. Greater comparative PPPY costs were seen for all stages of CKD with concurrent DM. For Blacks/African Americans in Stage 4-5 of CKD with concurrent DM, PPPY costs rose 8.3 percent between 2011 and 2012, while PPPY costs for comparable White patients decreased by 2.0 percent.

vol 1 Table 6.3 Per person per year costs for Parts A and B services for Medicare CKD patients with DM, by CKD stage, age, sex, race, and year, 2009 and 2012

	2009					2012				
	Any CKD	Stages 1-2	Stage 3	Stages 4-5	Unk/ unspc	Any CKD	Stages 1-2	Stage 3	Stages 4-5	Unk/ unspc
All	$23,240	$20,692	$22,130	$28,694	$23,037	$22,723	$20,247	$22,007	$29,378	$22,190
Population	778,557	68,088	257,455	97,343	355,671	778,557	68,088	257,455	97,343	355,671
Age:										
66-69	$21,615	$18,199	$20,202	$29,882	$21,505	$21,330	$19,670	$19,918	$30,064	$21,075
70-74	$21,689	$17,995	$21,122	$28,108	$21,292	$20,629	$17,337	$19,719	$28,304	$20,599
75-80	$22,841	$20,565	$21,834	$27,836	$22,677	$22,095	$18,874	$21,680	$28,408	$21,538
70-84	$24,551	$24,737	$23,191	$27,883	$24,532	$23,451	$21,540	$22,707	$29,456	$22,775
85+	$25,960	$24,981	$24,977	$30,265	$25,365	$26,408	$26,439	$26,249	$30,779	$25,094
Male	$22,680	$19,541	$21,626	$29,512	$22,381	$22,587	$20,117	$22,101	$29,830	$21,799
Female	$23,788	$21,948	$22,658	$28,011	$23,666	$22,853	$20,383	$21,913	$29,007	$22,558
White	$22,719	$20,794	$21,668	$27,958	$22,472	$22,494	$20,279	$21,976	$28,472	$21,913
Black/Af Am	$25,518	$22,019	$24,211	$31,968	$25,058	$24,696	$21,198	$22,838	$32,817	$25,132
Other race	$25,028	$17,418	$24,063	$29,545	$25,989	$21,541	$18,305	$20,724	$31,379	$20,042

Data source: Medicare 5 percent sample. Abbreviations: Af Am, African American; CKD, chronic kidney disease; Unk/unspc, CKD stage unknown.

Table 6.4 shows PPPY costs for patients with both CKD and concurrent CHF. In 2012, PPPY costs for Black/African American patients with both conditions reached $35,989, 14.0 percent higher than the $30,943 PPPY cost for their White counterparts.

This cost difference, however, is decreasing; in 2011, costs for Blacks/African American patients were 15.5 percent higher than for Whites.

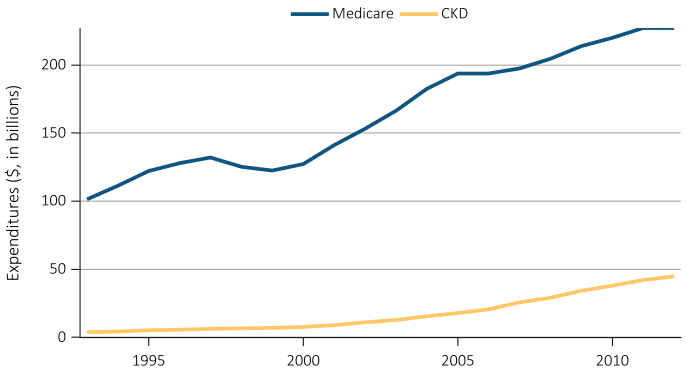
vol 1 Table 6.4 Per person per year costs for Parts A and B services for Medicare CKD patients with CHF, by CKD stage, age, sex, race, and year, 2009 and 2012

	2009					2012				
	Any CKD	Stages 1-2	Stage 3	Stages 4-5	Unk/ unspc	Any CKD	Stages 1-2	Stage 3	Stages 4-5	Unk/ unspc
All	$31,537	$31,444	$31,242	$36,013	$30,403	$31,648	$30,850	$31,301	$37,295	$30,159
Population	650,385	53,480	273,146	86,839	236,920	650,385	53,480	273,146	86,839	236,920
Age:										
66-69	$32,896	$34,075	$32,129	$37,935	$31,711	$34,610	$36,698	$32,620	$45,419	$32,814
70-74	$32,640	$29,107	$33,077	$38,163	$31,353	$31,720	$28,523	$30,698	$38,903	$31,258
75-80	$31,678	$30,702	$31,486	$36,504	$30,471	$31,498	$30,081	$31,783	$36,879	$29,529
70-84	$31,808	$33,222	$31,143	$34,649	$31,138	$32,036	$30,058	$31,753	$37,563	$30,660
85+	$30,172	$30,698	$29,548	$35,097	$28,986	$30,460	$30,818	$30,518	$34,409	$28,855
Male	$31,068	$31,196	$30,762	$36,597	$29,621	$31,656	$31,668	$31,587	$37,552	$29,571
Female	$31,970	$31,683	$31,748	$35,511	$31,080	$31,641	$30,086	$31,026	$37,080	$30,646
White	$30,703	$30,258	$30,424	$34,479	$29,861	$30,943	$30,250	$30,802	$35,605	$29,598
Black/Af Am	$35,688	$37,547	$35,865	$44,088	$32,290	$35,990	$34,245	$34,398	$44,559	$34,873
Other race	$36,464	$34,734	$35,946	$40,037	$35,713	$33,551	$31,441	$32,551	$45,961	$29,712

Data source: Medicare 5 percent sample. Abbreviations: Af Am, African American; CKD, chronic kidney disease; Unk/unspc, CKD stage unknown.

Over time, the costs for Medicare patients aged 65 and older with recognized CKD have accounted for an increasing share of Medicare expenditures, expanding from 4.2 percent in 1995, to 7.1 percent in 2002, and 19.6 percent in 2012. Much of this growth is due to the increased ascertainment of CKD as shown in Chapter 2 of this volume. Figure 6.2 shows total expenditures on Part A and Part B services for the Medicare fee-for-service patients as a whole, and for patients with CKD.

vol 1 Figure 6.2 Overall expenditures on Parts A and B services for the Medicare population age 65+ and for those with CKD, by year, 1993-2012

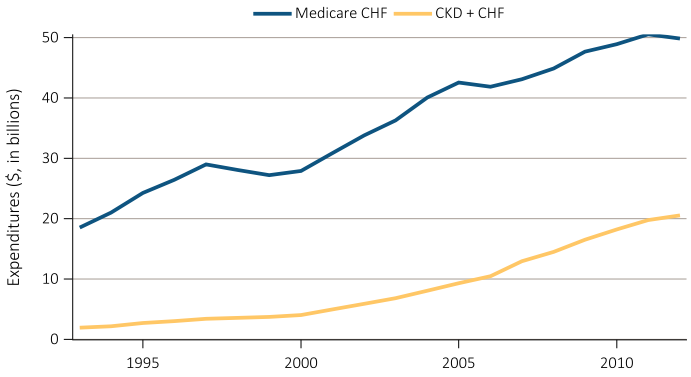


Data source: Medicare 5 percent sample. Abbreviations: CKD, chronic kidney disease.

In Figures 6.3 and 6.4 we show total Part A and Part B service expenditures for Medicare fee-for-service patients with DM and CHF, respectively. Spending for patients with comorbid DM and CKD, and CHF and CKD are also shown. Costs for patients with CKD and concurrent DM amounted to $24.2 billion in 2012, or 31.3 percent of total Medicare spending on DM.

Spending on CHF in the Medicare population was $49.8 billion in 2012. Of this, $20.6 billion (41 percent) was spent on the CKD patient population with CHF. Costs decreased by $0.8 billion in 2012 for the entire Medicare CHF population, representing the first decrease in costs for this cohort since 2005-2006.

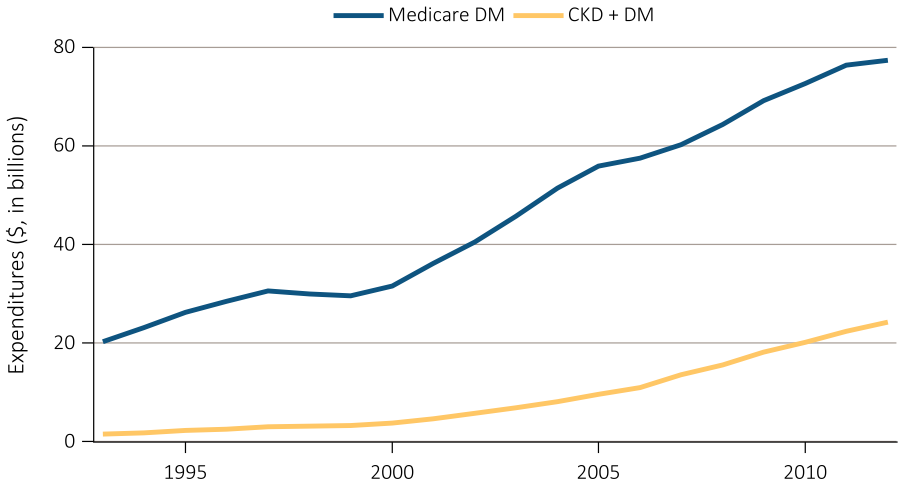
vol 1 Figure 6.4 Overall expenditures on Parts A and B services for the Medicare CHF population age 65+ and for those with CKD and CHF, by year, 1993-2012



Data Source: Medicare 5 percent sample. Abbreviations: CKD, chronic kidney disease; CHF, congestive heart failure.

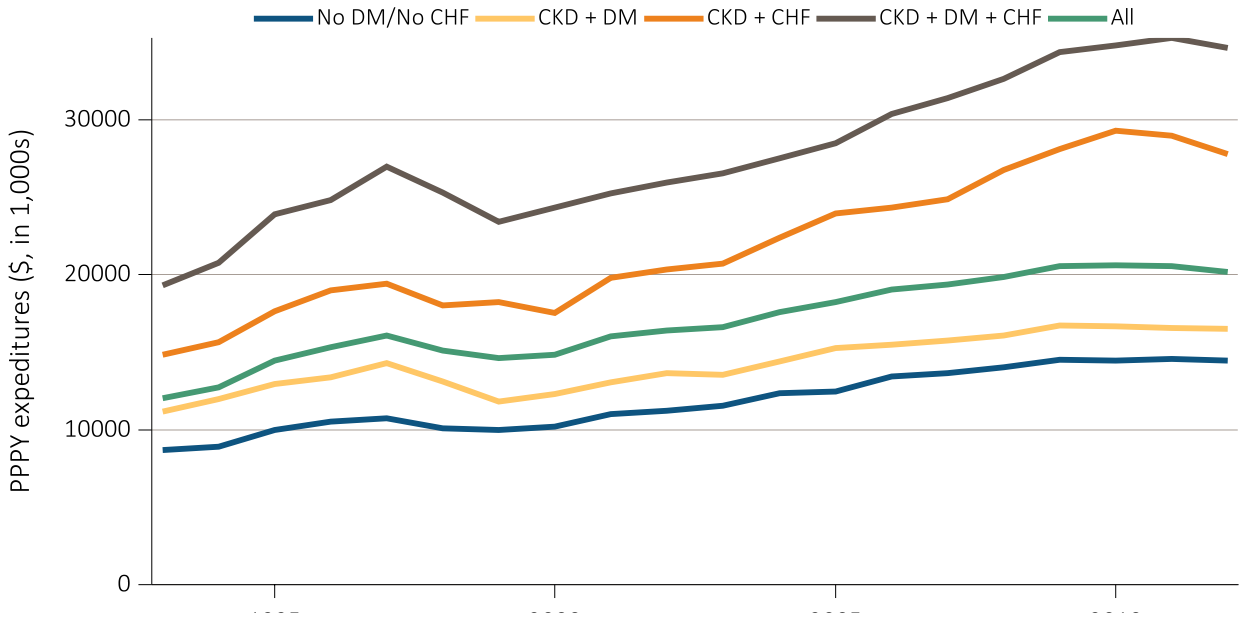
Figure 6.5 illustrates per person per year costs for Medicare CKD patients aged 65 and older by the presence of DM and CHF. In 2012, PPPY costs for CKD patients varied greatly by the presence of their comorbidities. CKD patients without DM or CHF cost $14,469 per person per year. Those with DM in addition to CKD averaged $27,810 PPPY, and patients with CKD and CHF cost $27,810, while expenditures for those with all three conditions reached $34,631 PPPY.

vol 1 Figure 6.3 Overall expenditures on Parts A and B services for the Medicare DM population age 65+ and for those with CKD and DM, by year, 1993-2012



Data Source: Medicare 5 percent sample. Abbreviations: CKD, chronic kidney disease; DM, diabetes mellitus.

vol 1 Figure 6.5 Per person per year expenditures on Parts A and B services for the CKD Medicare population age 65+, by DM, CHF, and year, 1993-2012



Data Source: Medicare 5 percent sample. Abbreviations: CKD, chronic kidney disease; CHF, congestive heart failure, DM, diabetes mellitus; PPPY, per person per year.

Cost growth per patient per year as shown in Figure 6.5 was considerably smaller in the 2008-2012 period than the total costs for these comorbidity combinations that were shown in Figure 6.1. These variable results indicate that the growth in overall costs was influenced more by an increase in the number of patients with these conditions, than by growth in actual PPPY costs.

Conclusion

The analysis of several years of cost data in the Medicare CKD population indicates avenues for potential cost savings, enduring racial cost disparities, and the effect of cost containment efforts in the CKD population. Potential cost savings could be achieved through the prevention of disease progression to later stages of CKD, and development of concurrent chronic conditions such as DM and CHF. Data indicate that not only are costs for CKD patients with concurrent DM or CHF higher than for patients without DM or CHF, but also that individual costs are rising at a higher rate in this population. In the Medicare CKD population, Black/African American patients continue to exhibit higher costs in all disease categories as compared to Whites. There are, however, distinct segments of the CKD population in which the percentage difference in cost between Black/African American and White patients is decreasing. Overall, despite accounting for an increasing share of Medicare spending, recent cost data shows that there have been decreases in the overall costs of CKD per patient per year, especially for those in the later stages of the disease. This may potentially be reflective of the effectiveness of CKD management in the Medicare-covered CKD population through early-stage interventions.

CKD Analytical Methods

Contents

Introduction

In this chapter we describe the datasets and methods used for the analyses contained in Volume 1 of the 2014 USRDS Annual Data Report (ADR), which focuses on chronic kidney disease (CKD) prior to end-stage renal disease (ESRD). Data management and preparation, database definitions, and the data sources used for ESRD analyses are described in the Methods chapter of Volume 2.

Data Sources

The USRDS maintains several databases to describe kidney disease in the United States (U.S.). Data on the non-institutionalized, general population are from the National Health and Nutrition Examination Survey (NHANES). Diagnoses, demographic characteristics, and health care procedures for patients with CKD, acute kidney injury (AKI) and related comorbidities are obtained from the standard Centers for Medicare and Medicaid Services (CMS) Medicare 5 percent sample claims files and beneficiary summary files. Patients in the 5 percent files are matched to the USRDS ESRD databases to obtain the date of first service, which is used as the starting date of ESRD.

National Health and Nutrition Examination Survey

NHANES is a series of health examination surveys conducted by the National Center for Health Statistics (NCHS) of the U.S. Centers for Disease Control and Prevention (CDC). Begun in 1959, NHANES was designed to monitor the health and nutritional status of the non-institutionalized civilian population in the United States. NHANES III was conducted in two phases between 1988 and 1994. In 1999, NHANES became a continuous, annual survey to allow regular estimates, with the release of public-use data files every two years. Both NHANES III and NHANES 1999–2012 were nationally-representative, cross-sectional surveys that used a complex, stratified, multi-stage probability cluster sampling design that included the selection of primary sampling units (counties), household segments within the counties, and sample persons from selected households (Johnson et al., 2013). Survey participants were interviewed in their homes and/or received standardized medical examinations in mobile examination centers. Both sets of surveys over-sampled African Americans, Mexican Americans, and individuals aged 60 or older to improve the estimates for these subgroups.

Centers for Medicare and Medicaid Services Medicare 5 Percent Sample

These files contain billing data from final action claims, those in which all adjustments have been resolved, submitted to Medicare for reimbursement by health care providers on behalf of Medicare beneficiaries. CMS and its contractors produce the 5 percent data sets by selecting all final action claims for Medicare beneficiaries whose CMS Health Insurance Claims (HIC) number has the last two digits of 05, 20, 45, 70 or 95. These five two-digit pairs were randomly selected to create a sample containing five percent of the total number of Medicare beneficiaries (Merriman and Asper, 2007). The sample design has the effect of creating a built-in longitudinal panel dataset. Once in the sample, a beneficiary will remain a part of all future-year data files until death or a change to their HIC number. As of 2012, we receive the Master Beneficiary Summary File (formerly the Denominator file) with demographic information on each beneficiary in the sample, as well as dates of enrollment in the various Medicare programs (Hospital Insurance [Part A], Supplemental Medical Insurance [Part B], Medicare Advantage managed care plans [Part C] and Prescription Drug Benefit [Part D]). Institutional claims for beneficiaries in the 5 percent sample are received in five files based on the type of medical service: inpatient, outpatient, home health agency, hospice, and skilled nursing facility care. Physician and supplier claims (also referred to as carrier claims) are received in one file for durable medical equipment and another for all other Part B covered services. These files collectively are called the Medicare 5 percent files in this ADR. The USRDS 2014 ADR includes all claims up to December 31, 2012, that were submitted and processed by June of 2013.

ESRD Medical Evidence Form

The analyses in this volume of the ADR often exclude patients with ESRD or censor time-dependent outcomes at the point when a patient reaches ESRD. To obtain this information on ESRD, we search the USRDS ESRD databases for the beneficiaries in the Medicare 5 percent files. The date of ESRD is determined from the ESRD Medical Evidence form (CMS 2728), the official form for registering ESRD patients, which must be submitted by dialysis or transplant providers within 45 days of ESRD initiation. First service date for ESRD is reported on this form

and is used as the date when ESRD began for analyses in this Volume. See Volume 2 for more information on how the Medical Evidence form is used in analyses of ESRD patients.

ESRD Death Notification Form

The Master Beneficiary Summary File delivered with the Medicare 5 percent sample files contains the date of death as reported to Medicare. For this volume, we supplement this date of death for patients in the Medicare 5 percent file who experience ESRD prior to death with information from the ESRD Death Notification form (CMS 2746; the official form for reporting the death of a patient with ESRD). According to CMS policy, this form must be submitted by dialysis or transplant providers within 30 days of a patient's death.

General Methods for the Medicare 5 Percent Files

For the purpose of analysis, several restrictions are applied to the raw Medicare 5 percent files to create a sample cohort. The specific restrictions used for each figure and table are detailed in the chapter-specific sections. The general rationale and explanation of these restrictions apply to all the analyses with the Medicare 5 percent files and are detailed here. It is important to remember that the primary purpose of the data collection underlying this dataset is to reimburse health care providers for services performed for beneficiaries; items that are not necessary to facilitate payment for services generally are not available in the dataset.

Plan Participation

Medicare currently provides medical benefits through four programs known by the part of Title XVIII of the Social Security Act that created them—Part A provides hospital insurance, Part B provides supplemental medical insurance, Part C provides managed care plans, and Part D provides prescription drug coverage (CMS, 2014). Part A coverage is free to beneficiaries while the other parts can have premiums paid by the beneficiary and are optional. Beneficiaries are also allowed to switch between original Medicare (fee-for-service) to Medicare Advantage plans (Part C) during open enrollment. Medicare Advantage plan providers are not paid through the claims submission process; therefore, there are no data in the Medicare 5 percent claims files for these patients. Over the course of a year, people become newly eligible for Medicare (e.g., reach age 65) and enroll in the program, people die and therefore are not eligible during part of the year, and people drop their coverage. To create appropriate denominators for the statistics that are presented, samples are often limited to beneficiaries that are enrolled in both Parts A and B and are not enrolled in a Medicare Advantage plan (Part C). In some analyses, the cohort will be limited to patients who meet these restrictions on a certain date, such as January 1 of the reported year. In other cases the sample may be limited to beneficiaries meeting those enrollment restrictions during the entire calendar year.

In most analyses that are limited to patients with a certain disease or disorder, such as CKD, the beneficiaries must have been enrolled in Parts A and B and not Part C for the year prior to the reported year (the entry period or 'year one'). This ensures that each patient has 12 months of Medicare claims from which to determine the presence of the disorder. The outcome under analysis is then determined from claims in the year following the entry period (year two). Prevalence analyses, however, are not subject to this requirement and often use claims during the reported year (the typical year two) to determine the presence of the disorder.

Reason for Entitlement

In this volume, the majority of analyses are restricted to beneficiaries that are age-eligible for Medicare and, therefore, aged 65 and older. Beneficiaries under the age of 65 may qualify for Medicare on the basis of disability (meeting requirements for one of the Social Security Administration's income support programs for disabled individuals) or diagnosis of ESRD (patients that are excluded from the CKD volume) and are not necessarily representative of the U.S. population of the same age. In contrast, 98 percent of the U.S. population aged 65 and older is eligible for Medicare (McBean, 2012). However, unlike the chapter figures and tables, the reference tables for this Volume include all adult (age 20 or older) Medicare beneficiaries regardless of reason for entitlement, except for ESRD patients.

ESRD

Since the focus of this volume is on patients that do not have ESRD, patients under age 65 who are only eligible for Medicare due to ESRD are excluded. Most analyses restrict the sample to beneficiaries that do not have ESRD, either as of a certain date or for the entire calendar year. Additionally, analyses of time-to-event outcomes (e.g., mortality, hospitalization, rehospitalization, time to the performance of a laboratory test) often censor a patient at the start of ESRD, as well as at death, disenrollment from Parts A and B of Medicare or upon switch to a Medicare Advantage plan. The start of ESRD is the date of first service from the CMS 2728 form.

Identification of Major Comorbidities

According to a previously validated method for using Medicare claims to identify diabetic patients, a patient is considered diabetic if, within a one-year observation period, he or she has a qualifying ICD-9-CM diagnosis code of diabetes mellitus (DM) on one or more Part A institutional claims (inpatient, skilled nursing facility, or home health agency), or two or more institutional outpatient claims and/or Part B physician/supplier claims (Herbert et al., 1999). This algorithm—one inpatient claim, or two outpatient claims with specified diagnosis codes—is used to determine the presence of CKD and 13 other conditions commonly associated with CKD as risk factors, co-occurring conditions, or consequences of the disease. Tables m.1 and m.2 list these conditions and the ICD-9-CM diagnosis codes used to define them. Additionally, the overall grouping of cardiovascular disease (CVD) includes patients with at least one of these individual conditions: atherosclerotic heart disease, congestive heart failure, cerebrovascular accident/transient ischemic attack, peripheral vascular disease, dysrythmias, or other cardiac conditions. Analyses within individual chapters also define additional conditions using the same algorithm, as described in the chapter-specific sections below.

vol 1 Table m.1 ICD-9-CM diagnosis codes used to define chronic kidney disease in the Medicare 5 percent sample throughout Volume 1 of the ADR

Condition name	ICD-9-CM codes
Chronic kidney disease	016.0; 095.4; 189.0,189.9; 223.0; 236.91; 250.4; 271.4; 274.1; 283.11; 403; 404; 440.1; 442.1; 477.3; 572.4; 581-588; 591; 642.1; 646.2; 753.12-753.19; 753.2; 794.4
Staging of chronic kidney disease	
Stage 1	585.1
Stage 2	585.2
Stage 3	585.3
Stage 4	585.4
Stage 5	585.5 or 585.6 with no CMS 2728 form
Stage unknown or unspecified	Patient has no claims with codes 585.1-585.6 but has: 016.0; 095.4; 189.0,189.9; 223.0; 236.91; 250.4; 271.4; 274.1; 283.11; 403; 404; 440.1; 442.1; 477.3; 572.4; 581-584; 585.9; 586-588; 591; 642.1; 646.2; 753.12-753.19; 753.2; 794.4

Source: ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification. Diagnosis codes can have up to five digits with a decimal point between the 3rd and 4th digit. Codes listed with three digits include all existing 4th and 5th digits, and those listed with four digits include all existing 5th digits.

vol 1 **Table m.2 ICD-9-CM diagnosis codes used to define medical conditions in the Medicare 5 percent sample throughout Volume 1 of the ADR**

Condition name	ICD-9-CM codes
Anemia	280-285
Atherosclerotic heart disease (ASHD)	410-414; V45.81; V45.82
Cancer	140-172; 174-208; 230-231; 233-234
Cardiac, other	420-424; 429; 785.0-785.3; V42.2; V43.3
Cerebrovascular accident (CVA) / transient ischemic attack (TIA)	430-438
Chronic obstructive pulmonary disorder (COPD)	491-494; 496; 510
Congestive heart failure (CHF)	398.91; 402.01, 402.11, 402.91; 404.01, 404.03, 404.11, 404.13, 404.91, 404.93; 422; 425; 428; V42.1
Diabetes mellitus (DM)	250; 357.2; 362.0; 366.41
Dysrhythmia	426-427; V45.0; V53.3
Gastrointestinal bleeding disorders (GI)	456.0-456.2; 530.7; 531-534; 569.84-569.85; 578
Hypertension (HTN)	362.11; 401-405; 437.2
Liver disease	570-571; 572.1, 572.4; 573.1-573.3; V42.7
Peripheral vascular disease (PVD)	440-444; 447; 451-453; 557

Source: ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification. Diagnosis codes can have up to five digits with a decimal point between the 3rd and 4th digit. Codes listed with three digits include all existing 4th and 5th digits, and those listed with four digits include all existing 5th digits.

Chapter 1: CKD in the General Population

Analyses in this chapter use data collected through the NHANES, a nationally representative survey that combines interviews and medical examinations to assess the health of the U.S. non-institutionalized civilian population (Johnson et al., 2013). NHANES III was fielded in 1988-1994; starting in 1999 and continuing to the present, the NHANES collects data continuously and releases the public-use data files in two-year cycles. Data for this chapter comes from participants 20 years and older in NHANES III (1988–1994) and in the NHANES continuous cycle years 2005–2006, 2007–2008, 2009–2010, and 2011-2012. The statistical software package SAS®, version 9.3, was used to analyze all NHANES data, incorporating the sampling weights and survey design through its survey procedures.

In this chapter, age is defined as the participant's age at the time of the household interview, categorized into the following age groups: 20-39, 40-59, or 60 and older. Race and ethnicity is self-reported and categorized as non-Hispanic White, non-Hispanic African American, or other.

The identification of CKD is based on the 2012 guidelines from the Kidney Disease: Improving Global Outcomes (KDIGO) CKD Work Group (KDIGO, 2013) implemented with the data available in NHANES. KDIGO defines CKD as "abnormalities of kidney structure or function, present for >3 months, with implications for health." Decreased glomerular filtration rate (GFR) is defined as GFR less than 60 ml/min/1.73 m2, which we calculate using the Chronic Kidney Disease - Epidemiology Collaboration (CKD-EPI) estimated glomerular filtration rate (eGFR) equation (Levey et al., 2009). Markers of kidney damage include albuminuria, a history of kidney transplantation, and abnormalities as detected by histology or in urine sediment, electrolytes (due to tubular disorders), or structure (detected by imaging). From NHANES data we use the urine albumin creatinine ratio (ACR) to measure albuminuria but do not have information regarding the other markers of kidney damage. Also, the NHANES only includes a single measurement of both serum creatinine (sCR, used to generate eGFR) and ACR, so we cannot address the three-month persistence criteria for defining CKD.

The eGFR (measured in ml/min/1.73 m2) is calculated using the CKD-EPI equation, based on the NCHS-recommended standardized creatinine values (Selvin et al., 2007). The CKD-EPI equation is:

$$eGFR = 141 * \min\left(\frac{sCR}{\kappa},1\right)^{\alpha} * \max\left(\frac{sCR}{\kappa},1\right)^{-1.209} * 0.993^{AGE} * 1.018 * F * 1.159 * B$$

where:

sCR = serum creatinine in mg/dL
κ = 0.7 if female, 0.9 if male
α = -0.329 if female, -0.411 if male
F = 1 if female, 0 if male
B = 1 if Black/African American, 0 otherwise
AGE is measured in years

The ACR is the ratio of urinary albumin (mg/L) to urinary creatinine (mg/dL). Based on an NCHS suggestion, the urine creatinine value is adjusted to NHANES 2007-2008 (CDC, 2009).

Staging of CKD was first introduced by the National Kidney Foundation's Kidney Disease Outcomes and Quality Improvement guidelines in 2002 (NKF, 2002). Following these guidelines, we defined stages of CKD in this chapter as:

- Stage 1: ACR ≥30 and eGFR ≥90
- Stage 2: ACR ≥30 and 60 ≤ eGFR <90
- Stage 3: 30≤ eGFR <60
- Stage 4: 15≤ eGFR <60
- Stage 5: eGFR <15

Participants with diabetes mellitus (DM) are those with any of the following: (1) an affirmative answer to the question "Have you ever been told by a doctor or other health professional that you have diabetes or sugar diabetes (other than during pregnancy)?", (2) an affirmative response to either "are you now taking insulin?" or "are you now taking diabetic pills to lower your blood sugar?", or (3) hemoglobin A1c (HbA1c; glycohemoglobin) ≥7 percent. Participants with self-reported diabetes mellitus (SR DM) are those who report having been told by a doctor that they have diabetes or sugar diabetes (other than during pregnancy). In NHANES 2005–2012, participants answering "borderline" are classified as non-diabetic to agree with NHANES III coding. Control of DM is assessed as an HbA1c less than 7 percent.

Patients with hypertension (HTN) are those with either (1) high blood pressure, defined as systolic blood pressure above 140 mmHg (>130 mmHg for those with CKD or SR DM) or diastolic blood pressure above 90 mmHg (>80 mmHg for those with CKD or SR DM) or (2) an affirmative answer to the question "Are you now taking prescribed medicine for high blood pressure?" Self-reported hypertension (SR HTN) is identified through an affirmative answer to the question "Have you ever been told by a doctor or other health professional that you had hypertension, also called high blood pressure?" Patients are classified as aware of their HTN if they report having been told they have high blood pressure, as treated for their HTN if they report currently taking a prescription medication to control HTN, and as in control of their HTN if their current blood pressure is ≤140/≤90 (≤130/≤80 for CKD or SR DM).

Participants who self-report any of the following diseases are considered to have self-reported cardiovascular disease (SR CVD): angina, myocardial infarction, stroke, coronary heart disease, or congestive heart failure. Hyperlipidemia is measured in the medical examination. We assess whether total cholesterol falls into one of three categories: <200 (desirable), 200–239 (borderline high), and ≥240 (high). Individuals are classified as current smokers if they gave an affirmative answer to the question "Do you now smoke cigarettes?" and former smokers if they responded negatively to the previous question, but affirmatively to the question "Have you smoked at least 100 cigarettes in your life?"

Adjusted odds ratios in Figures 1.8-1.10 are calculated using logistic regression, incorporating the sampling weight and survey design. Each figure displays results of seven logistic models. The model for age includes age (20-39/40-59/60+), sex (male/female) and race (White/Black/other). Models for the six other factors shown in the figure (DM, SR DM, HTN, SR HTN, SR CVD, and body mass index [BMI] greater than 30) includes age (20-39/40-59/60+), sex (male/female), race (White/Black/other) and the risk factor shown (yes vs. no). Ninety-five percent confidence intervals are displayed.

Chapter 2: Identification and Care of Patients with CKD

All of the analyses in the P*revalence of Recognized CKD* and *Prevalence & Odds of a CKD Diagnosis Code* sections of this chapter include point prevalent patients who survived all of the reported year (2012 for most of the figures and tables), were continuously enrolled in Medicare Parts A and B in the reported year, were not enrolled in a Medicare Advantage plan (Part C), did not have or develop ESRD during reported year, and were aged 65 or older as of January 1 of the reported year. The sections *Laboratory Testing of Patients With and Without CKD* and *Visits with a Physician after CKD Diagnosis* include patients meeting the restrictions described above, for a one-year entry period (year one) before the reported year (year two) and on January 1 of year two. Patients are then censored in the analysis if they die, develop ESRD, switch to a Medicare Advantage plan (Part C), or disenroll from Parts A and B during year two.

Table 2.1 presents the distribution of comorbidities in the fee-for-service, age-eligible Medicare population. These include diabetes mellitus (DM), CKD, stroke (cerebrovascular accident [CVA] and transient ischemic attack [TIA]), and congestive heart failure (CHF). Table 2.2 shows the distribution of characteristics among the prevalent fee-for-service, age-eligible Medicare population, both overall and among those with CKD, by age, sex, race, and comorbidity in 2012. Comorbidities included are DM, hypertension (HTN), CHF, and cancer. Each comorbidity is defined by medical claims (at least one inpatient or two outpatient claims) during the reported year. Refer to the *Identification of Major Comorbidities* section of this chapter for the complete methodology used to identify these comorbidities and Tables m.1 and m.2 for a list of ICD-9-CM codes used.

Table 2.3 shows the unadjusted prevalence and adjusted odds ratios for the presence of diagnosed CKD by age (65-74/75-85/85+), sex (male/female), race (White/Black/Native American/Asian/other), and comorbidity in 2012. Comorbidities included are DM, HTN and cardiovascular disease (CVD). Logistic regression is used to estimate the odds ratios of the probability of having a CKD diagnosis. Figure 2.1 and Figure 2.2 illustrate the prevalence of CKD over time in the fee-for-service, age-eligible Medicare population—overall, by CKD stages, and by race. Table 2.4 shows the percent of patients with CKD by demographic characteristics, among patients overall and those with DM, HTN, or CVD, in both the NHANES (2011-2012, see the section *Chapter 1: CKD in the General Population* in this chapter for methods) and the Medicare 5 percent (2012) datasets. NHANES data includes the 2011-2012 survey years and is restricted to participants aged 65 or older. NHANES CVD is self-reported and defined as having at least one of the following comorbidities: CVA, peripheral vascular disease (PVD), atherosclerotic heart disease (ASHD), CHF, dysrhythmia, or other cardiac comorbidities. Medicare CVD is defined by claims as having at least one of the following comorbidities: CVA, PVD, ASHD, CHF, dysrhythmia or other cardiac comorbidities. Values for cells with 10 or fewer patients are suppressed and marked with an asterisk.

Figures 2.3–2.6 show statistics on laboratory testing for serum creatinine and urine albumin among various patient populations and by various patient characteristics. For these analyses, a one-year period is used to define comorbid conditions (year one) and then laboratory testing is assessed in the following year (year two, the year reported in the figures). Patients must have Medicare Parts A and B coverage, no Part C participation (Medicare Advantage plans), no ESRD, and be alive for all of year one, through to January 1 of year two. Additionally, the sample is limited to patients residing in the 50 states, the District of Columbia, Puerto Rico, or the U.S. territories. First urinary microalbumin measurement is defined as the first claim with a Healthcare Common Procedure Coding System (HCPCS, similar to the Current Procedural Terminology, CPT®, system) code of 82042, 82043, 82044, or 84156. Likewise, first serum creatinine measurement is defined as the first claim with a HCPCS code of 80047, 80048, 80049, 80050, 80053, 80054, 80069, or 82565.

Figures 2.3 and 2.4 show the unadjusted probabilities across time from 2000-2012 for patients with (Figure 2.4) and without (Figure 2.3) CKD. The Kaplan-Meier method is used to calculate the unadjusted cumulative probability of having a claim for each type of laboratory test, from 1/1 through 12/31 of year two, with patients censored at death, development of ESRD, switch to a Medicare Advantage plan (Part C) or loss of Parts A or B coverage. Figures 2.5 and 2.6 show the adjusted probabilities for 2012 by age, sex, race, and a variable for DM and HTN status for those with (Figure 2.6) and without (Figure 2.5) CKD. The four categories of this combined DM and HTN variable are (1) the

patient has neither DM nor HTN; (2) the patient has HTN but not DM; (3) the patient has DM but not HTN; and (4) the patient has both DM and HTN. The Kaplan-Meier method – corrected group prognosis methodology is used to calculate the adjusted cumulative probability for each patient characteristic category shown in the figures. Adjustments were age (65-<75/75-<85/85+), sex (male/female), and race (White/Black/Native American/Asian /Hispanic/other/unknown). Probabilities presented for one factor are adjusted for the other factors.

Table 2.5 examines physician visits in the year after a diagnosis of CKD. Similar to the laboratory testing, the sample includes patients who are alive, without ESRD, do not have a Medicare Advantage plan, and have both Parts A and B coverage for all of 2011. The date of the earliest CKD claim (any CKD or Stage 3/4/5 [585.3–585.6]) in 2011 is used as the date of CKD diagnosis, and claims are then searched for services provided by primary care physicians, nephrologists, and cardiologists for 365 days following that date. Primary care visits are defined based on a physician specialty code of 01, 08 and 11; cardiologist visits are defined based on specialty code 06, and nephrology visits are defined based on specialty code 36. Adjusted cumulative probability is obtained from the corrected group prognosis method.

Chapter 3: Morbidity and Mortality

The analyses in this chapter use a one-year entry period to determine disease conditions prior to hospitalization, referred to as 'year one'. Patients are required to be alive, aged 65 or older (on January 1), without ESRD, not in a Medicare Advantage plan (Part C) and covered by Parts A and B for all of year one. Claims from year one are then searched for diagnoses as described in the *Identification of Major Comorbidities* section of this chapter. Additionally, patients must meet these criteria and be aged 66 or older on January 1 of the following year (year two). Mortality and hospitalization are then determined from January 2 to December 31 of year two. Analyses are also limited to patients residing in the 50 states, the District of Columbia, Puerto Rico, or the U.S. territories. The calculation of years at risk begins on January 1 of year two, and is censored at the earliest of the date of death, start of ESRD, disenrollment from Medicare Parts A or B, switch to a Medicare Advantage plan (Part C) or December 31 of year two.

Mortality

The date of death is provided by CMS in the Master Beneficiary Summary File. If the patient experienced ESRD prior to death, the date of death from the USRDS ESRD database was also used in the analysis (this date integrates data from the ESRD Death Notification form CMS 2746 and Social Security Death Master file). Figure 3.1 shows time trends in unadjusted and adjusted all-cause mortality by CKD status from 1995 to 2012, and Figure 3.2 shows rates for 2012 by CKD status and stage. Unadjusted mortality is calculated as the number of deaths divided by the number of patient-years at risk and expressed as "per 1,000 patient years." Adjusted mortality is based on a Cox regression model and adjusted for age (66-<70/70-<75/75-<85/85+ years), race (White, Black or African American/all others), sex, hospitalization in the prior year, and atherosclerotic heart disease (ASHD), anemia, congestive heart failure (CHF), chronic obstructive pulmonary disorder (COPD), stroke (CVA/TIA), cancer (other than non-melanoma skin cancer), diabetes mellitus (DM), dysrhythmias, gastrointestinal bleeding disorders (GI), hypertension (HTN), liver disease, other cardiac conditions, and peripheral vascular disease (PVD). See Table m.2 in the section on *Identification of Major Comorbidities* in this chapter for ICD-9-CM codes. All patients in 2010 are used as the reference cohort for Figure 3.1, while all patients in 2012 form the reference cohort for Figure 3.2. Table 3.1 and Figures 3.3 and 3.4 use the same cohort and modeling as Figures 3.1 and 3.2, but with slightly different covariates. Age, race, sex, prior hospitalization, anemia, cancer, COPD, GI, HTN and liver disease are the same as above, but instead of individual cardiovascular diseases (ASHD, CHF, CVA/TIA, dysrhythmias, PVD, and other cardiac conditions) and DM, a variable representing cardiovascular disease in combination with DM is included. The four categories are: patients without CVD and DM (reference group), patients with CVD but not DM, patients with DM but not CVD, and patients with both CVD and DM. All patients alive without ESRD and with Parts A and B coverage but not Part C on 1/1/2012 are used as the reference cohort.

Hospitalization

For the hospitalization analysis, additional processing is performed on the inpatient claims data. A patient's inpatient claims are ordered by date and compared

to identify overlapping claims (two claims covering the same time frame), consecutive claims (one claim's admission date is the day following the previous claim's discharge date), transfers (patient discharge status of 02 on the claim), and interim claims (claim sequence number, the third digit of the 'type of bill' code, of 2, 3, or 4). In these cases, the claims are consolidated into one claim with dates, diagnoses, and procedures combined. Analyses exclude claims from non-acute care facilities such as rehabilitation hospitals (the last four digits of the provider number between 2500 and 3999 or the third digit of R or T).

Unadjusted admission rates are calculated as the number of hospitalizations divided by the number of patient years at risk and expressed as "per 1,000 patient years." Adjusted admission rates in this chapter include the following variables as adjustments: age (66-<70/70-<74/75-<85/85+), race (White/Black/other), sex (male/female), hospitalization in the prior year, no DM or CVD (reference group), DM only, CVD only, both DM and CVD, anemia, COPD, cancer (other than non-melanoma skin cancer), GI bleeding disorders, HTN, and liver disease. A model-based adjustment method is used, with a generalized linear model using a Poisson distribution and log link function. The sample includes data from the current and previous two years, with respective weights of 1.0, 0.25 and 0.125. Adjusted rates reflect the distribution of a reference cohort, specified below in the discussion of the respective figures. With this method, the parameter estimates from the model are used to calculate an estimated admission rate for each patient in the reference cohort. Overall adjusted rates are then computed as the weighted average of these individual rates, using the time at risk of each patient in the reference cohort as the weight.

Table 3.2 and Figures 3.5 - 3.7 show adjusted all-cause admission rates for fee-for-service Medicare patients aged 66 and older. Table 3.2 also shows the unadjusted rates. As mentioned above, comorbidities are ascertained in 2011 for the analysis of hospital admissions in 2012. All patients must be 66 or older and not have ESRD on 1/1/2012, have Medicare Parts A and B coverage for all of 2011 and on 1/1/2012, and not participate in a Medicare Advantage plan from 1/1/2011 through 1/1/2012. Rates presented by one factor are adjusted for the others. The reference cohort includes Medicare patients in 2011, aged 66 and older.

vol 1 Table m.3 ICD-9-CM diagnosis codes used to define cause of hospitalization

Hospitalization cause	Primary claim diagnosis for hospital stay, ICD-9-CM codes
Cardiovascular hospitalizations	276.6; 394-398; 401-405; 410-438; 440-459
Infectious hospitalizations	001-139; 254.1; 320-326; 331.81; 372.0-372.3; 373.0-373.3; 382.0-382.4; 383; 386.33, 386.35; 388.6; 390-391; 392.0, 392.9; 393; 421.0, 421.1; 422.0, 422.91-422.93; 460-466; 472-473; 474.0; 475; 476.0, 476.1;478.21, 478.22, 478.24, 478.29; 480-490; 491.1; 494; 510; 511; 513.0; 518.6; 519.01; 522.5, 522.7; 527.3; 528.3; 540-542; 566-567; 569.5; 572.0-572.1; 573.1-573.3; 575.0-575.12; 590; 595.1-595.4; 597; 598.0; 599.0; 601; 604; 607.1-607.2; 608.0, 608.4; 611.0; 614-616.1, 616.3, 616.4, 616.8; 670; 680-686; 706.0; 711; 730.0-730.3, 730.8-730.9; 790.7, 790.8; 996.6; 998.5; 999.3
Other cause of hospitalization	All codes except those in Cardiovascular or Infectious above.

Source: ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification. Diagnosis codes can have up to five digits with a decimal point between the 3rd and 4th digit. Codes listed with three digits include all existing 4th and 5th digits, and those listed with four digits include all existing 5th digits.

Figures 3.8 - 3.10 show adjusted, cause-specific admission rates by CKD status and stage. Cause-specific rates reflect hospital admissions for the purpose of the specified condition, cardiovascular or infectious, and are identified using the principal ICD-9-CM diagnosis code on the claim. Code values are shown in Table m.3. The 'other cause' of hospitalization is a residual category consisting of all hospitalizations other than cardiovascular or infectious.

Rehospitalization

Analyses of rehospitalization focus on the 30 days following discharge from a hospitalization in year two, the year reported in the figure. As in all the analyses in this chapter, comorbidities, including CKD, are defined during year one, the year prior to that reported in the figure. Each of a person's hospitalizations between January 1 and December 1 of year two is identified; the latter date (12/1) is a cutoff to allow a 30-day follow-up period after discharge to evaluate rehospitalization. The unit of analysis is a hospital discharge rather than a patient. Hospital stays are excluded if the patient died before discharge, developed ESRD within 30 days of

discharge, switched to a Medicare Advantage (Part C) plan or disenrolled from Parts A and B coverage within 30 days of discharge (unless the Parts A and B coverage loss was due to death). Due to the December 1 cutoff, all patients are at risk of death or rehospitalization for the entire 30 day period, so results are presented as percentages. Since death and rehospitalization are competing risks the outcome is presented as: (1) the percent of hospital discharges that had the patient both return to the hospital and die within 30 days, (2) the percent with the patient rehospitalized within 30 days but alive on day 30, and (3) the percent where the patient died within 30 days without a rehospitalization. Figure 3.11 shows results for 2012 for patients with and without CKD before the index hospitalization, Figure 3.12 illustrates this by age group, Figure 3.13 by race group, and Figure 3.15 for cardiovascular-related hospitalization instead of all-cause. Table 3.3 shows the percentage rehospitalized (both alive and dead on day 30) for age, sex, and race groups, plus the composite death and rehospitalization outcome described above by CKD status and stage. Figure 3.14 displays annual trends in rates of rehospitalization and/or death within 30 days after hospital discharge among CKD patients. Live hospital discharges from January 1 to December 1 of each year are included. Rates are adjusted for age, sex, and race using direct adjustment, and the reference group is discharges in 2011.

Chapter 4: Cardiovascular Disease in Patients with CKD

This chapter describes the prevalence of cardiovascular comorbidities and selected cardiovascular procedures in fee-for-service, age-eligible Medicare enrollees. Cardiovascular comorbidities include atherosclerotic heart disease (ASHD), acute myocardial infarction (AMI), congestive heart failure (CHF), cerebrovascular accident/transient ischemic attack (CVA/TIA), peripheral arterial disease (PAD), atrial fibrillation (AFIB), and sudden cardiac arrest and ventricular arrhythmias (SCA/VA). The same algorithm described in the Identification of Major Comorbidities section of this chapter (one inpatient or two outpatient claims with the specific diagnosis) is used to define these cardiovascular conditions. Code values are shown in Table m.4. The presence of CKD, CKD staging, and comorbidities such as diabetes mellitus (DM) and hypertension (HTN) are also defined as described in the Identification of Major Comorbidities section of this chapter and Tables m.1 and m.2.

vol 1 **Table m.4 ICD-9-CM diagnosis codes used to define cardiovascular disorders in chapter four of Volume 1 of the ADR**

Condition name	ICD-9-CM diagnosis codes
Any cardiovascular disease (CVD)	398.91; 402.01, 402.11, 402.91; 404.01, 404.03, 404.11, 404.13, 404.91, 404.93; 410-414; 422; 425-428; 430-438; 440-444; 447; 451-453; 557; V42.1, V45.0, V45.81, V45.82, V53.3
Atherosclerotic heart disease (ASHD)	410-414; V45.81, V45.82
Acute myocardial infarction (AMI)	410; 412
Congestive heart failure (CHF)	398.91; 402.01, 402.11, 402.91; 404.01, 404.03, 404.11, 404.13, 404.91, 404.93; 422[a]; 425[a]; 428; V42.1[a]
Systolic or both systolic & diastolic	428.2, 428.4
Diastolic only	428.3
Heart failure, unspecified	398.91; 402.01, 402.11, 402.91; 404.01, 404.03, 404.11, 404.13, 404.91, 404.93; 422[a]; 425[a]; 428 (not 428.2-428.4); V42.1[a]
Cerebrovascular accident/transitory ischemic attack (CVA/TIA)	430–438
Peripheral arterial disease (PAD)	440–444; 447; 557
Atrial fibrillation (AFIB)	427.3
Sudden cardiac arrest/ventricular arrhythmias (SCA/VA)	427.1, 427.4, 427.41, 427.42, 427.5, 427.69

Source: ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification. Diagnosis codes can have up to five digits with a decimal point between the 3rd and 4th digit. Codes listed with three digits include all existing 4th and 5th digits, and those listed with four digits include all existing 5th digits. Peripheral arterial disease is defined as having a diagnosis and/or a procedure. [a]These codes are used to determine prevalent or comorbid CHF, but are excluded when determining incident CHF events and when CHF is the dependent variable.

Cardiovascular procedures include percutaneous coronary interventions (PCI), coronary artery bypass grafting (CABG), and the placement of implantable cardioverter defibrillators (ICD) and cardiac resynchronization devices with defibrillators (CRT-D). Procedures require only one claim with the procedure code. The presence of PAD is determined by the diagnosis or a claim for a procedure. Table m.5 shows the codes and type of claims used to identify each procedure.

vol 1 Table m.5 Procedure codes (ICD-9-CM and HCPCS) & claims files used to define cardiovascular procedures in chapter four of Volume 1 of the ADR

Peripheral arterial disease (PAD)	
ICD-9-CM Procedure codes: Claims files searched: IP, OP, SN Values:	*39.25, 39.26, 39.29; 84.0, 84.1, 84.91*
HCPCS codes: Claims files searched: PB, OP-revenue Values:	*24900, 24920, 25900, 25905, 25920, 25927, 27295, 27590, 27591, 27592, 27598, 27880, 27881, 27882, 27888, 27889, 28800, 28805, 34900, 35131, 35132, 35141, 35142, 35151, 35152, 34051, 34151, 34201, 34203, 34800–34834, 35081–35103, 35331, 35341, 35351, 35355, 35361, 35363, 35371, 35372, 35381, 35450, 35452, 35454, 35456, 35459, 35470, 35471, 35472, 35473, 35474, 35480, 35481, 35482, 35483, 35485, 35490, 35491, 35492, 35493, 35495, 35521, 35531, 35533, 35541, 35546, 35548, 35549, 35551, 35556, 35558, 35563, 35565, 35566, 35571, 35583, 35585, 35587, 35621, 35623, 35646, 35647, 35651, 35654, 35656, 35661, 35663, 35665, 35666, 35671*
Percutaneous coronary interventions (PCI)	
ICD-9-CM Procedure codes: Claims files searched: IP, OP, SN Values:	*00.66; 36.01, 36.02, 36.05, 36.06, 36.07*
HCPCS codes: Claims files searched: PB, OP-revenue Values:	*92980-92982, 92984, 92995-92996, G0290, G0291*
Coronary artery bypass graft (CABG)	
ICD-9-CM Procedure codes: Claims files searched: IP Values:	*36.1*
Implantable cardioverter defibrillators & cardiac resynchronization therapy with defibrillator (ICD/CRT-D)	
ICD-9-CM Procedure codes: Claims files searched: IP, OP, SN Values:	*00.51; 37.94*

Source: ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification; HCPCS, Healthcare Common Procedure Coding System, IP, inpatient, OP, outpatient services during inpatient stay, SN, skilled nursing facility, PB, physician and supplier services covered by Part B, OP-revenue, outpatient revenue claims during inpatient stay. ICD-9-CM procedure codes have up to four digits with a decimal point between the 2nd and 3rd digits. Codes listed with three digits include all possible 4th digits. HCPCS codes have 5 digits without a decimal point. Peripheral arterial disease is defined as having a diagnosis and/or a procedure.

For Figure 4.1, the study cohort includes Medicare enrollees who are alive, aged 66 and older, reside in the 50 states, the District of Columbia, Puerto Rico, or the U.S. territories, do not have ESRD on December 31, 2012, and who are continuously enrolled in Medicare Parts A and B and not enrolled in a Medicare Advantage plan (Part C) for all of 2012. Cardiovascular conditions, CKD, and CKD staging are determined from claims in 2012.

Table 4.1 presents the prevalence data shown in Figure 4.1 by age, race, sex and CKD status and presents data on cardiovascular procedures performed in 2012. The cohort is the same one used for Figure 4.1. However, the denominators for the cardiovascular procedures are not "all patients in the cohort", which is the denominator for the prevalence statistics. The percent with PCI and the percent with CABG are out of cohort members with ASHD, and the percent with ICD/CRT-D is out of cohort members with CHF.

Figure 4.2 presents the unadjusted, two-year survival of patients with cardiovascular conditions or cardiovascular procedures. To form the study cohort for each condition and procedure, Medicare claims from 1/1/2009 through 12/31/2012 are searched for the diagnoses/procedure codes specified in Tables m.4 and m.5, and the date of the first claim with a specified code is considered the index date. To be retained in the analysis cohort, the patient must be aged 66 or older on the index date, reside in the 50 states, the District of Columbia, Puerto Rico, or the U.S. territories, be enrolled in Medicare Parts A and B, and not enrolled in a Medicare Advantage plan (Part C). Patients with ESRD on or before the index date are excluded. Claims for the patient in the 365 days prior to the index date are then searched for a prior occurrence of the given condition/procedure, and these patients are excluded from the analysis. CHF in this figure excludes those with only diagnosis codes of 422, 425, and V42.1. CKD status and stage are also determined from the patient's claims in the 365 days prior to the index date. Patients are then followed from the index date until the earliest of date of death, three years after the index date, ESRD diagnosis, or December 31, 2012. The Kaplan-Meier method is used to estimate survival.

Type of heart failure for the calendar year is determined by frequency of diagnoses and a hierarchy. The presence of systolic (428.2x or 428.4), diastolic (428.3x) and unspecified (all other CHF diagnosis codes in Table m.4 excluding 422, 425, and V42.1) diagnoses is determined by searching all reported diagnoses on all claims for a given calendar day. Each day is counted as systolic if there were any systolic diagnoses, as diastolic if there were no systolic diagnoses but at least one diastolic diagnosis, and as unspecified if there were no systolic or diastolic diagnoses but at least one unspecified diagnosis. The number of days with systolic, diastolic and unspecified diagnoses is then summed for the calendar year. The patient's type of heart failure for the year is then determined by a hierarchy similar to that applied for each calendar day: if the patient has any systolic heart failure and no diastolic-only heart failure, he/she is classified as systolic heart failure; if the patient had diastolic heart failure and no systolic, he/she is classified as diastolic heart failure; and if the patient had only unspecified heart failure, he/she is classified as unspecified heart failure. When a patient had both systolic and diastolic-only diagnosis days during the year, he/she is assigned to the heart failure type that was most frequent during the year.

Table 4.2 describes the characteristics of CHF patients by age, sex, race, diabetic status, and type of heart failure. The study cohort includes Medicare enrollees who are alive, aged 66 and older, reside in the 50 states, the District of Columbia, Puerto Rico, or the U.S. territories, who do not have ESRD on December 31, 2012, and who are continuously enrolled in Medicare Parts A and B and not enrolled in a Medicare Advantage plan (Part C) for all of 2012.

Figure 4.3 shows the distribution of heart failure type by CKD status in 2012 and uses the same study cohort as in Table 4.2. The denominators are the total numbers of patients in each CKD status or stage group, and the numerators are the numbers of patients with the given heart failure type within that CKD status or stage group.

Table 4.3 shows the results of two separate Cox models of two-year all-cause mortality in two separate groups of patients—those with CKD (panel a) and those with CHF (panel b). CHF, CKD, DM and HTN statuses are determined from claims for 2010; the study cohort includes Medicare enrollees who are alive and aged 66 or older on December 31, 2010, reside in the 50 states, the District of Columbia, Puerto Rico, or the U.S. territories, are continuously enrolled in Medicare Parts A and B, and are not enrolled in a Medicare Advantage plan for all of 2010. Patients with ESRD on or before December 31, 2010 are excluded. Follow-up began on 1/1/2011 and continued until death or 12/31/2012. The sample for Panel a is all patients in the cohort who had CKD in 2010, while the sample for Panel b is all patients in the cohort with CHF in 2010. Type of heart failure is determined by the same procedure as the previous figures using claims from 2010. Codes used to define DM and HTN can be found in Table m.2 of this chapter. Age is defined as of 12/31/2010.

Chapter 5: Acute Kidney Injury

The manner of defining acute kidney injury (AKI) has been changed for the 2014 ADR. In prior years, a patient had an AKI hospitalization if either (1) he/she had an AKI diagnosis during an inpatient stay (ICD-9-CM code of 584.5-584.9) or (2) had dialysis as an inpatient prior to the first service date from the ESRD Medical Evidence Form (CMS 2728) or had no form. For this year's ADR, in order to qualify as having an AKI hospitalization patients must have a diagnosis code for AKI associated with their inpatient stay (not necessarily as the primary diagnosis). As in prior years, this chapter is only concerned with in-hospital AKI. Dialysis during the AKI hospitalization is defined using diagnosis, procedure, and revenue center codes. The inpatient claims file is searched for ICD-9-CM diagnosis codes V45.1, V56.0, and V56.1; ICD-9-CM procedure codes 39.95 and 54.98; and Medicare revenue center codes 0800–0809. Additionally, physician and supplier claims (PB file) are searched for HCPCS codes 90935, 90937, 90945, and 90947 with service dates that correspond to the patient's inpatient stay. Patients with ESRD prior to the inpatient stay are not counted as having AKI.

Characteristics of Patients with AKI

The cohort used for Figures 5.1-5.4 and Table 5.1 is different this year compared to prior years' ADRs. Previously, these statistics were shown for patients who had an AKI hospitalization in a given calendar year and were alive, without ESRD, continuously enrolled in Medicare Parts A and B, and not enrolled in a Medicare Advantage plan (Part C) for the entire year. Given the relatively high death rates for AKI patients, both during the hospital stay and within

the first several months following discharge, we removed the requirement for the patient to be alive without ESRD for the entire calendar year of the AKI hospitalization. In this year's ADR, the cohort sample for Figures 5.1-5.4 and Table 5.1 includes all patients alive, aged 66 or older, enrolled in Medicare Parts A and B, not enrolled in a Medicare Advantage (Part C) program, and without ESRD on January 1 of the reported year. The comorbidities of CKD and diabetes mellitus (DM) are determined as described in the Identification of Major Comorbidities section of this chapter and Tables m.1 and m.2, using claims from a one-year entry period (year one, the calendar year before the year in which hospitalization is assessed for AKI) and then assessing hospitalization in the following year (year two, the year reported in the figures and tables). While a patient can have more than one hospitalization with AKI during a given calendar year, the figures and table in this section count only the first AKI hospitalization per patient, per year. Each calendar year forms a separate cohort; so a patient can have a "first" AKI hospitalization in multiple years.

Figure 5.1 has two panels that employ different denominators. Panel a shows the fraction of the entire cohort (described in the previous paragraph) that had a hospitalization with a diagnosis of AKI in each year. Panel b, however, uses the numerator of Panel a as its denominator, showing the fraction of cohort patients who had at least one AKI hospitalization that received a dialysis procedure during that AKI hospitalization. Note that these percentages do not take into account each patient's individualized time at risk—for example, a patient who dies in February is still included in the denominator for the entire year, even though he/she is not at risk of having an AKI hospitalization after February. These percentages answer the question—what percent of people (meeting the cohort inclusion criteria in the previous paragraph) alive on January 1 experience an AKI hospitalization during the year. Table 5.1 also uses the total number of cohort patients with at least one AKI hospitalization as the denominator and presents the distribution of age, sex, race, DM and CKD for those with AKI.

Figures 5.2-5.4 use the entire analysis cohort as the denominator to calculate rates of first AKI per 1,000 patient years at risk. Only the first hospitalization with AKI for a patient is counted as an event, and years at risk are calculated for each patient as the time (total days divided by 365.25) between January 1 of the reported year (year two) to the earliest date of AKI hospitalization, ESRD, disenrollment from Medicare Parts A and B, switch to a Medicare Advantage plan, death, or December 31 of year two. Age is as of January 1 of year two, while CKD and DM status is determined by claims in year one. A Cox proportional hazard model with no covariates, stratified by the variable of interest, is used to estimate survival, and the rate is calculated as –[log(survival)] and multiplied by 1,000 to generate the rate per 1000 patient years at risk.

Hospitalization for AKI

Figures 5.5 and 5.6 present results from two Cox proportional hazard models—one for time to first AKI hospitalization and one for time to first AKI hospitalization when that hospitalization included dialysis treatment. Each model includes the following covariates: age (66-<70/70-<75/75-<79/80-<85/85+ years), race (White/Black or African American/ all others), sex (male/female), and a variable representing CKD in combination with DM. The four categories of the combined DM and CKD variable are: patients without CKD and DM (reference group), patients with CKD but not DM, patients with DM but not CKD, and patients with both CKD and DM. Figure 5.5 presents the hazard ratios (HRs) for age from the model, while Figure 5.6 presents the HRs for the CKD and DM variable from that same model. The darker bars are from the 'time to first-AKI' model, while the lighter bars are from the 'time to first-AKI when that hospitalization included dialysis' model. The cohort used is the same as the 2012 cohort used for Figures 5.1-5.4 and Table 5.1: all Medicare patients alive, aged 66 or older, without ESRD, with Parts A and B coverage and no Medicare Advantage plan on 1/1/2012. Each patient is followed from January 1, 2012, to the earliest of date of death, ESRD first service date, disenrollment from Part A or B, switch to a Medicare Advantage plan, or December 31, 2012.

Figure 5.7 shows the probability of having a second hospitalization for AKI within 24 months of the first AKI hospitalization. The sample for this figure starts with the 2010 cohort as used in the Characteristics of Patients with Acute Kidney Injury section above—alive, aged 66 or older, without ESRD, with Medicare Parts A and B, and not in a Medicare Advantage plan on 1/1/2010. The first AKI hospitalization in 2010 is identified. Age is as of 1/1/2010 and comorbidities are defined by searching claims one year prior to the AKI

admission date (admission date-365 through one day before admission). Within this customized date range, CKD and DM status are defined according to the algorithm and codes described in the Identification of Major Comorbidities section and Tables m.1 and m.2 of this chapter. The final cohort for Figure 5.7 includes only those patients with at least one AKI hospitalization in 2010 who are discharged alive. Follow-up begins on the date of discharge listed on the claim for the AKI hospitalization and continues until the earlier of a second AKI hospitalization, death, ESRD, disenrollment from Parts A or B, switch to a Medicare Advantage program, or 730 days following the first AKI discharge. Kaplan Meier methods are used to estimate survival with the cumulative probability of a recurrent AKI hospitalization defined as (1-survival).

Patient Care and Outcomes

Figure 5.8 shows the outcomes of death or ESRD within one year of a live discharge from an AKI hospitalization. To increase the precision of these estimates, we created the cohort for this figure as patients with a first AKI hospitalization in 2010 or 2011. Patients are alive, aged 66 or older, without ESRD, with Parts A and B coverage and no Medicare Advantage plan on January 1 of the year of their AKI hospitalization. Those who are discharged alive from their AKI hospitalization are followed from the date of discharge until 365 days after discharge. For the models of time to ESRD and time to the composite end point of ESRD or death, the survival time is calculated from the date of AKI discharge to the earliest date of ESRD, death, disenrollment from Parts A or B, switch to a Medicare Advantage program, or 365 days following the first AKI discharge. Note that the mortality model in this year's ADR is not censored at the start of ESRD. For the mortality model, survival time is calculated from the date of AKI discharge to the earliest of death, disenrollment from Parts A or B, switch to a Medicare Advantage program, or 365 days following the first AKI discharge.

Figures 5.9 and 5.10 examine physician visits after a live discharge from an AKI hospitalization. Claims are searched for services provided by primary care physicians, nephrologists, and cardiologists for 365 days following the discharge date of the AKI hospitalization. Primary care visits are defined based on the Medicare physician specialty code values of 01, 08 and 11; cardiologist visits with specialty code 06, and nephrology visits with specialty code 36. Figures 5.11 and 5.12 show time-to-first-claim for the specified laboratory test. A first serum creatinine measurement is defined as the first claim with an Healthcare Common Procedure Coding System (HCPCS) code of 80047, 80048, 80049, 80050, 80053, 80054, 80069, or 82565. Likewise, first urinary microalbumin measurement is defined as the first claim with an HCPCS code of 82042, 82043, 82044, or 84156. Patients are followed from date of discharge until 365 days after discharge and censored on the earliest date of death, development of ESRD, disenrollment from Parts A or B, or switch to a Medicare Advantage program.

Figure 5.13 shows the renal status after one year for patients discharged alive from their first AKI hospitalization. To increase the precision of the estimates, we created the cohort for this figure from patients with a first AKI hospitalization in 2010 or 2011. Patients are alive, aged 66 or older, without ESRD, with Parts A and B coverage, and no Medicare Advantage plan on January 1 of the year of their AKI hospitalization, and do not have any claims with a diagnosis of CKD in the 365 days prior to that AKI admission. Renal status after AKI is determined from claims occurring between discharge from the AKI hospitalization and 365 days after discharge. CKD stage is determined by the 585.x claim closest to 365 days after discharge and ESRD by first service date on the ESRD Medical Evidence form.

Figure 5.14 shows discharge status following a patient's first AKI hospitalization in 2012. The cohort includes all patients who experienced an AKI hospitalization during 2012 and who are alive, aged 66 or older, enrolled in Medicare Parts A and B, not enrolled in a Medicare Advantage program, and without ESRD on January 1, 2012. Patients admitted to the acute care hospital from a long-term care facility ('point of origin for admission,' previously named 'source of admission,' is 5) are excluded. Patients with a 'patient discharge status' code of 01 (routine discharge to home) or 06 (discharged to home under care of a home health service organization in anticipation of covered skilled care) are identified as being discharged home. Those with a 'patient discharge status' of 50 (discharged to routine or continuous hospice at home) or 51 (transferred to an inpatient hospice program or facility) were identified as being discharged to hospice. Those identified as being discharged to an institution are those whose 'patient discharge status' is 03 (transferred to a Skilled Nursing Facility

with Medicare certification in anticipation of skilled care), 62 (transferred to an inpatient rehabilitation facility including distinct part units of a hospital), or 63 (transferred to long term care hospital). Death is determined both by the date of death from the Master Beneficiary Summary File and the 'patient discharge status' of 20 (expired—this code is used only when the patient dies). 'Other' is a residual category that includes all discharges not identified by the previous categories.

Chapter 6: Medicare Expenditures for CKD

For this year's ADR, data on the Medicare Part D prescription drug program were not available in time to include in the analyses. Consequently, costs in this year's chapter only refer to expenditures under the Medicare Part A (Hospital Insurance) and Part B (Supplemental Medical Insurance) programs. Analyses of costs from Medicare Part D will be available again in the 2015 ADR.

The cohort used for this chapter continues the methodology introduced in the 2010 ADR, which only tabulates CKD costs for patients with at least one CKD diagnosis among their claims in the year prior to the reported year (year one). For example, the total costs of CKD for 2012 (year two) includes all costs incurred by patients with a CKD diagnosis in 2011 (year one). Prior to the 2010 ADR, patients newly diagnosed with CKD during year two were also included in the total.

The same general Medicare point prevalent cohort is used to create all the tables and figures in this chapter. Each year's cohort includes patients aged 65 and older who are alive and without ESRD on January 1 of the reported year (year two). Cohort members are continuously enrolled in Medicare Parts A and B and not enrolled in a Medicare Advantage plan (Part C) for all of year one (the one-year entry period prior to the year in which costs were assessed). Costs are aggregated for the reported year (year two). Patient years at risk are calculated as the number of days (divided by 365.25) between January 1 of year two and the earliest of death, development of ESRD, disenrollment from Parts A or B, switch to a Medicare Advantage program, or December 31 of year two. Dividing the total cost amount by the patient years at risk yields the per person per year (PPPY) costs. Since these total costs and number of patients are based on the 5 percent Medicare files, counts and expenditures are multiplied by 20 to represent 100 percent of Medicare fee-for-service Parts A and B expenditures for age-eligible patients who are continuously enrolled in Parts A and B and not enrolled in a Medicare Advantage plan for all of the previous year (year one).

Claims can be submitted for episodes of care that span calendar years. The expenditures for these claims are split across calendar years based on the fraction of the claim's total days that occurred in the reported year. For example, if a claim began on December 29, 2011, and ended on January 7, 2012, it spanned 10 days, with 3 days in 2011 and 7 days in 2012. Seventy percent of that claim's total expenditure amount would be added to total expenditures for 2012.

The disease conditions of CKD, congestive heart failure (CHF), diabetes mellitus (DM), and the stage of CKD are determined from the claims in the year prior to the reported year (year one) with the algorithm described in the Identification of Major Comorbidities section of this chapter, using the diagnosis codes listed in Tables m.1 and m.2. Age is determined as of December 31 of year one. Race and sex are provided by the Master Beneficiary Summary File.

Reference Tables: CKD

Reference Tables B.1–B.6 present estimated point prevalent (December 31) counts of the Medicare non-ESRD population, based on the 5 percent Medicare sample, for adults aged 20 and older rather than the age-eligible (age 65 and older) cohort presented in Chapter 2. Each year's cohort includes all patients alive and without ESRD, who were continuously enrolled in Medicare Parts A and B, and not enrolled in a Medicare Advantage program (Part C) for the entire year. Age is calculated as of December 31 of the reported year. Race and sex are provided by the Master Beneficiary Summary File. The disease conditions of CKD, congestive heart failure (CHF), and diabetes mellitus (DM) and the stage of CKD are determined from the claims in the reported year, using the methods described in the Identification of Major Comorbidities section of this chapter and the diagnosis codes listed in Tables m.1 and m.2. Counts are multiplied by 20 to represent 100% of the Medicare population meeting the cohort definition.

Reference Tables B.7-B.10 are based on NHANES data. See the NHANES methods description in Chapter 1: CKD in the General Population in this chapter. For Table B.8, CKD is defined as estimated glomerular

filtration rate (eGFR) less than 60 ml/min/1.73m2 (which identifies Stages 3 and 4) or urine albumin creatinine ratio (ACR) greater than 30 mg/g (which identifies Stages 1 and 2). eGFR is estimated from one serum creatinine measurement using the CKD-EPI equation (Levey et al., 2009). The consensus definition of CKD requires two measurements of both eGFR and ACR meeting the criteria above, within three months of each other, but only one measurement of each is available in NHANES. Therefore, the resulting numbers overestimate the true number of CKD patients in the general U.S. population. CKD staging is as defined by the Kidney Disease Outcomes and Quality Improvement (KDOQI) CKD guidelines (NKF, 2002). In Table B.9, DM is defined as in Chapter 1, and eGFR and ACR as described for Table B.8. Table B.10 presents results for CHF, which is self-reported in NHANES as an affirmative answer to, "Has a doctor or other health professional ever told you that you have congestive heart failure?"

Tables K.1–5 present estimates of per-person per-year Parts A and B Medicare expenditures for point prevalent (December 31) general Medicare patients, also derived from the 5 percent Medicare sample. Methods for these tables are the same as those described in the Chapter 6: Costs of CKD section of this document. The reference tables include all adult patients aged 20 and older, while the chapter presents these costs only for those age-eligible for Medicare (aged 65 or older).

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