Chapter 1:
CKD in the General Population

- In light of the 2017 blood pressure guidelines from the American College of Cardiology/American Heart Association (ACC/AHA), this year we examine hypertension control at both 130/80 mm Hg and 140/90 mm Hg. In a comparison of four cohorts of NHANES participants (2001-2004, 2005-2008, 2009-2012, and 2013-2016), little change was seen among individuals without chronic kidney disease (CKD), but among individuals with CKD, the percentage within the ACC/AHA guidelines has improved from 40.4% to 48.8% for BP <130/80 and from 61.5% to 68.4% for BP <140/90 (Figures 1.10.b and 1.10.a).
- Also new to the chapter is a deeper look into kidney disease awareness by comorbid health status and age. Comparing these same four NHANES cohorts, we continue to see little improvement in the percentage of individuals with CKD who were aware of their disease in the early stages, but among individuals in Stage 4 CKD awareness increased from 36% to 57%. For individuals with hypertension (HTN) and diabetes mellitus (DM), only 15% were aware of their kidney disease. Awareness improved slightly with older age, but among those 60+ years old with CKD, only 10% reported they had the condition (Figures 1.13.a–1.13.d).
    - Dietary intake was also examined for the first time among individuals with and without CKD. Among individuals with CKD, overall calorie intake increased slightly, while sodium and total sugar intake were very high in all years. Potassium intake appears below the recommended guidelines and did not change over the four cohorts (Table 1.4).
    - Overall prevalence of CKD (Stages 1-5) in the United States adult general population was 14.8% in 2013-2016. CKD Stage 3 (6.4%) was the most prevalent (Figure 1.1). Overall, CKD prevalence has remained relatively stable during the last 2 decades.
- In the general U.S. population during the years 2013-2016, the prevalence of a urinary albumin-to-creatinine ratio (ACR) of >10mg/g of creatinine was 33%, including 8.5% with ACR 30–300 mg/g and 1.6% with ACR >300 mg/g (Figure 1.3). Overall, prevalence of albuminuria does not appear to have changed much since 2001, although in the subgroup with stage 4 CKD, it appears to have increased (Figure 1.4).
- The prevalence of CKD among diabetics has decreased over time among the four cohorts of NHANES participants, from 43.6% (2001-2004) to 36.0% in (2013-2016). A similar decrease was not seen among individuals with hypertension, whose CKD prevalence remains about 31% (Table 1.2).
- Age had the highest correlation with low estimated glomerular filtration rate (eGFR; <60 ml/min/1.73 m^2), with an odds ratio (OR) of 70 in the 2013-2016 cohort, while HTN was the greatest predictor of albuminuria, with an OR of 4.5 in this cohort (Figures 1.7 and 1.8).
- Over time, among those with CKD, only minimal changes in self-reported physical activity have occurred, with around 60% reporting either moderate or vigorous activity (Figure 1.9).
- Among those with CKD, following an initial increase in the percentage of individuals with DM having glycosylated hemoglobin (HbA1c) <7%, the proportion of individuals with this degree of glycemic control declined from 48% to 42% over time (Figure 1.12 and Table 1.5).
    - Among those with CKD, the percentage of individuals with HTN who were unaware of their HTN condition decreased to 20%, while the percentage with treated/controlled HTN increased from 17% to 27% (Table 1.5).
- Among those with CKD, the percentage of individuals with normal cholesterol levels (Figure 1.11) increased over time from under 50% to over 60%.

- The prevalence of self-reported CKD was very low in the U.S. general population, as indicated in a large representative telephone-based survey. For 2016, reports ranged from 1.8% in Wyoming to 4.0% in Mississippi. Given the overall prevalence of CKD in the U.S. population of about 14%, these numbers are consistent with limited awareness of CKD among those who have the condition (Figure 1.14).

Introduction

This chapter presents representative cross-sectional estimates of CKD prevalence in the United States, through analysis of data from the National Health and Nutrition Examination Survey (NHANES; CDC, 2018) and from the Behavioral Risk Factors Surveillance System (BRFSS; CDC, 2018), a large representative telephone-based survey, both administered by the Centers for Disease Control and Prevention (CDC). Both surveys use a stratified probability sampling design to select participants, rather than a simple random sample.

The NHANES program of studies combines interviews and physical examinations, creating a valuable source of information for assessing disease prevalence overall and in at-risk groups. This sample is representative of the civilian, non-institutionalized U.S. population, with oversampling of certain population subgroups to increase the reliability and precision of health status indicator estimates for these groups.

The NHANES data are collected and released biennially; therefore, we primarily report trends based on four, four-year periods within the last 16 years—2001-2004, 2005-2008, 2009-2012, and 2013-2016. These years include the most recent years of the "continuous" NHANES data collection. Data from NHANES III (1988-1994) and the first two years of continuous NHANES data (1999-2001) can be found in previous Annual Data Reports (ADRs). New data available for the 2018 ADR is limited to the 2015-2016 information on CKD, which became available in February of 2018.

The Behavioral Risk Factors Surveillance System (BRFSS; CDC, 2018) is a system of health-related telephone surveys that collect state-level data of U.S. residents regarding their health-related risk behaviors, chronic health conditions, and use of preventive services. Similar to the NHANES survey methodology, the data is weighted to allow generation of estimates considered representative of the U.S. population. In the survey, each participant is asked, "(Ever told) you have kidney disease?" In contrast to the NHANES, this data source contains participants' residence information and allows an assessment of the geographic distribution of self-reported kidney disease. As BRFSS conducts annual data collection, we present analyses of data from the past four years, including the newest data gathered in 2016.

Defining Chronic Kidney Disease

While the definition of CKD as initially proposed by K/DOQI (NKF, 2002) and subsequently by KDIGO (KDIGO, 2012) has well served the renal community, it is pertinent to discuss its application to public health surveillance of kidney disease, as opposed to clinical practice. The definition requires that a measured eGFR abnormality or evidence of kidney damage (e.g., albuminuria), or both, be present for a minimum of three months. In examining survey data from random samples of the general population (e.g., NHANES) or available data within health systems (e.g., the national Veterans Affairs Health System, or others), repeat laboratory values are either not available, or repeat testing is conducted based on clinical indication, and thus being subject to bias-by-indication. In future years the NHANES survey may begin to include repeat measurements of serum creatinine and urine albumin in a significant proportion of its participants. Recently published evidence suggest that that estimates of CKD prevalence, based on single laboratory values may be biased upward, especially in those with stage 3A CKD (De Broe, 2017). Future studies may need to consider repeat testing for both albuminuria and serum creatinine (more than simply checking it twice) in large

numbers of individuals in the general population, followed over long periods of time, to clarify existing gaps in the literature in this contentious area. Proposals for an age-based definition of CKD remain the subject of debate (Glassock, 2015; Levey, 2015). Currently, therefore, we must contend with the practical reality of relying on single-point-in-time measurements of serum creatinine (to estimate eGFR) and urine albumin-to-creatinine ratios for public health surveillance, using the KDIGO definition in principle, but without application of its 'persistence' criterion.

Kidney function was evaluated by eGFR as calculated using the CKD-EPI creatinine equation (Levey et al., 2009). Individuals with eGFR <60 ml/min/1.73 m² were considered to have reduced kidney function. In addition, we used the ACR to assess urinary albumin excretion, and considered four categories: <10 mg/g, 10-<30 mg/g, 30-300 mg/g, and >300 mg/g. We then created a composite measure of both eGFR and ACR, classifying individuals as CKD if they had either an eGFR <60 ml/min/1.73 m² or ACR ≥30 mg/g. Staging of kidney disease follows the Kidney Disease Outcomes and Quality Improvement (KDOQI) CKD guidelines (Table A; NKF, 2002).

Estimates presented in this chapter may differ from those published by the Centers for Disease Control Chronic Kidney Disease (CDC CKD) Surveillance project. This is because the CDC CKD Surveillance project has historically employed the Modification of Diet in Renal Disease (MDRD) formula (Levey et al., 1999) to calculate eGFR. Currently, though, the project is actively transitioning to use of the CKD-EPI creatinine equation.

Table A. Kidney Disease Outcomes and Quality Improvement (KDOQI) CKD Staging Guidelines

CKD Stage	Description	GFR (ml/min/1.73 m²)
1	Kidney damage with normal or ↑ GFR	>90
2	Kidney damage with mild ↓ in GFR	60-89
3	Moderate ↓ in GFR	30-59
4	Severe ↓ in GFR	15-29
5	Kidney failure	<15 (or dialysis)

In contrast, all other chapters in this ADR volume identify the presence of CKD and its related stages based on ICD-9-CM and ICD-10-CM (International Classification of Diseases, Ninth and Tenth revisions, clinical modification) diagnosis codes. These classification systems are more likely to underreport the initial stages of CKD, as care providers often do not document formal diagnoses of CKD early in the disease process, or may have not yet clinically identified CKD. In addition, because of the asymptomatic nature of much of CKD, many individuals with early stage CKD will not have sought medical care. NHANES data allows us to distinguish individuals within Stage 1 (eGFR >90 with ACR >30) and Stage 2 (eGFR 60-89 with ACR >30).

By examining level of kidney function and the related comorbidities of DM, HTN, and CVD in the general population, this chapter sets the stage for Volume 1, Chapter 2: *Identification and Care of Patients with CKD*. There we discuss CKD as recognized in the health care system via analysis of Medicare claims, data from OPTUM Clinformatics™, and data from the U.S. Department of Veterans Affairs (VA), providing information on morbidity, interventions, and costs.

Methods

Two nationally representative data sources are included in the analyses for this chapter: NHANES (2001-2016) and BRFSS (2013-2016).

The National Health and Nutrition Examination Survey (NHANES) is a sample of about 5,000 individuals per year drawn from the U.S. civilian, noninstitutionalized population. Respondents answer survey questions, receive a medical examination, and provide blood and urine samples that are tested for various biochemical markers, including serum creatinine and urine albumin. Except for Figure 1.14, all tables and figures in this chapter are based on NHANES data.

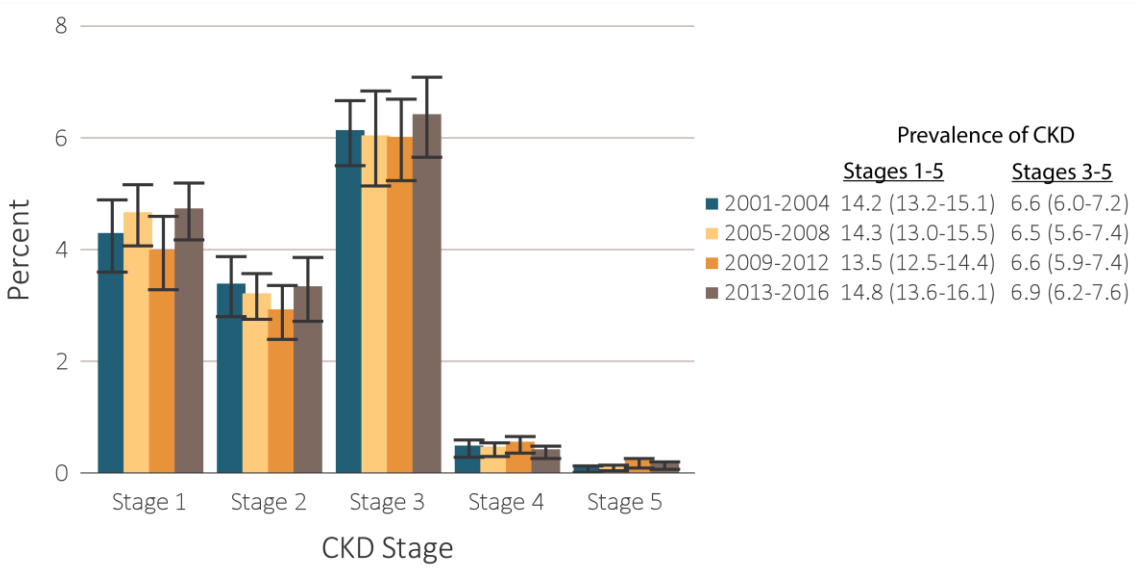
Figure 1.14 employs data from the Behavioral Risk Factor Surveillance System (BRFSS) to illustrate the geographic distribution by state of self-reported (SR) kidney disease. These data are also a sample of the U.S. general population, but respondents answer survey questions during a phone interview, and there is no medical examination. However, the sample size is large and data includes residence information, allowing precise estimation for U.S. states.

A full explanation of these data is included in the *Data Sources* section of the CKD Analytical Methods chapter. See the section on *Chapter 1*, in the *CKD Analytical Methods* chapter for an explanation of the analytical methods used to generate the study cohorts, figures, and tables in this chapter. Downloadable Microsoft Excel and PowerPoint files containing the data and graphics for these figures and tables are available from the *USRDS website*. Downloadable Microsoft Excel and PowerPoint files containing the data and graphics for these figures and tables are available from the *USRDS website*.

Prevalence of CKD

Figure 1.1 presents the U.S. prevalence of CKD, over four periods from 2001 to 2016. A small increase occurred in Stage 3 CKD, which rose from 6.1% to 6.4% over the four periods. The percent of individuals in Stages 1-2 decreased from 2001 to 2012, but reverted to initial levels in the most recent period. The trend in increasing prevalence for Stages 3-5 (non-ESRD) was statistically significant in past ADRs due to the inclusion of the 1999-2000 data, however, from 2001 to 2016 the change in prevalence was positive, but not significant (OR=1.02, p=0.50 per 1 more recent NHANES cohort).

vol 1 Figure 1.1 Prevalence of CKD by stage among NHANES participants, 2001-2016



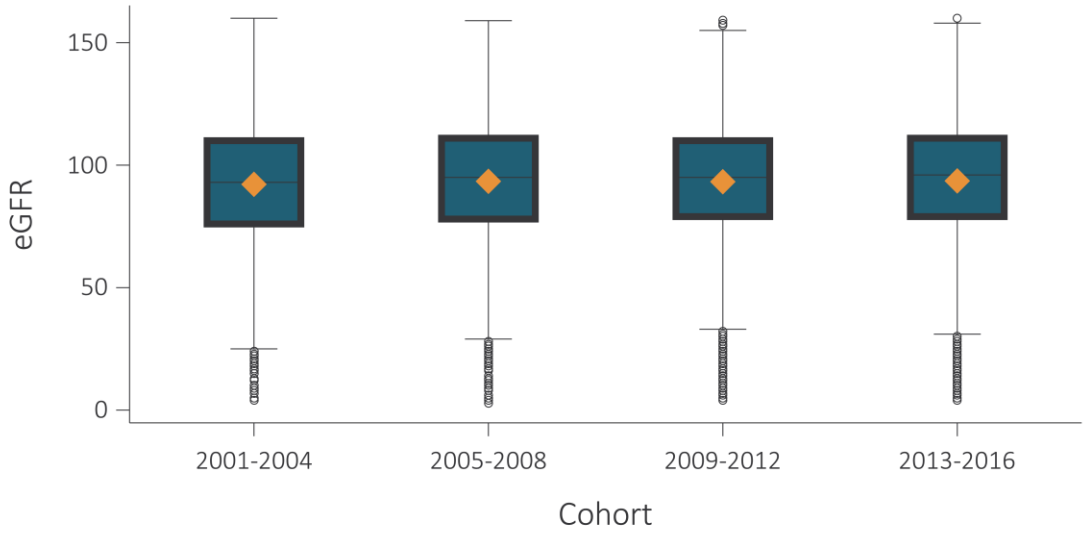
Data Source: National Health and Nutrition Examination Survey (NHANES), 2001-2004, 2005-2008, 2009-2012 & 2013-2016 participants aged 20 & older. Whisker lines indicate 95% confidence intervals. Abbreviation: CKD, chronic kidney disease.

Figure 1.2 provides the density distributions of eGFR in NHANES during 2001-2004, 2005-2008, 2009-2012, and 2013-2016. Overall, minimal population changes have been observed over the entire period. We also examined these densities among individuals over the age of 60 years, as this group experiences the highest prevalence of CKD. The average eGFR for individuals over 60 years was approximately 20 ml/min/1.73 m^2, lower than for the complete sample (Figure 1.2.b).

vol 1 Figure 1.2 eGFR distribution among NHANES participants, 2001-2016

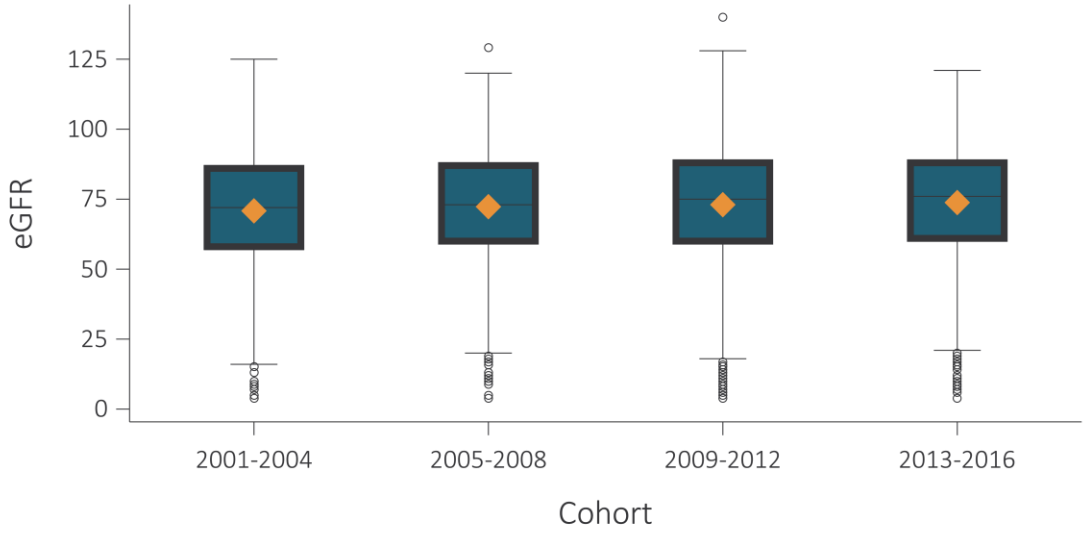
(a) All individuals

Cohort	Mean	SE
2001-2004	94.4	0.54
2005-2008	94.6	0.68
2009-2012	94.6	0.50
2013-2016	94.3	0.52



(b) Individuals 60+ years

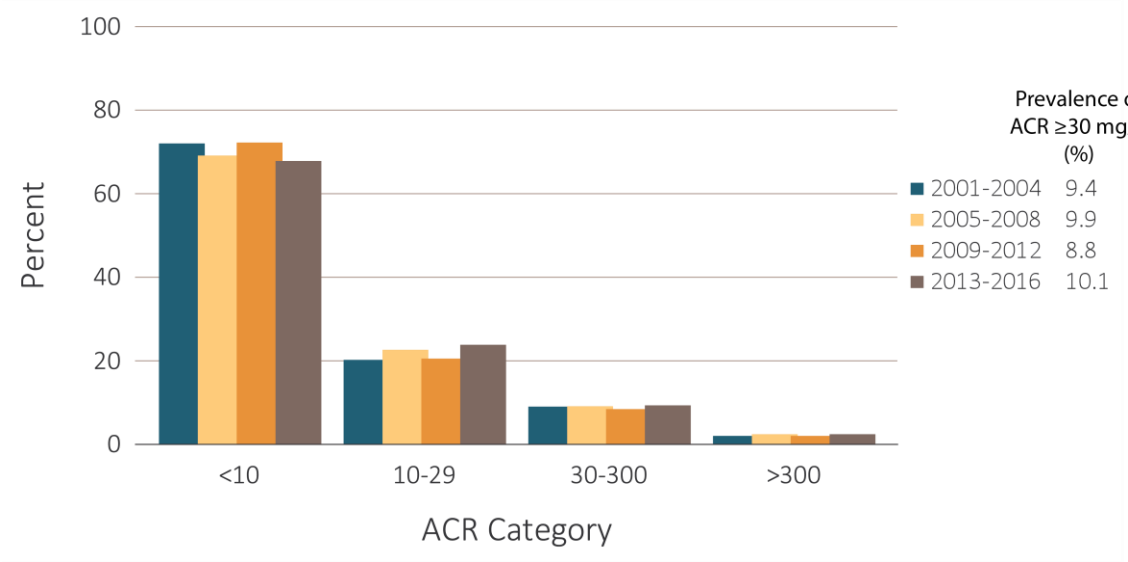
Cohort	Mean	SE
2001-2004	70.7	0.52
2005-2008	72.2	0.49
2009-2012	73.3	0.39
2013-2016	74.0	0.55



Data Source: National Health and Nutrition Examination Survey (NHANES), 2001-2016 participants aged 20 & older. Single-sample estimates of eGFR; eGFR calculated using the CKD-EPI equation. Abbreviations: eGFR, estimated glomerular filtration rate; SE, standard error. Accounts for change in serum creatinine assays.

Figure 1.3, with corresponding findings for ACR, shows little change over time in the distribution patterns of individuals with ACR >300 mg/g. However, comparison of the groups with ACR 10-29 mg/g and 30-300 shows a slight increase, with a corresponding decrease in the proportions of individuals with ACR <10 mg/g, over the four periods. This has important mortality implications, as increased rates of all-cause mortality have occurred with ACR values as low as 10 mg/g (Matsushita, 2010).

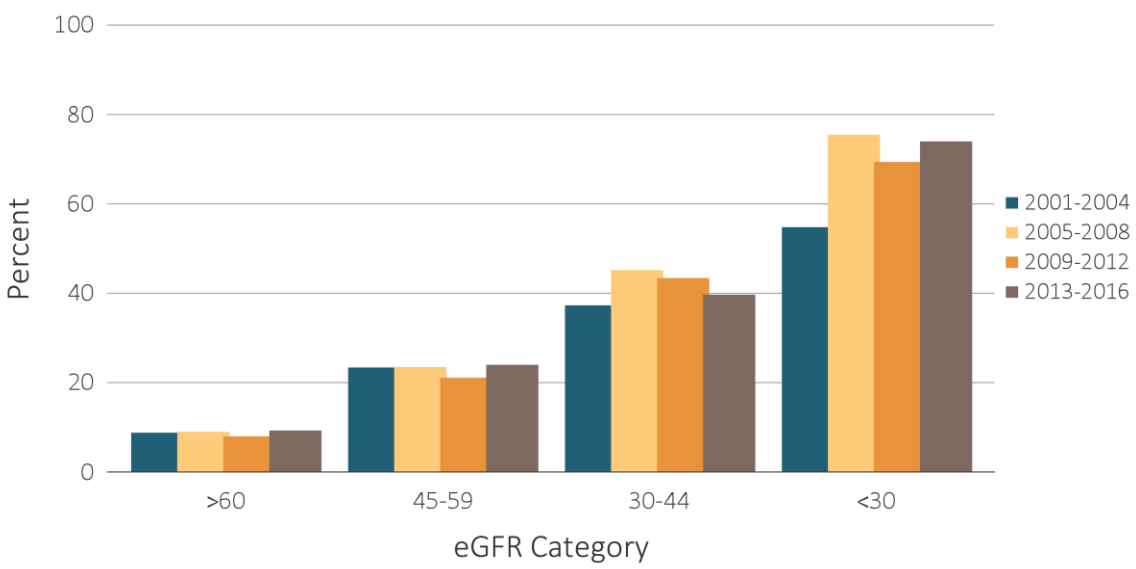
vol 1 Figure 1.3 Urine albumin/creatinine ratio (ACR) distribution among NHANES participants, 2001-2016



Data Source: National Health and Nutrition Examination Survey (NHANES), 2001-2016 participants aged 20 & older. Single-sample estimates of ACR. Abbreviation: ACR, urine albumin (mg)/creatinine (g) ratio.

Figure 1.4 displays the prevalence of albuminuria (ACR >30mg/g) by eGFR category over time. Albuminuria is more prevalent at lower levels of kidney function and has increased the most among individuals with eGFR <30 ml/min/1.73 m². In the 2013-2016 NHANES sample, 8.6% of persons with eGFR >60 ml/min/1.73 m² had some evidence of albuminuria. This rose to 23.3% among individuals with an eGFR of 45-59 and 39.0% for those with an eGFR of 30-44. Of individuals with Stage 4 CKD (eGFR <30 ml/min/1.73 m²), the majority had evidence of albuminuria (73.3%).

vol 1 Figure 1.4 Percentage of NHANES (2001-2016) participants with ACR >30 mg/g, by eGFR category



Data Source: National Health and Nutrition Examination Survey (NHANES), 2001-2016 participants aged 20 & older. Single-sample estimates of eGFR. Abbreviations: ACR, urine albumin (mg)/creatinine (g) ratio; eGFR, estimated glomerular filtration rate.

When assessing the joint distribution of eGFR and ACR, using the KDIGO 2012 framework (Table 1.1), which was developed based on the prognostic value of these measures, we see in the most recent cohort (2013-2016) that 14.8% are classified as high risk (10.7% at moderately high risk, 2.7% at high risk, and 1.4% at very high risk). Since 2001 the prevalence of individuals within the high risk categories has increased slightly (14.2-14.8%), with a dip in the 2009-2012 cohort (Table 1.1.b).

vol 1 Table 1.1 Percentage of NHANES 2013-2016 participants, in the various CKD (eGFR and albuminuria) risk categories (KDIGO 2012)

(a) Percentage in each category (2013-2016)

GFR categories (ml/min/1.73 m²)				Albuminuria categories			Total
				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	
	G1	Normal to high	≥90	54.9	4.2	0.5	59.6
	G2	Mildly decreased	60-89	30.2	2.9	0.3	33.5
	G3a	Mildly to moderately decreased	45-59	3.6	0.8	0.3	4.7
	G3b	Moderately to severely decreased	30-44	1.0	0.4	0.2	1.7
	G4	Severely decreased	15-29	0.13	0.10	0.15	0.37
	G5	Kidney failure	<15	0.01	0.04	0.09	0.13
			Total	89.9	8.5	1.6	100

(b) Summary of prevalence in each risk category, by cohort (2001-2016)

	2001-2004	2005-2008	2009-2012	2013-2016
Low risk	85.8	85.6	86.5	85.1
Moderately high risk	14.2 = 10.6	14.4 = 10.3	13.5 = 9.7	14.8 = 10.7
High risk	2.4	2.7	2.4	2.7
Very high risk	1.2	1.4	1.4	1.4

Data source: National Health and Nutrition Examination Survey (NHANES), 2001-2004, 2005-2008, 2009-2012 & 2013-2016 participants aged 20 and older. Single-sample estimates of eGFR and ACR; eGFR calculated using the CKD-EPI equation. Low risk: eGFR ≥60 ml/min/1.73 m² and ACR <30 mg/g; moderately high risk: eGFR 45-59 ml/min/1.73 m² or eGFR ≥60 ml/min/1.73 m² and ACR 30-300 mg/g; high risk: eGFR 30-44 ml/min/1.73 m² or eGFR 45-59 ml/min/1.73 m² and ACR 30-300 mg/g or eGFR ≥60 ml/min/1.73 m² and ACR >300 mg/g; very high risk: eGFR <30 ml/min/1.73 m² or eGFR 30-44 ml/min/1.73 m² and ACR 30-300 mg/g or eGFR ≥60 ml/min/1.73 m² and ACR >300 mg/g. 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.

Demographic Characteristics and Risk Factors for CKD

Many studies have shown that older age, diabetes mellitus (DM), hypertension (HTN), cardiovascular disease (CVD), and higher body mass index (≥30 kg/m²; BMI) are associated with CKD. Data showing the percentage of adult NHANES participants with either eGFR <60 ml/min/1.73 m² or an ACR ≥30 mg/g confirmed a higher estimated prevalence in the presence of each of these risk factors, although with a smaller increase in relation to BMI ≥30 kg/m² (Table 1.2). Other observations of interest include that CKD was more prevalent in women and those over 60 years of age, and that DM was the most common comorbid risk factor for CKD. Ethnic and racial comparisons showed that non-Hispanic Blacks had a higher prevalence of ACR ≥30 but lower prevalence of eGFR <60, as compared to non-Hispanic Whites.

Table 1.2 shows that CKD defined by an eGFR <60 was much more prevalent in individuals aged 60 and older. Low eGFR was present in this age group for over 21.0% of the 2013-2016 participant cohort, compared to 0.4% of individuals aged 20 to 39 years and 2.8% of those aged 40 to 59 years.

Examining trends over time within these risk factor categories shows that CKD prevalence has decreased markedly among individuals with diabetes (from 43.6% to 36.0%). This is in contrast to other comorbid conditions such as hypertension, where little change has been seen (32.7% to 31.2%) or obesity (16.5% to 16.8%). When examining eGFR <60 ml/min/1.73 m² and ACR ≥30 mg/g independently, the decrease in prevalence appears to be due to ACR ≥30 mg/g, which decreased from 33.2% to 25.8% among patients with diabetes during these time periods. Also of interest is that prevalence of all three measures of CKD have decreased among the individuals aged 60+ years, while prevalence increased among individuals <60 years of age.

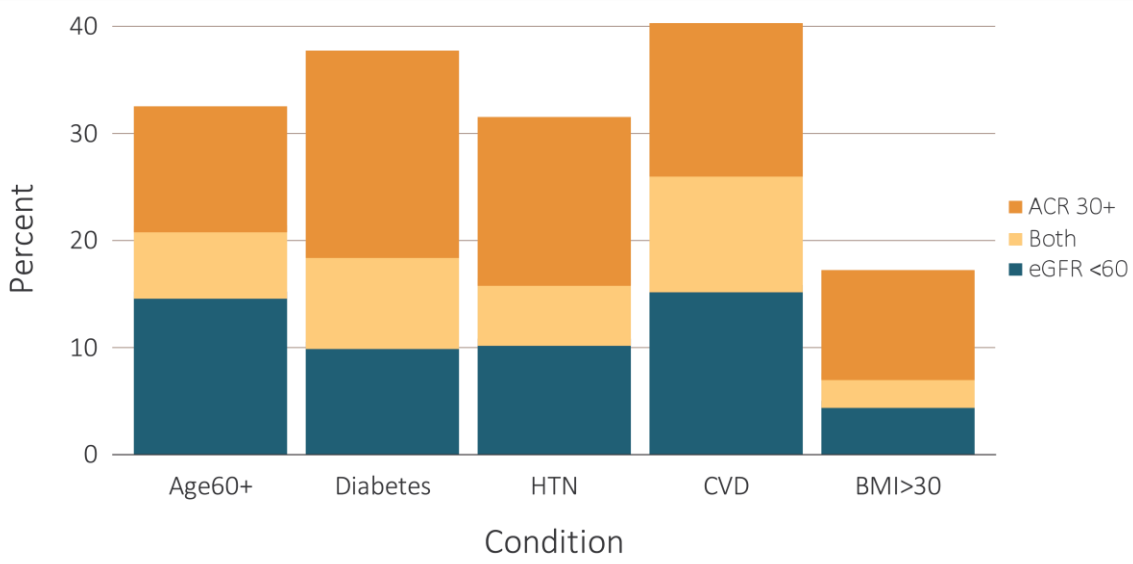
vol 1 Table 1.2 Prevalence (%) of CKD in NHANES population within age, sex, race/ethnicity, & risk factor categories, 2001-2016

	All CKD				eGFR <60 ml/min/1.73 m^2				ACR ≥30 mg/g			
	2001-2004	2005-2008	2009-2012	2013-2016	2001-2004	2005-2008	2009-2012	2013-2016	2001-2004	2005-2008	2009-2012	2013-2016
Age												
20-39	5.4	6.1	5.5	6.3	0.2	0.2	0.2	0.4	5.3	6.0	5.4	6.1
40-59	9.7	10.1	8.3	10.4	2.1	2.5	2.2	2.8	8.2	8.2	6.8	8.6
60+	38.8	34.5	33.1	32.2	26.7	23.5	23.0	21.1	19.4	19.1	17.0	17.3
Sex												
Male	12.7	12.1	12.3	12.9	5.4	5.4	5.7	6.1	9.1	8.5	8.5	8.9
Female	15.5	16.3	14.6	16.7	7.7	7.5	7.5	7.6	9.7	9.1	9.1	11.2
Race/Ethnicity												
Non-Hispanic White	14.3	14.4	13.6	15.6	7.7	7.7	7.7	8.2	8.5	9.0	7.9	9.6
Non-Hispanic Black/African American	14.7	16.3	16.1	15.9	4.7	5.7	6.5	5.8	12.4	13.3	12.2	12.6
Mexican American	11.4	11.8	11.9	12.6	1.5	1.9	2.1	3.3	10.5	10.9	10.9	11.2
Other Hispanic	13.0	14.9	11.5	11.4	3.9	2.7	4.3	3.0	11.4	13.1	9.3	9.1
Other Non-Hispanic	15.9	11.4	11.7	12.6	5.2	2.1	4.1	4.7	12.8	10.2	9.8	9.8
Risk Factor												
Diabetes	43.6	40.1	38.6	36.0	18.2	17.4	21.0	18.7	33.2	31.6	26.9	25.8
Self-reported diabetes	43.8	41.8	39.5	37.1	19.2	18.7	22.4	19.3	32.4	33.1	27.1	27.3
Hypertension	32.7	31.6	30.9	31.2	17.7	16.8	17.4	16.1	20.4	20.8	19.3	20.7
Self-reported hypertension	27.2	26.6	26.1	26.6	15.8	14.8	15.7	14.7	16.4	17.3	15.8	16.9
Self-reported cardiovascular disease	42.2	40.6	40.8	40.3	29.4	27.3	28.2	26.3	22.8	25.6	23.2	24.8
Obesity (BMI ≥30)	16.5	17.2	16.5	16.8	6.6	7.0	7.8	7.2	11.9	12.6	10.8	12.1
All	14.2	14.3	13.5	14.8	6.6	6.5	6.6	6.9	9.4	9.9	8.8	10.1

Data source: National Health and Nutrition Examination Survey (NHANES), 2001-2004, 2005-2008, 2009-2012 & 2013-2016 participants age 20 & older. Single-sample estimates of eGFR & ACR; eGFR calculated using the CKD-EPI equation. Diabetes defined as HbA1c >7%, 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.

Figure 1.5 displays the prevalence of CKD markers (eGFR <60 ml/min/1.73 m² and ACR ≥30 mg/g) among adult NHANES 2013–2016 participants—specifically those aged 60 years and older, and those of all ages who had the comorbid conditions of DM, HTN, SR CVD, and higher BMI. The prevalence of eGFR <60 was highest among those aged 60+ years (21.1%) and those with SR CVD (26.3%), followed by those with DM (18.7%), HTN (16.1%), and higher BMI (7.3%). An ACR ≥30 was most common in those with DM (27.2%), followed by those with HTN (20.7%), aged+ 60years (17.3%), with SR CVD (14.8%), and of higher BMI (12.2%). The presence of both eGFR <60 and ACR ≥30 was most common with SR CVD, at 10.8%, followed by DM at 8.5%, those aged 60+ years (6.2%), with HTN (5.6%), and with higher BMI (2.6%).

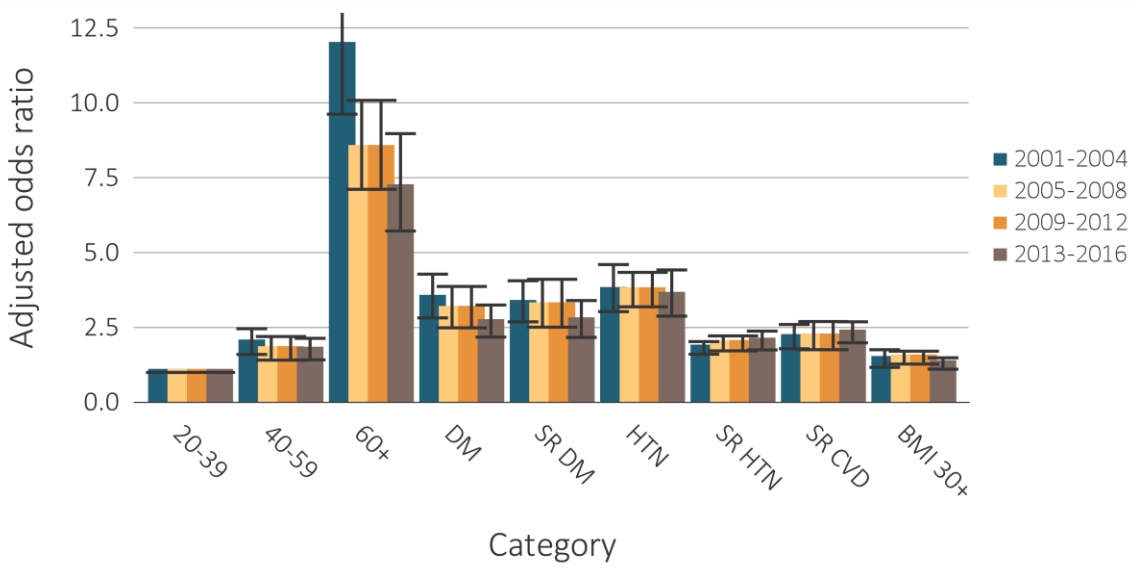
vol 1 Figure 1.5 Distribution of markers of CKD in NHANES participants with diabetes, hypertension, self-reported cardiovascular disease, & obesity, 2013–2016



Data Source: National Health and Nutrition Examination Survey (NHANES), 2013-2016 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.

Figures 1.6-1.8 illustrate the odds ratios for presence of CKD for each of the common comorbid conditions. Analyses were adjusted for age, sex, and race. As consistent with the remainder of this chapter, presence of CKD was indicated by either eGFR <60 ml/min/1.73 m² or ACR ≥30 mg/g.

vol 1 Figure 1.6 Adjusted odds ratios of CKD in NHANES participants, by risk factor, 2001-2016



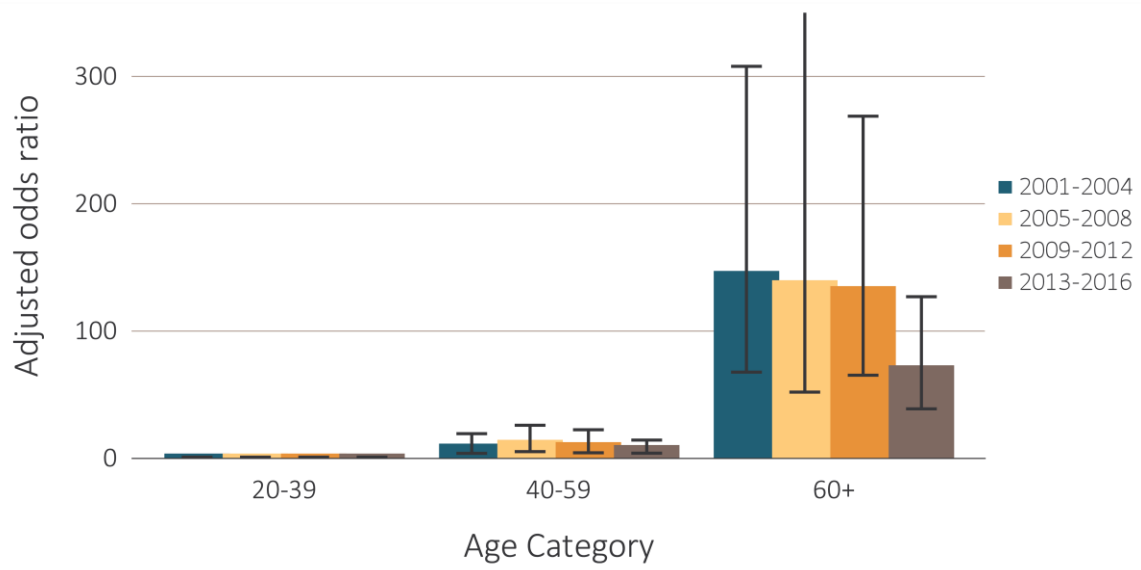
Data Source: National Health and Nutrition Examination Survey (NHANES), 2001-2004, 2005-2008, 2009-2012 & 2013-2016 participants age 20 & older; single-sample estimates of eGFR & ACR. Adjusted for age, sex, & race; eGFR calculated using the CKD-EPI equation. Whisker lines indicate 95% confidence intervals. 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-reported.

Adjusted odds ratios for presence of CKD (Figure 1.6) were generally lower in NHANES 2005-2008, 2009-2012, and 2013-2016 participants than during 2001-2004. This was true for each risk factor except SR HTN and SR CVD, where adjusted odds ratios rose from 1.81 to 2.04 and 2.16 to 2.31 over these periods. Age had the strongest association with CKD, followed by HTN, DM, and CVD; these comorbidities contributed about one-third of the effect size as did age.

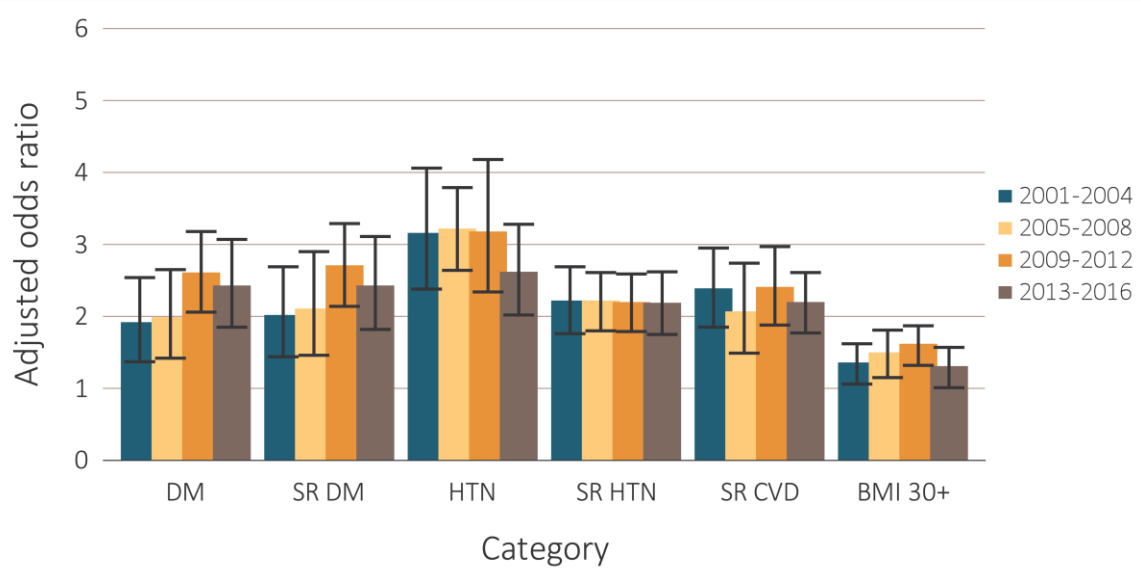
For eGFR <60 alone (Figure 1.7), adjusted odds ratios followed a similar pattern, except for DM and SR DM, where the odds increased from 1.9 to approximately 2.4 in both groups. Also, eGFR <60 showed a very strong association with age, with adjusted odds ratios in the 100 range. For ACR ≥30 alone (Figure 1.8), a substantial decline in the adjusted odds ratio was seen among both those with DM (from 4.16 to 3.03) and aged 60 or older (from 4.94 to 3.40), while a substantial increase in the adjusted odds ratio was seen for those with SR CVD (from 1.80 to 2.30).

vol 1 Figure 1.7 Adjusted odds ratios of eGFR <60 ml/min/1.73 m^2 in NHANES participants, by age & risk factor, 2001-2016

(a) Age category

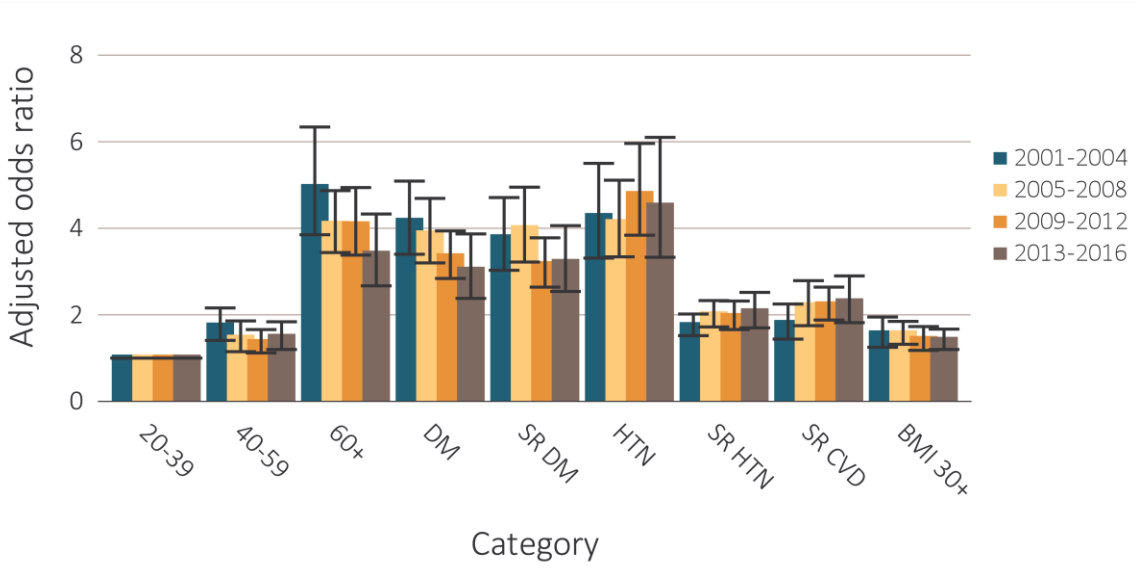


(b) CKD risk factor



Data Source: National Health and Nutrition Examination Survey (NHANES), 2001-2004, 2005-2008, 2009-2012 & 2013-2016 participants age 20 & older; single-sample estimates of eGFR & ACR. Adjusted for 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-reported.

vol 1 Figure 1.8 Adjusted odds ratios of urine albumin/creatinine ratio ≥30 mg/g in NHANES participants, by age & risk factor, 2001-2016



Data Source: National Health and Nutrition Examination Survey (NHANES), 2001-2004, 2005-2008, 2009-2012 & 2013-2016 participants age 20 & older; single-sample estimates of eGFR & ACR. Adjusted for 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-reported.

Time Trends in Characteristics of Individuals with and without CKD

In this section, we will examine changes over the four time periods in characteristics for both individuals with and without CKD in the U.S. general population. Specifically we examine socio-economic factors, including health insurance status, household income, and education. We also examine health behaviors of individuals focusing on activity level, smoking status, sleep, and nutritional intake.

Socioeconomic Factors

Table 1.3 examines the socioeconomic factors of health insurance status, income, and education level among individuals with and without CKD over time. The overall proportion with health care coverage remained steady between approximately 87%-91%. The highest coverage was seem among individuals with eGFR <60, who were typically older in age. The highest percentage of individuals had a combination of government provided health insurance (mainly Medicare) and private insurance coverage. The proportion of individuals without CKD who had insurance coverage also remained quite stable during this time period, but in contrast to individuals with CKD, they had a lower prevalence of insurance coverage (79%-84%) with the majority of those insured reporting private insurance. This observation is likely due to the fact that individuals with CKD tend to be older and a higher proportion are eligible for Medicare coverage.

Income levels for these cohorts appear to have risen over time; approximately 25% of individuals with CKD reported an income of $75,000 or more in 2013-2016. Comparatively, the U.S. median income fluctuated across the same period, decreasing from $57,909 in 1999 to $56,716 in 2015, with the lowest income of $52,666 reported in 2012 (U.S. Census Bureau). Overall, individuals without CKD had higher proportions in the upper income levels, which is also consistent with their younger age and ability to work.

Education levels also rose over time, especially among those with eGFR <60. The percentage of individuals with less than high school education decreased from 31.5% in 2001-2004 to 17.4% from 2013-2016, while the group with at least some college increased from 42.4% to 57.3% over the same period. These trends are similar to those of the general U.S. population. The National Center for Education Statistics reports that adjusted high school graduation rates increased from 79% 2010-2011 to 83% percent in 2014-2015. Rates were highest overall among those of White and Asian race, and lowest for Blacks and American Indians. In addition, college enrollment rose from 35% in 2000 to 40% in 2015. Overall college enrollment rates were higher for females compared to males.

Health Risk Behaviors

Historically, health risk behaviors for CKD have received less emphasis than have the contributing biological risk factors. Table 1.4 examines self-reported activity level, smoking status, amount of sleep, and new to the chapter this year, nutrient intake for individuals with and without CKD. An increase in in activity level across the cohorts was seen among individuals with both eGFR <60 and ACR ≥30. The percent of individuals with CKD reporting a sedentary life-style decreased from 44.9% to 38.2%. This trend is similar to individuals who do not have CKD, who have reported an increase in physical activity (69.0% to 75.4%, Figure 1.9). Overall, individuals without CKD reported more activity.

A moderate decrease in the percentage of individuals reporting current smoking was seen across the cohorts, primarily in individuals with ACR ≥30 mg/g. The percentage of current smokers increased among those with eGFR <60 ml/min/1.73 m^2. Reported amount of sleep was lowest for those with albuminuria, while a higher percentage of those with eGFR <60 reported more than nine hours of sleep per night. The percent of individuals getting less than 6 hours of sleep has decreased in all populations, except eGFR <60.

Nutrient intake was examined in terms of total energy (kcals), fat, carbohydrates, protein, total sugars, sodium, and potassium estimated as daily intake. In patients with CKD, calorie intake increased slightly, but remained under 2,000 kcals. Individuals without CKD reported higher calorie intake, ranging from 2,200-2,300 kcal/day. Daily intake of sugar and protein was very high across all years studied. Most striking is sodium intake, which is high and has increased from 2,965 mg to 3,192 mg among those with CKD, from 2,617 mg to 2,950 mg among those with eGFR <60, and from 3,142 mg to 3,303 mg among those with ACR ≥30 g/mg. Most striking, though, is the reported sodium intake for individuals without CKD, which averages >3,500 mg over the entire time period. Contrary to this, potassium intake is below the recommended guidelines and has not changed substantially over the time periods.

vol 1 Table 1.3 Time trends in socioeconomic factors among individuals with and without CKD, percent of NHANES participants, 2001-2016

	No CKD				All CKD				eGFR <60 ml/min/1.73 m^2				ACR ≥30 mg/g			
	2001-2004	2005-2008	2009-2012	2013-2016	2001-2004	2005-2008	2009-2012	2013-2016	2001-2004	2005-2008	2009-2012	2013-2016	2001-2004	2005-2008	2009-2012	2013-2016
Health insurance status																
Not insured	18.8	20.0	21.5	16.4	9.4	12.1	13.5	11.6	2.8	4.8	3.2	4.7	12.7	15.1	18.9	14.9
Insured	81.2	80.0	78.5	83.6	90.6	87.9	86.5	88.4	97.2	95.2	96.8	95.3	87.3	84.9	81.1	85.1
Private only	61.1	59.5	56.0	54.9	32.7	31.2	28.0	29.9	19.8	18.1	19.7	19.4	39.0	36.1	31.3	33.6
Medicare only	4.6	3.8	3.8	4.7	19.7	14.1	16.6	14.4	28.1	18.5	23.5	20.9	16.6	12.6	13.6	11.6
Other government only	6.7	5.0	6.0	7.6	5.8	5.1	5.8	8.1	2.0	2.7	3.9	5.3	8.0	6.0	7.2	10.8
Private and any government	6.0	6.7	7.1	8.0	23.8	27.8	26.1	24.2	36.1	44.6	39.2	36.3	16.1	21.3	18.6	17.0
Other/Unknown	2.8	5.0	5.6	8.4	8.6	9.7	10	11.8	11.2	11.3	10.5	13.4	7.6	8.9	10.4	12.1
Income																
Less than $10,000	7.4	4.9	6.0	5.0	10.6	6.6	7.8	7.6	10.2	5.2	5.3	6.6	12.7	7.0	9.6	8.7
$10,000 – $24,999	20.5	16.8	16.1	14.3	29.2	25.7	23.8	22.4	30.7	29.2	24.5	24.0	29.1	26.4	25.0	22.2
$25,000 – $44,999	20.4	19.9	19.1	17.5	20.9	23.7	21.6	20.3	23.6	24.2	25.2	18.6	18.1	22.9	19.1	21.7
$45,000 – $74,999	22.0	22.3	19.5	20.4	18.9	19.5	18.5	17.9	17.5	19.0	20.0	18.5	19.1	19.0	16.6	17.3
$75,000 or more	24.2	31.2	32.7	35.8	12.6	17.7	19.8	24.6	10.7	13.9	17.0	24.8	12.7	18.4	20.7	22.6
Missing	5.5	4.9	6.6	7.1	7.8	6.8	8.4	7.3	7.3	8.4	8.0	7.6	8.3	6.3	9.0	7.4
Education																
<High School	16.8	17.3	16.2	13.9	28.8	27.0	25.8	19.2	31.5	27.3	26.1	17.4	29.2	28.1	27.2	21.2
High School Graduate/GED	25.9	24.2	21.1	20.5	26.3	28.0	23.1	24.5	26.2	31.6	23.7	25.3	25.9	26.6	23.1	24.3
At least some College	57.3	58.5	62.7	65.6	44.9	45.0	51.1	56.3	42.4	41.1	50.2	57.3	44.9	45.3	49.7	54.5

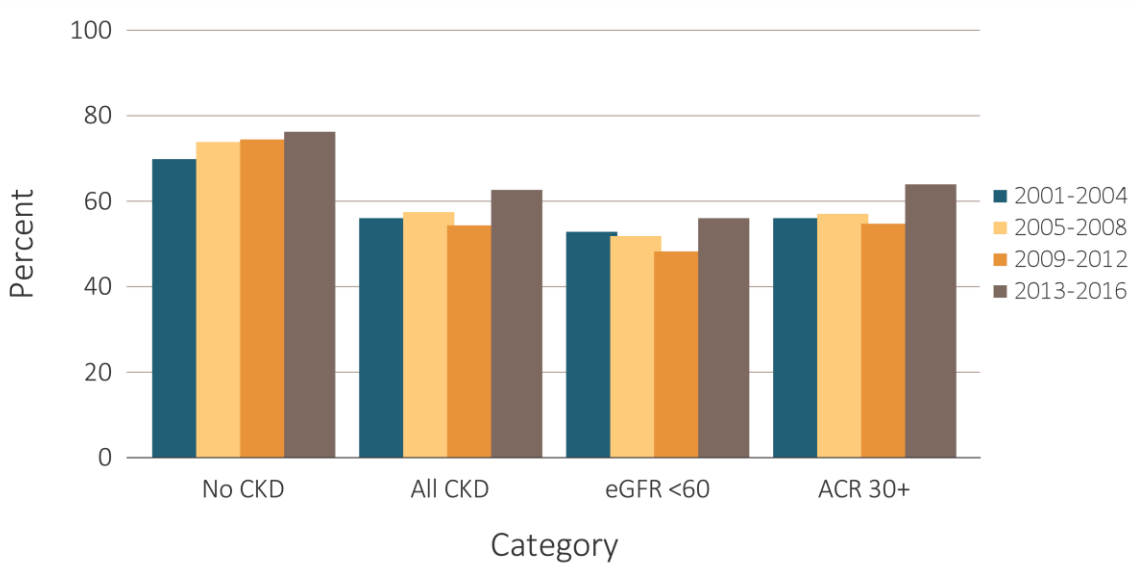
Data Source: National Health and Nutrition Examination Survey (NHANES), 2001-2004, 2005-2008, 2009-2012 & 2013-2016 participants age 20 & older. Single-sample estimates of eGFR & ACR; eGFR calculated using the CKD-EPI equation. Abbreviations: ACR, urine albumin/creatinine ratio; CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate.

vol 1 Table 1.4 Time Trends in Health Risk Behaviors among individuals with and without CKD, percent of NHANES participants, 2001-2016

	No CKD				All CKD				eGFR <60 ml/min/1.73 m^2				ACR ≥30 mg/g			
	2001-2004	2005-2008	2009-2012	2013-2016	2001-2004	2005-2008	2009-2012	2013-2016	2001-2004	2005-2008	2009-2012	2013-2016	2001-2004	2005-2008	2009-2012	2013-2016
Physical Activity (%)																
Vigorous	37.4	40.9	41.0	44.2	18.6	23.3	20.9	26.7	13.8	16.0	13.6	19.4	20.0	25.1	23.9	28.5
Moderate	30.9	31.8	32.6	31.1	36.6	33.3	32.6	35.1	38.2	35.0	33.8	35.8	35.2	31.1	30.0	34.6
Sedentary	31.7	27.3	26.4	24.7	44.9	43.4	46.5	38.2	48.0	49.0	52.6	44.8	44.8	43.8	46.1	36.9
Smoking (%)																
Current	21.5	20.3	17.2	15.0	20.0	17.8	16.1	16.8	9.0	9.7	9.7	10.1	25.9	21.4	19.2	21.0
Former	23.5	23.9	23.1	23.0	32.4	28.7	31.4	30.3	39.6	36.6	38.8	36.3	28.1	26.4	28.1	27.9
Never	55.0	55.8	59.6	62.0	47.6	53.4	52.5	52.8	51.4	53.7	51.4	53.6	46.0	52.2	52.7	51.1
Amount of Sleep (%)																
Less than 6 hours	-	13.9	13.1	12.3	-	14.7	14.8	14.0	-	9.2	12.9	14.1	-	18.0	16.5	14.1
6 hours	-	23.4	24.2	22.5	-	22.2	19.7	21.8	-	22.1	15.6	20.5	-	22.9	22.6	22.8
7-8 hours	-	57.2	57.1	58.3	-	53.9	55.5	53.2	-	57.5	57.3	48.6	-	51.2	53.2	54.9
9 hours or more	-	5.5	5.6	6.9	-	9.2	10.0	11.0	-	11.1	14.2	16.8	-	7.9	7.8	8.2
Macronutrient Intake*																
Energy (kcal)	2,307	2,254	2,238	2,212	1,862	1,885	1,883	1,916	1,637	1,712	1,712	1,800	1,973	1,943	1,958	1,963
Fat (grams)	87	86	84	86	70	73	72	73	62	67	66	71	74	75	74	74
Carbohydrates (grams)	282	269	271	260	230	226	229	228	205	208	209	216	241	232	238	232
Protein (grams)	86	86	85	86	70	75	73	74	63	69	66	70	74	76	76	76
Total Sugars (grams)	135	123	121	114	107	102	102	101	95	95	93	99	112	103	105	100
Sodium (mg)	3,576	3,622	3,685	3,632	2,965	3,082	3,175	3,192	2,617	2,825	2,913	2,950	3,142	3,162	3,297	3,303
Potassium (mg)	2,806	2,743	2,829	2,721	2,468	2,510	2,529	2,450	2,376	2,434	2,376	2,466	2,488	2,505	2,572	2,407

Data Source: National Health and Nutrition Examination Survey (NHANES), 2001-2004, 2005-2008, 2009-2012 & 2013-2016 participants age 20 & older. Single-sample estimates of eGFR & ACR; eGFR calculated using the CKD-EPI equation. – Data not available. Abbreviations: ACR, urine albumin/creatinine ratio; CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate.
**Dietary intake data not yet available for 2015/2016.*

vol 1 Figure 1.9 NHANES participants physically active, 2001-2016



Data Source: National Health and Nutrition Examination Survey (NHANES), 2001-2004, 2005-2008, 2009-2012 & 2013-2016 participants aged 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.

Time Trends in Treatment and Control of Patients with CKD

Table 1.5 presents reported awareness of HTN, treatment of CKD-contributing conditions, and control of HTN, hyperlipidemia, and DM in the NHANES adult participants with eGFR <60 ml/min/1.73 m^2 or ACR ≥30 mg/g. While the 73%-74% prevalence of HTN among CKD patients was similar in the four periods, the proportion of participants unaware of their HTN fell from 28.5% to 20.0% in those years. The proportion of hypertensive individuals who were aware, treated, and disease-controlled rose steadily from approximately 17% in the early cohorts to 27% in 2013-2016. In the subgroup with DM, glycemic control initially improved, but then dropped in the most recent cohort, with 58.3% remaining uncontrolled in 2013-2016.

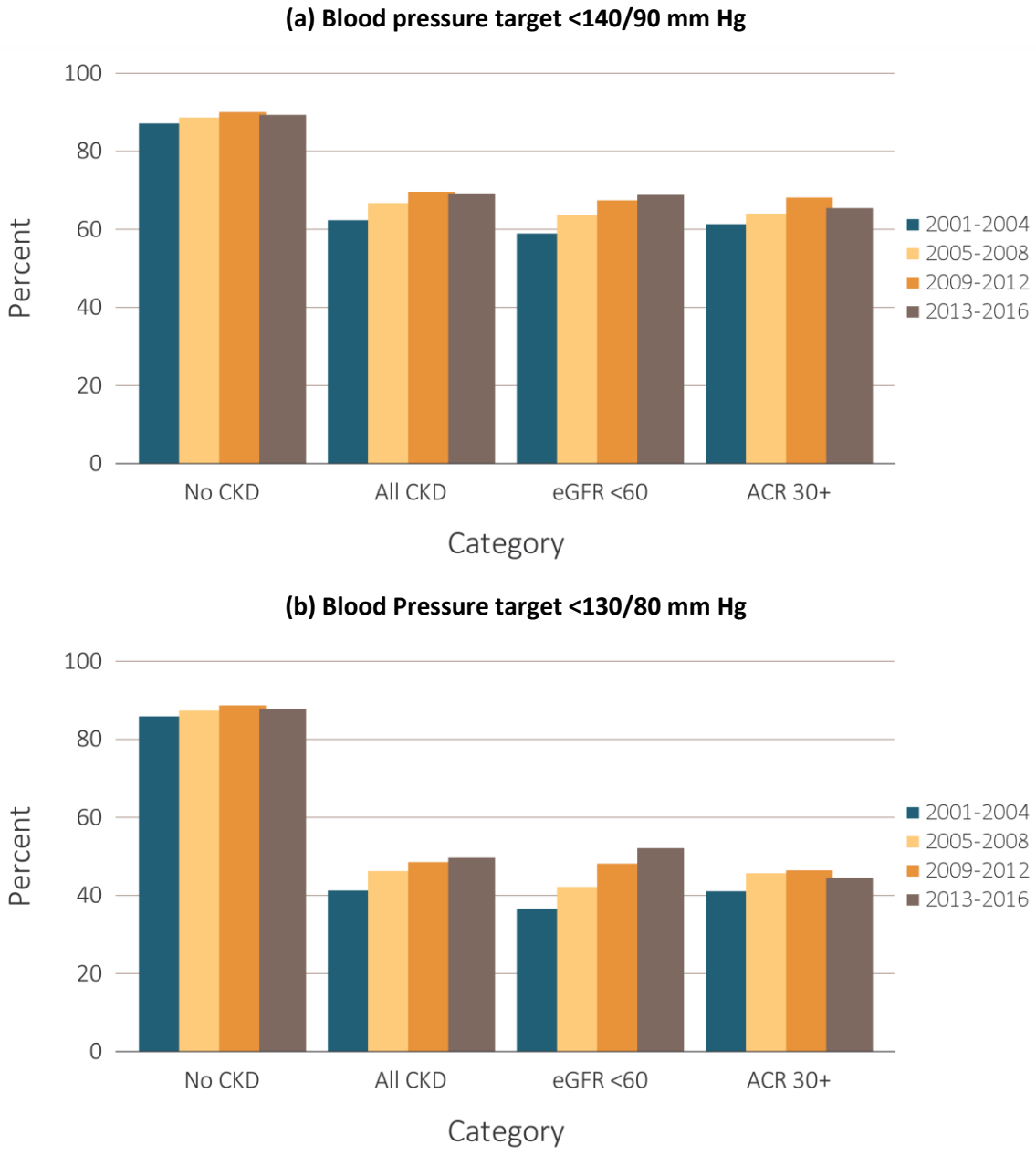
vol 1 Table 1.5 Treatment, and measures of control of CKD risk factors, among NHANES participants with CKD, 2001-2016

	All CKD					eGFR <60 ml/min/1.73 m^2					ACR ≥30 mg/g				
	2001-2004	2005-2008	2009-2012	2013-2016	Trend p-value	2001-2004	2005-2008	2009-2012	2013-2016	Trend p-value	2001-2004	2005-2008	2009-2012	2013-2016	Trend p-value
Hypertension, by current hypertensive status [a]															
Non-hypertensive status	25.6	26.9	25.0	27.7	0.50	15.4	16.1	15.7	19.7	0.05	29.4	30.1	27.9	29.4	0.82
Hypertensive (measured/treated)	74.4	73.1	75.0	72.3		84.6	83.9	84.3	80.3		70.6	69.9	72.1	70.6	
Control of hypertension among hypertensive patients [b]															
Unaware	28.5	24.5	21.9	20.0	<0.01	21.9	19.0	16.0	13.3	<0.01	31.3	26.3	24.9	23.5	<0.01
Aware, not treated	9.2	8.0	6.2	12.1		5.8	4.1	2.4	5.1		10.7	10.6	8.4	15.9	
Aware, treated, uncontrolled	45.6	44.6	43.4	40.5		51.0	48.8	46.3	44.1		45.8	44.9	43.9	42.0	
Aware, treated, controlled	16.7	22.8	28.4	27.4		21.3	28.0	35.3	37.3		12.2	18.2	22.8	18.6	
Total cholesterol [c]															
<200 (desirable)	48.7	54.6	60.2	62.2	<0.01	49.0	58.2	64.5	66.6	<0.01	49.0	54.8	58.9	60.7	<0.01
200–239 (borderline high)	31.0	27.2	26.0	23.3		31.7	24.2	22.7	20.7		30.8	27.6	27.3	23.9	
240+ (high)	20.3	18.2	13.9	14.5		19.2	17.7	12.7	12.6		20.3	17.6	13.7	15.4	
Control of diabetes among patients with diabetes [d]															
HbA1c <7% (controlled)	43.8	47.8	46.3	41.7	0.42	54.8	59.6	56.3	48.0	0.11	37.0	43.4	37.1	36.3	0.45
HbA1c 7% - 7.9% (borderline)	21.1	25.3	25.3	22.7		24.4	24.1	26.4	27.0		22.3	25.6	26.8	21.9	
HbA1c 8% + (uncontrolled)	35.1	27.0	28.4	35.6		20.8	16.3	17.3	25.0		40.7	31.0	36.1	41.8	

Data Source: National Health and Nutrition Examination Survey (NHANES), 2001-2004, 2005-2008, 2009-2012 & 2013-2016 participants age 20 & older. Single-sample estimates of eGFR & ACR; eGFR calculated using the CKD-EPI equation. [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] Glycosylated hemoglobin (HbA1c) classified according to American Diabetes Association guidelines. Abbreviations: ACR, urine albumin/creatinine ratio; CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate; HbA1c, glycosylated hemoglobin.

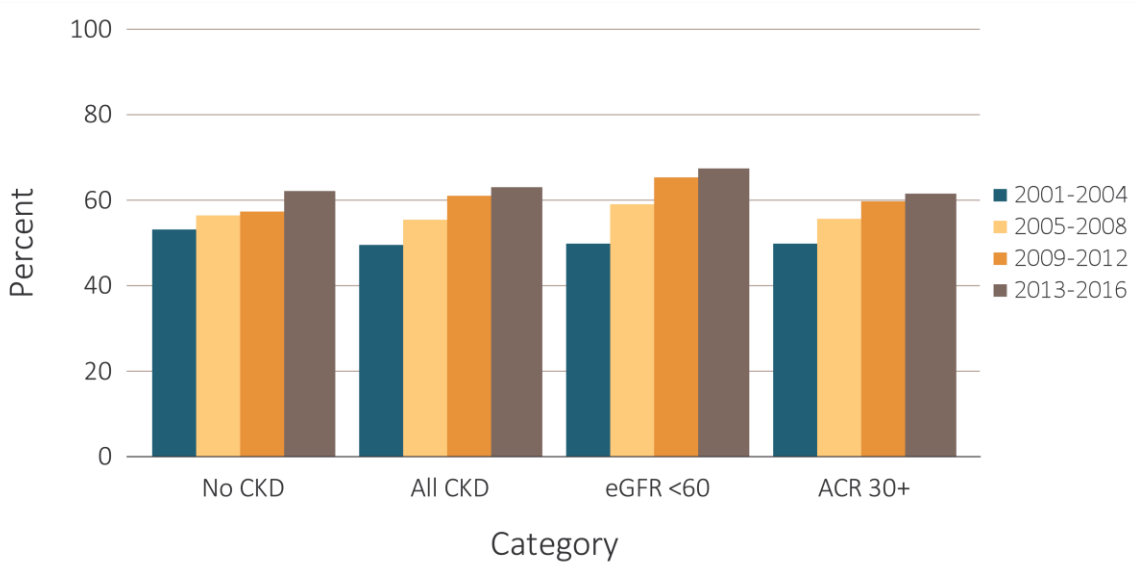
As illustrated by Figures 1.10-1.12, over the periods of 2001-2004, 2005-2008, 2009-2012, & 2013–2016, improvements in the management of HTN and cholesterol were observed, regardless of whether the criterion was eGFR or ACR level. For comparison, these figures include estimates for individuals without CKD.

vol 1 Figure 1.10 Time Trends of NHANES participants with and without CKD at target blood pressure, 2001-2016



Data Source: National Health and Nutrition Examination Survey (NHANES), 2001-2004, 2005-2008, 2009-2012 & 2013-2016 participants aged 20 & older. Single-sample estimates of eGFR & ACR; eGFR calculated using the CKD-EPI equation. Figure represents all hypertensive participants including those who were at target blood pressure, probably due to medication. Abbreviations: ACR, urine albumin/creatinine ratio; CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate.

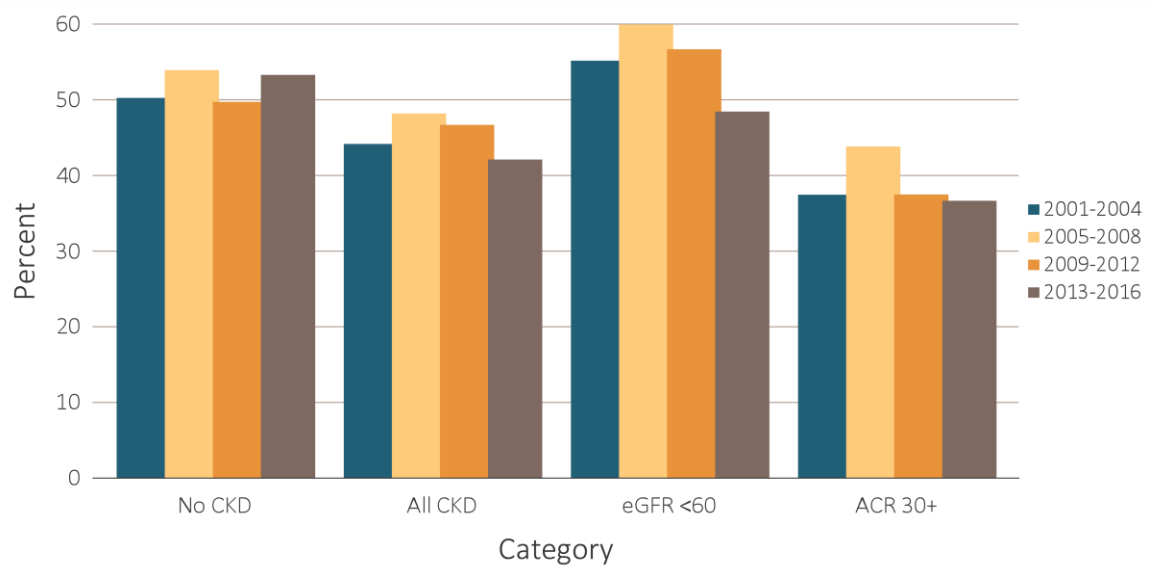
vol 1 Figure 1.11 Time Trends of NHANES participants with and without CKD with respect to cholesterol in the normal range, 2001-2016



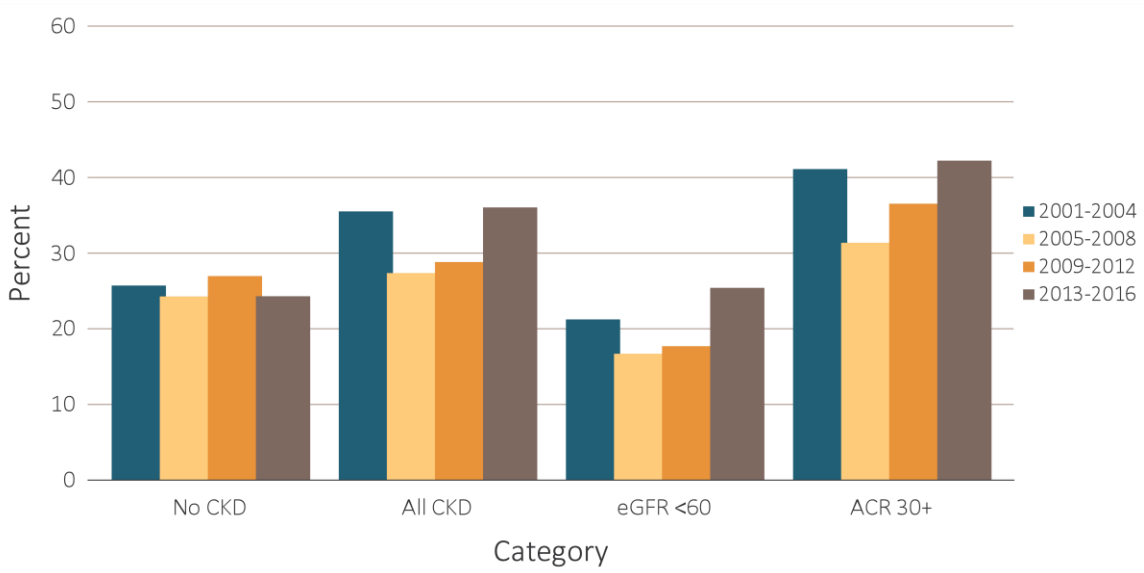
Data Source: National Health and Nutrition Examination Survey (NHANES), 2001-2004, 2005-2008, 2009-2012 & 2013-2016 participants aged 20 & older. Single-sample estimates of eGFR & ACR; eGFR calculated using the CKD-EPI equation. Abbreviations: ACR, urine albumin/creatinine ratio; CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate.

vol 1 Figure 1.12 Time trends of diabetic NHANES participants with and without CKD with respect to glycemic control, 2001-2016

(a) Glycosylated hemoglobin <7%



(b) Glycosylated hemoglobin >8%



Data Source: National Health and Nutrition Examination Survey (NHANES), 2001-2004, 2005-2008, 2009-2012 & 2013-2016 participants aged 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.

CKD Awareness

Among the individuals who were classified by laboratory measurements as having CKD, the percentage who were aware of their kidney disease remained low from 2001-2016 (Figure 1.13). There is a suggestion of an improvement among individuals with Stage 4 CKD between 2009-2012 and 2013-2016. We do not present awareness data for those in Stage 5 CKD because of a very small sample size. When examined by eGFR <60 vs. ACR >30, awareness was markedly higher for individuals who had both conditions.

When examining awareness by conditions that are known risk factors for CKD (DM and HTN), awareness was still very low. Even among individuals with both conditions, awareness was steady around 15% (Figure 1.13.c). Figure 1.13.d displays awareness by age categories, and while older patients have slightly better awareness, those 60+ years only reached 10% in the most recent cohort (2013-2016).

vol 1 Figure 1.13 Time trends of individuals with CKD aware of their kidney disease, NHANES 2001-2016

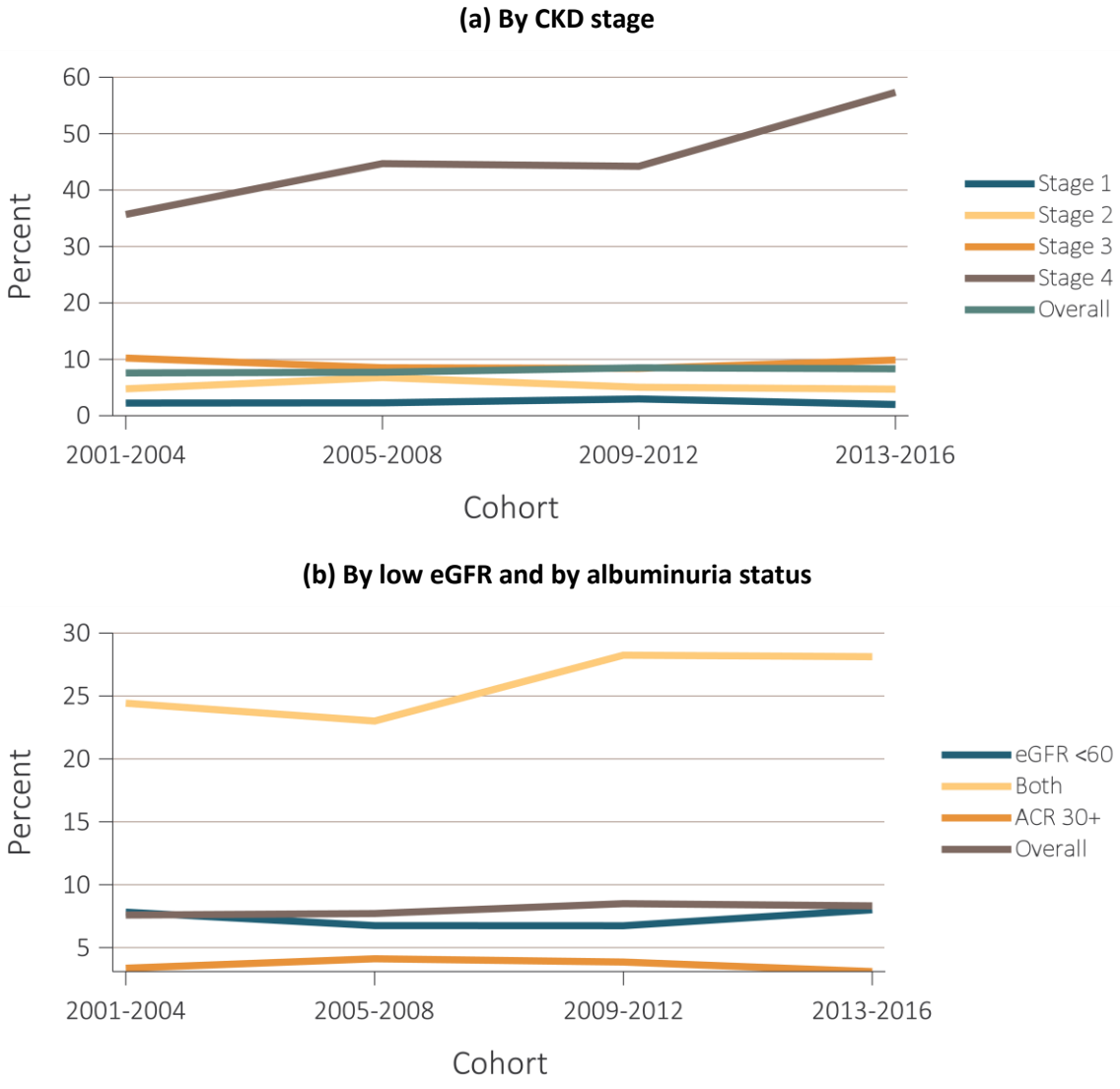
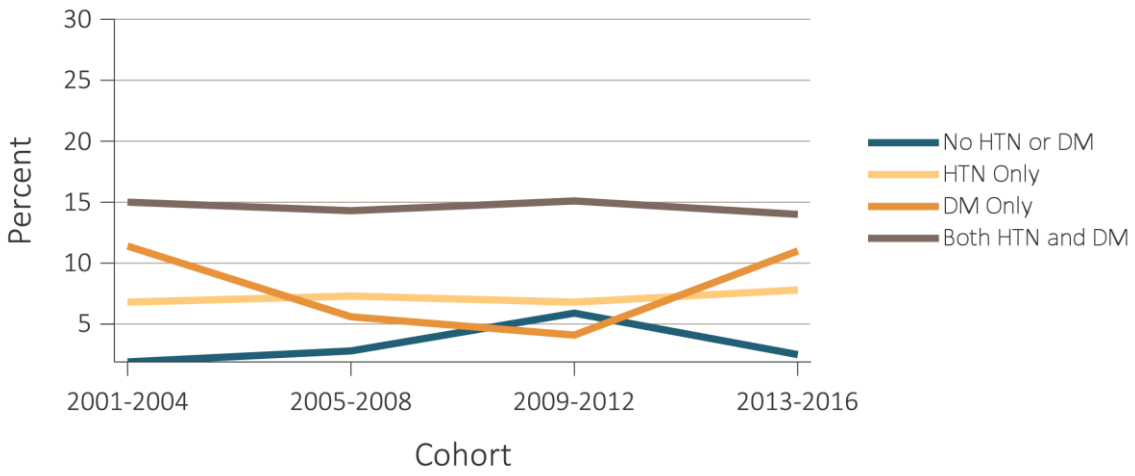


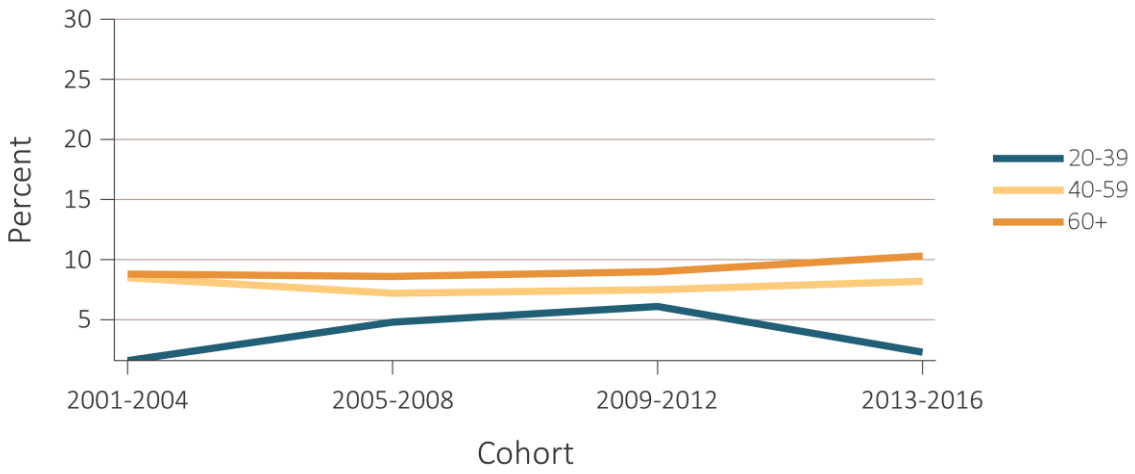
Figure 1.13 continued on next page.

vol 1 Figure 1.13 Time trends of individuals with CKD aware of their kidney disease, NHANES 2001-2016 (continued)

(c) By diabetes and hypertension status



(d) By age categories

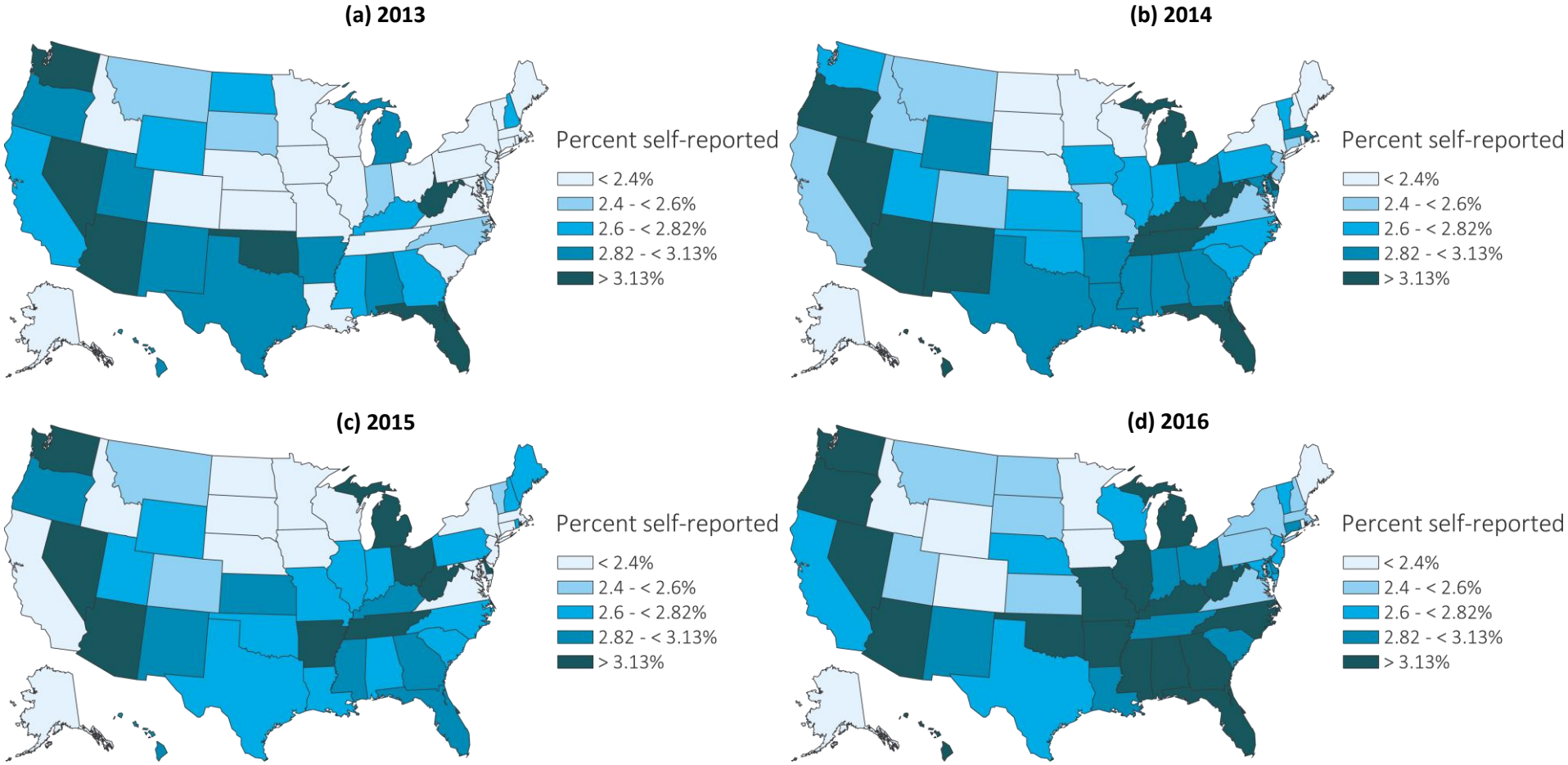


Data Source: National Health and Nutrition Examination Survey (NHANES), 2001-2016 participants aged 20 & older. Abbreviations: ACR, urine albumin/creatinine ratio; CKD, chronic kidney disease; DM, diabetes mellitus; eGFR, estimated glomerular filtration rate; HTN, hypertension.

Figure 1.14 displays the state-specific proportions of individuals who reported being told they had 'kidney disease', based on the 2013 and 2016 BRFSS cohorts. The overall national averages were very low, hovering just under 3% for all years. The NHANES prevalence of self-reported kidney disease ('weak or failing kidneys') of 2.8% matches this national estimate from the BRFSS survey, suggesting poor identification or awareness of kidney disease in the general population.

States with the highest proportion of participants over the years who indicated that they had been informed they had kidney disease included Hawaii, Arizona, Michigan, and West Virginia. Conversely, the states with the lowest proportion of BRFSS participants self-reporting kidney disease included Alaska, Minnesota, Colorado, and New York. These differences could reflect varying prevalence of kidney disease by state, or variations in survey participants' awareness of the condition, if present. The true underlying prevalence of kidney disease by individual state is currently unknown as no state-level NHANES-like surveys are conducted in the United States. Estimates of CKD prevalence and awareness of CKD by state have been computed recently, using prediction modeling (Dharmarajan, 2017).

vol 1 Figure 1.14 Estimated prevalence of self-reported kidney disease by state, BRFSS participants ages 18 and older



Data source: Behavioral Risk Factors Surveillance System (BRFSS), participants aged 18 & older. 2013 (N=491,777), 2014 (N=464,617), 2015 (N=441,460), and 2016 (N=486,303).

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Chapter 2: Identification and Care of Patients with CKD

- Over half of patients in the Medicare 5% sample (aged 65 and older) had at least one of three diagnosed chronic conditions – chronic kidney disease (CKD), cardiovascular disease (CVD), or diabetes mellitus (DM), while 19.9% had two or more of these conditions. Within a younger population derived from the Optum Clinformatics™ Data Mart (ages 22-64 years), 10.6% had at least one of the three conditions, and 1.6% had two or more. As indicated by diagnosis claims and biochemical data from the Department of Veterans Affairs (VA), 15.6% of patients had at least one of the three conditions, while 2.4% had at least two (Table 2.2.b).
- In the Medicare 5% sample and VA data, 13.8% and 14.9% of patients had a diagnosis of CKD in 2016, as opposed to only 2.0% of patients in the Optum Clinformatics™ population (Table 2.4).
- The proportion of patients with recognized CKD in the Medicare 5% sample has grown steadily, from 2.7% in 2000 to 13.8% in 2016 (Figure 2.2).
- Of those in the 2011 Medicare 5% sample who had a diagnosis of CKD Stage 3, by 2016 3.2% had progressed to end-stage renal disease (ESRD) with or without death, and 40.9% had died (without reaching ESRD). For these Medicare patients without identified CKD, progressions to ESRD and death by 2016 were 0.2% and 20.9% (Table 2.5).
- Testing for urine albumin is recommended for patients with DM. Among Medicare patients with a diagnosis of DM, claims data indicated that testing for urine albumin has become more common, but was conducted for less than half of these patients—41.8% in 2016, up from 26.4% in 2006. In 2016, urine albumin testing was performed in 49.9% of diabetic Medicare patients who also had diagnoses of CKD and hypertension (HTN). Patterns were similar in the Optum Clinformatics™ population, but with somewhat lower rates of testing (Figures 2.3 and 2.4).
- Among Medicare patients with recognized CKD in 2015, patients who saw a nephrologist were roughly twice as likely to have a claim for urine albumin testing in 2016 (55.4%) than those who saw only a primary care physician (26.7%; Figure 2.5).

Introduction

Epidemiological evaluations of the identification and care of patients with CKD are a significant challenge, as unlike with ESRD, no single data source contains all the information necessary to definitively identify CKD-related care practices in the United States (U.S.) population. Furthermore, most large administrative health care datasets lack the biochemical data (serum creatinine and urine albumin or urine total protein) required per Kidney Disease Improving Global Outcomes (KDIGO) guidelines for definitive identification of CKD.

As presented in Volume 1, Chapter 1: *CKD in the General Population*, The National Health and Nutrition Examination Survey (NHANES) is a nationally representative survey that contains the biochemical information with which to estimate the prevalence of CKD in the United States. However, NHANES is constrained by its cross-sectional nature, a relatively small sample size, and lack of geographic detail. This limits precision in estimating prevalence, in evaluating long-term outcomes, adverse events, and quality of care delivered, and in the ability to conduct analyses by geography or on subsets of patients.

In addition, NHANES includes only a single measure of serum creatinine and urine albumin for each patient. Per KDIGO guidelines, two abnormal measures over at least 90 days are necessary to definitively diagnose CKD. Because NHANES-based calculations rely on laboratory measures at a single

time point, they may overestimate the national prevalence of CKD. Nevertheless, NHANES is generally considered the best available source of such information at the present time.

To provide a more comprehensive picture of the identification and care of CKD throughout the nation, in this chapter, we complement NHANES with the examination of health care data in large and diverse administrative health care datasets: the Medicare 5% sample, Optum Clinformatics™ Data Mart, and from the U.S. Veterans Health Administration (VHA).

We first present the prevalence of CKD in these health system populations as recognized through diagnosis claims (Medicare 5% and Optum Clinformatics™ Data Mart), and biochemical data (VHA)—both for the overall disease state and with the comorbidities of DM and HTN. This was achieved through comparison of rates in the NHANES, Medicare 5% sample, Optum Clinformatics™, and VHA populations among cohorts of patients aged 22-64, or 65 and older. These were stratified by demographic characteristics in order to highlight challenges with identification of CKD across these various types of data.

We next examined longitudinal changes in CKD status and general outcomes for patients at high risk for kidney disease, by presenting trends in laboratory screening and monitoring of patients with and without CKD. Finally, we assessed the spectrum and impact of follow-up care received by newly diagnosed CKD patients.

Methods

For this year's chapter we utilized several large health care datasets. The general Medicare 5% sample includes an average of 1.2 million patients each year. The Optum Clinformatics™ Data Mart cohort was drawn from the commercial plans of a large U.S. national health insurance company, and holds health care information on about nine million lives per year. The national health system-derived data from the U.S. Veterans Health Administration (VHA), also referred to here as Veterans Affairs data, represents more than six million veterans.

Analyses using the Medicare 5% dataset are restricted to patients aged 65 and older with both Part A and Part B fee-for-service coverage. Persons covered by Medicare managed care programs are not included in this source because of the absence of billing claims. The Optum Clinformatics™ Data Mart data provides insight into a younger, employed population and their dependent children. Like Medicare data, it contains diagnosis and procedure codes as found on claims. The Optum Clinformatics™ dataset also includes information on pediatric age groups, although for some analyses in this chapter only adult patients (ages 22-64 years) are included. Finally, the VHA dataset includes both diagnosis and procedure codes and more complete biochemical test data. This allowed us to estimate the prevalence of CKD as indicated by diagnosis codes combined with serum creatinine blood test results, wherever available.

Throughout this chapter, the term 'recognized CKD' is used when patients are identified based on the presence of a relevant diagnosis code in Medicare, Optum Clinformatics™, or Veterans Affairs data. This implies that either a provider or billing coder in the health care system recognized the presence of CKD. As such, prevalence of 'recognized CKD' likely underestimates true disease prevalence. An observed trend may not necessarily indicate a true change in disease prevalence, but rather a change in clinical awareness or recognition of CKD, or indeed, evolving billing practice. Studies have shown that diagnosis codes for CKD generally have excellent specificity (>90%), though their sensitivity is low (Grams et al., 2011).

To identify the recognized CKD population we selected 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 other conditions that are kidney-disease specific, such as glomerular disease (583.x). In 2006, CKD stage-specific 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 been increasingly utilized, accounting for 49% of all CKD diagnostic documentation in 2007 and 68% in 2016.

Beginning on October 1, 2015, the new ICD-10-CM coding system was implemented, and its related diagnosis codes were then utilized to identify CKD stages and comorbid conditions. Table A lists the CKD-related ICD-9-CM and ICD-10-CM codes used in this chapter.

Further details of the data utilized for this chapter are described in the *Data Sources* section of the *CKD Analytical Methods* chapter.

For an explanation of the analytical methods used to generate the study cohorts, figures, and tables in this chapter, see the section on *Chapter 2* within the *CKD Analytical Methods* chapter. Downloadable Microsoft Excel and PowerPoint files containing the data and graphics for these figures and tables are available from the *USRDS website*.

Table A. ICD-9-CM and ICD-10-CM codes for Chronic Kidney Disease (CKD) stages

ICD-9-CM code[a]	ICD-10-CM code[a]	Stage
585.1	N18.1	CKD, Stage 1
585.2	N18.2	CKD, Stage 2 (mild)
585.3	N18.3	CKD, Stage 3 (moderate)
585.4	N18.4	CKD, Stage 4 (severe)
585.5	N18.5	CKD, Stage 5 (excludes 585.6: Stage 5, requiring chronic dialysis[b])
CKD Stage-unspecified	CKD Stage-unspecified	For these analyses, identified by multiple codes including 585.9, 250.4x, 403.9x & others for ICD-9-CM and A18.xx, E08.xx, E11.xx and other for ICD-10-CM.

[a]For analyses in this chapter, CKD stage estimates require at least one occurrence of a stage-specific code, and the last available CKD stage in a given year is used. [b]In USRDS analyses, patients with ICD-9-CM code 585.6 or ICD-10-CM code N18.6 & with no ESRD 2728 form or other indication of end-stage renal disease (ESRD) are considered to have code 585.5 or N18.5.

Patient Characteristics across Datasets

Table 2.1 presents demographic and comorbidity characteristics of individuals in the Medicare 5% sample (aged 65 and older), the Optum Clinformatics™ dataset (aged 22 and older), and Veterans Affairs data (aged 22 and older). The mean age of Medicare patients was 74.7 years, of Optum Clinformatics™ patients was 44.7 years, and for U.S. Veterans was 62.7 years. The high prevalence of comorbid conditions in the Medicare 5% sample reflects the older age of these patients. For example, 60.5% and 24.0% of the Medicare sample had diagnoses of HTN or DM. In comparison, only 14.5% and 6.1% of the total Optum Clinformatics™ population had diagnoses of HTN or DM. In VHA data these proportions were 24.0% (HTN) and 16.6% (DM).

vol 1 Table 2.1 Demographic characteristics of all patients, among Medicare (aged 65+ years), Optum Clinformatics™ (ages 22 or older) and Veterans Affairs (ages 22 or older) patients, 2016

	Medicare 5%		Optum Clinformatics™		Veterans Affairs	
	Sample count	Percent (%)	Sample count	Percent (%)	Sample count	Percent (%)
All	1,286,211	100	5,354,131	100	6,673,889	100
Age						
22-30	-	-	934,959	17.5	311,807	4.7
31-40	-	-	1,223,069	22.8	647,353	9.7
41-50	-	-	1,258,509	23.5	640,908	9.6
51-64	-	-	1,674,668	31.3	1,485,870	22.3
65-74	729,462	56.7	206,188	3.9	2,010,195	30.1
75-84	388,900	30.2	39,653	0.7	918,428	13.9
85+	167,849	13.1	17,085	0.3	659,328	9.9
Sex						
Male	559,118	43.5	2,725,981	50.9	692,611	10.4
Female	727,093	56.5	2,627,281	49.1	5,981,174	89.6
Race/Ethnicity						
White	1,098,136	85.4	3,458,337	67.8	4,626,512	69.3
Black/African American	96,120	7.5	463,015	9.1	1,040,546	15.6
Native American	5,681	0.4	-	-	53,816	0.8
Asian	24,921	1.9	285,804-	5.6	67,768	1.0
Hispanic	42818	3.3-	646,123	12.7	-	-
Other/Unknown/Missing	18535	1.44	245,002	4.8	885,247	13.3
Comorbidity						
Diabetes mellitus	309,241	24.0	328,822	6.1	1,110,214	16.6
Hypertension	777,832	60.5	778,159	14.5	1,604,804	24.0
Cardiovascular disease	513,794	40.0	327,865	6.1	766,053	11.5

Data Source: Special analyses, Medicare 5% sample (aged 65 and older), Optum Clinformatics™ (ages 22 or older) and Veterans Affairs (ages 22 or older) alive & eligible for all of 2016. Abbreviation: CKD, chronic kidney disease. CVD is defined as presence of any of the following comorbidities: cerebrovascular accident, peripheral vascular disease, atherosclerotic heart disease, heart failure, dysrhythmia or other cardiac comorbidities. - No available data.

Table 2.2 provides the prevalence of recognized CKD, DM, and cardiovascular comorbid conditions among patients aged 65 and older in the Medicare population, for Optum Clinformatics™ adults aged 22 through 64 years, and for VHA patients aged 22 to 64. Younger Optum Clinformatics™ patients were excluded as these comorbidities are rare in this population. Of Medicare patients aged 65 and older, recognized (i.e., coded diagnosis of) CKD was observed in 13.8%. Over half of the Medicare cohort (53.1%) had at least one of these comorbid conditions, 19.9% had two or more, and 4.8% had all three. As expected, the prevalence of recognized CKD in the Optum Clinformatics™ population was substantially lower, driven by the lower prevalence among younger patients. Approximately 10.6% of this cohort had at least one of these comorbid conditions, and 1.6% had two or more.

vol 1 Table 2.2 Prevalence of comorbid conditions by diagnosis codes (CKD, CVD, & DM), (a) total & (b) one or more, among Medicare (aged 65+ years) , Optum Clinformatics™ (aged 22-64 years) and Veterans Affairs (aged 22-64 years) patients, 2016

(a) Any diagnosis of CKD, CVD, or DM

	Medicare 5%		Clinformatics™		Veterans Affairs	
	Sample count	%	Sample count	%	Sample count	%
All	1,286,211	100	5,091,205	100	3,085,938	100
Total CKD	178,025	13.8	85,789	1.7	82,755	2.7
Total CVD	513,794	39.9	261,580	5.1	152,029	4.9
Total DM	309,241	24.0	282,139	5.5	302,803	9.8

(b) Combinations of CKD, CVD, or DM diagnoses

	Medicare 5%		Clinformatics™		Veterans Affairs	
	Sample count	%	Sample count	%	Sample count	%
All	1,286,211	100	5,091,205	100	3,085,938	100
Only CKD	33,386	2.6	48,807	1.0	41,469	1.3
Only CVD	281,665	21.9	195,910	3.8	94,794	3.1
Only DM	112,358	8.7	217,275	4.3	238,002	7.7
CKD & DM, no CVD	23,971	1.9	13,293	0.3	18,637	0.6
CKD & CVD, no DM	59,217	4.6	14,099	0.3	11,071	0.4
DM & CVD, no CKD	111,461	8.7	41,981	0.8	34,586	1.1
CKD & CVD & DM	61,451	4.8	9,590	0.2	10,529	0.3
At least one comorbidity	683,509	53.1	540,955	10.6	438,559	14
At least two comorbidities	256,100	19.9	78,963	1.6	74,823	2.4
No CKD, no CVD, no DM	602,702	46.9	4,550,250	89.4	2,635,801	85.4

Data Source: Special analyses, Medicare 5% sample (aged 65 and older), Optum Clinformatics™ (aged 22-64), and Veterans Affairs (ages 22-64 years) alive & eligible for all of 2016. Abbreviations: CKD, chronic kidney disease; CVD, cardiovascular disease; DM, diabetes mellitus. CVD is defined as presence of any of the following comorbidities: cerebrovascular accident, peripheral vascular disease, atherosclerotic heart disease, congestive heart failure, dysrhythmia or other cardiac comorbidities. CKD in the VA is defined as anyone with at least one inpatient ICD-9 or ICD-10 diagnosis or two outpatient diagnosis codes in 2016 or eGFR<60 ml/min/1.73m^2 based on at least one outpatient serum creatinine available in 2016; eGFR was calculated using the CKD-EPI formula; if more than one value was available, the last one in the year was used. The denominator included everyone with at least one outpatient visit in 2016.

Comparison of CKD Prevalence across Datasets

Table 2.3 compares the prevalence of CKD in the NHANES, Medicare 5% sample, Optum Clinformatics™, and VHA populations among patients aged 65 and older. We stratified by demographic characteristics in order to highlight issues with identification of CKD in the varying types of data. Across all datasets, the prevalence of CKD increased with older age. Variance between the data sources, however, can somewhat be explained by the nature of their measurements and specific populations.

The absolute prevalence of CKD was highest in the NHANES data, intermediate in the VHA data (code and eGFR-based), and lowest when based on diagnosis codes alone in Medicare claims and Optum Clinformatics™.

The NHANES, by design, includes laboratory measurement of kidney function in all participants, thus providing the closest estimate of the true prevalence of CKD in the United States. Overestimation is possible, however, because it relies on a single measurement. In addition, NHANES does not represent people living in long-term care facilities—many of those residents have Medicare insurance and are represented in the Medicare 5% sample.

The prevalence of recognized CKD based on diagnosis codes was lowest due to under-recognition and likely under-coding of the condition, particularly in its earlier stages, with more accurate capture of advanced cases of CKD.

For the VHA population, CKD prevalence is presented based on diagnosis codes and available laboratory data documenting at least one serum creatinine result corresponding to an eGFR <60 ml/min/1.73m^2. Blood and urine assays are initiated by clinical indication and not performed in all patients, and thus likely underestimate the true prevalence in the population served by the VHA health system.

The overall CKD prevalence, and CKD prevalence by gender and race/ethnicity varies substantially depending on the method of CKD ascertainment: survey (NHANES), vs. claim-based (Medicare and Optum Clinformatics™), vs. claim and lab based data (VHA data).

vol 1 Table 2.3 Percent of patients with CKD by demographic characteristics, among individuals aged 65+ years in NHANES (2013-2016), Optum Clinformatics™ (2016), Medicare 5% sample (2016), and Veterans Affairs (2016) datasets

	Survey-based	Claim-based		Claim and lab-based
	NHANES	Optum	Medicare	Veterans Affairs
	CKD(eGFR)	CKD (Code)	CKD (Code)	CKD (Code or eGFR)
All	38.1	8.1	13.8	23.9
Age				
65-74	28.7	6.2	10.1	17.1
75-79	42.6	13.5	17.2	29.3
80+	58.5	18.9	22.6	37.4
Race				
White	38.1	8.4	13.5	24.4
Black/African American	39.7	9.5	18.7	25.7
Native American		-	14.1	21.1
Asian		5.73	14.3	17.3
Other/Unknown	33.8	7.86	11.6	19.6
Sex				
Male	36.0	9.2	15.6	24.1
Female	38.9	6.8	12.5	19.3

Data Source: Special analyses, Medicare 5% sample aged 65 and older alive & eligible for all of 2016. NHANES 2013-2016 participants aged 65 and older, Clinformatics patients aged 65 and older, and VA aged 65 and older alive & eligible for all of 2016. CKD in the Veterans Affairs data is defined as anyone with at least one inpatient ICD-9 or ICD-10 diagnosis or two outpatient diagnosis codes in 2016 or eGFR<60 ml/min/1.73m^2 based on at least one outpatient serum creatinine available in 2016; eGFR was calculated using the CKD-EPI formula; if more than one value was available, the last one in the year was used. The denominator included everyone with at least one outpatient visit in 2016. Abbreviations: CKD, chronic kidney disease; VA, Veterans Affairs. - No available data.

Table 2.4 presents the prevalence of recognized CKD by demographic characteristics and comorbidities in the Medicare (ages 65 years and older), Optum Clinformatics™ (ages 22 years and older) and the VHA (ages 22 years and older) populations, overall and with DM or HTN. The prevalence of recognized CKD increased with age in all three datasets, and from 10.1% at ages 65–74 to 22.6% at age 85 and older in the Medicare data. Males had slightly higher prevalence than females in all of the datasets.

The prevalence of CKD among Blacks/African Americans (hereafter, Blacks) was higher than among Whites in the Medicare and Optum Clinformatics™ datasets, but lower in the VHA dataset. Results from adjusted analyses of the Medicare dataset (data not shown) confirm greater odds of recognized CKD in older patients, Blacks, and those with DM, HTN, or cardiovascular disease. Among Optum Clinformatics™ patients comparable in age to the Medicare population, the prevalence remained lower, possibly reflecting a healthier, employed population. As expected, the prevalence of recognized CKD was higher in all three datasets among those with a diagnosis of DM or HTN, and particularly so among younger patients in the Optum Clinformatics™ dataset.

vol 1 Table 2.4 Prevalence of CKD, by demographic characteristics and comorbidities, among Medicare 5% sample (aged 65+ years), Optum Clinformatics™ (ages 22 or older), and Veterans Affairs (ages 22 or older) patients overall, and with diabetes mellitus or hypertension, 2016

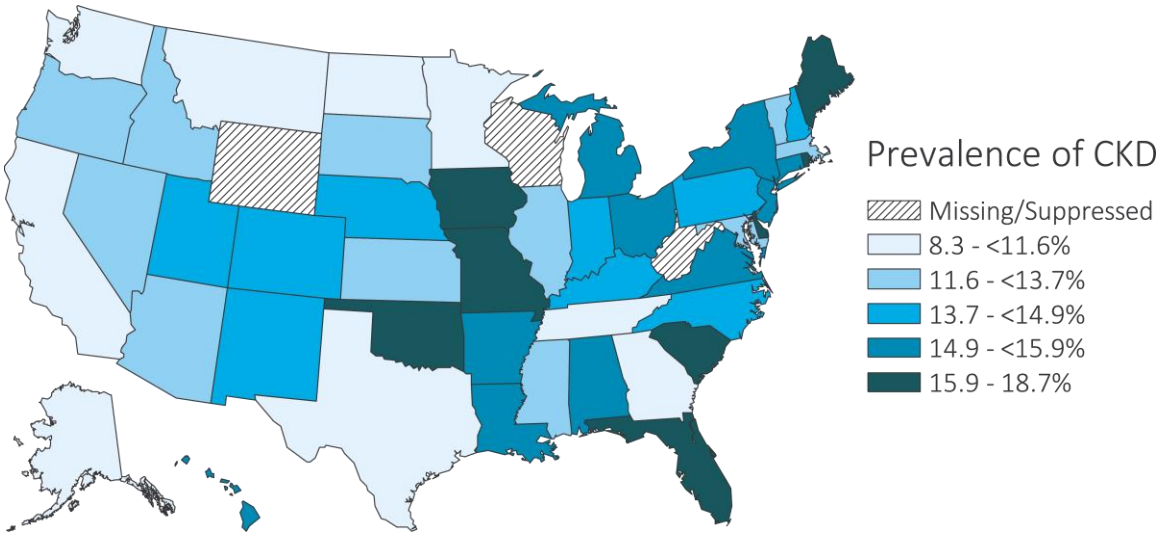
	All			Diabetes mellitus (with or without hypertension)			Hypertension (without diabetes mellitus)		
	Medicare 5%	Optum Clinformatics™	Veterans Affairs	Medicare 5%	Optum Clinformatics™	Veterans Affairs	Medicare 5%	Optum Clinformatics™	Veterans Affairs
Overall	13.8	2.0	14.9	27.6	9.7	31.3	15.6	6.6	23.8
Age									
22-30	-	0.6	0.4	-	5.0	3.2	-	6.2	3.6
31-40	-	0.9	1.0	-	4.8	3.7	-	5.0	4.4
41-50	-	1.5	2.5	-	6.1	6.9	-	4.9	6.3
51-64	-	3.0	7.2	-	9.4	16.2	-	6.1	11.6
65-74	10.1	6.2	17.1	23.1	15.9	29.5	11.1	9.6	21.3
75-84	17.2	13.5	29.3	31.4	27.4	47.8	17.4	17.6	38.2
85+	22.6	18.9	37.4	37.1	33.9	61.4	24.3	26.1	55.2
Sex	.	.		.	.		.	.	
Male	15.6	2.2	16.0	29.9	10.5	31.8	18.0	7.3	24.3
Female	12.5	1.8	5.3	25.6	8.5	20.5	13.9	5.8	15.7
Race/Ethnicity	.	.		.	.		.	.	
White	13.5	2.1	16.3	27.4	10.1	32.5	15.4	6.8	25.0
Black/African American	18.7	2.3	12.8	31.1	10.5	27.6	18.8	6.7	19.5
Native American	14.1	-	11.5	25.4	-	26.1	13.7	5.7	19.8
Asian	14.3	1.2	7.4	26.8	6.5	22.8	14.9	-	19.8
Hispanic	13.2	1.7	-	25.5	8.4	-	14.5	5.9	-
Other/Unknown	7.8	2.0	9.9	19.7	9.0	31.2	9.9	6.8	25.6

Data Source: Special analyses, Medicare 5% sample (aged 65 and older), Optum Clinformatics™ data (ages 22 or older) and the Veterans Affairs data (ages 22 or older) alive & eligible for all of 2016. Abbreviation: CKD, chronic kidney disease. CKD in the VA is defined as anyone with at least one inpatient ICD-9 or ICD-10 diagnosis or two outpatient diagnosis codes in 2016 or eGFR<60 ml/min/1.73m^2 based on at least one outpatient serum creatinine available in 2016; eGFR was calculated using the CKD-EPI formula; if more than one value was available, the last one in the year was used. The denominator included everyone with at least one outpatient visit in 2016. - No available data. Data suppressed.*

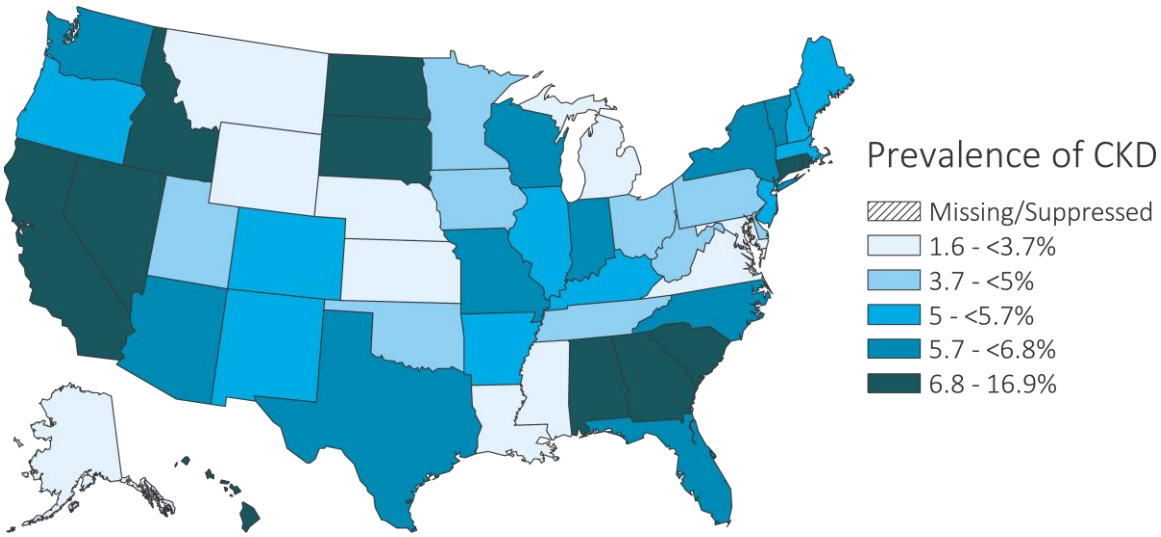
The maps in Figure 2.1 illustrate the prevalence of recognized CKD by state in the Medicare 5% sample and the Optum Clinformatics™ dataset. Variation in prevalence across states was more than two-fold in both datasets.

vol 1 Figure 2.1 Prevalence of CKD by state among Medicare 5% sample (aged 65+ years) and Optum Clinformatics™ (ages 22 or older) patients, 2016

(a) Medicare 5%



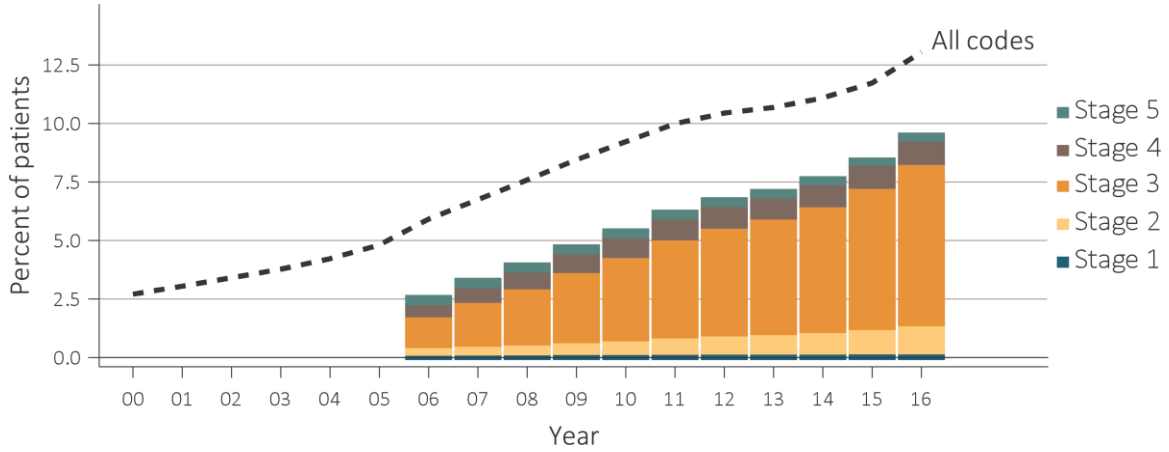
(b) Optum Clinformatics™



Data Source: Special analyses, Medicare 5% sample (aged 65 and older) and Optum Clinformatics™ data (ages 22 or older) alive & eligible for all of 2016. Abbreviation: CKD, chronic kidney disease.

Figure 2.2 shows the 2000-2016 Medicare trend in prevalence of recognized CKD overall and by CKD stage-specific code. The prevalence of recognized CKD has steadily risen each year, accompanied by a comparable increase in the percentage of patients with a stage-specific CKD diagnosis code. There was a particularly sharp increase in 2016 versus 2015, possibly related to the switch to the ICD-10 diagnosis coding system which occurred on October 1, 2015.

vol 1 Figure 2.2 Trends in prevalence of recognized CKD, overall and by CKD stage, among Medicare patients (aged 65+ years), 2000-2016



Data Source: Special analyses, Medicare 5% sample. Known CKD stages presented as bars; curve showing "All codes" includes known CKD stages (ICD-9 codes 585.1-585.5 or ICD-10 codes N18.1-N18.5) and the CKD-stage unspecified codes (ICD-9 code 585.9, ICD-10 code N18.9 and remaining non-stage specific CKD codes). For years 2000-2016, ICD-9 codes are used to identify CKD; additionally, starting October 1, 2015, ICD-10 codes are used to identify CKD. Note: In previous years, this graph reported 585.9 codes as a component of the stacked bars. Abbreviation: CKD, chronic kidney disease.

Longitudinal Change in CKD Status and Outcomes, Based on Diagnosis Codes

Table 2.5 shows patient status of CKD stage, ESRD, or death in 2015-2016 for those who had a CKD diagnosis in 2011. Among patients with no CKD in 2011, 20.9% had died after five years, while 0.1% had reached ESRD prior to dying, and 0.1% were alive with ESRD by the end of 2016. In comparison, patients with any CKD diagnosis in 2011 were much more likely to have these outcomes. Among CKD patients, by 2016, 42.9% had died without ESRD, while 2.0% had reached ESRD prior to dying, and 1.7% were alive with ESRD by the end of 2016.

vol 1 Table 2.5 Change in CKD status from 2011 to 2016, among Medicare patients (aged 65+ years) alive and without ESRD in 2011

2011Status	2015-2016 Status (row %)											
	No CKD Diagnosis	CKD Stage 1	CKD Stage 2	CKD Stage 3	CKD Stage 4	CKD Stage 5	CKD Stage-unspecified	ESRD alive	ESRD death	Death without ESRD	Lost to follow-up	Total N
No CKD Diagnosis	54.6	0.2	1.0	5.2	0.5	0.1	4.5	0.1	0.1	20.9	12.8	1,101,461
Any CKD	11.6	0.5	2.4	19.1	4.2	0.6	6.2	1.7	2.0	42.9	8.9	122,233
CKD Stage 1	14.7	5.5	4.6	17.7	2.2	0.5	6.1	1.0	0.8	36.2	10.7	2,761
CKD Stage 2	13.7	0.8	10.6	20.2	2.5	0.3	4.9	0.5	0.6	35.4	10.4	8,571
CKD Stage 3	7.6	0.3	1.8	28.1	5.1	0.5	3.5	1.6	1.6	40.9	9.0	51,237
CKD Stage 4	2.3	0.2	0.5	8.1	11.6	1.7	1.5	7.0	8.4	52.2	6.5	10,942
CKD Stage 5	6.0	0.2	0.7	6.8	2.9	1.9	3.1	8.2	10.8	52.6	6.9	2,455
CKD Stage Unspecified	17.8	0.4	1.8	12.4	2.1	0.4	10.6	0.6	0.7	44.1	9.0	46,267
Total	50.3	0.2	1.1	6.6	0.9	0.2	4.6	0.3	0.3	23.1	12.4	
Total N	615,594	2,894	13,904	80,181	11,059	1,940	56,545	3,294	3,584	283,057	151,642	1,223,694

Data Source: Special analyses, Medicare 5% sample. Patients alive & eligible for all of 2011. Death and ESRD status were examined yearly between 2011-2016, and were carried forward if present. Among patients without death or ESRD by 2016, the last CKD diagnosis claim was used; if not available, then the last CKD diagnosis claim from 2015 was used. Lost to follow-up represents the patients who were not in Medicare Part A and Part B fee for service in 2015 or 2016. These persons moved to a Medicare Advantage Plan and thus did not generate billing data from which CKD status could be determined. Abbreviations: CKD, chronic kidney disease; ESRD, end-stage renal disease.

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 part of the Healthy People 2020 goals developed by the Department of Health and Human Services (see the *Healthy People 2020* volume). Individuals at high risk for CKD, most notably those with DM, should be screened periodically for kidney disease and those with CKD should be monitored for progression of disease.

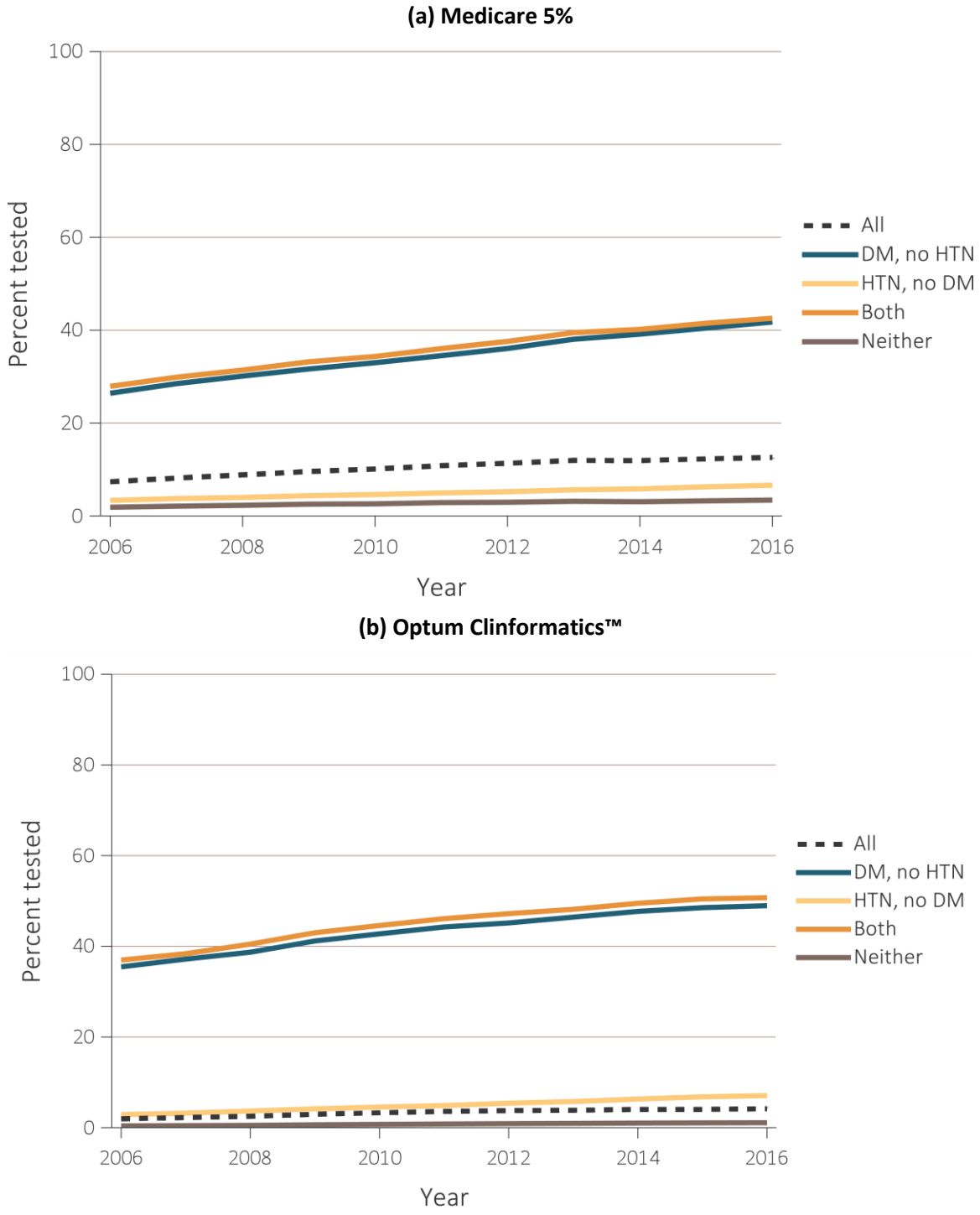
Urine albumin is a valuable laboratory marker used to detect signs of kidney damage and to evaluate for disease progression. Serum creatinine measurement is usually included as part of a standard panel of blood tests, but urine albumin testing must be ordered separately. For this reason, urine albumin testing may better represent intent to assess kidney disease.

The American Diabetes Association recommends urine testing for albumin in patients with DM. The 2012 KDIGO guidelines on CKD evaluation and management recommend risk stratification of CKD patients using both the urine albumin/creatinine ratio and the estimated eGFR (based on estimating equations incorporating serum creatinine values). They emphasized that these tests are needed to understand patients' kidney disease status, risk of death, and progression to ESRD (Matsushita et al., 2010; KDIGO CKD Work Group, 2012).

As shown in Figure 2.3, 12.6% of Medicare patients aged 65 and over and 4.2% of Optum Clinformatics™ patients aged 22 to 64 years without diagnosed CKD received urine albumin testing in 2016. Assessment of urine protein was also included in these percentages, representing approximately 20% of the testing performed. Among Medicare patients, 41.8% with DM alone had urine albumin testing, compared to 6.6% of patients with HTN alone.

Having both DM and HTN is known to increase the likelihood of developing CKD. Among Medicare beneficiaries without a CKD diagnosis, 42.6% had urine albumin testing in 2016. Similar patterns were seen in the Optum Clinformatics™ population—49.0% of patients with DM alone in 2016 had urine albumin testing, compared to 7.1% with HTN alone, and 50.7% with both DM and HTN.

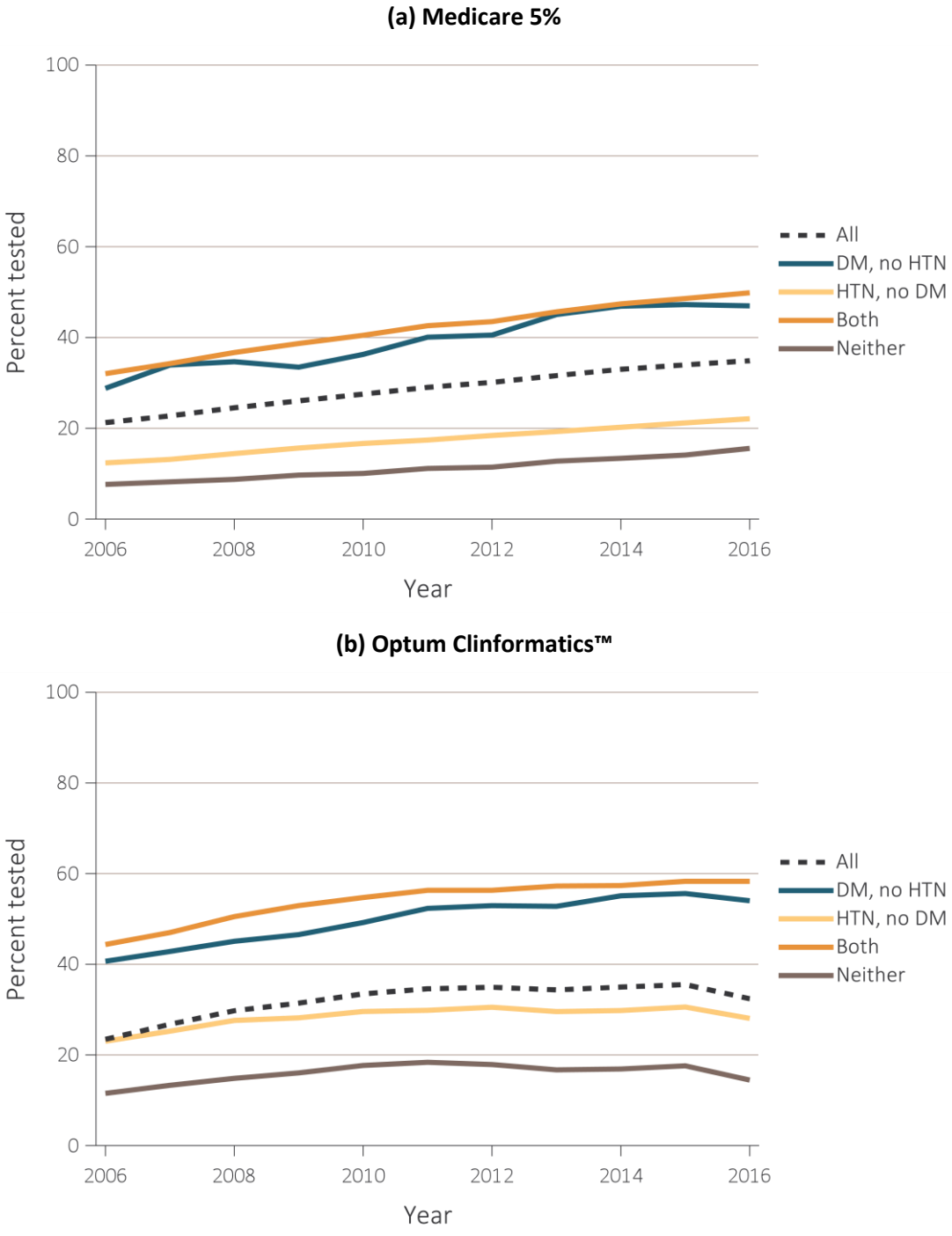
vol 1 Figure 2.3 Trends in percent of patients with testing of urine albumin (a) in Medicare 5% sample (aged 65+ years), & (b) Optum Clinformatics™ (aged 22-64 years) patients without a diagnosis of CKD, by year from 2006 to 2016



Data Source: Special analyses, Medicare 5% sample aged 65 and older with Part A & B coverage in the prior year and Optum Clinformatics™ patients aged 22-64 years. Tests tracked during each year. Abbreviations: CKD, chronic kidney disease; DM, diabetes mellitus; HTN, hypertension.

As shown in Figure 2.4, patients with a diagnosis of CKD were tested for urine albumin at similar, though somewhat higher rates, than patients without CKD. In 2016, patients with the combined diagnoses of CKD, DM, and HTN, were tested for urine albumin in 49.9% of the Medicare and 58.3% of the Optum Clinformatics™ cohorts.

vol 1 Figure 2.4 Trends in percent of patients with testing of urine albumin in (a) Medicare 5% (aged 65+ years), & (b) Optum Clinformatics™ (aged 22-64 years) patients with a diagnosis of CKD, by year from 2006-2016



Data Source: Special analyses, Medicare 5% sample (aged 65 and older) with Part A & B coverage in the prior year and Optum Clinformatics™ population (aged 22-64 years). Tests tracked during each year. Abbreviations: CKD, chronic kidney disease; DM, diabetes mellitus; HTN, hypertension.

Physician Visits after a CKD Diagnosis

Table 2.6 indicates the percentage of patients with a CKD diagnosis in 2015 who had at least one visit to a primary care physician, cardiologist, or nephrologist in 2016. Patients with any CKD diagnosis were far more likely to visit a primary care physician or a cardiologist than a nephrologist. This may relate to the fact that most guidelines, including KDIGO CKD, indicate the need for referral to nephrology only for those with advanced, Stage 4 CKD (see Table A), unless there are other concerns such as rapid progression of disease. Indeed, one-quarter of patients with any CKD claim in 2015 were seen by a nephrologist in the subsequent year. However, 41.1% with CKD Stage 3 and roughly two-thirds with CKD Stage 4 or higher visited a nephrologist in 2016. Whether the involvement of a nephrologist improves outcomes, and at what stage of CKD, is a matter of ongoing research interest.

Overall, the patterns of physician visits varied little across demographic categories. A notable exception was that patients aged 85 and older with CKD Stage 3 or higher were as likely as younger patients to visit a primary care physician or cardiologist, but substantially less likely to visit a nephrologist.

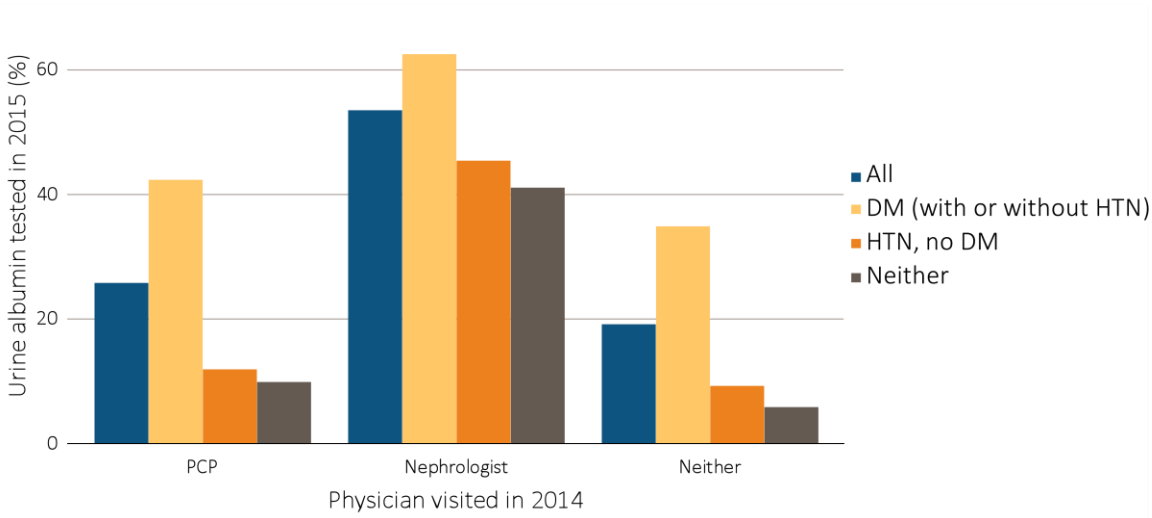
vol 1 Table 2.6 Percent of patients with a physician visit in 2016 after a CKD diagnosis in 2015, among Medicare 5% patients (aged 65+ years)

	Any CKD diagnosis			CKD diagnosis code of 585.3/N18.3 (Stage 3)			CKD diagnosis code of 585.4/N18.4 (Stage 4) or 585.5/N18.5 (Stage 5)		
	Primary care	Cardiologist	Nephrologist	Primary care	Cardiologist	Nephrologist	Primary care	Cardiologist	Nephrologist
Overall	89.6	54.4	25.7	90.8	55.6	41.1	89.9	60.9	64.2
Age									
65-74	87.6	49.0	26.1	89.1	51.2	47.1	80.9	46.4	69.7
75-84	91.3	58.9	27.3	91.7	58.2	41.0	84.3	51.8	66.6
85+	92.9	61.5	21.9	92.7	59.9	29.2	86.6	51.8	52.0
Sex									
Male	89.9	54.7	24.8	91.0	55.9	39.8	83.7	49.8	63.8
Female	90.8	56.6	32.8	90.9	56.6	48.0	84.0	50.3	67.7
Race									
White	89.4	49.9	25.7	89.7	50.6	41.2	82.6	46.0	64.8
Black/African American	90.4	51.8	25.2	91.0	52.0	38.6	84.0	46.9	62.3
Other	89.5	57.5	26.2	90.8	59.6	43.3	83.2	52.9	67.1

Data Source: Special analyses, Medicare 5% sample aged 65 and older alive & eligible for all of 2015. CKD diagnosis is at date of first CKD claim in 2015; claims for physician visits were searched during the 12 months following that date. ICD-9 CKD diagnosis code of 585.4 or higher or ICD-10 CKD diagnosis code of N18.4 or higher represents CKD Stages 4-5. Abbreviation: CKD, chronic kidney disease.

Figure 2.5 illustrates the proportion of patients with CKD in 2015 who were tested for urine albumin in 2016, according to whether they saw a primary care physician or nephrologist in 2015. Patients who saw a nephrologist were more likely to be tested for urine albumin than those who saw only a primary care physician. This difference was greatest for those without DM. Diabetic patients showed a smaller difference in testing for urine albumin across provider type, which is likely due to the wide dissemination of guidelines for routine renal function assessment in diabetics that are directed at primary care physicians by organizations such as the American Diabetes Association.

vol 1 Figure 2.5 Percent of CKD patients in 2015 with physician visit (nephrologist, primary care provider, both, and neither), with laboratory testing in the following year (2016), by comorbidity



Data Source: Special analyses, Medicare 5% sample aged 65 and older alive & eligible for all of 2016, with a CKD diagnosis claim based on ICD-9 diagnostic codes and a physician visit in 2015. Patient visits with both PCP and nephrologists are classified as nephrologist. Abbreviations: CKD, chronic kidney disease; DM, diabetes mellitus; HTN, hypertension; PCP, primary care physician.

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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. PMC3993088

Chapter 3: Morbidity and Mortality in Patients with CKD

- In the 2018 Annual Data Report (ADR), we introduce analysis of a new dataset. To provide a more comprehensive examination of morbidity patterns, we now compliment the Medicare 5% sample with information from the Optum Clinformatics™ Data Mart, including beneficiaries of a large commercial insurance provider. This allows us to further examine trends with respect to rates of hospitalization for all-cause and cause-specific reasons.

Mortality

- In 2016, Medicare patients with chronic kidney disease (CKD) experienced a mortality rate of 122.6 per 1,000 patient-years. When adjusted for sex, age, and race, the rate remained more than double the 43.1 per 1,000 patient-years of those without CKD. Mortality rates increased with CKD severity, but the gap has narrowed between CKD and non-CKD patients from 2004-2016 (Table 3.1 and Figure 3.1).
- Male patients without CKD experienced higher adjusted mortality rates of 48.2 per 1,000 patient-years than did females, at 39.2. This relative difference was similar among those with CKD, with an adjusted mortality rate of 114.4 per 1,000 patient-years for males and 94.9 for females (Table 3.1 and Figure 3.4).
- In 2016, Medicare age and sex adjusted mortality rates were 104.2 per 1,000 patient-years for Whites and 106.6 per 1,000 person years for Blacks/African Americans (Figure 3.5).

Hospitalization

- Adjusted hospitalization rates declined from 2015 to 2016 in both the Medicare and Optum Clinformatics™ CKD and non-CKD patients. The decline was greater for CKD patients than for patients without CKD in both populations (Figure 3.7).
- Not surprisingly, among Medicare patients, after adjustment for sex and race, rates of hospitalization in older patients were greater than for younger age cohorts. In the CKD group, hospitalization rates for those over 85 years was 39.7% higher than among those aged 66 to 69 years: 706.2 vs. 505.4 admissions per 1,000 patient-years at risk (Figure 3.12).
- For Medicare patients, racial differences in hospitalization rates were notable. Black patients with CKD had higher adjusted rates of hospitalization than did Whites and Other races (651.8 vs. 568.3 vs. 471.1 per 1,000 patient-years). Disparities in outcomes increased with disease severity (Figure 3.14).

Hospital readmission

- At 21.6%, unadjusted rates of hospital readmission in Medicare patients with CKD were higher than the 15.3% for those without CKD (Table 3.3).
- In Medicare patients without CKD, males exhibited a higher readmission rate than did females, with age and race adjusted percentages of 16.2 and 14.6 (Table 3.3).

Introduction

In Volume 1, Chapter 2: *Identification and Care of Patients with Chronic Kidney Disease*, we analyzed diagnosis codes from Medicare and Optum Clinformatics™ claims to document the increasing recognition of CKD. The ascertainment of CKD cases through claims data has improved in recent years. This has likely resulted in decreased estimates of average disease severity, as influenced by the early disease stages of those identified most recently. Thus, recent changes in mortality- and hospitalization-rate trends should be interpreted in this context.

In this chapter, we evaluate the morbidity and mortality of patients with and without CKD. We begin by examining mortality as it interacts with the patient characteristics of CKD severity, age, sex, race, and the common comorbid conditions of diabetes mellitus (DM) and cardiovascular disease (CVD). The co-occurrence of DM and CVD with CKD increase a patient's risk of death. This is clinically significant, as cardiovascular risk factors are relatively undertreated in CKD patients in the United States (U.S.). We illustrate this in Volume 1, Chapter 1: *CKD in the General Population*, through data on disease awareness, treatment, and control of risk factors from the population-level National Health and Nutrition Examination Survey (NHANES) cohorts.

We then similarly focus on patient hospitalization—for all-causes, and separately for CVD, infection, and other cause-related admissions. It has been established for over a decade that rates of hospitalization for CVD and infection also rise with increasing CKD stage (Go et al., 2004). In general, and not surprisingly, rates of hospitalization among CKD patients also increase in the presence of underlying comorbidities, such as DM and CVD. While hospitalization rates have been decreasing over time, the underlying causes for this decline and the lessons learned from these data trends require both further research and the application of enhanced quality improvement efforts.

We end with an examination of patient readmission to the hospital within 30 days of discharge from their first hospitalization of the calendar year (referred to as the index hospitalization). 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), to reduce Medicare payments to hospitals with excess readmissions. Patients with CKD are readmitted more frequently than those without diagnosed CKD. These rates have not changed significantly in the past decade, which is of major concern.

Clearly, early detection and active treatment are important considerations in reducing morbidity and mortality in the CKD population. In future iterations of the ADR, we will also examine additional non-Medicare data sources for Emergency Department visits in the CKD population.

Methods

As in previous years, we use data from the Medicare 5% sample's fee-for-service patients aged 66 and older. Roughly 98% of Americans aged 65 and older qualify for Medicare, and as a result, analysis of Medicare data is representative of this demographic. However, as Medicare only covers persons with disabilities for those under age 65, data for these persons will be unrepresentative of that age group. Therefore, we do not include Medicare patients under 65 in the analyses for this chapter.

All Medicare analysis samples were limited to patients aged 66 and older who were continuously enrolled in Medicare. Employing a one-year entry period allowed us to identify CKD and other medical conditions using ICD-9-CM (International Classification of Diseases, Ninth Revision, Clinical Modification) and ICD-10-CM (International Classification of Diseases, Tenth Revision, Clinical Modification) diagnosis codes as available from Medicare.

This year, in addition to the Medicare 5% sample, for analyses of hospitalization rates we utilized one additional data source: the Optum Clinformatics™ Data Mart dataset available from OptumInsight, which provides claims data from a large U.S. national health insurance company. In contrast to the

Medicare data, the Optum Clinformatics™ Data Mart dataset represents primarily working-age people and their minor dependents. We limited inclusion to patients aged 22 and older who were continuously enrolled in Optum Clinformatics™. Employing a one-year entry period again allowed us to identify CKD and other medical conditions using ICD-9-CM and ICD-10-CM diagnosis codes.

Optum Clinformatics™ includes the date of death from the Social Security Death Master File. In November 2011, the Social Security office stopped sourcing mortality dates from states, and now only includes dates obtained from other sources such as funeral homes and family members. This resulted in a 30% drop in reported dates of death. We considered this to be a limitation to the data, and chose not to include Optum Clinformatics™ in the mortality analyses.

Details of these data are described in the *Data Sources* section of the *CKD Analytical Methods* chapter. For an explanation of the analytical methods used to generate the study cohorts, figures, and tables in this chapter, see the section on *Chapter 3* within the *CKD Analytical Methods* chapter for an explanation of the analytical methods used to generate the study cohorts, figures, and tables in this chapter. Microsoft Excel and PowerPoint files containing the data and graphics for these figures and tables are available to download from the USRDS website.

Mortality Rates

As with many chronic conditions, mortality in patients with CKD is of paramount importance as a major outcome. In Table 3.1 we present mortality rates for several demographic subgroups of patients, both unadjusted and adjusted for age, sex, and race. This year, we again applied modified adjustment variables; in the 2014 ADR and in previous years, data was also adjusted for prior year hospitalization and disease comorbidities. We removed these covariates in the 2015 ADR as we believed that adjustment to this extent would result in artificially low mortality rates. This modification should be kept in mind when comparing adjusted rates with those in prior ADRs.

For patients with CKD, the unadjusted mortality rate in 2016 was 122.6 per 1,000 patient-years; this decreased to 103.0 per 1,000 patient-years after adjusting for age, sex, and race (standard population: 2016). As expected, mortality rates rose as age increased, particularly for the oldest cohort. In all cases, male patients had slightly higher mortality rates than did females, more so for those with CKD and when adjusted.

For patients with CKD, White patients had higher unadjusted mortality rates than did Blacks. However, racial differences in mortality trends between Whites and Blacks with CKD decreased when adjusted for age and sex.

vol 1 Table 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, 2016

	Unadjusted		Adjusted	
	No CKD	All CKD	No CKD	All CKD
All	41.3	122.6	43.1	103.0
Age				
66–69	15.3	61.0	15.0	59.4
70–74	20.1	70.4	19.8	68.5
75–84	40.7	106.3	40.7	104.1
85+	135.7	237.4	136.3	236.0
Sex				
Male	42.0	127.6	48.2	114.4
Female	40.7	118.1	39.2	94.9
Race				
White	42.2	126.2	43.4	104.2
Black/African American	41.6	113.7	46.9	106.6
Other	27.9	88.9	33.2	78.3

Data source: Medicare 5% sample. January 1, 2016 point prevalent patients aged 66 and older. Adjusted for age/sex/race. Standard population: all patients, 2016. Abbreviation: CKD, chronic kidney disease.

Trends in the mortality rates for Medicare patients aged 66 and older are shown in Figure 3.1. Unadjusted mortality in CKD patients has decreased by 30.0% since 2004, from 175 deaths per 1,000 patient-years to 123 deaths in 2016. For those without CKD, the unadjusted rate decreased from 51 deaths per 1,000 patient-years in 2004 to 41 deaths in 2016, a reduction of 19.3%.

When adjusted for age, race, and sex, the 2016 mortality rate for CKD patients reduced to 111 deaths per 1,000 patient-years at risk (Figure 3.1.b; standard population: 2011). Among those without CKD, adjustment for these factors resulted in a slightly higher mortality rate of 45 deaths per 1,000, as compared to the unadjusted rate of 41. One major contributor to the discrepancy between adjusted and unadjusted death rates was the relative age difference between the CKD and no-CKD cohorts. In 2016, the mean age of patients with CKD was 78.4 years, compared to 75.2 years for those without, and 75.7 years for the sample as a whole. In 2006, CKD stage-specific coding was introduced. This may explain the increased mortality rate for the CKD group in 2006.

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, 2004-2016

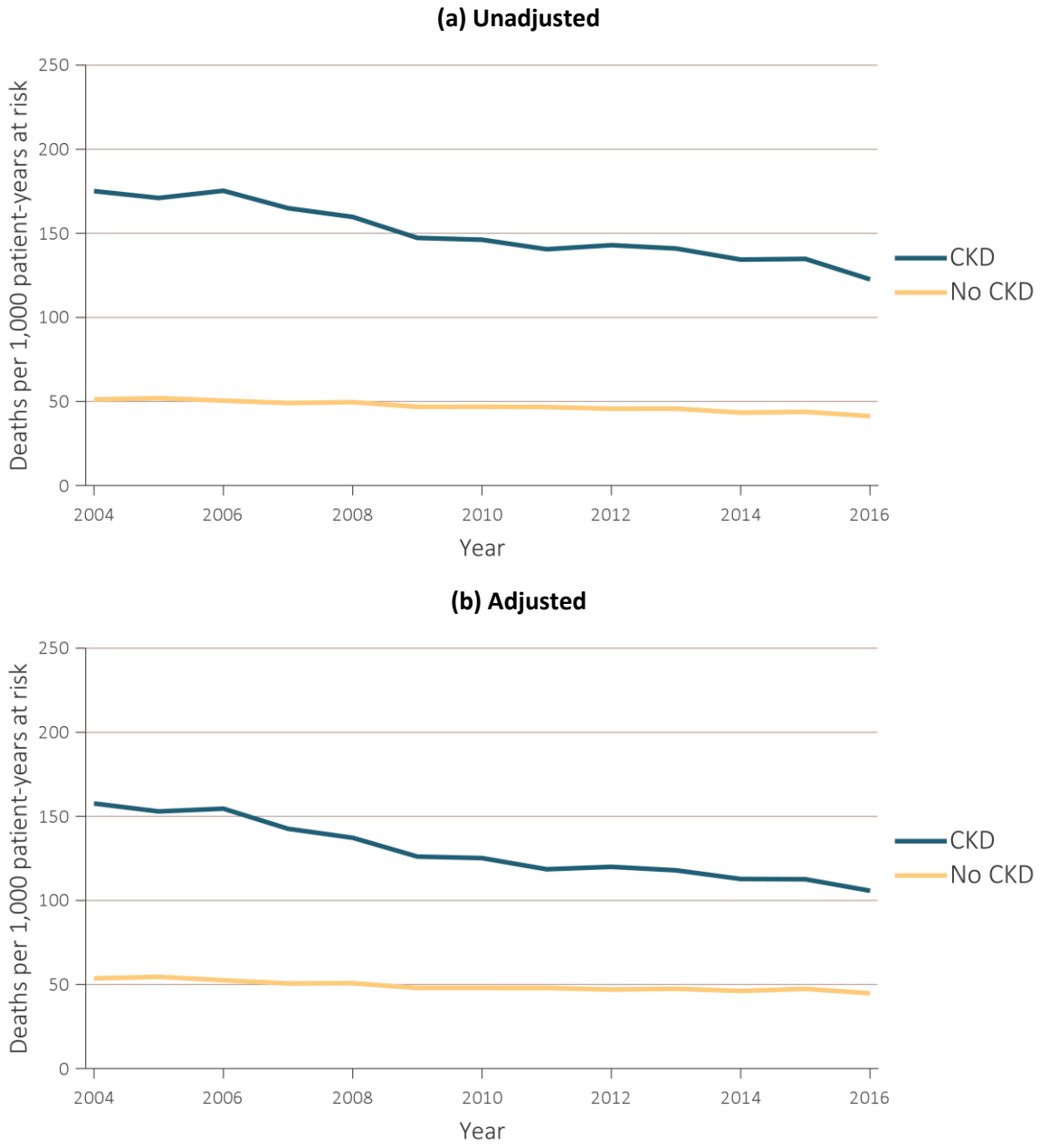


Figure 3.1 continued on next page.

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, 2004-2016 (continued)

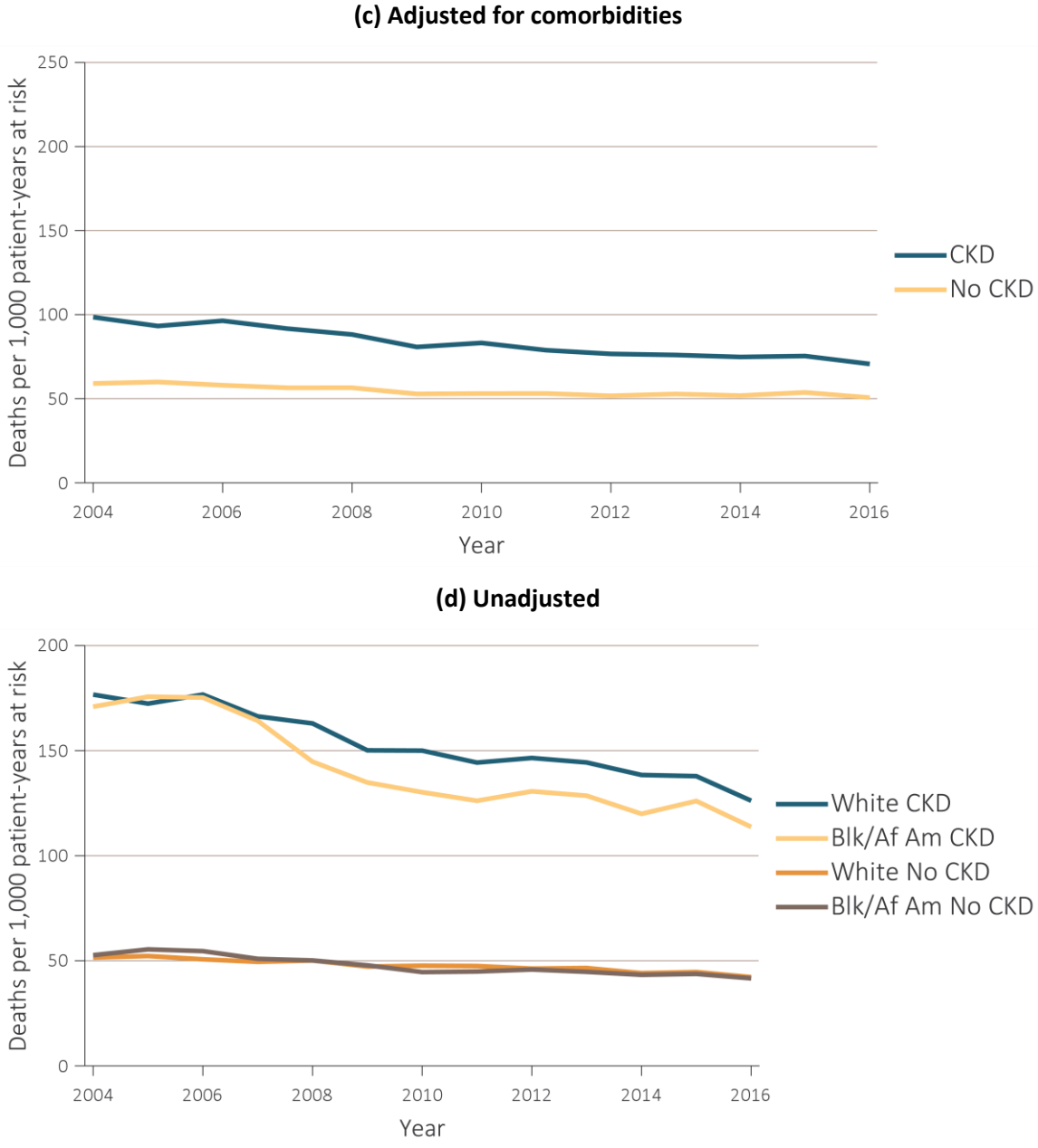
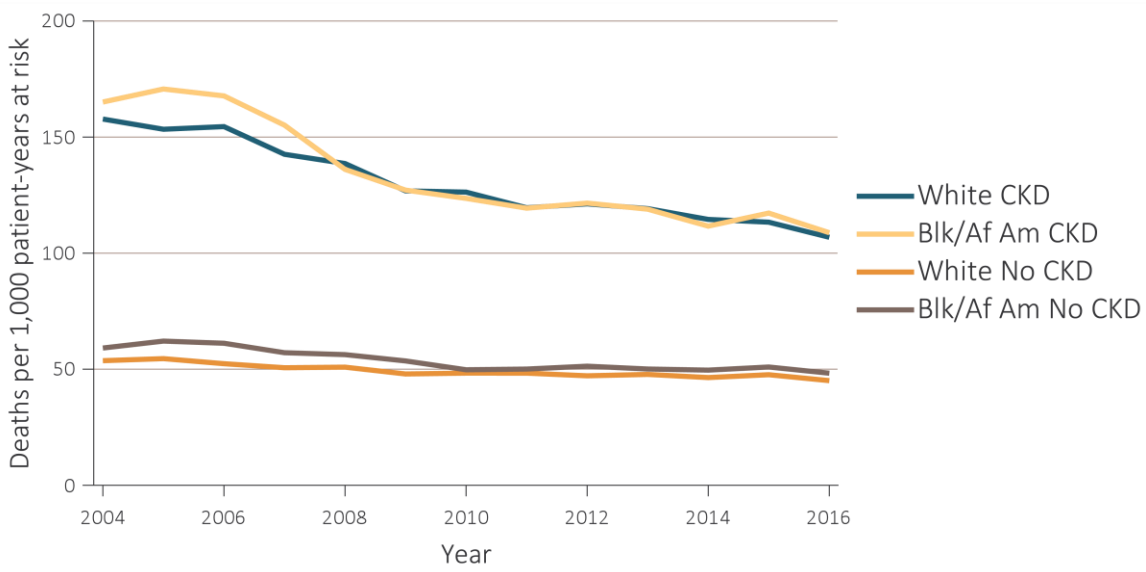


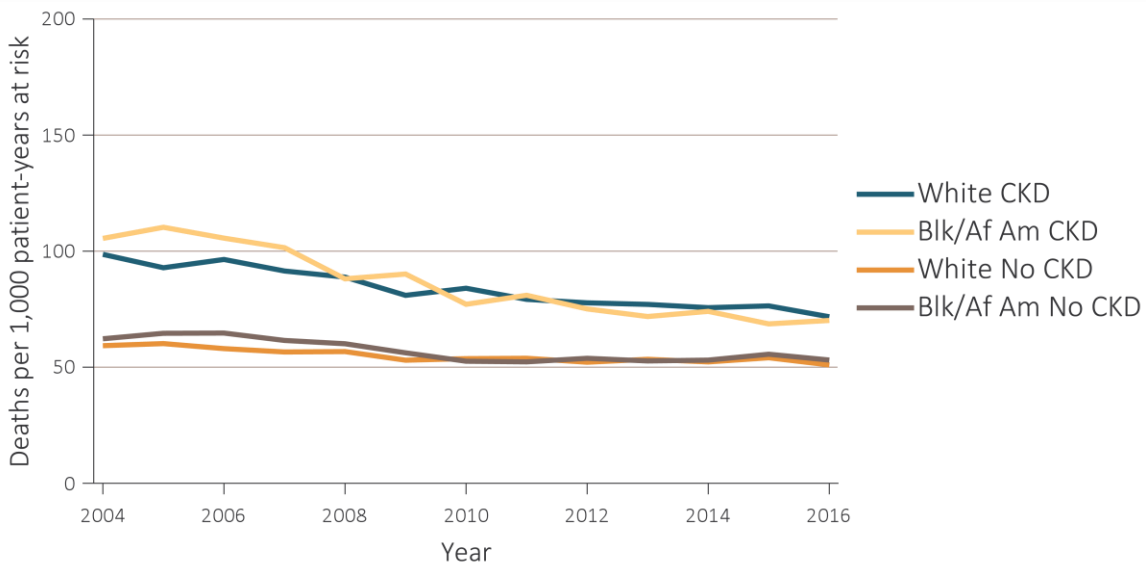
Figure 3.1 continued on next page.

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, 2004-2016 (continued)

(e) Adjusted



(f) Adjusted for comorbidities

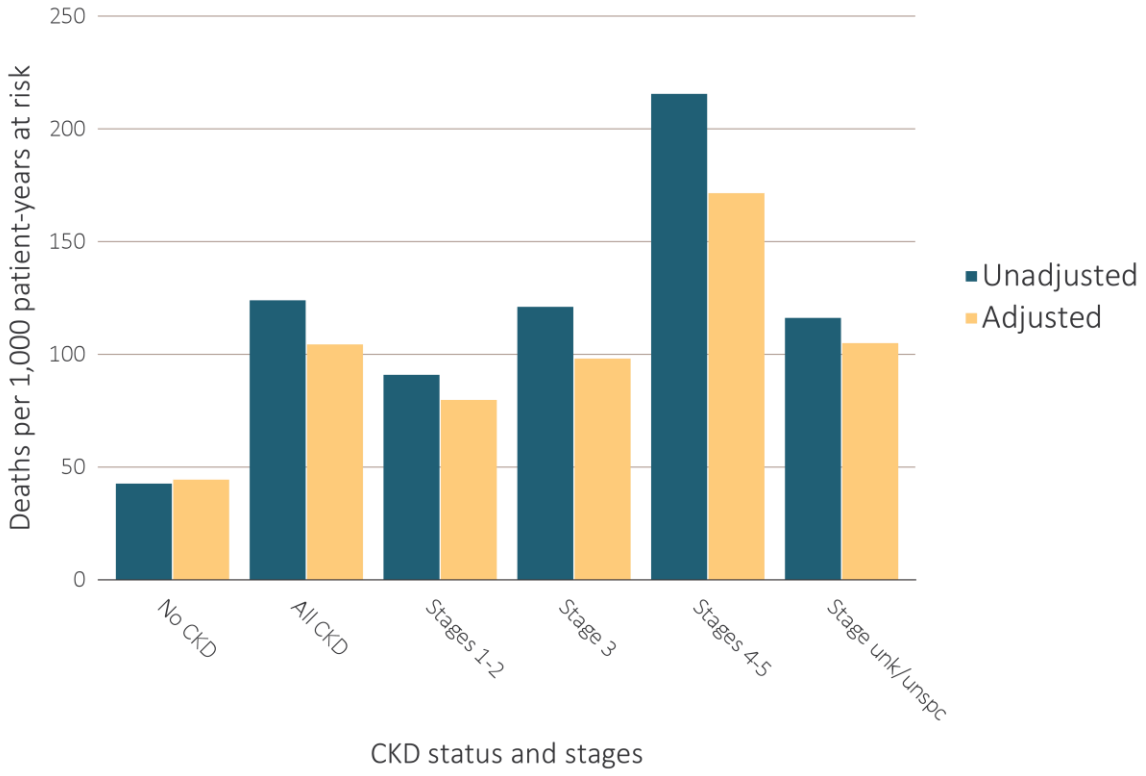


Data source: Special analyses, Medicare 5% sample. January 1 of each reported year, point prevalent Medicare patients aged 66 and older. Panels (a) and (d) show unadjusted rates; (b) is adjusted for age/sex/race, (c) is adjusted for age/sex/race/comorbidities. (e) is adjusted for age/sex and (f) is adjusted for age/sex/comorbidities. Standard population: Medicare 2011 patients. Abbreviation: CKD, chronic kidney disease.

Mortality rates increased with advancing CKD stage, as shown in Figure 3.2, a finding consistent with studies using biochemical measures of serum creatinine with validated equations to estimate glomerular filtration rate to define CKD (Matsushita et al., 2010). As expected, unadjusted mortality rates rose progressively, from 90 deaths per 1,000 patient-years for those in Stages 1 or 2, to 120 for Stage 3, and 214 for Stages 4 or 5 (without ESRD; stages identified by the ICD-10-CM codes, see Table A). Those without an identified CKD stage or with a diagnosis other than from the N18 code series had an unadjusted mortality rate falling between that of Stages 1 or 2 and Stage 3, at 115 deaths per 1,000 patient-years at risk.

Adjusted mortality rates for Stages 1-2, 3, and 4-5 were 79, 97, and 170 deaths per 1,000 patient-years, respectively.

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, 2016



Data source: Special analyses, Medicare 5% sample. January 1 of each reported year, point prevalent Medicare patients aged 66 and older. Adjusted for age/sex/race. Standard population: Medicare 2016 patients. Abbreviations: CKD, chronic kidney disease; unk/unspc, CKD stage unidentified.

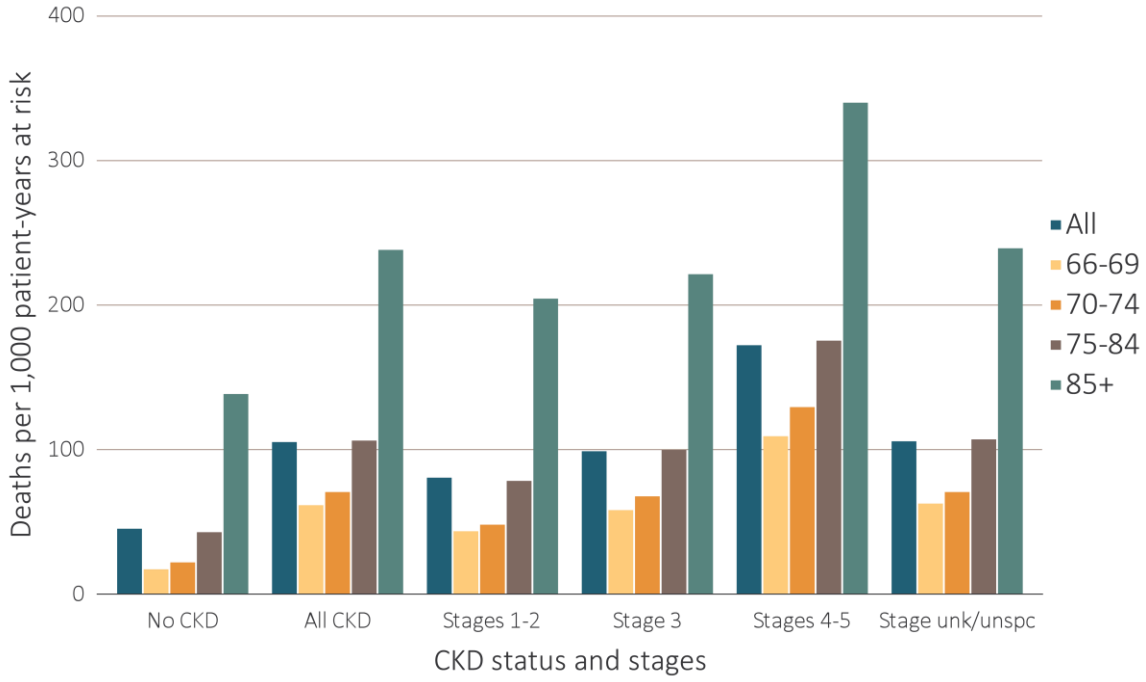
Table A. ICD-9-CM and ICD-10-CM codes for Chronic Kidney Disease (CKD) stages

ICD-9-CM code[a]	ICD-10-CM code[a]	Stage
585.1	N18.1	CKD, Stage 1
585.2	N18.2	CKD, Stage 2 (mild)
585.3	N18.3	CKD, Stage 3 (moderate)
585.4	N18.4	CKD, Stage 4 (severe)
585.5	N18.5	CKD, Stage 5 (excludes 585.6: Stage 5, requiring chronic dialysis[b])
CKD Stage-unspecified	CKD Stage-unspecified	For these analyses, identified by multiple codes including 585.9, 250.4x, 403.9x & others for ICD-9-CM and A18.xx, E08.xx, E11.xx, and others for ICD10-CM.

[a] For analyses in this chapter, CKD stage estimates require at least one occurrence of a stage-specific code, and the last available CKD stage in a given year is used. [b] In USRDS analyses, patients with ICD-9-CM code 585.6 or ICD-10-CM code N18.6 & with no ESRD 2728 form or other indication of end-stage renal disease (ESRD) are considered to have code 585.5 or N18.5.

Adjusted mortality rates for 2016 are shown in Figure 3.3 by CKD status, stage, and age group. As expected, the mortality rates for older patient groups were higher. Among CKD patients, those aged 66-69 years had a mortality rate of 60 deaths per 1,000 patient-years at risk, while those aged 75-84 had nearly double that, at 104 deaths. As also might be expected, patients aged 85 and older experienced the highest rates of mortality, with 236 deaths per 1,000 patient-years. As expected, the mortality rates for later CKD stage groups were higher.

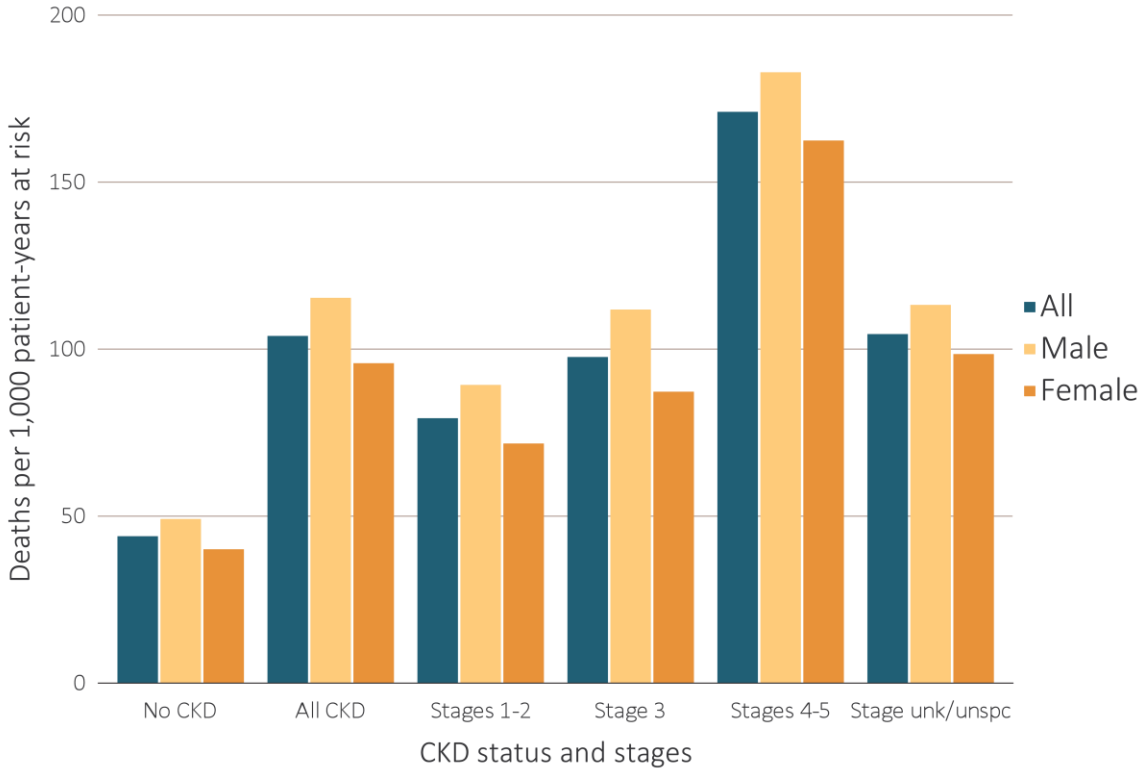
vol 1 Figure 3.3 Adjusted all-cause mortality rates per 1,000 patient-years at risk for Medicare patients aged 66 and older, by age, CKD status, and stage, 2016



Data source: Special analyses, Medicare 5% sample. January 1 of each reported year, point prevalent Medicare patients aged 66 and older. Adjusted for age/sex/race. Standard population: Medicare 2016 patients. Abbreviations: CKD, chronic kidney disease; unk/unspc, CKD stage unidentified.

A comparison of adjusted 2016 mortality rates by CKD status, stage, and sex is shown in Figure 3.4. The mortality rates for males were higher than for females in all stages.

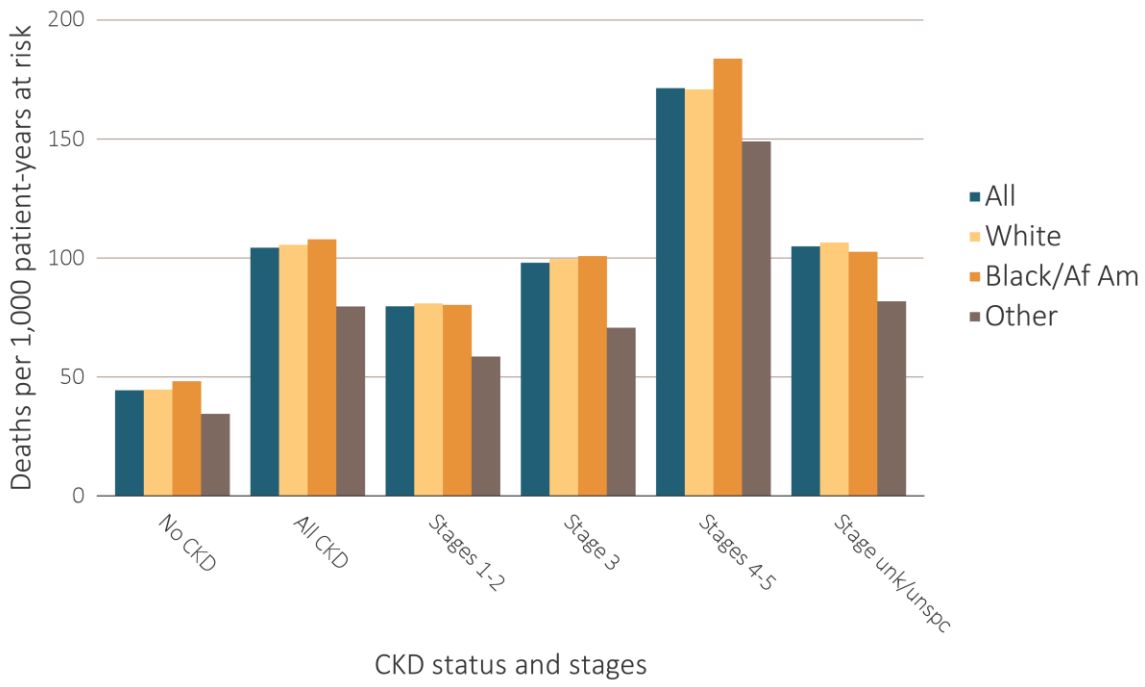
vol 1 Figure 3.4 Adjusted all-cause mortality rates per 1,000 patient-years at risk for Medicare patients aged 66 and older, by sex, CKD status, and stage, 2016



Data source: Special analyses, Medicare 5% sample. January 1 of each reported year, point prevalent Medicare patients aged 66 and older. Adjusted for age/sex/race. Standard population: Medicare 2016 patients. Abbreviations: CKD, chronic kidney disease; unk/unspc, CKD stage unidentified.

Figure 3.5 shows adjusted mortality rates by race, CKD status, and stage. The rates for patients with CKD were more than twice for those who had no CKD for all races. Variation by race was inconsistent across CKD stages. There were virtually no differences between Blacks and Whites in Stages 1-2 and 3. However, in Stages 4-5, Blacks had higher mortality than did Whites, with 183 and 170 per 1,000 patient-years, respectively.

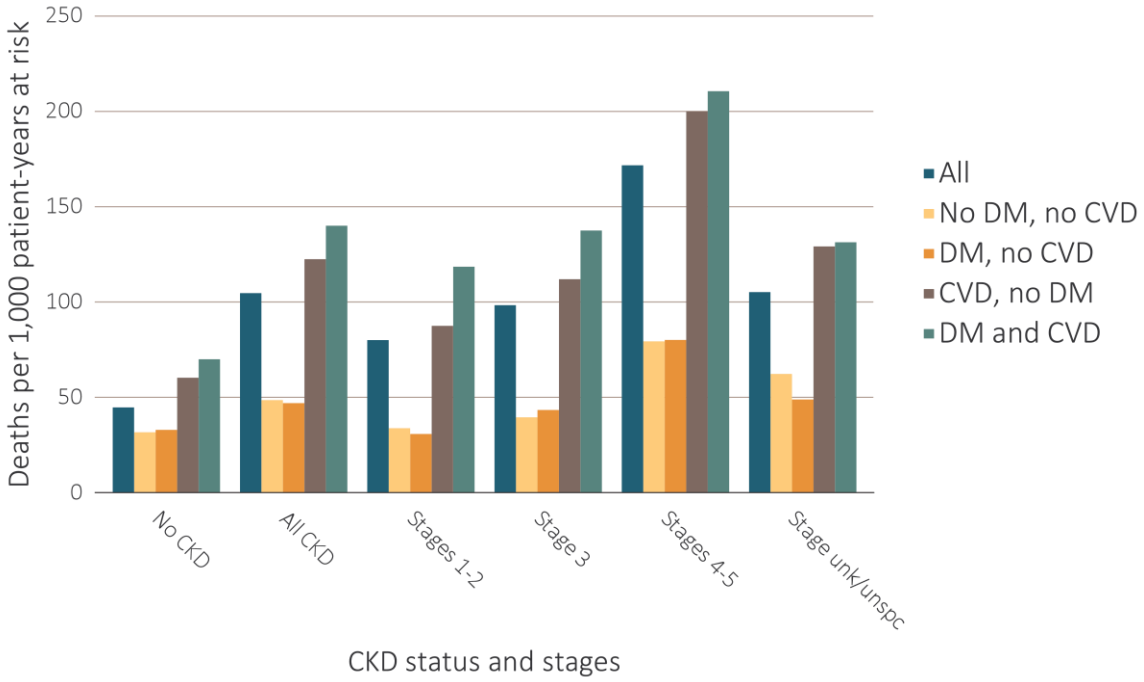
vol 1 Figure 3.5 Adjusted all-cause mortality rates per 1,000 patient-years at risk for Medicare patients aged 66 and older, by race, CKD status, and stage, 2016



Data source: Special analyses, Medicare 5% sample. January 1 of each reported year, point prevalent Medicare patients aged 66 and older. Adjusted for age/sex/race. Standard population: Medicare 2016 patients. Abbreviations: Af Am, African American; CKD, chronic kidney disease; unk/unspc, CKD stage unidentified.

Adjusted rates of mortality also increased with greater patient health complexity. Figure 3.6 presents adjusted mortality rates by the presence of two common comorbidities of CKD: DM and CVD. Diabetes had little effect on CKD mortality, whereas the effect of CVD was dramatic. In 2016, those with CKD but without DM or CVD had an adjusted mortality rate of 47 deaths per 1,000 patient-years at risk, while those with both DM and CVD experienced almost triple that rate, at 138 deaths per 1,000 patient-years.

vol 1 Figure 3.6 Adjusted all-cause mortality rates per 1,000 patient-years at risk for Medicare patients aged 66 and older, by cardiovascular disease and diabetes mellitus, CKD status, and stage, 2016



Data source: Special analyses, Medicare 5% sample. January 1 of each reported year, point prevalent Medicare patients aged 66 and older. Adjusted for age/sex/race. Standard population: Medicare 2016 patients. Abbreviations: CKD, chronic kidney disease; CVD, cardiovascular disease; DM, diabetes mellitus; unk/unspc, CKD stage unidentified.

Hospitalization Rates

Table 3.2 presents all-cause hospitalization rates in 2016 for older Medicare patients and younger Optum Clinformatics™ patients, by whether they had recognized CKD during 2016. Among Medicare patients, the unadjusted rate for those with CKD was 623 hospitalizations per 1,000 patient-years at risk, 2.7 times as great as the rate of 230 for patients without CKD. Among Optum Clinformatics™ patients, the unadjusted rate for those with CKD was 312.7 hospitalizations per 1,000 patient-years at risk, compared to a much lower rate of 32 for patients without CKD.

Across all demographic characteristics, the 2016 unadjusted hospitalization rate for patients with CKD was about twice the corresponding rate for patients without CKD. Once adjustment was made for age, race, and sex, the hospitalization rate for Medicare patients with CKD of 568.0 per 1,000 patient-years at risk was 147.0% greater than for those without CKD, at 230. The hospitalization rate for Optum Clinformatics™ patients with CKD was 831% greater than for those without CKD: 326 vs. 35 per 1,000 patient-years at risk. As with mortality, the adjusted hospitalization rate increased with age for all patients, except among those 40-65 years.

In contrast to the mortality findings, however, for Medicare recipients, women with CKD had higher adjusted hospitalization rates than did men: 576 vs. 562 per 1,000 patient-years at risk. For Medicare recipients, women without CKD had lower adjusted hospitalization rates of 224 per 1,000 patient-years than did men, at 238. For Optum Clinformatics™ patients, women had higher unadjusted and adjusted hospitalization rates than men, among both with and without CKD cohorts.

vol 1 Table 3.2 Unadjusted and adjusted all-cause hospitalization rates per 1,000 patient-years at risk for Medicare and Optum Clinformatics™ patients, by CKD status, 2016

	Medicare (aged 66+)				Optum Clinformatics™ (aged 22+)			
	Unadjusted		Adjusted		Unadjusted		Adjusted	
	No CKD	All CKD	No CKD	All CKD	No CKD	All CKD	No CKD	All CKD
All	230.1	622.5	229.9	568.0	32.3	312.7	34.9	326.2
Age								
22-39	.	.	.	.	35.8	361.8	40.0	356.6
40-65	.	.	.	.	27.7	287.3	29.4	289.8
65+	.	.	.	.	68.0	382.8	69.6	384.8
66–69	139.7	527.6	148.4	505.5	.	.	.	.
70–74	182.3	524.3	181.5	527.4	.	.	.	.
75–84	265.7	619.5	256.0	595.0	.	.	.	.
85+	419.4	759.7	399.7	706.2	.	.	.	.
Sex								
Male	222.3	611.8	238.3	562.0	20.2	299.9	22.6	295.0
Female	235.9	632.2	224.4	575.6	44.9	329.2	47.2	350.4
Race								
White	233.5	620.6	232.3	568.3	37.1	316.3	37.5	321.4
Black/African American	241.7	689.1	246.0	651.8	36.8	349.9	35.9	371.1
Other	166.4	528.7	177.3	471.1	26.6	297.3	26.8	312.3

Data source: Medicare 5% sample and Optum Clinformatics™. January 1, 2016 point prevalent Medicare patients, aged 66 and older. Standard population: all Medicare patients, 2016. Optum Clinformatics™ commercial insurance patients aged 22 and older who were enrolled in the plan, did not have diagnoses of ESRD, and were alive on January 1, 2016. Adjusted for age/sex/race; rates by one factor are adjusted for the others. A dot (.) represents a zero value. Standard population: all Optum Clinformatics™ patients, 2016. Abbreviations: CKD, chronic kidney disease; ESRD, end-stage kidney disease.

Figure 3.7 presents the trends in hospitalization rates for Medicare and Optum Clinformatics™ patients over the past 13 years. The overall trend relationships between adjusted and unadjusted rates, CKD and no-CKD groups, were consistent with other data presented thus far.

The trend in adjusted hospitalization rates from 2004 through 2016 shows a gradual decline and less variability. From 2015 to 2016, adjusted Medicare rates showed a decrease of 3.7%, from 594.8 to 573.5 per 1,000 patient-years at risk for the CKD group, and by 2.0%, from 240.3 to 235.5 per 1,000 for the no-CKD group. The adjusted Optum Clinformatics™ hospitalization rates decreased by 16.0%, from 378.5 to 326.2 per 1,000 patient-years at risk for the CKD group, and increased by 1.7%, from 34.3 to 34.9 per 1,000 for the no-CKD group.

vol 1 Figure 3.7 Unadjusted and adjusted all-cause hospitalization rates per 1,000 patient-years at risk for Medicare and Optum Clinformatics™ patients, by CKD status and year, 2004-2016

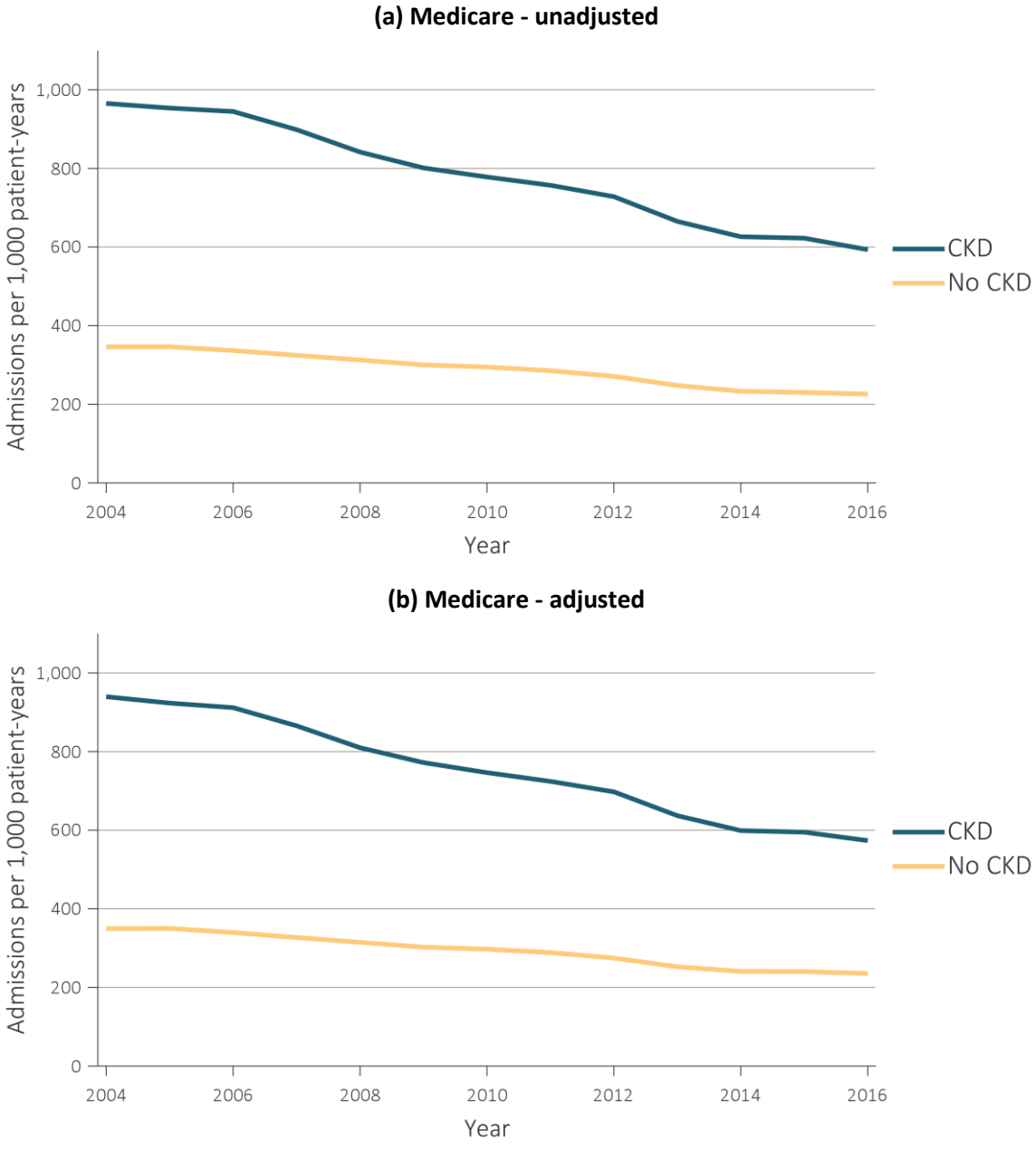
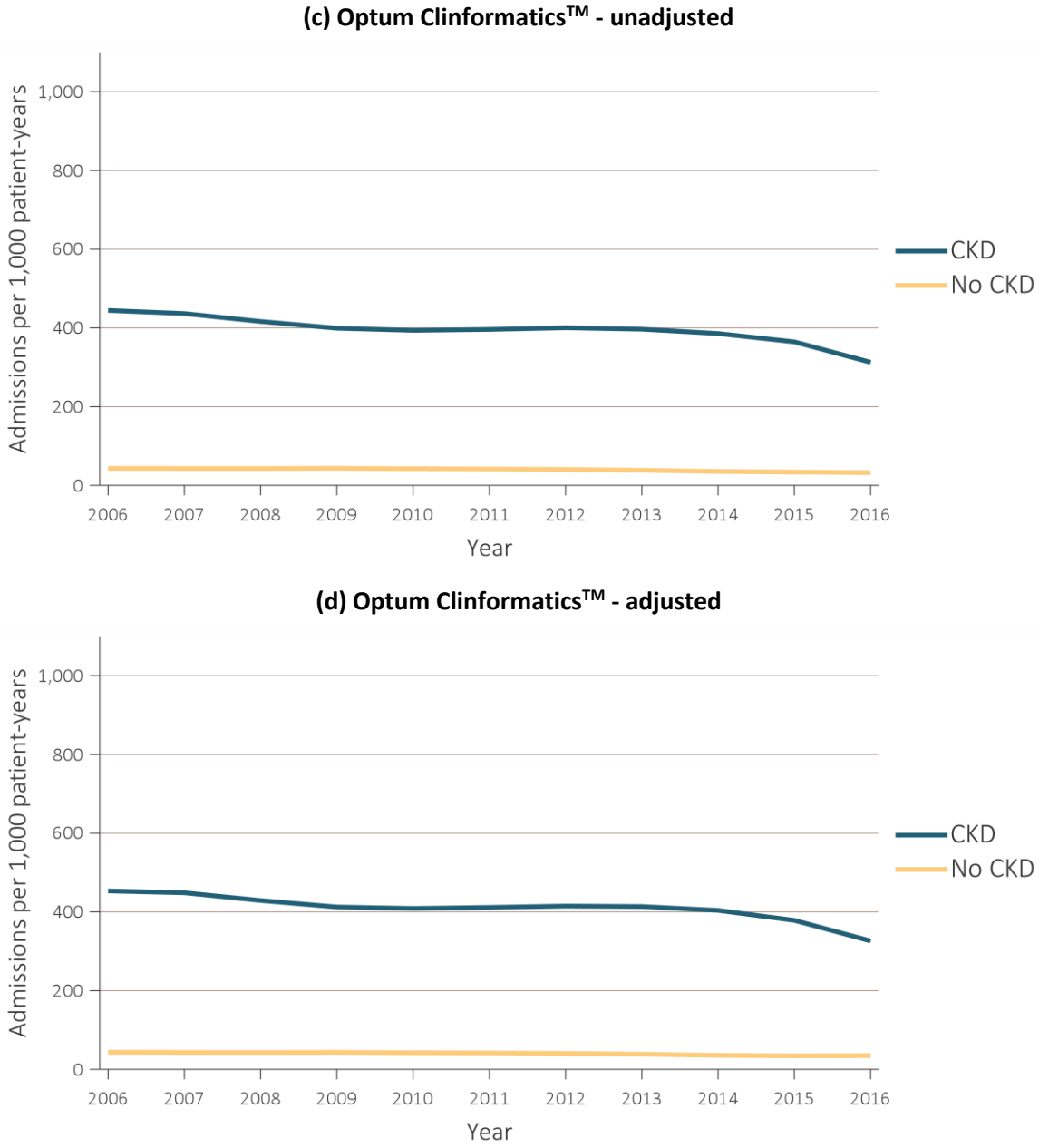


Figure 3.7 continued on next page.

vol 1 Figure 3.7 Unadjusted and adjusted all-cause hospitalization rates per 1,000 patient-years at risk for Medicare and Optum Clinformatics™ patients, by CKD status and year, 2004-2016 (continued)

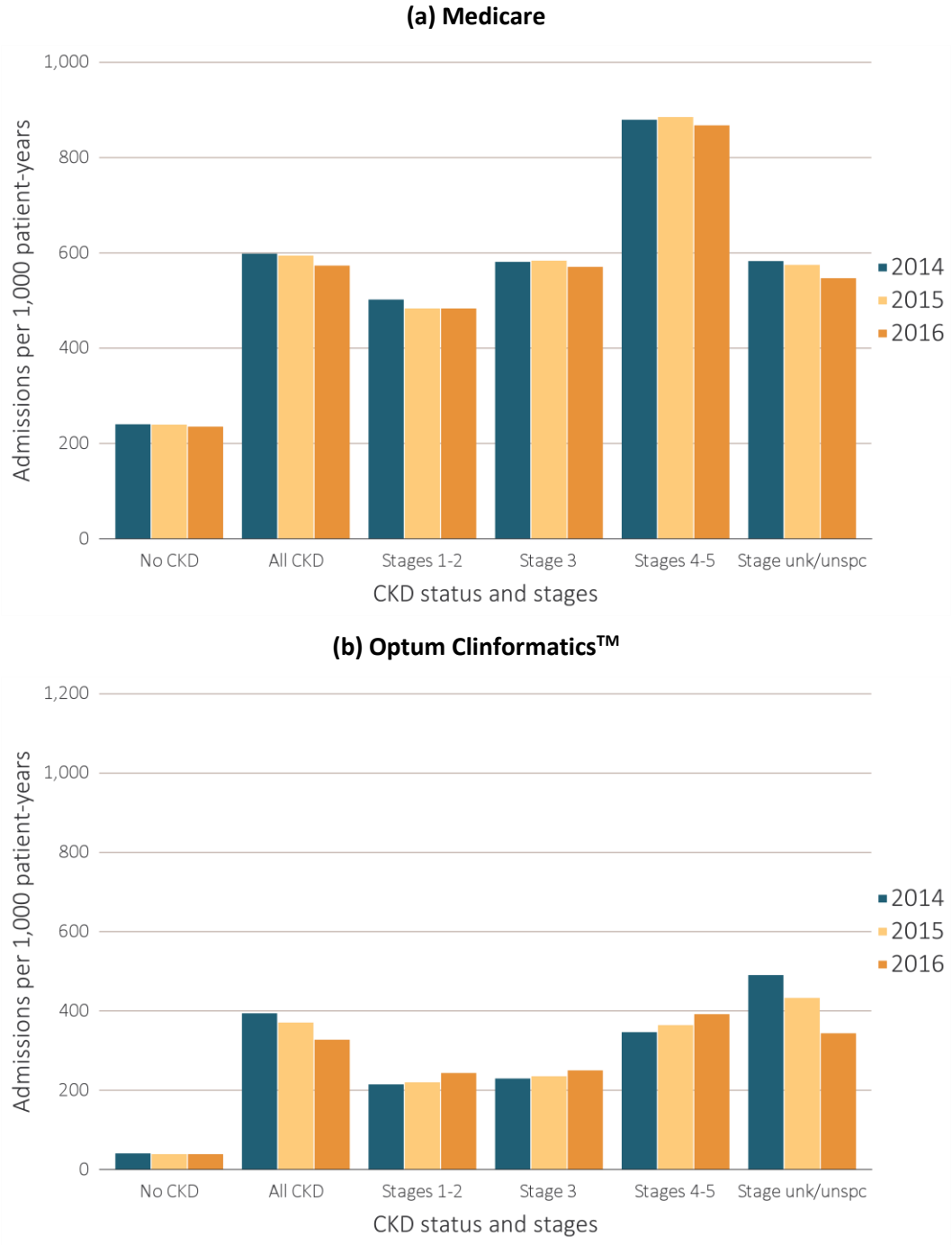


Data source: Medicare 5% sample and Optum Clinformatics™. January 1 of each reported year, point prevalent Medicare patients, aged 66 and older. Standard Medicare population: all patients, 2011. Optum Clinformatics™ commercial insurance patients aged 22 and older who were enrolled in the plan, did not have diagnoses of ESRD, and were alive on January 1 of each reported year. Adjusted for age/sex/race; rates by one factor are adjusted for the others. Standard Optum Clinformatics™ population: all patients, 2011. Abbreviation: CKD, chronic kidney disease.

For patients with CKD, differences were observed in the rates of hospitalization necessary to treat different comorbid conditions. Figure 3.8 shows the adjusted hospitalization rates for all causes. In Figures 3.9 through 3.11, we present Medicare hospitalization rates resulting from CVD (19.7% of all-cause admissions), infection (17.8%), and from a combination of all other cause categories (62.5%). For the Optum Clinformatics™ population, we also present hospitalization rates resulting from CVD (23.0% of all-cause admissions), infection (19.0%), and all other cause categories (44.2%). As the covariates in the adjusted model no longer include comorbidities and prior year hospitalizations, the Medicare adjusted rates may vary noticeably from results presented prior to the 2014 ADR.

Rates of all-cause hospitalization in 2016 increased with disease severity, from 478 admissions per 1,000 patient-years for Medicare patients in Stages 1-2, to 565 for Stage 3, and 863 for Stages 4-5. For the Optum Clinformatics™ cohort, the rates were 237 admissions per 1,000 patient-years for those in Stages 1-2, to 244 for Stage 3, and 386 for Stages 4-5 (see Figure 3.8).

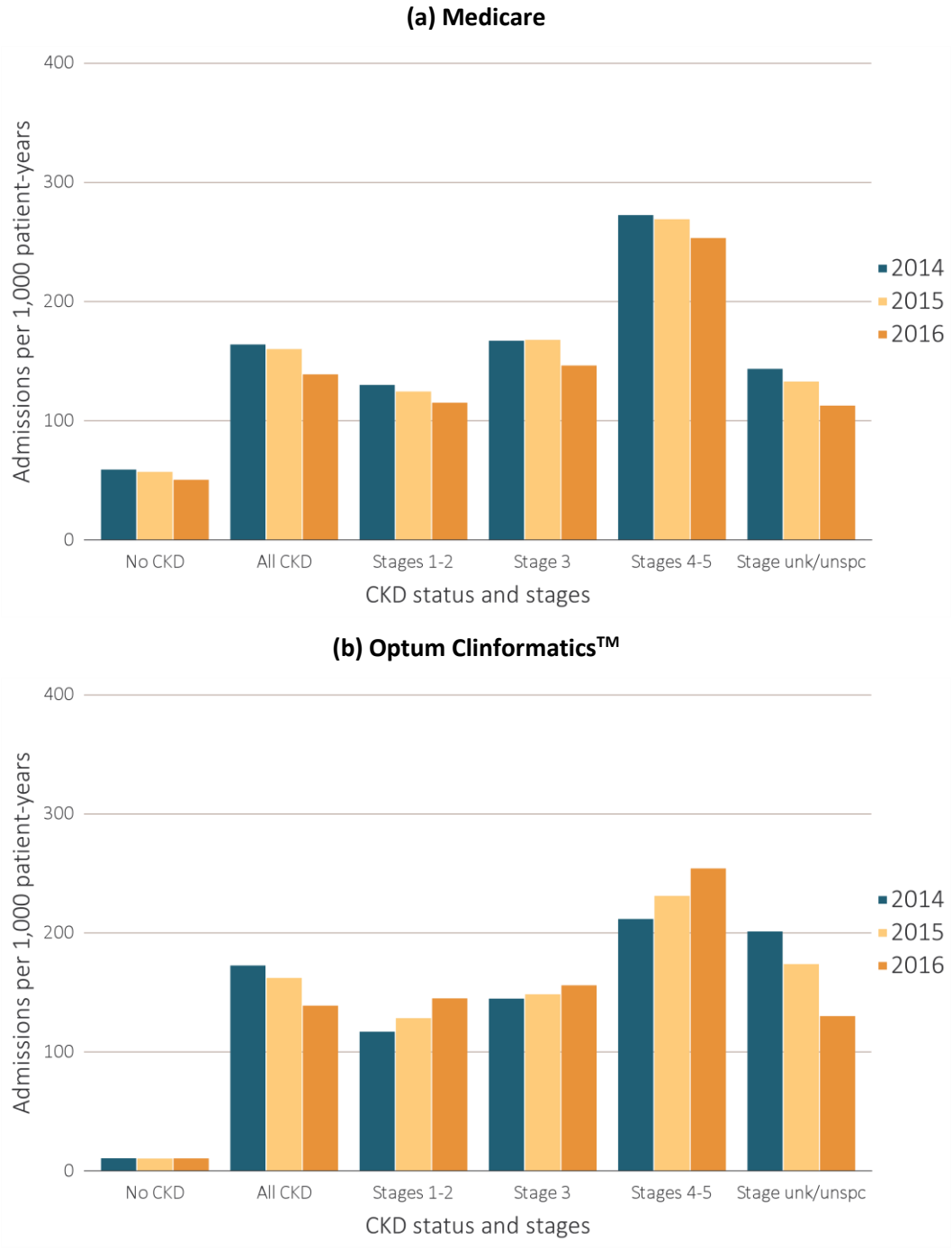
vol 1 Figure 3.8 Adjusted all-cause hospitalization rates per 1,000 patient-years at risk for Medicare patients aged 66 and older and Optum Clinformatics™ patients aged 22 and older, by CKD status and stage, 2014-2016



Data source: Medicare 5% sample and Optum Clinformatics™. January 1, 2016 point prevalent Medicare patients, aged 66 and older. Standard Medicare population: all patients, 2016. Optum Clinformatics™ commercial insurance patients aged 22 and older who were enrolled in the plan, did not have diagnoses of ESRD, and were alive on January 1, 2016. Adjusted for age/sex/race; rates by one factor are adjusted for the others. Standard population: all Optum Clinformatics™ patients, 2016. Abbreviations: CKD, chronic kidney disease unk/unspc, CKD stage unidentified.

The pattern of increase for Medicare hospitalizations resulting from a primary diagnosis of CVD was similar, with rates rising from 113 admissions per 1,000 patient-years for CKD Stages 1-2, to 144 for Stage 3, and 251 for Stages 4-5. Patients in the Optum Clinformatics™ group experienced 143 admissions per 1,000 patient-years in Stages 1-2, increasing to 154 for Stage 3, and 252 for Stages 4-5 (Figure 3.9).

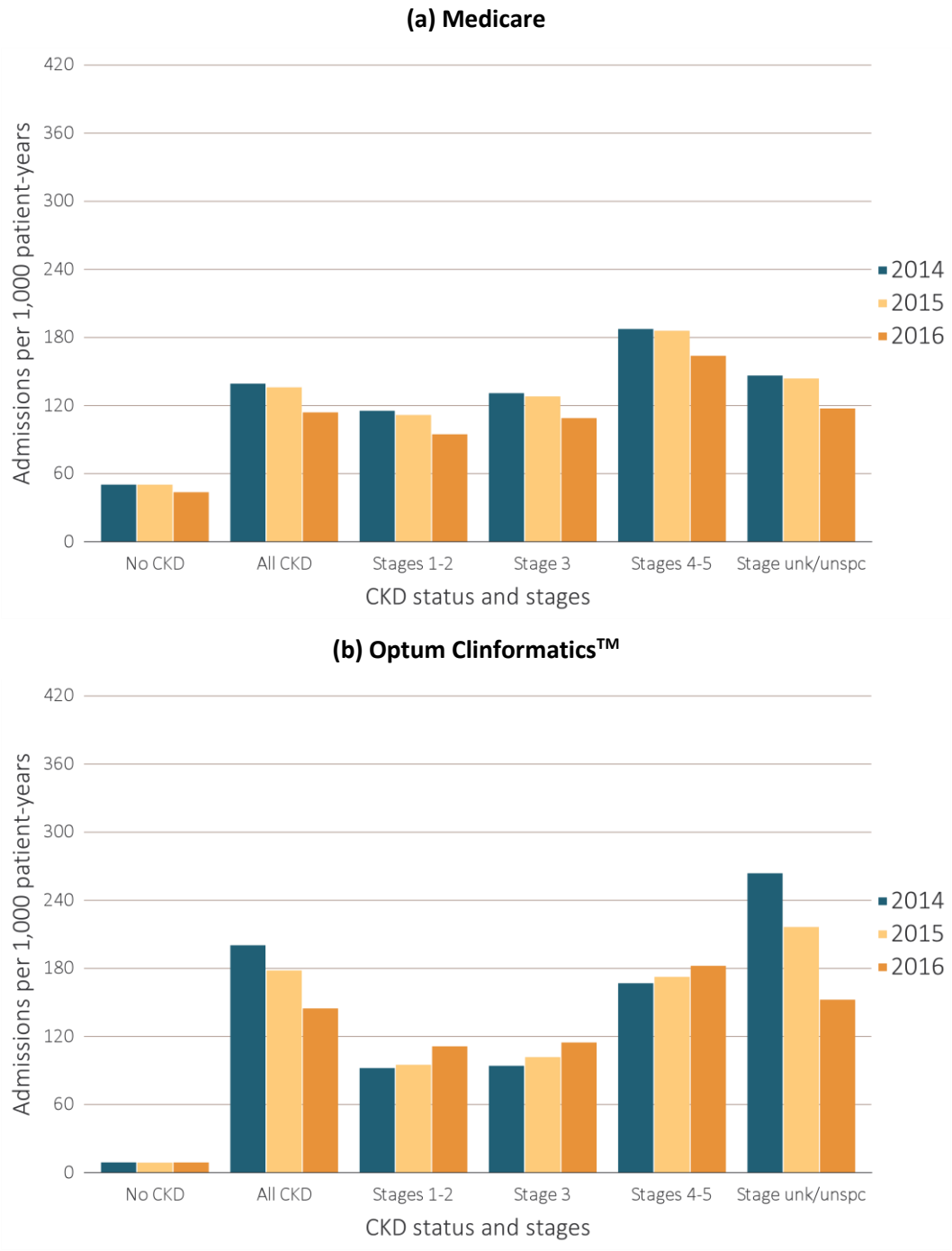
vol 1 Figure 3.9 Adjusted rates of hospitalization for cardiovascular disease per 1,000 patient-years at risk for Medicare patients aged 66 and older and Optum Clinformatics™ patients aged 22 and older, by CKD status and stage, 2014-2016



Data source: Medicare 5% sample and Optum Clinformatics™. January 1, 2016 point prevalent Medicare patients, aged 66 and older. Standard Medicare population: all patients, 2016. Optum Clinformatics™ commercial insurance patients aged 22 and older who were enrolled in the plan, did not have diagnoses of ESRD, and were alive on January 1, 2016. Adjusted for age/sex/race; rates by one factor are adjusted for the others. Standard Optum Clinformatics™ population: all patients, 2016. Abbreviations: CKD, chronic kidney disease unk/unspc, CKD stage unidentified.

Adjusted rates of hospitalization for infection are shown by CKD status and stage in Figure 3.10. Rates in all subgroups among Medicare patients decreased from 2014 to 2016. However, among Optum Clinformatics™ patients, rates increased from 2014 to 2016 for Stages 1-2, Stage 3, and Stages 4-5.

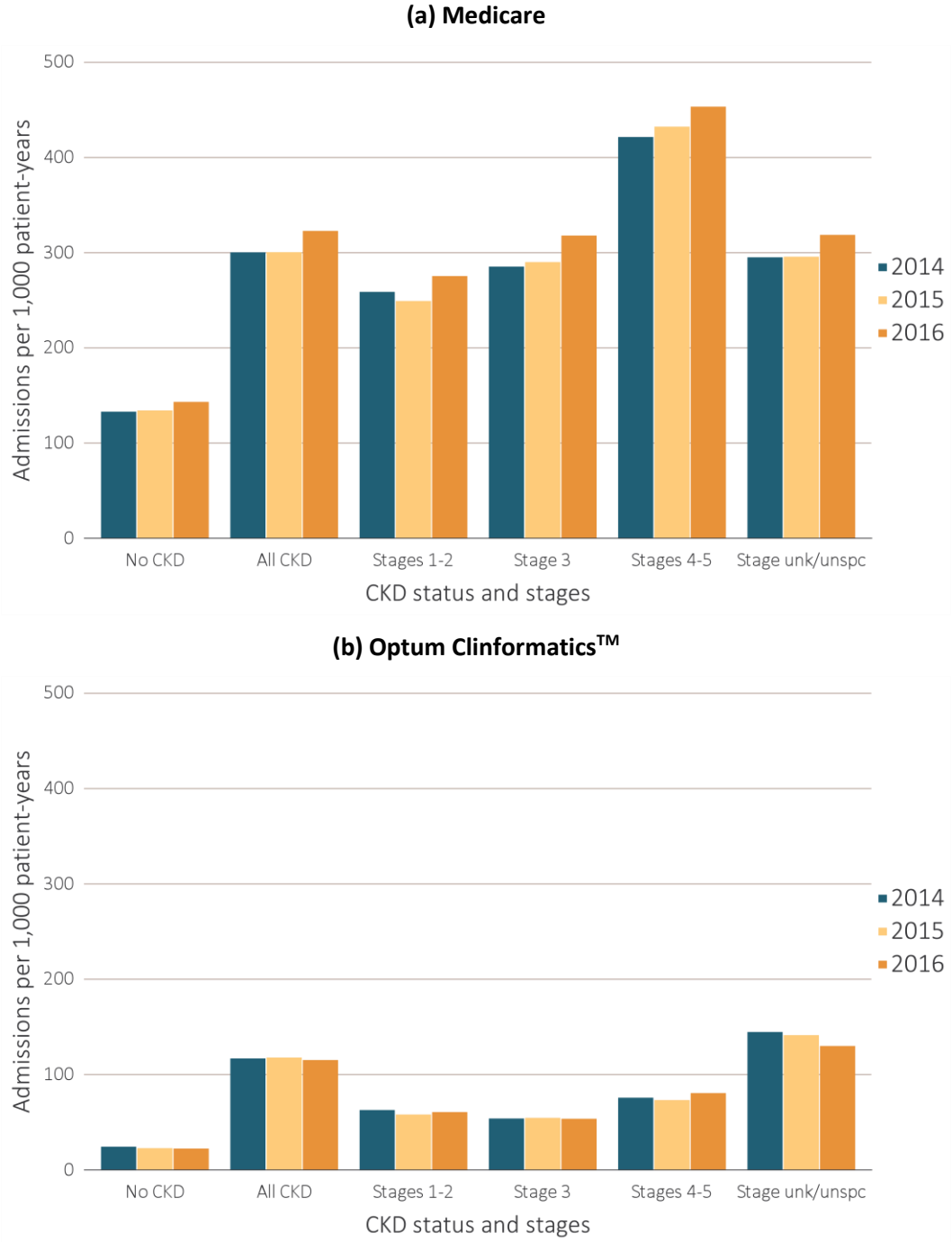
vol 1 Figure 3.10 Adjusted rates of hospitalization for infection per 1,000 patient-years at risk for Medicare aged 66 and older and Optum Clinformatics™ patients aged 22 and older, by CKD status and stage, 2014-2016



Data source: Medicare 5% sample and Optum Clinformatics™. January 1, 2016 point prevalent Medicare patients, aged 66 and older. Standard Medicare population: all patients, 2016. Optum Clinformatics™ commercial insurance patients aged 22 and older who were enrolled in the plan, did not have diagnoses of ESRD, and were alive on January 1, 2016. Adjusted for age/sex/race; rates by one factor are adjusted for the others. Standard population: all Optum Clinformatics™ patients, 2016. Abbreviations: CKD, chronic kidney disease unk/unspc, CKD stage unidentified.

Figure 3.11 presents the adjusted rates of hospitalization resulting from all other health causes. The admission rates for Medicare patients steadily increased from 2014 to 2016.

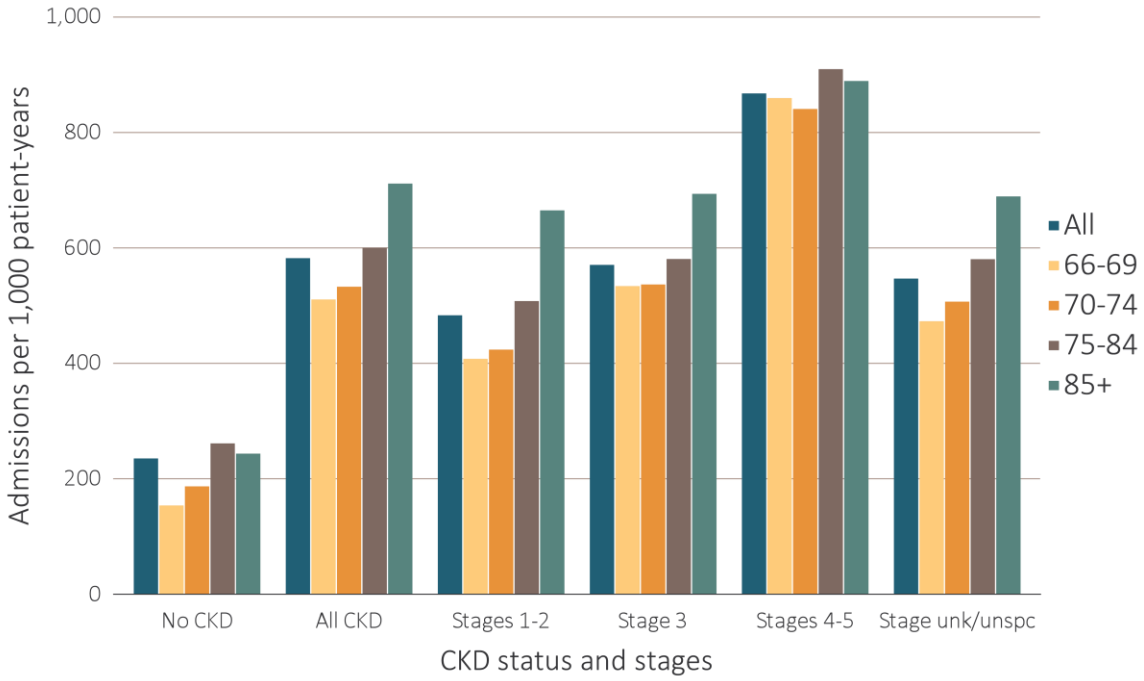
vol 1 Figure 3.11 Adjusted rates of hospitalization for causes other than cardiovascular disease and infection per 1,000 patient-years at risk for Medicare aged 66 and older and Optum Clinformatics™ patients aged 22 and older, by CKD status and stage, 2014-2016



Data source: Medicare 5% sample and Optum Clinformatics™. January 1, 2016 point prevalent Medicare patients, aged 66 and older. Standard Medicare population: all patients, 2016. Optum Clinformatics™ commercial insurance patients aged 22 and older who were enrolled in the plan, did not have diagnoses of ESRD, and were alive on January 1, 2016. Adjusted for age/sex/race; rates by one factor are adjusted for the others. Standard Optum Clinformatics™ population: all patients, 2016. Abbreviations: CKD, chronic kidney disease unk/unspc, CKD stage unidentified.

Demographic comparisons also highlight differences in all-cause hospitalization rates for CKD, as shown in Figures 3.12-3.14. In general, and consistent with mortality patterns, older Medicare patients exhibited higher rates of hospitalization than did the younger age cohorts, although the age effect was less pronounced for the CKD population than for the no-CKD population.

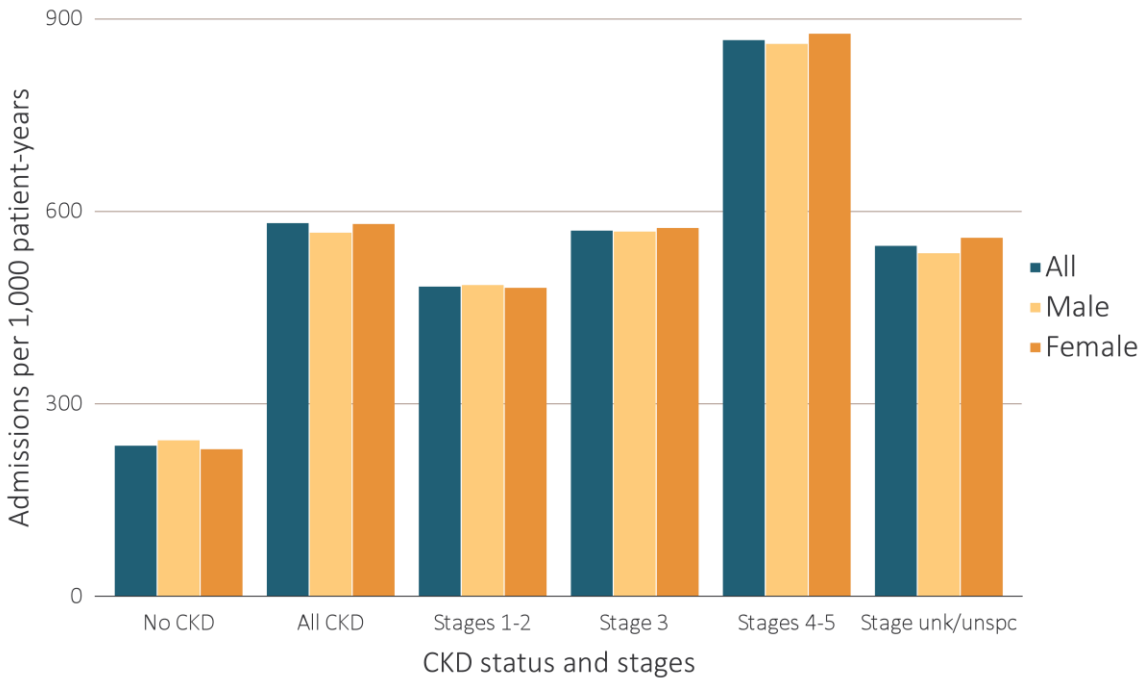
vol 1 Figure 3.12 Adjusted all-cause hospitalization rates per 1,000 patient-years at risk for Medicare patients aged 66 and older, by age, CKD status, and stage, 2016



Data source: Medicare 5% sample. January 1, 2016 point prevalent Medicare patients aged 66 and older. Adjusted for age/sex/race; rates by one factor are adjusted for the others. Standard population: all patients, 2016. Abbreviations: CKD, chronic kidney disease; unk/unspc, CKD stage unidentified.

A comparison of adjusted 2016 all-cause hospitalization rates by CKD status and sex is shown in Figure 3.13. The rates for females in all stages of CKD were slightly higher than for males except for Stages 1-2.

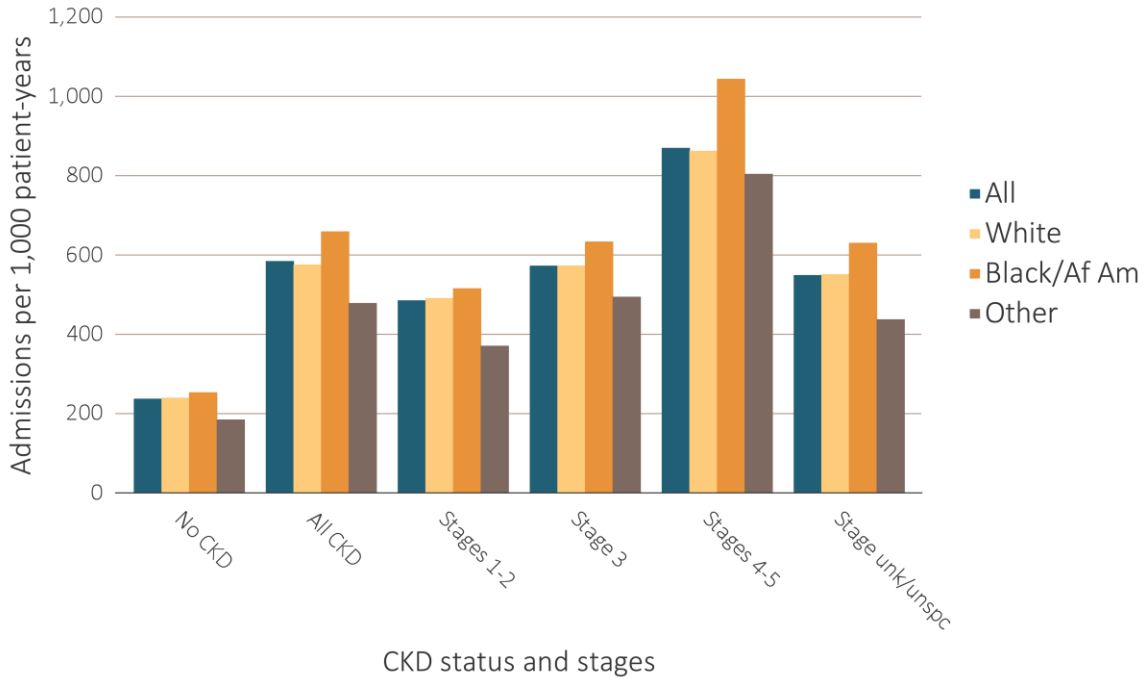
vol 1 Figure 3.13 Adjusted all-cause hospitalization rates per 1,000 patient-years at risk for Medicare patients aged 66 and older, by sex, CKD status, and stage, 2016



Data source: Medicare 5% sample. January 1, 2016 point prevalent Medicare patients aged 66 and older. Adjusted for age/sex/race; rates by one factor are adjusted for the others. Standard population: all patients, 2016. Abbreviations: CKD, chronic kidney disease; unk/unspc, CKD stage unidentified.

Racial differences in Medicare hospitalization rates were notable. In both the CKD and no-CKD populations, Black patients were hospitalized more frequently than those of Other races. In 2016, Black patients with CKD showed higher rates than did Whites or those of Other races, at 652 per 1,000 patient-years versus 568 for Whites and 471 for Other patients (Figure 3.14). This disparity decreased with disease severity; rates for Black patients were 5.0% higher than Whites in Stages 1-2 (508 vs. 484), 10.4% higher in Stage 3 (626 vs.566) and 21.3% higher in Stages 4-5 (1,037 vs. 855). Patients of Other races experienced the lowest rates of hospitalization in all disease stages.

vol 1 Figure 3.14 Adjusted all-cause hospitalization rates per 1,000 patient-years at risk for Medicare patients aged 66 and older, by race, CKD status, and stage, 2016

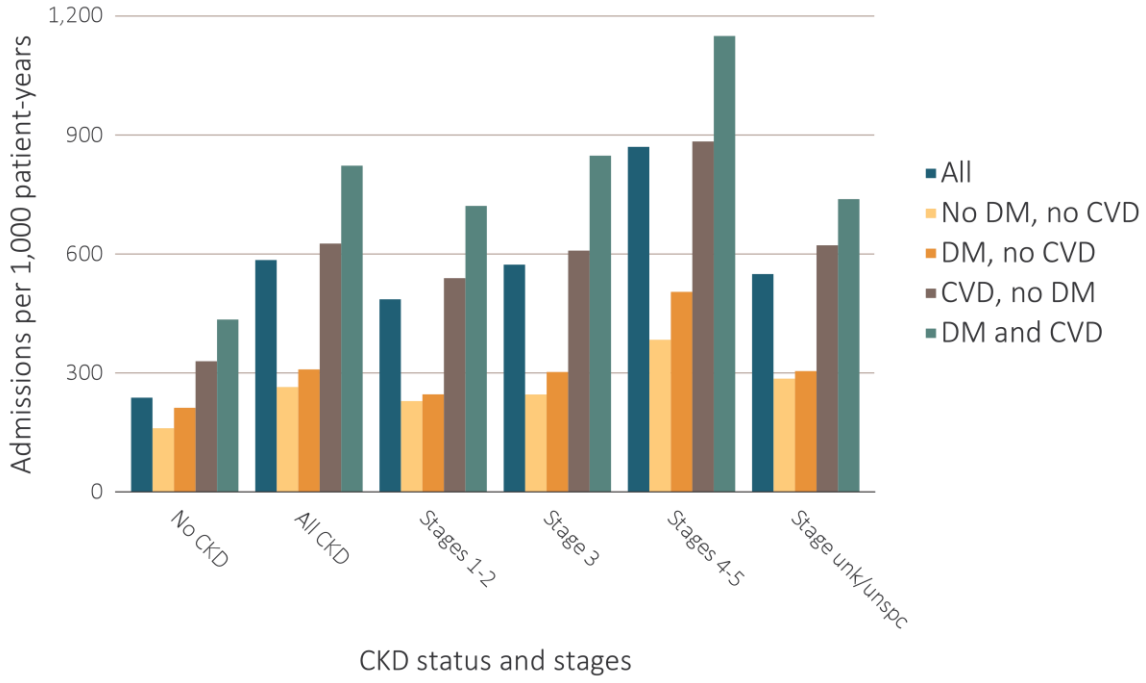


Data source: Medicare 5% sample. January 1, 2016 point prevalent Medicare patients aged 66 and older. Adjusted for age/sex/race; rates by one factor are adjusted for the others. Standard population: all patients, 2016. Abbreviations: Af Am, African American; CKD, chronic kidney disease; unk/unspc, CKD stage unidentified.

Adjusted rates of all-cause hospitalization increased in the presence of DM and CVD for Medicare patients both with and without CKD (see Figure 3.15). In the no-CKD population, the adjusted hospitalization rates were 153 per 1,000 patient-years for those without DM or CVD, 204 per 1,000 for patients with DM only, 322 for those with CVD only, and 427 for patients with both DM and CVD.

In 2016, admissions per 1,000 patient-years for those with CKD increased from 257 for patients without DM or CVD, to 301 for those with only DM, and 619 with only CVD, to a high of 815 for CKD patients with both comorbidities. This additional disease burden was most striking for patients with Stage 4 or 5 CKD. Patients with both DM and CVD in addition to late-stage CKD had an all-cause hospitalization rate of 1,142 admissions per 1,000 patient-years, about 3 times as great as the rate of 376 for late-stage CKD patients without either comorbidity.

vol 1 Figure 3.15 Adjusted all-cause hospitalization rates per 1,000 patient-years at risk for Medicare patients aged 66 and older, by cardiovascular disease and diabetes mellitus, CKD status, and stage, 2016



Data source: Medicare 5% sample. January 1, 2016 point prevalent Medicare patients aged 66 and older. Adjusted for age/sex/race; rates by one factor are adjusted for the others. Standard population: all patients, 2016. Abbreviations: CKD, chronic kidney disease; CVD, cardiovascular disease; DM, diabetes mellitus; unk/unspc, CKD stage unidentified.

Hospital Readmission

Reducing the rate of patient readmission within 30 days of discharge from the initial or index hospitalization is a quality assurance goal for many healthcare systems, including the Medicare program. Table 3.3 shows the distribution of unadjusted percentages of hospital readmission in the 2016 Medicare population among those with and without recognized CKD, by CKD status and stage, and stratified by age group, sex, and race. The unadjusted proportion of Medicare patients aged 66 and older who were readmitted to the hospital within 30 days of discharge from a first, all-cause hospitalization was 15.3% for those without CKD and 21.6% for those with CKD (see Table 3.3). These rates represent a slight decrease from 2015 levels except for the no-CKD group. Readmission rates were about 2% higher among Stages 4-5 patients than in lower stage CKD patients.

vol 1 Table 3.3 Unadjusted percentage of patients readmitted to the hospital within 30 days of discharge, among Medicare patients aged 66 and older who were discharged alive from an all-cause index hospitalization between January 1 and December 1, by CKD status and stage, 2016

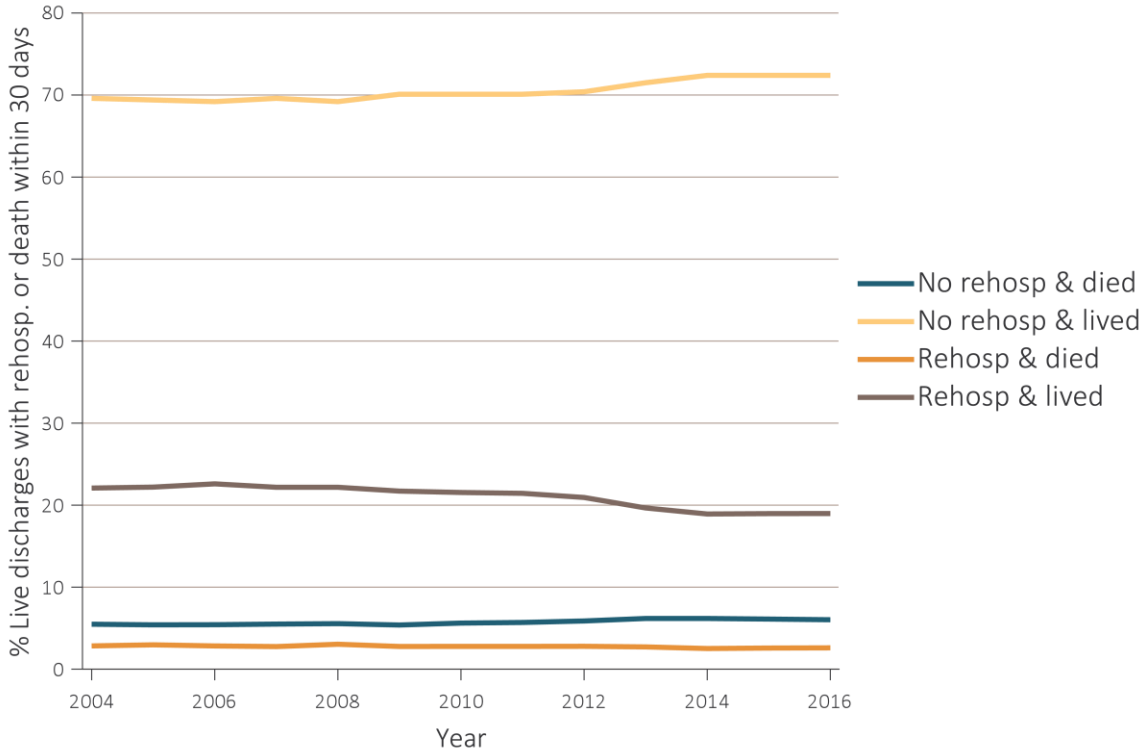
	No CKD (%)	All CKD (%)	Stages 1 or 2 (%)	Stage 3 (%)	Stages 4 or 5 (%)	Stage Unknown (%)
All	15.3	21.6	21.6	21.7	23.6	20.9
Age						
66-69	14.9	23.2	22.4	23.6	25.5	22.5
70-74	15.2	22.9	23.8	23.1	24.7	22.1
75-84	15.6	21.7	19.9	21.9	24.5	20.9
85+	15.2	19.8	22.0	19.6	21.4	18.9
Sex						
Male	16.2	22.0	21.3	22.2	23.9	21.2
Female	14.6	21.3	21.8	21.1	23.4	20.7
Race						
White	15.1	21.4	21.4	21.4	23.2	20.8
Black/African American	17.7	23.1	23.2	23.0	25.1	22.2
Other	16.0	21.7	20.2	21.7	25.3	20.9
Hospital readmission						
No readmission & died	4.5	6.0	4.9	6.0	7.6	5.7
Readmission & died	1.7	2.6	2.2	2.7	3.0	2.4
Readmission & lived	13.6	19.0	19.3	18.9	20.6	18.5

Data source: Medicare 5% sample. January 1, 2016 point prevalent Medicare patients aged 66 and older, discharged alive from an all-cause index hospitalization between January 1, 2016, and December 1, 2016; unadjusted. Abbreviation: CKD, chronic kidney disease.

The adjusted trend for Medicare readmissions occurring from 2004-2016 is shown in Figure 3.16. Results may differ from those presented in previous ADR editions, in part, because the adjustment variables of disease comorbidity and prior year hospitalization are no longer applied in the model.

Specifically, the percentage of patients who were readmitted to the hospital within 30 days of their initial discharge and survived declined from 22.1% in 2004 to 19.0% in 2016, a decrease of 16.3% over the 13-year period. While any reductions in readmission are encouraging, the 1.1% increase from 2015 in the proportion of patients who were readmitted and subsequently died within 30 days of the initial discharge is not considered significant. Of note, the rate of patients who were not readmitted, but died, within 30 days of the initial discharge has decreased somewhat, by 1.3% since 2015.

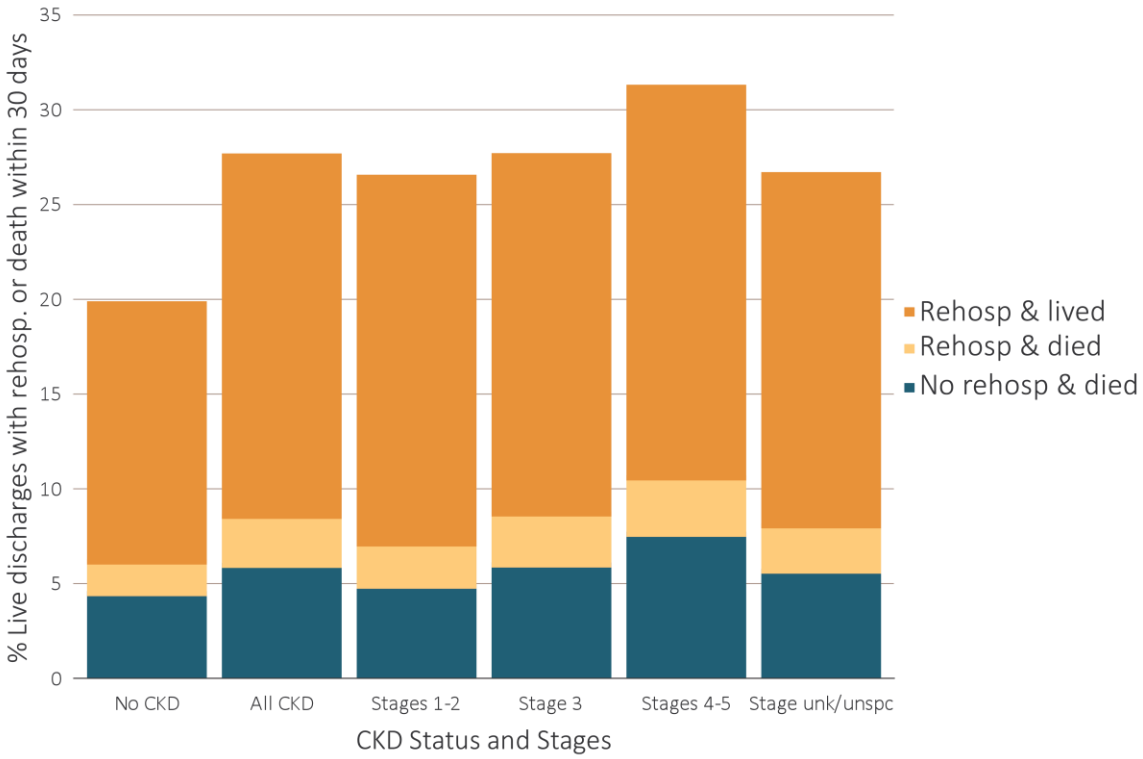
vol 1 Figure 3.16 Adjusted percentage of patients readmitted to the hospital within 30 days of discharge, among Medicare CKD patients aged 66 and older who were discharged alive from an all-cause index hospitalization between January 1 and December 1, by year, 2004-2016



Data source: Medicare 5% sample. January 1 of each reported year, point prevalent Medicare patients aged 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. Adjusted for age/sex/race. Standard population: 2011. Abbreviations: CKD, chronic kidney disease; Rehosp, rehospitalized.

Figure 3.17 presents the percentages of Medicare patients who were rehospitalized and/or died, with or without hospital readmission, within 30 days of discharge following an index hospitalization. Compared to those without a diagnosis of CKD, patients with CKD had a higher proportion of live discharges linked to a readmission or death.

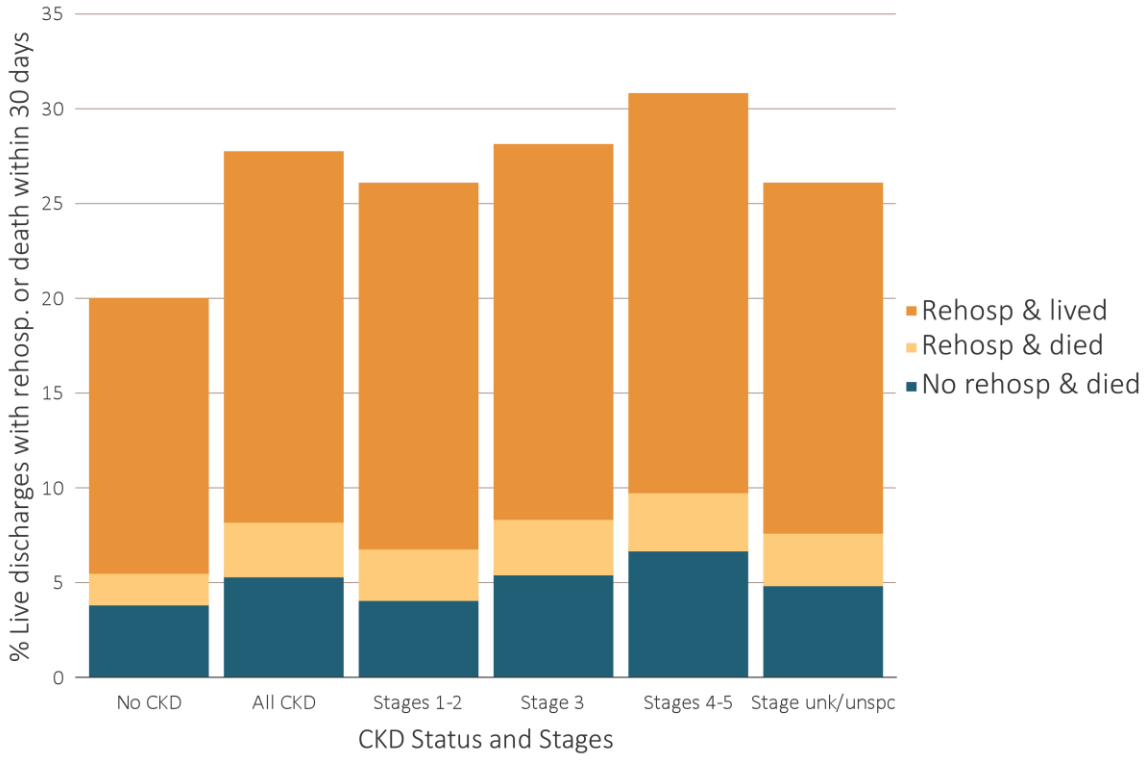
vol 1 Figure 3.17 Unadjusted percentage of patients readmitted to the hospital within 30 days of discharge, among Medicare patients aged 66 and older who were discharged alive from an all-cause index hospitalization between January 1 and December 1, by CKD status and stage, 2016



Data source: Medicare 5% sample. January 1, 2016 point prevalent Medicare patients aged 66 and older, discharged alive from an all-cause index hospitalization between January 1, 2016, and December 1, 2016, unadjusted. Abbreviations: CKD, chronic kidney disease; Rehosp, rehospitalized; unk/unspc, CKD stage unidentified.

Figure 3.18 shows the death and readmission percentages for older Medicare patients who were discharged alive from a CVD-related index hospitalization. Within 30 days of the initial discharge, 19.3% of patients with CKD were subsequently rehospitalized and lived, an additional 2.9% died following rehospitalization, and 5.4% of patients were not rehospitalized but later died. Otherwise, the magnitude and pattern of these readmission rates were similar to those for all-cause index hospitalizations.

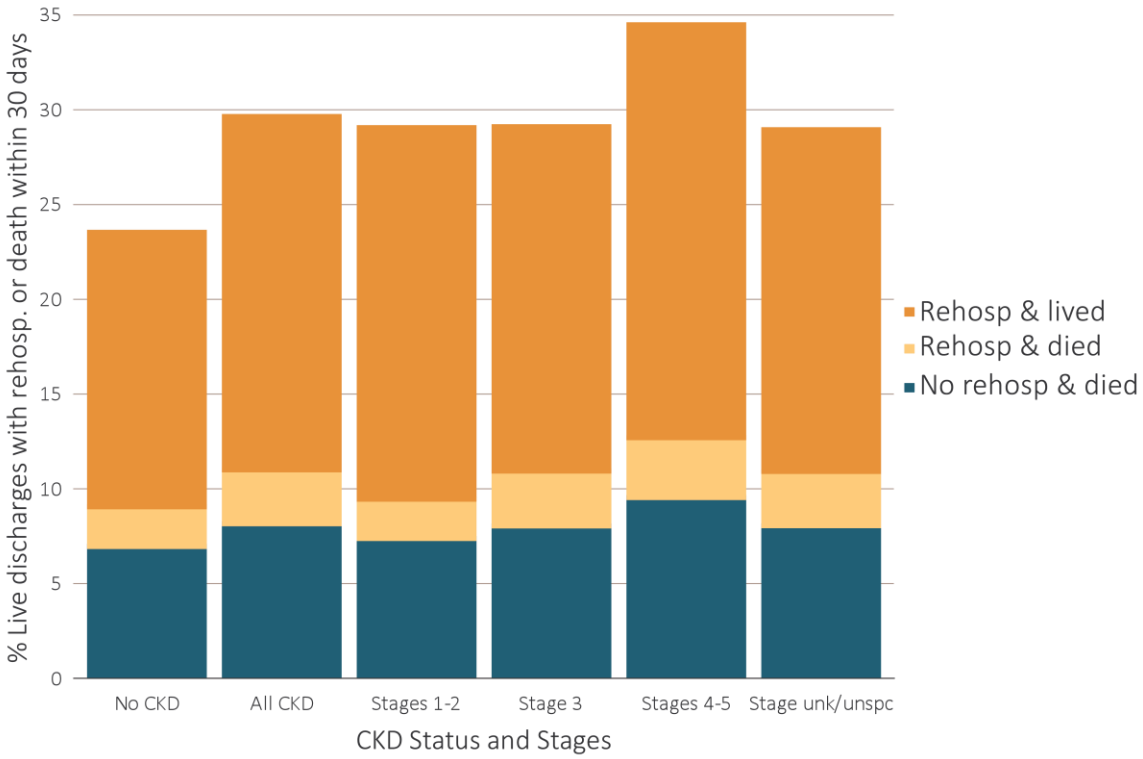
vol 1 Figure 3.18 Unadjusted percentage of patients readmitted to the hospital within 30 days of discharge, among Medicare patients aged 66 and older who were discharged alive from a cardiovascular-related index hospitalization between January 1 and December 1, by CKD status and stage, 2016



Data source: Medicare 5% sample. January 1, 2016 point prevalent Medicare patients aged 66 and older, discharged alive from a CVD index hospitalization between January 1, 2016, and December 1, 2016; unadjusted. Abbreviations: CKD, chronic kidney disease; Rehosp, rehospitalized; unk/unspc, CKD stage unidentified.

Of all patients without CKD who experienced an infection-related admission, 16.6% required readmission (see Figure 3.19). Of these, 2.1% died following rehospitalization, and 7.0% were not rehospitalized and later died. In the CKD group, within 30 days of the initial discharge 18.6% of patients were subsequently rehospitalized and lived, an additional 2.8% died following rehospitalization, and 8.2% of patients were not rehospitalized but later died.

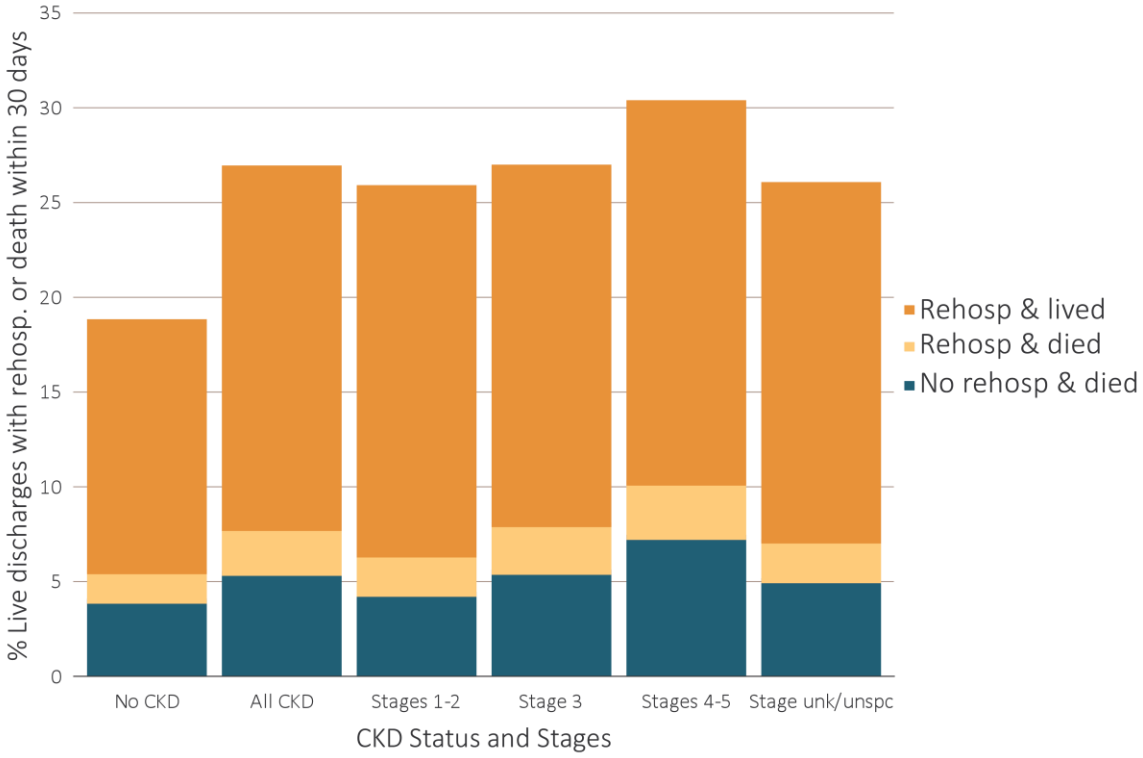
vol 1 Figure 3.19 Unadjusted percentage of patients readmitted to the hospital within 30 days of discharge, among Medicare patients aged 66 and older who were discharged alive from an infection-related index hospitalization between January 1 and December 1, by CKD status and stage, 2016



Data source: Medicare 5% sample. January 1, 2016 point prevalent Medicare patients aged 66 and older, discharged alive from an infection index hospitalization between January 1, 2016, and December 1, 2016, unadjusted. Abbreviations: CKD, chronic kidney disease; Rehosp, rehospitalized; unk/unspc, CKD stage unidentified.

Figure 3.20 shows the death and hospital readmission percentages for Medicare patients aged 66 and older who were discharged alive from an index hospitalization for all causes other than CVD and infection. The patterns of these percentages were similar to those for the entire group of index hospitalizations, for all causes. For those with CKD, 5.4% of patients were not rehospitalized but died, 2.4% were rehospitalized and died, and 19.0% were rehospitalized and lived. In the no-CKD group, these percentages were somewhat lower, at 4.0%, 1.6%, and 13.2%, respectively.

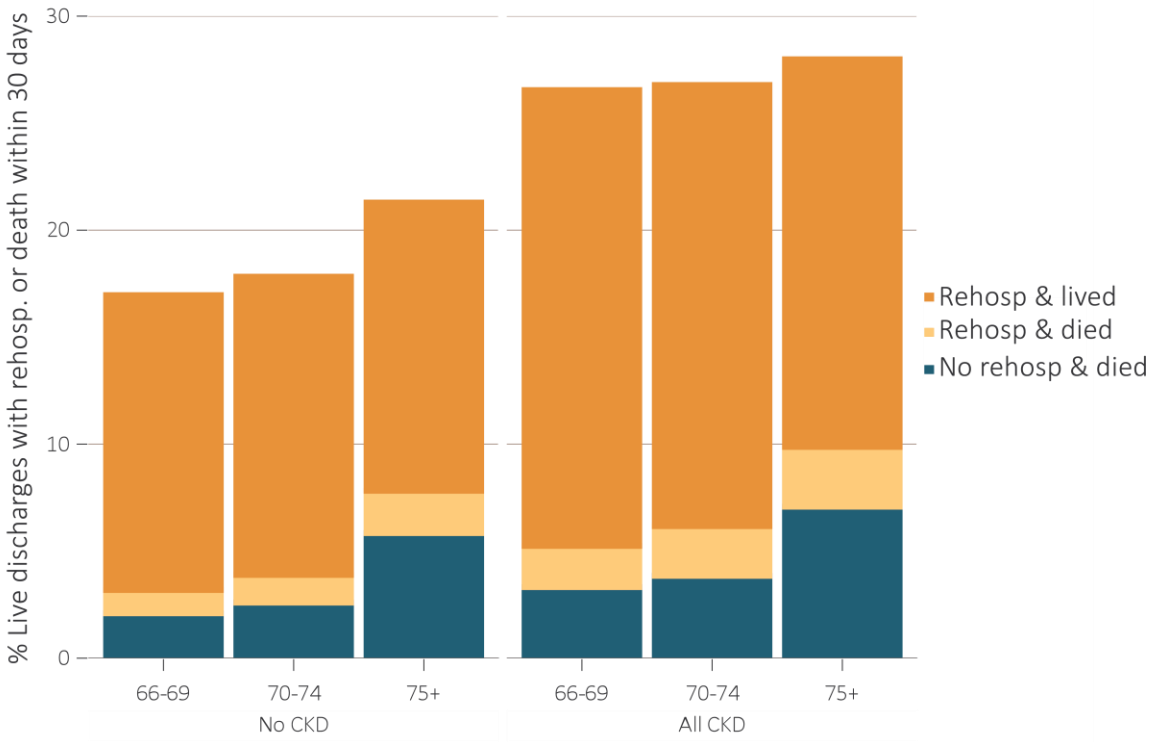
vol 1 Figure 3.20 Unadjusted percentage of patients readmitted to the hospital within 30 days of discharge, among Medicare patients aged 66 and older who were discharged alive from a no-cardiovascular and no-infection-related index hospitalization between January 1 and December 1, by CKD status and stage, 2016



Data Source: Medicare 5% sample. January 1, 2016 point prevalent Medicare patients aged 66 and older, discharged alive from a no-cardiovascular and no-infection index hospitalization between January 1, 2016, and December 1, 2016; unadjusted. Abbreviations: CKD, chronic kidney disease; Rehosp, rehospitalized; unk/unspc, CKD stage unidentified.

Figure 3.21 illustrates a comparison by age group and presence of CKD of those Medicare patients who were readmitted or died within 30 days of discharge from an all-cause, index hospitalization. In the Medicare population, rates of rehospitalization with survival decreased with increasing age across all stages of CKD. These findings were likely influenced by the competing risk of death in older age groups. Consistently, for both patients with and without CKD, the proportion returning to the hospital and dying within 30 days of discharge, or dying without readmission, increased with older age.

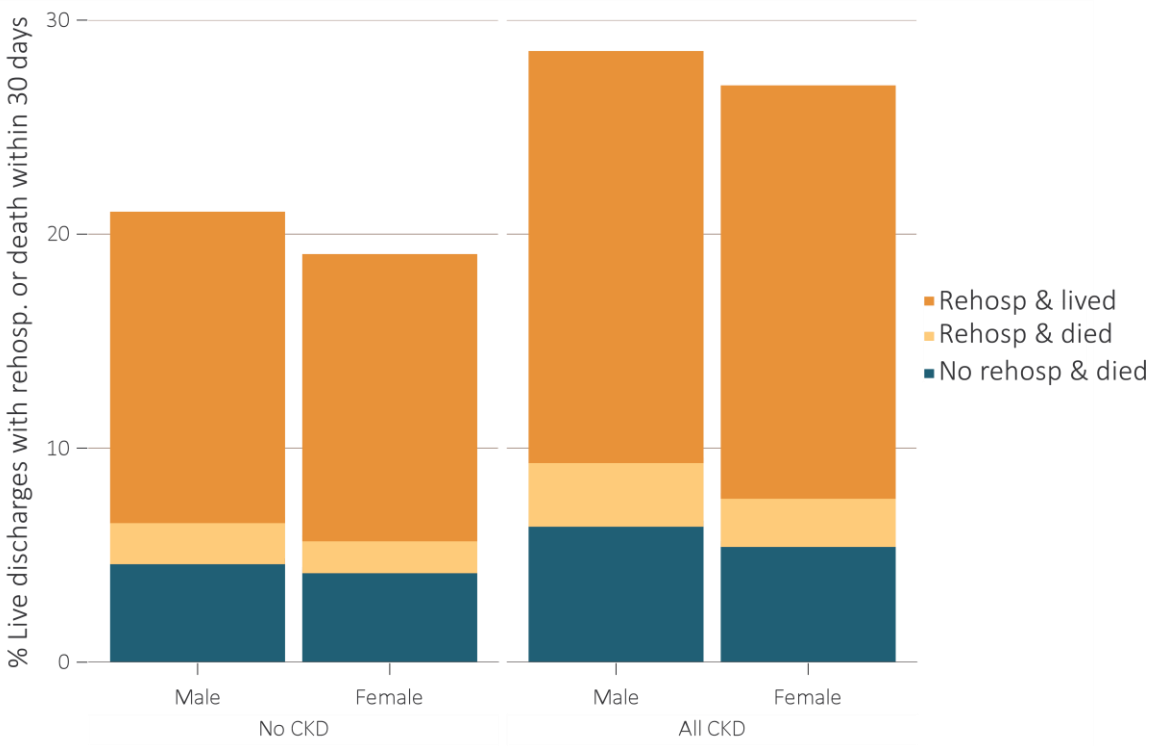
vol 1 Figure 3.21 Unadjusted percentage of patients readmitted to the hospital within 30 days of discharge, among Medicare patients aged 66 and older who were discharged alive from an all-cause index hospitalization between January 1 and December 1, by age and CKD status, 2016



Data source: Medicare 5% sample. January 1, 2016 point prevalent Medicare patients aged 66 and older, discharged alive from an all-cause index hospitalization between January 1, 2016, and December 1, 2016; unadjusted. Abbreviations: CKD, chronic kidney disease; Rehosp, rehospitalized.

Figure 3.22 compares the rates of all-cause hospitalization by sex. Male patients exhibited higher rates than did females in all outcome categories. Specifically, 6.5% of male CKD patients did not require readmission but later died, 3.0% were rehospitalized and later died within 30 days of the initial discharge, and 19.0% were rehospitalized and lived. CKD patients in all subgroups experienced higher rates of readmission than did those without CKD.

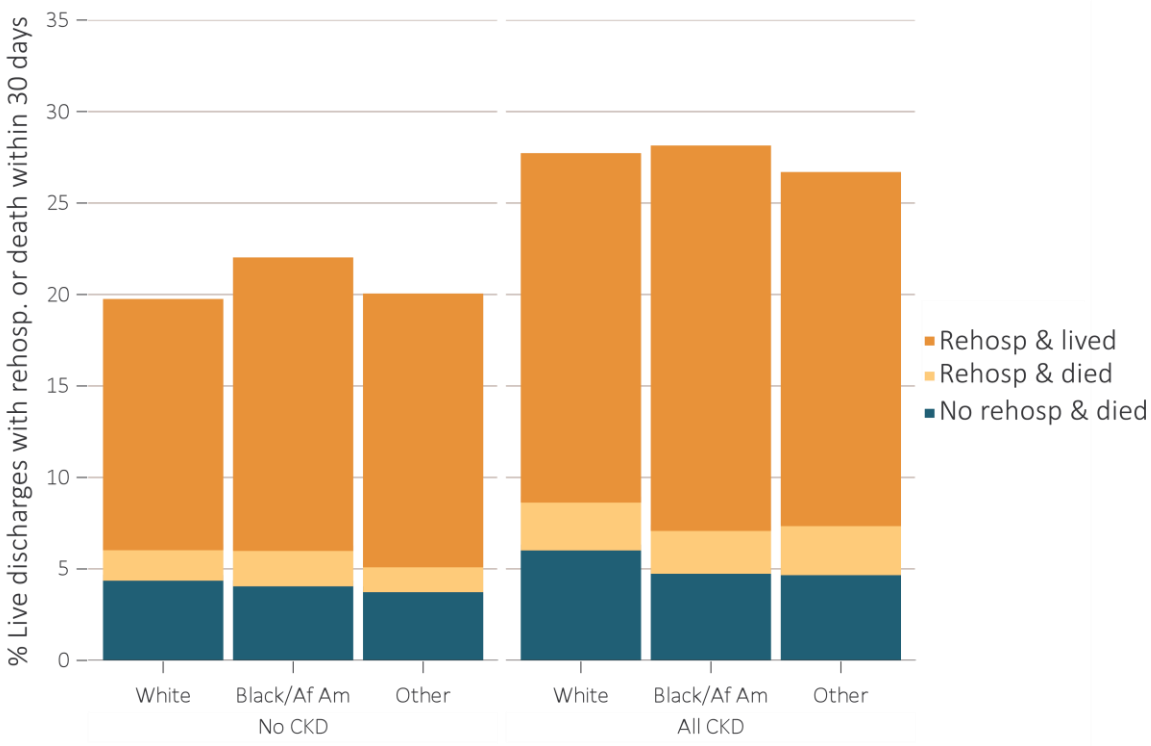
vol 1 Figure 3.22 Unadjusted percentage of patients readmitted to the hospital within 30 days of discharge, among Medicare patients aged 66 and older who were discharged alive from an all-cause index hospitalization between January 1 and December 1, by sex and CKD status, 2016



Data source: Medicare 5% sample. January 1, 2016 point prevalent Medicare patients aged 66 and older, discharged alive from an all-cause index hospitalization between January 1, 2016, and December 1, 2016; unadjusted. Abbreviations: CKD, chronic kidney disease; Rehosp, rehospitalized.

Racial trends in post-discharge outcomes were mixed. As shown in Figure 3.23, for patients without CKD, Blacks who were rehospitalized subsequently survived at greater rates (15.7%) than did both Whites (13.4%) and patients of Other races (14.6%). For patients with CKD, Blacks survived hospital readmission at 20.7%, Whites at 18.8%, and those of Other races at 19.0%. Whites with or without CKD experienced the highest rates of death without readmission (4.5% for no-CKD, 6.2% with CKD); more CKD patients of Other races were observed to have died following readmission (2.7%).

vol 1 Figure 3.23 Unadjusted percentage of patients readmitted to the hospital within 30 days of discharge, among Medicare patients aged 66 and older who were discharged alive from an all-cause index hospitalization between January 1 and December 1, by race and CKD status, 2016



Data Source: Medicare 5% sample. January 1, 2016 point prevalent Medicare patients aged 66 and older, discharged alive from an all-cause index hospitalization between January 1, 2016, and December 1, 2016; unadjusted. Abbreviations: Af Am, African American; CKD, chronic kidney disease; Rehosp, rehospitalized.

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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. PMC3993088

Notes

Chapter 4: Cardiovascular Disease in Patients with CKD

- The prevalence of cardiovascular disease (CVD) was 64.5% among patients aged 66 and older who had chronic kidney disease (CKD), compared to 32.4% among those who did not have CKD (Table 4.1).
- The presence of CKD is associated with worsened short- and long-term prognosis for many common cardiovascular diseases. The adjusted two-year survival of patients with acute myocardial infarction (AMI) and without a diagnosis of CKD was 82%, compared with 75% for CKD Stage 1-2 patients and 59% for Stage 4-5 patients (Figure 4.2).
- The presence of cardiovascular disease is also associated with worsened short- and long-term prognosis for patients with CKD. Over a two-year period, Medicare patients with both heart failure and CKD had an adjusted survival probability of 77.8%, compared to 90.2% for those with CKD alone (Figure 4.5).
- Atrial fibrillation (AF) was common among Medicare patients with CKD (23.8%). The prevalence of AF was higher among males, older persons, and patients with hypertension (HTN), advanced stages of CKD, and heart failure (HF). Nearly half of CKD patients with heart failure had a diagnosis of AF (Table 4.5).
- Angiotensin converting enzyme inhibitors (ACEs) and angiotensin receptor blockers (ARBs) are mainstays of heart failure therapy and were prescribed to 59.9% of CKD patients with HF, compared to 61.2% of non-CKD patients with HF. Although direct oral anticoagulants have been less studied among patients with CKD, these drugs were prescribed to 30.9% of patients with AF and CKD, as compared with 33.2% of patients with AF and no CKD (Table 4.4).

Introduction

Cardiovascular disease (CVD) remains the leading cause of death in the United States and most other developed countries (Centers for Disease Control and Prevention, 2015). It accounts for approximately 39% of deaths among those on dialysis (see Volume 2, Chapter 5: *Mortality*). Among patients with chronic kidney disease (CKD), death from CVD is far more common than progression to end-stage renal disease (ESRD; Gargiulo et al., 2015).

CKD has been identified as an independent risk factor for CVD, and experts have argued that it should be recognized as a coronary disease risk equivalent (Briasoulis and Bakris, 2013; Sarnak et al., 2003), similar to diabetes mellitus (DM). The complex relationship between CVD and kidney disease is thought to be due to shared traditional risk factors, such as DM, hypertension (HTN), physical inactivity, left ventricular hypertrophy, smoking, family history, and dyslipidemia.

Non-traditional risk factors may also exert an additional influence in the presence of CKD—some examples include endothelial dysfunction, vascular medial hyperplasia, sclerosis and calcification, volume overload, abnormalities in mineral metabolism, anemia, malnutrition, inflammation, oxidative stress, and autonomic imbalance. In cardiorenal syndrome, dysfunction in the heart or kidney may directly induce dysfunction in the other organ. In particular, this continues to pose both a diagnostic and therapeutic challenge for managing fluid status when treating those with heart failure (HF) (Husain-Syed et al., 2015). Thus, characterizing the epidemiology of cardiovascular comorbidities is a critical step toward improving morbidity and mortality in the CKD population.

In this chapter, we review recent trends in the prevalence and outcomes of cardiovascular disease in CKD patients and compare these to outcomes of CVD in patients without CKD, focusing on the high-risk, elderly Medicare population.

Methods

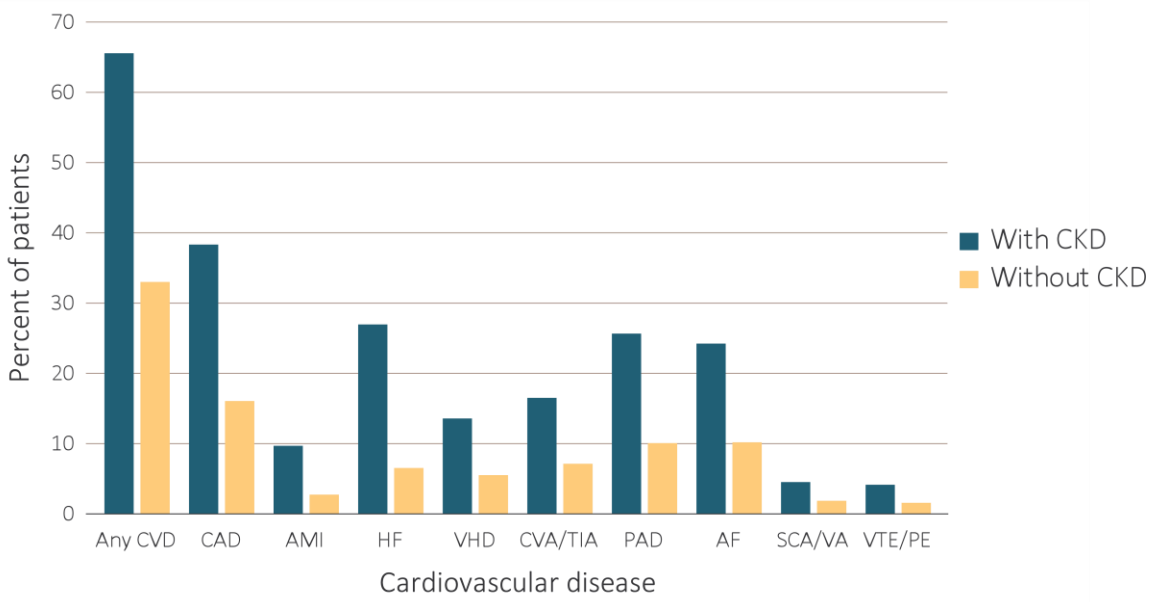
The findings presented in this chapter were drawn from data from the Medicare 5% sample's fee-for-service patients aged 66 and older. Those in the cohort were alive, without end-stage renal disease, and residing in the U.S. on 12/31/2016, with fee-for-service coverage for the entire calendar year of 2016. CKD and CVD diagnoses were obtained via billing claims from the Medicare 5% sample. The overall study cohort for 2016 included 1,262,072 patients, of whom 175,840 had CKD. Details of this data are described in the *Data Sources* section of the *CKD Analytical Methods* chapter.

For an explanation of the analytical methods used to generate the study cohorts, figures, and tables in this chapter, see the section on *Chapter 4* within the *CKD Analytical Methods* chapter. Downloadable Microsoft Excel and PowerPoint files containing the data and graphics for these figures and tables are available from the *USRDS website*.

Cardiovascular Disease Prevalence and Outcomes in CKD

As shown in Figure 4.1, elderly CKD patients had a greater burden of cardiovascular disease than did their counterparts without a diagnosis of CKD. A wide range of conditions were more common in CKD patients aged 66 and older than in those without CKD, including stable coronary artery disease (CAD), acute myocardial infarction (AMI), heart failure (HF), valvular heart disease (VHD), stroke (cerebrovascular accident/transient ischemic attack, or CVA/TIA), peripheral arterial disease (PAD), atrial fibrillation (AF), sudden cardiac arrest and ventricular arrhythmias (SCA/VA), and venous thromboembolism and pulmonary embolism (VTE/PE). Indeed, the overall prevalence of these cardiovascular conditions was double among those with CKD compared to those without (65.1% versus 32.6%). Part of this differential results from the older age of CKD patients (see Volume 1, Chapter 2: *Identification and Care of Patients with CKD)*.

vol 1 Figure 4.1 Prevalence of common cardiovascular diseases in patients with or without CKD, 2016



Data Source: Special analyses, Medicare 5% sample. Abbreviations: AF, atrial fibrillation; AMI, acute myocardial infarction; CAD, coronary artery disease; CKD, chronic kidney disease; CVA/TIA, cerebrovascular accident/transient ischemic attack; CVD, cardiovascular disease; HF, heart failure; PAD, peripheral arterial disease; SCA/VA, sudden cardiac arrest and ventricular arrhythmias; VHD, valvular heart disease; VTE/PE, venous thromboembolism and pulmonary embolism.

The prevalence of these conditions generally increases with age and presence of CKD (Table 4.1). The relationships with race, ethnicity, and sex are less straightforward.

vol 1 Table 4.1 Prevalence of (a) cardiovascular comorbidities & (b) annual incidence of cardiovascular procedures, by CKD status, age, race, & sex, 2016

	(a) Cardiovascular comorbidities									
	# Patients	% Patients								
		Overall	66-69	70-74	75-84	85+	White	Blk/Af Am	Other	Male	Female
Any CVD											
Without CKD	1,086,232	32.4	19.8	27.3	39.2	52.1	33.4	28.7	23.8	36.3	29.5
Any CKD	175,840	64.5	50.0	56.9	66.9	76.5	65.3	62.1	57.3	68.1	61.0
Coronary artery disease (CAD)											
Without CKD	1,086,232	15.6	10.0	13.9	19.4	22.1	16.2	12.3	11.9	21.2	11.5
Any CKD	175,840	37.9	29.3	34.4	40.2	42.8	38.8	33.2	33.3	45.0	31.1
Acute myocardial infarction (AMI)											
Without CKD	1,086,232	2.3	1.6	2.1	2.7	3.4	2.4	1.9	1.6	3.1	1.7
Any CKD	175,840	9.3	8.1	8.5	9.5	10.4	9.5	8.2	7.6	11.0	7.6
Heart failure (HF)											
Without CKD	1,086,232	6.1	3.1	4.3	7.2	13.3	6.2	7.1	4.2	6.5	5.9
Any CKD	175,840	25.9	18.3	20.1	25.7	36.1	25.9	28.4	21.5	25.9	25.9
Valvular heart disease (VHD)											
Without CKD	1,086,232	5.1	2.6	3.9	6.6	9.3	5.4	3.4	3.5	5.0	5.2
Any CKD	175,840	12.8	7.5	9.3	13.6	18.1	13.4	10.1	10.2	12.8	12.9
Cerebrovascular accident/transient ischemic attack (CVA/TIA)											
Without CKD	1,086,232	6.7	3.7	5.5	8.6	11.0	6.8	7.2	4.9	6.9	6.6
Any CKD	175,840	16.1	11.4	13.8	17.5	18.9	15.9	18.6	14.7	16.4	15.8
Peripheral artery disease (PAD)											
Without CKD	1,086,232	9.7	4.8	7.1	11.6	20.1	9.8	10.6	7.1	10.0	9.4
Any CKD	175,840	25.2	17.4	20.9	26.0	32.8	25.3	26.3	22.2	26.6	24.0
Atrial fibrillation (AF)											
Without CKD	1,086,232	9.8	4.4	7.0	12.5	19.8	10.5	4.8	5.3	11.2	8.7
Any CKD	175,840	23.8	13.5	17.3	25.3	33.7	25.5	15.0	15.6	26.1	21.6
Cardiac arrest and ventricular arrhythmias (SCA/VA)											
Without CKD	1,086,232	1.4	1.0	1.4	1.8	1.8	1.5	1.1	0.9	2.0	1.0
Any CKD	175,840	4.1	3.4	3.9	4.4	4.3	4.1	4.5	3.0	5.5	2.8
Venous thromboembolism and pulmonary embolism (VTE/PE)											
Without CKD	1,086,232	1.2	0.8	1.0	1.3	1.8	1.2	1.3	0.6	1.2	1.1
Any CKD	175,840	3.7	3.3	3.4	3.8	4.2	3.7	5.1	2.2	3.7	3.8

Table 4.1 continued on next page.

vol 1 Table 4.1 Prevalence of (a) cardiovascular comorbidities & (b) annual incidence of cardiovascular procedures, by CKD status, age, race, & sex, 2016 (continued)

	(b) Cardiovascular procedures									
	# Patients	% Patients								
		Overall	66-69	70-74	75-84	85+	White	Blk/Af Am	Other	Male	Female
Revascularization – percutaneous coronary interventions (PCI)											
Without CKD	169,959	2.1	3.0	2.5	1.9	1.3	2.1	1.5	2.2	2.2	2.0
Any CKD	66,659	3.1	4.1	3.5	3.4	2.0	3.1	2.9	3.3	3.2	2.9
Revascularization – coronary artery bypass graft (CABG)											
Without CKD	169,959	1.1	1.8	1.5	1.0	0.2	1.1	0.6	1.3	1.3	0.7
Any CKD	66,659	1.5	2.7	2.4	1.6	0.3	1.6	1.0	1.0	2.0	0.9
Implantable cardioverter defibrillators & cardiac resynchronization therapy with defibrillator (ICD/CRT-D)											
Without CKD	66,426	0.6	0.6	0.8	0.6	0.3	0.6	0.4	0.6	0.8	0.4
Any CKD	45,552	1.0	1.5	1.4	1.1	0.6	1.0	1.4	1.0	1.4	0.7
Carotid artery stenting and carotid artery endarterectomy (CAS/CEA)											
Without CKD	268,808	0.5	0.6	0.7	0.6	0.2	0.6	0.3	0.4	0.6	0.4
Any CKD	93,656	0.7	0.8	0.8	0.8	0.4	0.7	0.4	0.6	0.8	0.6

Data Source: Special analyses, Medicare 5% sample. Patients aged 66 and older, alive, without end-stage renal disease, and residing in the United States on 12/31/2016 with fee-for-service coverage for the entire calendar year. Abbreviations: AF, atrial fibrillation; AMI, acute myocardial infarction; Blk/Af Am, Black African American; CABG, coronary artery bypass grafting; CAD, coronary artery disease; CAS/CEA, carotid artery stenting and carotid endarterectomy; CKD, chronic kidney disease; CVA/TIA, cerebrovascular accident/transient ischemic attack; CVD, cardiovascular disease; HF, heart failure; 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; VHD, valvular heart disease; VTE/PE, venous thromboembolism and pulmonary embolism. (a) The denominators for overall prevalence of all cardiovascular comorbidities were Medicare enrollees aged 66+ by CKD status. (b) The denominators for overall prevalence of PCI and CABG were Medicare enrollees aged 66+ with CAD by CKD status. The denominators for overall prevalence of ICD/CRT-D were Medicare enrollees aged 66+ with HF by CKD status. The denominators for overall prevalence of CAS/CEA were Medicare enrollees aged 66+ with CAD, CVA/TIA, or PAD by CKD status.

The presence of CKD also worsens the short- and long-term prognosis for many common cardiovascular diseases and for patients who undergo cardiovascular procedures. From a pathophysiologic standpoint, mechanisms by which CKD may predispose patients to cardiovascular events include alterations in sodium and fluid balance, vascular calcification, and inflammatory changes leading to atherosclerotic plaque destabilization (Briasoulis and Bakris, 2013). Figures 4.2.a through 4.2.i and Table 4.2 illustrate survival among patients with CVD. Figures 4.3.a through 4.3.d and Table 4.3 illustrate survival among patients undergoing cardiovascular procedures. Results were stratified by the presence of CKD and its severity, and adjusted for age and sex. In general, CKD patients had a lower probability of survival for all of the conditions reported, with late stages of CKD being associated with the worst outcomes. For example, the adjusted two-year survival of AMI patients without a diagnosis of CKD was 81.7%, compared to 74.5% for CKD Stage 1-2 patients, and 58.6% for CKD Stage 4-5 patients (see Table A for CKD stage definitions). This pattern also held for patients who underwent common major procedures for the treatment of CVD. The adjusted two-year survival of patients undergoing PCI without a diagnosis of CKD was 83.2%, compared to 76.3% for CKD Stage 1-2 patients and 64.3% for CKD Stage 4-5 patients.

Table A. ICD-9-CM and ICD-10-CM codes for Chronic Kidney Disease (CKD) stages

ICD-9-CM code[a]	ICD-10-CM code	Stage
585.1	N18.1	CKD, Stage 1
585.2	N18.2	CKD, Stage 2 (mild)
585.3	N18.3	CKD, Stage 3 (moderate)
585.4	N18.4	CKD, Stage 4 (severe)
585.5	N18.5	CKD, Stage 5 (excludes 585.6: Stage 5, requiring chronic dialysis[b])
CKD Stage-unspecified	CKD Stage-unspecified	For these analyses, identified by multiple codes including 585.9, 250.4x, 403.9x & others for ICD-9-CM and A18.xx, E08.xx, E11.xx and others for ICD-10-CM.

[a] For analyses in this chapter, CKD stage estimates require at least one occurrence of a stage-specific code, and the last available CKD stage in a given year is used. [b] In USRDS analyses, patients with ICD-9-CM code 585.6 or ICD-10-CM code N18.6 & with no ESRD 2728 form or other indication of end-stage renal disease (ESRD) are considered to have code 585.5 or N18.5.

vol 1 Figure 4.2 Probability of survival of patients with a prevalent cardiovascular disease, by CKD status, adjusted for age and sex, 2015-2016

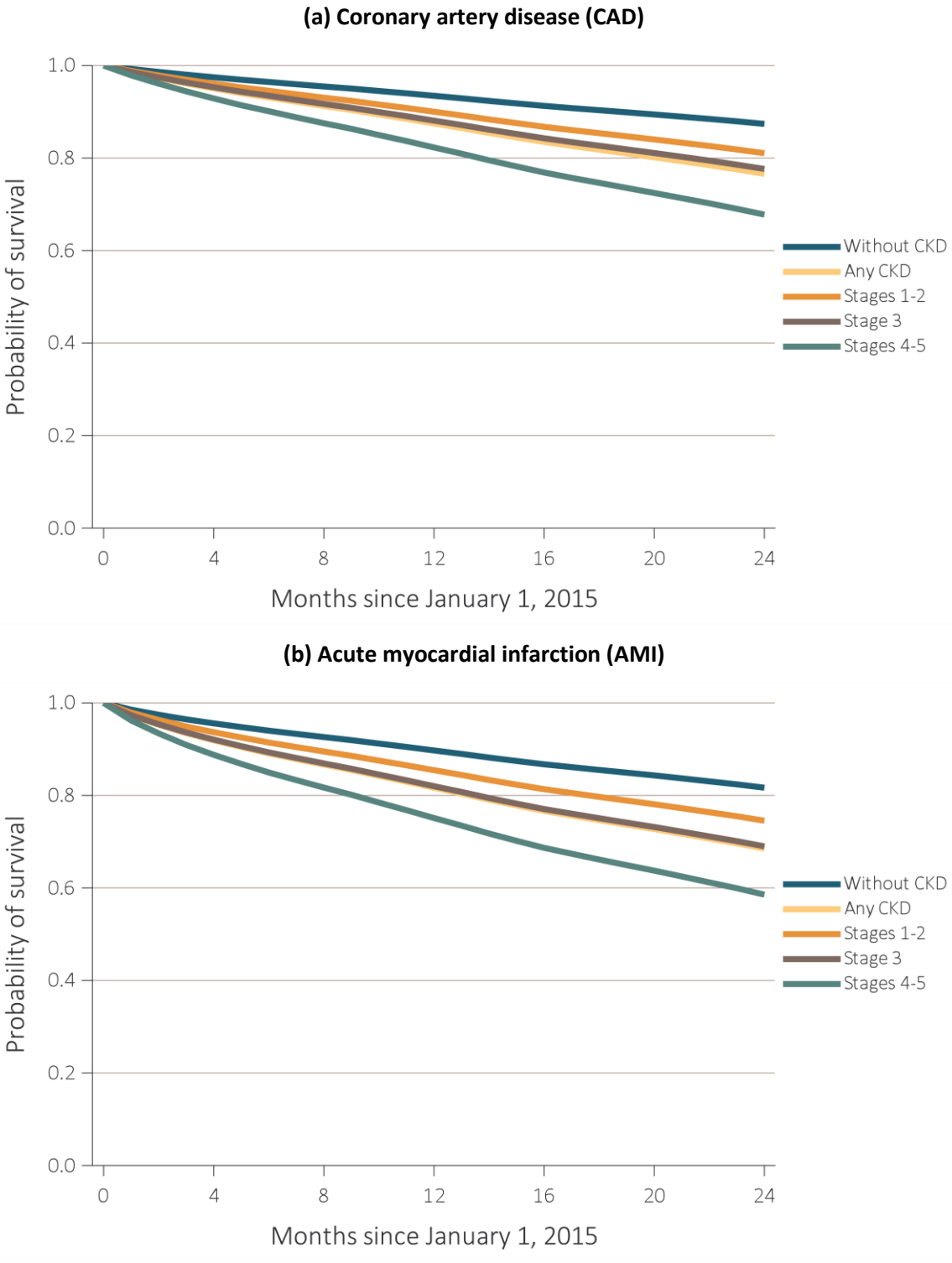


Figure 4.2 continued on next page.

vol 1 Figure 4.2 Probability of survival of patients with a prevalent cardiovascular disease, by CKD status, adjusted for age and sex, 2015-2016 (continued)

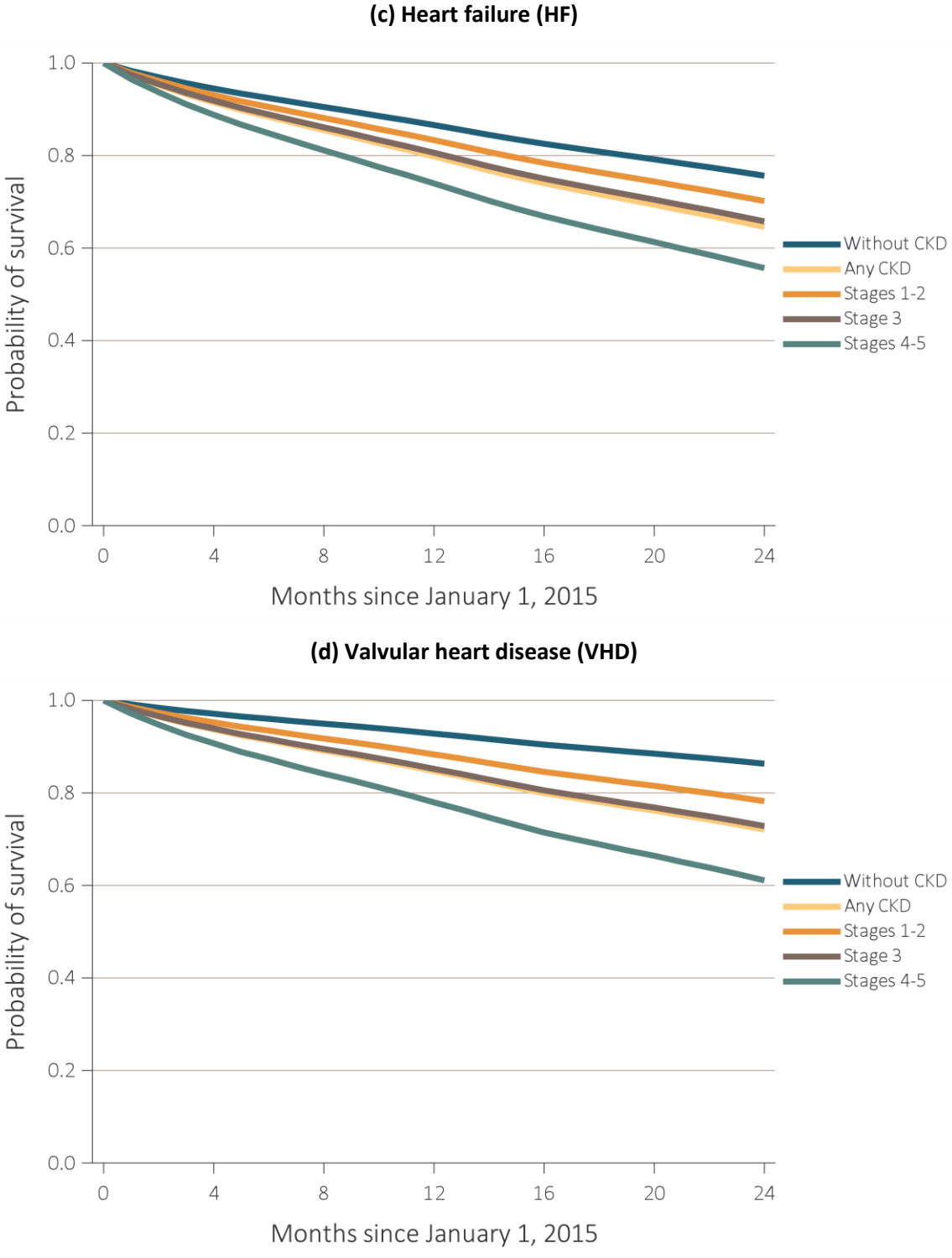
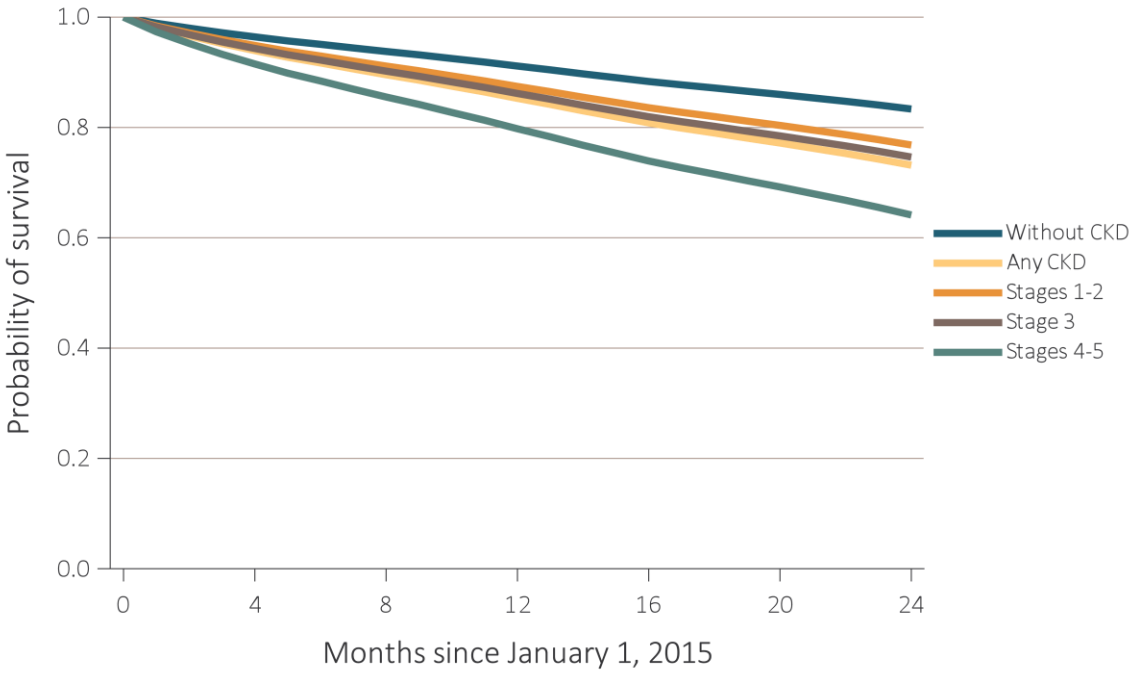


Figure 4.2 continued on next page.

vol 1 Figure 4.2 Probability of survival of patients with a prevalent cardiovascular disease, by CKD status, adjusted for age and sex, 2015-2016 (continued)

(e) Cerebrovascular accident/transient ischemic attack (CVA/TIA)



(f) Peripheral arterial disease (PAD)

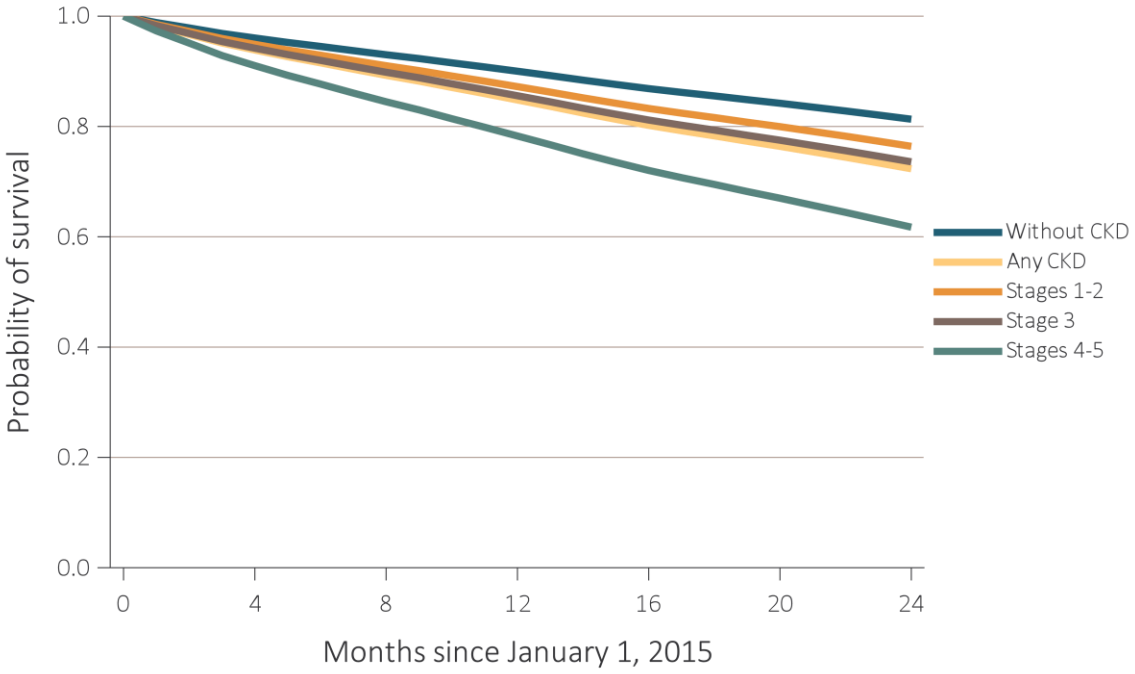
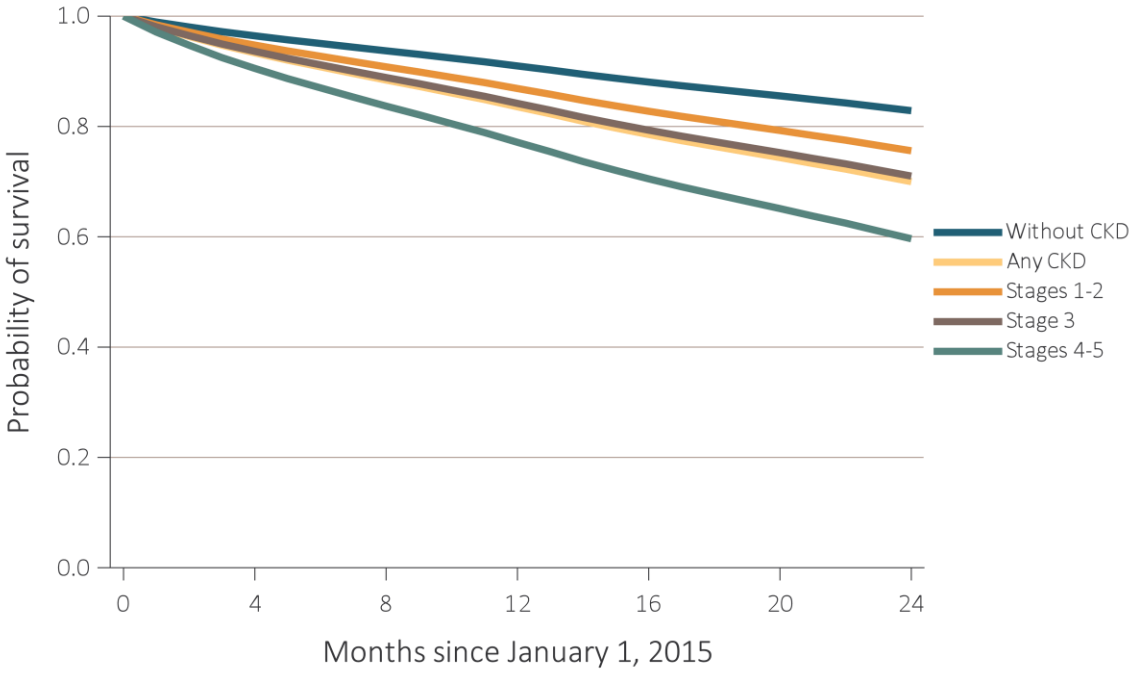


Figure 4.2 continued on next page.

vol 1 Figure 4.2 Probability of survival of patients with a prevalent cardiovascular disease, by CKD status, adjusted for age and sex, 2015-2016 (continued)

(g) Atrial fibrillation (AF)



(h) Sudden cardiac arrest and ventricular arrhythmias (SCA/VA)

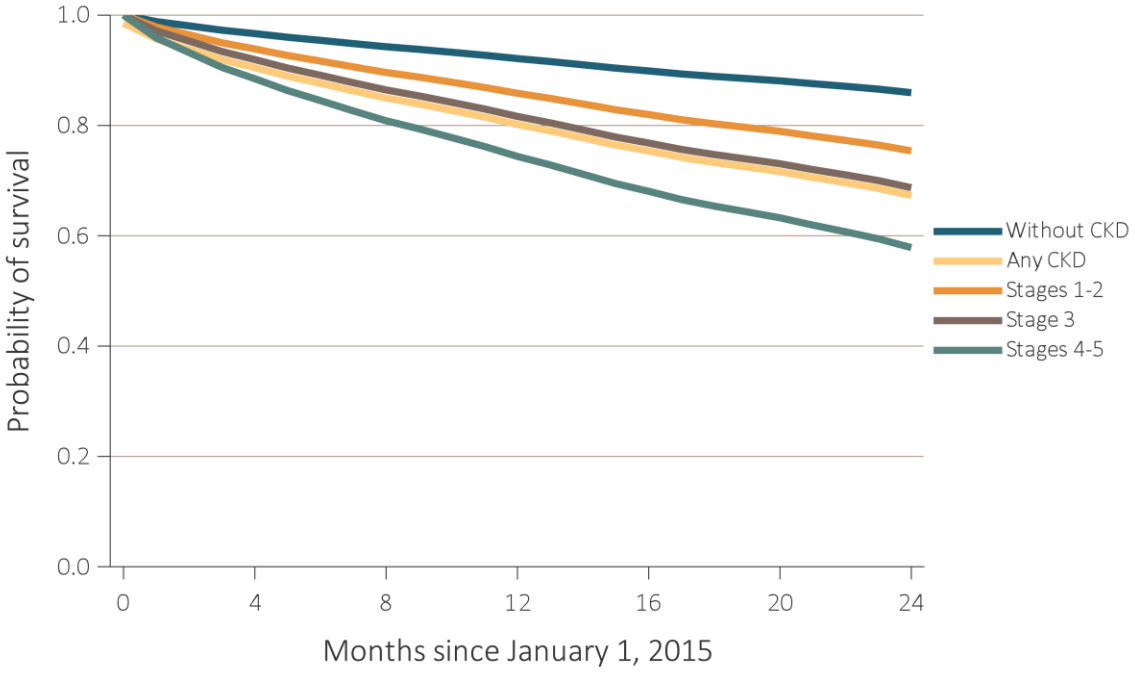
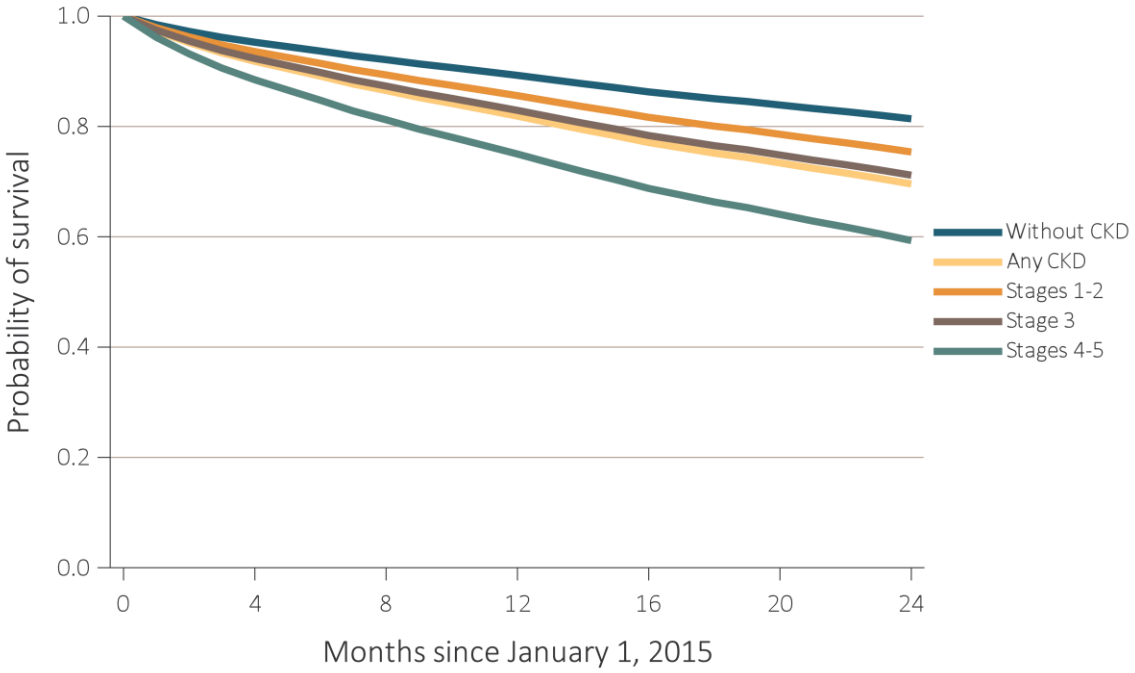


Figure 4.2 continued on next page.

vol 1 Figure 4.2 Probability of survival of patients with a prevalent cardiovascular disease, by CKD status, adjusted for age and sex, 2015-2016 (continued)

(i) Venous thromboembolism and pulmonary embolism (VTE/PE)



Data Source: Special analyses, Medicare 5% sample. Patients aged 66 and older, alive, without end-stage renal disease, and residing in the United States on 12/31/2014, with fee-for-service coverage for the entire calendar year. Abbreviation: CKD, chronic kidney disease.

vol 1 Table 4.2 Two-year survival of patients with a prevalent cardiovascular disease, by CKD status, adjusted for age and sex, 2015-2016

	CKD status				
Cardiovascular disease	No CKD (%)	CKD (%)	Stages 1 to 2 (%)	Stage 3 (%)	Stages 4 to 5 (%)
CAD	87.4	76.6	81.1	77.6	67.4
AMI	81.7	68.5	74.5	69.0	58.6
HF	75.6	64.6	70.2	65.8	55.7
VHD	86.3	72.1	78.2	72.8	61.1
CVA/TIA	83.3	73.2	76.8	74.6	64.1
PAD	81.3	72.3	76.4	73.6	61.7
AF	82.9	70.0	75.6	71.0	59.6
SCA/VA	86.0	68.8	75.4	68.7	57.9
VTE/PE	81.4	69.6	75.4	71.2	59.3

Data Source: Special analyses, Medicare 5% sample. Patients aged 66 and older, alive, without end-stage renal disease, and residing in the United States on 12/31/2014, with fee-for-service coverage for the entire calendar year. Abbreviations: AF, atrial fibrillation; AMI, acute myocardial infarction; CAD, coronary artery disease; CKD, chronic kidney disease; CVA/TIA, cerebrovascular accident/transient ischemic attack; HF, heart failure; PAD, peripheral arterial disease; SCA/VA, sudden cardiac arrest and ventricular arrhythmias; VHD, valvular heart disease; VTE/PE, venous thromboembolism and pulmonary embolism.

vol 1 Figure 4.3 Probability of survival of patients with a cardiovascular procedure, by CKD status, adjusted for age and sex, 2014-2016

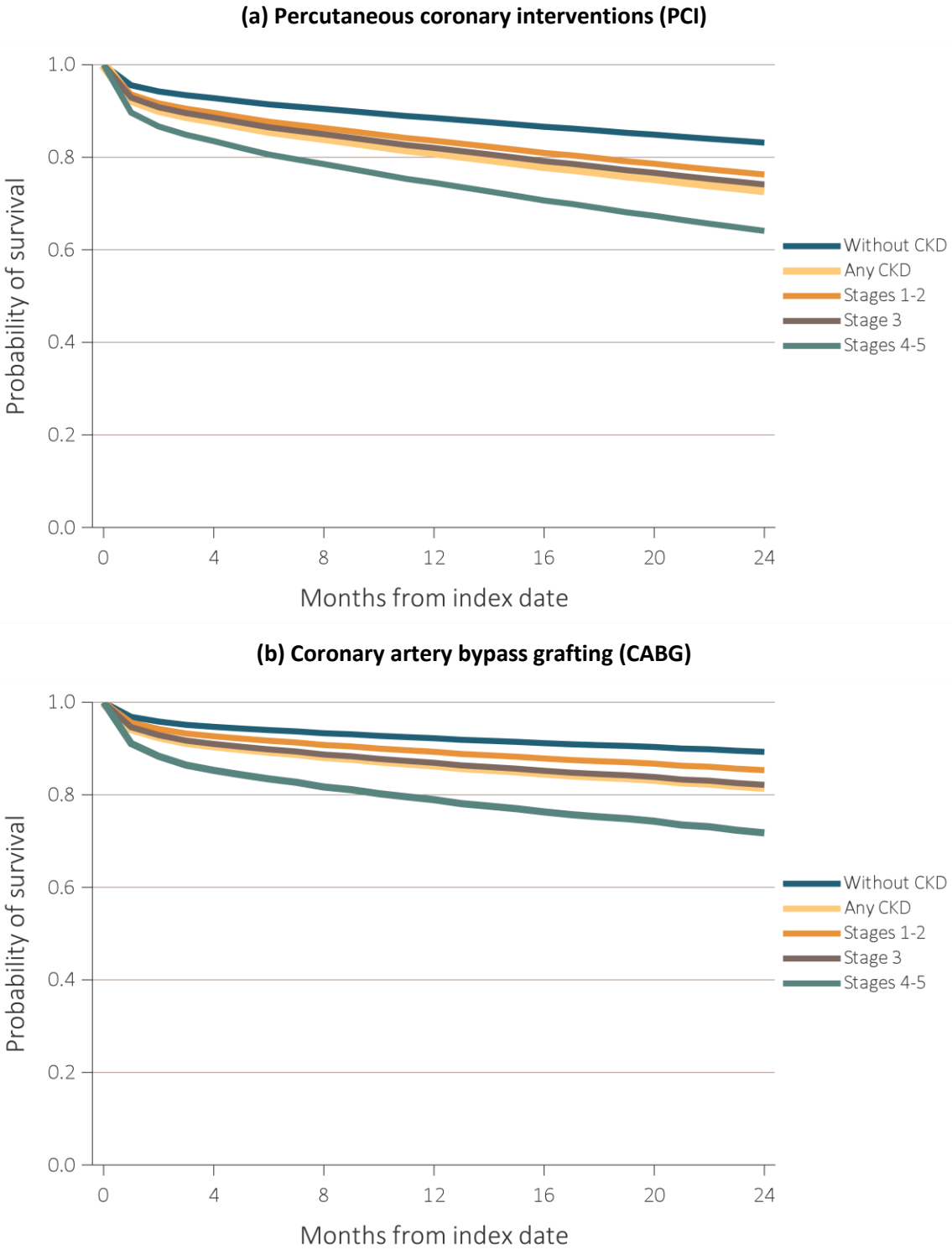
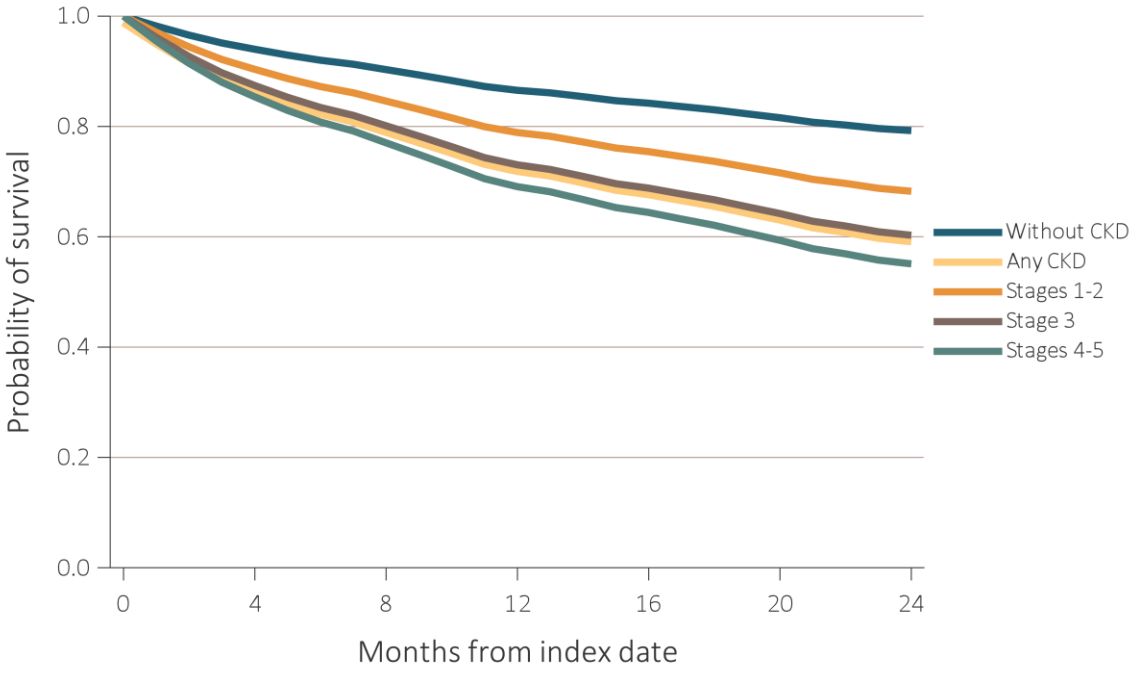


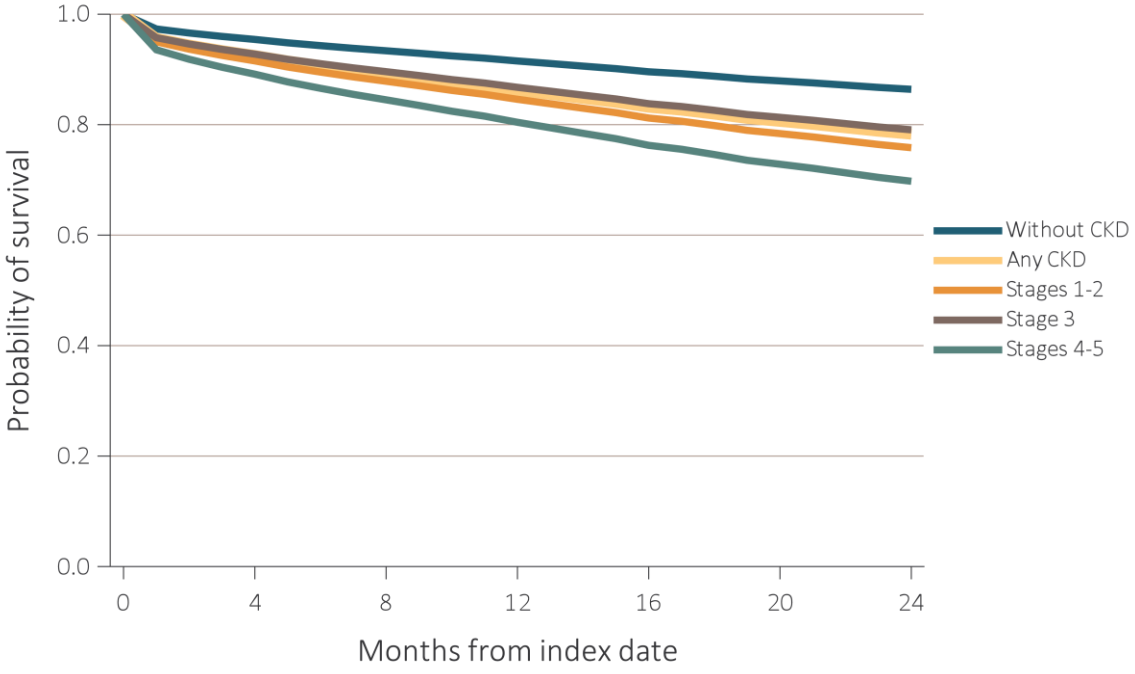
Figure 4.3 continued on next page.

vol 1 Figure 4.3 Probability of survival of patients with a cardiovascular procedure, by CKD status, adjusted for age and sex, 2014-2016 (continued)

(c) Implantable cardioverter defibrillators/cardiac resynchronization therapy with defibrillator devices (ICD/CRT-D)



(d) Carotid artery stenting and carotid endarterectomy (CAS/CEA)



Data Source: Special analyses, Medicare 5% sample. Patients aged 66 and older, alive, without end-stage renal disease, and residing in the United States on the index date, which was the date of the first procedure claim, with fee-for-service coverage for the entire year prior to this date. Abbreviation: CKD, chronic kidney disease.

vol 1 Table 4.3 Two-year survival of patients with a cardiovascular procedure, by CKD status, adjusted for age and sex, 2014-2016

	CKD status				
Cardiovascular procedure	No CKD (%)	CKD (%)	Stages 1 to 2 (%)	Stage 3 (%)	Stages 4 to 5 (%)
PCI	83.2	73.0	76.3	74.1	64.3
CABG	89.3	81.8	85.3	82.2	71.8
ICD/CRT-D	79.2	60.3	68.3	60.3	55.1
CAS/CEA	86.4	78.2	78.5	79.0	70.1

Data Source: Special analyses, Medicare 5% sample. Patients aged 66 and older, alive, without end-stage renal disease, and residing in the United States on the index date, which was the date of the first procedure claim, with fee-for-service coverage for the entire year prior to this date. Abbreviations: CABG, coronary artery bypass grafting; CAS/CEA, carotid artery stenting and carotid endarterectomy; CKD, chronic kidney disease; ICD/CRT-D, implantable cardioverter defibrillators/cardiac resynchronization therapy with defibrillator devices; PCI, percutaneous coronary interventions.

Cardiovascular Disease and Pharmacological Treatments

For clinicians, pharmacological treatment of cardiovascular disorders in the CKD population is fraught with challenges given that many drugs are cleared by the kidneys. Patients with advanced renal dysfunction are often excluded from large clinical trials, so the risk-benefit ratios of their treatment with various medications are often unclear. Angiotensin converting enzyme inhibitors (ACEs) and angiotensin receptor blockers (ARBs) are mainstays of HF therapy and are frequently prescribed to CKD patients. In 2016, these drugs were prescribed to 59.7% of CKD patients, as compared with 53.8% of non-CKD patients who also had CVD (Table 4.4). This difference may be explained in part by the fact that ACEs and ARBs are also used for their nephroprotective effects. Despite the potential clinical benefits, these drugs must be prescribed with caution in this population due to increased risk of hyperkalemia.

Warfarin dose adjustment can be more difficult among patients with CKD, and renal failure is a risk factor for bleeding while on warfarin therapy. Although direct oral anticoagulants have not been as well studied as warfarin among patients with CKD, these drugs were used quite frequently in this group, particularly for stroke prevention in the context of AF (Table 4.4). Aspirin is commonly recommended to those with cardiovascular diseases such as CAD and PAD, regardless of the patient's renal function. As it is most often purchased over the counter, however, prescribing rates for aspirin were low (<1%) for patients with all types of CVD; therefore, aspirin is omitted from Table 4.4.

vol 1 Table 4.4 Cardiovascular pharmacological treatments by (a) comorbidities and (b) procedures, by CKD status, 2016

		(a) Cardiovascular comorbidities					
		% Patients					
	# Patients	Beta-blockers	Statins	P2Y12 inhibitors	Warfarin	Direct Oral Anticoagulants	ACEs/ ARBs
Any CVD							
Without CKD	247,266	54.6	63.0	16.2	12.8	11.8	53.8
Any CKD	80,331	65.1	68.2	20.4	15.3	13.4	59.7
Coronary artery disease (CAD)							
Without CKD	119,066	65.2	75.7	26.1	9.8	9.5	59.2
Any CKD	47,197	73.0	75.7	28.7	14.8	13.0	61.8
Acute myocardial infarction (AMI)							
Without CKD	17,202	74.8	78.4	40.4	11.5	11.5	63.6
Any CKD	11,514	79.9	78.8	39.8	16.6	14.8	63.4
Heart failure (HF)							
Without CKD	47,170	70.5	60.6	16.6	18.9	16.6	61.2
Any CKD	32,658	75.6	67.3	21.7	20.5	17.1	59.9
Valvular heart disease (VHD)							
Without CKD	38,681	57.6	61.7	13.9	15.4	13.1	55.0
Any CKD	15,804	71.3	69.0	21.5	20.2	16.9	61.0
Cerebrovascular accident/transient ischemic attack (CVA/TIA)							
Without CKD	51,550	49.1	69.3	24.7	10.5	9.9	54.4
Any CKD	20,225	64.7	73.5	30.6	14.2	13.0	60.8
Peripheral artery disease (PAD)							
Without CKD	75,554	48.3	59.5	17.8	9.4	8.3	52.3
Any CKD	31,982	63.6	68.2	24.3	14.0	12.1	59.5
Atrial fibrillation (AF)							
Without CKD	73,778	67.2	57.9	8.7	34.6	33.2	51.3
Any CKD	29,174	74.0	65.7	14.2	34.8	30.9	56.8
Cardiac arrest and ventricular arrhythmias (SCA/VA)							
Without CKD	10,866	69.9	63.9	17.4	13.2	14.4	58.4
Any CKD	5,014	79.4	70.6	25.2	22.0	19.4	64.0
Venous thromboembolism and pulmonary embolism (VTE/PE)							
Without CKD	8,895	41.7	49.4	7.8	47.8	31.8	45.3
Any CKD	4,695	59.3	57.2	12.0	45.2	32.5	54.2

Table 4.4 continued on next page.

vol 1 Table 4.4 Cardiovascular pharmacological treatments by (a) comorbidities and (b) procedures, (%) by CKD status, 2016 (continued)

		(b) Cardiovascular procedures					
		% Patients					
	# Patients	Beta-blockers	Statins	P2Y12 inhibitors	Warfarin	Direct Oral Anticoagulants	ACEs/ ARBs
Revascularization – percutaneous coronary interventions (PCI)							
Without CKD	2,390	84.8	88.2	94.5	7.7	8.6	73.9
Any CKD	1,418	88.5	87.0	92.5	13.6	12.6	70.0
Revascularization – coronary artery bypass graft (CABG)							
Without CKD	1,210	92.1	90.0	39.1	17.4	12.0	68.3
Any CKD	681	92.7	90.7	38.6	21.4	16.0	70.5
Implantable cardioverter defibrillators & cardiac resynchronization therapy with defibrillator (ICD/CRT-D)							
Without CKD	337	85.2	72.1	25.2	24.9	23.7	72.7
Any CKD	345	88.4	74.5	29.3	30.1	28.7	72.5
Carotid artery stenting and carotid artery endarterectomy (CAS/CEA)							
Without CKD	1,018	56.2	82.8	50.3	7.5	11.1	63.2
Any CKD	437	71.4	87.6	54.5	12.1	11.4	65.7

Data Source: Special analyses, Medicare 5% sample. Patients aged 66 and older, alive, without end-stage renal disease, and residing in the United States on 12/31/2016 with fee-for-service and Part D coverage for the entire calendar year. Abbreviations: ACEs/ARBs, Angiotensin converting enzyme inhibitors and angiotensin receptor blockers; AF, atrial fibrillation; AMI, acute myocardial infarction; CAD, coronary artery disease; CABG, coronary artery bypass grafting; CAS/CEA, carotid artery stenting and carotid endarterectomy; CKD, chronic kidney disease; CVA/TIA, cerebrovascular accident/transient ischemic attack; CVD, cardiovascular disease; HF, heart failure; 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; VHD, valvular heart disease; VTE/PE, venous thromboembolism and pulmonary embolism.

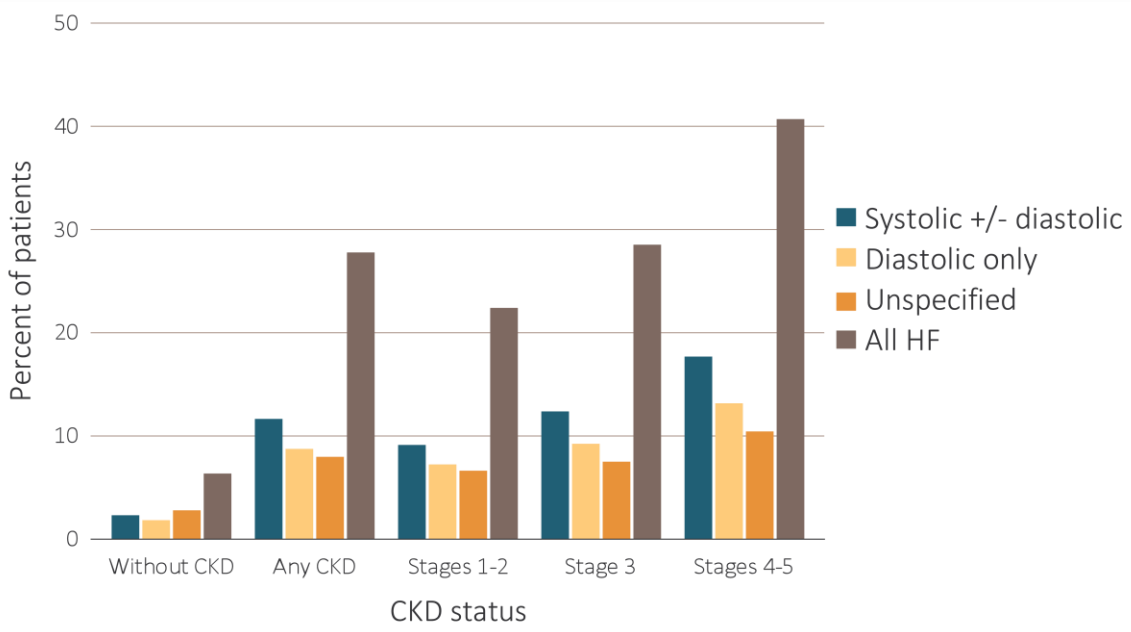
Heart Failure and CKD

Heart failure (HF) is among the more frequently diagnosed cardiovascular diseases in the CKD population. Given the critical role of the kidney in sodium and fluid handling, derangements in kidney function can have a profound impact on intracardiac filling pressures. Conversely, in the setting of heart failure when intracardiac filling pressures are elevated and/or cardiac output is reduced, venous congestion and reduced perfusion can worsen kidney function, often in a dynamic fashion. This bidirectional pathophysiologic interaction between heart and kidney, often referred to as cardiorenal syndrome (Damman and Testani, 2015), is both clinically challenging and epidemiologically important, particularly as the U.S. population ages.

In 2016, the prevalence of HF in CKD patients aged 66 and older was close to 26%, compared to 6% among patients without CKD (Table 4.1). Given its importance in this population, we further examined key characteristics of HF in CKD patients after stratifying HF based on presence or absence of left ventricular systolic dysfunction (i.e., "systolic" heart failure with decreased ejection fraction, "diastolic" heart failure with preserved ejection fraction, or unspecified; Figure 4.4). For ease of reporting and consistency with clinical approaches for categorizing the disease, systolic HF includes patients with left ventricular systolic dysfunction, regardless of the presence of concomitant diastolic dysfunction. Patients with isolated diastolic HF were treated separately, since long-term risk assessments and treatments vary for this group.

All types of HF were more common among those with CKD than among non-CKD patients. The relative proportion of CKD patients with systolic HF was higher than with diastolic HF, and increased with greater severity of CKD stage. The percentage of patients without CKD who had unspecified HF was slightly higher than for systolic or diastolic HF. For patients with CKD, the percentage with unspecified HF was slightly lower than with systolic HF (Figure 4.4).

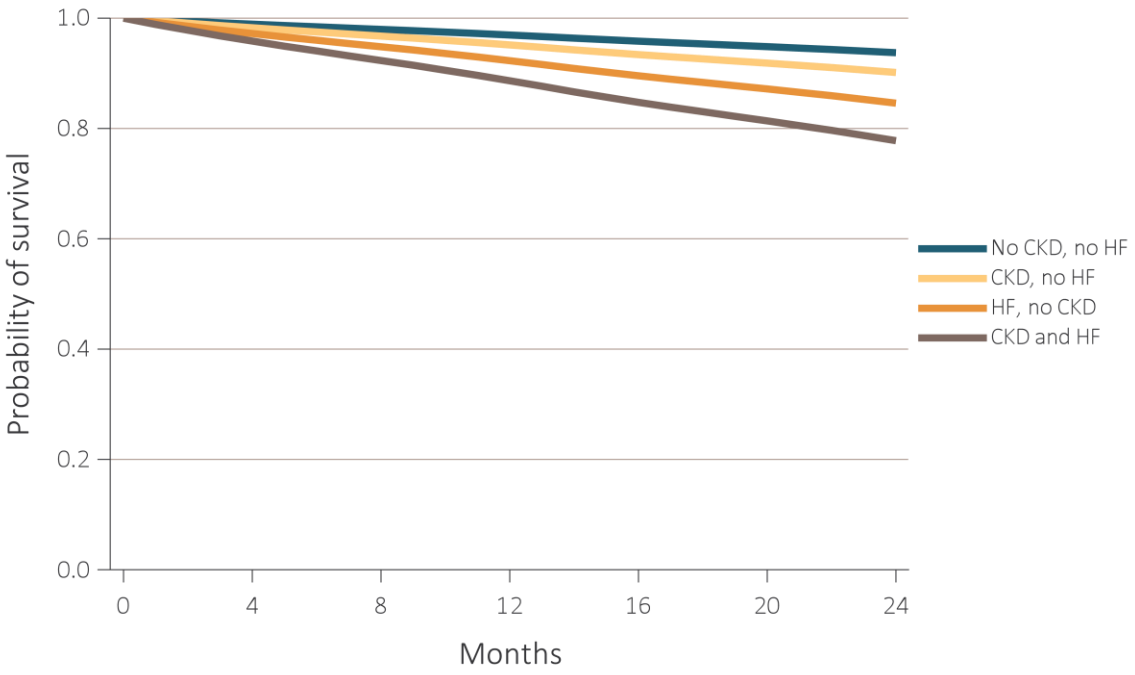
vol 1 Figure 4.4 Heart failure in patients with or without CKD, 2016



Data Source: Special analyses, Medicare 5% sample. Patients aged 66 and older, alive, without end-stage renal disease, and residing in the United States on 12/31/2016 with fee-for-service coverage for the entire calendar year. Abbreviation: CKD, chronic kidney disease.

The presence of HF reduced the probability of survival among patients both with and without CKD (Figure 4.5), but to a greater extent among those with CKD (p-value for interaction <0.0001). Over a two-year period, patients with both HF and CKD had an adjusted survival probability of 77.8%, as compared to 84.6% for those with HF alone, 90.2% for those with CKD alone, and 93.7% for those without HF or CKD.

vol 1 Figure 4.5 Adjusted survival of patients by CKD and heart failure status, 2015-2016



Data Source: Special analyses, Medicare 5% sample. Patients aged 66 and older, alive, without end-stage renal disease, and residing in the United States on 12/31/2014 with fee-for-service coverage for the entire calendar year. Survival was adjusted for age, sex, race, diabetic status, and hypertension status. Abbreviation: CKD, chronic kidney disease.

Atrial Fibrillation and CKD

Atrial fibrillation (AF) is one of the most common arrhythmias seen in the general U.S. population, and is associated with significant morbidity and mortality. Multiple comorbidities that are common among CKD patients, including hypertension, HF, diabetes mellitus, and obesity, are well-established risk factors for AF. Cardiac structural changes accompanying these disease states, including left ventricular hypertrophy, atrial dilation, and atrial fibrosis, have been implicated in the pathophysiology of AF (Lau et al., Circulation 2017). The prevalence of AF among CKD patients is high, being present in approximately one-quarter of the population.

In 2016, the prevalence of AF increased with more advanced stages of CKD, age, male sex, white race, hypertension, and heart failure (Table 4.5). In patients with CKD, the presence of HF increased the prevalence of AF to about half of all patients. Patients with AF and CKD have an increased risk of stroke and bleeding, making the use of oral anticoagulants challenging, as demonstrated by recent reports. Warfarin was prescribed to 34.6% of patients without CKD and 34.8% of patients with CKD, while direct oral anticoagulants were prescribed to 33.2% of patients without CKD and 30.9% of patients with CKD (Table 4.4).

vol 1 Table 4.5 Prevalence of atrial fibrillation by stage of CKD, age, race, sex, and diabetic, hypertension, and heart failure status, 2016

	No CKD	CKD stage				
		Stages 1-2	Stage 3	Stages 4-5	Unknown stage	All CKD stages
# Patients	1,086,232	18,750	88,322	14,833	53,935	175,840
Atrial fibrillation (Overall)	9.8	21.3	25.4	28.3	20.9	23.8
Age						
66-69	4.4	11.9	15.5	17.8	11.3	13.5
70-74	7.0	15.9	18.4	22.0	15.4	17.3
75-84	12.5	23.2	26.1	28.3	23.7	25.3
85+	19.8	32.4	34.0	35.6	32.7	33.7
Sex						
Male	11.2	24.1	28.2	30.8	22.4	26.1
Female	8.7	18.5	22.8	26.3	19.2	21.6
Race						
White	10.5	23.1	27.1	30.8	22.2	25.5
Black/African American	4.8	13.9	15.7	18.3	12.7	15.0
Other	5.3	13.9	16.9	19.1	13.3	15.6
Comorbidity						
No diabetes	9.0	21.0	25.2	28.1	20.2	23.4
Diabetes	12.9	21.7	25.6	28.5	21.6	24.3
No hypertension	4.0	9.8	14.3	15.5	8.6	11.0
Hypertension	14.3	22.5	26.2	28.9	23.3	25.2
No heart failure	7.5	13.4	15.1	15.0	13.7	14.4
Heart failure	44.6	50.0	51.8	48.2	49.4	50.6

Data Source: Special analyses, Medicare 5% sample. Patients aged 66 and older, alive, without end-stage renal disease, and residing in the United States on 12/31/2016 with fee-for-service coverage for the entire calendar year. Abbreviation: CKD, chronic kidney disease.

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Chapter 5: Acute Kidney Injury

- In 2016, 4.4% of Medicare fee-for-service beneficiaries experienced a hospitalization complicated by Acute Kidney Injury (AKI), double the proportion of 2.2% in 2006 (Figure 5.1).
- Risk of AKI increases with age and in the presence of comorbidities such as chronic kidney disease (CKD) and diabetes mellitus (DM). About 1 in 5 hospitalized Medicare patients with both CKD and DM experience a hospitalization with AKI each year (Figure 5.5).
- Among hospitalized veterans aged 22+ years, 25.4% met Kidney Disease: Improving Global Outcomes (KDIGO) guidelines for AKI as defined using serum creatinine-based criteria (Table A). This included 21.4%, 0.8%, and 3.2% of patients with Stage 1, Stage 2, and Stage 3 AKI (Table 5.2). Just over half (52.6%) of patients meeting criteria for AKI were given a diagnosis of AKI.
- In 2014, Medicare patients aged 66+ years who were hospitalized for AKI had a 36% cumulative probability of a recurrent AKI hospitalization within one year (Figure 5.6.a). For Optum Clinformatics™ patients aged 22+ years, the probability of recurrent AKI hospitalization was 23% (Figure 5.7.a).
- Among Medicare patients without a pre-existing diagnosis of CKD, 30.8% were given a new diagnosis of CKD in the year following an AKI hospitalization (Figure 5.10.a). In the Optum Clinformatics™ population, 33.8% of patients with an AKI hospitalization were newly classified as having CKD in the subsequent year (Figure 5.10.b). In contrast, among Medicare patients with a "new" diagnosis of CKD in 2016, 25% had an AKI hospitalization in the preceding year.
- Among Medicare patients aged 66+ years with a first AKI hospitalization in 2016, the in-hospital mortality rate was 8.2%, or 13.2% when including discharge to hospice. Comparable mortality rates for non-AKI hospitalizations were 1.8% and 3.8%. Less than half of all patients returned to their home on discharge, as compared to two-thirds of non-AKI patients, while 30.1% were discharged to an institution such as a rehabilitation or skilled nursing facility (Figure 5.11).

Introduction

Acute kidney injury (AKI) is a common complication among hospitalized patients, and is associated with substantial morbidity and mortality. Among survivors, AKI is recognized as a major risk factor for the development of chronic kidney disease (CKD). Studies have demonstrated significantly increased long-term risk of CKD and ESRD following AKI, even after initial kidney function recovery (Heung, 2012). Furthermore, this relationship is bidirectional—CKD patients are at substantially higher risk for AKI. As a result, AKI is frequently superimposed on CKD, and can contribute significantly to progression of CKD. As such, an examination into the epidemiology and outcomes of AKI is an intrinsic aspect to understanding the landscape of CKD.

This year we again present data from three sources: the Medicare 5% sample, the Optum Clinformatics™ Data Mart dataset (from OptumInsight, representing claims from a large U.S. national health insurance company), and national data from the U.S. Department of Veterans Affairs (VA) health system. Medicare and Optum Clinformatics™ administrative data do not contain clinical or biochemical data with which to identify an AKI episode using the consensus criteria that are based on changes in serum creatinine or urinary output. In these data sources, episodes of AKI were identified using ICD-9-CM and ICD-10-CM (International Classification of Diseases, Ninth/Tenth Revision, Clinical Modification) diagnosis codes from

claims. While this approach carries a high degree of specificity, an important limitation of this indirect method is poor sensitivity, generally <30%, and even lower for less severe cases of AKI. In particular, 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 and recognition of AKI increase the likelihood of administrative coding for AKI. Thus, a rising incidence of AKI may represent a true increase in cases, an increased likelihood to code for AKI, or a combination of both factors. In addition, a lower threshold for coding would lead to identification of less severe episodes and an apparent decrease in the rate of associated adverse outcomes.

In contrast to Medicare and Optum Clinformatics™, VA data contain clinical information to identify episodes of AKI through serum creatinine-based criteria. We present some data from the VA population to illustrate the potential gap between AKI episodes identified by administrative coding versus clinical data.

We begin this chapter by exploring trends in hospitalizations complicated by AKI, and describing the characteristics of those patients. We refer to "AKI hospitalizations" as any hospitalization during which there was a diagnosis (billing code) of AKI; the AKI diagnosis was not necessarily the primary or admitting diagnosis. We focus on hospitalizations because the occurrence of AKI exclusively in the community is uncommon and often unrecognized. Next, we explore the risk of hospital readmissions with recurrent AKI, and describe follow-up care after an episode. We end by examining the impact of AKI on outcomes, including subsequent CKD status and patient disposition after an AKI hospitalization.

Methods

Starting with the 2013 claim year, the USRDS Coordinating Center has received the Medicare 5% sample from the Medicare Chronic Conditions Warehouse, a different data source than in previous years. This has coincided with a subsequent decrease in AKI hospitalizations, and we cannot rule out that this is an artifact of the differing source of the Medicare 5% data files. Conclusions regarding trends should be made in this context.

As noted above, for administrative data (Medicare and Optum Clinformatics™) AKI episodes were identified through diagnosis codes from claims. These claims could be from any point during hospitalization and were not limited to the primary diagnosis. AKI episodes are presented both as a proportion (where denominator is either all patients or all hospitalizations), and as a rate (where denominator is patient population at risk). For VA data, AKI was defined using serum creatinine-based criteria (see Table A below), but not urine output criteria.

For the Medicare data, we often present results for those aged 66 and older. This allows a full year of Medicare eligibility (ages 65-66) for us to assess the patient's CKD and diabetes mellitus (DM) status prior to the hospitalization within which AKI occurred.

To supplement the Medicare data, we also present data on patients aged 22+ years from the commercial insurance plans of a large national U.S. health insurance company, as included in the Optum Clinformatics™ Data Mart from OptumInsight. These data represent mainly working-age people and their minor dependents. For the prevalence of CKD and related conditions among these patients, see Volume 1, Chapter 2, Identification and Care of Patients with CKD, Table 2.1 for demographic characteristics of the Optum Clinformatics™ population (all ages) and Table 2.2 (ages 22-64). Additionally, Table 5.2 of this chapter uses data from all patients hospitalized at a VA hospital during fiscal year 2016, to show AKI as defined by serum creatinine measurements and staged as outlined in the KDIGO clinical practice guideline for AKI (KDIGO, 2012). Note that urine output data was not available, so identification of AKI episodes did not include the KDIGO criteria related to urine output.

Age is a major risk factor for AKI. Each of the included datasets had interactions between sex and age that are important to keep in mind when comparing differences in AKI by sex. Within both Optum Clinformatics™ and the VA data, women were younger on average than men. In Optum Clinformatics™, 55.6% of women were between the ages of 22 and 39, compared to only 19.8% of men.

Conversely, women in the Medicare 5% sample were older, on average: women had a mean age of 77.1 years while for men it was 75.4 years, and a higher proportion of women (20.4%) than men (13.3%) were aged 85 and older.

Note that the analyses for all figures, except Figure 5.11, were based on all beneficiaries meeting the specified inclusion criteria. In Figure 5.11, we excluded those beneficiaries who were admitted from a long-term care facility to the inpatient setting where the AKI hospitalization occurred. Therefore, the category of institution in this figure includes only those newly readmitted following a hospitalization.

Details of this data are described in the Data Sources section of the CKD Analytical Methods chapter. Also see the CKD Analytical Methods section of the CKD Analytical Methods chapter for an explanation of the analytical methods used to generate the study cohorts, figures, and tables in this chapter. Microsoft Excel and PowerPoint files containing the data and graphics for these figures and tables are available to download from the USRDS website.

Further details of the data utilized for this chapter are described in the Data Sources section of the *CKD Analytical Methods* chapter. For an explanation of the analytical methods used to generate the study cohorts, figures, and tables in this chapter, see the section on *Chapter 5* within the *CKD Analytical Methods* chapter. Downloadable Microsoft Excel and PowerPoint files containing the data and graphics for these figures and tables are available from the *USRDS website.*

Characteristics of Patients with Acute Kidney Injury

The percentage of Medicare fee-for-service patients with an AKI hospitalization has doubled over the past decade (Figure 5.1.a). However, the rate of AKI with an intensive care unit (ICU) stay has been relatively stable since 2010, and the increase has been in patients who did not require ICU stay during their hospitalization. Over the same period, the proportion of AKI patients requiring inpatient dialysis declined. Not surprisingly, a higher proportion of patients with an ICU stay had AKI requiring dialysis, compared to patients without an ICU stay (Figure 5.1.b). The proportion of patients with an AKI hospitalization who had a nephrology consultation has also fallen over the past decade, from 42.1% in 2006 to 25.2% in 2016 (Figure 5.1.c). Together, these findings seem to support the notion of "code creep", in which there may be greater identification in billing codes of less severe cases of AKI, including those occurring outside the ICU and those that are managed without nephrology input.

Figure 5.2 reveals a similar rising trend of AKI in the Optum Clinformatics™ population, although the overall percentage of patients with an AKI hospitalization was far lower for these younger patients, at 0.3% in 2016.

vol 1 Figure 5.1 Percent of Medicare patients aged 66+ (a) with at least one AKI hospitalization, and (b) percent among those with an AKI hospitalization who required dialysis, and (c) percent of patients with nephrology consultation, among those with a first AKI hospitalization, by whether an intensive care unit (ICU) stay was required, 2006-2016

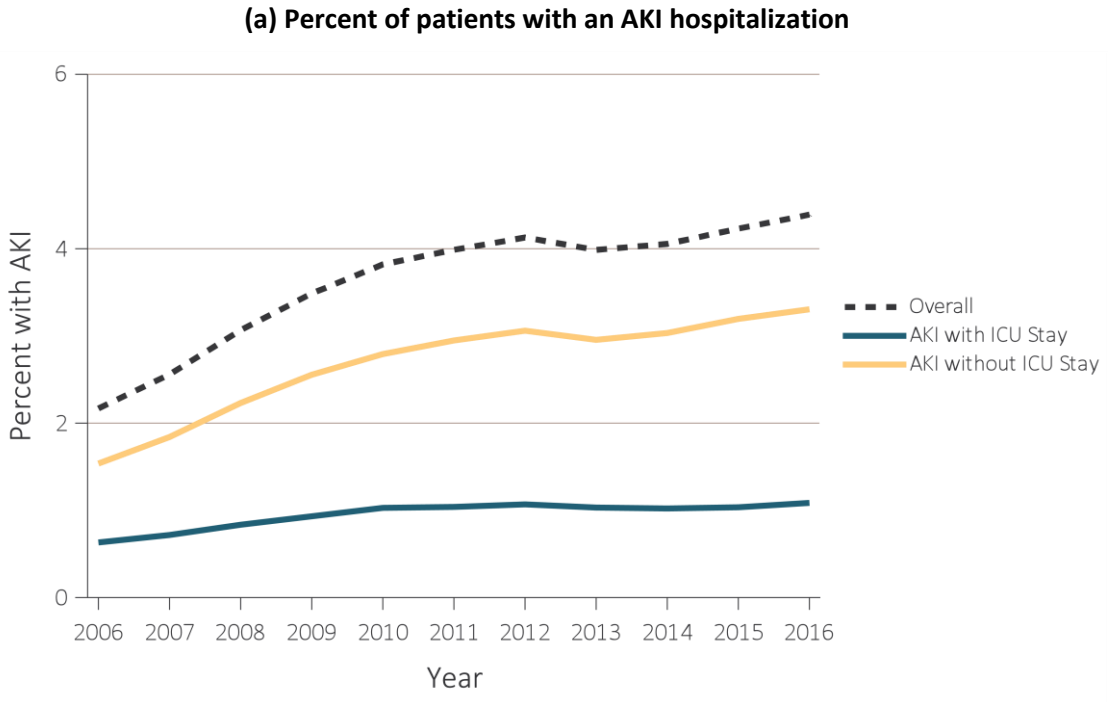
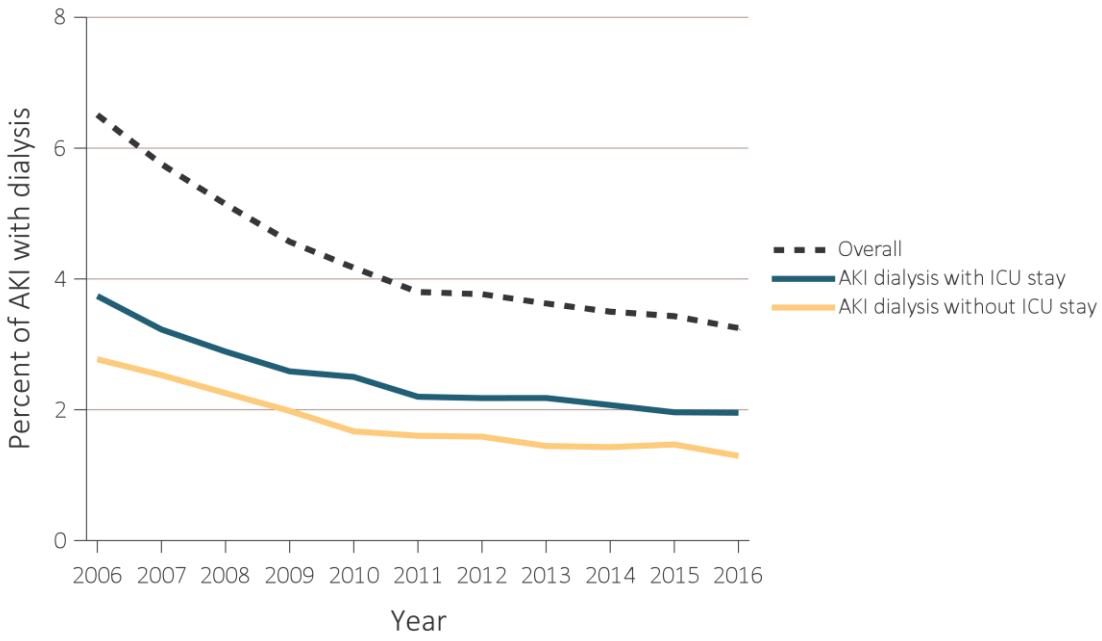


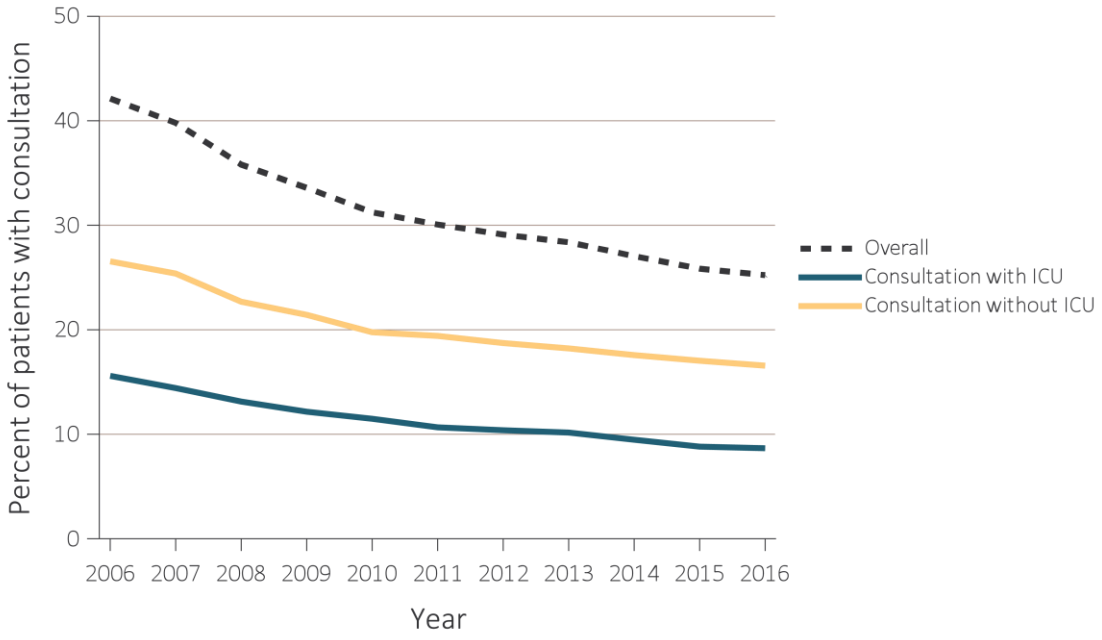
Figure 5.1 continued on next page.

vol 1 Figure 5.1 Percent of Medicare patients aged 66+ (a) with at least one AKI hospitalization, and (b) percent among those with an AKI hospitalization who required dialysis, and (c) percent of patients with nephrology consultation, among those with a first AKI hospitalization, by whether an intensive care unit (ICU) stay was required, 2006-2016 (continued)

(b) Percent of patients requiring inpatient dialysis, among those with a first AKI hospitalization

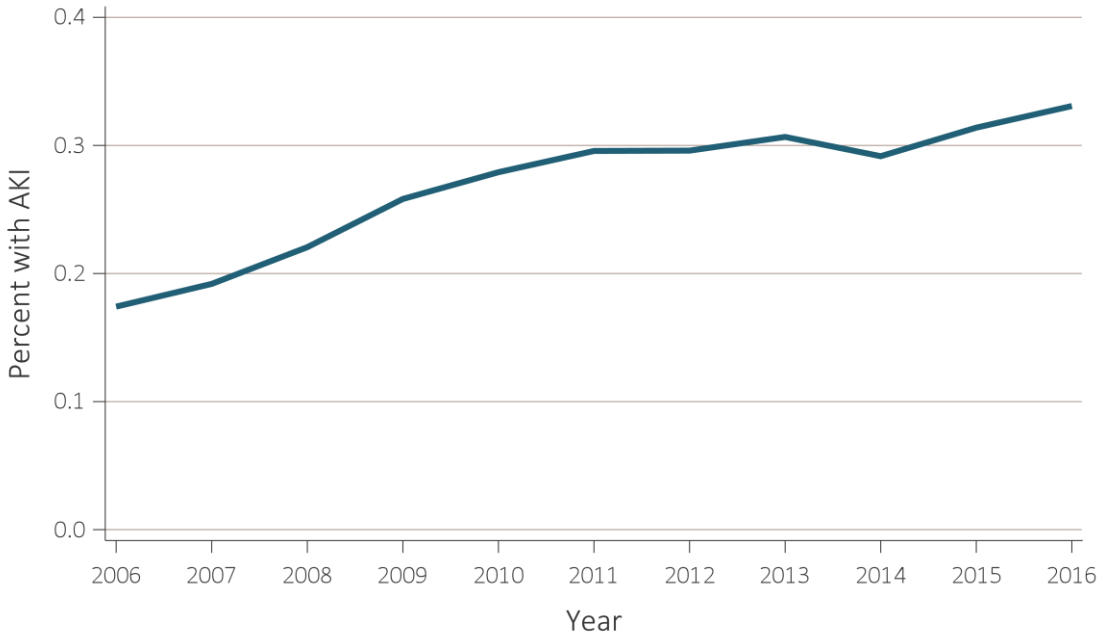


(c) Percent of patients with nephrology consultation, among those with a first AKI hospitalization



Data Source: Special analyses, Medicare 5% sample. (a) Percent with an AKI hospitalization among all Medicare patients aged 66 and older who had both Medicare Parts A & B, no Medicare Advantage plan, no ESRD by first service date from Medical Evidence form, and were alive on January 1 of year shown. (b) 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 of the AKI inpatient claim. Abbreviations: AKI, acute kidney injury; ESRD, end-stage renal disease; ICU, intensive care unit.

vol 1 Figure 5.2 Percent of Optum Clinformatics™ patients aged 22+ with at least one AKI hospitalization, by year, 2006-2016



Data Source: Special analyses, Optum Clinformatics™. Percent with an AKI hospitalization among all Optum Clinformatics™ commercial insurance patients aged 22 and older who were enrolled in the plan, did not have diagnoses of ESRD, and were alive on January 1 of year shown. Abbreviations: AKI, acute kidney injury; ESRD, end-stage renal disease.

As shown in Figure 5.3, rates of AKI were strongly influenced by age. Among fee-for-service Medicare patients in 2016, the rate of AKI for those aged 66-69 was 23.0 per 1,000 patient years, increasing to 31.3, 44.2, 62.9, and 95.7 for those aged 70-74, 75-79, 80-84, and 85 years and older. Unadjusted rates of AKI have risen in all age groups over the past decade, although the rate of rise seems to have slowed since 2011 in patients younger than 80 years. The rates of AKI requiring dialysis have remained fairly consistent across all age groups over the past decade. Among Optum Clinformatics™ patients, the overall group AKI rate increased over time, peaking at 3.8 per 1,000 patient years in 2016. For the subgroup aged 66 and older, the 2011 rate was 23.7 per 1,000 patient-years and remained somewhat stable at 21.8 per 1,000 in 2016.

vol 1 Figure 5.3 Unadjusted rates of hospitalization with AKI and AKI requiring dialysis, per 1,000 patient-years at risk, by age, 2006-2016

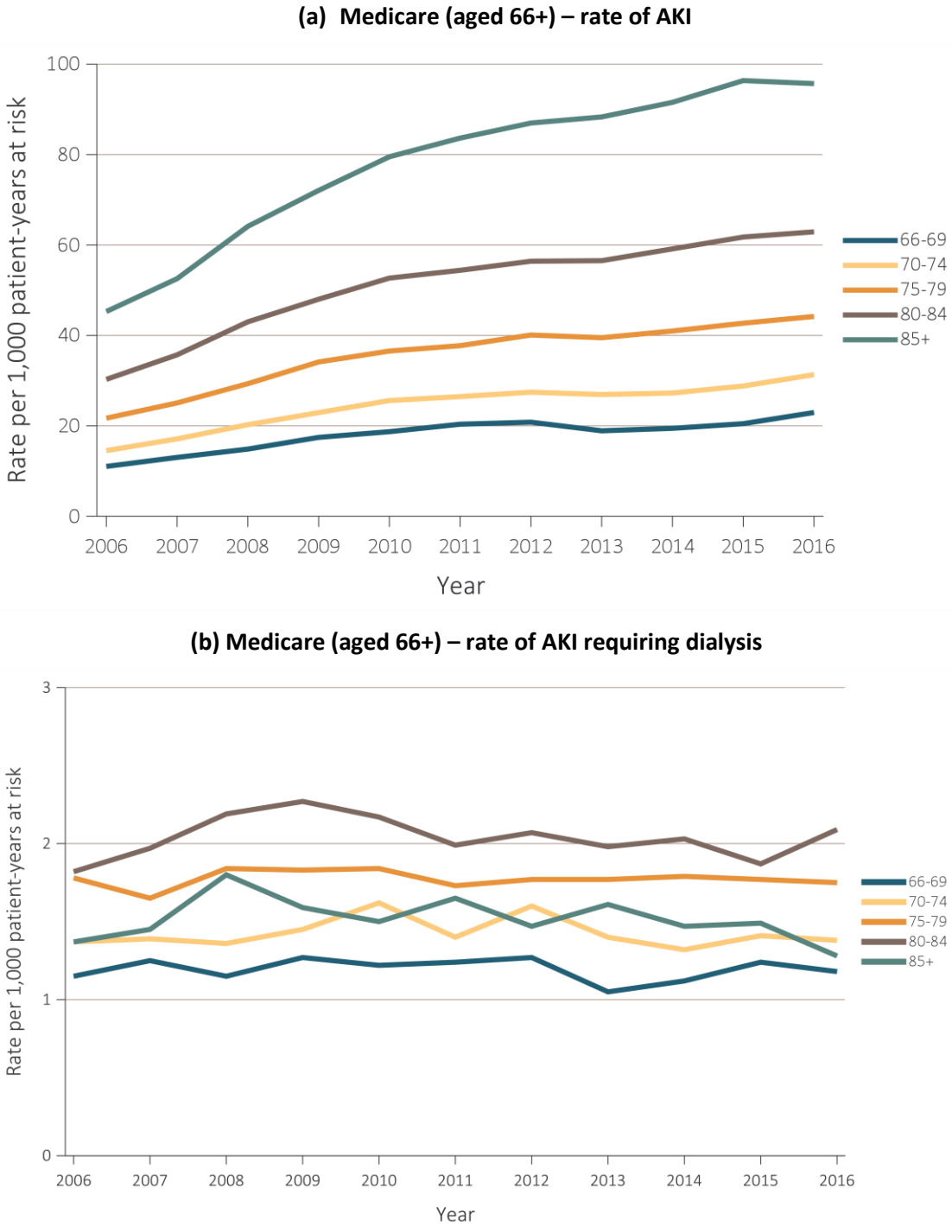
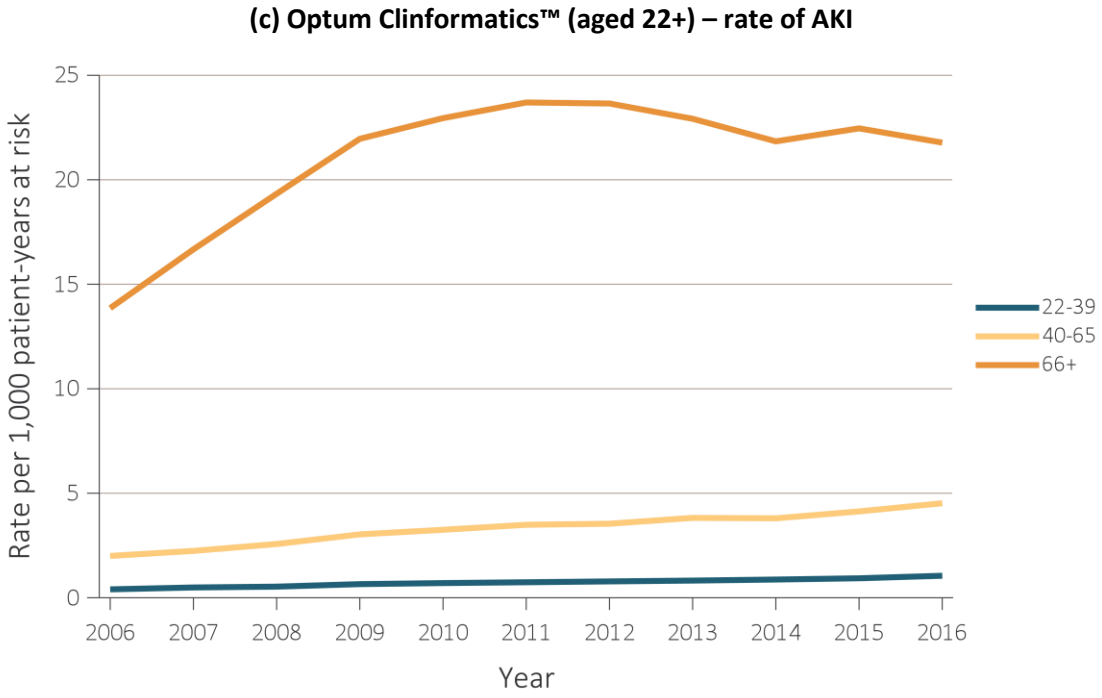


Figure 5.3 continued on next page.

vol 1 Figure 5.3 Unadjusted rates of hospitalization with AKI and AKI requiring dialysis, per 1,000 patient-years at risk, by age, 2006-2016 (continued)



Data Source: Special analyses, Medicare 5% sample and Optum Clinformatics™. (a) and (b) 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, 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. (c) All patient-years at risk for Optum Clinformatics™ commercial insurance patients aged 22 and older who were enrolled in the plan, did not have diagnoses of ESRD, and were alive on January 1 of year shown. Abbreviation: AKI, acute kidney injury; ESRD, end-stage renal disease.

Figure 5.4 highlights differences in AKI rates by race. In 2016, among fee-for-service Medicare patients aged 66 and older, the incidence rate for those of Black race was 71.6 per 1,000 patient-years at risk compared to 44.7 and 35.8, in Whites and individuals of other races. A similar relationship was observed in the Optum Clinformatics™ population, albeit at much lower rates: 5.6, 4.0, and 3.0 per 1,000 patient-years at risk in Blacks, Whites, and individuals of other races. Rates of AKI rose across all race subgroups between 2006 and 2016. However, the rate of AKI requiring dialysis appears to have remained stable.

vol 1 Figure 5.4 Unadjusted rates of hospitalization with AKI, and AKI requiring dialysis, per 1,000 patient-years at risk, by race, 2006-2016

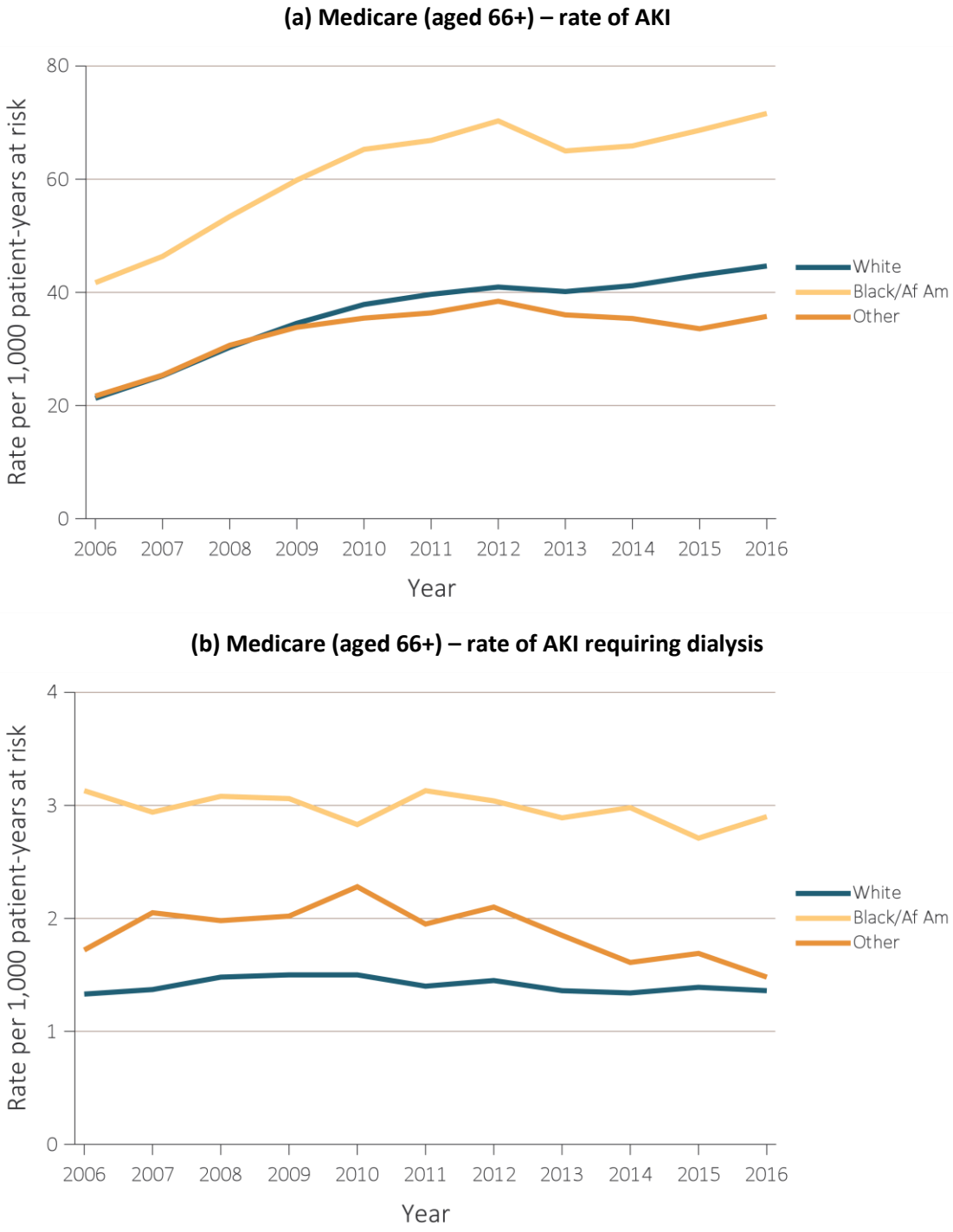
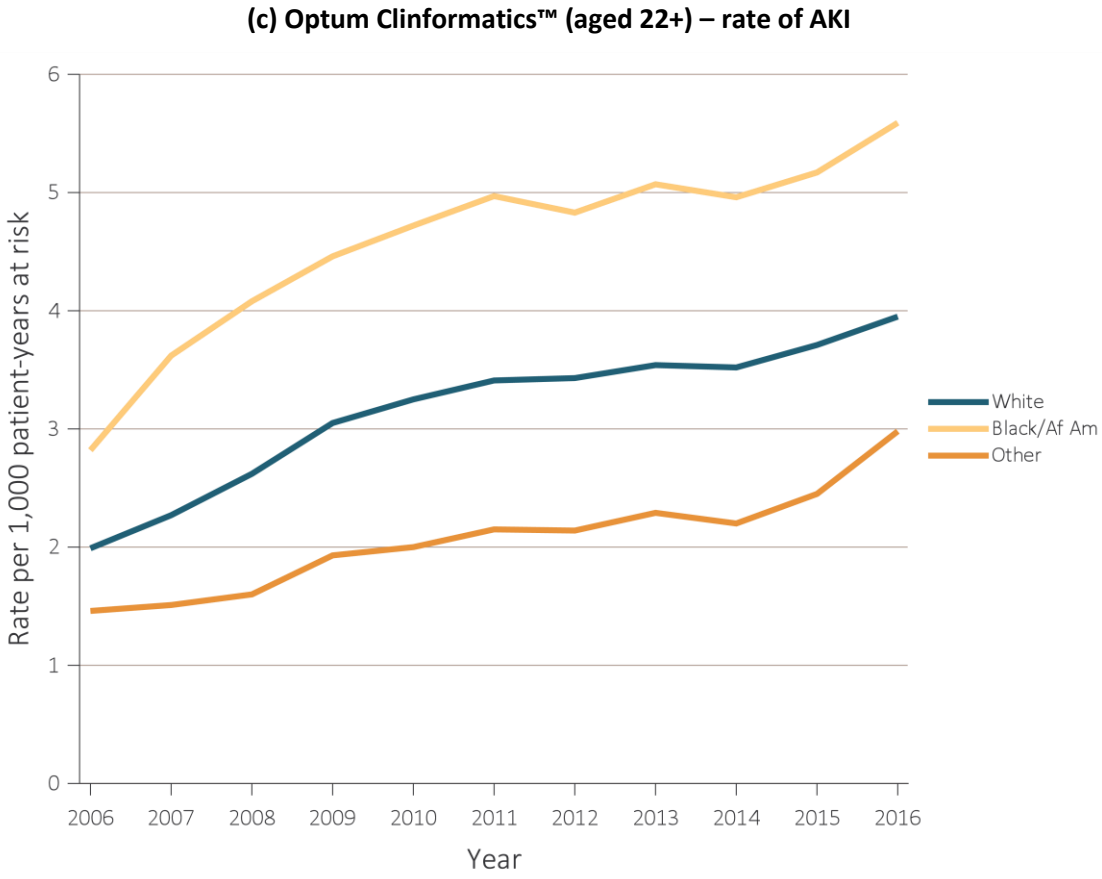


Figure 5.4 continued on next page.

vol 1 Figure 5.4 Unadjusted rates of hospitalization with AKI, and AKI requiring dialysis, per 1,000 patient-years at risk, by race, 2006-2016 (continued)



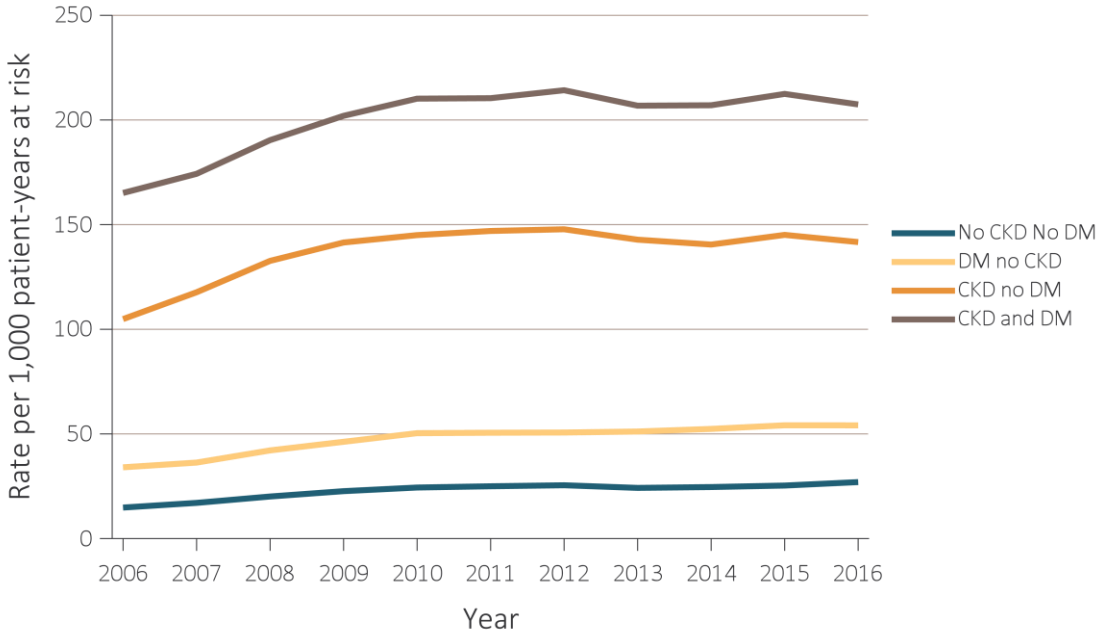
Data Source: Special analyses, Medicare 5% sample and Optum Clinformatics™. (a) and (b) All patient-years at risk for Medicare patients aged 66 and older who had both Medicare Parts A & B, no Medicare Advantage plan, no ESRD by first service date from Medical Evidence form, and were alive on January 1 of year shown. Censored at death, ESRD, end of Medicare Parts A & B participation, or switch to Medicare Advantage program. (c) All patient-years at risk for Optum Clinformatics™ commercial insurance patients aged 22 and older who were enrolled in the plan, did not have diagnoses of ESRD, and were alive on January 1 of year shown. Abbreviations: Af Am, African American; AKI, acute kidney injury; ESRD, end-stage renal disease.

As shown in Figure 5.5, incidence rates for AKI also varied substantially by underlying comorbidity. In 2016, Medicare patients with DM, but no known CKD, had an AKI incidence rate of 54.1 per 1,000 patient-years, compared to 27.0 per 1,000 patient-years in non-diabetic, non-CKD patients. Non-diabetic patients with CKD experienced an AKI incidence rate of 141.7 per 1,000 patient-years, while the rate in patients with both DM and CKD was 207.4 per 1,000.The overall rate of hospitalization with AKI appears to be stable between 2010 and 2016. However, the rate of AKI requiring dialysis has declined in patients with CKD and those with both CKD and DM.

The Optum Clinformatics™ population showed similar relationships. Patients with both CKD and DM experienced the highest rates of AKI hospitalization at 100.9 per 1,000 patient-years. However, their overall rates were much lower than among the Medicare population, presumably reflecting the younger age range in this population.

vol 1 Figure 5.5 Unadjusted rates of hospitalization with AKI, and AKI requiring dialysis, per 1,000 patient-years at risk, by CKD and DM, 2006-2016

(a) Medicare (aged 66+) – rate of AKI



(b) Medicare (aged 66+) – rate of AKI requiring dialysis

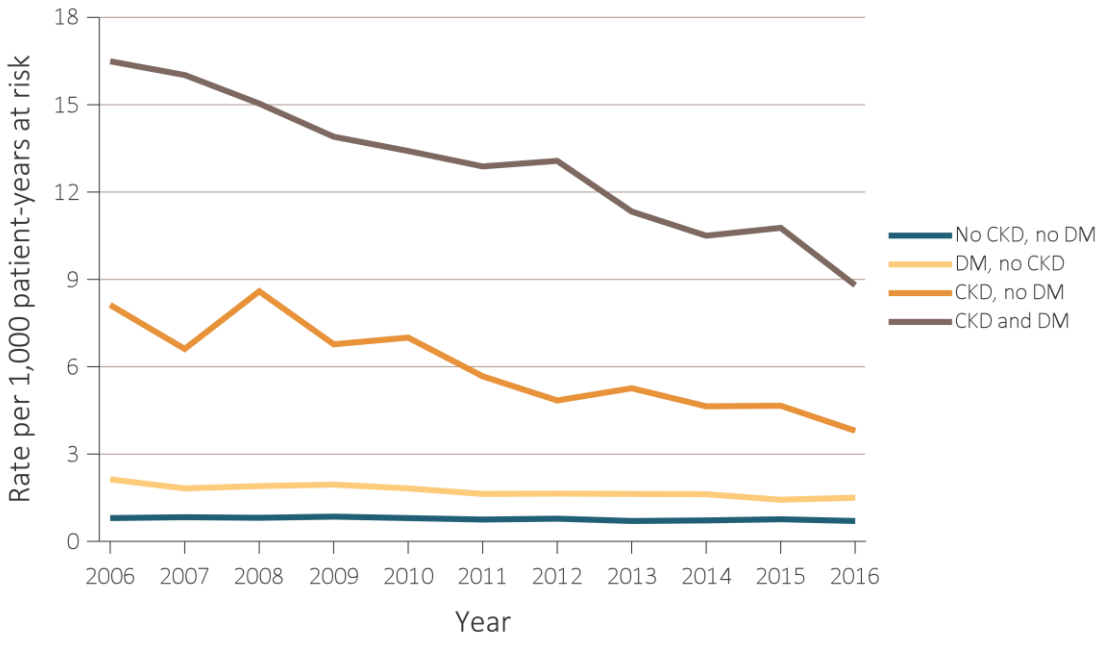
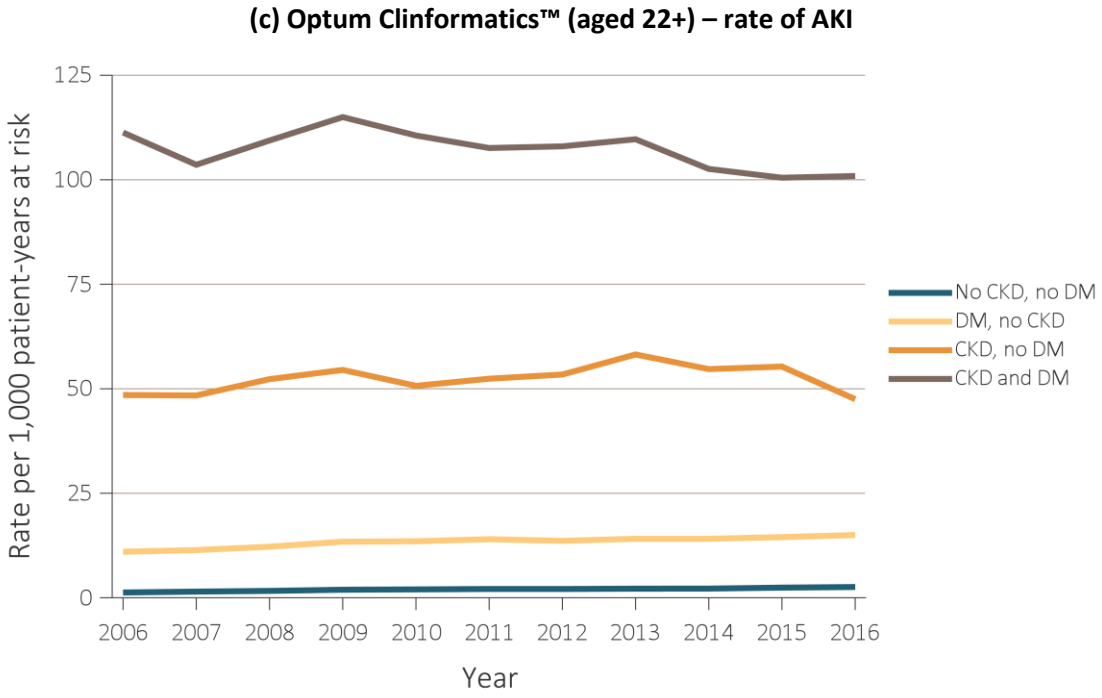


Figure 5.5 continued on next page.

vol 1 Figure 5.5 Unadjusted rates of hospitalization with AKI, and AKI requiring dialysis, per 1,000 patient-years at risk, by CKD and DM, 2006-2016 (continued)



Data Source: Special analyses, Medicare 5% sample and Optum Clinformatics™. (a) and (b) All patient-years at risk for Medicare patients aged 66 and older who had both Medicare Parts A & B, no Medicare Advantage plan, 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. (c) All patient-years at risk for Optum Clinformatics™ commercial insurance patients aged 22 and older who were enrolled in the plan, did not have diagnoses of ESRD, and were alive on January 1 of year shown. Abbreviations: AKI, acute kidney injury; CKD, chronic kidney disease; DM, diabetes mellitus; ESRD, end-stage renal disease.

Table 5.1 presents characteristics of hospitalized Medicare and Optum Clinformatics™ patients in 2016, along with their demographic and comorbidity characteristics by whether or not AKI occurred (defined as an inpatient stay with any diagnosis for AKI during any hospitalization during the year). AKI occurs commonly in older adults, impacting nearly 25% of Medicare patients aged 66 or older who have at least one hospitalization, and the incidence rises with age. Persons over age 80 accounted for 44% of all hospitalizations and 51% of hospitalizations with AKI. Although males appear to be more likely to develop AKI than females, it is important to remember that this does not account for differences in age distribution, although an age adjustment would tend to exacerbate the gender differential. In both the Medicare and Clinformatics™ populations, a higher proportion of Black/African American patients had AKI compared to Whites or Asians. Diabetes and pre-existing CKD are recognized as two major risk factors for AKI; at least one of these risk factors was present in 57.2% of Medicare patients with an AKI hospitalization and 23.4% of patients had both. Even in the younger Optum Clinformatics™ population, about 40.2% of patients with an AKI hospitalization had either DM, CKD, or both.

vol 1 Table 5.1 Characteristics of Medicare and Optum Clinformatics™ patients with at least one hospitalization, by age, sex, race, CKD, DM, and presence of AKI, 2016

	Medicare (Age 66+)					Clinformatics™ (Age 22+)				
	Total	No AKI		Any AKI		Total	No AKI		Any AKI	
	N	N	%	N	%	N	N	%	N	%
Total	238,839	179,641	75.2%	59,198	24.8%	304,907	281,791	92.4	23,116	7.6
Age										
22-39	—	—	—	—	—	129,410	126,921	98.1	2,489	1.9
40-65	—	—	—	—	—	147,949	132,480	89.5	15,469	10.5
65+	—	—	—	—	—	27,548	22,390	81.3	5,158	18.7
66-69	39,652	31,974	80.6	7,678	19.4	—	—	—	—	—
70-74	48,717	38,289	78.6	10,428	21.4	—	—	—	—	—
75-79	44,691	34,005	76.1	10,686	23.9	—	—	—	—	—
80-84	40,775	29,822	73.1	10,953	26.9	—	—	—	—	—
85+	65,004	45,551	70.1	19,453	29.8	—	—	—	—	—
Sex										
Male	103,628	74,289	71.7	29,339	28.3	108,157	93,743	86.7	14,414	13.3
Female	135,211	105,352	77.9	29,859	22.1	196,750	188,048	95.6	8,702	4.4
Race & Ethnicity										
White	207,287	158,061	76.3	49,226	23.8	213,520	197,182	92.3	16,338	7.7
Black/African American	19,096	12,347	64.7	6,749	35.3	30,737	27,564	89.7	3,173	10.3
Native American	1,274	949	74.5	325	25.5	—	—	—	—	—
Hispanic	—	—	—	—	—	33,397	31,240	93.5	2,157	6.5
Asian	3,186	2,264	71.1	922	28.9	12,882	12,422	96.4	460	3.6
Other	7,996	6,020	75.3	1,976	24.7	14,371	13,383	93.1	988	6.9
Pre-existing comorbidities										
No DM or CKD, prior year	141,826	116,465	82.1	25,361	17.9	263,756	249,928	94.8	13,828	5.2
DM no CKD, prior year	43,073	32,816	76.2	10,257	23.8	25,916	21,762	84.0	4,154	16.0
CKD no DM, prior year	23,738	14,001	60.0	9,737	41.0	8,378	6,064	72.4	2,314	27.6
Both CKD & DM, prior year	30,202	16,359	54.2	13,843	45.8	6,857	4,037	58.9	2,820	41.1

Data Source: Special analyses, Medicare 5% sample and Optum Clinformatics™. Medicare patients aged 66 and older who had both Medicare Parts A & B, no Medicare Advantage plan, no ESRD by first service date from Medical Evidence form, and were alive on January 1, 2016. Optum Clinformatics™ commercial insurance patients aged 22 and older who were enrolled in the plan, did not have diagnoses of ESRD, and were alive on January 1, 2016. AKI is defined by a diagnosis code anywhere in the hospitalization claim. — Data not available. Abbreviations: AKI, acute kidney injury; CKD, chronic kidney disease; DM, diabetes mellitus; ESRD, end-stage renal disease.

Table 5.2 presents characteristics of hospitalized VA patients who had an AKI hospitalization in fiscal year 2016. Here, AKI was defined using serum creatinine-based criteria per the KDIGO guidelines (Table A). The incidence of AKI generally increased with age, and among race/ethnicity groups the highest proportion of AKI was again observed among non-Hispanic Black patients. For VA patients with diabetes, about 26.0% had an AKI hospitalization as defined by KDIGO criteria. Although this proportion appears similar to that observed in the Medicare population, direct comparison is not possible due to unaccounted for differences in patient characteristics as well as differences in methodology to identify AKI episodes (i.e. clinical vs claims data). The percentage of VA patients with an AKI hospitalization increased to 42.4% among CKD patients, and 53.7% among patients with both DM and CKD. Of note, among VA patients with an AKI hospitalization as defined by KDIGO serum creatinine-based criteria, only 52.6% were given a diagnosis of AKI.

Table A. KDIGO definition and staging of Acute Kidney Injury (AKI)

Definition of AKI

An increase in serum creatinine (SCR) by >0.3mg/dL (>26.5 µmol/l) within 48 hours; or an increase in SCR to >1.5 times baseline, which is known or presumed to have occurred within the prior 7 days; or urine volume <0.5ml/kg/h for 6 hours.

Stage	Serum creatinine	Urine output
1	1.5–1.9 times baseline OR >0.3 mg/dL (>26.5 µmol/l) increase	<0.5 ml/kg/h for 6-12 hours
2	2.0–2.9 times baseline	<0.5 ml/kg/h for >12 hours
3	3.0 times baseline OR increase in SCR to ≥4.0 mg/dL (≥353.6 µmol/l) OR initiation of renal replacement therapy OR, in patients <18 years, decrease in eGFR to <35 ml/min/1.73m^2	<0.3 ml/kg/h for >24 hours OR anuria for >12 hours

Adapted from KDIGO (2012). Abbreviations: AKI, acute kidney injury; eGFR, estimated glomerular filtration rate; KDIGO, Kidney Disease Improving Global Outcomes; SCR, serum creatinine.

vol 1 Table 5.2 Characteristics of Veterans Affairs patients aged 22+ with at least one hospitalization, by age, sex, race, CKD, DM, presence and stage of AKI, defined by serum creatinine (KDIGO criteria), FY 2016

	Total	No AKI		Any Stage AKI		Stage 1		Stage 2		Stage 3[a]	
	N	N	%	N	%	N	%	N	%	N	%
Total	301,876	225,090	74.6	76,786	25.4	64,601	21.4	2,455	0.8	9,730	3.2
Diagnosis of AKI											
No	249,650	213,229	85.4	36,421	14.6	32,379	13.0	1,045	0.4	2,997	1.2
Yes	52,226	11,861	22.7	40,365	77.3	32,222	61.7	1,410	2.7	6,733	12.9
Age at this inpatient admission											
22-39	12,166	11,106	91.3	1,060	8.7	899	7.4	47	0.4	114	0.9
40-59	51,418	41,857	81.4	9,561	18.6	7,786	15.1	446	0.9	1,329	2.6
60-65	48,075	36,306	75.5	11,769	24.5	9,637	20.0	466	1.0	1,666	3.5
66-69	50,086	36,503	72.9	13,583	27.1	11,163	22.3	482	1.0	1,938	3.9
70-74	57,804	42,384	73.3	15,420	26.7	13,166	22.8	431	0.7	1,823	3.2
75-79	26,928	18,981	70.5	7,947	29.5	6,798	25.2	181	0.7	968	3.6
80-84	21,662	14,712	67.9	6,950	32.1	5,945	27.4	172	0.8	833	3.8
85+	33,737	23,241	68.9	10,496	31.1	9,207	27.3	230	0.7	1,059	3.1
Sex											
Male	284,150	209,947	73.9	74,203	26.1	62,499	22.0	2,308	0.8	9,396	3.3
Female	17,726	15,143	85.4	2,583	14.6	2,102	11.9	147	0.8	334	1.9
Race/ethnicity											
Non-Hispanic White	205,660	156,425	76.1	49,235	23.9	42,388	20.6	1,597	0.8	5,250	2.6
Non-Hispanic Black	59,063	41,142	69.7	17,921	30.3	14,288	24.2	513	0.9	3,120	5.3
American Indian/Alaska Native	1,923	1,490	77.5	433	22.5	354	18.4	17	0.9	62	3.2
Hispanic	17,615	12,824	72.8	4,791	27.2	3,883	22.0	207	1.2	701	4.0
Asian	2,905	2,143	73.8	762	26.2	627	21.6	12	0.4	123	4.2
Other/Unknown	14,710	11,066	75.2	3,644	24.8	3,061	20.8	109	0.7	474	3.2
Had CKD before admission											
No	245,319	196,479	80.1	48,840	19.9	42,320	17.3	2,144	0.9	4,376	1.8
Yes	56,557	28,611	50.6	27,946	49.4	22,281	39.4	311	0.5	5,354	9.5
Had hypertension before admission											
No	108,948	90,340	82.9	18,608	17.1	15,514	14.2	780	0.7	2,314	2.1
Yes	192,928	134,750	69.8	58,178	30.2	49,087	25.4	1,675	0.9	7,416	3.8
Had diabetes before admission											
No	194,998	155,138	79.6	39,860	20.4	33,579	17.2	1,593	0.8	4,688	2.4
Yes	106,878	69,952	65.5	36,926	34.5	31,022	29.0	862	0.8	5,042	4.7
Pre-admission CKD and diabetes status											
Neither	165,385	138,092	83.5	27,293	16.5	23,755	14.4	1,416	0.9	2,122	1.3
Diabetes only	73,997	54,726	74.0	19,271	26.0	17,183	23.2	728	1.0	1,360	1.8
CKD only	29,613	17,046	57.6	12,567	42.4	9,824	33.2	177	0.6	2,566	8.7
Diabetes & CKD	32,881	15,226	46.3	17,655	53.7	13,839	42.1	134	0.4	3,682	11.2

Data Source: Special analyses, Veterans Health Administration data. Patients aged 22 and older with at least one hospitalization in fiscal year 2016. AKI defined by serum creatinine criteria as in KDIGO (2012), see Table A for details. [a] Stage 3 includes those requiring dialysis. Diabetes and CKD determined by ICD-9-CM diagnosis codes. Excludes those with evidence of ESRD prior to admission by diagnosis and procedure codes. Abbreviations: AKI, acute kidney injury; CKD, chronic kidney disease; DM, diabetes mellitus; FY, federal fiscal year (October 1, 2015 to September 30, 2016).

Readmission Associated with Acute Kidney Injury

Figures 5.6 and 5.7 show the probability of a patient's recurrent AKI hospitalization after live discharge from an initial AKI hospitalization. Among 2014 Medicare patients aged 66 and older the overall probability of a recurrent AKI event was 0.36 in the next 12 months and 0.49 by 24 months, as shown in Figure 5.6.a. Among Optum Clinformatics™ patients, these probabilities were 0.23 and 0.31. In contrast to first episodes, the rate of recurrent AKI was relatively similar across age groups in the fee-for-service Medicare population (Figure 5.6.b). Interpretation of this finding is limited, however, because of the effect of death censoring, which was higher in older age groups. In Optum Clinformatics™ patients, who represent a wider range of ages, older patients appeared to have a higher probability for recurrent AKI (Figure 5.7.b).

In both the Medicare and Optum Clinformatics™ populations, Blacks had a higher probability of recurrent AKI compared to Whites or individuals of other races (Figures 5.6.c and 5.7.c). Similarly, having either DM or CKD was associated with an increased probability for recurrent AKI compared to having neither (see Figures 5.6.d and 5.7.d). The highest probability for recurrent AKI was for patients with both DM and CKD, reaching 0.59 by 24 months among Medicare patients and 0.38 among Optum Clinformatics™ patients. In contrast, Medicare patients with neither comorbidity had a cumulative probability for recurrent AKI hospitalization of 0.33 by 24 months, while their Optum Clinformatics™ counterparts had a probability of 0.17 by 24 months.

Siew et al. (2016) examined recurrent AKI for VA patients in 2003 and 2010 who survived their first AKI hospitalization (n=11,683). Of these, 8.5% had a second AKI episode within 30 days, 14.6% within 90 days, 19.5% within 180 days, and 25.3% with 12 months. AKI was defined according to KDIGO criteria using serum creatinine.

vol 1 Figure 5.6 Cumulative probability of a recurrent AKI hospitalization within two years of live discharge from first AKI hospitalization in 2014 for Medicare patients aged 66+, (a) overall, (b) by age, (c) by race, and (d) by CKD and DM

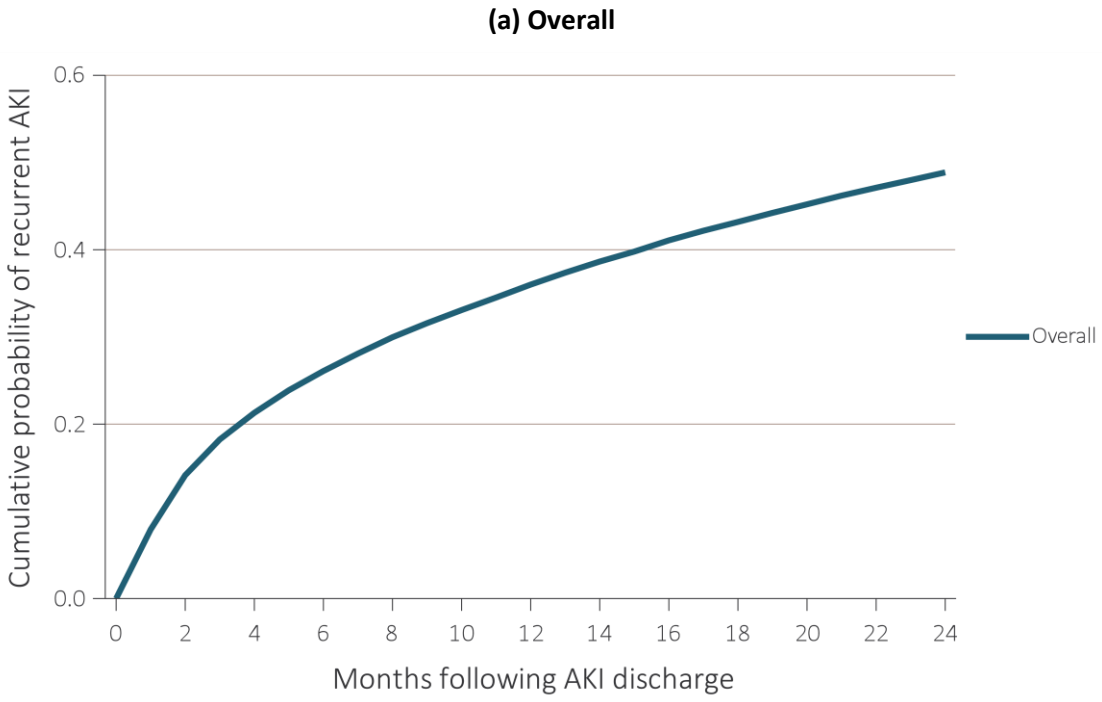
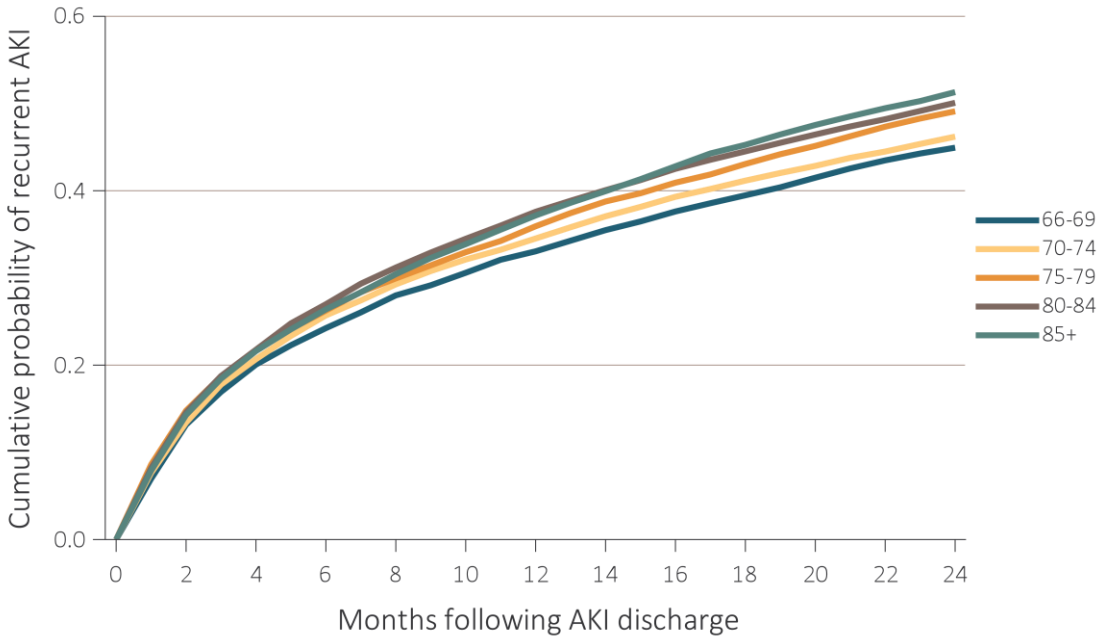


Figure 5.6 continued on next page.

vol 1 Figure 5.6 Cumulative probability of a recurrent AKI hospitalization within two years of live discharge from first AKI hospitalization in 2014 for Medicare patients aged 66+, (a) overall, (b) by age, (c) by race, and (d) by CKD and DM (continued)

(b) Age



(c) Race

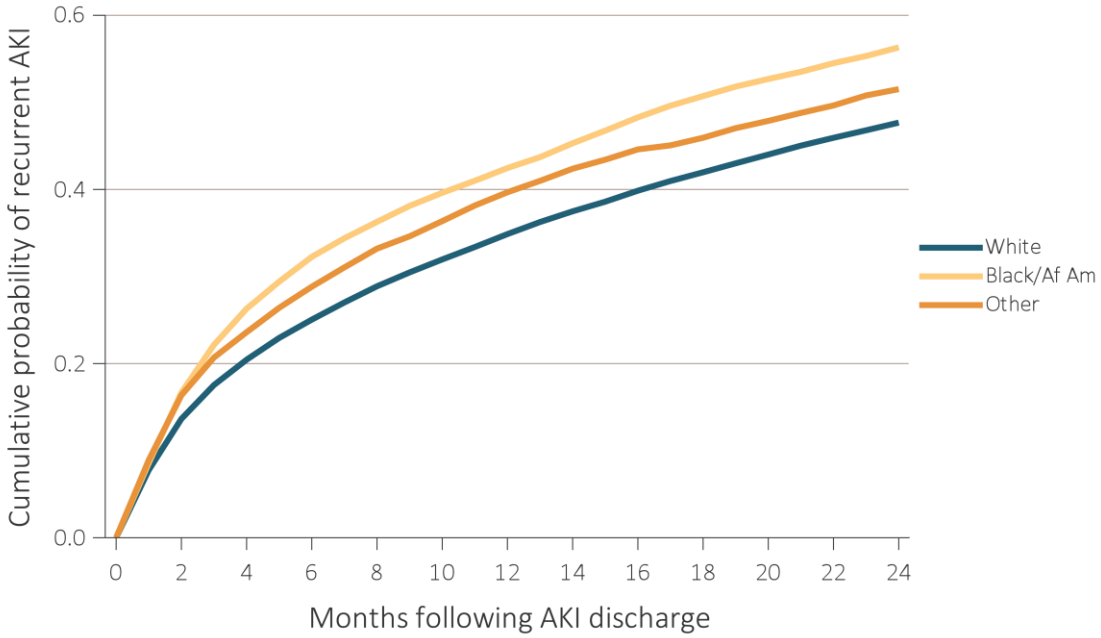
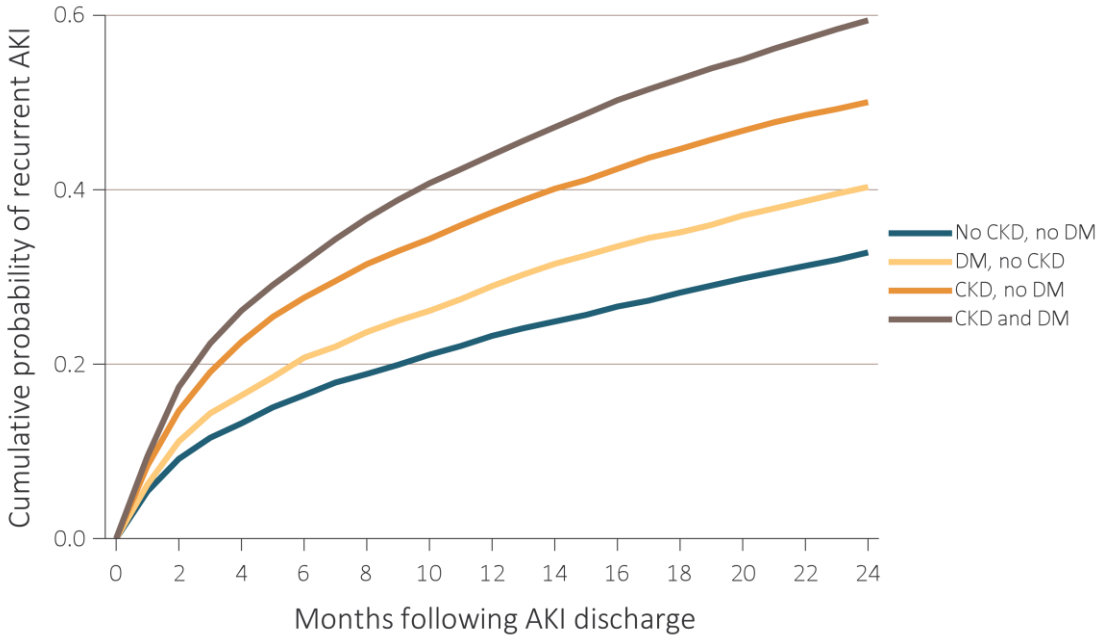


Figure 5.6 continued on next page.

vol 1 Figure 5.6 Cumulative probability of a recurrent AKI hospitalization within two years of live discharge from first AKI hospitalization in 2014 for Medicare patients aged 66+, (a) overall, (b) by age, (c) by race, and (d) by CKD and DM (continued)

(d) CKD and DM



Data Source: Special analyses, Medicare 5% sample. Age on January 1, 2014. Medicare patients aged 66 and older who had both Medicare Parts A & B, no Medicare Advantage plan, no ESRD by first service date from Medical Evidence form on 1/1/2014, and were discharged alive from an AKI hospitalization in 2014. 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; CKD, chronic kidney disease; DM, diabetes mellitus; ESRD, end-stage renal disease.

vol 1 Figure 5.7 Cumulative probability of a recurrent AKI hospitalization within two years of live discharge from first AKI hospitalization in 2014 for Optum Clinformatics™ patients aged 22+, (a) overall, (b) by age, (c) by race, and (d) by CKD and DM

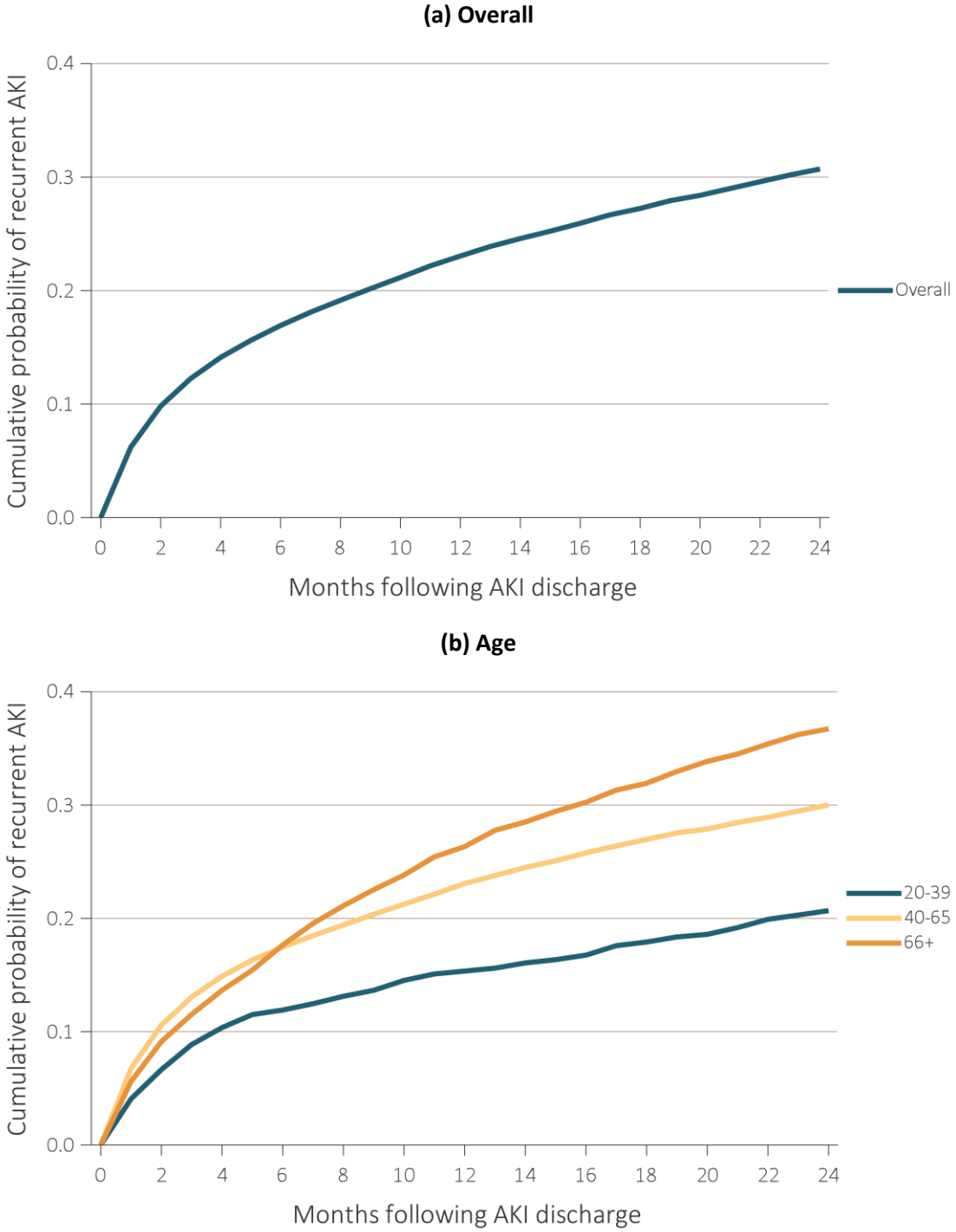
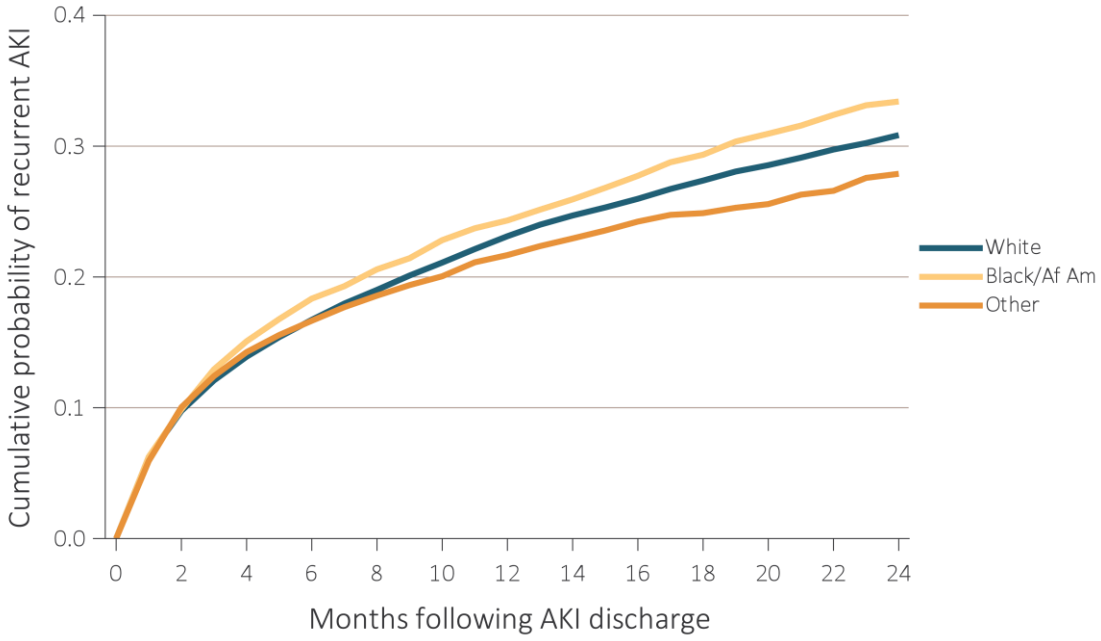


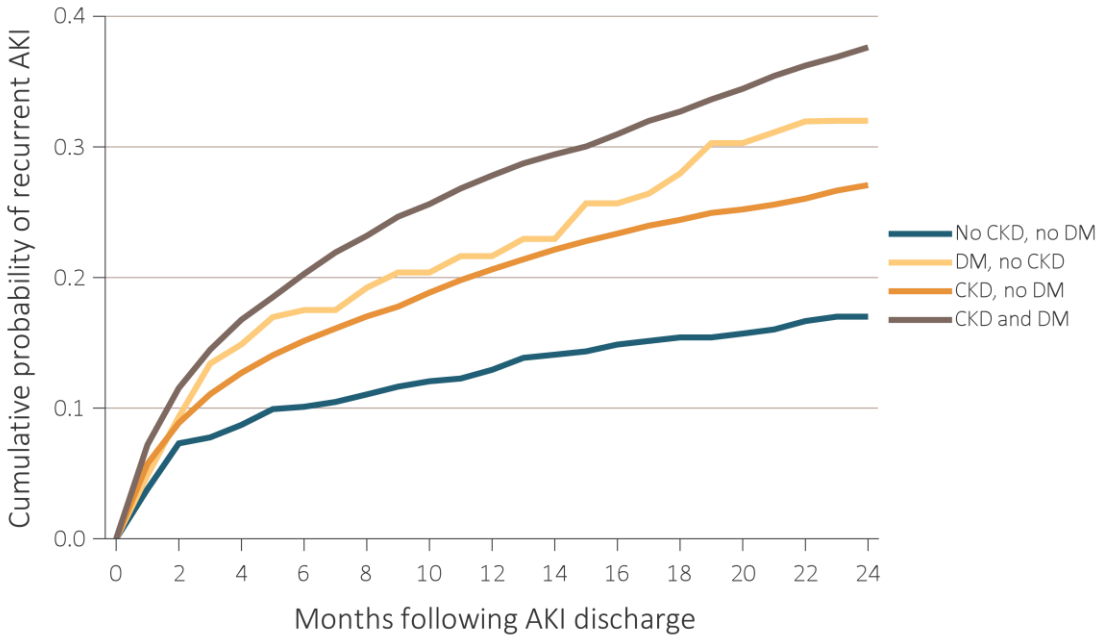
Figure 5.7 continued on next page.

vol 1 Figure 5.7 Cumulative probability of a recurrent AKI hospitalization within two years of live discharge from first AKI hospitalization in 2014 for Optum Clinformatics™ patients aged 22+, (a) overall, (b) by age, (c) by race, and (d) by CKD and DM (continued)

(c) Race



(d) CKD and DM

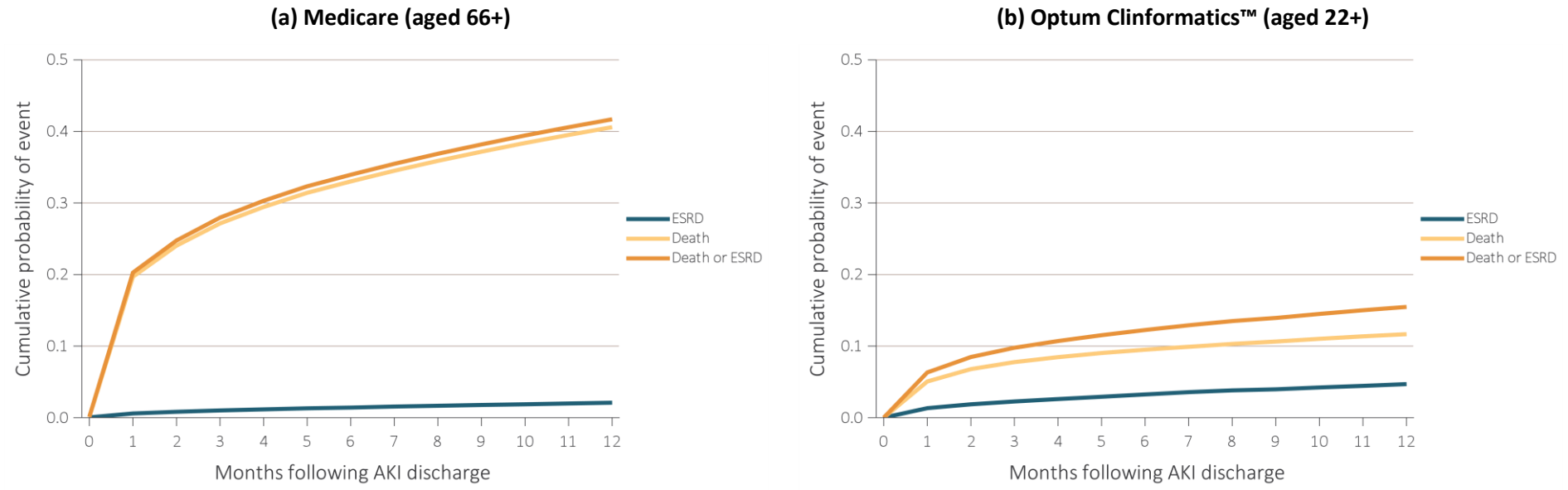


Data Source: Special analyses, Optum Clinformatics™. Age as of January, 2014. Optum Clinformatics™ commercial insurance patients aged 22 and older who were enrolled in the plan, did not have diagnoses of ESRD on January 1, 2014, and were discharged alive from an AKI hospitalization in 2014. Censored at death, ESRD diagnosis, or plan disenrollment. Abbreviations: Af/Am, African American; AKI, acute kidney injury; CKD, chronic kidney disease; DM, diabetes mellitus; ESRD, end-stage renal disease.

Patient Care and Outcomes

Poor short-term outcomes for AKI, including hospital mortality, are well recognized. However, survivors of an AKI hospitalization continue to be at risk for significant adverse outcomes. Figure 5.8 illustrates that, among survivors of an AKI hospitalization in 2014-2015, the overall probability of developing ESRD in the following year was about 2% in the Medicare fee-for-service population aged 66 and older, and 5% in the Optum Clinformatics™ population. The seemingly paradoxical higher risk for ESRD in the younger Optum Clinformatics™ population may be due to higher competing risk of death in the Medicare population: in this same period, the probability of death was 40.6% and 11.7% in the Medicare and Optum Clinformatics™ populations, respectively.

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 2014-2015

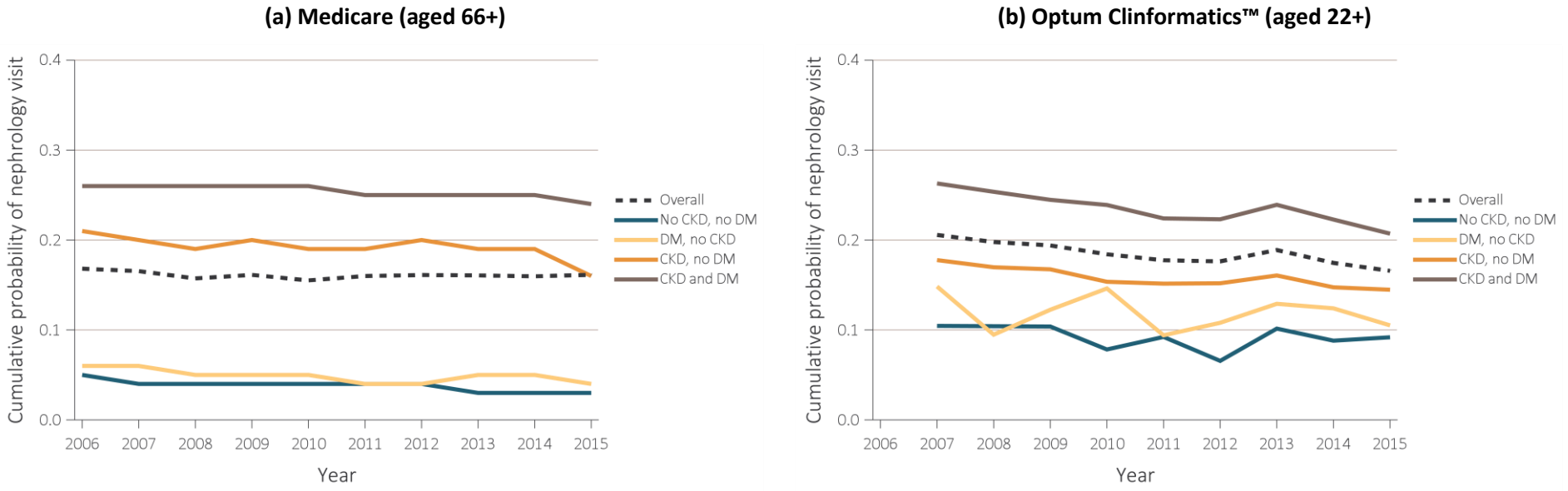


Data Source: Special analyses, Medicare 5% sample. (a) Medicare patients aged 66 and older who had both Medicare Parts A & B, no Medicare Advantage plan, no ESRD by first service date from Medical Evidence form, and were discharged alive from a first AKI hospitalization in 2014 or 2015. (b) All patient-years at risk for Optum Clinformatics™ commercial insurance patients aged 22 and older who were enrolled in the plan, did not have diagnoses of ESRD, and were alive on January of year shown. 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 was censored at death. Model for death was not censored at the start of ESRD. Abbreviations: AKI, acute kidney injury; ESRD, end-stage renal disease.

Recognizing that AKI can be associated with adverse long-term renal outcomes, including CKD and ESRD, both KDIGO guidelines and HP2020 objectives recommend follow-up renal evaluation after an AKI episode. In 2015, 16% of Medicare patients discharged alive from an AKI hospitalization had outpatient nephrology follow-up within the next six months, while 17% of Optum Clinformatics™ patients had follow-up over the same period. As shown in Figure 5.9, follow-up rates varied by comorbidity. Among patients with AKI superimposed on pre-existing CKD, but without DM, 16% of Medicare and 14% of Optum Clinformatics™ patients were seen by a nephrologist within six months following discharge. For patients with both CKD and DM, these proportions rose to 24% and 21%. In contrast, just 3% of Medicare and 9% of Optum Clinformatics™ AKI patients without DM or CKD were seen by a nephrologist by six months following an AKI hospitalization.

Trends over the past decade showed a slight decrease in post-AKI hospitalization nephrology follow-up for both the Medicare and Optum Clinformatics™ populations. This may once again reflect code creep: the milder cases of AKI captured by diagnosis may have been the least likely to require nephrology referral.

vol 1 Figure 5.9 Cumulative probability of a claim for an outpatient nephrology visit within six months of live discharge from first AKI hospitalization, overall and by CKD and DM, 2006-2015



Data Source: Special analyses, Medicare 5% sample and Optum Clinformatics™. (a) Medicare patients aged 66 and older who had both Medicare Parts A & B, no Medicare Advantage plan, no ESRD by first service date from Medical Evidence form on January 1 of year shown and were discharged alive from a first AKI hospitalization during the year. Censored at death, ESRD, end of Medicare Parts A & B participation, or switch to Medicare Advantage program. Physician visits are from physician/supplier claims with provider specialty codes for nephrology (39) and claim source indicating an outpatient setting. (b) Optum Clinformatics™ commercial insurance patients aged 22 and older who were enrolled in the plan, did not have diagnoses of ESRD, and were discharged alive from an AKI hospitalization in the year shown. Censored at death, ESRD, or plan disenrollment. Provider specialty of "nephrologist" used to identify nephrology visits. Abbreviations: AKI, acute kidney injury; CKD, chronic kidney disease; DM, diabetes mellitus; ESRD, end-stage renal disease.

Changes in CKD Status after Acute Kidney Injury

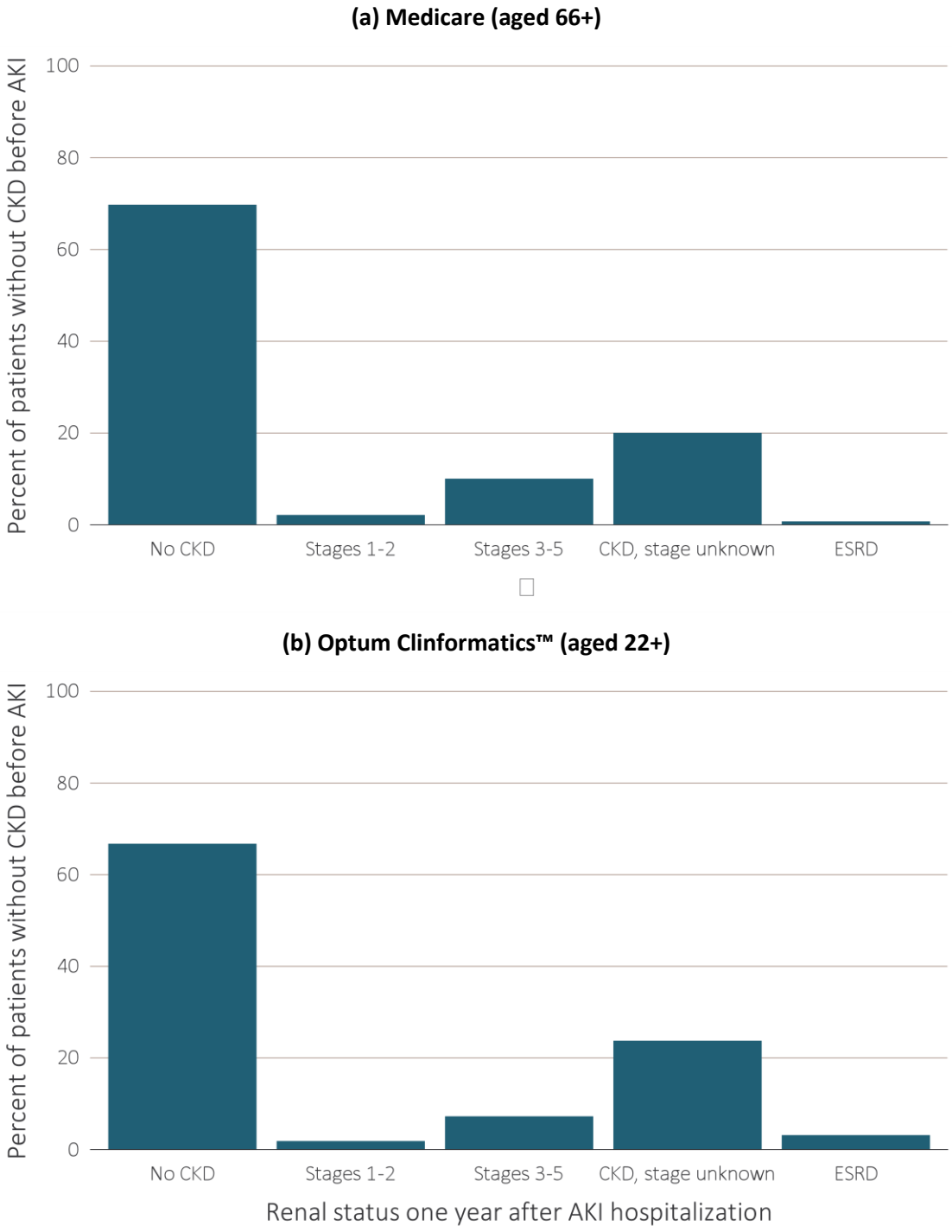
CKD status changed significantly in the year following an AKI hospitalization, as shown in Figure 5.10. Among Medicare patients without baseline CKD, 30.8% were reclassified as having some degree of CKD, including 0.2% being declared ESRD. In the Optum Clinformatics™ population, about 33.8% of patients with an AKI hospitalization were newly classified as having CKD in the subsequent year, and 2.6% were given a diagnosis of ESRD. Although the percent of patients with ESRD was markedly higher in the younger Optum Clinformatics™ population as compared to Medicare patients, it is important to note that these were proportions of surviving patients only. Table B shows the ICD-9-CM diagnosis codes used to define stages of CKD for Figure 5.10.

Table B. ICD-9-CM and ICD-10-CM codes for Chronic Kidney Disease (CKD) stages

ICD-9-CM code[a]	ICD-10-CM code	Stage
585.1	N18.1	CKD, Stage 1
585.2	N18.2	CKD, Stage 2 (mild)
585.3	N18.3	CKD, Stage 3 (moderate)
585.4	N18.4	CKD, Stage 4 (severe)
585.5	N18.5	CKD, Stage 5 (excludes 585.6/N18.6: Stage 5, requiring chronic dialysis)
CKD stage-unspecified		For these analyses, identified by multiple codes including ICD-9-CM code 585.9, 250.4x, 403.9x & others and ICD-10-CM code N18.9, E11.29, I12.9 & others

[a] For analyses in this chapter, CKD stage estimates require at least one occurrence of a stage-specific code, and the last available CKD stage in a given year was used. [b] In USRDS analyses, patients with ICD-9-CM code 585.6 or ICD-10-CM code N18.6 & with no ESRD 2728 form or other indication of end-stage renal disease (ESRD) are considered to have code 585.5/N18.5. ICD-10-CM codes became effective on October 1, 2015.

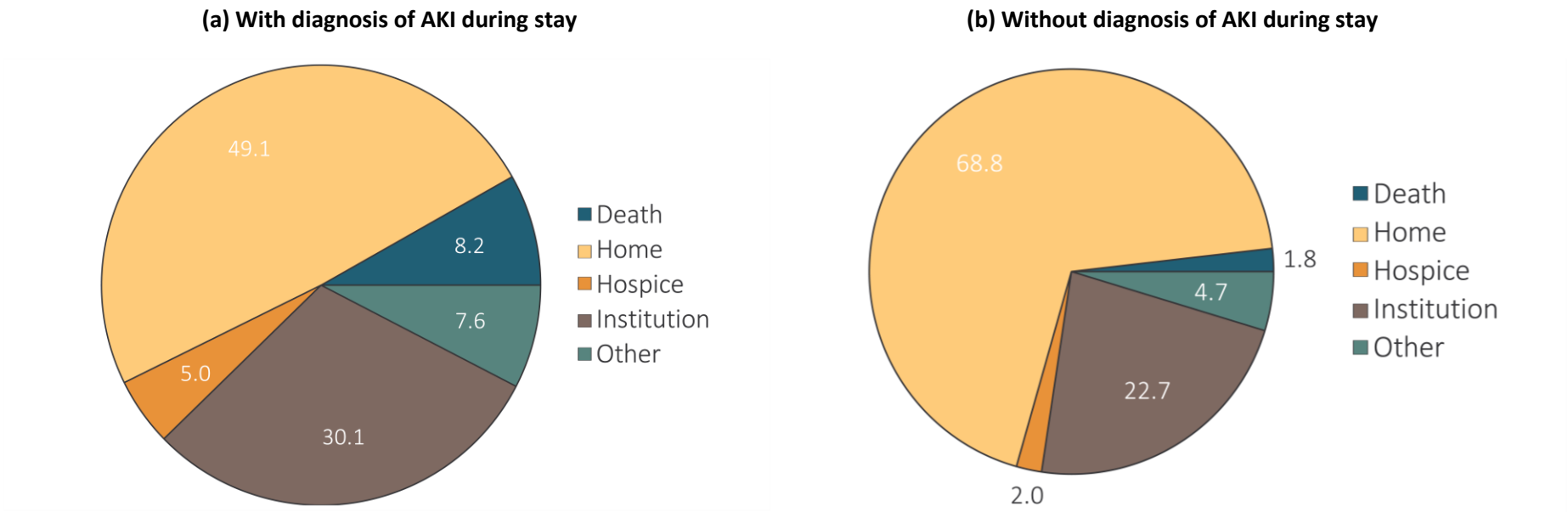
vol 1 Figure 5.10 Renal status one year following discharge from AKI hospitalization in 2014-2015, among surviving patients without kidney disease prior to AKI hospitalization, by CKD stage and ESRD status



Data Source: Special analyses, Medicare 5% sample. (a) Medicare patients aged 66 and older who had both Medicare Parts A & B, no Medicare Advantage plan, did not have ESRD, were discharged alive from a first AKI hospitalization in 2014 or 2015, and did not have any claims with a diagnosis of CKD in the 365 days prior to the AKI. (b) Optum Clinformatics™ commercial insurance patients aged 22 and older who were enrolled in the plan, did not have diagnoses of ESRD, and were discharged alive from an AKI hospitalization in 2014 or 2015, 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; ESRD, end-stage renal disease.

In Figure 5.11, we examined the status and disposition of 2016 Medicare AKI patients once they were discharged from the hospital. We excluded patients admitted from a skilled nursing facility (SNF; n=1,942), leaving 57,256 AKI discharges. Among AKI patients aged 66 and older about 49.1% were discharged directly to their home. Mortality (including those discharged to hospice) was 13.2%, while 30.1% of patients were discharged to institutions such as short-term SNFs, rehabilitation hospitals, or long-term care facilities. By comparison, among hospitalized Medicare patients without a diagnosis of AKI (excluding those admitted from a SNF, n= 2,837, leaving 174,193 discharges), 68.8% returned home and approximately 22.7% were discharged to institutions. It is worth noting that, due to data limitations, we cannot fully ascertain and exclude admissions from residential facilities; therefore the high rate of "long-term care facility" in the discharge status could be a reflection of a higher rate of admissions from these facilities.

vol 1 Figure 5.11 Hospital discharge status of first hospitalization for Medicare patients aged 66+ (a) with diagnosis of AKI during stay, and (b) without diagnosis of AKI during stay, 2016



Data Source: Special analyses, Medicare 5% sample. Medicare patients aged 66 and older who had both Medicare Parts A & B, no Medicare Advantage plan, did not have ESRD on January 1 of 2016, had a first hospitalization in 2016, and were not admitted to the acute care hospital from a skilled nursing facility. Institution includes short-term skilled nursing facilities, rehabilitation hospitals, and long-term care facilities. Home also includes patients receiving home health care services. Abbreviations: AKI, acute kidney injury; ESRD, end-stage renal disease.

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Chapter 6: CKD among Children and Adolescents

- 2.7 per 1,000 children with healthcare coverage within a single commercial payer had chronic kidney disease (CKD) (Table 6.2).
- Hospitalization rates was 12 times higher for children with CKD than for all children (Table 6.3).
- Between 2006 and 2016, healthcare expenditures increased by 50% for children with CKD, compared to 25% for children without CKD (Figure 6.3).
- Healthcare expenditures for children with CKD in 2016 were 7.6 times higher than expenditures for children without CKD (Figure 6.3).

Introduction

This chapter presents single private payer estimates of pediatric chronic kidney disease (CKD) prevalence in the United States. The chapters in the CKD volume have historically examined Medicare 5% sample data. Medicare beneficiaries are primarily aged 65 and older or disabled. The only category of children (aged 0-21) eligible for Medicare are those with end-stage renal disease (ESRD); this dataset therefore does not support investigation of CKD in. In the 2018 Annual Data Report (ADR), we introduce this new chapter as based on the Optum Clinformatics™ Data Mart cohort, utilizing a dataset of participants in the commercial insurance plans of a large U.S. managed-care health insurance company. Children with end-stage kidney disease were excluded from this chapter.

Methods

The Optum Clinformatics™ Data Mart data provides insight into a younger, employed population and their dependent children—approximately nine million lives per year, representing all areas of the country. Of these, this sample provides information for 1,970,375 individuals in pediatric age groups.

To be included in these analyses, eligible beneficiaries were required to have been enrolled in both a medical and a prescription plan throughout the one-year entry period (year one, the calendar year before the year reported in the figures and tables), and be alive, without ESRD, and still enrolled on January 1 of the reported year (year two). All beneficiaries in the Optum Clinformatics™ dataset had prescription drug coverage.

We present Optum Clinformatics™ data from 2005 through 2016 in the 2018 ADR, which is obtained from OptumInsight and includes claims from a large U.S. national health insurance company. To comply with the Health Insurance Portability and Accountability Act of 1996 (HIPAA) and prevent the re-identification of individuals in the database, certain combinations of sensitive data elements are not allowed. OptumInsight provides the data as different 'views', each containing a limited amount of sensitive data. Like Medicare data, Optum Clinformatics™ contains paid medical and prescription claims, enrollment information, and diagnosis and procedure codes as found on claims. Enrollment and member information such as year of birth, sex, race/ethnicity, state of residence, and plan participation are included, but detailed geographic and socio-economic data are not available. . Specifically, we are not able to report on laboratory within an individual case consequently we cannot report on prevalence of proteinuria, albuminuria or estimates of glomerular filtration rate.

Defining chronic kidney disease

The definition of CKD typically includes the presence of structural or functional kidney damage over a minimum period of three months. Functional damage is often characterized by sustained reduction in estimated glomerular filtration rate (eGFR), persistent elevations in urinary albumin excretion or a combination thereof (KDIGO, 2012). The presence of a structural abnormality of the kidney also fulfills the criteria for CKD.

Serum creatinine is a key laboratory measure for the estimation of GFR and GFR-based presence of CKD. Normal serum creatinine values increase with increasing child size and age from infancy to adulthood. Consequently, GFR estimation in children requires laboratory information as well as patient height at the time of laboratory testing. Blood laboratory testing is not a ubiquitous component of pediatric ambulatory care. Heights have not typically been available to laboratories, posing another barrier for the reporting of eGFR in children. The use of electronic health records and interoperable lab and electronic health records have the potential to solve the issue regarding height requirement for pediatric GFR reporting. Depending on available data sources, national surveillance initiatives may rely solely on diagnoses as represented in medical claims data.

Additionally, the American Academy of Pediatrics no longer recommends screening urinalyses in well child visits. While urinalyses are still recommended for cause, the absence of screening urine testing is reflected in the observed prevalence of urine testing of 0.2% in this cohort. Thus, the use of urinary albumin or protein excretion to define CKD will not contribute substantially to national surveillance initiatives overall nor to the surveillance in this Clinformatics™ cohort. Urine lab testing results were not included in our case definition.

Documentation of the presence of chronic structural or functional abnormalities of the kidney in medical claims may include traditional CKD codes or may only include a more precise structural or functional diagnosis. Consequently, a pediatric code set using ICD-9 and ICD-10 codes is used for this chapter. Laboratory results including urine protein, urine albumin, and serum creatinine were not available for analysis for this chapter and were not included in case definitions.

Details of this data are described in the *Data Sources* section of the *CKD Analytical Methods* chapter. For an explanation of the analytical methods used to generate the study cohorts, figures, and tables in this chapter, see the section on *Chapter 6* in the *CKD Analytical Methods* chapter. Microsoft Excel and PowerPoint files containing the data and graphics for these figures and tables are available to download from the *USRDS website*.

Population

Table 6.1 presents the comparison of all children and those with CKD within the 1,970,375 privately insured children in 2016. Overall CKD was present in 2.7 cases per 1,000 children. CKD was more common in children under 4 years of age and adolescents age 18 to 21. Proteinuria or albuminuria was tested in 11.7% of children with CKD compared to less than 0.2% of children without CKD. Although urine albumin and protein testing was infrequent in this Optum Clinformatics™ data set, others have reported frequencies of albuminuria in the National Health and Nutrition Examination Survey (NHANES), showing proteinuria in 3.5% of all adolescents surveyed (Saydah et el., 2018). Given the differences in data sources and methodology, we are not able to replicate NHANES data for accurate comparison. Co-existing conditions such as diabetes (4.1%), hypertension (8.8%), and cardiovascular diseases (10.3%) were more common in children with CKD than in the full pediatric population. However, these frequencies are much lower than reported in adults with CKD managed within the Medicare system (23.6%, 58.9%, and 38.8%, respectively) and similar to the young adult population included in the Optum Clinformatics™ sample (4.4%, 10.3%, and 4.5%, respectively) (see Volume 1, Chapter 2: *Identification and Care of Patients with CKD*).

vol 1 Table 6.1 Demographic characteristics of Optum Clinformatics™ pediatric patients, 2016

	All children		Children with CKD	
	Sample count	**Percent (%)**	**Count**	Percent (% of all children)
All	1,970,375	100	5,285	0.27
Age				
0-4	308,099	15.6	1,122	0.36
5-9	445,408	22.6	1,027	0.23
10-13	392,978	19.9	839	0.21
14-17	411,582	20.9	1,085	0.26
18-21	412,308	20.9	1,212	0.29
Sex				
Male	1,007,120	51.1	2,491	0.25
Female	963,175	48.9	2,794	0.29
Unknown	80	<0.01	0	0.00
Race/Ethnicity				
White	1,265,505	64.2	3,459	0.27
Black/African American	149,789	7.6	342	0.23
Asian	104,525	5.3	239	0.23
Hispanic	244,113	12.4	626	0.26
Unknown/Missing	206,443	10.5	619	0.30
Comorbidity				
Diabetes Mellitus	6,546	0.3	217	3.32
Hypertension	3,483	0.2	463	13.29
Cardiovascular Disease	17,549	0.9	543	3.09

Data Source: Special analyses, Optum Clinformatics™ (aged <22) alive & eligible for all of 2016. CVD is defined as presence of any of the following comorbidities: cerebrovascular accident, peripheral vascular disease, atherosclerotic heart disease, heart failure, dysrhythmia or other cardiac comorbidities. Abbreviation: CKD, chronic kidney disease.

Co-existing conditions

The prevalence of co-existing conditions within the pediatric sample highlights the presence of cardiovascular disease and diabetes mellitus as exemplar conditions and as conditions commonly associated with CKD progression in adults (Table 6.2). For this analysis, cardiovascular disease includes congenital and acquired heart disease but excludes hypertension. Overall, cardiovascular disease was present in 85 per 10,000 children and diabetes in 31 per 10,000 children in 2016. Concurrently diagnosed CKD and cardiovascular disease was present in 3 per 10,000 and CKD and diabetes was present in 1 per 10,000 children. Children with any of these three conditions account for 144 per 10,000 persons, or about 1.4 percent.

vol 1 Table 6.2 Prevalence of comorbid conditions by diagnosis codes (CKD, CVD, & DM), (a) total & (b) one or more, among Optum Clinformatics™ pediatric patients, 2016

(a) Total

	Optum Clinformatics™	
	Sample count	Cases per 10,000
All		
Total CKD	5,285	27
Total CVD	17,549	89
Total DM	6,546	33

(b) Combinations of CKD, CVD, or DM diagnoses

	Optum Clinformatics™	
	Sample count	Cases per 10,000
All		
Only CKD	4,564	23
Only CVD	16,731	85
Only DM	6,054	31
CKD & DM, no CVD	178	1
CKD & CVD, no DM	504	3
DM & CVD, no CKD	275	1
CKD & CVD & DM	39	<1
At least one comorbidity	28,345	144
At least two comorbidities	996	5
No CKD, no CVD, no DM	1,942,030	9,856

Data Source: Special analyses, Optum Clinformatics™ (aged <22) alive & eligible for all of 2016. CVD is defined as presence of any of the following comorbidities: cerebrovascular accident, peripheral vascular disease, atherosclerotic heart disease, congestive heart failure, dysrhythmia or other cardiac comorbidities. Abbreviations: CKD, chronic kidney disease; CVD, cardiovascular disease; DM, diabetes mellitus.

Hospitalizations

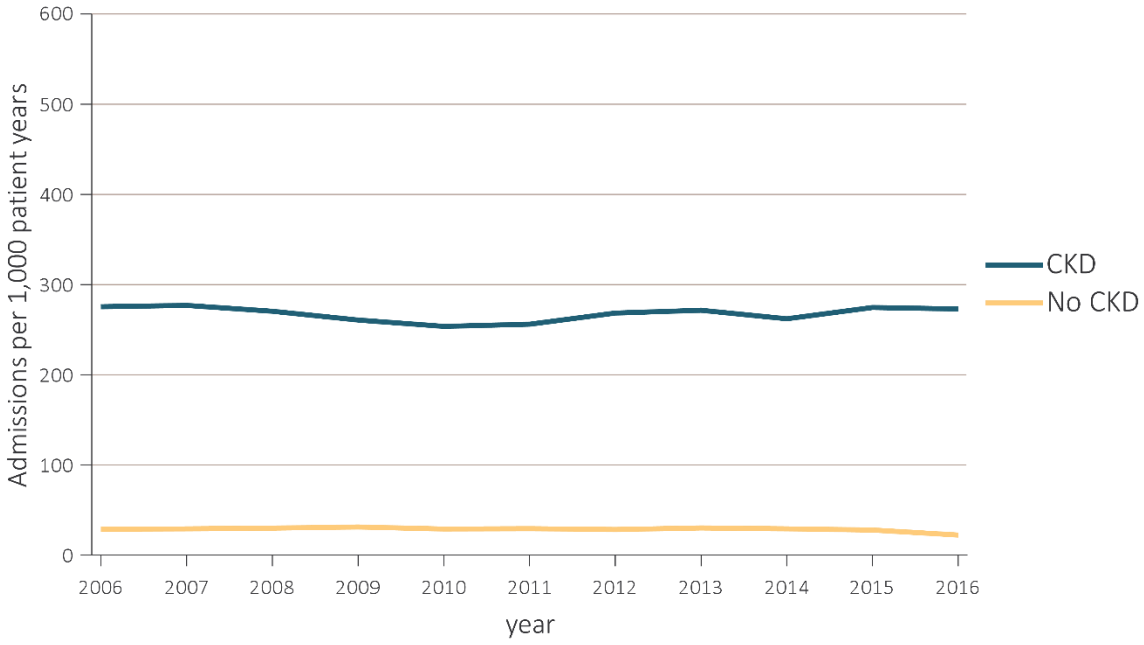
Table 6.3 displays the hospitalization rates of children with CKD and provides the all child hospitalization comparisons. Overall, children with CKD have 12 times higher hospitalizations per 1,000 patient-years compared to all children. The youngest children, age 4 years and below, have the highest frequency of hospitalizations in the full and CKD pediatric subsets. Longitudinal trends reveal a stable hospitalization rate between 2006 and 2016 for children overall and for the CKD subset (Figure 6.1).

vol 1 Table 6.3 Unadjusted and adjusted all-cause hospitalization rates (per 1,000 patient years at risk) for Optum Clinformatics™ patients aged <22, by CKD status, 2016

	Unadjusted		Adjusted	
	No CKD	All CKD	No CKD	All CKD
All	28.3	325.8	22.4	273.0
0-4	95.2	482.5	55.9	366.4
5-9	5.4	216.0	5.6	218.6
10-13	6.3	174.1	6.7	174.2
14-17	14.1	227.8	14.9	228.1
18-21	20.1	345.0	21.3	343.3
Male	26.9	346.9	20.8	275.5
Female	29.8	304.9	24.0	268.0
White	12.7	247.4	13.7	244.0
Blk/Af Am	14.0	267.1	15.1	262.8
Other	44.8	407.5	36.2	303.8

Data source: Special analyses, Optum Clinformatics™. January 1, 2016 point prevalent patients, aged <22. Optum Clinformatics™ commercial insurance patients aged <22 who were enrolled in the plan, did not have diagnoses of ESRD, and were alive on January 1, 2016. Adjusted for age/sex/race. Standard population: all patients, 2010-2011. Abbreviations: Blk/Af Am, Black/African American; CKD, chronic kidney disease.

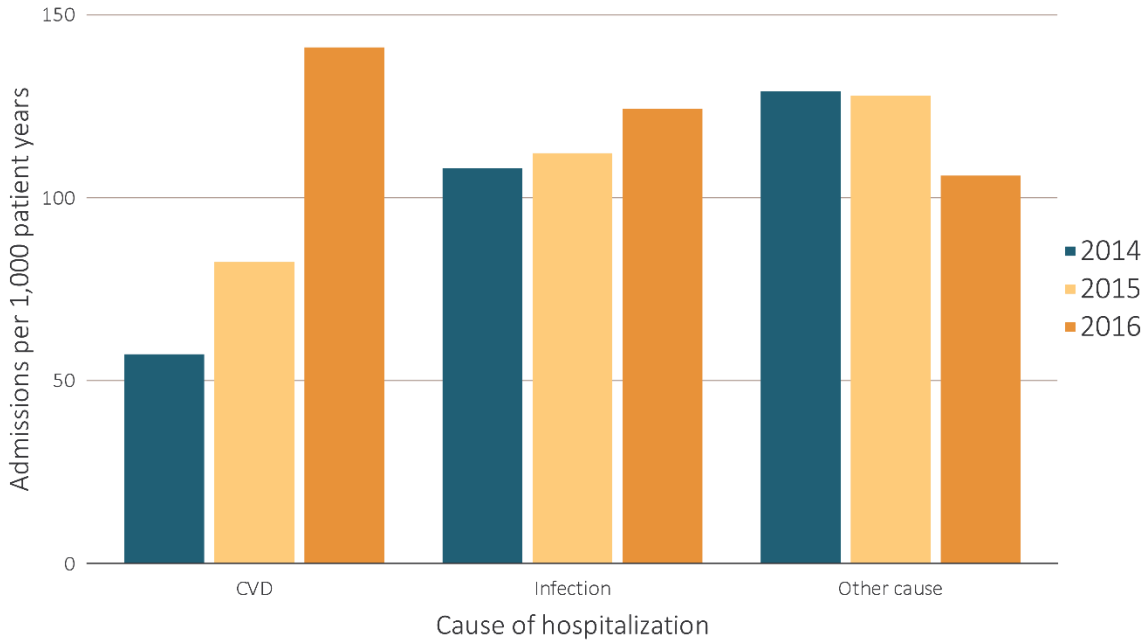
vol 1 Figure 6.1 Adjusted all-cause hospitalization rates (per 1,000 patient-years at risk) for Optum Clinformatics™ patients aged <22, by CKD status and year, 2006-2016



Data source: Special analyses, Optum Clinformatics™. January 1, point prevalent Optum Clinformatics™ patients aged <22 who were enrolled in the plan, did not have diagnoses of ESRD, and were alive on January 1. Adjusted for age/sex/race. Standard population: 2010-2011 patients. Abbreviations: CKD, chronic kidney disease.

CKD associated hospitalizations were categorized as cardiovascular, infectious and other. (Figure 6.2). Of the 273 adjusted hospitalizations per 1,000 patient years, adjusted cardiovascular was 140.5, infection was 123.6, and other diagnosis was 105.4. The leading causes of hospitalizations in other group includes kidney and urinary tract; metabolic, endocrine, nutritional; hematology/oncology, and gastrointestinal diagnoses. The cardiovascular disease associated hospitalizations has dramatically increased over this three-year period. As this period includes the transition from ICD-9 to ICD-10 codes, it may be that the shift in cardiovascular attribution is related more to this coding change rather than true changes in cardiovascular disease prevalence in hospitalized children.

vol 1 Figure 6.2 Adjusted rates of hospitalization (per 1,000 patient-years at risk) for Optum Clinformatics™ patients aged <22 with CKD, by cause, 2014-2016

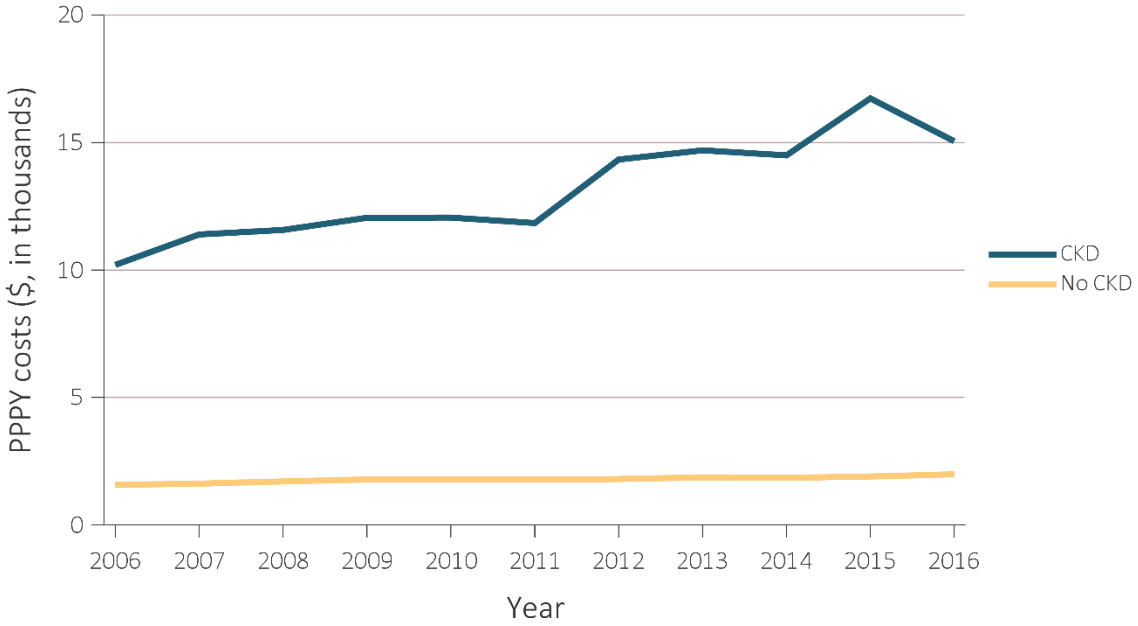


Data source: Special analyses, Optum Clinformatics™. January 1, 2016 point prevalent Optum Clinformatics™ patients, aged <22 who were enrolled in the plan, did not have diagnoses of ESRD, and were alive on January 1, 2014/2015/2016. Adjusted for age/sex/race; rates by one factor are adjusted for the others. Standard population: all patients, 2010-2011. Abbreviations: CKD, chronic kidney disease; CVD, cardiovascular disease.

Spending for CKD

Individuals with CKD often have extensive healthcare needs from CKD, CKD-related complications and from co-existing conditions. This chapter uses commercial spending to represent healthcare expenditures for children with CKD. This estimate does not include expenditures from other potential sources including co-insurance such as Medicaid, another commercial insurance, and self-pay costs. Between 2006 and 2016, single commercial healthcare expenditures for children with CKD increased 47.6%, from $10,200 per patient-year to $15,053 per patient-year (Figure 6.3). In comparison, expenditures for non-CKD children rose by 26.4% percent, from $1,571 to $1,985 per patient-year. Overall, expenditures were 7.6 times higher for children with CKD compared with non-CKD children in 2016.

vol 1 Figure 6.3 Per person per year commercial spending ($, in thousands) for Optum Clinformatics™ patients aged <22, by CKD status, and year, 2006-2016



Data Source: Special analyses, Optum Clinformatics™. Abbreviations: CKD, chronic kidney disease; PPPY, per person per year.

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Chapter 7: Healthcare Expenditures for Persons with CKD

- In this 2018 Annual Data Report (ADR), we introduce information from the Optum Clinformatics™ DataMart for persons with Medicare Advantage and commercial managed care coverage. This will provide a more comprehensive examination of the financial costs necessary to provide care to beneficiaries with chronic kidney disease (CKD).
- Medicare spending for all beneficiaries who had CKD (12.5% of total) exceeded $79 billion in 2016, an increase of 23% from 2015 (Tables 7.1 and 7.3). When adding an extra $35 billion for end-stage renal disease (ESRD) costs (see Volume 2, Chapter 9: Healthcare Expenditures for Persons with ESRD, Figure 9.2), total Medicare spending on both CKD and ESRD was over $114 billion, representing 23% of total Medicare fee-for-service (FFS) spending.
- In 2016, Medicare spending for beneficiaries with CKD aged 65 and older exceeded $67 billion, representing 25% of all Medicare spending in this age group (Figure 7.1). Medicare expenditures for CKD were 20% higher in 2016 than in 2015 ($55 billion).This was mostly due to an 18% increase in the ascertainment of CKD.
- Medicare spending for beneficiaries with CKD who were younger than age 65 (8% of total) exceeded $12 billion in 2016, representing 18% of total spending in this age group (Table 7.3).
- Growth in total CKD spending has primarily been driven by an increase in the number of identified cases, particularly those in the earlier stages (CKD Stages 1-3).
- Over half of the 2016 Medicare spending for beneficiaries aged 65 and older was for those who had diagnoses of CKD, diabetes mellitus (DM), or heart failure (HF; Figure 7.1).
- Over 78% of total Medicare spending for beneficiaries with CKD who were aged 65 and older was incurred by the 71% of these patients who also had DM, HF, or both (Table 7.1).
- Spending per patient-year for those with all three chronic conditions of CKD, DM, and HF was more than twice as high ($39,506) than for beneficiaries with only CKD ($16,176; Table 7.1).
- Per-person per-year spending for Medicare Advantage enrollees over age 65 and those enrolled in Optum Clinformatics™ managed care over age 65 was slightly higher, at 79% and 123% of the expenditures for FFS Medicare (Table 7.2).
- For beneficiaries under age 65, spending was somewhat higher in the Medicare Advantage program than in FFS Medicare, both when averaged across all beneficiaries (12% higher) and among all those with CKD (6% higher; Table 7.3).
- In the FFS Medicare CKD population, Black/African American beneficiaries continued to exhibit higher spending in all disease categories as compared to Whites and those of other races (Table 7.5). However, Blacks with Medicare Advantage had lower spending than patients of other races (Table 7.6).
- The analysis of expenses for beneficiaries with CKD indicates the effect of cost-containment efforts in this population, and avenues for potential savings. Reduction in expenditures could be achieved through the prevention of disease progression to later stages of CKD, and prevention of the development of concurrent chronic conditions such as DM and HF.

Introduction

Persons with chronic kidney disease (CKD) but not end-stage renal disease (ESRD) often have extensive healthcare needs and frequently face co-existing illnesses. This chapter assesses the overarching financial cost of caring for persons with CKD through comparison of expenditures in three payment systems. As in previous Annual Data Reports (ADR), the Medicare 5% sample was used to determine spending for Medicare fee-for-service (FFS) beneficiaries. In this chapter, we present recent patterns and longer-term trends in both total claims-based spending and spending by CKD status, patient characteristics such as age, sex, and race, and diabetes mellitus (DM) and heart failure (HF) status.

In this 2018 ADR, we add comparable information from the Optum Clinformatics™ DataMart for persons enrolled in Medicare Advantage and through a large commercial managed care organization. The percent of Medicare beneficiaries enrolled in managed care grew from 13% in 2004 to 33% in 2017 (Kaiser, 2017); 19.0 million individuals were enrolled in an Medicare Advantage plan in March 2017. Addition of this dataset makes our assessment of CKD spending significantly more comprehensive, particularly for the CKD population aged 65 and older. Similarly, the addition of commercial insurance data allows more complete assessment of CKD spending, particularly for those younger than age 65, as commercial insurance was the largest source of payment for this group.

While our analyses provide a sound and valid estimate of the costs of CKD to healthcare systems, when interpreting spending levels and trends in these claims data, the impact of potential under-identification should be kept in mind. Unlike ESRD, where determination is straightforward due to the need for renal replacement services, CKD can be under-identified. There may be valid under-recognition that occurs when patients who have impaired renal function have not yet been tested. Claims-based under-identification can also occur when patients who have been tested and identified clinically do not have a CKD diagnosis listed on an insurance claim. Such under-identification makes the determination of the full economic impact of CKD on a healthcare system challenging.

Under-recognition of CKD can affect estimates of CKD-related expenditures in several ways. Identification of persons with CKD using ICD-9-CM and ICD-10-CM (International Classification of Diseases, Ninth and Tenth Revision, Clinical Modification) diagnosis codes will result in an underestimate of total CKD expenditures, as early in the disease process formal diagnoses of CKD are not commonly documented or may not even have been identified clinically (Grams, 2011). Assuming that under-identification occurs most often in the earliest and least costly patient cases, spending estimates per patient per year (PPPY) calculated solely from the claims-based diagnoses of CKD are likely to be biased upwards. To the extent that under-identification is not constant over time, interpretation of trend data for both total and PPY expenditures should be made in this context.

In addition, it is not possible to attribute healthcare expenditures solely to kidney disease with any accuracy; the costs of CKD are influenced by its interactive nature and associations with other chronic conditions such as DM and hypertension (HTN), and with cardiovascular diseases (CVD) such as coronary artery disease, cerebrovascular disease, peripheral arterial disease, and HF. In order to understand better the complexity of how these conditions contribute to costs, we often present and compare results for patients with varying combinations of CKD, DM, and HF.

Similar issues of CKD under-identification are also discussed in this 2018 ADR in the following chapters in Volume 1: Chapter 1: CKD in the General Population; Chapter 2: Identification and Care of Patients with CKD; and Chapter 3: Morbidity and Mortality in Patients with CKD.

Methods

This chapter uses data from three primary sources including beneficiaries of general Medicare, those enrolled in Medicare Advantage plans, and a cohort of individuals enrolled in a commercial managed care plan.

The Medicare 5% sample provides information on FFS beneficiaries aged 66 and older. Roughly 98% of Americans aged 65 and older qualify for Medicare, and as a result, analysis of Medicare data is representative of beneficiaries age 65 and older.

Medicare prescription drug coverage through Part D plans is also included in this chapter. Note that beneficiaries have many options to purchase prescription drugs, so the claims filled through the Part D plan may not represent all medications prescribed to Medicare beneficiaries.

In addition to reporting on the population aged 65 and older, beginning in 2014, we have added information on beneficiaries younger than 65 who generally were Medicare-eligible due to disability. Data from the Optum Clinformatics™ DataMart is presented for those both younger than 65, and 65 and older.

The Optum Clinformatics™ DataMart includes a cohort of individuals with commercial managed care plans. Optum Clinformatics™ data provides paid medical and prescription claims and enrollment information for national participants in the commercial managed care plans of a large U.S. health insurance company. The data was purchased from OptumInsight, and participants are enrolled in both a medical and a prescription plan. There was a complete refresh of data for all years for Optum this year in comparison with last year. Optum also added new claims sources, which contributed to the increase in claim counts and the difference in this year's counts compared to the 2017 ADR.

The methodology we employed to calculate costs related to CKD (excluding ESRD) utilizes ICD-9-CM and ICD-10-CM diagnosis codes to define the point prevalent CKD cohort. We included only those beneficiaries classified as having CKD on January 1 of each given year, to avoid possible association with acute kidney injury (AKI). How to best integrate the costs of AKI patients into CKD calculations is a continuing area for research, due to the potential for transition from AKI to CKD.

In this chapter, we defined costs as insurance expenditures rather than true economic costs, using claims from Medicare Parts A, B, and D as based on the 5% Medicare sample for calendar years 1996-2016 and from 100% of the Optum Clinformatics™ dataset for calendar years 2006-2016. To account for differences in pricing across health plans and provider contracts, Optum Clinformatics™ applies standard pricing algorithms to claims data. These algorithms were designed to create standard prices that reflect allowed payments across all provider services.

Details of this data are described in the *Data Sources* section of the *CKD Analytical Methods* chapter. For an explanation of the analytical methods used to generate the study cohorts, figures, and tables in this chapter, see the section on *Chapter 7* within the *CKD Analytical Methods* chapter. Downloadable Microsoft Excel and PowerPoint files containing the data and graphics for these figures and tables are available on the *USRDS website*.

Spending for CKD and Related Chronic Comorbidities

Beneficiaries Aged 65 and Older

Fee-For-Service Medicare

Examining FFS Medicare spending reinforces CKD's reputation as a cost multiplier. Beneficiaries with recognized CKD represent 13% of the point prevalent aged Medicare population, yet accounted for 25% of total expenditures (Table 7.1).

We examined 2016 costs in relation to beneficiaries' CKD stage, age, sex, race, and concurrent disease, focusing on DM and HF. These conditions, in addition to CKD, represent some of the costliest chronic disease populations for Medicare. For example, HF affects 9% of beneficiaries in the FFS Medicare population, but accounts for 20% of expenditures. Thirty-five percent of overall expenditures were directed toward the 24% of beneficiaries with DM.

In those aged 65 and older, per-person per-year (PPPY) costs were 93% higher for patients with CKD only, versus those with no CKD, DM, or HF ($16,176 vs $8,400). Costs for those with CKD and DM were 54% higher than for those with DM only. Similarly, expenditures for those with CKD and HF were 46% higher than for those with HF alone. For beneficiaries with CKD, HF, and DM, costs were 49% higher than for those with only HF and DM. Overall, people with diagnoses of any condition of CKD, DM, and/or HF accounted for one-third of the Medicare aged 65 and older population, but over half of total programmatic costs.

vol 1 Table 7.1 Prevalent Medicare fee-for-service patient counts and spending for beneficiaries aged 65 and older, by diabetes, heart failure, and/or CKD, ESRD excluded, 2016

	U.S. Medicare Population	Total Spending (millions, U.S. $)	PPPY (U.S. $)	Population (%)	Spending (%)
All	24,247,520	$271,334	$11,534	100	100
With HF or CKD or DM	8,246,040	$139,538	$17,809	34.01	51.43
CKD only (- DM & HF)	1,176,200	$18,139	$16,176	4.85	6.69
DM only (- HF & CKD)	3,730,480	$44,533	$12,229	15.39	16.41
HF only (- DM & CKD)	860,780	$17,372	$21,808	3.55	6.40
CKD and DM only (- HF)	1,183,580	$21,738	$19,243	4.88	8.01
CKD and HF only (- DM)	367,500	$10,124	$31,887	1.52	3.73
DM and HF only (- CKD)	424,260	$10,445	$26,544	1.75	3.85
CKD and HF and DM	503,240	$17,187	$39,506	2.08	6.33
No CKD or DM or HF	16,001,480	$131,796	$8,400	65.99	48.57
All CKD (+/- DM & HF)	3,230,520	$67,188	$22,369	13.32	24.76
All DM (+/- CKD & HF)	5,841,560	$93,904	$16,769	24.09	34.61
All HF (+/- DM & CKD)	2,155,780	$55,128	$28,378	8.89	20.32
CKD and DM (+/- HF)	1,686,820	$38,925	$24,877	6.96	14.35
CKD and HF (+/- DM)	870,740	$27,311	$36,291	3.59	10.07
DM and HF (+/- CKD)	927,500	$27,633	$33,350	3.83	10.18

Data Source: Medicare 5% sample. Abbreviations: CKD, chronic kidney disease; ESRD, end-stage renal disease; HF, heart failure; DM, diabetes mellitus; PPPY, per-person per-year.

Medicare Advantage and Commercial Managed Care Coverage

CKD was also a cost multiplier for individuals 65 and older who were beneficiaries of Medicare Advantage or commercial managed care plans. The Medicare Advantage population was similar to FFS Medicare, with 15% having CKD and those with CKD accounting for 24% of spending. The managed care population had a lower prevalence of CKD (8%), but those with CKD also accounted for an outsized (17%) proportion of spending.

Per-person per-year spending in these populations was somewhat higher than that for FFS Medicare (Zuckerman, 2017). In this dataset, Optum Clinformatics™ Medicare Advantage spending was 79% of those receiving FFS Medicare, with managed care beneficiaries at 123%. Such differences can arise from plan effects (e.g., care management activities of Medicare Advantage plans) or patient selection (e.g., those over 65 with commercial coverage are often still employed). Spending for those with CKD only was 72% ($13,418 vs $7,813) and 132% ($22,124 vs $9,527) higher than for those with no CKD, DM, or HF in the Medicare Advantage and managed care populations.

vol 1 Table 7.2 Prevalent Medicare Advantage and managed care spending for beneficiaries aged 65 and older, by diabetes, heart failure, and/or CKD, ESRD excluded, 2016

	Medicare Advantage			Managed care		
	PPPY (U.S. $)	Population (%)	Spending (%)	PPPY (U.S. $)	Population (%)	Spending (%)
All	$10,356	100	100	$12,176	100	100
With HF or CKD or DM	$15,362	34.15	49.97	$20,562	24.15	40.53
CKD only (- DM & HF)	$13,418	5.96	7.63	$22,124	3.33	6.04
DM only (- HF & CKD)	$11,942	15.48	17.92	$15,627	13.74	17.63
HF only (- DM & CKD)	$18,291	2.74	4.67	$24,352	1.98	3.93
CKD and DM only (- HF)	$16,051	5.31	8.15	$25,132	2.68	5.51
CKD and HF only (- DM)	$24,601	1.53	3.36	$37,903	0.77	2.25
DM and HF only (- CKD)	$23,949	1.38	3.08	$32,561	0.87	2.28
CKD and HF and DM	$33,143	1.75	5.17	$48,110	0.78	2.90
No CKD or DM or HF	$7,813	65.85	50.03	$9,527	75.85	59.47
All CKD (+/- DM & HF)	$17,757	14.54	24.30	$27,289	7.56	16.70
All DM (+/- CKD & HF)	$14,968	23.92	34.32	$19,164	18.07	28.31
All HF (+/- DM & CKD)	$24,063	7.40	16.28	$32,359	4.40	11.35
CKD and DM (+/- HF)	$20,066	7.06	13.32	$30,085	3.46	8.41
CKD and HF (+/- DM)	$29,158	3.28	8.52	$43,047	1.55	5.15
DM and HF (+/- CKD)	$28,988	3.13	8.25	$39,754	1.65	5.18

Data Source: Optum Clinformatics™. Abbreviations: CKD, chronic kidney disease; ESRD, end-stage renal disease; HF, heart failure; DM, diabetes mellitus; PPPY, per-person per-year. Numbers of 'All' patients included in this table are 2,536,831 and 236,268 for Medicare Advantage and Commercial managed care respectively.

Beneficiaries Younger than Age 65

Fee-For-Service Medicare

For the FFS Medicare population under age 65 only 8% had CKD, but those individuals accounted for 18% of spending. One-fourth had one or more of CKD, DM, and/or HF, accounting for almost 44% of spending for this group (Table 7.3). Much of these expenditures, however, were for those who had DM, at 22% of the population and 34% of spending.

vol 1 Table 7.3 Prevalent Medicare fee-for-service patient counts and spending for beneficiaries younger than age 65, by diabetes, heart failure, and/or CKD, ESRD excluded, 2016

	U.S. Medicare Population	Total Costs (millions, U.S. $)	PPPY spending (U.S. $)	Population (%)	Spending (%)
All	4,709,780	$66,276	$14,558	100	100
With HF or CKD or DM	1,269,900	$28,917	$23,851	26.96	43.63
CKD only (- DM & HF)	111,820	$2,691	$25,394	2.37	4.06
DM only (- HF & CKD)	714,800	$12,248	$17,705	15.18	18.48
HF only (- DM & CKD)	96,120	$2,401	$26,462	2.04	3.62
CKD and DM only (- HF)	190,680	$5,429	$30,002	4.05	8.19
CKD and HF only (- DM)	23,400	$992	$46,599	0.50	1.50
DM and HF only (- CKD)	67,100	$2,078	$33,051	1.43	3.14
CKD and HF and DM	65,980	$3,079	$52,335	1.40	4.65
No CKD or DM or HF	3,439,880	$37,359	$11,185	73.04	56.37
All CKD (+/- DM & HF)	391,880	$12,190	$33,214	8.32	18.39
All DM (+/- CKD & HF)	1,038,560	$22,834	$22,961	22.05	34.45
All HF (+/- DM & CKD)	252,600	$8,549	$36,580	5.36	12.90
CKD and DM (+/- HF)	256,660	$8,508	$35,482	5.45	12.84
CKD and HF (+/- DM)	89,380	$4,071	$50,812	1.90	6.14
DM and HF (+/- CKD)	133,080	$5,157	$42,374	2.83	7.78

Data Source: Medicare 5% sample. Abbreviations: CKD, chronic kidney disease; DM, diabetes mellitus; ESRD, end-stage renal disease; HF, heart failure; PPPY, per-person per-year.

Medicare Advantage and commercial Managed Care Coverage

The Medicare Advantage population under age 65 was similar to the FFS Medicare population. Thirty-three percent of the Medicare Advantage beneficiaries had one or more of CKD, DM, and/or HF, accounting for 49% of spending for this group (Table 7.4). The managed care population under age 65 was much less likely to have CKD, DM, or HF (6%) than the Medicare Advantage population (33%).

For those under age 65, spending was somewhat higher for beneficiaries in the Medicare Advantage program, both when averaged across all beneficiaries (12% higher: $16,358 vs $14,558) and among all with CKD (1.9% lower: $32,571 vs $33,214; Tables 7.3 and 7.4). Consistent with our other findings, average spending for those with CKD was considerably lower (27% lower for those with CKD: $24,214 vs $33,214) in the managed care population than in the Medicare FFS and Medicare Advantage populations.

vol 1 Table 7.4 Prevalent Medicare Advantage and managed care fee-for-service spending for beneficiaries younger than age 65, by diabetes, heart failure, and/or CKD, ESRD excluded,2016

	Medicare Advantage			Managed care		
	PPPY (U.S. $)	Population (%)	Spending (%)	PPPY (U.S. $)	Population (%)	Spending (%)
All	$16,358	100	100	$5,317	100	100
With HF or CKD or DM	$24,317	33.34	49.24	$15,313	6.43	18.54
CKD only (- DM & HF)	$25,398	3.24	5.00	$18,996	0.77	2.74
DM only (- HF & CKD)	$18,863	19.32	22.30	$12,161	4.77	10.96
HF only (- DM & CKD)	$27,505	2.06	3.41	$23,139	0.29	1.25
CKD and DM only (- HF)	$28,616	4.62	8.03	$25,423	0.40	1.91
CKD and HF only (- DM)	$45,866	0.67	1.78	$52,704	0.05	0.42
DM and HF only (- CKD)	$33,680	1.83	3.70	$32,309	0.10	0.59
CKD and HF and DM	$54,296	1.60	5.01	$71,480	0.05	0.66
No CKD or DM or HF	$12,416	66.66	50.76	$4,629	93.57	81.46
All CKD (+/- DM & HF)	$32,571	10.13	19.83	$24,214	1.27	5.73
All DM (+/- CKD & HF)	$23,449	27.37	39.04	$14,066	5.32	14.13
All HF (+/- DM & CKD)	$38,093	6.15	13.91	$32,647	0.49	2.92
CKD and DM (+/- HF)	$34,971	6.22	13.05	$30,457	0.45	2.57
CKD and HF (+/- DM)	$51,798	2.26	6.80	$62,768	0.10	1.08
DM and HF (+/- CKD)	$43,101	3.42	8.71	$45,383	0.15	1.25

Data Source: Optum Clinformatics™. Abbreviations: CKD, chronic kidney disease; HF, heart failure; DM, diabetes mellitus; ESRD, end-stage renal disease; PPPY, per-person per-year. Number of 'All' patients included in this table are 279,972 and 5,011,031 for Medicare Advantage and Managed care respectively.

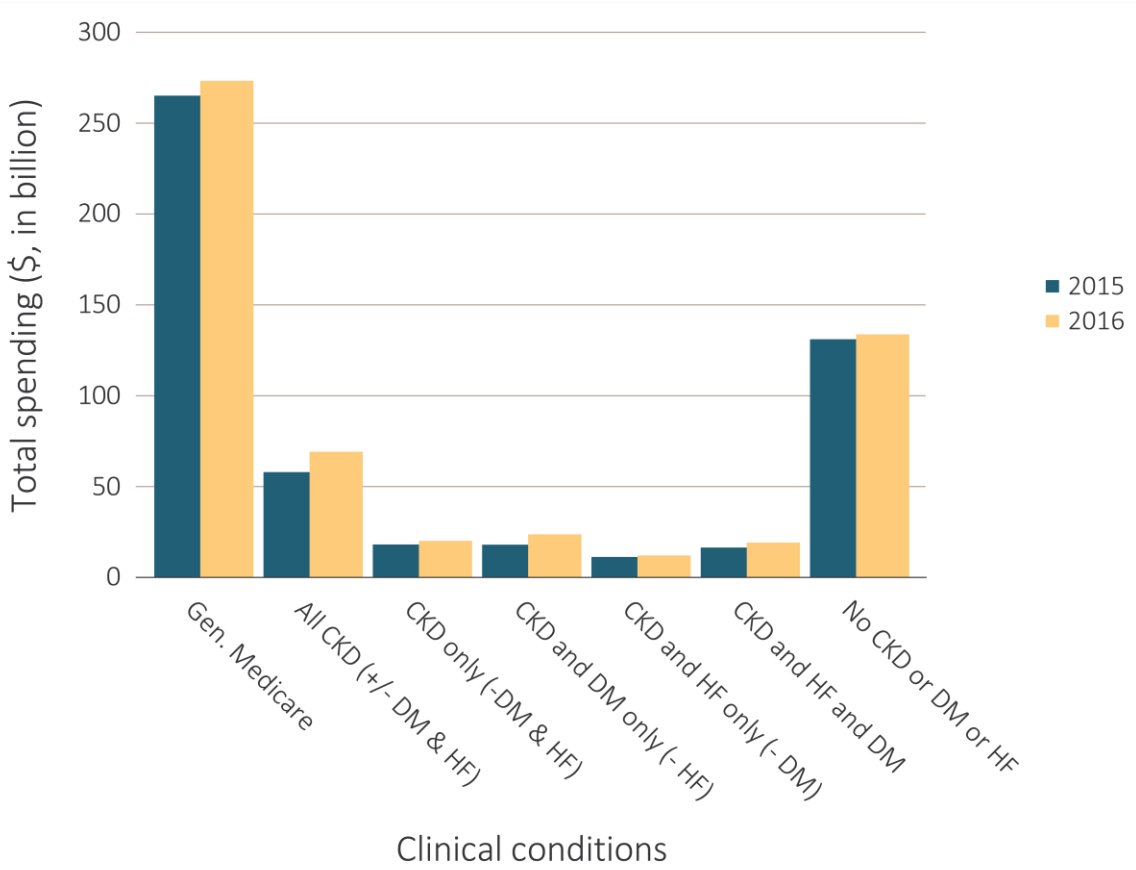
Spending for CKD by Stage and Patient Characteristics

Among the FFS Medicare population aged 65 and older, between 2015 and 2016 total spending for Parts A, B, and D rose by $8 billion, to $271 billion. Total spending for CKD patients rose by $11.2 billion, to $67.2 billion (Figure 7.1).

Further, total Medicare expenditures were higher for beneficiaries with CKD than for beneficiaries with ESRD ($67.2 billion vs. $35.4 billion; see Volume 2, Chapter 9: Healthcare Expenditures for Persons with ESRD). Expenditures for beneficiaries with CKD now represent 24.8% of all Medicare Parts A, B, and D non-ESRD spending.

Expenditures increased for all covered groups, but the highest growth rates occurred in those with CKD and DM, followed by all CKD, and then CKD and HF and DM. The spending increase appears to be driven by a rise in the proportion of beneficiaries with recognized CKD (see Table 7.7 and Volume 1, Chapter 2: Identification and Care of Patients with CKD, Figure 2.2).

vol 1 Figure 7.1 Overall Medicare Parts A, B, and D fee-for-service spending for beneficiaries aged 65 and older, by CKD, diabetes, and heart failure, ESRD excluded, 2015 & 2016



Data source: Medicare 5% sample. Abbreviations: CKD, chronic kidney disease; DM, diabetes mellitus; ESRD, end-stage renal disease; HF, heart failure.

All CKD patients 65 and older required increased care as they progressed to later stages of disease (Figures 7.2.a-c; see Table A for CKD definitions). In the FFS Medicare population, PPPY expenditures in 2016 ranged from $19,074 for those in Stages 1-2, to $29,151 for those in Stages 4-5. In the Medicare Advantage population, expenditures increased from $17,756 in Stages 1-2 to $26,314 in Stages 4-5. The managed care population was similar, with expenditures of $27,289 in Stages 1-2 to $35,886 in Stages 4-5.

Group trends in PPPY spending from 2013-2016 were mixed (Figures 7.2.a-c). FFS Medicare saw PPPY expenditures increase 1.7% overall for individuals with any CKD, but the increase was most dramatic for those in Stages 4-5, rising by 6.3%. However, PPPY spending dropped 15% over this period for Medicare Advantage beneficiaries with CKD. Spending for managed care beneficiaries moved without clear patterns, but it should be noted that in 2016 the Optum Clinformatics™ population of managed care enrollees with CKD was relatively small (N=17,864). Overall PPPY spending was slightly higher in 2016 than in 2013, but spending on beneficiaries in Stages 1-2 decreased by 2%, while expenditures on beneficiaries in Stages 4-5 decreased by 15%.

vol 1 Figure 7.2 Overall per-person per-year spending for beneficiaries aged 65 and older, by CKD stage, and year, ESRD excluded, 2013-2016

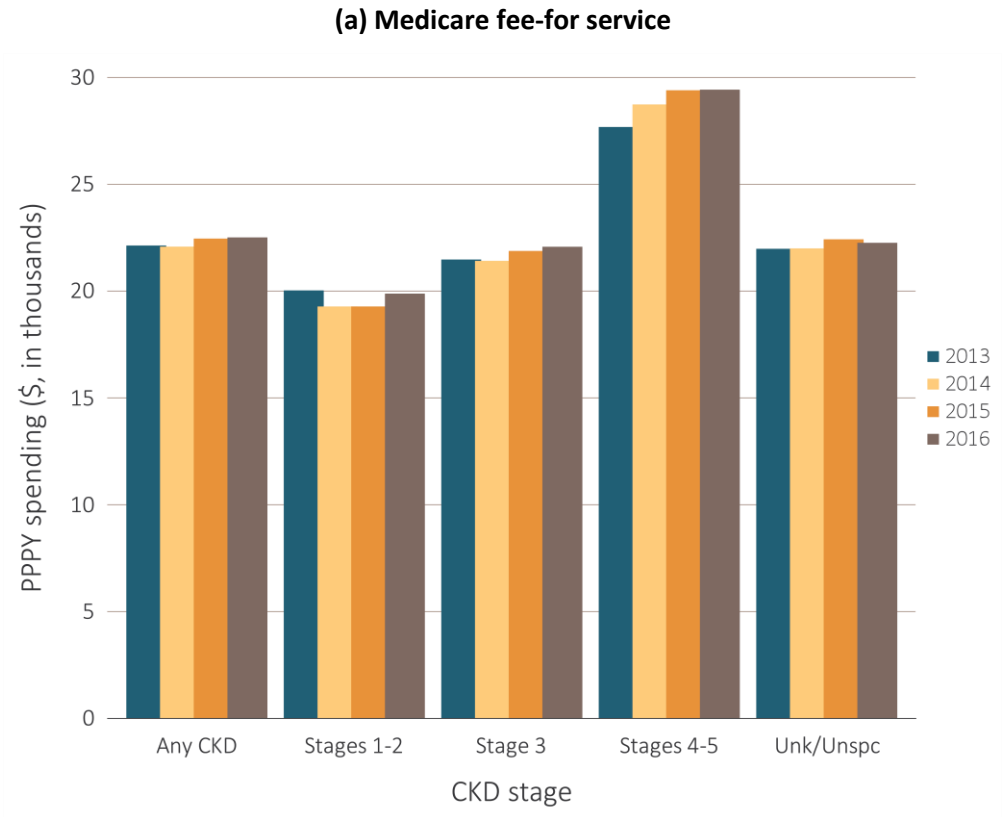
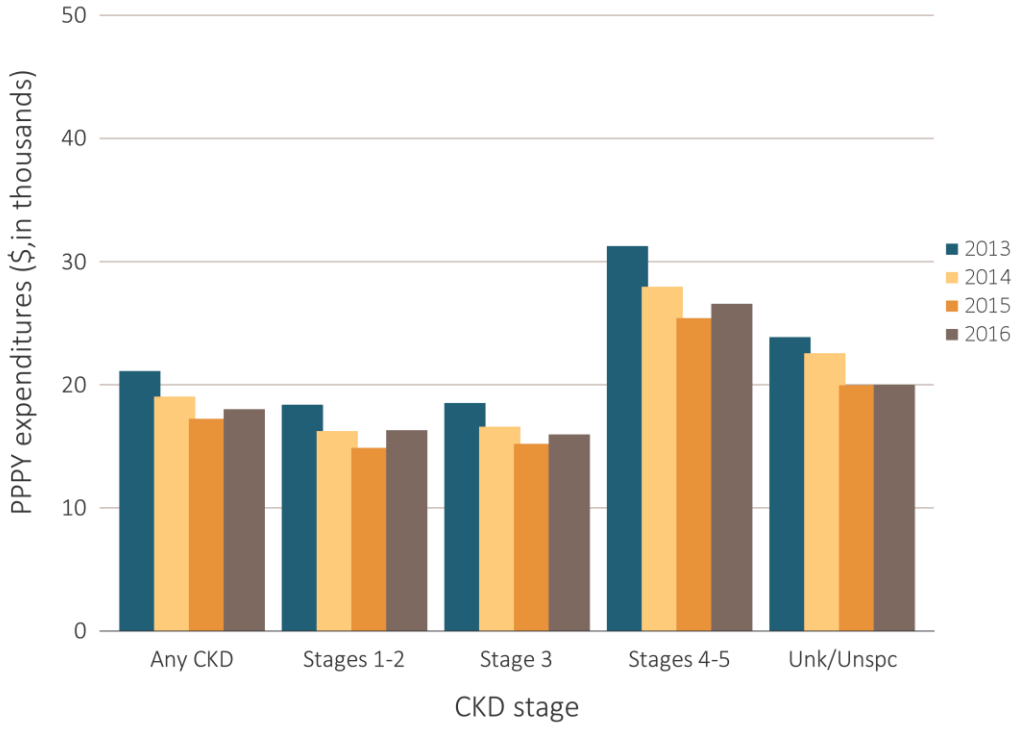


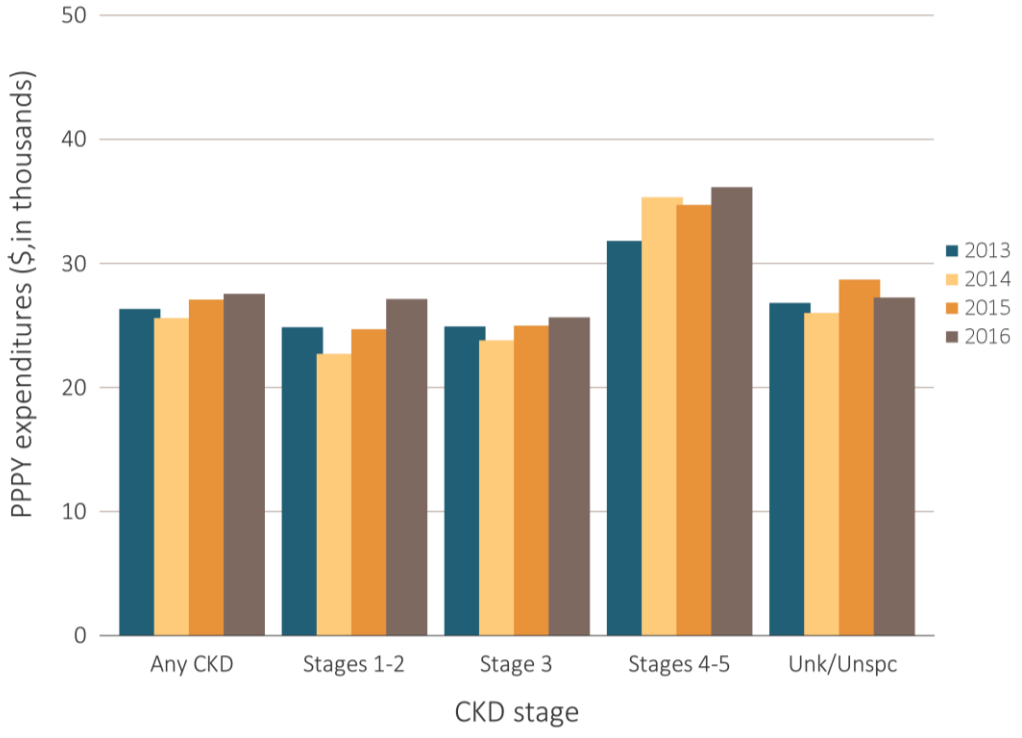
Figure 7.2 continued on next page.

vol 1 Figure 7.2 Overall per-person per-year spending for beneficiaries aged 65 and older, by CKD stage, and year, ESRD excluded, 2013-2016 (continued)

(b) Medicare Advantage



(c) Managed care



Data Source: Medicare 5% sample and Optum Clinformatics™. Abbreviations: CKD, chronic kidney disease; ESRD, end-stage renal disease; PPPY, per-person per-year; Unk/Unspc, CKD stage unknown or unspecified.

Table A. ICD-9-CM and ICD-10-CM codes for Chronic Kidney Disease (CKD) stages

ICD-9-CM code[a]	ICD-10-CM code[a]	Stage
585.1	N18.1	CKD, Stage 1
585.2	N18.2	CKD, Stage 2 (mild)
585.3	N18.3	CKD, Stage 3 (moderate)
585.4	N18.4	CKD, Stage 4 (severe)
585.5	N18.5	CKD, Stage 5 (excludes 585.6: Stage 5, requiring chronic dialysis[b])
CKD Stage-unspecified	CKD Stage-unspecified	For these analyses, identified by multiple codes including 585.9, 250.4x, 403.9x & others for ICD-9-CM and A18.xx, E08.xx, E11.xx and others for ICD-10-CM.

[a] For analyses in this chapter, CKD stage estimates require at least one occurrence of a stage-specific code, and the last available CKD stage in a given year is used. [b] In USRDS analyses, patients with ICD-9-CM code 585.6 or ICD-10-CM code N18.6 & with no ESRD 2728 form or other indication of end-stage renal disease (ESRD) are considered to have code 585.5 or N18.5.

Table 7.5 presents PPPY Medicare FFS spending for Parts A, B, and D services, for beneficiaries with CKD (but not ESRD), by stage of CKD. In 2016, PPPY costs reached $22,369 for FFS Medicare CKD patients aged 65 and older, a slight increase from 2015 ($22,314). The spending was increased slightly across all the CKD stages. During this period, the distribution of identified patient years also shifted towards the less severe and less costly stages. In 2016, costs for beneficiaries with Stages 4-5 CKD ($29,285) were 48% greater than for beneficiaries with Stages 1-2 CKD ($19,737). Although the number of beneficiaries with unknown/unspecified CKD stage increased, this still accounted for one-third of all cases of CKD. The PPPY costs for those unknown/unspecified were similar to the overall CKD population.

Spending for Black beneficiaries with CKD exceeded that for Whites by 9.6%, a slightly increase over the 9.1% disparity observed in 2015. Per capita spending for Whites increased slightly while per capita spending for Blacks stayed the same.

vol 1 Table 7.5 Per-person-per year Medicare Parts A, B, and D fee-for-service spending for all CKD beneficiaries aged 65 and older, by CKD stage, age, sex, and race, ESRD excluded, 2015 & 2016

	2015					2016				
	Any CKD	Stages 1-2	Stage 3	Stages 4-5	Unk/ Unspc	Any CKD	Stages 1-2	Stage 3	Stages 4-5	Unk/ Unspc
Patient years at risk	2,509,508	266,835	1,231,417	228,519	782,737	3,003,561	307,714	1,411,160	244,364	1,040,323
All patients	$22,314	$19,137	$21,734	$29,256	$22,282	$22,369	$19,737	$21,932	$29,285	$22,117
Age										
65-69	$21,234	$17,945	$20,897	$31,636	$20,597	$21,266	$18,456	$21,820	$31,291	$20,150
70-74	$20,461	$16,844	$20,053	$28,638	$20,518	$21,237	$17,800	$21,018	$28,904	$21,184
75-79	$21,587	$18,772	$20,921	$28,608	$21,818	$22,082	$19,493	$21,517	$29,940	$21,951
80-84	$22,818	$19,844	$22,266	$28,770	$22,862	$22,683	$20,711	$21,724	$29,032	$23,051
85+	$24,674	$22,812	$23,725	$29,305	$24,972	$24,178	$22,713	$23,180	$28,460	$24,776
Sex										
Male	$22,031	$18,577	$21,685	$29,345	$21,770	$22,134	$19,636	$21,974	$29,488	$21,485
Female	$22,573	$19,681	$21,780	$29,184	$22,754	$22,585	$19,835	$21,894	$29,118	$22,699
Race										
White	$22,074	$18,880	$21,643	$28,387	$22,051	$22,189	$19,695	$21,809	$28,440	$22,013
Black/African American	$24,086	$19,907	$22,549	$34,080	$24,264	$24,086	$20,229	$23,104	$34,126	$23,600
Other	$22,577	$20,928	$21,654	$30,097	$22,261	$21,970	$19,373	$21,727	$29,794	$21,312

Data source: Medicare 5% sample. Abbreviations: CKD, chronic kidney disease; ESRD, end-stage renal disease; Unk/Unspc, CKD stage unknown or unspecified.

Table 7.6 presents overall PPPY spending for Medicare Advantage and managed care beneficiaries with CKD (but not ESRD) by stage of CKD (see Table A for definitions). In contrast to the FFS Medicare population, for these patients spending generally decreased with age and was substantially lower for Blacks than Whites, by 24% for those covered by Medicare Advantage and 28% in the managed care population.This is an area for further research.

vol 1 Table 7.6 Per-person per-year Medicare Advantage and managed care spending for all CKD beneficiaries aged 65 and older, by CKD stage, age, sex, and race, ESRD excluded, 2016

	Medicare Advantage					Managed care				
	Any CKD	Stages 1-2	Stage 3	Stages 4-5	Unk/ Unspc	Any CKD	Stages 1-2	Stage 3	Stages 4-5	Unk/ Unspc
Patient years at risk	350,359	70,836	169,180	37,853	72,490	16,032	2,945	6,534	1,752	4,802
All patients	$17,757	$16,051	$15,708	$26,314	$19,737	$27,289	$26,869	$25,394	$35,886	$26,989
Age										
65-69	$20,238	$16,993	$18,456	$33,200	$21,153	$27,172	$27,963	$45,841	$29,063	$27,172
70-74	$18,399	$14,977	$16,476	$31,252	$20,080	$28,435	$27,221	$41,549	$28,127	$28,435
75-79	$18,411	$16,221	$16,645	$27,323	$20,342	$23,993	$24,890	$33,114	$26,535	$23,993
80-84	$17,602	$16,536	$15,505	$26,061	$19,339	$29,480	$23,935	$29,858	$24,574	$29,480
85+	$15,161	$15,931	$13,307	$19,254	$17,391	$24,092	$20,803	$23,593	$19,529	$24,092
Sex										
Male	$18,745	$17,096	$16,836	$27,768	$19,949	$27,717	$26,428	$38,560	$27,726	$27,717
Female	$16,936	$15,071	$14,841	$25,094	$19,550	$25,316	$23,820	$31,944	$25,683	$25,316
Race										
White	$18,655	$18,145	$16,437	$25,779	$20,591	$27,390	$27,099	$25,287	$35,284	$27,487
Black/African American	$13,489	$10,069	$12,821	$21,514	$14,478	$19,682	$13,956	$17,829	$24,685	$26,569
Other	$16,545	$13,617	$14,579	$27,751	$18,631	$27,686	$27,816	$26,475	$38,685	$25,260

Data Source: Optum Clinformatics™. Abbreviations: CKD, chronic kidney disease; ESRD, end-stage renal disease; Unk/Unspc, CKD stage unknown or unspecified.

Tables 7.7 and 7.8 present PPPY spending for beneficiaries with both CKD and DM. These tables show similar results as in the overall CKD population. Among the 2016 FFS Medicare beneficiaries with these two conditions, PPPY spending for Blacks was $26,168—5.6% greater than the $24,788 incurred for Whites. Yet, spending by Medicare Advantage was 27% lower for Blacks than Whites and 33% lower for the managed care population.

vol 1 Table 7.7 Per-person per-year Medicare Parts A, B, and D fee-for-service spending for CKD patients with diabetes, aged 65 and older, by CKD stage, age, sex, and race, ESRD excluded, 2015 & 2016

	2015					2016				
	Any CKD	Stages 1-2	Stage 3	Stages 4-5	Unk/ Unspc	Any CKD	Stages 1-2	Stage 3	Stages 4-5	Unk/ Unspc
Patient years at risk	1,202,549	128,812	594,206	120,943	358,589	1,564,729	153,255	682,630	129,606	599,238
All patients	$25,386	$21,872	$24,986	$33,107	$24,708	$24,877	$22,575	$25,140	$32,671	$23,480
Age										
65-69	$24,704	$20,387	$24,908	$35,736	$23,152	$23,643	$21,975	$25,439	$34,027	$21,248
70-74	$23,604	$19,389	$23,191	$32,814	$23,305	$23,728	$20,446	$24,415	$31,653	$22,549
75-79	$24,944	$22,135	$24,224	$32,342	$24,790	$24,873	$21,861	$24,822	$33,501	$23,834
80-84	$26,131	$22,499	$25,907	$32,660	$25,275	$25,641	$24,027	$25,134	$31,797	$25,020
85+	$27,935	$27,447	$27,135	$32,671	$27,413	$27,029	$26,592	$26,089	$32,614	$26,632
Sex										
Male	$24,598	$21,033	$24,355	$33,343	$23,660	$24,178	$22,149	$24,529	$32,248	$22,652
Female	$26,174	$22,778	$25,627	$32,910	$25,766	$25,556	$23,036	$25,761	$33,031	$24,244
Race										
White	$25,145	$21,348	$25,039	$32,129	$24,396	$24,788	$22,586	$25,118	$31,979	$23,478
Black/African American	$27,126	$23,396	$25,293	$37,237	$27,145	$26,168	$22,530	$25,623	$36,148	$24,927
Other	$24,968	$24,044	$23,808	$34,054	$24,066	$23,769	$22,539	$24,583	$32,358	$21,599

Data source: Medicare 5% sample. Abbreviations: CKD, chronic kidney disease; ESRD, end-stage renal disease; Unk/Unspc, CKD stage unknown or unspecified.

vol 1 Table 7.8 Per-person per-year Medicare Advantage and managed care spending for CKD patients with diabetes, aged 65 and older, by CKD stage, age, sex, and race, ESRD excluded, 2016

	Medicare Advantage					Managed care				
	Any CKD	Stages 1-2	Stage 3	Stages 4-5	Unk/ Unspc	Any CKD	Stages 1-2	Stage 3	Stages 4-5	Unk/ Unspc
Patient years at risk	169,933	36,448	78,671	19,927	34,887	7,323	1,436	3,026	899	1,963
All patients	$20,066	$18,014	$18,305	$30,438	$20,256	$30,085	$29,580	$28,857	$40,934	$27,382
Age										
65-69	$22,819	$18,630	$21,982	$37,769	$22,060	$32,165	$29,730	$32,715	$51,024	$27,152
70-74	$20,443	$17,046	$18,762	$34,665	$20,469	$30,947	$28,247	$29,552	$42,224	$30,225
75-79	$20,287	$18,195	$18,954	$30,031	$20,082	$30,153	$29,062	$28,802	$37,813	$28,707
80-84	$19,474	$18,477	$17,322	$29,088	$19,658	$27,405	$35,741	$23,699	$32,824	$25,213
85+	$17,150	$18,149	$15,238	$22,104	$17,973	$23,650	$26,235	$22,955	$25,248	$22,205
Sex										
Male	$20,438	$18,826	$18,805	$30,954	$19,950	$30,792	$31,236	$29,317	$45,524	$25,997
Female	$19,725	$17,185	$17,867	$29,985	$20,544	$28,729	$26,324	$28,036	$33,388	$29,361
Race										
White	$21,777	$21,466	$19,700	$30,212	$21,888	$30,043	$30,565	$28,207	$39,625	$27,941
Black/African American	$14,619	$10,894	$14,592	$24,679	$13,445	$20,035	$17,429	$18,962	$24,341	$22,318
Other	$18,148	$14,814	$16,533	$31,354	$18,496	$31,290	$28,702	$31,656	$46,461	$26,432

Data Source: Optum Clinformatics™. Abbreviations: CKD, chronic kidney disease; ESRD, end-stage renal disease; Unk/Unspc, CKD stage unknown or unspecified.

Tables 7.9 and 7.10 present PPPY spending for beneficiaries with CKD and concurrent HF. The presence of HF greatly increased the costs of care for persons with CKD. Persons with both CKD and HF cost 62% more ($36,291) than the average CKD patient ($22,369). These results were consistent with those seen in the previous tables. In 2016, FFS Medicare PPPY expenditures for Black beneficiaries with both conditions reached $39,825—12.0% higher than the $35,690 PPPY for their White counterparts. In contrast to FFS Medicare, Black Medicare Advantage beneficiaries required 14% less spending than did their White counterparts, and Black managed care beneficiaries 21% less.

vol 1 Table 7.9 Per-person per-year Medicare Parts A, B, and D fee-for-service spending for CKD patients with heart failure, aged 65 and older, by CKD stage, age, sex, race, and year, ESRD excluded, 2015 & 2016

	2015					2016				
	Any CKD	Stages 1-2	Stage 3	Stages 4-5	Unk/ Unspc	Any CKD	Stages 1-2	Stage 3	Stages 4-5	Unk/ Unspc
Patient years at risk	660,426	57,097	330,474	83,233	189,622	752,556	64,737	379,373	88,744	219,701
All patients	$35,986	$33,929	$35,666	$41,519	$34,735	$36,291	$34,604	$35,526	$41,496	$36,008
Age										
65-69	$39,993	$36,445	$39,285	$50,581	$38,097	$40,114	$38,820	$40,323	$47,286	$38,072
70-74	$37,006	$31,130	$37,176	$42,916	$36,281	$39,302	$34,516	$39,155	$42,003	$40,068
75-79	$36,622	$35,836	$36,073	$41,927	$35,632	$37,129	$35,314	$36,343	$44,253	$36,424
80-84	$35,532	$33,653	$35,623	$39,917	$33,932	$35,066	$32,929	$33,951	$42,310	$34,702
85+	$34,014	$33,384	$33,527	$38,856	$32,748	$33,571	$33,400	$32,648	$37,845	$33,267
Sex										
Male	$35,131	$32,898	$34,802	$41,353	$33,834	$35,546	$33,684	$34,895	$41,333	$35,060
Female	$36,800	$34,948	$36,518	$41,658	$35,576	$37,000	$35,574	$36,153	$41,633	$36,856
Race										
White	$35,352	$33,103	$35,207	$40,043	$34,293	$35,690	$34,129	$34,948	$40,120	$35,732
Black/African American	$39,567	$34,923	$38,751	$48,514	$37,464	$39,825	$35,848	$39,255	$46,995	$38,235
Other	$38,735	$43,312	$37,110	$45,230	$36,570	$38,715	$39,151	$37,912	$47,167	$36,165

Data source: Medicare 5% sample. Abbreviations: CKD, chronic kidney disease; ESRD, end-stage renal disease; Unk/Unspc, CKD stage unknown or unspecified.

vol 1 Table 7.10 Per-person per-year Medicare Advantage and managed care spending for CKD patients with heart failure, aged 65 and older, by CKD stage, age, sex, and race, ESRD excluded, 2016

	Medicare Advantage					Managed care				
	Any CKD	Stages 1-2	Stage 3	Stages 4-5	Unk/ Unspc	Any CKD	Stages 1-2	Stage 3	Stages 4-5	Unk/ Unspc
Patient years at risk	74,824	14,160	35,035	10,933	14,697	3,132	616	1,307	426	783
All patients	$29,158	$30,079	$26,155	$37,063	$29,550	$43,047	$45,986	$43,565	$47,448	$37,476
Age										
65-69	$39,570	$39,471	$37,984	$48,091	$37,586	$60,018	$64,900	$68,670	$63,410	$46,224
70-74	$34,879	$33,139	$31,908	$48,930	$33,058	$51,973	$49,037	$52,791	$61,756	$47,758
75-79	$32,857	$33,107	$30,207	$42,309	$32,079	$37,381	$32,973	$40,399	$42,768	$32,597
80-84	$27,510	$28,022	$24,745	$36,553	$27,075	$38,351	$45,237	$39,906	$35,767	$31,106
85+	$21,381	$23,538	$19,169	$25,115	$22,496	$26,505	$29,758	$25,309	$33,010	$22,180
Sex										
Male	$29,982	$30,449	$27,358	$37,716	$29,941	$43,976	$43,990	$45,970	$51,554	$36,552
Female	$28,406	$29,670	$25,105	$36,485	$29,212	$41,479	$49,337	$39,623	$41,231	$38,960
Race										
White	$29,348	$31,528	$26,268	$35,957	$29,994	$41,251	$42,145	$41,520	$48,100	$36,261
Black/African American	$24,994	$20,677	$25,183	$32,092	$22,611	$33,798	$38,872	$15,882	$13,468	$55,978
Other	$29,041	$28,039	$25,968	$39,652	$29,064	$50,436	$59,821	$53,558	$45,521	$40,594

Data Source: Optum Clinformatics™. Abbreviations: CKD, chronic kidney disease; ESRD, end-stage renal disease; Unk/Unspc, CKD stage unknown or unspecified.

Over time FFS Medicare beneficiaries aged 65 and older with recognized CKD have accounted for an increasing share of Medicare expenditures, expanding from 5.8% in 2000 to 14.1% in 2008, and 24.8% in 2016. Much of this growth was due to the increased ascertainment of CKD as shown in Volume 1, Chapter 2: Identification and Care of Patients with CKD, Figure 2.2. Persons aged 65 and older with CKD accounted for 2.1%, 8.8%, and 11.2% of the FFS Medicare population in 2000, 2008, and 2016.

Figure 7.3 presents total expenditures on Parts A, B, and D services for Medicare FFS beneficiaries with CKD, DM, and HF. In 2016, expenditures for CKD patients reached $67.2 billion, accounting for 24.8% of the total spending for all FFS Medicare beneficiaries. Care of beneficiaries with CKD and concurrent DM required $38.9 billion in 2016, or 41.5% of the total FFS Medicare spending on DM. Spending on HF in the FFS Medicare population was $55.1 billion in 2016. Of this, $27.3 billion (49.5%) was spent on the CKD patient population with HF. Medicare expenditures for CKD were 20% higher in 2016 ($67 billion) than in 2015 ($55 billion).This was mostly due to an 18% increase in the ascertainment of CKD.Although 2016 represented a change in coding (ICD-9 to ICD-10), the reason for this increase is not known.

vol 1 Figure 7.3 Overall Medicare Parts A, B, and D fee-for-service spending for general Medicare population aged 65 and older and for those with CKD, ESRD excluded, 1996-2016

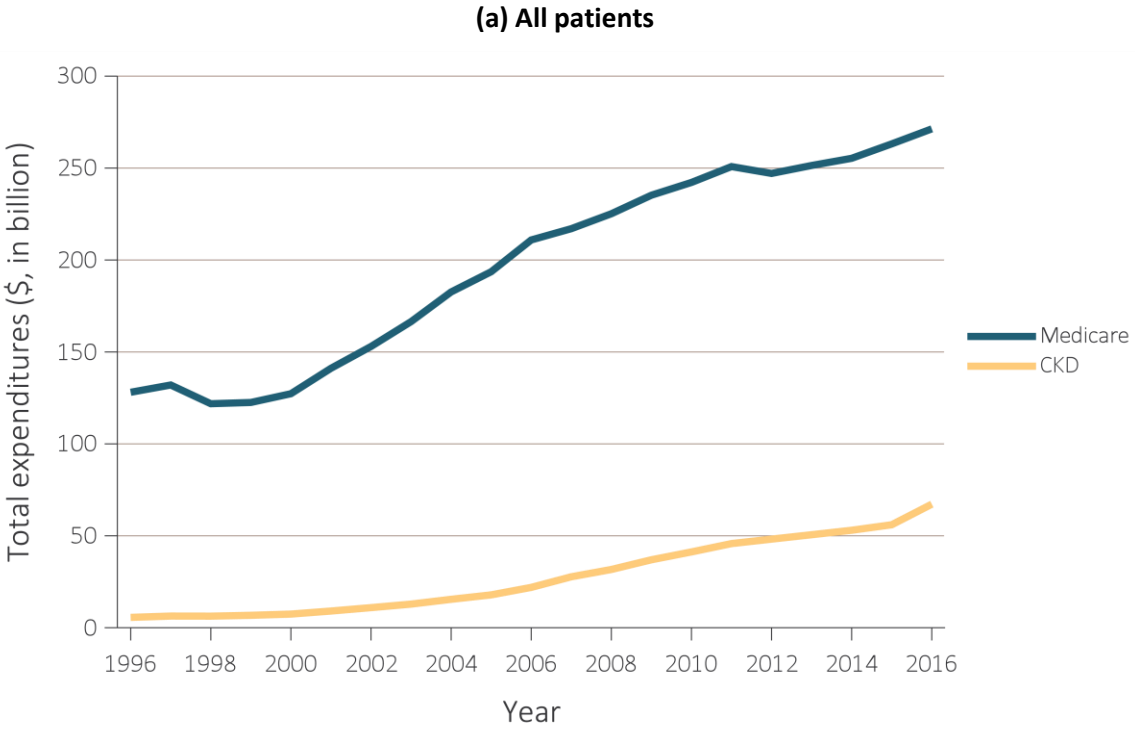
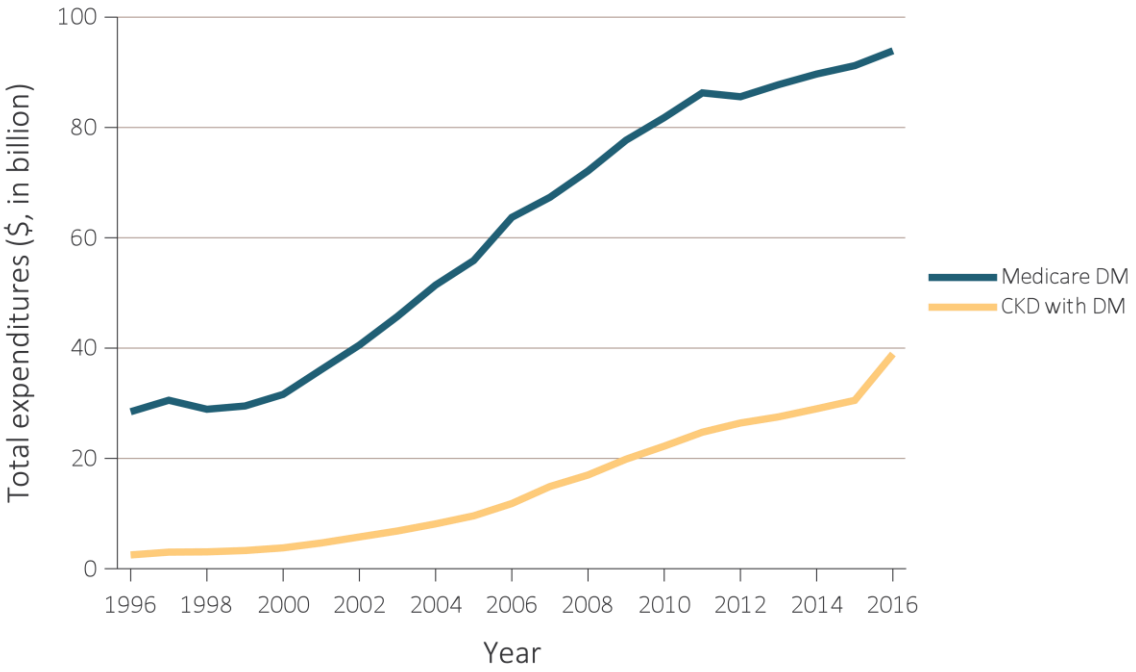


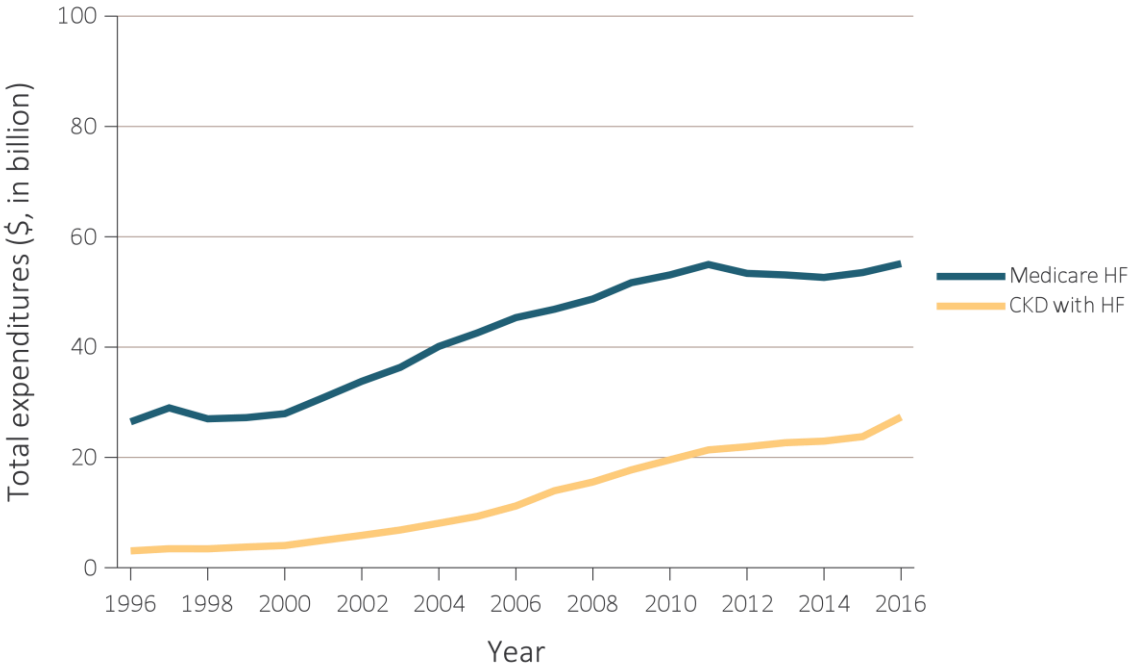
Figure 7.3 continued on next page.

vol 1 Figure 7.3 Overall Medicare Parts A, B, and D fee-for-service spending for general Medicare population aged 65 and older and for those with CKD, ESRD excluded, 1996-2016 (continued)

(b) Patients with diabetes



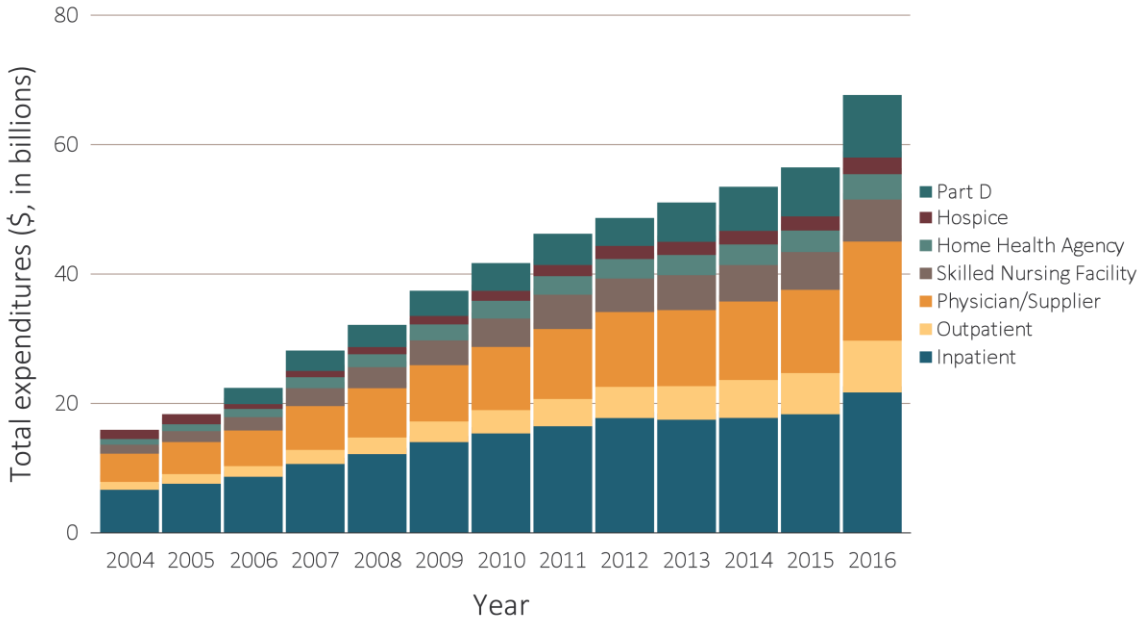
(c) Patients with heart failure



Data Source: Medicare 5% sample. Abbreviations: CKD, chronic kidney disease; DM, diabetes mellitus; ESRD, end-stage renal disease; HF, heart failure.

Most spending for CKD patients was incurred for inpatient and outpatient care, physician/supplier services, and care in skilled nursing facilities. Spending for Part D increased a great deal in recent years. The proportion of total FFS Medicare expenditures required to provide inpatient care was 33% in 2016, while outpatient costs were predictably lower at 12%. Physician/supplier service costs amounted to 23%, spending for skilled nursing facilities was 10%, while spending for Part D reached 13% (Figure 7.4). In the Medicare non-CKD population, these expenditure percentages were 29% to provide inpatient care, 15% for outpatient, 28% for physician/supplier services, and 7% for skilled nursing facility care (not shown).

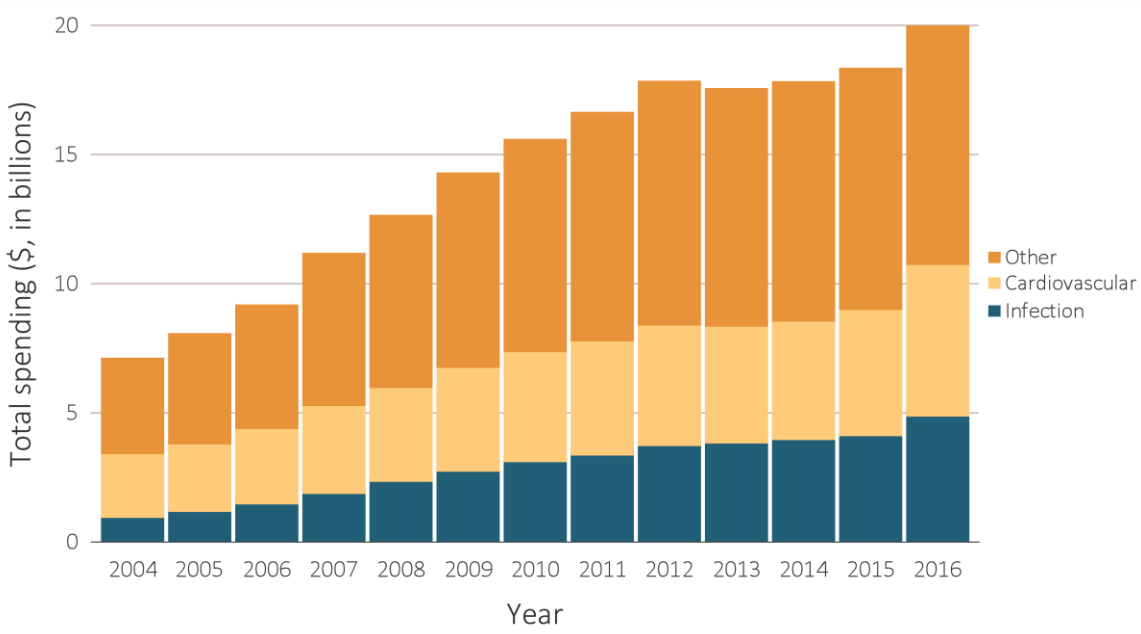
vol 1 Figure 7.4 Trends in total Medicare Parts A, B, and D fee-for-service spending for CKD patients aged 65 and older, by claim type, ESRD excluded, 2004-2016



Data source: Medicare 5% sample. Part D data occurring since 2006. Abbreviations: CKD, chronic kidney disease; ESRD, end-stage renal disease.

Hospitalization expenditures accounted for a large proportion of spending for CKD. Of the 2016 inpatient hospitalization spending for those with CKD, 23% resulted from admissions to treat infections, and 27% from cardiovascular conditions, with the remaining 50% resulting from all other causes (Figure 7.5).

vol 1 Figure 7.5 Total Medicare fee-for-service inpatient spending for CKD patients aged 65 and older, by cause of hospitalization, ESRD excluded, 2004-2016



Data source: Medicare 5% sample. Part D data occurring since 2006. Abbreviations: CKD, chronic kidney disease; ESRD, end-stage renal disease.

Figure 7.6 illustrates PPPY costs for CKD patients aged 65 and older by the presence of DM and HF. In 2016, PPPY costs for CKD patients varied greatly by the presence of these comorbidities. CKD patients without DM and HF required $18,525 PPPY from FFS Medicare. Those with DM in addition to CKD averaged $22,751 PPPY, and beneficiaries with both CKD and HF cost $29,664. Expenditures for those with all three conditions reached $40,075 PPPY in 2016 for FFS Medicare. Spending was also higher as comorbidities increased in the managed care populations.

vol 1 Figure 7.6 Per-person per-year Medicare, Medicare advantage, and managed care spending for CKD patients aged 65 and older, by diabetes and heart failure, ESRD excluded, 2006-2016

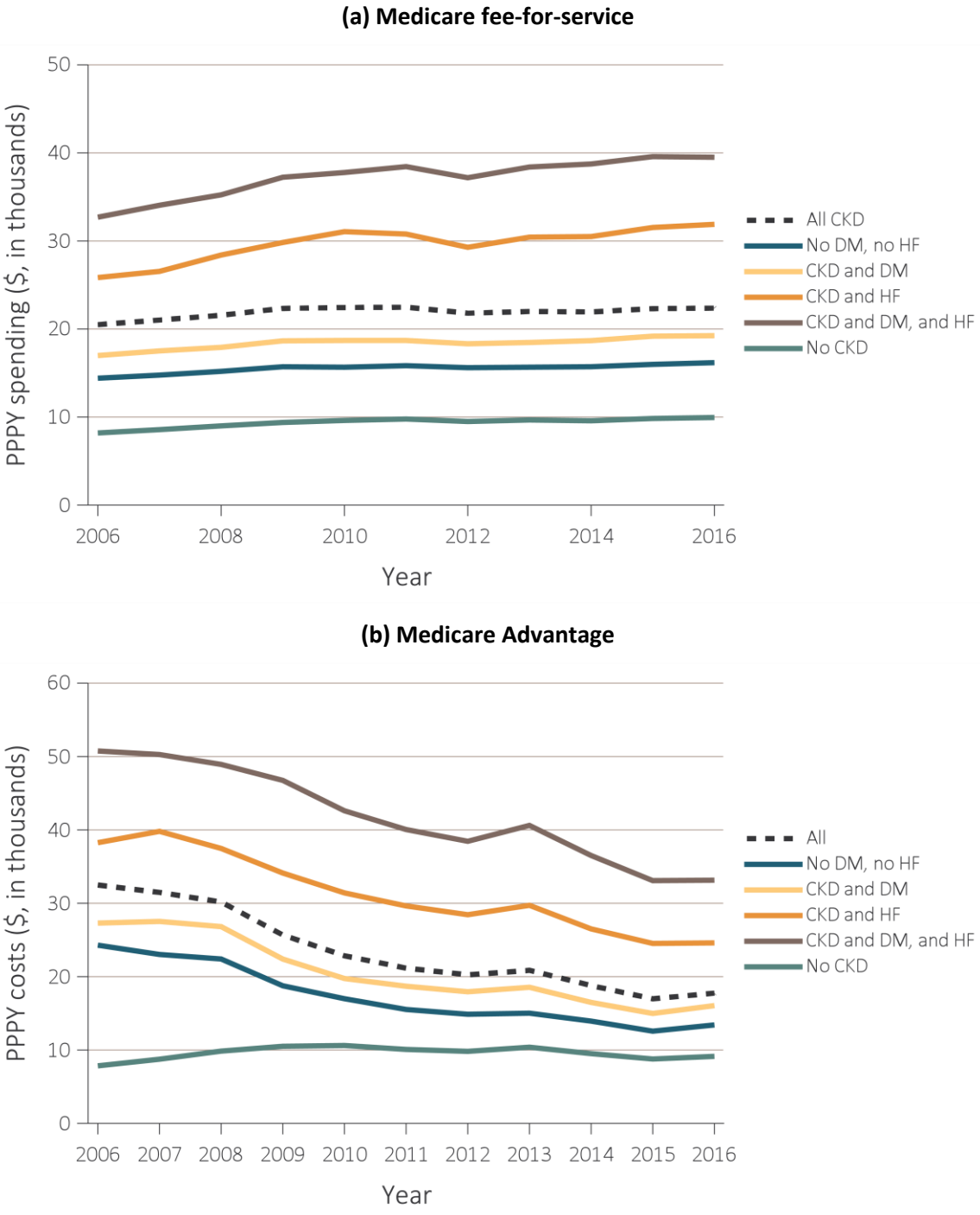
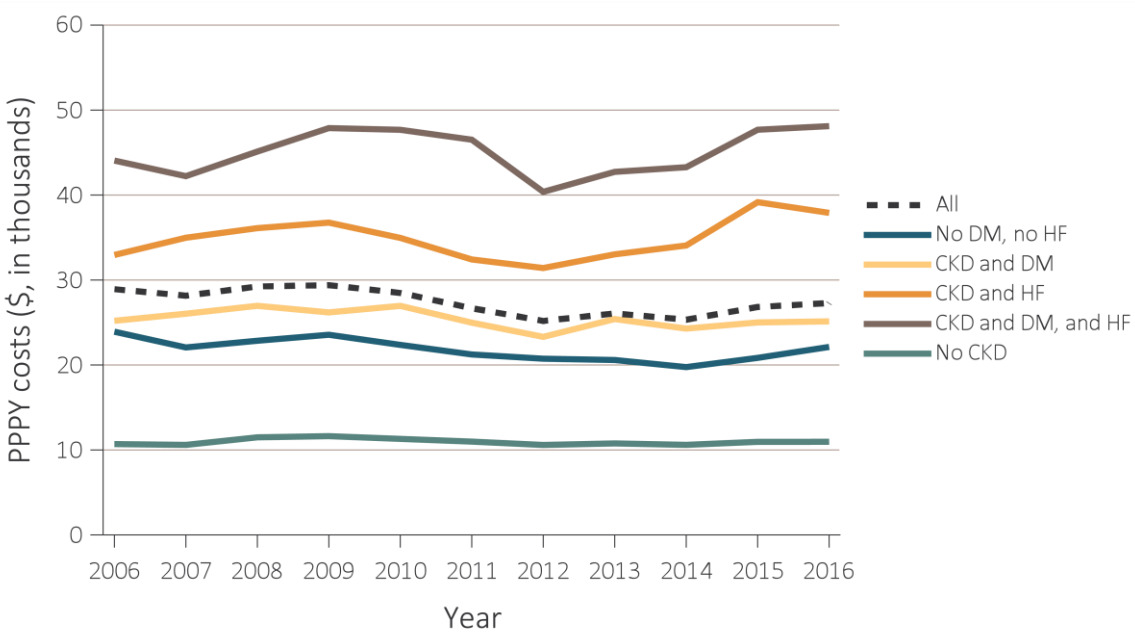


Figure 7.6 continued on next page.

vol 1 Figure 7.6 Per-person per-year Medicare, Medicare advantage and managed care spending for CKD patients aged 65 and older, by diabetes and heart failure, ESRD excluded, 2006-2016 (continued)

(c) Managed care



Data Source: Medicare 5% sample and Optum Clinformatics™. Abbreviations: CKD, chronic kidney disease; DM, diabetes mellitus; ESRD, end-stage renal disease; HF, heart failure; PPPY, per person per year.

Table 7.11 shows the distribution of CKD stages by payer. For all payer types, reporting has become more specific since stage specific reported began in 2007, with the percentage of CKD cases of unknown stage declining over time. Nonetheless, over 20% of cases for each payer type were still of unknown stage in 2016. The distribution of cases with reported stage became somewhat less severe over time. The percentage of cases in the Stages 1 & 2 and Stage 3 categories grew between 2007 and 2016. Conversely, despite the increase in stage-specific reporting overall, the percentage of cases in Stages 4 & 5 actually declined.

vol 1 Table 7.11 Overall CKD percentage for Medicare, Medicare advantage, and managed care beneficiaries aged 65 and older, by CKD stage, and year, ESRD excluded, 2006-2016

Year	Insurance Plan	CKD Stages 1 & 2 (%)	CKD Stage 3 (%)	CKD Stages 4 & 5 (%)	CKD Stage Unknown (%)
2006	Medicare FFS	0.0	0.0	0.0	100.0
	Managed care	0.0	0.0	0.0	100.0
	Medicare Advantage	0.0	0.0	0.0	100.0
2007	Medicare FFS	8.6	22.2	12.5	56.7
	Managed care	17.4	23.7	13.3	45.5
	Medicare Advantage	19.1	23.8	12.6	44.5
2008	Medicare FFS	8.5	27.7	12.6	51.2
	Managed care	18.0	28.3	15.5	38.2
	Medicare Advantage	19.8	28.1	14.8	37.2
2009	Medicare FFS	8.3	31.5	12.3	47.9
	Managed care	17.4	31.1	14.0	37.5
	Medicare Advantage	18.7	34.9	13.3	33.1
2010	Medicare FFS	8.5	35.4	11.9	44.2
	Managed care	16.9	34.6	13.2	35.4
	Medicare Advantage	18.9	41.0	11.9	28.1
2011	Medicare FFS	8.7	38.6	11.4	41.3
	Managed care	17.1	36.6	12.7	33.6
	Medicare Advantage	18.2	44.8	11.4	25.6
2012	Medicare FFS	9.3	41.8	11.0	37.9
	Managed care	17.0	38.0	12.5	32.4
	Medicare Advantage	18.4	46.4	11.2	23.9
2013	Medicare FFS	9.7	44.0	10.8	35.6
	Managed care	17.1	38.9	12.1	31.9
	Medicare Advantage	19.4	45.9	11.0	23.7
2014	Medicare FFS	10.0	46.1	10.2	33.7
	Managed care	17.0	40.3	11.4	31.2
	Medicare Advantage	19.7	47.2	10.9	22.2
2015	Medicare FFS	10.4	48.5	9.9	31.2
	Managed care	17.0	42.1	11.3	29.6
	Medicare Advantage	18.7	48.7	10.7	21.9
2016	Medicare FFS	10.0	46.7	8.8	34.4
	Managed care	18.5	40.1	11.2	30.2
	Medicare Advantage	20.1	48.0	11.0	20.8

Data Source: Optum Clinformatics™. Abbreviations: CKD, chronic kidney disease; FFS, fee-for-service; ESRD, end-stage renal disease.

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Notes

Chapter 8: Prescription Drug Coverage in Patients with CKD

- In this 2018 Annual Data Report (ADR), we introduce new chapter features:
  - Because of the continuing prescription opioid epidemic, this year we retain the section of analgesic use and update the map with non-steroidal anti-inflammatory agents (NSAIDs) and opioid use in the United States using 2016 data.
  - Because of increasing use of high-cost antivirals nationally, this year we specifically investigate the spending and utilization rates of antivirals, including prescription antiretrovirals, nucleosides and nucleotides, and protease inhibitors.
- Approximately 73.7% of chronic kidney disease (CKD) patients enrolled in Medicare Part D in 2016, including both the fee-for-service stand-alone and Medicare Advantage plans. The Part D enrollment rate for the CKD group was slightly higher than in the general Medicare population (69.5%; Figure 8.1).
- The percentage of Medicare beneficiaries who received the Low-income Subsidy (LIS) was higher for CKD patients across all age and race categories than in the general Medicare population (Figures 8.2 and 8.3).
- As compared to White beneficiaries (29.3%), much higher proportions of Asian (73.8%) and Black/ African American (62.8%) CKD Part D beneficiaries qualified for the LIS (Figure 8.3).
- Among patients with stand-alone Part D plans, per person per year (PPPY) insurance spending on prescriptions was 1.6 times higher for Medicare patients with CKD than for general beneficiaries ($4,941 vs. $3,027) in 2016. Spending for CKD patients with Medicare Advantage plans was 1.6 times higher ($2,926, vs. $1,834), and 4.1 times higher for those with managed care coverage ($4,164 vs. $1,013; Figure 8.5.a).
- Total spending for Part D-covered medications in 2016 was more than twice as high for patients with the LIS than for those without, regardless of the presence of CKD. Patient out-of-pocket costs for LIS patients represented only a 1.2-1.3% share of these total expenditures, as compared to 25.3-27.0% in each of the non-LIS populations (Figure 8.5.b).
- Prescriptions for lipid-lowering agents, antibacterials, renin-angiotensin-aldosterone system inhibitors, and β-adrenergic blocking agents (beta blockers) were each filled by more than 50% of Medicare CKD patients during 2016 (Table 8.6). CKD patients with Medicare Advantage and managed care coverage showed similar patterns of use for these drug classes.
- By drug class, the highest medication expenditures for patients with CKD were for antidiabetic agents, followed by antineoplastic agents, antivirals, and lipid-lowering agents (Table 8.7).
- In the United States (U.S.), the overall proportion of CKD patients using prescription NSAIDs and opioids were 16.4% and 43.8%, respectively (Figure 8.6-8.7).
- In 2016, approximately 5.0% of Medicare CKD patients had at least one filled prescription antiviral, and PPPY Medicare Part D spending among these users is $5,421 (Figure 8.9-8.10).

Introduction

Pharmaceutical therapy serves as a critical part of CKD treatment to control and reduce complications and delay disease progression. This chapter assesses prescription drug coverage, prescription drug-related costs, and patterns of prescription drug use for CKD patients in three health systems. The Medicare 5% sample is used to describe Part D enrollment patterns in Medicare beneficiaries and Medicare Part D spending under stand-alone prescription drug plans (PDPs). Beginning from the 2017 ADR (USRDS, 2017) we have added information on prescription drug use and associated costs from the Optum Clinformatics™ DataMart (obtained from OptumInsight) for persons with Medicare Advantage and managed care coverage.

In 2016, 45% of general Medicare beneficiaries enrolled in a stand-alone PDP, while 25% received coverage through a Medicare Advantage plan (Kaiser, 2018); adding information for Medicare Advantage beneficiaries thus makes our assessment of prescription drug use in CKD more complete. Additionally, Optum Clinformatics™ data for beneficiaries with managed care complements our report by providing insight into a younger and employed population.

Starting in 2017, we annually select a different drug class for a more detailed investigation of medication use patterns. In the 2017 ADR, we reported analgesics used by CKD patients. Because of the continuing opioid epidemic, we continue that analysis this year, but we have also added a section on prescription antivirals, a category with high and growing costs.

A parallel examination of prescription drug use and associated costs in patients with end-stage (ESRD) can be found in Volume 2, Chapter 10: *Prescription Drug Coverage in Patients with ESRD*.

Methods

In this chapter, we examine the Medicare 5% sample data to describe Part D enrollment and prescription utilization for Medicare beneficiaries. Enrollment data are available for both traditional Medicare (fee-for-service) enrollees and Medicare Advantage enrollees; however, actual claim data and spending data are only available for beneficiaries with traditional Medicare. Thus, our past estimations for Part D enrollment applied to all Medicare beneficiaries, but the reporting of prescription utilization and associated costs applied only to the sub-group of Medicare fee-for-services Part D enrollees. We have now introduced Optum Clinformatics™ data to augment our assessment of prescription utilization and associated costs for both the Medicare Advantage population and a commercially insured, managed care population.

Details of these data are described in the *Data Sources* section of the *CKD Analytical Methods* chapter. See the section on *Chapter 8* in the *CKD Analytical Methods* chapter for an explanation of the analytical methods used to generate the study cohorts, figures, and tables in this chapter. Downloadable Microsoft Excel and PowerPoint files containing the data and graphics for these figures and tables are available on the *USRDS website.*

To be included in analyses specific to the Medicare 5% population, eligible beneficiaries must have been enrolled in traditional Medicare for all of the one-year entry period (year one, the calendar year before the year reported in the figures and tables), and be alive, without ESRD, and enrolled in Medicare on January 1 of the reported year (year two). These criteria were necessary to enable CKD identification, as diagnosis codes were not available for patients before they became eligible for fee-for-service Medicare. CKD patients were identified by having a minimum of one inpatient and/or two outpatient CKD diagnoses claims in year one. We assessed Part D enrollment and prescription utilization for year two. The Medicare Part D drug event file provided data to evaluate prescription utilization; it contains records of all prescriptions filled by the beneficiaries under Medicare Part D.

For beneficiaries selected from the Optum Clinformatics™ data, to create comparable results we applied the same eligibility algorithm as for the Medicare population. Beneficiaries were required to be in the Optum Clinformatics™ dataset throughout year one, be alive, without ESRD, and covered by either a Medicare Advantage plan or a managed care plan on January 1 of year two. Those with Medicare

Advantage at the beginning of year two were classified as the Medicare Advantage population; otherwise, they were classified as the managed care population. All beneficiaries in the Optum Clinformatics™ dataset had prescription drug coverage.

In this chapter, we define spending as insurance plan payments. For example, Medicare Part D spending is the sum of Medicare net payment and the Low-income Supplement (LIS) amount. Patients' obligations (out-of-pocket costs) are the sum of the deductible and copayment.

Medicare Part D Coverage Plans

The optional Medicare Part D prescription drug benefit has been available to all beneficiaries since 2006. Part D benefits can be managed through a stand-alone PDP or through a Medicare Advantage plan. Most Medicare Advantage plans offer prescription drug coverage (Medicare Advantage prescription drug plan, MA-PD). CKD patients have the option to enroll in a Medicare Advantage plan; end-stage renal disease (ESRD) patients, in contrast, are precluded from entering a Medicare Advantage plan if they are not already enrolled in one when they reach ESRD.

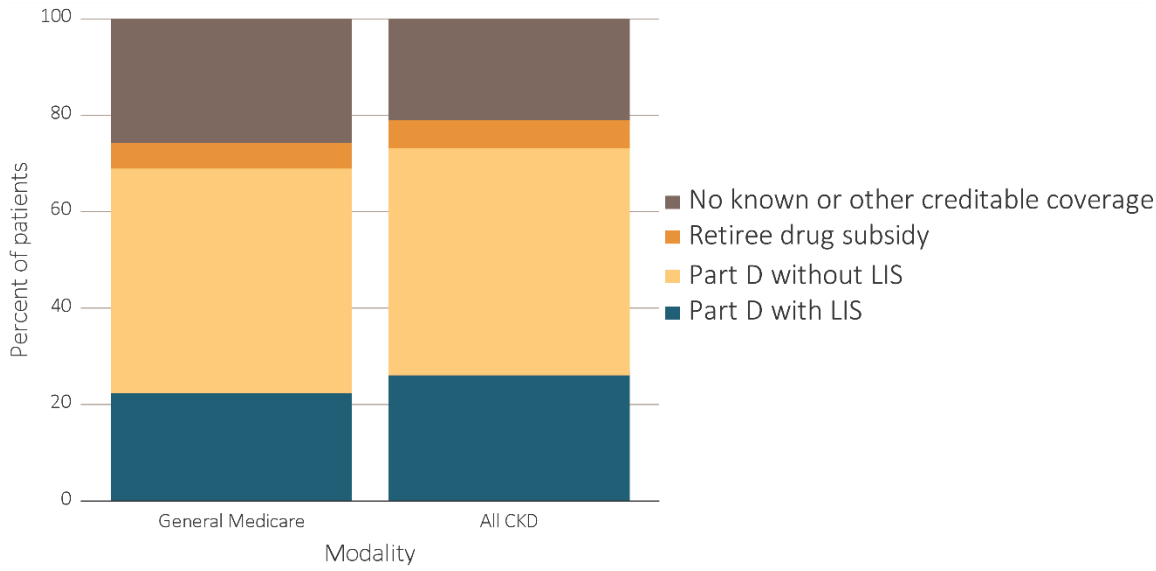
Before 2006, Medicare beneficiaries obtained drug coverage through various avenues—insurance plans, state Medicaid programs, pharmaceutical assistance programs, or samples received from physicians. Those with none of these options paid for their medications out-of-pocket. Beneficiaries with low income who were dually enrolled in Medicare and Medicaid received prescription benefits under state Medicaid programs.

After 2006, the majority of Medicare enrollees obtained Part D coverage. The Part D program offers a substantial Low-income Subsidy (LIS) benefit to enrollees with limited assets and income, including those dually enrolled. The LIS provides full or partial waivers for many out-of-pocket cost-sharing requirements, including premiums, deductibles, and copayments, and provides full or partial coverage during the Part D coverage gap (commonly referred to as the "donut hole").

Besides Medicare Part D plans (PDP and MA-PD), Medicare beneficiaries can choose instead to obtain outpatient medication benefits through retiree drug subsidy plans or other creditable coverage such as employer group health plans, other private coverage, or Veterans Health Administration (VHA) benefits. Some enrollees remain uninsured and pay out-of-pocket for their outpatient prescription medications. The premiums for Part D coverage are partially subsidized. Beneficiaries who delay voluntary enrollment, yet lack other creditable coverage at least equivalent to Part D, pay higher premiums once they do enroll.

In 2016, approximately 73.7% of CKD patients enrolled in Medicare Part D (including both stand-alone and Medicare Advantage plans). This rate was slightly higher than Part D enrollment by those in the general Medicare population (69.5%, Figure 8.1). Compared to Part D enrollees in the general population, a higher percentage of CKD patients qualified for the LIS (26.6% vs. 22.8%).

vol 1 Figure 8.1 Sources of prescription drug coverage in Medicare enrollees, by population, 2016



Data source: Medicare 5% sample. Point prevalent Medicare enrollees alive on January 1, 2016. Abbreviations: CKD, chronic kidney disease; LIS, Medicare Low-income Subsidy; Part D, Medicare prescription drug coverage benefit.

The proportion of beneficiaries that enrolled in Medicare Part D rose between 2011 and 2016, among both general Medicare beneficiaries and patients with CKD (Table 8.1). In each year, enrollment was slightly higher for those with CKD than in the general Medicare population.

vol 1 Table 8.1 General Medicare and CKD patients enrolled in Part D

	General Medicare (%)	All CKD (%)
2011	55.7	59.3
2012	57.6	60.5
2013	65.7	69.3
2014	66.3	71.1
2015	67.1	71.9
2016	69.5	73.7

Data source: Medicare 5% sample. Point prevalent Medicare enrollees alive on January 1. Abbreviations: CKD, chronic kidney disease; Part D, Medicare prescription drug coverage benefit.

The Centers for Medicare & Medicaid Services (CMS) provides prescription drug plans (PDPs) with guidance on structuring a "standard" Part D PDP. The upper portion of Table 8.2 shows the standard benefit design for PDPs in 2011 and 2016. In 2016, for example, beneficiaries shared costs with the PDP as co-insurance or copayments, until the combined total during the initial coverage period reached $3,310. After reaching this level, beneficiaries entered the coverage gap ("donut hole") where they paid 100% of prescription costs. Under the original Affordable Care Act, the coverage gap in the Part D benefit will be phased out by 2020.

As part of the phase-out, the government began providing non-LIS recipients reaching the coverage gap with increasing assistance each year. In 2016, beneficiaries received a 50% discount on brand name drugs from manufacturers plus 5% coverage from their Part D plans; plans also paid 42% of generic drug costs in the gap. Beneficiaries who had paid yearly out-of-pocket drug costs of $4,850 reached the catastrophic coverage phase, in which they then had only a small copayment for their drugs until the end of the year.

PDPs have the latitude to structure their plans differently than the model presented here; companies offering non-standard plans must show that their coverage is at least actuarially equivalent to the standard plan. Many have developed plans with no deductibles or with drug copayments instead of the 25% co-insurance, and some plans provide generic and/or brand name drug coverage during the coverage gap.

Part D does not cover all medications prescribed for Medicare enrollees. Several drug categories—such as over-the-counter medications, anorexia and weight loss or gain medications, prescription vitamins (except for prenatal vitamins), and cough and cold medications are excluded from the Part D program formulary. This creates a lack of support for some drugs commonly prescribed to treat CKD, including oral iron, ergocalciferol, and cholecalciferol. In January 2013, Medicare expanded Part D coverage to include benzodiazepines without restriction, and barbiturates when prescribed for specific indications.

vol 1 Table 8.2 Medicare Part D parameters for defined standard benefit, 2011 & 2016

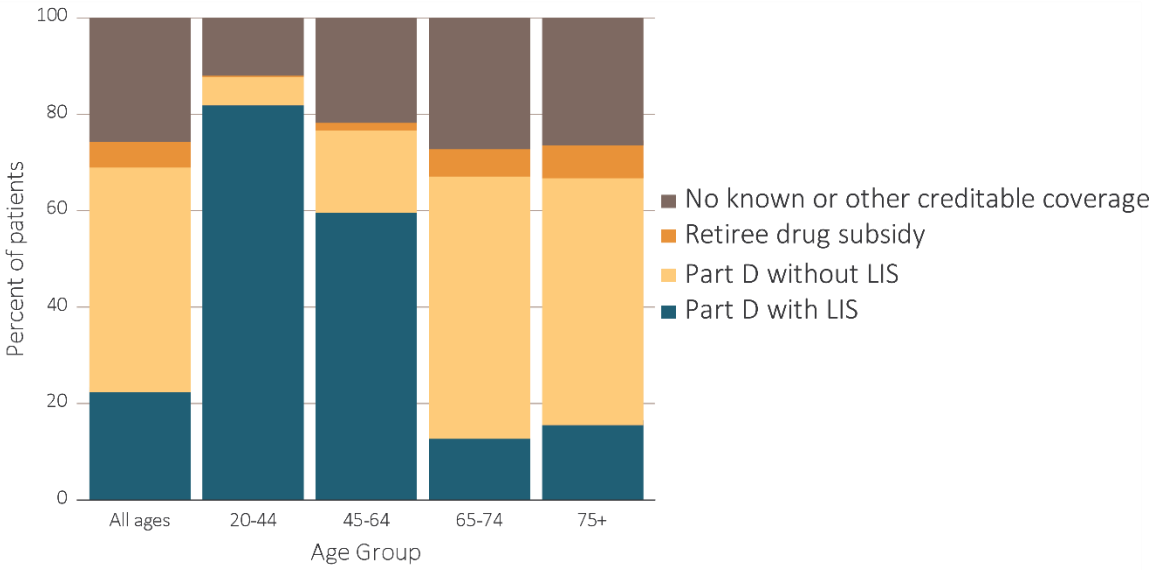
	2011	2016
Deductible After the deductible is met, the beneficiary pays 25% of total prescription costs up to the initial coverage limit.	$310	$360
Initial coverage limit The coverage gap ("donut hole") begins at this point. The beneficiary pays 100% of their prescription costs up to the out-of-pocket threshold	$2,840	$3,310
Out-of-pocket threshold The total out-of-pocket costs including the "donut hole"	$4,550	$4,850
Total covered Part D prescription out-of-pocket spending Catastrophic coverage begins after this point (including the coverage gap)[a]	$6,448	$7,063
Catastrophic coverage benefit	$2.50	$2.95
Generic/preferred multi-source drug	$6.30	$7.40
2016 Example:		
$360 (deductible)	$310	$360
+(($3,310-$360)*25%)(initial coverage)	$633	$738
+(($7,063-$3,310)*100%)(coverage gap)	$3,608	$3,753
Total (maximum out-of-pocket costs prior to catastrophic coverage, excluding plan premium)	$4,550	$4,850

Data source: Table adapted from http://www.q1medicare.com/PartD-The-2016-Medicare-Part-D-Outlook.php. Medicare Part D Enrollment Patterns. [a]The catastrophic coverage amount is the greater of 5% of medication cost or the values shown in the chart above. In 2016, beneficiaries were charged $2.95 for those generic or preferred multisource drugs with a retail price less than $59 and 5% for those with a retail price over $59. For brand name drugs, beneficiaries paid $7.4 for those drugs with a retail price less than $148 and 5% for those with a retail price over $148. In 2016, beneficiaries received a 50% discount on brand name drugs from manufacturers plus 5% coverage from their Part D plans; plans also paid 42% of generic drug costs in the gap. Abbreviation: Part D, Medicare prescription drug coverage benefit.

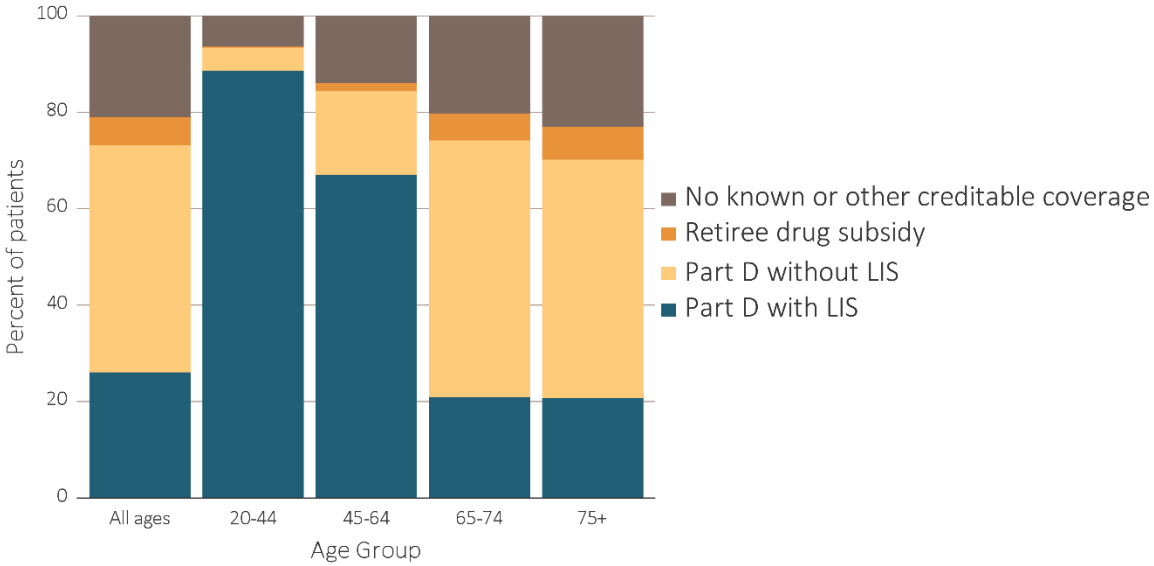
Among both general Medicare beneficiaries and those with CKD, the percentage of beneficiaries enrolled in Part D generally declined with age (Figure 8.2). The proportion of beneficiaries with LIS declined with age in both populations, with the exception of general Medicare population aged 75 and older. CKD patients in all age categories were more likely to receive this subsidy.

vol 1 Figure 8.2 Sources of prescription drug coverage in Medicare enrollees, by age, 2016

(a) All general Medicare enrollees



(b) Enrollees with CKD

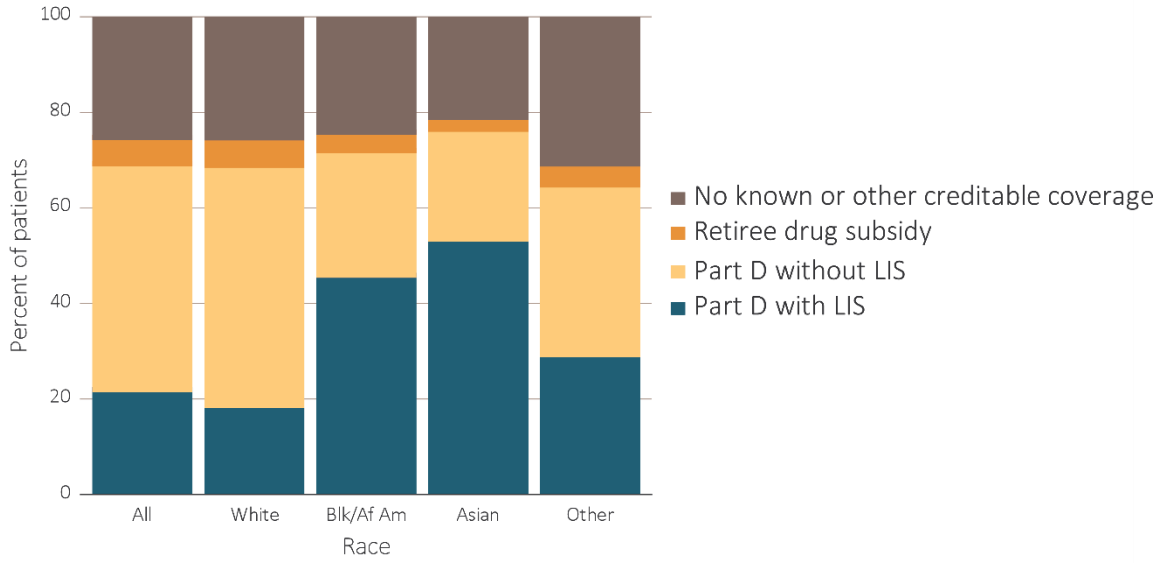


Data source: Medicare 5% sample. Point prevalent Medicare enrollees alive on January 1, 2016. Abbreviations: CKD, chronic kidney disease; LIS, Medicare Low-income Subsidy; Part D, Medicare prescription drug coverage benefit.

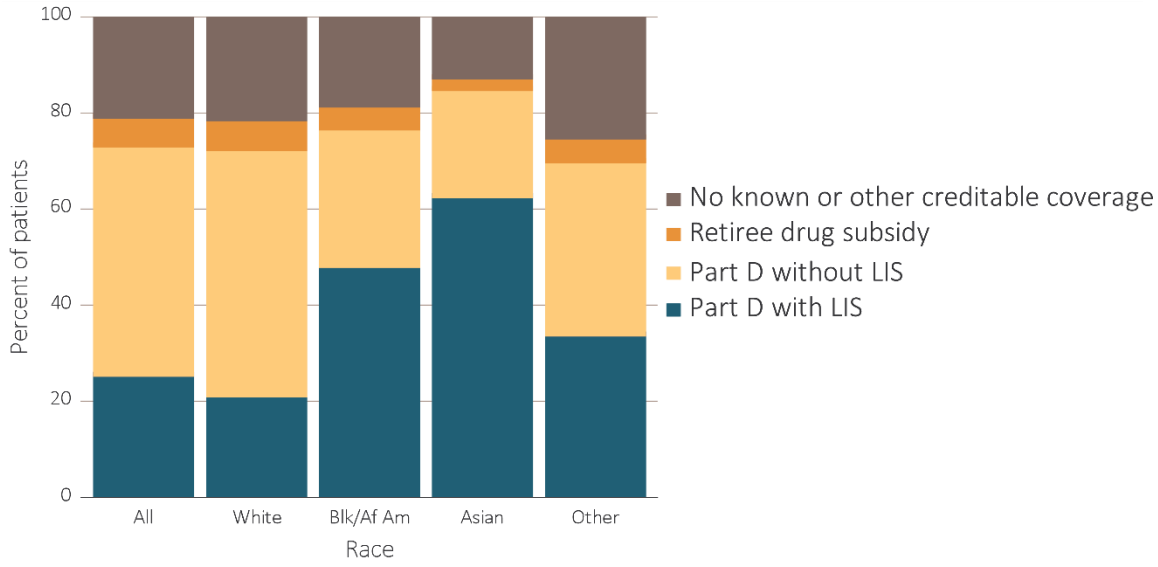
Patterns of coverage by race were similar for both general Medicare beneficiaries and for those with CKD (Figure 8.3). The percentage of beneficiaries with the LIS was higher for CKD patients than their general Medicare counterparts. Table 8.3 reports the percentage of general Medicare and CKD enrollees who were eligible for the LIS, stratified by both age and race. Among Medicare Part D enrollees with CKD, 73.8% of Asian beneficiaries received the LIS, compared to 62.8% of Blacks, and 29.3% of Whites. Although Asian Americans of all ages overall have higher incomes and lower poverty rates, the Administration for Community Living (ACL) and Administration on Aging (AoA) reports in 2015 that the poverty rate of Asians over 65 in the United States is higher than among all older adults, and a higher percent of elderly Asians were covered by both Medicare and Medicaid (ACL, 2015).

vol 1 Figure 8.3 Sources of prescription drug coverage in Medicare enrollees, by race, 2016

(a) All general Medicare enrollees



(b) Enrollees with CKD



Data source: Medicare 5% sample. Point prevalent Medicare enrollees alive on January 1, 2016. Abbreviations: Blk/Af Am, Black/African American; CKD, chronic kidney disease; LIS, Medicare Low-income Subsidy; Part D, Medicare prescription drug coverage benefit.

vol 1 Table 8.3 Medicare Part D enrollees with the Low-income Subsidy, by age & race, 2016

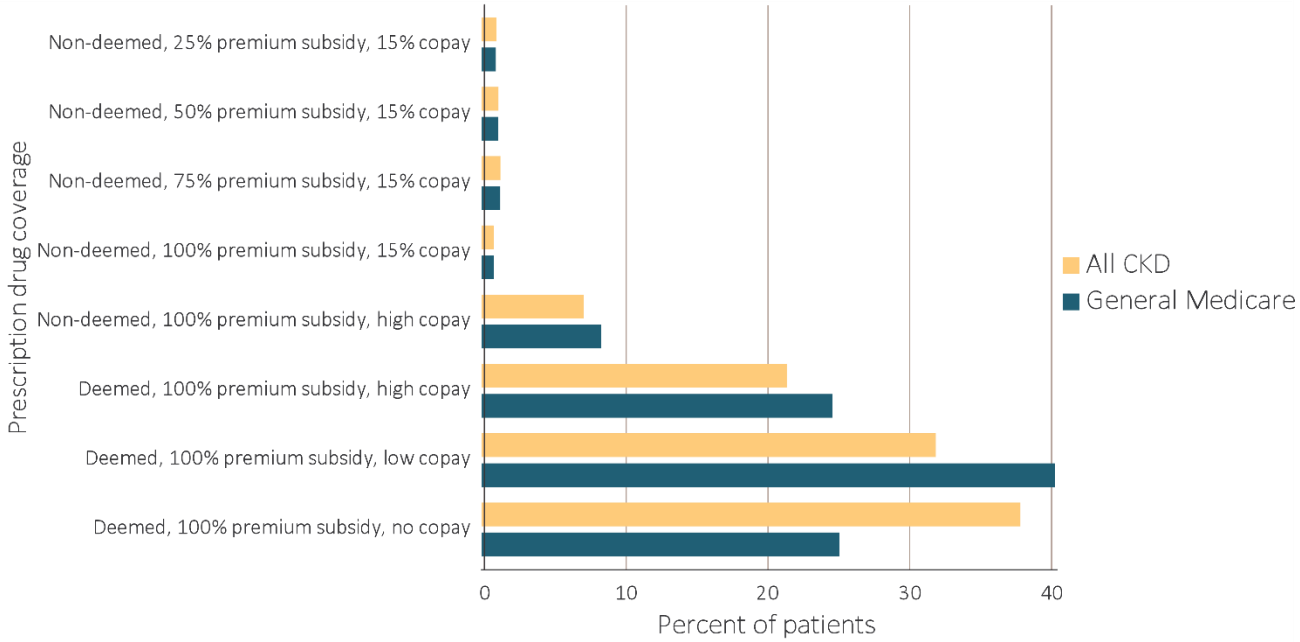
	General Medicare (%)	All CKD (%)
	Part D with Low-income Subsidy	Part D with Low-income Subsidy
All	32.9	36.1
White		
All ages	27.0	29.3
20-44	92.4	94.2
45-64	75.4	76.8
65-74	15.1	23.2
75+	18.8	23.7
Black/African American		
All ages	63.8	62.8
20-44	95.2	96.6
45-64	85.4	85.5
65-74	44.8	50.5
75+	52.7	58.2
Asian		
All ages	70.0	73.8
20-44	93.1	93.1
45-64	85.3	84.1
65-74	60.0	63.8
75+	73.9	77.2
Other races		
All ages	45.2	48.5
20-44	94.9	96.5
45-64	80.6	81.9
65-74	30.4	35.3
75+	39.8	47.7

Data source: Medicare 5% sample. Point prevalent Medicare enrollees alive on January 1, 2016. Abbreviations: CKD, chronic kidney disease; Part D, Medicare prescription drug coverage benefit.

Several categories of Medicare beneficiaries automatically qualify for LIS and Part D benefits, and are considered to be 'deemed'. These individuals include full-benefit Medicare/Medicaid dual eligible individuals, partial dual eligible individuals, Qualified Medicare Beneficiaries (QMB-only), Specified Low-income Medicare Beneficiaries (SLMB-only), Qualifying Individuals (QI), and people who receive Supplemental Security Income (SSI) benefits but not Medicaid. Other Medicare beneficiaries with limited incomes and resources who do not automatically qualify for LIS (non-deemed) can apply for LIS and have their eligibility determined by their State Medicaid agency or the Social Security Administration.

Figure 8.4 illustrates the distribution of Part D enrollees receiving the LIS across the benefit categories of premium subsidy and copayment. The largest group of LIS recipients who had CKD was eligible for a full premium subsidy—21.1% had a high copay, 31.6% had a low copay, and 37.6% had no copay.

vol 1 Figure 8.4 Distribution of Low-income Subsidy categories in Part D general Medicare and CKD patients, 2016



Data source: Medicare 5% sample. Point prevalent Medicare enrollees alive on January 1, 2016. Abbreviations: CKD, chronic kidney disease; Part D, Medicare prescription drug coverage benefit.

Spending for Prescriptions

In 2016, Medicare Part D spending for fee-for-service beneficiaries reached $56.9 billion. Table 8.4 represents the sum of the Medicare covered amount and the LIS amount. Medicare Part D spending for beneficiaries with CKD was $11.8 billion—about 20.8% of overall Medicare Part D spending. Data over a six-year period shows a consistent trend of increasing costs; between 2011 and 2016 spending rose by 42.0% for general Medicare patients ($16.8 billion) and 129.6% for Medicare CKD patients ($6.7 billion). This increase mirrors the increase of CKD ascertainment and the increase in Medicare part D spending per capita in the same period. Per capita spending for general Medicare increased by 12.6% during this five year interval compared to a 24.2% increase among CKD patients. ESRD patients also had higher than average increases during these years (see Volume 2, Chapter 10: *Prescription Drug Coverage in Patients with ESRD*).

vol 1 Table 8.4 Total estimated Medicare Part D spending for fee-for-service beneficiaries, 2011-2016

	General Medicare		All CKD	
Year	Medicare spending (in billions)	Medicare spending / PPPY	Medicare spending (in billions)	Medicare spending / PPPY
2011	$40.1	$2,689	$5.2	$3,978
2012	$35.7	$2,610	$4.8	$3,918
2013	$45.7	$2,584	$6.8	$3,947
2014	$50.5	$2,806	$7.7	$4,229
2015	$54.2	$2,970	$8.7	$4,545
2016	$56.9	$3,027	$11.8	$4,941

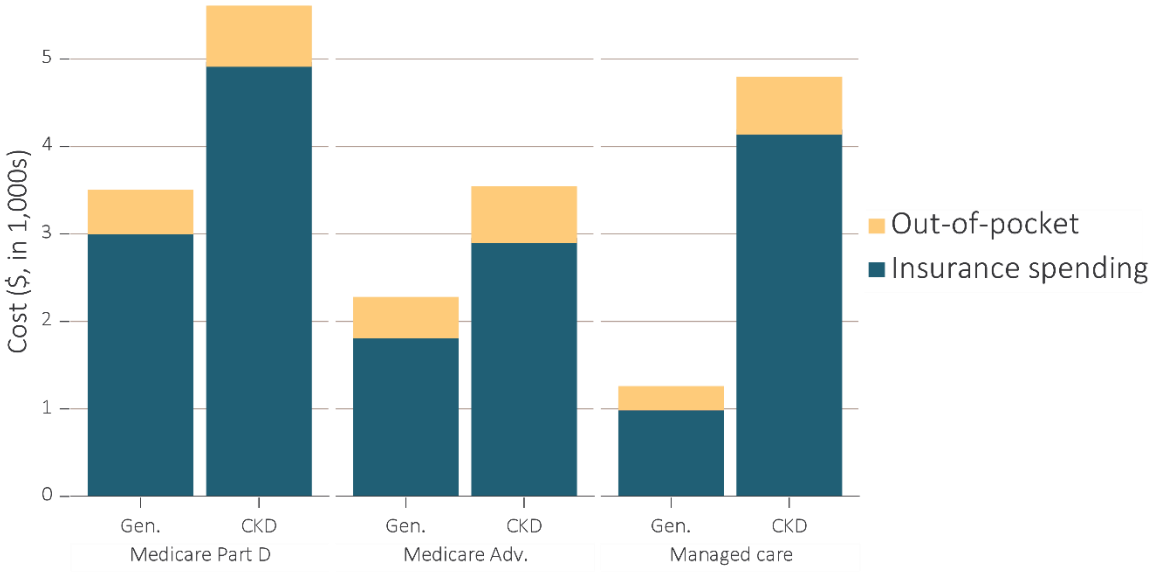
Data source: Medicare Part D claims. Medicare totals include Part D claims for Part D enrollees with traditional Medicare (Parts A & B). CKD totals include Medicare CKD patients, as determined from claims. Abbreviations: CKD, chronic kidney disease; Part D, Medicare prescription drug coverage benefit; PPPY, per person per year.

Figure 8.5.a illustrates PPPY spending and patient out-of-pocket costs by type of coverage. In 2016, PPPY insurance spending for CKD beneficiaries was 1.6, 1.6, and 4.1 times higher than for general beneficiaries of the Medicare Part D, Medicare Advantage, and managed care cohorts. Similar to patterns of spending, out-of-pocket costs for CKD patients were 1.5, 1.4, and 2.8 times higher than for general populations with Medicare Part D, Medicare Advantage, and managed care coverage. Out-of-pocket costs represented a larger share of total prescription spending in the general Medicare Advantage cohort (18.6%), the general managed care cohort (17.8%) and the CKD Medicare Advantage cohort (16.8%) than in the general Medicare Part D cohort (13.0%), the CKD managed care cohort (12.7%) and the CKD Medicare Part D cohort (11.9%).

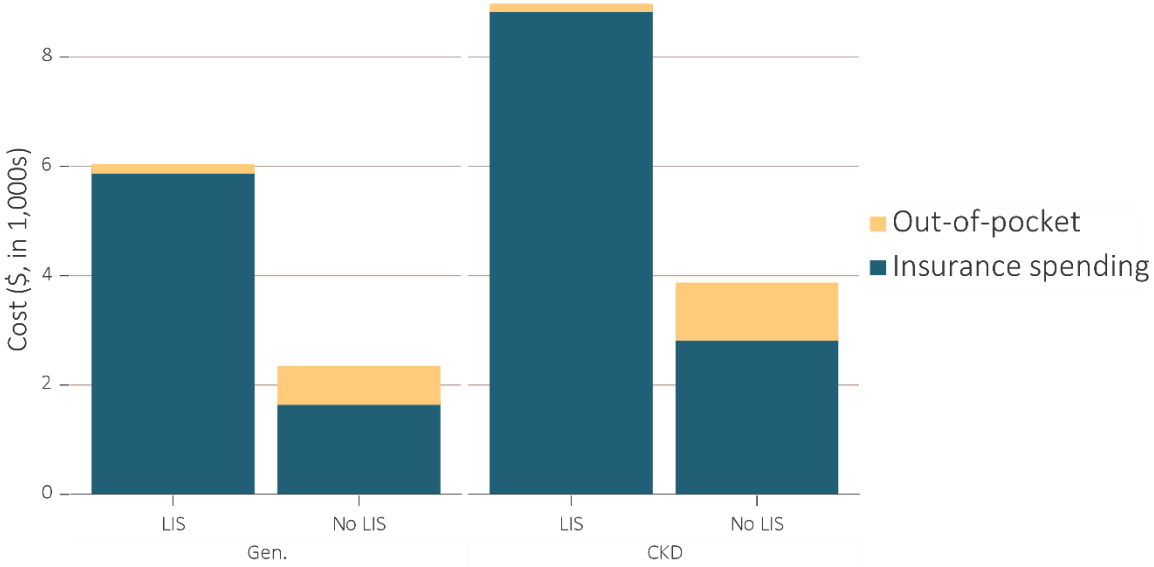
Per person per year spending for general and CKD Medicare Part D enrollees was further stratified by their LIS status (Figure 8.5.b). Total 2016 spending for Part D-covered medications was more than twice as high for beneficiaries with the LIS than for those without, regardless of the presence of CKD. In the LIS populations, however, out-of-pocket costs represented only 1.2-1.3% of these total expenditures, compared to 25.3-27.0% in each of the non-LIS populations.

vol 1 Figure 8.5 Per person per year insurance & out-of-pocket costs (in $1,000s) for enrollees, 2016

(a) All enrollees by type of insurance and modality



(b) Medicare Part D enrollees by Low-income Subsidy status



Data source: Medicare Part D claims and Optum Clinformatics™ claims. Medicare totals include Part D claims for Part D enrollees with traditional Medicare (Parts A & B). CKD totals include Medicare CKD patients as determined from claims. Costs are per person per year for calendar year 2016. Medicare total is the sum of Medicare net payment plus Low-income Supplement amount. Abbreviations: Gen., general enrollees; CKD, chronic kidney disease; LIS, Medicare Low-income Subsidy; Medicare adv., Medicare Advantage plans; Part D, Medicare prescription drug coverage benefit.

PPPY Medicare Part D spending for prescriptions (excluding patient obligations) varied widely by coverage (Table 8.5). Overall, expenditures for beneficiaries with CKD were higher than in the general populations. PPPY insurance spending for prescriptions was highest in Medicare Part D beneficiaries with LIS for both the general and CKD populations ($5,916 and $8,870). For the general population cohorts, spending was lowest in managed care ($1,013), and for the CKD cohorts was lowest in Medicare Part D without LIS ($2,861). For both general Medicare, and CKD Medicare, LIS per capita spending was over 3 times as great as for non-LIS patients. Reasons for this difference have yet to be determined.

As there are differences between the Medicare and Optum Clinformatics™ beneficiary populations and in their methods of reporting costs, these results may not be directly comparable and should be interpreted with caution and with understanding of those differences.

vol 1 Table 8.5 Per person per year insurance spending ($) for enrollees, 2016

	(a) Medicare Part D			
	Medicare Part D with LIS, General	Medicare Part D with LIS, CKD	Medicare Part D without LIS, General	Medicare Part D without LIS, CKD
Age				
All	$5,916	$8,870	$1,684	$2,861
20-44	$5,757	$12,015	$3,000	$2,921
45-64	$7,883	$12,742	$3,806	$5,828
65-74	$5,171	$9,010	$1,614	$3,374
75+	$4,317	$6,254	$1,550	$2,356
Sex				
Male	$5,900	$9,407	$1,830	$3,087
Female	$5,926	$8,536	$1,576	$2,633
Race				
White	$6,119	$9,063	$1,670	$2,827
Black/African American	$5,779	$8,579	$1,968	$2,952
Asian	$4,973	$7,541	$1,346	$2,716
Other race	$5,016	$7,931	$1,768	$3,611

	(b) Medicare Advantage and Managed Care			
	Medicare Advantage, General	Medicare Advantage, CKD	Managed Care, General	Managed Care, CKD
Age				
All	$1,834	$2,926	$1,013	$4,164
20-44	$5,149	$9,767	$579	$2,566
45-64	$5,045	$7,862	$1,323	$4,480
65-74	$1,610	$3,401	$2,087	$5,134
75+	$1,438	$2,211	$2,623	$3,772
Sex				
Male	$1,812	$2,892	$986	$4,401
Female	$1,850	$2,954	$1,040	$3,850
Race				
White	$1,851	$2,880	$1,045	$4,260
Black/African American	$2,761	$4,159	$982	$3,993
Asian	$1,765	$3,213	$597	$3,234
Other race	NA	NA	NA	NA

Data source: Medicare Part D claims and Optum Clinformatics™ claims. CKD determined from claims. Costs are per person per year for calendar year 2016. Medicare PPPY is the sum of Medicare net payment and the Low-income Supplement amount. LIS status is determined from the Part D enrollment. A person is classified as LIS if they are eligible for the LIS for at least one month during 2016. Abbreviations: CKD, chronic kidney disease; LIS, Medicare Low-income Subsidy; NA, not applicable; Part D, Medicare prescription drug coverage benefit.

Prescription Drug Classes

Ranking of the top 15 prescription drug classes used by CKD patients is based on the percentage of beneficiaries with at least one claim for a medication in that class during 2016. The proportion of patients using each drug class was somewhat lower for Medicare Advantage and managed care enrollees in the Optum Clinformatics™ database than for those having Medicare Part D. These differences could arise from plan effects such as coverage or care management activities, or from patient selection in the younger and healthier Optum Clinformatics™ cohort. The most commonly used drug classes were similar between the different cohorts. The list was led by lipid-lowering agents, antibacterials, renin-angiotensin-aldosterone system inhibitors, β-adrenergic blocking agents (Beta Blockers), and analgesics and antipyretics (Table 8.6).

vol 1 Table 8.6 Top 15 drug classes received by CKD cohorts in different health plans, by percent of patients, 2016

(a) Medicare Part D

Rank	Drug class	Percent of patients
1	Lipid-lowering agents	65.2%
2	Antibacterials	60.2%
3	Renin-angiotensin-aldosterone system Inhibitors	59.2%
4	β-adrenergic blocking agents	54.6%
5	Analgesics and antipyretics	49.5%
6	Diuretics	46.0%
7	Antiulcer agents and acid suppressants	42.3%
8	Antidiabetic agents	42.1%
9	Calcium-channel blocking agents	38.0%
10	Psychotherapeutic agents	37.6%
11	Antithrombotic agents	31.1%
12	Anticonvulsants	27.7%
13	Thyroid and antithyroid agents	25.5%
14	Anxiolytics, sedatives, and hypnotics	23.3%
15	Adrenals	22.1%

(b) Medicare Advantage

Rank	Drug class	Percent of patients
1	Lipid-lowering agents	53.0%
2	Renin-angiotensin-aldosterone system	50.4%
3	Antibacterials	44.3%
4	β-adrenergic blocking agents	40.6%
5	Analgesics and antipyretics	36.7%
6	Diuretics	33.4%
7	Calcium-channel blocking agents	31.2%
8	Antiulcer agents and acid suppressants	30.3%
9	Antidiabetic agents	29.8%
10	Psychotherapeutic agents	26.3%
11	Antithrombotic agents	21.1%
12	Vaccines	20.4%
13	Diabetic consumables	19.5%
14	Thyroid and antithyroid agents	18.8%
15	Anticonvulsants	18.3%

Table 8.6 continued on next page.

vol 1 Table 8.6 Top 15 drug classes received by CKD cohorts in different health plans, by percent of patients, 2016 (continued)

(c) Managed Care

Rank	Drug class	Percent of patients
1	Antibacterials	48.5%
2	Renin-angiotensin-aldosterone system	48.2%
3	Lipid-lowering agents	45.0%
4	Analgesics and antipyretics	41.8%
5	β-adrenergic blocking agents	31.2%
6	Antidiabetic agents	30.6%
7	Calcium-channel blocking agents	24.6%
8	Diuretics	23.8%
9	Psychotherapeutic agents	23.7%
10	Antiulcer agents and acid suppressants	20.6%
11	Adrenals	18.9%
12	Anxiolytics, sedatives, and hypnotics	18.7%
13	Diabetic consumables	18.0%
14	Anticonvulsants	15.4%
15	Thyroid and antithyroid agents	14.2%

Data source: Medicare Part D claims and Optum Clinformatics™ claims. CKD patients with Medicare Part D stand-alone prescription drug plans in the Medicare 5% sample. Diabetic Consumables refers to blood glucose test strips, blood glucose meters/sensors, lancets, needles, pen needles etc. Abbreviations: CKD, chronic kidney disease; Part D, Medicare prescription drug coverage benefit.

For the CKD Medicare Part D cohort, antidiabetic agents required the greatest spending, at 23.5% of the total for this group. For the Medicare Advantage and managed care cohorts, antidiabetic agents accounted for 18.9% and 23.2% of total spending. Other costly medications include antineoplastic agents, antivirals, and lipid-lowering agents (Table 8.7).

For an examination of the prevalence of cardiovascular agent use among Medicare beneficiaries, see Volume 1, Chapter 4: *Cardiovascular Disease in Patients with CKD*. This chapter includes comparisons by cardiovascular comorbidities, procedures, and CKD status.

vol 1 Table 8.7 Top 15 drug classes received by different CKD cohorts (Medicare Part D/Medicare Advantage programs/Managed Care health plans), by insurance spending, 2016

(a) Medicare Part D

Rank	Drug class	Spending ($ in millions)	Percent of total spending
1	Antidiabetic agents	2787	23.5%
2	Antineoplastic agents	1367	11.5%
3	Antivirals	664	5.6%
4	Lipid-lowering agents	541	4.6%
5	Antithrombotic agents	462	3.9%
6	Psychotherapeutic agents	447	3.8%
7	Anticonvulsants	343	2.9%
8	Anti-inflammatory agents	338	2.9%
9	Analgesics and antipyretics	319	2.7%
10	Antiulcer agents and acid	274	2.3%
11	Disease-modifying antirheumatic agents	256	2.2%
12	Anticholinergic agents	219	1.9%
13	Vasodilating agents (respiratory tract)	202	1.7%
14	Central nervous system agents, miscellaneous	185	1.6%
15	Antibacterials	182	1.5%

(b) Medicare Advantage

Rank	Drug class	Spending ($ in millions)	Percent of total spending
1	Antidiabetic agents	210	18.9%
2	Antineoplastic agents	126	11.3%
3	Lipid-lowering agents	71	6.4%
4	Antivirals	49	4.5%
5	Antithrombotic agents	49	4.4%
6	Diabetes consumables	48	4.3%
7	Anti-inflammatory agents	36	3.3%
8	Psychotherapeutic agents	34	3.0%
9	Analgesics and antipyretics	29	2.7%
10	Anticonvulsants	28	2.6%
11	Renin-angiotensin-aldosterone system inhibitors	24	2.2%
12	Anticholinergic agents	24	2.1%
13	Disease-modifying antirheumatic agents	22	2.0%
14	Antiulcer agents and acid	21	1.9%
15	Vasodilating agents	19	1.7%

Table 8.7 continued on next page.

vol 1 Table 8.7 Top 15 drug classes received by different CKD cohorts (Medicare Part D/Medicare Advantage programs/Managed Care health plans), by insurance spending, 2016 (continued)

(c) Managed Care

Rank	Drug class	Spending ($ in millions)	Percent of total spending
1	Antidiabetic agents	72	23.2%
2	Antineoplastic agents	43	14.0%
3	Antivirals	23	7.3%
4	Disease-modifying antirheumatic agents	16	5.1%
5	Lipid-lowering agents	15	5.0%
6	Antithrombotic agents	11	3.4%
7	Analgesics and antipyretics	9	2.7%
8	Psychotherapeutic agents	8	2.4%
9	Diabetic consumables	7	2.3%
10	Anticonvulsants	6	1.8%
11	Anti-inflammatory agents	6	1.8%
12	Immunomodulatory agents	5	1.7%
13	Renin-angiotensin-aldosterone system inhibitors	5	1.6%
14	Antibacterials	5	1.5%
15	Skin and mucous membrane agents, miscellaneous	4	1.4%

Data source: Medicare Part D claims and Optum Clinformatics™ claims. CKD patients with Medicare Part D stand-alone prescription drug plans in the Medicare 5% sample. Medicare Part D spending represents the sum of the Medicare covered amount and the Low-income Subsidy amount. Diabetic Consumables refers to blood glucose test strips, blood glucose meters/sensors, lancets, needles, pen needles etc. Abbreviations: CKD, chronic kidney disease; Part D, Medicare prescription drug coverage benefit.

Medications for Pain Management

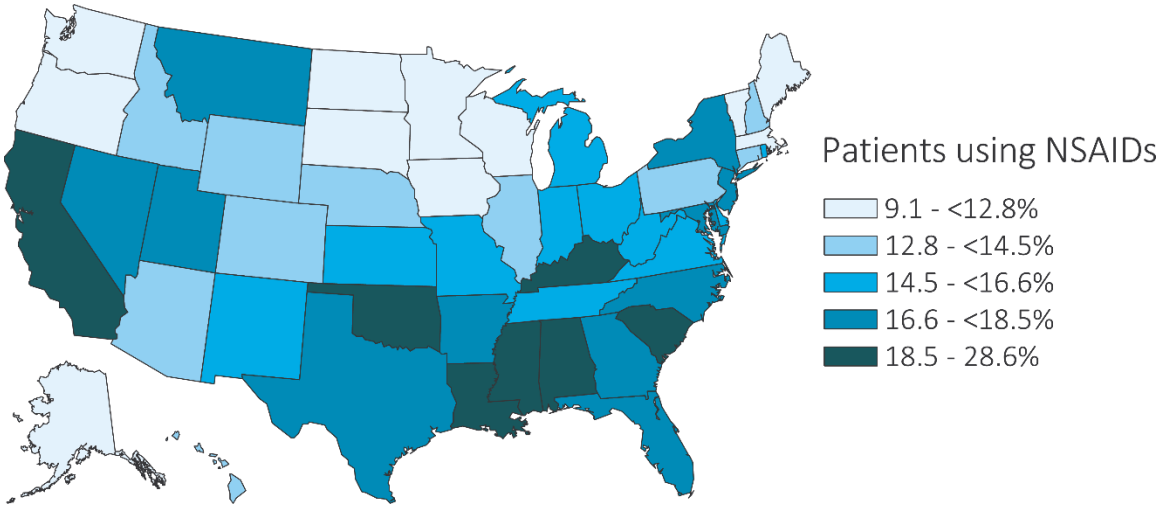
CKD patients often experience pain, yet the various medications for pain have different drawbacks. Non-steroidal anti-inflammatory drugs (NSAIDs) may induce renal function abnormalities and opioid abuse has been a growing national problem.

NSAIDs and opioid analgesics are two of the primary drug classes used for pain management. Figures 8.6 and 8.7 display the state-specific proportion of CKD Medicare Part D beneficiaries who were prescribed NSAIDs or opioid analgesics in 2016.

Nationally, 16.4% of these patients used prescription NSAIDs at some time during the year. The Southern region of the United States demonstrated the highest proportion of use, including Oklahoma, Alabama, Mississippi, and Louisiana. As NSAIDs are widely available over-the-counter, however, these findings likely underestimate the proportions of actual NSAID use.

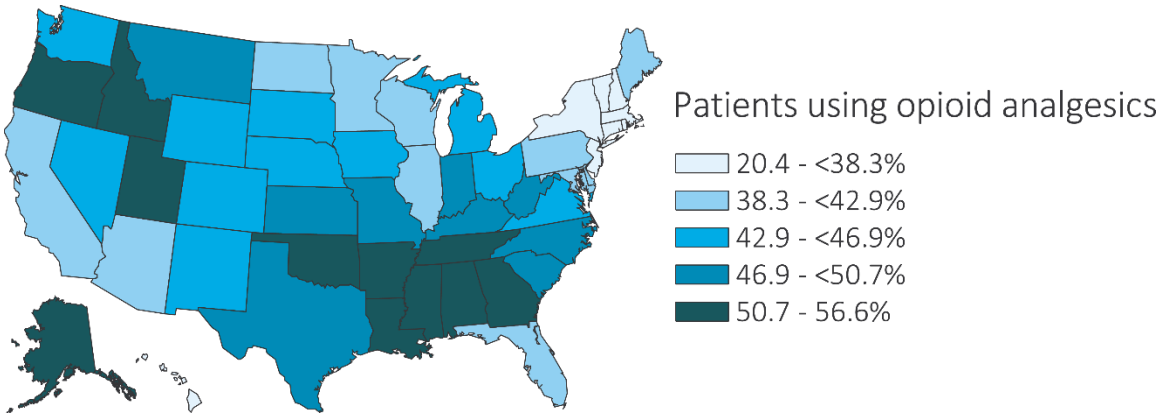
The national proportion of patients using opioid analgesics was higher, at 43.8%. Greatest by-state use occurred in the South Central region (Mississippi, Alabama, Arkansas, Oklahoma, Louisiana and Tennessee,) and the Mountain region (Idaho and Utah). More than half of patients with CKD in these states had received opioid analgesics at some point in 2016. Medication use varies by CKD stage, so results may reflect differences in pain management strategies by state.

vol 1 Figure 8.6 Estimated utilization rate of prescription NSAIDs, by state, Medicare CKD Patients, 2016



Data source: Medicare Part D claims. CKD patients with Medicare Part D stand-alone prescription drug plans in the Medicare 5% sample. Abbreviations: CKD, chronic kidney disease; NSAIDs, nonsteroidal anti-inflammatory agents; Part D, Medicare prescription drug coverage benefit. NSAIDs filled under Medicare Part D represent a fraction of actual NSAID use.

vol 1 Figure 8.7 Estimated utilization rate of opioid analgesics, by state, Medicare CKD Patients, 2016



Data source: Medicare Part D claims. CKD patients with Medicare Part D stand-alone prescription drug plans in the Medicare 5% sample. Abbreviations: CKD, chronic kidney disease; Part D, Medicare prescription drug coverage benefit.

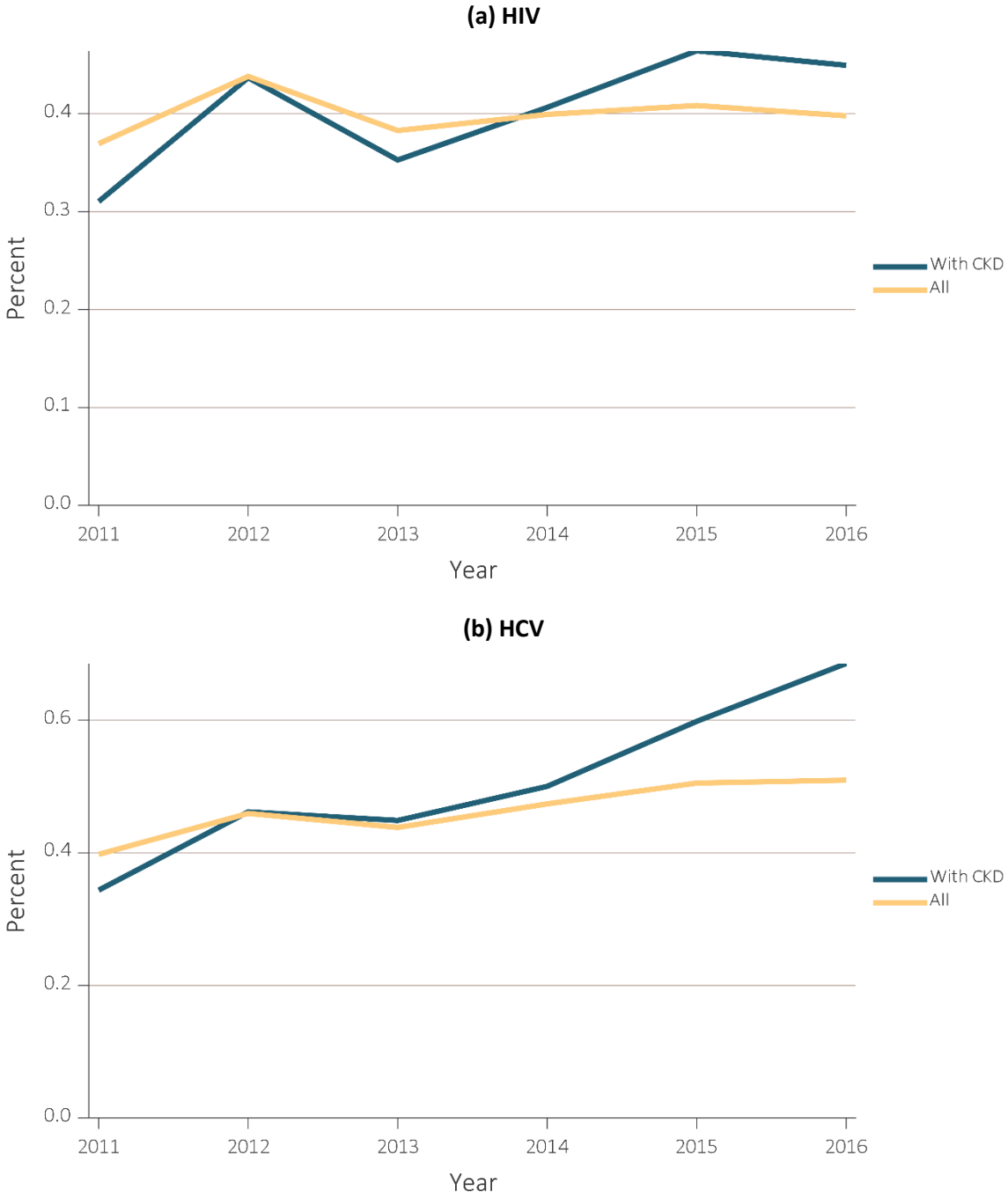
Antiviral Medications

In this section, we examine use of prescribed antiviral medications in Medicare Part D enrollees and particularly assess three main drug classes used for antiviral management—prescription antiretrovirals, nucleosides and nucleotides, and protease inhibitors. These classes of agents are prescribed solely or in combination with others to treat human immunodeficiency virus (HIV), herpes virus infections, hepatitis C (HCV), and hepatitis B. The prevalence of HIV fluctuated in both CKD patients and general Medicare beneficiaries from 2011 to 2016, and the prevalence is slightly higher in CKD than in the general population after 2014 (Figure 8.8.a). The prevalence of HCV stands at 0.4%-0.5% in the general population, while it has gone up from 0.3% in 2011 to 0.7% in 2016 among CKD patients (Figure 8.8.b).

Figure 8.9 displays the proportions of Medicare Part D enrollees prescribed antivirals in 2011-2016. There is a notable increase in use of prescription antivirals among aged CKD patients in the past six years, from 4.2% in 2011 to a peak of 6.5% in 2015, with a decline to 5.0% in 2016. Antiviral use was slightly higher among CKD patients than general Medicare beneficiaries.

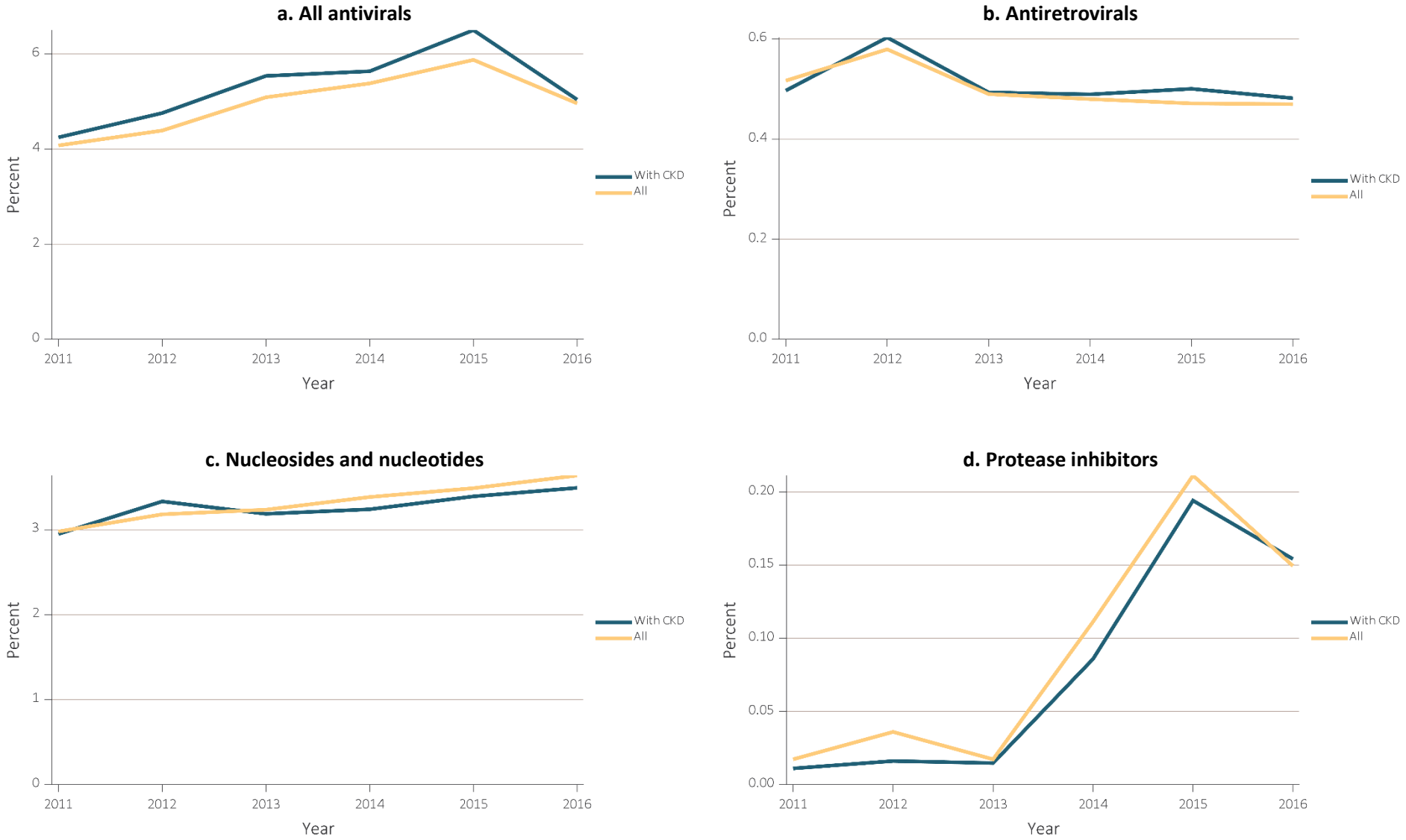
Figure 8.10 displays the PPPY Medicare Part D spending on antivirals by CKD from 2011 to 2016. PPPY Medicare Part D spending was $2,936 in 2011, peaking at $5,628 in 2014, before gradually declining to $5,421 in 2016. PPPY Medicare Part D spending on antivirals was higher among general Medicare beneficiaries than among CKD patients over this period, except during 2016.

vol 1 Figure 8.8 Estimated prevalence of HIV and HCV in Medicare Part D enrollees, 2011-2016



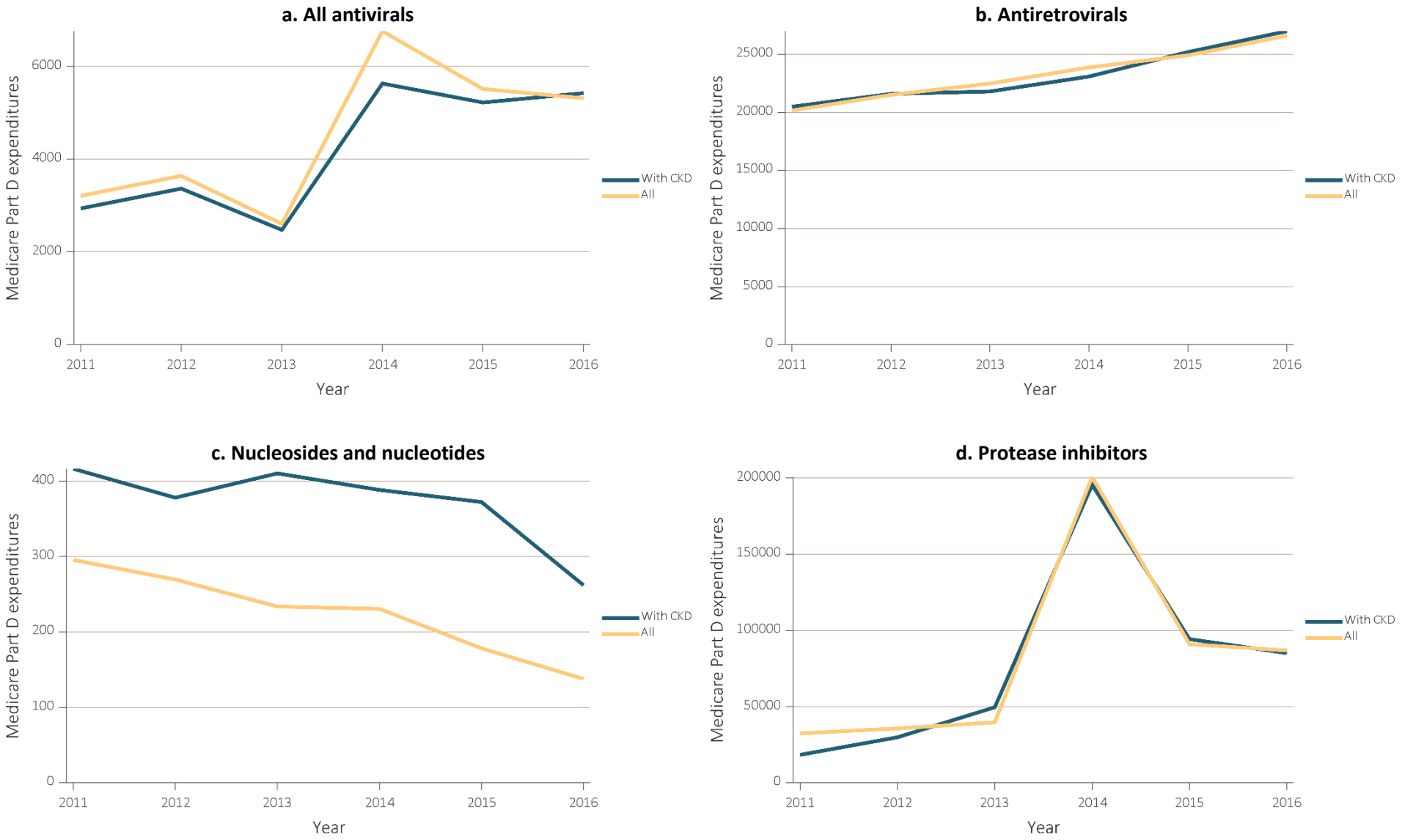
Data source: Medicare Part D claims. CKD patients with Medicare Part D stand-alone prescription drug plans in the Medicare 5% sample. Abbreviations: CKD, chronic kidney disease; HCV, hepatitis C; HIV, human immunodeficiency virus; Part D, Medicare prescription drug coverage benefit.

vol 1 Figure 8.9 Estimated utilization rate of prescription antivirals in Medicare Part D enrollees, 2011-2016



Data source: Medicare Part D claims. CKD patients with Medicare Part D stand-alone prescription drug plans in the Medicare 5% sample. Abbreviations: CKD, chronic kidney disease; Part D, Medicare prescription drug coverage benefit.

vol 1 Figure 8.10 Estimated PPPY Medicare Part D spending on antivirals in Medicare Part D enrollees, 2011-2016



Data source: Medicare Part D claims. CKD patients with Medicare Part D stand-alone prescription drug plans in the Medicare 5% sample. Abbreviations: CKD, chronic kidney disease; Part D, Medicare prescription drug coverage benefit; PPPY, per person per year.

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Notes

Chapter 9: Transition of Care in Chronic Kidney Disease

- Compared to all USRDS patients who transitioned to end stage renal disease (ESRD) between 10/1/2007-3/31/2015, U.S. veteran patients were older, more likely to be non-Hispanic and White, more likely to have cardiovascular or pulmonary comorbidities, and more likely to have pre-transition nephrology care or have an arteriovenous (AV) fistula as their primary access type (Table 9.1).
- Kaiser Permanente Southern California (KP-SC) patients had a lower age and sex adjusted incidence rate of ESRD, compared to the general population (Table 9.7). In KP-SC patients who transitioned to ESRD between 1/1/2007-12/31/2016, 20% were Black, 37% Hispanic, 11% Asian, and 42% female.
- Female U.S. veterans comprised less than 2% of all USRDS females transitioning to ESRD between 10/1/2007 and 3/31/2015. Female veterans were similar in most characteristics with the total USRDS female population transitioning to ESRD during this period, with the exception that they were more likely to be Black.
- Across the incidence years of transition to ESRD, female U.S. veterans were increasingly more likely to be Black, to have less cardiovascular comorbidities at transition, and were increasingly more likely to have had nephrology care prior to transition or an AV fistula as the primary access type.
- Both U.S. veterans and KP-SC patients had seasonal variations in the number of patients who transitioned to ESRD, where there were peaks in the number of patients transitioning to ESRD in January and March, and lower numbers in November (Figures 9.13 and 9.54).
- The median estimated glomerular filtration rate (eGFR) at transition for U.S. veterans was higher than that of the total USRDS population. The highest median eGFRs at transition were found in North Dakota, Idaho, and Arizona, while the lowest were in South Carolina, District of Columbia, and Alabama. Females had lower median eGFRs at transition to ESRD, compared to males.
- In the year prior to ESRD transition, the median slope of eGFR for U.S. veterans was -10.4 mL/min/1.73m^2/year. Median eGFR slope varied across states differently for all U.S. veterans, and in patients with diabetes or hypertension as the primary cause of ESRD.
- Across states, U.S. veterans showed different proportions and temporal changes in the proportions of patients with diabetes or hypertension as the primary cause of ESRD, preemptive transplants, AV fistula or AV graft as the initial access type, cardiovascular disease and infection-related cause of death, and hospitalizations during transition.
- U.S. veterans had a lower body mass index (BMI) at transition compared to all USRDS patients transitioning between 10/1/2007-3/31/2015. There were also differences in mean BMI per state overall and for each racial ethnic group. Although mean BMI at transition has increased over time for all racial/ethnic groups, compared to racial/ethnic differences in mean BMI level in the total USRDS, there was less difference in mean BMI level across racial ethnic categories in U.S. veterans.
- Of the 12,242 KP-SC patients who transitioned to ESRD, 315 (2.6%) had a preemptive transplant and 1,731 (14%) initiated dialysis with peritoneal dialysis (PD). Hemodialysis (HD) catheter was the most frequent access type at the initiation of dialysis, while AV grafts remained the least frequent access type (Figure 9.53). Between 2010 and 2012, there was a marked decrease in the use of HD catheters and an increase in the use of fistulas and PD catheters.
- In the year prior to ESRD transition, the median eGFR decreased from 18.4 to 11.2 mL/min/1.73m^2 among 11,927 KP-SC patients (Figure 9.58). Younger patients had a more rapid decrease of eGFR than older ones (Figure 9.59). Patients with diabetes had a faster progression rate of eGFR than those with other health conditions (Figure 9.60).

- Among U.S. veterans, in the quarter immediately prior to transition, there was a sharp increase in the proportion of patients with serum phosphorous ≥5.5 mg/dL; however, by the first quarter post-transition to ESRD, the proportion of patients with a phosphorous level in the target range of 3.5-<5.5 mg/dL or lower increased again and remained relatively stable after the third quarter post-transition. Similarly, in KP-SC patients, mean phosphorous levels increased in the prelude (pre-ESRD) period from 4.2 mg/dL to 5.2 mg/dL and decreased to 4.4 mg/dL immediately after transition (Figure 9.63).
- Among U.S. veterans, increases in beta blocker prescriptions prior to ESRD were mostly attributed to increases in prescriptions for non-dialyzable beta blockers.
- The proportions of U.S. veteran patients within different pain score categories did not vary across the quarters prior to and after transition to ESRD; however, the proportion of patients prescribed opioids increased in the period prior to transition, and reached the highest proportion (46%) in the 6 months after transition to ESRD, but then gradually declined.
- The proportion of U.S. veterans who received an opioid prescription in the 6 months prior to transition increased linearly between 2007 and 2013, then decreased sharply during 2014 and 2015, with the proportion of veterans receiving opioids in 2015 falling below the level observed in 2007.

Introduction

The Transition of Care in Chronic Kidney Disease (TC-CKD) Special Study Center examines the transition of care to renal replacement therapy (i.e. dialysis or transplantation) in patients with very-late-stage (advanced) non-dialysis dependent (NDD) CKD. These are often people with an estimated glomerular filtration rate (eGFR) <25 mL/min/1.73m^2. The primary sources used in these analyses were created from the linkage between the national USRDS data and two large longitudinal data sources of NDD-CKD patients—the national Veterans Health Administration (VHA) database and the electronic medical records capturing the care delivered to members of the Kaiser Permanente Southern California (KP-SC) health plan. These linkages have allowed for the identification of nearly all VHA and KP-SC patients who transitioned to end-stage renal disease (ESRD) from the index point (Year 2007) in time onwards. Each of these linked databases included thousands of NDD-CKD patients who transitioned to ESRD each year, in whom historical data for up to -5 (minus five) years prior to ESRD ("prelude" period) and up to +2 (plus two) years after ESRD transition (early "vintage" period) were examined.

In this USRDS Special Study, we have examined the most recent VHA and KP-SC cohorts of incident ESRD patients. We have provided pre-ESRD (prelude) data on all available ESRD transitions since 10/1/2007 among veterans. Analyses that examined pre- and post-ESRD data of approximately 52,000 incident ESRD veterans who transitioned to ESRD between 10/1/2007-9/30/2011 were presented in our 2014 and 2015 Annual Data Report (ADR) chapters. In our 2016 ADR chapter, we presented transition-to-ESRD data on approximately 85,000 incident ESRD veterans who transitioned to ESRD over 6.5 years (10/1/2007-3/31/2014) across the entire nation, and in the 2017 ADR, we presented similar data on more than 100,000 incident ESRD veterans who transitioned between 10/1/2007 and 3/31/2015. In this year's chapter, we feature additional data on these 100,000 veterans, including comparisons with the entire USRDS cohort that transitioned over that period, seasonal trends, and variations across the United States. We also include data on the racially and ethnically diverse KP-SC member population who transitioned to ESRD over 10 years between 1/1/2007-12/31/2016.

As stated in the original goals of this Special Study Center, we have continued to test the hypotheses that a pre-ESRD (prelude) data-driven personalized approach to the transition of care into ESRD in very-late-stage NDD-CKD is associated with more favorable outcomes, particularly if the decision is based on pre-ESRD factors such as

clinical and laboratory variables, including CKD progression rate, comorbid conditions during the prelude period, and demographics. Some of these concepts and data have been published in the form of abstracts, as well as peer-reviewed manuscripts over the past 4 years.[1-26] We have also developed and validated a scoring system derived from these pre-ESRD data to better ascertain the extent to which timing, preparation, and modality of ESRD may be associated with better outcomes.[13]

The Veterans Health Administration

There are more than 20 million veterans in the United States; approximately nine million are enrolled in the VHA, including approximately six million who receive their healthcare in one of the VHA facilities. Whereas approximately 90% of the U.S. veteran population is presently male, it is estimated that in the next decade the proportion of females will rise to 18 to 20%.[27, 28] Minority veterans currently comprise about 22% of the overall veteran population, among whom the majority are of Black or African American race (12% of all veterans) and Hispanic or Latino ethnicity (7% of all veterans).[29, 30] Each year, approximately 13,000 veterans transition to renal replacement therapy, mostly in the form of maintenance dialysis treatment.[3] Among >6,000 dialysis units nationwide, there are currently approximately 70 VHA dialysis centers.[3] Given this number of VHA dialysis centers and their limited capacity, only 10% of all incident dialysis veterans initiate treatment in a VHA dialysis center.[3] Although almost 90% of the ESRD veterans receive dialysis treatment in non-VHA facilities, including large dialysis organizations, the transition data of these and other outsourced veterans, and in particular, their prelude and early vintage analyses and other data are also included in this chapter. Hence, our transition-of-care data for more than 100,000 (n=102,477) veterans with ESRD are inclusive and comprehensive.

ESRD Rates among Veterans

As reported in previous ADR chapters on the Transition of Care in CKD, on average 13,664 veterans transitioned to ESRD each year over the period of 2007-2015 (see below additional analyses on secular trend data), with an average rate of ESRD transition of 1,139 veterans per month across the entire nation. In the 2017 ADR, we also reported crude ESRD incident rates among U.S. veterans between 2008 and 2014, which were 635.3, 664.1, 646.5, 620.9, 635.6, 669.8, and 665.0 per million veterans, respectively; and compared them to the given ESRD incident rates of 488.1, 499.6, 495.7, 482.4, 485.5, 484.7, and 492.0 per million in the general U.S. population, respectively. This yielded the calculated crude rate ratios of ESRD incidence among veterans compared to the U.S. general population as 1.30, 1.33, 1.30, 1.29, 1.31, 1.38, and 1.35 for calendar years 2008 through 2014, respectively, suggesting that ESRD is 29% to 38% more likely to occur among veterans than the general U.S. population. However, due to the fact that the VHA population is considerably older than the general U.S. population, age-specific and age-adjusted VHA rates of ESRD were 25% to 40% lower than the U.S. rate of ESRD. The remarkably lower adjusted rate of ESRD among VHA patients, despite higher crude ESRD incidence rates, is currently unexplained. Further research may shed some light on this issue.

Comparisons of the Incident ESRD Veteran Population to the entire USRDS Incident ESRD Population between 10/1/2007 and 3/31/2015

Between 10/1/2007 and 3/31/2015 (over 7.5 years) 872,816 patients transitioned to ESRD, of which 102,477 were veterans. Among the U.S. veterans who transitioned to ESRD during this period, 14% were World War II veterans, 38% were Vietnam era veterans, 16% were Korean War veterans, 4% were Persian Gulf War veterans, 6% were from the post-Vietnam era, 8% were from the post-Korean era, and 14% were other or unknown. Across the years of transition, the proportion of veterans who served in World War II and Korea decreased, whereas the proportion who served in the post-Korean, post-Vietnam era and Persian Gulf War increased. In this veteran ESRD population, the mean ± standard deviation age was 70.2 ±12.0 years, and included 24% patients of Black race and 7% of Hispanic ethnicity. Compared to all USRDS patients who transitioned to

ESRD during this period (Table 9.1), U.S. veteran patients were older, more likely to be non-Hispanic and White, and more likely to have reported a cardiovascular or pulmonary comorbidity on the Centers for Medicare & Medicaid Services (CMS) 2728 form at the time of transition. They were also less likely to have peritoneal dialysis as a first dialysis modality, but more likely to have pre-transition nephrology care or have an arteriovenous (AV) fistula as their initial access type.

Approximately 19% of all male USRDS patients that transitioned to ESRD between 10/1/2007 and 3/31/2015 were U.S. veterans (Table 9.2). Among the male patients transitioning to ESRD, the TC-CKD veterans were still more likely to be older, non-Hispanic White and reported higher percentages of cardiovascular and pulmonary comorbidities at transition. However, among males, there was a slight difference in percentage of Blacks but no difference in percentage of reported tobacco use.

Conversely, U.S. female veterans comprised less than 2% of the USRDS females transitioning to ESRD between 10/1/2007 and 3/31/2015 (Table 9.3). The TC-CKD U.S. veteran females had similar characteristics to those of the entire population of female patients transitioning to ESRD, with the exception that they were more likely to be Black. They were also slightly older, and more likely to have certain cardiovascular comorbidities. They were equally likely to report tobacco use and have peritoneal dialysis as their first dialysis modality, but were more likely to have pre-transition nephrology care or AV fistula as their initial access type.

Across the incidence years of transition to ESRD, TC-CKD U.S. veteran females were increasingly more likely to be Black, had fewer cardiovascular comorbidities at transition, with the exception of cerebrovascular disease and other cardiac disease, and were increasingly more likely to report having had nephrology care prior to transition or an AV fistula as the primary access type (Table 9.4).

vol 1 Table 9.1 Baseline characteristics of 102,477 incident ESRD veterans compared to all 872,816 USRDS patients who transitioned to ESRD between 10/1/2007 and 3/31/2015 (For gender decomposed components, see Tables 9.2 and 9.3)

Variables	TC-CKD Total Veteran Cohort	USRDS Total Cohort
N	102,477	872,816
Age (mean±SD, years)	70.2±12.0	62.9±15.1
Female (%)	7	43
Race (%)		
White	73	67
Black	24	27
Asian	2	5
Native American	0.83	0.93
Other	0.19	0.26
Unknown	0.10	0.38
Ethnicity (%)		
Hispanic	7	15
Non-Hispanic	3	5
Unknown	1.06	1.90
Non-Hispanic White	66	52
Non-Hispanic Black	24	26
Access type (%)		
AV fistula	20	15
AV graft	3	3
Central venous catheter	77	81
Other	0.52	0.45
Comorbidity (%)		
Atherosclerotic heart disease	26	18
Congestive heart failure	36	31
Peripheral vascular disease	16	12
Cerebrovascular disease	10	9
Other cardiac disease	23	18
Chronic obstructive pulmonary disease	13	9
Tobacco use (current smoker)	7	6
Drug dependence	1.25	1.24
Alcohol dependence	2.02	1.61
Diabetes‡	54	55
Malignant neoplasm, cancer	11	7
Inability to ambulate	7	7
Inability to transfer	4	4
Amputation	3	3
Institutionalized	9	8
Institutionalized (assisted living)	0.82	0.64
Institutionalized (nursing home)	8	7
Institutionalized (other)	0.67	0.57
Needs assistance with daily activities	13	13
Non-renal congenital abnormality	0.11	0.24
Toxic nephropathy	0.45	0.42
Body mass index (kg/m^2)	28.5±6.9	29.5±8.0
Estimated GFR (mL/min/1.73m^2)	9.5 (6.9, 12.7)	8.9 (6.4, 12.2)
Initial dialysis modality (%)		
Hemodialysis	81	79
Home hemodialysis	0.51	0.54
Peritoneal dialysis	6	8
Uncertain dialysis	11	10
Preemptive transplant	1	2
Nephrologist care (%)		
Yes	64	59

Data source: VHA, CMS, and USRDS ESRD Databases. ‡Diabetes is presence of any of the following: Diabetes, currently on insulin; Diabetes, without medications; Diabetes, on oral medications; Diabetic, retinopathy. Abbreviations: ESRD, end-stage renal disease; AV, arteriovenous; GFR, glomerular filtration rate; kg, kilogram; m, meters; mL, milliliters; min, minute.

vol 1 Table 9.2 Baseline characteristics of 95,559 male incident ESRD veterans compared to all 499,643 USRDS males who transitioned to ESRD between 10/1/2007 and 3/31/2015

Variables	TC-CKD Veteran Male Cohort	USRDS Male Cohort
N	95,559	499,643
Age (mean±SD, years)	70.6±11.8	62.5±15.0
Race (%)		
White	74	69
Black	24	25
Asian	2	4
Native American	0.73	0.83
Other	0.18	0.26
Unknown	0.09	0.40
Ethnicity (%)		
Hispanic	7	15
Non-Hispanic	2	5
Unknown	1.04	1.87
Non-Hispanic White	67	54
Non-Hispanic Black	23	24
Access type (%)		
AV fistula	20	17
AV graft	2	2
Central venous catheter	77	80
Other	0.52	0.44
Comorbidity (%)		
Atherosclerotic heart disease	26	20
Congestive heart failure	36	30
Peripheral vascular disease	16	13
Cerebrovascular disease	11	9
Other cardiac disease	24	19
Chronic obstructive pulmonary disease	13	9
Tobacco use (current smoker)	7	7
Drug dependence	1.28	1.54
Alcohol dependence	2	2
Diabetes‡	54	54
Malignant neoplasm, cancer	11	8
Inability to ambulate	7	6
Inability to transfer	4	3
Amputation	3	4
Institutionalized	9	7
Institutionalized (assisted living)	0.82	0.56
Institutionalized (nursing home)	8	6
Institutionalized (other)	0.68	0.61
Needs assistance with daily activities	13	11
Non-renal congenital abnormality	0.10	0.24
Toxic nephropathy	0.45	0.43
Body mass index (kg/m^2)	28.4±6.8	28.8±7.3
Estimated GFR (mL/min/1.73m^2)	9.6 (7.0, 12.8)	9.2 (6.6, 12.6)
Initial dialysis modality (%)		
Hemodialysis	81	79
Home hemodialysis	0.52	0.57
Peritoneal dialysis	6	8
Uncertain dialysis	11	10
Preemptive transplant	1	2
Nephrologist care (%)		
Yes	64	59

Data source: VHA, CMS, and USRDS ESRD Databases. ‡Diabetes is presence of any of the following: Diabetes, currently on insulin; Diabetes, without medications; Diabetes, on oral medications; Diabetic, retinopathy. Abbreviations: ESRD, end-stage renal disease; AV, arteriovenous; GFR, glomerular filtration rate; kg, kilogram; m, meters; mL, milliliters; min, minute.

vol 1 Table 9.3 Baseline characteristics of 6,918 female incident ESRD veterans compared to all 373,143 USRDS females who transitioned to ESRD between 10/1/2007 and 3/31/2015 (For decomposition of female incident ESRD veterans across incident years, see Table 9.4)

Variables	TC-CKD Veteran Female Cohort	USRDS Female Cohort
N	6,918	373,143
Age (mean±SD, years)	64.9±13.5	63.5±15.1
Race (%)		
White	60	64
Black	33	30
Asian	4	5
Native American	2.08	1.05
Other	0.32	0.27
Unknown	0.19	0.37
Ethnicity (%)		
Hispanic	9	14
Non-Hispanic	6	6
Unknown	1.24	1.94
Non-Hispanic White	50	49
Non-Hispanic Black	33	29
Access type (%)		
AV fistula	15	13
AV graft	4	4
Central venous catheter	80	82
Other	0.40	0.45
Comorbidity (%)		
Atherosclerotic heart disease	17	17
Congestive heart failure	31	31
Peripheral vascular disease	12	11
Cerebrovascular disease	10	9
Other cardiac disease	18	17
Chronic obstructive pulmonary disease	10	9
Tobacco use (current smoker)	5	5
Drug dependence	0.86	0.85
Alcohol dependence	0.79	0.79
Diabetes‡	57	57
Malignant neoplasm, cancer	7	6
Inability to ambulate	8	8
Inability to transfer	4	4
Amputation	2	2
Institutionalized	10	10
Institutionalized (assisted living)	0.76	0.75
Institutionalized (nursing home)	8	8
Institutionalized (other)	0.46	0.51
Needs assistance with daily activities	14	14
Non-renal congenital abnormality	0.24	0.25
Toxic nephropathy	0.51	0.41
Body mass index (kg/m^2)	30.2±8.5	30.3±8.8
Estimated GFR (mL/min/1.73m^2)	8.6 (6.2, 11.6)	8.6 (6.1, 11.7)
Initial dialysis modality (%)		
Hemodialysis	79	80
Home hemodialysis	0.48	0.51
Peritoneal dialysis	8	8
Uncertain dialysis	10	10
Preemptive transplant	2	2
Nephrologist care (%)		
Yes	63	60

Data source: VHA, CMS, and USRDS ESRD Databases. ‡Diabetes is presence of any of the following: Diabetes, currently on insulin; Diabetes, without medications; Diabetes, on oral medications; Diabetic, retinopathy. Abbreviations: ESRD, end-stage renal disease; AV, arteriovenous; GFR, glomerular filtration rate; kg, kilogram; m, meters; mL, milliliters; min, minute.

vol 1 Table 9.4 Baseline characteristics of 6,918 female incident ESRD veterans who transitioned to ESRD between 10/1/2007 and 3/31/2015 according to incidence year at transition to ESRD

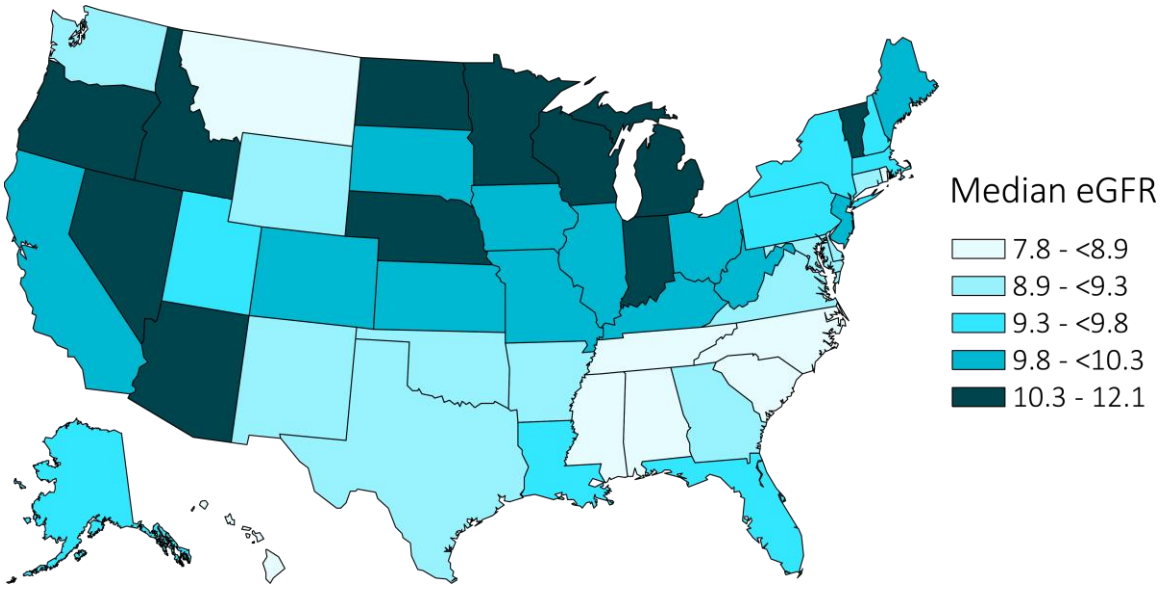
		Incidence Year								
Variables	**Total**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
N (%)	6,918	205 (3)	858 (12)	955 (14)	899 (13)	914 (13)	894 (13)	979 (14)	939 (14)	275 (4)
Age (mean±SD, years)	64.9±13.5	63.5±13.9	65.6±13.4	64.4±14.0	65.0±14.3	64.8±14.2	65.1±12.6	64.8±13.1	64.4±13.2	66.1±12.9
Race (%)										
White	60	61	60	59	62	61	58	61	57	59
Black	33	32	32	34	31	33	34	33	35	35
Asian	4	6	4	4	4	4	5	4	5	5
Native American	2.08	0.98	2.56	2.62	2.00	2.52	1.90	1.53	1.92	1.45
Other	0.32	0	0.35	0.21	0.33	0.11	0.34	0.10	0.85	0.36
Unknown	0.19	0	0.12	0.10	0.44	0	0.56	0	0.21	0
Ethnicity (%)										
Hispanic	9	10	8	11	10	9	9	11	9	7
Non-Hispanic	6	7	7	6	6	6	6	6	7	6
Unknown	1.24	0.49	1.75	1.68	1.89	1.20	1.57	0.41	0.85	0
Non-Hispanic White	50	52	51	48	52	53	50	50	49	53
Non-Hispanic Black	33	31	32	34	30	32	33	33	35	35
Access type (%)										
AV fistula	15	11	13	14	14	14	16	16	19	15
AV graft	4	3	3	5	4	6	5	4	5	3
Central venous catheter	80	84	82	80	82	80	79	79	76	82
Other	0.40	1.08	0.77	0.83	0.13	0.37	0.38	0.12	0	0.43
Comorbidity (%)										
Atherosclerotic heart disease	17	18	19	18	19	18	17	15	15	15
Congestive heart failure	31	35	32	32	32	31	32	29	29	31
Peripheral vascular disease	12	9	12	13	14	11	12	10	10	7
Cerebrovascular disease	10	8	11	11	10	10	10	10	9	10
Other cardiac disease	18	16	15	18	18	16	20	19	17	18
Chronic obstructive pulmonary disease	10	8	9	10	9	12	11	11	10	10
Tobacco use (current smoker)	5	4	5	5	5	6	5	5	7	2
Drug dependence	0.86	0.49	0.71	0.64	1.25	0.89	0.70	1.28	0.56	1.15
Alcohol dependence	0.79	0.98	0.83	0.53	0.68	0.78	0.93	1.17	0.79	0
Diabetes[‡]	57	51	58	56	57	52	57	61	60	57
Malignant neoplasm, cancer	7	5	5	7	9	7	7	7	8	9
Inability to ambulate	8	6	9	7	7	6	7	9	10	8
Inability to transfer	4	1	5	4	3	4	4	5	4	5
Amputation	2	2	2	2	2	3	2	2	2	2
Institutionalized	10	6	10	8	8	10	10	10	11	11
Institutionalized (assisted living)	0.76	0.49	0.95	0.32	0.91	0.78	0.81	0.64	0.90	1.15
Institutionalized (nursing home)	8	5	9	7	7	9	9	9	10	10
Institutionalized (other)	0.46	0.49	0.47	0.75	0.57	0.44	0.46	0.11	0.45	0.38
Needs assistance with daily activities	14	10	14	12	12	13	14	15	15	15
Non-renal congenital abnormality	0.24	0	0.24	0.43	0.23	0.33	0.23	0.11	0.11	0.38
Toxic nephropathy	0.51	0	0.36	0.96	0.91	0.67	0.23	0.53	0.11	0
Body mass index (kg/m^2)	30.2±8.5	29.0±8.1	30.0±8.5	30.1±8.7	30.1±8.5	30.1±8.5	30.2±8.2	30.5±8.5	30.5±8.5	30.2±7.8
Estimated GFR (mL/min/1.73m^2)	8.6 (6.2, 11.6)	9.0 (6.3, 11.6)	8.9 (6.2, 11.8)	8.6 (6.3, 11.8)	8.9 (6.5, 12.4)	8.5 (6.4, 11.7)	8.3 (6.2, 11.4)	8.5 (6.1, 11.8)	8.4 (5.9, 11.0)	8.7 (6.3, 11.3)
Initial dialysis modality (%)										
Hemodialysis	79	78	80	81	78	79	80	78	78	81
Home hemodialysis	0.48	0.98	0.47	0.42	0.11	0.55	0.67	0.51	0.21	1.45
Peritoneal dialysis	8	7	7	9	9	7	8	9	9	7
Uncertain dialysis	10	11	10	8	10	10	10	10	11	7
Preemptive transplant	2	4	2	2	2	3	2	2	2	3
Nephrologist care (%)										
Yes	63	58	62	61	63	63	63	63	66	71

Data source: VHA, CMS, and USRDS ESRD Databases. [‡]Diabetes is presence of any of the following: Diabetes, currently on insulin; Diabetes, without medications; Diabetes, on oral medications; Diabetic, retinopathy. Abbreviations: ESRD, end-stage renal disease; AV, arteriovenous; GFR, glomerular filtration rate; kg, kilogram; m, meters; mL, milliliters; min, minute.

ESTIMATED GLOMERULAR FILTRATION RATE PROFILE BETWEEN 10/1/2007 AND 3/31/2015

Of 102,477 veterans transitioning to ESRD, there were 99,614 patients with data on eGFR at the time of transition (within 45 days) as reported by the CMS 2728 form. Overall, the median eGFR in these patients was 9.5 mL/min/1.73m² (Table 9.1). We examined the median eGFR per state for TC-CKD veteran patients and found the highest median eGFRs at transition in North Dakota (12.1 mL/min/1.73m²), Idaho (11.1 mL/min/1.73m²), and Arizona (10.7 mL/min/1.73m²) (Figure 9.1). Nebraska, Oregon, Vermont and Nevada, as well as Midwestern states Minnesota, Wisconsin, Michigan, and Indiana were also in the highest quintile of eGFR at transition. The lowest median eGFRs at transition were in South Carolina (7.8 mL/min/1.73m²), the District of Columbia (8.0 mL/min/1.73m²), and Alabama (8.2 mL/min/1.73m²). Hawaii, Rhode Island, Montana, and the Southern states of Tennessee, Mississippi, and North Carolina were also in the lowest quintile of eGFR at transition to ESRD.

vol 1 Figure 9.1 Median estimated glomerular filtration rate (eGFR) at transition among 99,614 incident ESRD veterans across the United States, 10/1/2007-3/31/2015 (For gender decomposed components, see Figures 9.2 and 9.3) (For decomposition according to cause of ESRD, see Figures 9.4 and 9.5)

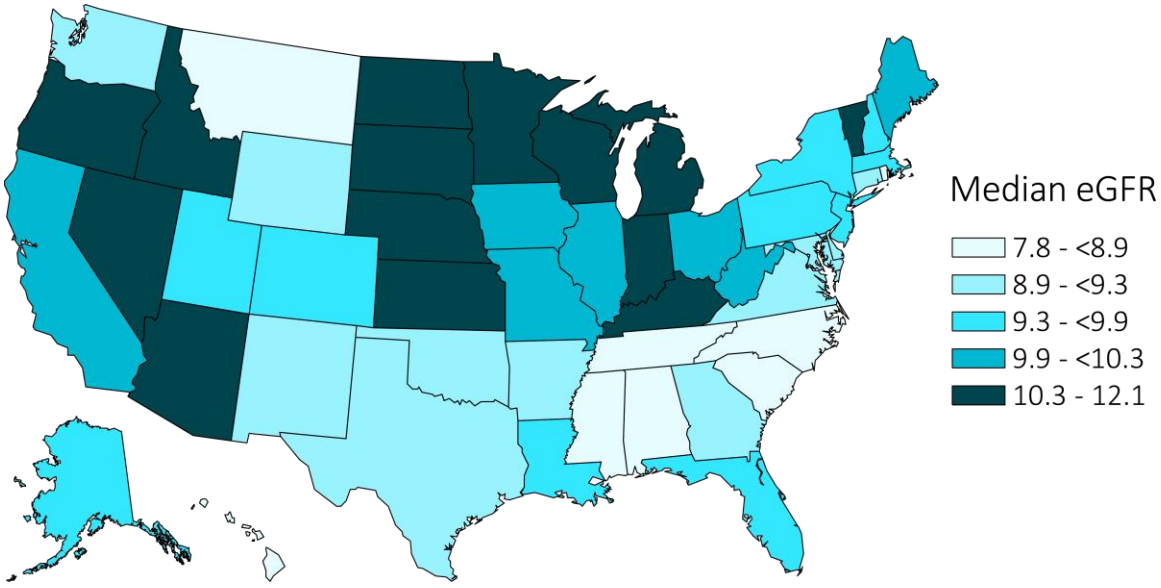


Data source: USRDS ESRD Database. Abbreviations: ESRD, end-stage renal disease; eGFR, estimated glomerular filtration rate.

The median eGFR in 92,894 male veterans who transitioned to ESRD between 10/1/2007 and 3/31/2015 was 9.6 mL/min/1.73m² (as shown in Table 9.2) and in 6,720 female veterans was 8.6 mL/min/1.73m². We created quintiles of eGFR for males and females separately. In both males and females, the highest median eGFRs per state were found in North Dakota (12.1 mL/min/1.73m² for males and 12.7 mL/min/1.73m² for females), and Idaho (11.1 mL/min/1.73m² for males and 11.7 mL/min/1.73m² for females) (Figure 9.2 and Figure 9.3, respectively). Michigan, Arizona, Minnesota, Oregon, Vermont, and Wisconsin were also in the highest eGFR quintiles for both male and female veterans. Indiana, South Dakota, Nebraska, Nevada, Kentucky, and Kansas were in the highest eGFR quintile for males, and Alaska, Iowa, and Maine were other states in the highest eGFR quintile for females. For males, South Carolina (7.8 mL/min/1.73m²), District of Columbia (8.0 mL/min/1.73m²), and Alabama (8.3 mL/min/1.73m²) had the lowest eGFRs at transition, and for females, Rhode Island (6.6 mL/min/1.73m²), South Carolina (6.7 mL/min/1.73m²), and Alabama (7.4

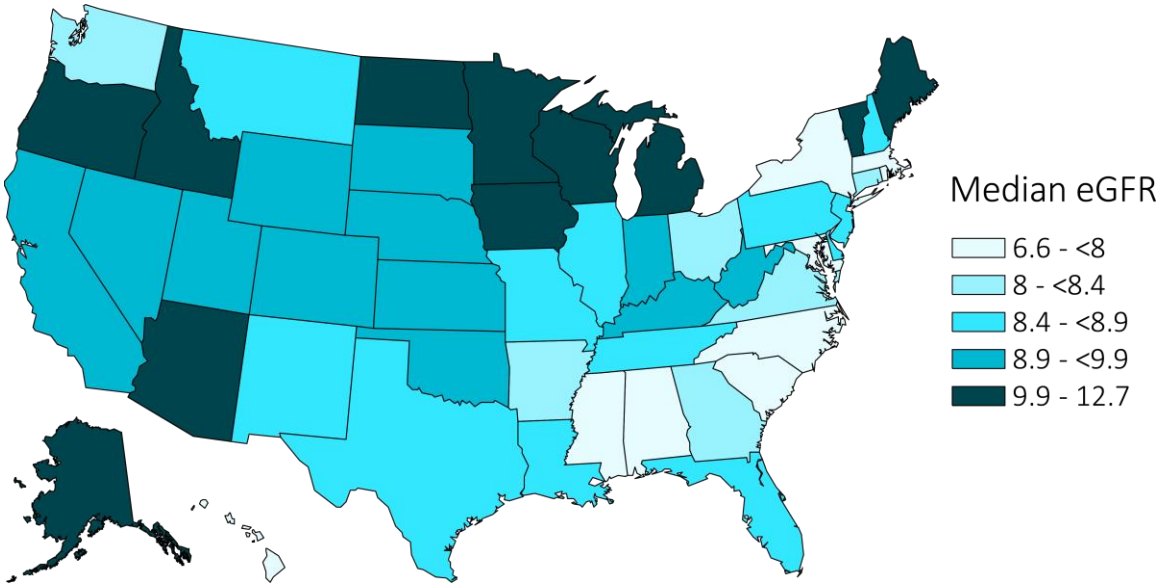
mL/min/1.73m²) had the lowest. For both males and females, lower eGFRs at transition were also present in North Carolina, Hawaii, and Mississippi. Additionally males had lower eGFRs in Rhode Island, Tennessee, and Montana, while females also had lower eGFRs at transition in District of Columbia, New York, Massachusetts, and Maryland.

vol 1 Figure 9.2 Median estimated glomerular filtration rate (eGFR) at transition among 92,894 male incident ESRD veterans across the United States, 10/1/2007-3/31/2015



Data source: USRDS ESRD Database. Abbreviations: ESRD, end-stage renal disease; eGFR, estimated glomerular filtration rate.

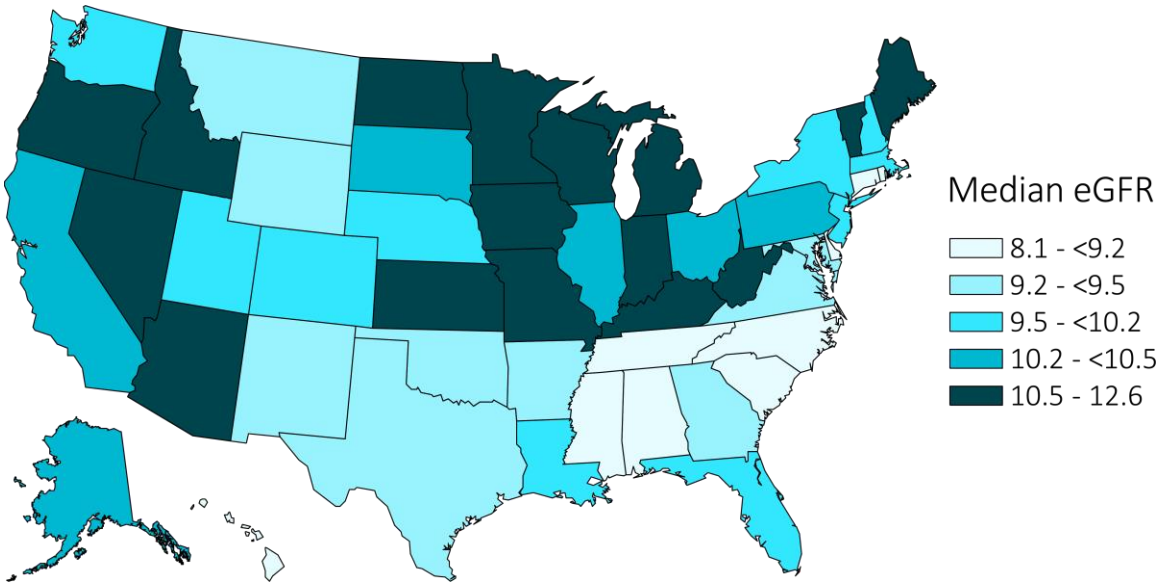
vol 1 Figure 9.3 Median estimated glomerular filtration rate (eGFR) at transition among 6,720 female incident ESRD veterans across the United States, 10/1/2007-3/31/2015



Data source: USRDS ESRD Database. Abbreviations: ESRD, end-stage renal disease; eGFR, estimated glomerular filtration rate.

For 43,062 veteran patients with diabetes as the primary cause of ESRD and an available eGFR measurement at transition, the median eGFR was 9.8 mL/min/1.73m^2. Vermont (12.6 mL/min/1.73m^2), North Dakota (12.5 mL/min/1.73m^2), and Idaho (12.0 mL/min/1.73m^2) had the highest eGFR at transition for veterans with diabetes listed as the primary cause of ESRD, while South Carolina (8.1 mL/min/1.73m^2), District of Columbia (8.3 mL/min/1.73m^2), and Alabama (8.4 mL/min/1.73m^2) had the lowest (Figure 9.4). Other states in the same Southern region (Tennessee, North Carolina, and Mississippi) as well as Hawaii, Delaware, Connecticut and Rhode Island also had veterans with diabetes as primary cause of ESRD with low eGFRs at transition. Other states with higher eGFRs at transition in veterans with diabetes as the primary cause of ESRD included Western states: Arizona, Oregon, and Nevada, and Midwestern states: Kansas, Michigan, Missouri, Minnesota, Iowa, Wisconsin, Indiana, as well as West Virginia, Kentucky and Maine.

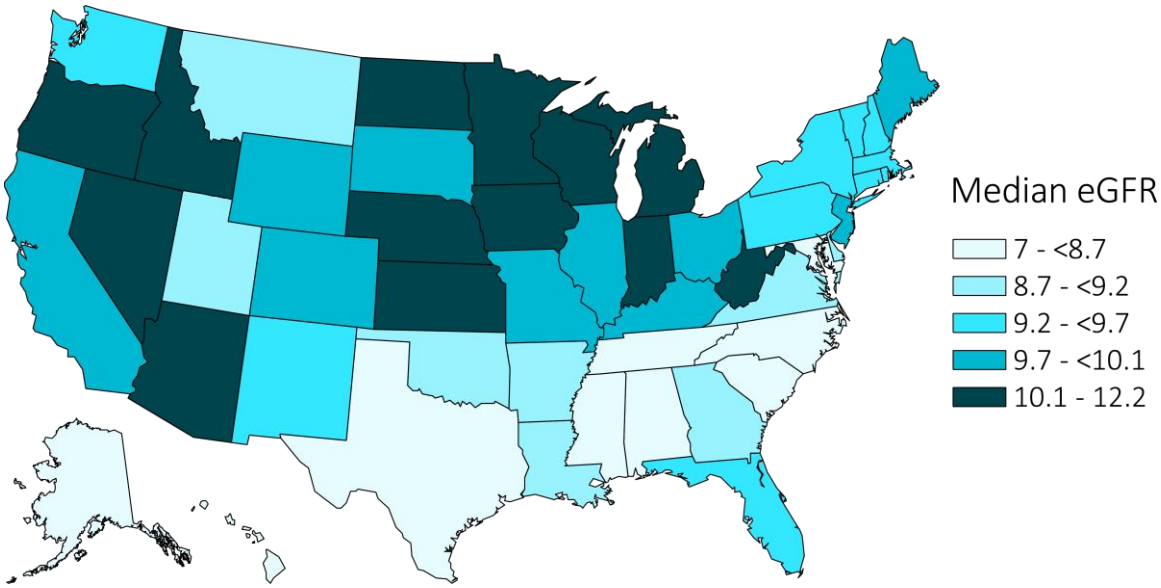
vol 1 Figure 9.4 Median estimated glomerular filtration rate (eGFR) at transition among 43,062 incident ESRD veterans with diabetes as the primary cause of ESRD across the United States, 10/1/2007-3/31/2015



Data source: USRDS ESRD Database. Abbreviations: ESRD, end-stage renal disease; eGFR, estimated glomerular filtration rate.

For 32,273 veteran patients with hypertension as the primary cause of ESRD and an available eGFR, the median was 9.3 mL/min/1.73m^2. North Dakota (12.2 mL/min/1.73m^2), Idaho (11.6 mL/min/1.73m^2), and Arizona (10.8 mL/min/1.73m^2) had the highest eGFRs at transition for these patients, while Alaska (7.0 mL/min/1.73m^2), South Carolina (7.3 mL/min/1.73m^2), and the District of Columbia (7.9 mL/min/1.73m^2) had the lowest (Figure 9.5). Similar to patients with diabetes as the primary cause of ESRD, for veterans with hypertension as the primary cause of ESRD, Midwestern states: Iowa, Indiana, Wisconsin, Minnesota, and Michigan as well as Kansas and Nevada had the higher median eGFRs at transition, and Southern States (North Carolina, Alabama, Mississippi, and Tennessee) as well as Hawaii, had the lower median eGFRs. For veteran patients with hypertension as the primary cause of ESRD, Texas and Maryland, additionally, had lower eGFRs at transition while Nebraska, Oregon, and West Virginia had higher eGFRs.

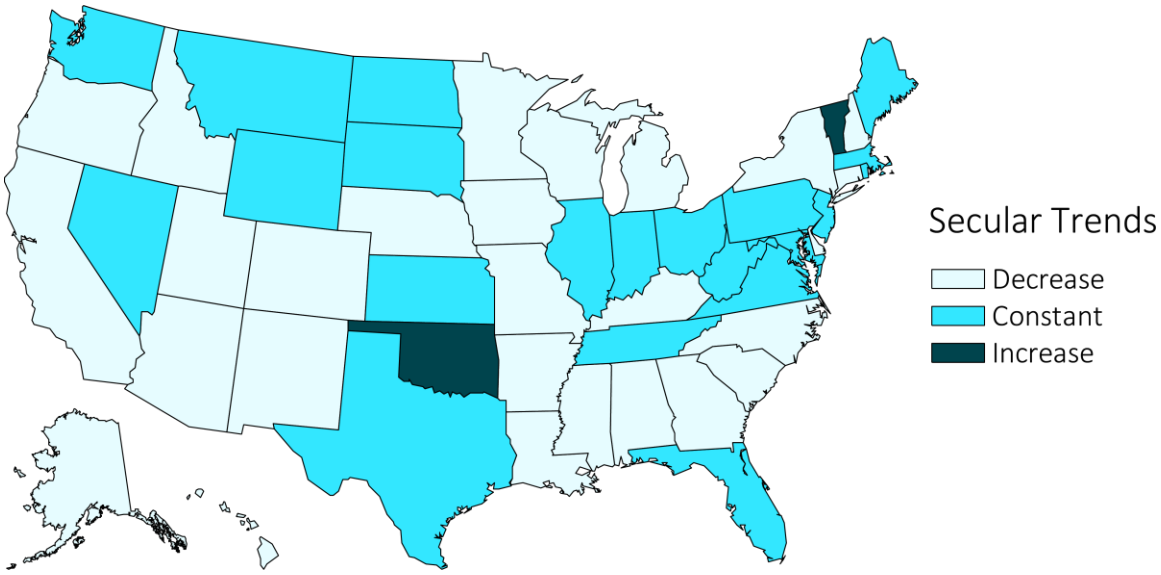
vol 1 Figure 9.5 Median estimated glomerular filtration rate (eGFR) at transition among 32,273 incident ESRD veterans with hypertension as the primary cause of ESRD across the United States, 10/1/2007-3/31/2015



Data source: USRDS ESRD Database. Abbreviations: ESRD, end-stage renal disease; eGFR, estimated glomerular filtration rate.

Over the 7.5 year period between 10/1/2007 and 3/31/2015, median eGFRs at transition decreased or remained the same for most states, while median eGFRs at transition increased for Oklahoma and Vermont (Figure 9.6).

vol 1 Figure 9.6 Distribution of secular trends of median estimated glomerular filtration rates (eGFR) between 10/1/2007-3/31/2015 among 99,614 incident ESRD veterans across the United States

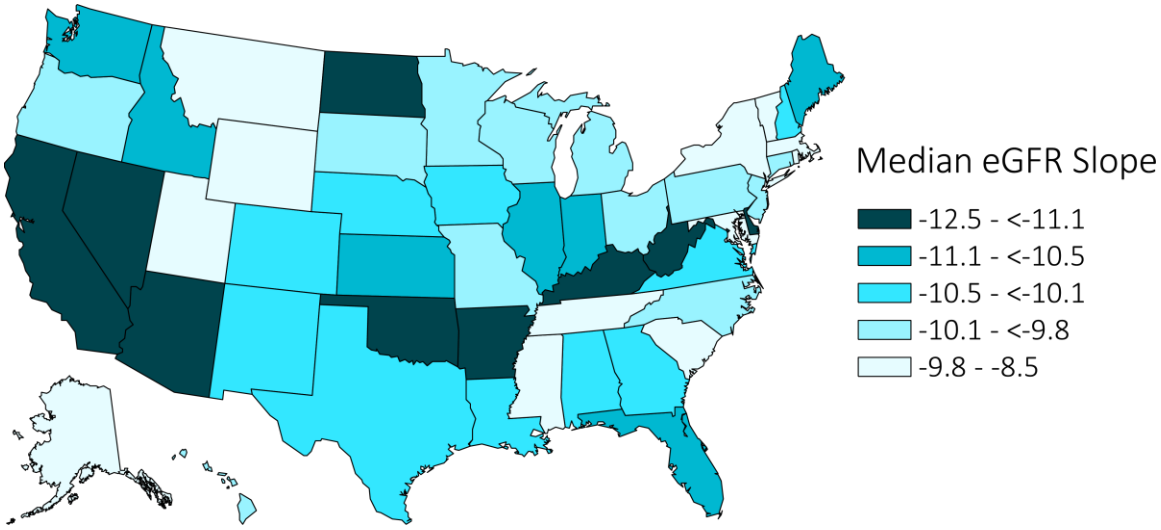


Data source: USRDS ESRD Database. Decrease: ≤-0.01; Constant: <-0.01 to ≤0.01; Increase: >0.01 (mL/min/1.73m² per year). Abbreviation: ESRD, end-stage renal disease.

KIDNEY DISEASE PROGRESSION ACCORDING TO SLOPE OF ESTIMATED GLOMERULAR FILTRATION RATE PROFILE BETWEEN 10/1/2007 AND 3/31/2015

Of 102,477 veterans transitioning to ESRD, we were able to create a profile of kidney disease progression in the year prior to transition by estimating the slope of eGFR in the last year prior to ESRD in 29,277 veterans who had at least two quarterly averaged eGFR measurements within one year prior to ESRD transition. Overall, the median slope of eGFR in the year prior to transition to ESRD was -10.4 mL/min/1.73m²/year. We also examined the median prelude (pre-ESRD) eGFR slope per state for TC-CKD veteran patients and found that the states with the steepest prelude slopes (rapid kidney disease progression) were North Dakota (-12.5 mL/min/1.73m²/year), Arizona (-12.0 mL/min/1.73m²/year), and the District of Columbia (-11.6 mL/min/1.73m²/year), while more gradual prelude slopes were found in Mississippi (-9.0 mL/min/1.73m²/year), Vermont (-8.9 mL/min/1.73m²/year) and Rhode Island (-8.5 mL/min/1.73m²/year) (Figure 9.7).

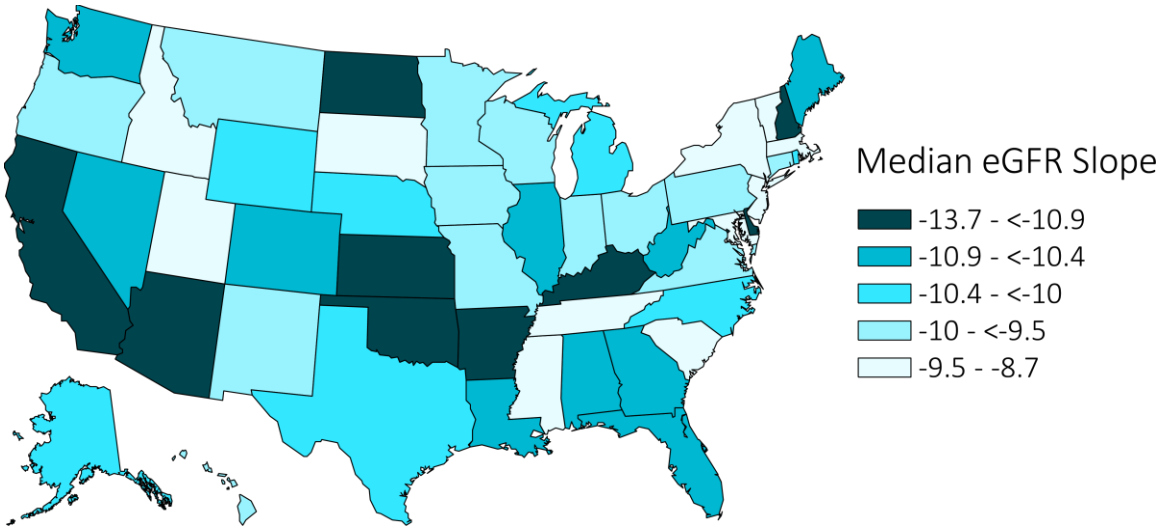
vol 1 Figure 9.7 Median estimated glomerular filtration rate (eGFR) slope in the one-year prelude (prior to transition) among 29,277 incident ESRD veterans across the United States, 10/1/2007-3/31/2015 (For decomposition according to cause of ESRD, see Figures 9.8 and 9.9)



Data source: VHA and USRDS ESRD Databases. Abbreviations: ESRD, end-stage renal disease; eGFR, estimated glomerular filtration rate.

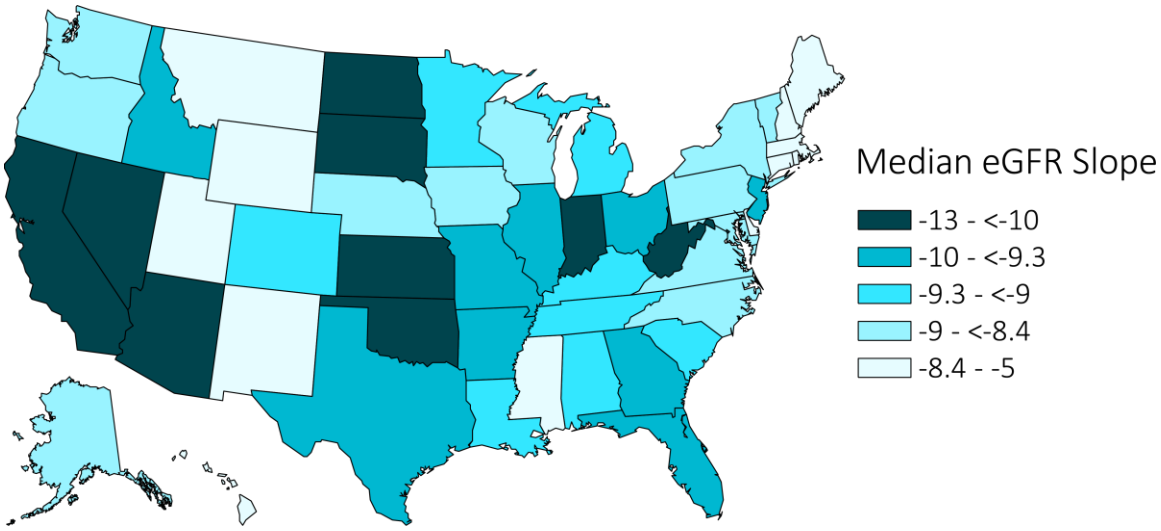
In 14,349 veterans with diabetes as the primary cause of ESRD and with an available prelude slope of eGFR in the last year prior to ESRD (Figure 9.8), the median pre-ESRD slope was -10.2 mL/min/1.73m²/year, and states with the steepest median pre-ESRD slopes were North Dakota (-13.7 mL/min/1.73m²/year), District of Columbia (-11.9 mL/min/1.73m²/year), and Arizona (-11.8 mL/min/1.73m²/year), while New Jersey (-9.1 mL/min/1.73m²/year), Vermont (-8.9 mL/min/1.73m²/year), and Tennessee (-8.7 mL/min/1.73m²/year) had the gentlest. California, Oklahoma, Kansas, Arkansas, Kentucky, Delaware, and New Hampshire were also among the states with steeper slopes prior to ESRD transition in veterans with diabetes as the cause of ESRD, while Idaho, South Dakota, Mississippi, South Carolina, Maryland, Massachusetts, and New York had gentler median eGFR slopes. However, for 7,845 veterans where hypertension was the primary cause of ESRD, the median pre-ESRD slope was -9.4 mL/min/1.73m²/year (Figure 9.9) and the states with the steepest slopes were Kansas (-13.0 mL/min/1.73m²/year), Nevada (-11.8 mL/min/1.73m²/year), and North Dakota (-12.1 mL/min/1.73m²/year), while the states with the gentlest slopes were Wyoming (-5.0 mL/min/1.73m²/year), Rhode Island (-7.1 mL/min/1.73m²/year), and New Hampshire (-6.3 mL/min/1.73m²/year).

vol 1 Figure 9.8 Median estimated glomerular filtration rate (eGFR) slope in the one-year prelude (prior to transition) among 14,349 incident ESRD veterans with diabetes as the cause of ESRD across the United States, 10/1/2007-3/31/2015



Data source: VHA and USRDS ESRD Databases. Abbreviations: ESRD, end-stage renal disease; eGFR, estimated glomerular filtration rate.

vol 1 Figure 9.9 Median pre-ESRD estimated glomerular filtration rate (eGFR) slope in the one-year prelude (prior to transition) among 7,845 incident ESRD veterans with hypertension as the cause of ESRD across the United States, 10/1/2007-3/31/2015

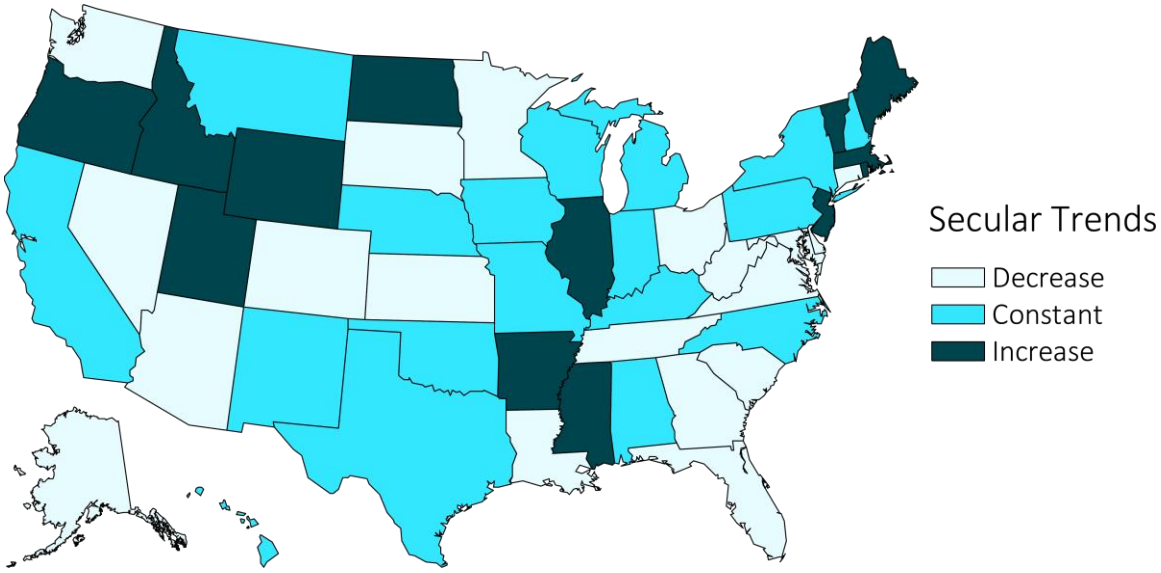


Data source: VHA and USRDS ESRD Databases. Abbreviations: ESRD, end-stage renal disease; eGFR, estimated glomerular filtration rate.

SECULAR TRENDS IN PRIMARY CAUSE OF ESRD AND SECULAR AND SEASONAL TRENDS OF TRANSPLANTS OVER 7.5 YEARS IN THE INCIDENT ESRD VETERAN POPULATION BETWEEN 10/1/2007 AND 3/31/2015

In the 2017 ADR chapter, we reported that the distribution of veteran patients with ESRD primarily due to diabetes between 10/1/2007- 3/31/2015 varied. Primarily, Southwestern states, such as Texas, New Mexico, Arizona, and Oklahoma, as well as California had a higher proportion of veterans with ESRD due to diabetes. In this year's chapter, we show that these higher proportions have remained constant over 7.5 years in Texas, New Mexico, Oklahoma, and California (Figure 9.10), while the proportions of ESRD primarily due to diabetes have actually decreased over the years in Alaska, Arizona, Nevada, Colorado, and Kansas. Proportions of ESRD primarily due to diabetes in veterans have also declined over time in the South and Southeast United States, including Georgia, Louisiana, Florida, Tennessee, and South Carolina, while states in the Northwest such as Oregon, Idaho, Utah, and Wyoming have had an increase in the proportion of veterans transitioning to ESRD primarily due to diabetes.

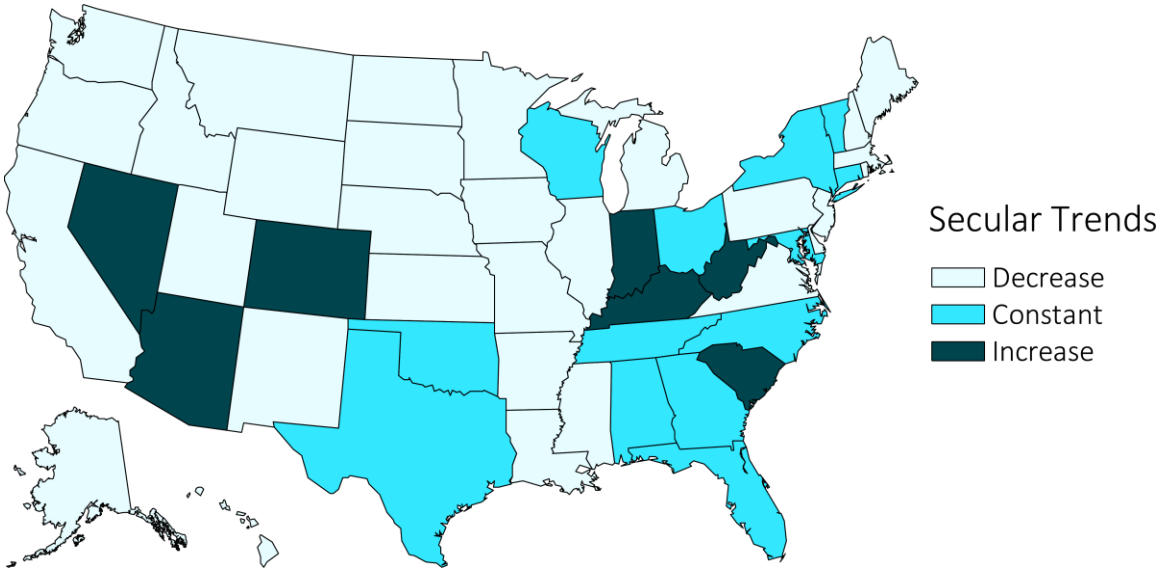
vol 1 Figure 9.10 Distribution of secular trends of diabetes (%) as the primary cause of ESRD between 10/1/2007-3/31/2015 among 102,477 incident ESRD veterans across the United States



Data source: USRDS ESRD Database. Decrease: ≤-0.01; Constant: <-0.01 to ≤0.01; Increase: >0.01 (% per year). Abbreviation: ESRD, end-stage renal disease.

Conversely, the proportions of veterans transitioning to ESRD primarily due to hypertension have increased between 10/1/2007 and 3/31/2015 in Nevada, Arizona, Colorado, Indiana, Kentucky, West Virginia, and South Carolina, and remained constant in Texas, Oklahoma, and the Southeastern states of Florida, Alabama, Georgia, Tennessee, and North Carolina (Figure 9.11).

vol 1 Figure 9.11 Distribution of secular trends of hypertension (%) as the primary cause of ESRD among 102,477 incident ESRD veterans across the United States, 10/1/2007-3/31/2015



Data source: USRDS ESRD Database. Decrease: ≤-0.01; Constant: <-0.01 to ≤0.01; Increase: >0.01 (% per year). Abbreviation: ESRD, end-stage renal disease.

Across the entire nation, 5,491 out of 102,477 veterans received a transplant between 10/1/2007 and 9/1/2015, including 1,355 preemptive transplantations. As in the general ESRD population, preemptive transplantation is fairly rare (Table 9.1) and even more rare in the veteran population. In Table 9.5, we show the characteristics of 5,169 patients who received a kidney transplant at or within 5 years after transition to ESRD according to the timing of kidney transplantation. Compared to the overall TC-CKD veteran cohort, veteran patients who received a transplant were younger, more likely to be female, White, and be on peritoneal dialysis prior to receiving a kidney transplant, if the transplant was not preemptive. Among the group of veteran patients who received a kidney transplant within Days 1-30 after ESRD transition, the proportion of females was lower than in other time periods, whereas the percentage of non-White veterans receiving a kidney transplant was higher from Day 365 to 5 years after ESRD transition.

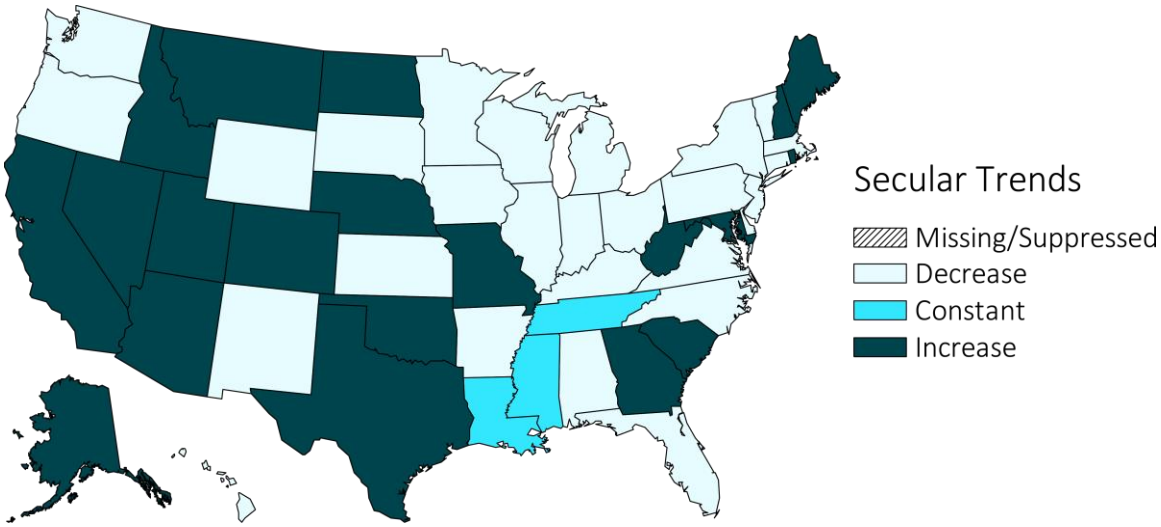
vol 1 Table 9.5 Baseline characteristics of 5,169 incident ESRD veterans who received a kidney transplant at or after ESRD transition between 10/1/2007 and 9/1/2015, according to timing of kidney transplant

	Timing of Renal Transplant in Relation to Transition to ESRD					
	Preemptive	**Day 1-30**	**Day 30-60**	**Day 60-90**	**Day 90-365**	**Day 365-5 years**
N	1,355	48	69	68	867	2,762
Age (mean±SD, years)	59.7±11.2	59.8±11.6	57.4±11.8	58.6±12.4	57.6±12.0	58.0±10.6
Female (%)	11	6	10	9	11	9
Race (%)						
White	79	83	78	84	77	64
Black	17	15	19	16	19	32
Asian	3	0	3	0	3	3
Native American	0.44	0	0	0	0.81	0.94
Other	1	2	0	0	0	0
Unknown	0	0	0	0	0	0
Ethnicity (%)						
Hispanic	7	4	4	4	8	9
Non-Hispanic	3	2	3	0	3	4
Unknown	8	0	0	0	1	0
Non-Hispanic White	68	79	74	79	69	55
Non-Hispanic Black	15	15	19	16	19	31
Access type (%)						
AV fistula	14	36	19	38	37	37
AV graft	0	4	2	2	4	3
Central venous catheter	71	54	77	60	59	59
Other	14	7	2	0	0	1
Comorbidity (%)						
Atherosclerotic heart disease	6	7	4	16	12	12
Congestive heart failure	4	18	6	6	11	13
Peripheral vascular disease	3	2	7	3	6	6
Cerebrovascular disease	2	2	6	3	4	4
Other cardiac disease	10	2	19	6	10	11
Chronic obstructive pulmonary disease	2	4	0	0	3	3
Tobacco use (current smoker)	1	2	3	6	4	4
Drug dependence	0.09	0.00	1.45	0.00	0.47	0.84
Alcohol dependence	2.33	6.67	1.45	1.49	1.29	0.91
Diabetes‡	30	27	39	36	42	46
Malignant neoplasm, cancer	5	4	3	6	5	5
Inability to ambulate	1	0	1	0	0	1
Inability to transfer	0	0	1	0	0	0
Amputation	1	0	0	0	1	2
Institutionalized	0	0	1	1	0	0
Institutionalized (assisted living)	0.09	0.00	0.00	0.00	0.00	0.11
Institutionalized (nursing home)	0	0	1	1	0	0
Institutionalized (other)	0.09	0.00	0.00	0.00	0.00	0.15
Needs assistance with daily activities	2	0	1	1	1	2
Non-renal congenital abnormality	1.81	0.00	0.00	0.00	0.23	0.04
Toxic nephropathy	0.35	2.22	0.00	0.00	0.35	0.47
Body mass index (kg/m^2)	28.9±5.8	28.6±4.3	28.1±6.1	28.8±5.4	28.9±5.9	29.4±5.8
Estimated GFR (eGFR) (mL/min/1.73m^2)	12.7 (9.4,17.1)	9.4 (6.4,11.7)	9.0 (6.1,12.0)	8.7 (6.7,9.9)	8.4 (6.2,11.3)	8.2 (6.0,11.0)
Initial dialysis modality (%)						
Hemodialysis	0	0	0	78	74	80
Home hemodialysis	0	0	0	0	1	1
Peritoneal dialysis	0	0	0	22	23	18
Uncertain dialysis	0	100	100	0	2	1
Nephrologist care (%)						
Yes	89	78	87	91	82	79

Data source: VHA, CMS, and USRDS ESRD Databases. ‡Diabetes is presence of any of the following: Diabetes, currently on insulin; Diabetes, without medications; Diabetes, on oral medications; Diabetic, retinopathy. Abbreviations: ESRD, end-stage renal disease AV, arteriovenous; eGFR, estimated glomerular filtration rate; kg, kilogram; m, meters; mL, milliliter; min, minute.

In the 2017 ADR, we showed that the states with the highest preemptive kidney transplant rates among veterans (>2.2%) were Alaska, Colorado, Delaware, Minnesota, Montana, Nebraska, New Mexico, Utah, Vermont, and Wyoming. In evaluating the proportion of 1,319 patients with preemptive transplantation between 10/1/2007-12/31/2014, the proportion of veterans with ESRD per state who received a preemptive transplant has increased in most Southwestern and Western states, while proportions have decreased in the Midwest and Northeast (Figure 9.12).

vol 1 Figure 9.12 Secular trends in the distribution of preemptive kidney transplant rates among 1,319 incident ESRD veterans across the United States between 10/1/2007-12/31/2014



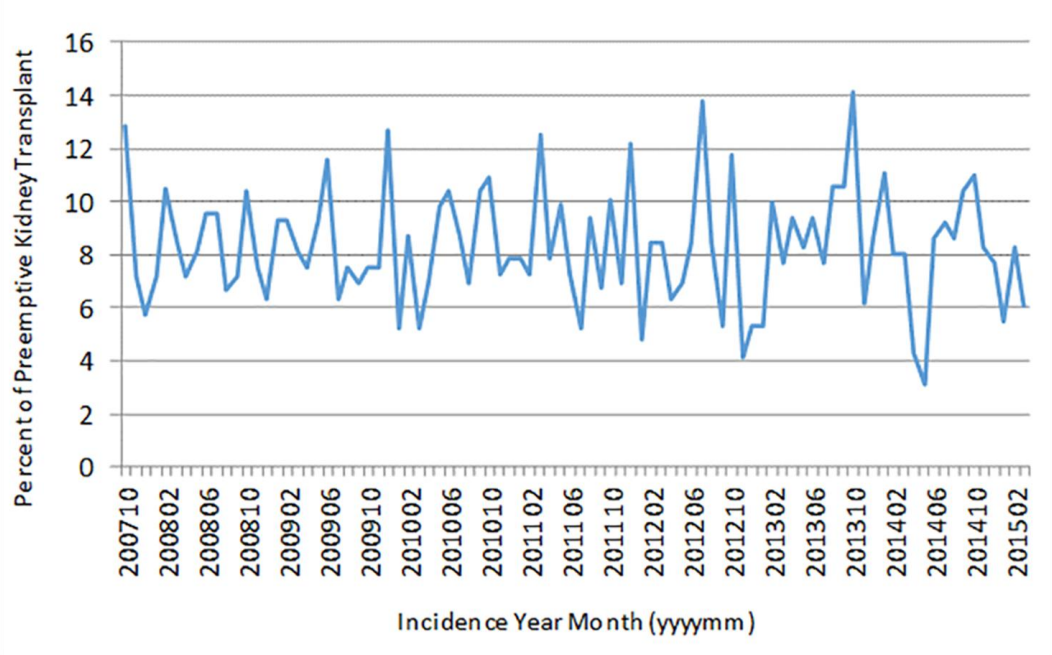
Data source: USRDS ESRD Database. Decrease: ≤-0.01; Constant: <-0.01 to ≤0.01; Increase: >0.01 (% per year). Abbreviation: ESRD, end-stage renal disease.

Between 10/1/2007 and 3/31/2015, 4,136 out of 102,477 U.S. veterans received a transplant after treatment with dialysis, which is a rate of 2 per 100 patient-years. Over 7.5 years, the proportion of veteran patients who received a transplant post-dialysis decreased for all states with the exception of Iowa (map not shown). For both preemptive and post-dialysis kidney transplants, the proportion of veterans receiving a kidney transplant per state decreased for all states, except Maine, which increased due to the higher number of preemptive transplants (data not shown).

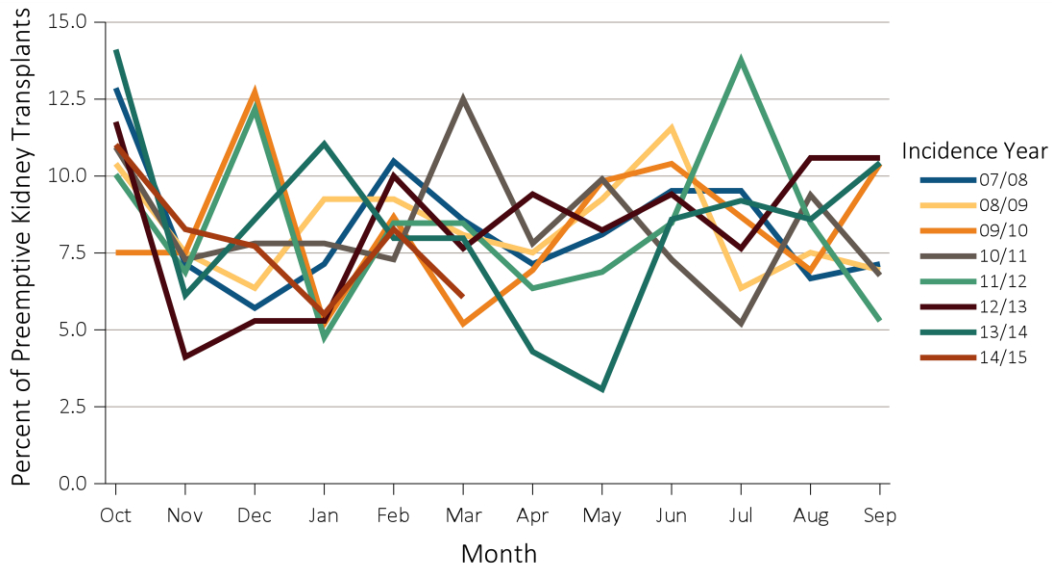
The percent of kidney transplants for each month per fiscal year between 10/1/2007 and 3/31/2015 can be seen in Figure 9.13. For most fiscal years (October-September), there was a peak in kidney transplants in October, with secondary peaks in summer months of May, June, or July, and for some years during the winter months of December, January, and February. In fiscal year 2011, the highest number of transplants occurred in March 2011. For 2012-2013, the lowest number of transplants occurred in the winter months of December or January, or in November. In fiscal year 2014, the lowest number of transplants occurred in May 2014.

vol 1 Figure 9.13 Seasonal variations across secular trends in the percent of kidney transplants among 1,355 incident ESRD veterans who received a preemptive kidney transplant between 10/1/2007 and 3/31/2015*

(a) Percent of patients for each month per fiscal year over 7.5 years



(b) Percent of patients for each month per fiscal year stratified by fiscal year

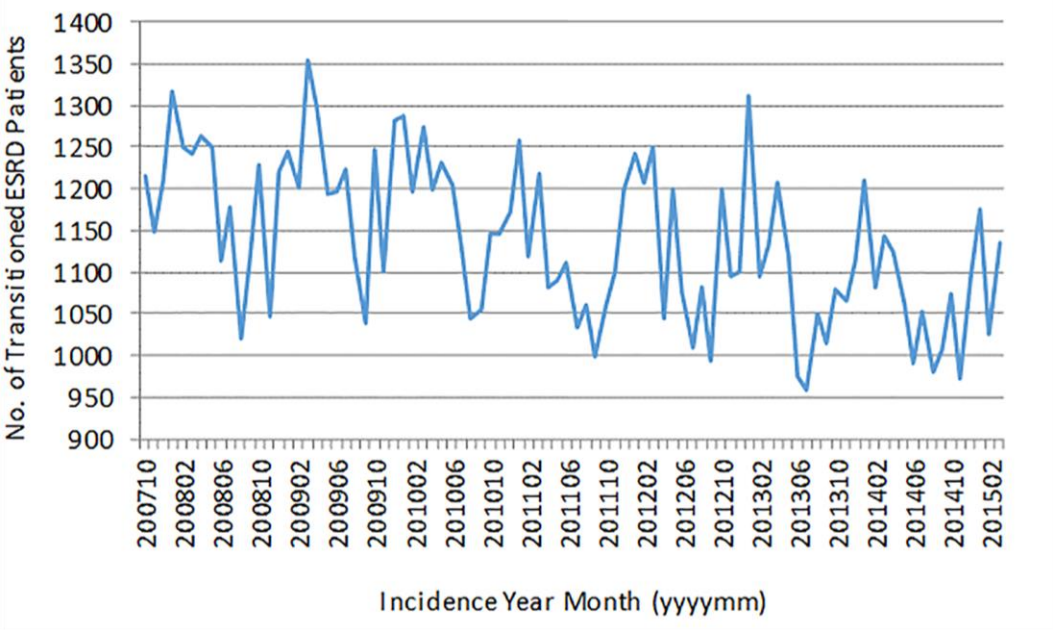


*Data source: USRDS ESRD Database. For Fiscal Year 14/15, percent was based on the averaged total number of preemptive transplants of previous 7 fiscal years. *Values for 10 or fewer patients are suppressed. Abbreviation: ESRD, end-stage renal disease.*

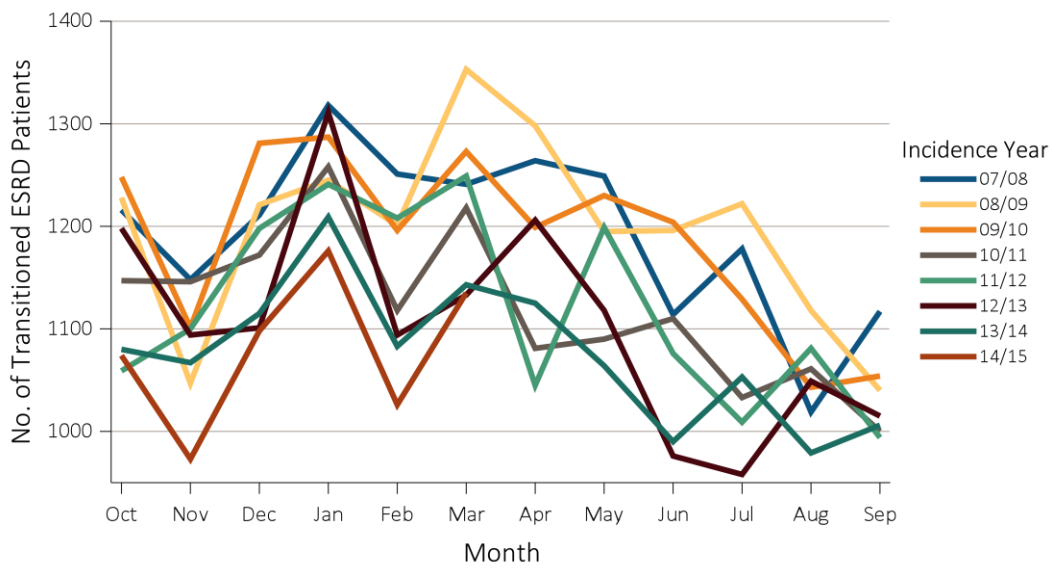
The frequency of veterans transitioning to ESRD has been relatively consistent over 7.5 years between 10/1/2007 and 3/31/2015 (Figure 9.14), with a slight downward trend in the latter years. The seasonal trend pattern of veterans transitioning to ESRD shows peaks in January and March and troughs in the summer months of June, July, August, and September, and secondary troughs in November and February.

vol 1 Figure 9.14 Seasonal variations across secular trends in the frequency of transition to ESRD in 102,477 veterans between 10/1/2007-3/31/2015

(a) Frequency of patients transitioned to ESRD per month over 7.5 years



(b) Frequency of patients transitioned to ESRD per month stratified by fiscal year



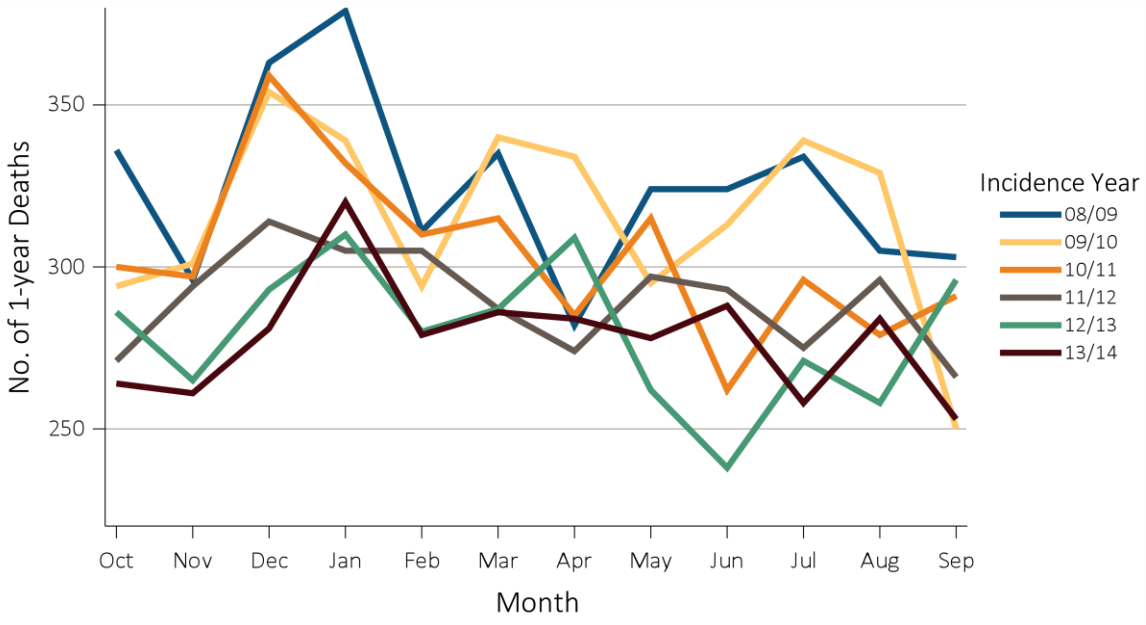
Data source: USRDS ESRD Database. Abbreviations: ESRD, end-stage renal disease; No., number.

SEASONAL AND SECULAR TRENDS AND STATE MAPS OF CAUSE OF DEATH OVER 7.5 YEARS IN THE INCIDENT ESRD VETERAN POPULATION BETWEEN 10/1/2007 AND 3/31/2015

In the previous TC-CKD ADR chapters, we have shown mortality peaks within the first 3 months after transition to ESRD in incident veteran ESRD patients. Out of 102,477 who transitioned to ESRD between 10/1/2007 and 3/31/2015, there were 10,324 (10%) veterans who died by Day 90 post-transition to ESRD. Follow-up information on all-cause mortality was available through September 1st, 2015 and for cause of death through August 1st 2015. Of 93,912 patients who transitioned to ESRD between 10/1/2007 and 9/1/2014 and had information on mortality, there were 24,982 deaths that occurred in the first year post-transition between 10/1/2007-9/1/2015.

In Figure 9.15, we show the seasonal patterns of mortality frequency in 21,483 of the 24,982 incident ESRD veterans who died between 10/1/2008 and 9/30/2014. Across all years, there was a peak in the number of deaths in winter months, either December or January, while in most years there were troughs with the lowest death frequency in the summer months of June and September.

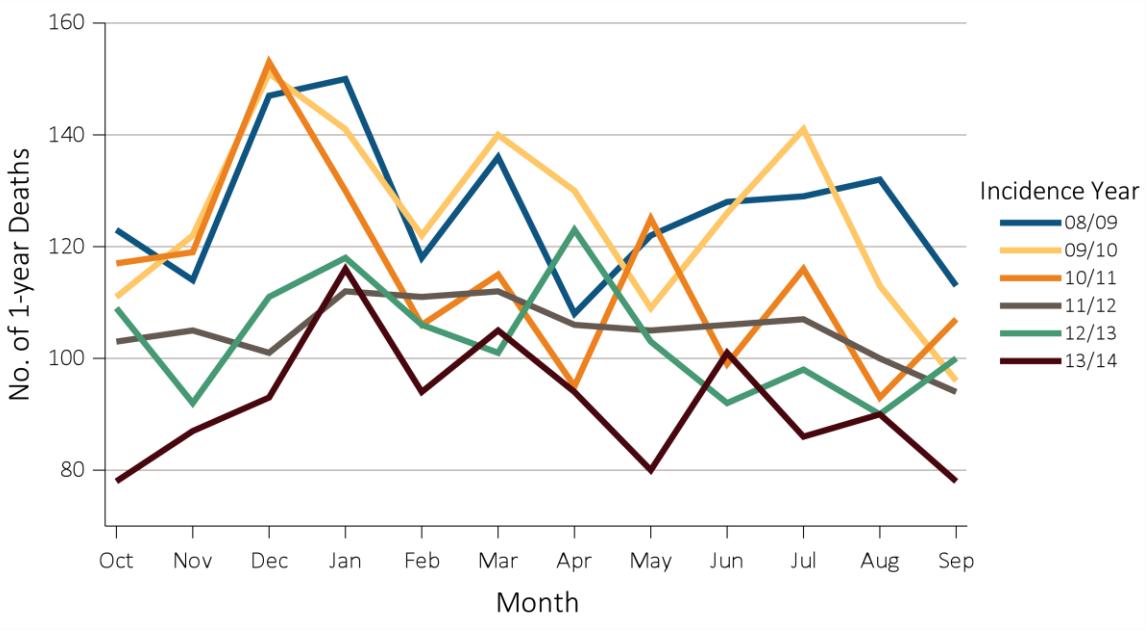
vol 1 Figure 9.15 Seasonal variations across secular trends for the one-year all-cause mortality frequency among 21,483 incident ESRD veterans who transitioned to ESRD between 10/1/2007-9/1/2014 and died between 10/1/2008 and 9/1/2014



Data source: USRDS ESRD Database. Abbreviations: ESRD, end-stage renal disease; No., number.

Of 92,987 patients who transitioned to ESRD between 10/1/2007 and 8/1/2014 and had information on mortality and cause of death, there were 9,234 deaths that occurred from cardiovascular causes in the first year post-transition and between 10/1/2007-8/1/2015. In Figure 9.16, we show the seasonal patterns of one-year cardiovascular mortality frequency in 8,004 incident ESRD veterans who died from cardiovascular causes within the first year post-transition to ESRD and between 10/1/2008-9/30/2014. The number of first year cardiovascular related deaths typically peaked in the winter months, December or January, with a secondary peak in March or April, while the lowest frequency of deaths typically occurred in the end of summer or beginning of autumn, in August, September, or October.

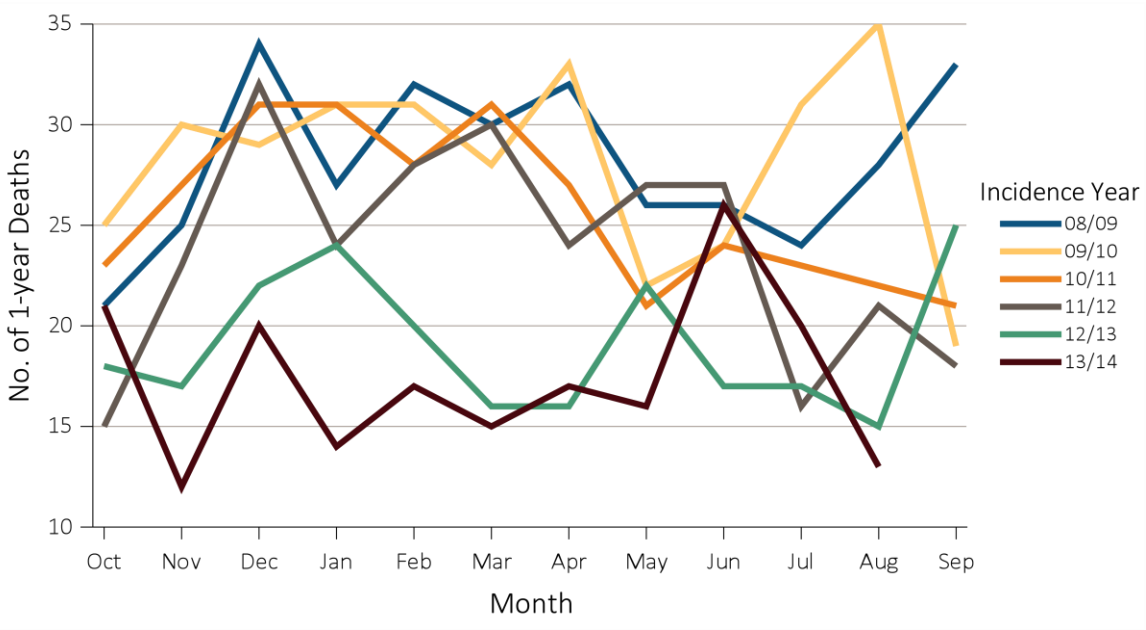
vol 1 Figure 9.16 Seasonal variations across secular trends for the one-year cardiovascular mortality frequency among 8,004 incident ESRD veterans who transitioned to ESRD between 10/1/2007-8/1/2013 and died from cardiovascular related causes between 10/1/2008 and 9/30/2014



Data source: USRDS ESRD Database. Abbreviations: ESRD, end-stage renal disease; No., number.

Seasonal patterns in infection-related mortality frequency were less discernable (Figure 9.17). Of 92,987 patients who transitioned to ESRD between 10/1/2007 and 8/1/2014 and had information on mortality and cause of death, there were 1,980 deaths that occurred from infection-related causes in the first year post-transition and between 10/1/2007-8/1/2015. Among 1,690 patients who died of infection-related causes in the first year after transition to ESRD and between 10/1/2008 - 8/31/2014, there appeared to be troughs in autumn months: September and October. Although less clear, there appeared to be peaks in December, March, and April for infection-related deaths in earlier years.

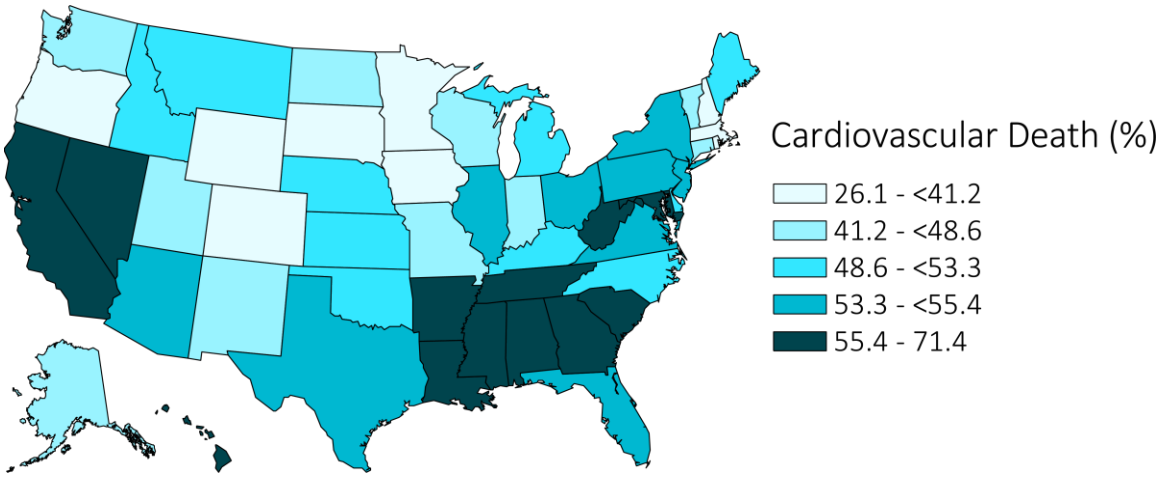
vol 1 Figure 9.17 Seasonal variations across secular trends for the one-year infection-related mortality frequency among 1,690 incident ESRD veterans who transitioned to ESRD between 10/1/2007-8/1/2013 and died from infection-related causes between 10/1/2008 and 8/31/2014*



*Data source: USRDS ESRD Database. *Values for 10 or fewer patients are suppressed. Abbreviations: ESRD, end-stage renal disease; No., number.*

We then examined the proportion of deaths attributed to particular cause of death categories in veterans who died in the first year after transition to ESRD between 10/1/2007-8/1/2015. From the 24,982 veterans that died in this period, 18,492 had a known cause of death. The proportion of these deaths attributed to cardiovascular causes (Figure 9.18) was highest in Hawaii (71%), Louisiana (63%), and Georgia (62%), and the lowest was in Wyoming (26%), District of Columbia (30%), and South Dakota (35%). Western states (California and Nevada) and Southern states (Tennessee, South Carolina, Mississippi, and Alabama) also had a higher proportion of first-year deaths attributed to cardiovascular causes; whereas Oregon, some Midwest states (Minnesota and Iowa), and Northeast states (New Hampshire, Rhode Island, and Massachusetts) had lower proportions of post-transition first-year deaths attributed to cardiovascular causes.

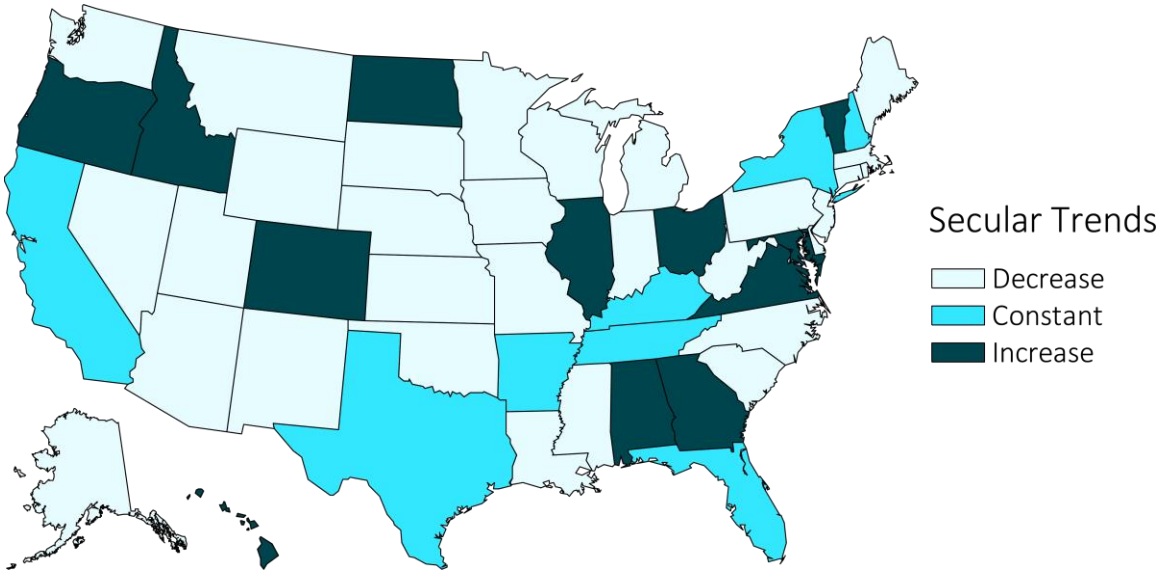
vol 1 Figure 9.18 Distribution of proportion of deaths in the first year post-transition to ESRD and between 10/1/2007-8/1/2015 attributed to cardiovascular causes among 18,492 incident ESRD veterans across the United States 10/1/2007-3/31/2015



Data source: VHA, CMS, and USRDS ESRD Databases. Abbreviation: ESRD, end-stage renal disease.

Over the 7.5 year period between 10/1/2007 and 3/31/2015, the proportion of deaths in the first year post-ESRD transition attributed to cardiovascular causes decreased in most of the United States, but increased in Vermont, Oregon, Idaho, Colorado, North Dakota, Illinois, Ohio, Maryland, Hawaii, Virginia, Georgia, District of Columbia, and Alabama (Figure 9.19).

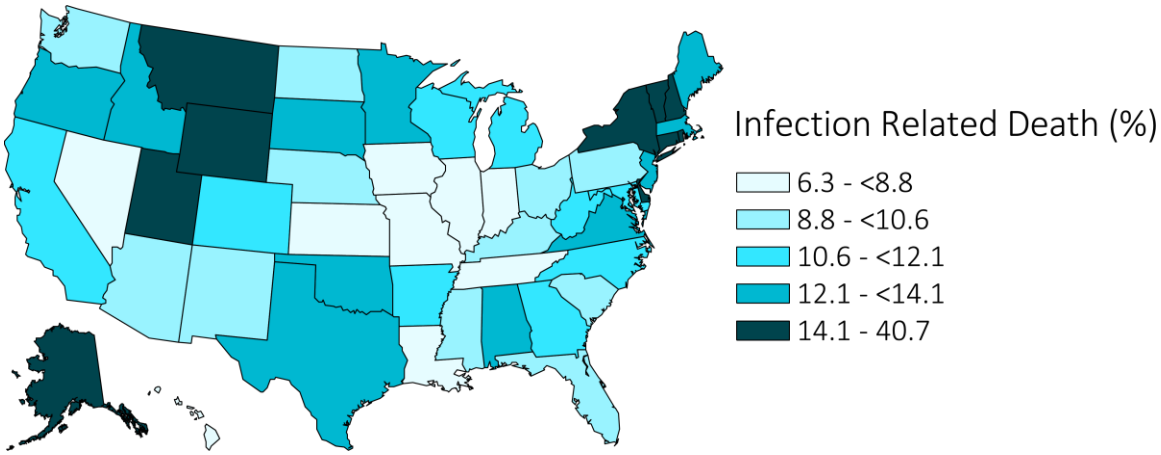
vol 1 Figure 9.19 Secular trends in the proportion of deaths in the first year post-transition to ESRD attributed to cardiovascular causes among 18,492 incident ESRD veterans who died between 10/1/2007-8/1/2015 and transitioned to ESRD across the United States, 10/1/2007-3/31/2015



Data source: VHA, CMS, and USRDS ESRD Databases. Decrease: ≤-0.01; Constant: <-0.01 to ≤0.01; Increase: >0.01 (% per year). Abbreviation: ESRD, end-stage renal disease.

Deaths in veterans within the first year of ESRD transition attributed to infection-related causes (Figure 9.20) were highest in the District of Columbia (41%), Wyoming (22%), and Rhode Island (18%). Other Northern states including Montana, Alaska, Delaware, New York, Connecticut, Vermont, New Hampshire, and Rhode Island, also had higher proportions of infection-related deaths. The lowest proportions of infection-related deaths were seen in Kansas (6%), Hawaii (6%), and Iowa (8%). Indiana, Nevada, Illinois, Tennessee, and Louisiana also had lower proportions of infection-related deaths in the first year post-ESRD transition.

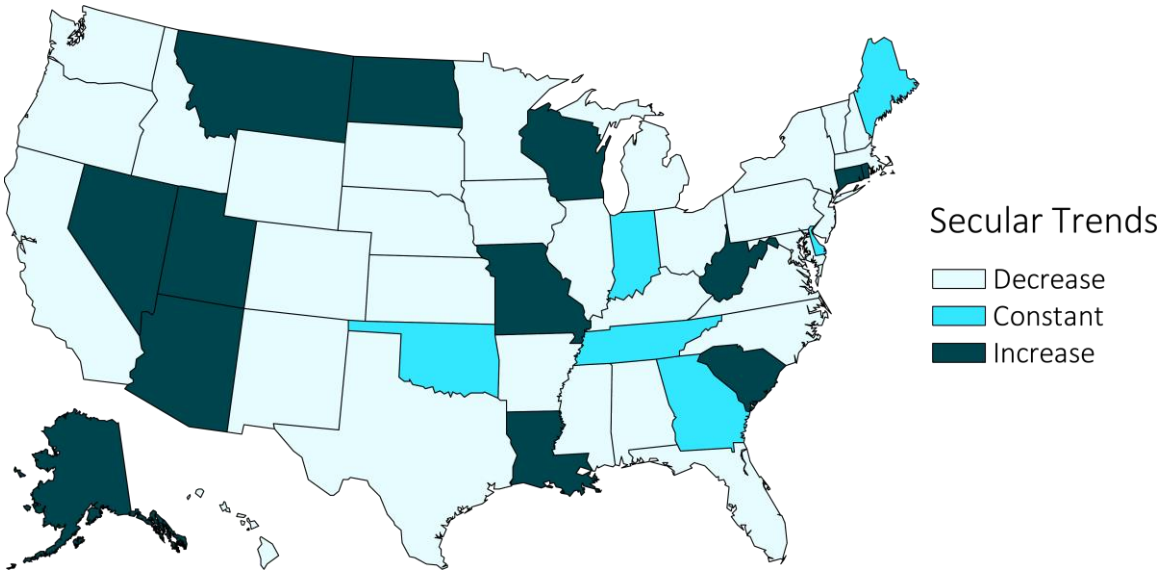
vol 1 Figure 9.20 Distribution of proportion of deaths in the first year post-ESRD transition attributed to infection-related causes among 18,492 incident ESRD veterans who died between 10/1/2007-8/1/2015 and transitioned to ESRD across the United States, 10/1/2007-3/31/2015



Data source: VHA, CMS, and USRDS ESRD Databases. Abbreviation: ESRD, end-stage renal disease.

For most of the United States, the proportion of deaths in the first year post-ESRD transition attributed to infection-related causes decreased or remained constant, but increased in Alaska, Nevada, Arizona, Connecticut, North Dakota, Utah, Montana, Louisiana, Missouri, Rhode Island, Wisconsin, West Virginia, and South Carolina (Figure 9.21).

vol 1 Figure 9.21 Secular trends in the proportion of deaths in the first year post-ESRD transition attributed to infection-related causes among 18,492 incident ESRD veterans who died between 10/1/2007-8/1/2015 and transitioned to ESRD across the United States, 10/1/2007-3/31/2015

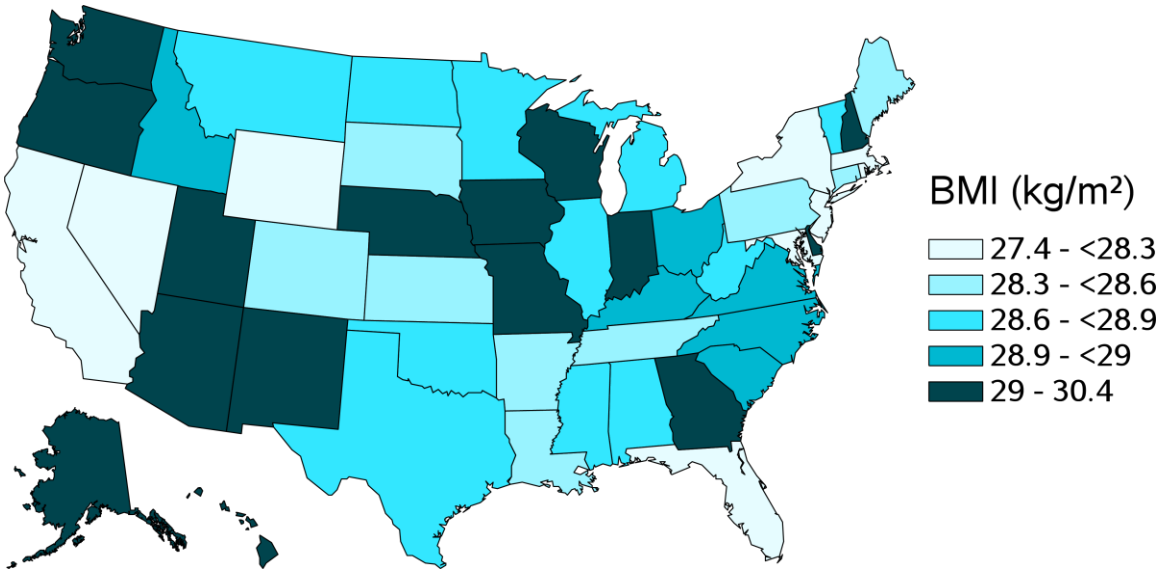


Data source: VHA, CMS, and USRDS ESRD Databases. Decrease: ≤-0.01; Constant: <-0.01 to ≤0.01; Increase: >0.01 (% per year). Abbreviation: ESRD, end-stage renal disease.

BODY MASS INDEX AMONG VETERANS WHO TRANSITIONED TO ESRD

As the obesity epidemic continually increases across the United States, and as obesity is a leading risk factor for diabetes, which is also the leading cause of ESRD, we sought to characterize body mass index (BMI) in U.S. veterans transitioning to ESRD. As noted in Table 9.1 above, the mean BMI for veterans transitioning to ESRD is slightly lower than in the total USRDS population transitioning to ESRD between 10/1/2007 and 3/31/2015. Across the United States, we found that the U.S. veterans with highest mean BMI levels at transition (Figure 9.22) were in Alaska (30.4 kg/m^2), Nebraska (29.8 kg/m^2), and New Hampshire (29.7 kg/m^2), while the District of Columbia (27.4 kg/m^2), New York (27.5 kg/m^2), and Massachusetts (27.7 kg/m^2) had the lowest mean BMI at transition.

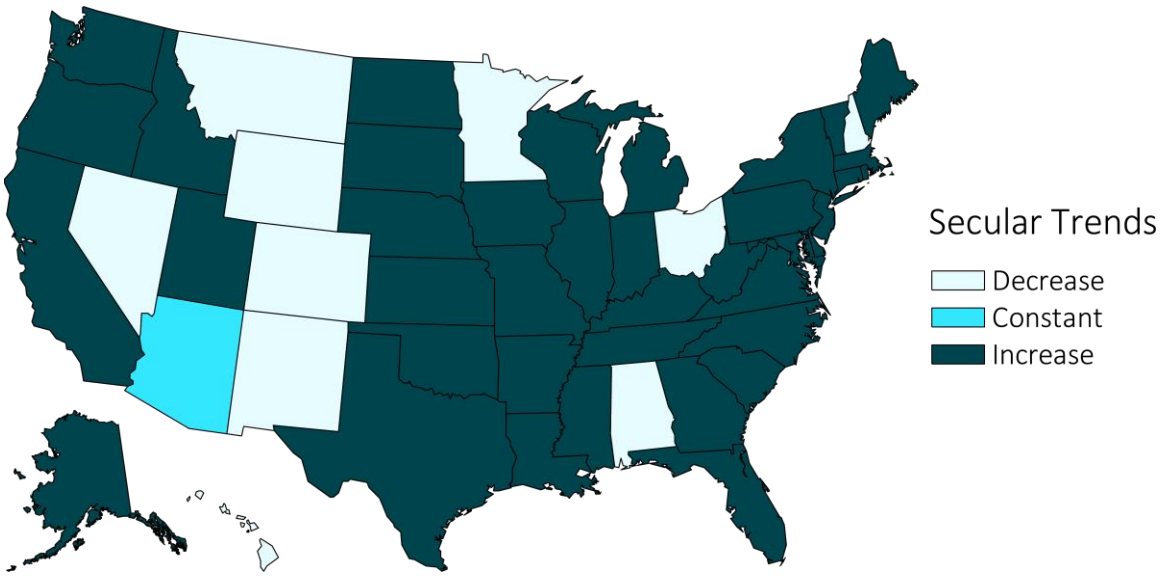
vol 1 Figure 9.22 Distribution of mean body mass index (BMI) levels at transition to ESRD among 98,701 incident ESRD veterans across the United States, 10/1/2007-3/31/2015



Data source: USRDS ESRD Database. Abbreviations: ESRD, end-stage renal disease; BMI, body mass index; kg, kilogram; m, meter.

Over the 7.5 year period between 10/1/2007 and 3/31/2015, the mean BMI at transition to ESRD for most U.S. veterans has increased. However, mean BMI has remained constant in Arizona, but has decreased in Western states, including Nevada, Montana, Wyoming, Colorado, and New Mexico, as well as New Hampshire, Hawaii, Alabama, Ohio, and Minnesota (Figure 9.23).

vol 1 Figure 9.23 Secular trends in the mean body mass index (BMI) level among 98,701 incident ESRD veterans across the United States, 10/1/2007-3/31/2015 (For decomposition by racial/ethnic categories, see Figures 9.25, 9.27, and 9.29)



Data source: USRDS ESRD Database. Decrease: ≤-0.01; Constant: <-0.01 to ≤0.01; Increase: >0.01 (kg/m² per year). Abbreviations: ESRD, end-stage renal disease; BMI, body mass index; kg, kilogram; m, meter.

As shown in Figure 9.24, mean BMI levels have gradually increased between 10/1/2007 and 3/31/2015 for (a) all racial/ethnic groups in the total USRDS transitioning population, and (b) in U.S. veterans. In the USRDS population, differences across racial/ethnic groups were maintained as mean BMI levels increased, whereas Non-Hispanic Black patients had persistently higher BMI levels at transition, followed by Non-Hispanic White patients, and Hispanics. However, less of a distinction across racial/ethnic groups is apparent in the veteran population, where BMI levels at transition are also on the rise over the 7.5 year period, but there is substantial overlap in the racial/ethnic groups with the highest and lowest BMI levels at transition.

vol 1 Figure 9.24 Secular trends in mean body mass index (BMI) across racial/ethnic groups in 98,704 veterans and 838,511 total USRDS patients transitioning to ESRD, 10/1/2007-3/31/2015

(a) USRDS cohort

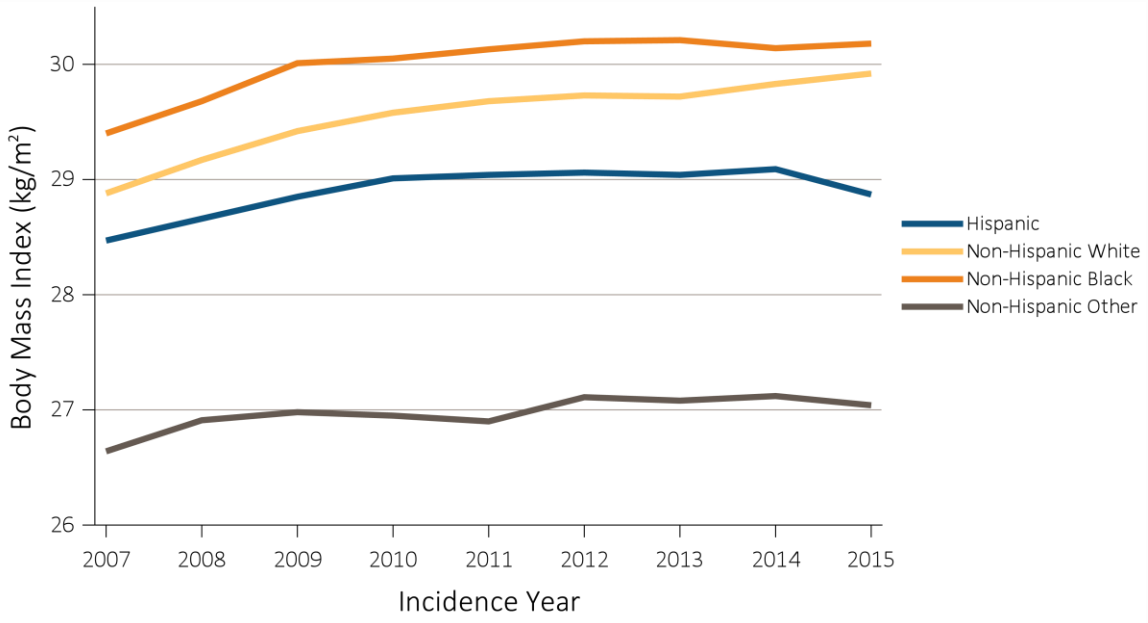
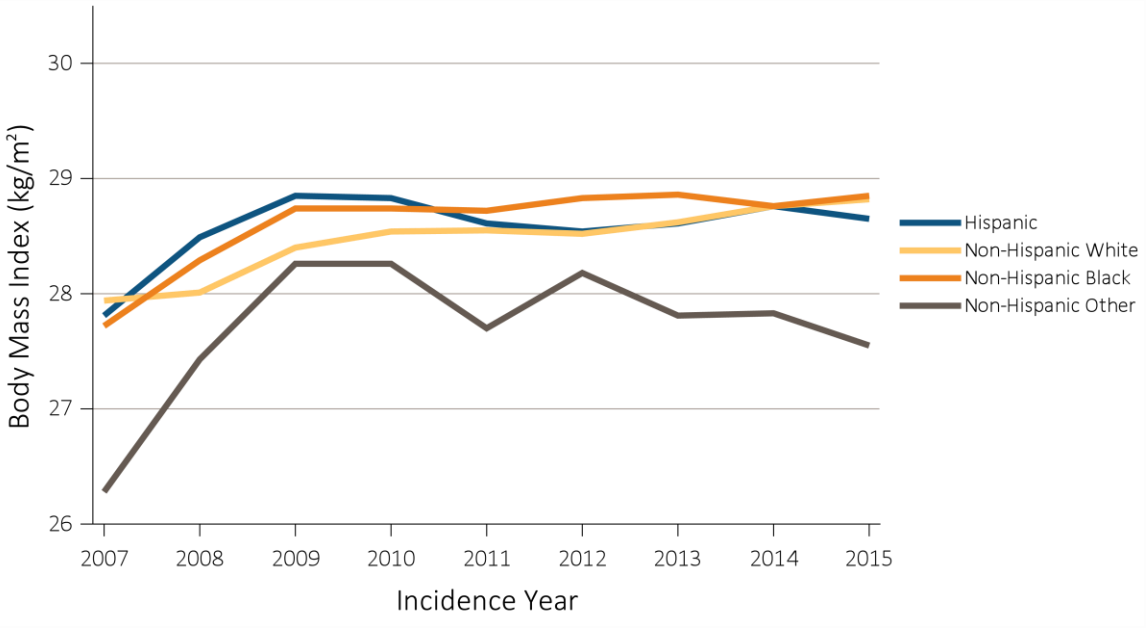


Figure 9.24 continued on next page.

vol 1 Figure 9.24 Secular trends in mean body mass index (BMI) across racial/ethnic groups in 98,704 veterans and 838,511 total USRDS patients transitioning to ESRD, 10/1/2007-3/31/2015 (continued)

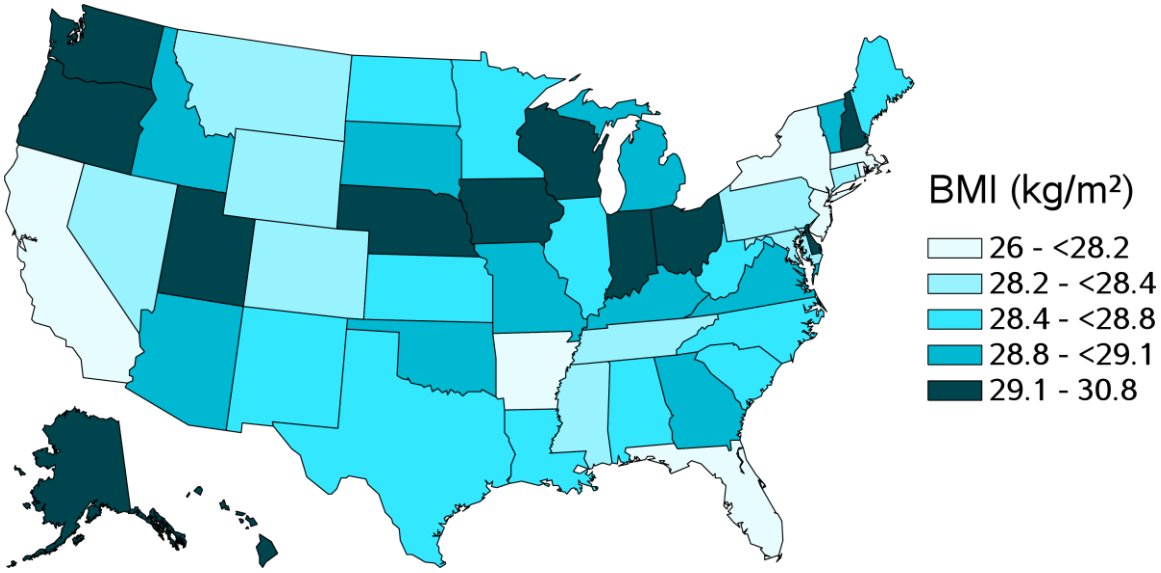
(b) TC-CKD cohort



Data source: USRDS ESRD Database. Abbreviations: ESRD, end-stage renal disease; kg, kilogram; m, meter.

The mean BMI level in 64,289 non-Hispanic White veterans, who transitioned to ESRD between 10/1/2007 and 3/31/2015 was 28.5 kg/m². Similar to mean BMI levels for the entire TC-CKD veteran population, higher levels of mean BMI levels for non-Hispanic White veterans (Figure 9.25), were seen in Hawaii (30.8 kg/m²), Alaska (30.0 kg/m²), and Nebraska (30.0 kg/m²), while the District of Columbia (26.0 kg/m²), New Jersey (27.5 kg/m²), and New York (27.6 kg/m²) had the lowest mean BMI levels at transition. Oregon, Washington, Utah, Wisconsin, Iowa, Indiana, Ohio, and New Hampshire also had higher levels of BMI at transition, while Florida, Rhode Island, Massachusetts, Arkansas, and California had lower levels of BMI for non-Hispanic White veterans transitioning to ESRD.

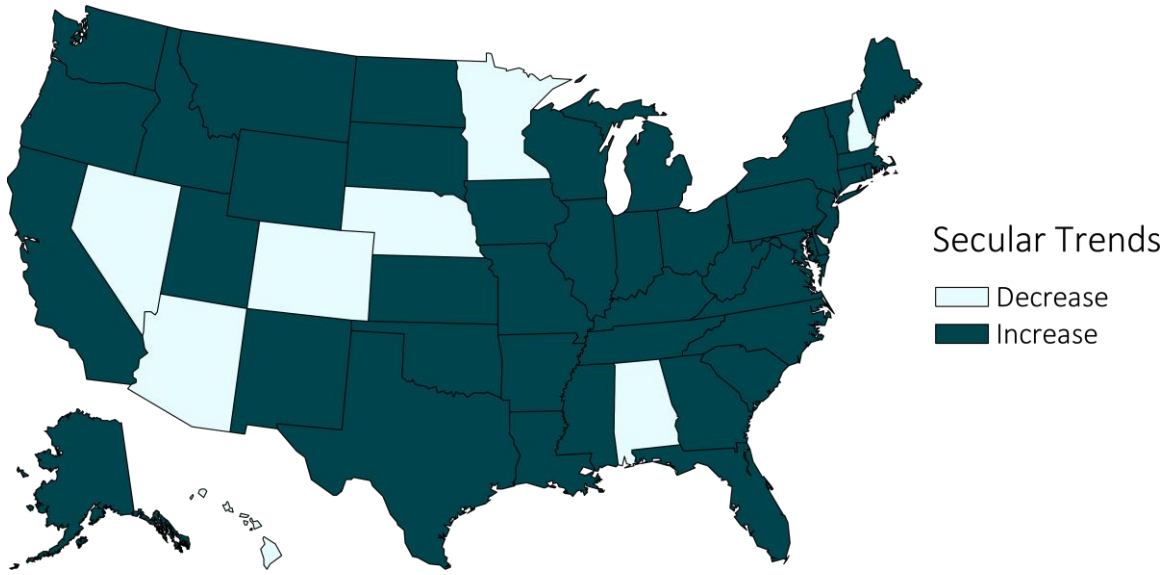
vol 1 Figure 9.25 Distribution of mean body mass index (BMI) levels at transition to ESRD among 64,289 Non-Hispanic White incident ESRD veterans across the United States, 10/1/2007-3/31/2015



Data source: USRDS ESRD Database. Abbreviations: ESRD, end-stage renal disease; BMI, body mass index; kg, kilogram; m, meter.

For Non-Hispanic Whites, the mean BMI level at transition increased from 27.9 kg/m² in 2007 to 28.8 kg/m² in 2015. For most of the United States, the mean BMI at transition increased between 10/1/2007-3/31/2015 (Figure 9.26) in U.S. veterans transitioning to ESRD, with the exception of Nevada, Arizona, New Hampshire, Colorado, Nebraska, Hawaii, Alabama, and Minnesota, where mean BMI at transition decreased over time.

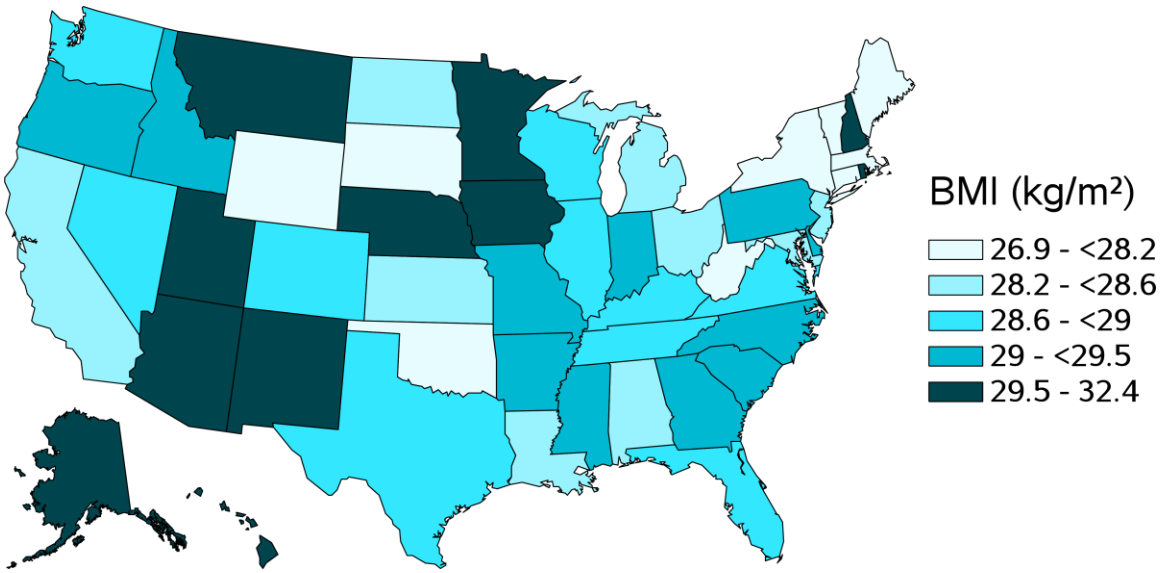
vol 1 Figure 9.26 Secular trends in the mean body mass index (BMI) level among 64,289 Non-Hispanic White incident ESRD veterans across the United States, 10/1/2007-3/31/2015



Data source: USRDS ESRD Database. Decrease: ≤-0.01; Constant: <-0.01 to ≤0.01; Increase: >0.01 (kg/m² per year). Abbreviations: ESRD, end-stage renal disease; BMI, body mass index; kg, kilogram; m, meter.

Non-Hispanic Black veterans on average had a higher BMI at transition, which was 28.7 kg/m² for 24,543 Non-Hispanic Black veterans who transitioned to ESRD between 10/1/2007 and 3/31/2015. Higher levels of mean BMI for non-Hispanic Black veterans (Figure 9.27) were seen in Alaska (32.4 kg/m²), Montana (31.7 kg/m²), and Rhode Island (31.6 kg/m²), as well as in Nebraska, Minnesota, Iowa, Utah, Arizona, New Mexico, Hawaii, and New Hampshire, while lower BMI levels for non-Hispanic Black veterans transitioning to ESRD were observed in Massachusetts (26.9 kg/m²), Wyoming (27.3 kg/m²), and West Virginia (27.4 kg/m²), as well as in South Dakota, Oklahoma, Maine, New York, Vermont, and the District of Columbia.

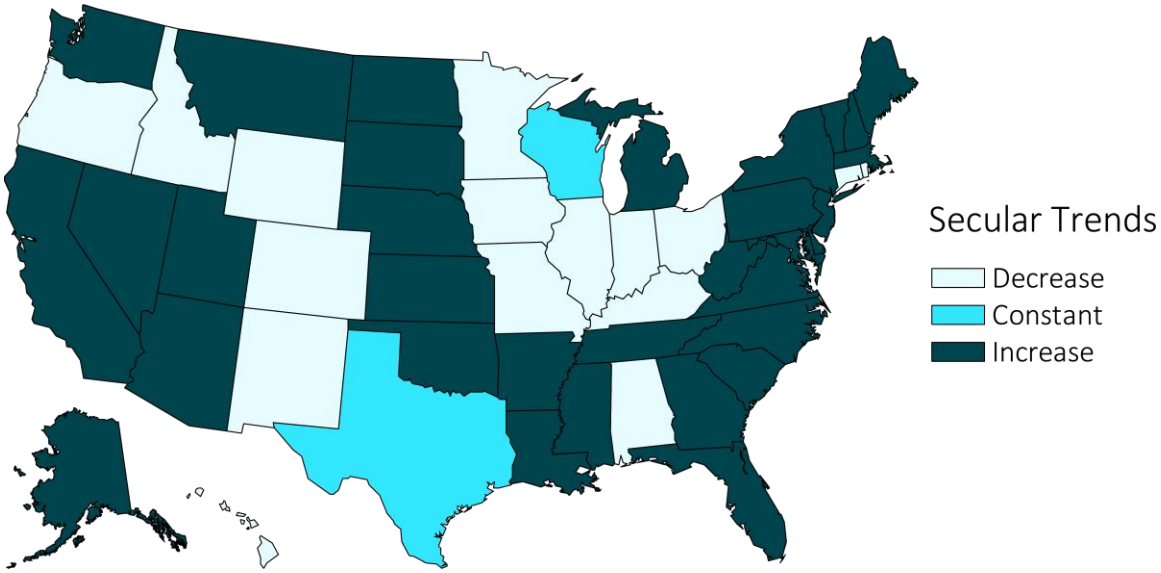
vol 1 Figure 9.27 Distribution of mean body mass index (BMI) levels at transition to ESRD among 24,543 Non-Hispanic Black incident ESRD veterans across the United States, 10/1/2007-3/31/2015



Data source: USRDS ESRD Database. Abbreviations: ESRD, end-stage renal disease; BMI, body mass index; kg, kilogram; m, meter.

Secular trends in mean BMI level for Non-Hispanic Black veterans across the U.S. were less consistent (Figure 9.28). Although the mean BMI at transition for Non-Hispanic Black veterans in the majority of the U.S. increased between 10/1/2007 and 3/31/2015, there were states that remained constant (Texas and Wisconsin) and pockets that decreased, such as in the Midwest and in the West, as well as in Alabama.

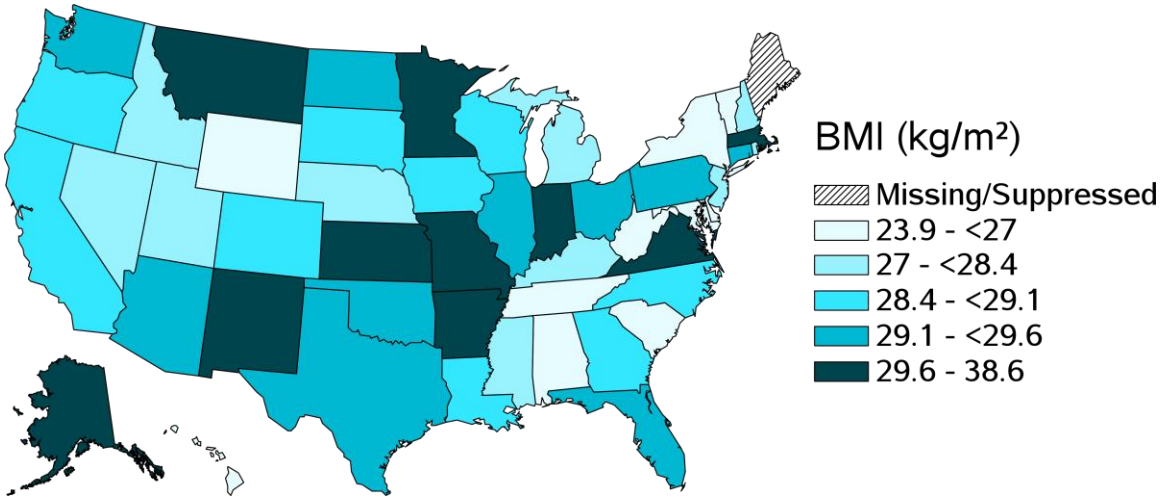
vol 1 Figure 9.28 Secular trends in the mean body mass index (BMI) level among 24,543 Non-Hispanic Black incident ESRD veterans across the United States, 10/1/2007-3/31/2015



Data source: USRDS ESRD Database. Decrease: ≤-0.01; Constant: <-0.01 to ≤0.01; Increase: >0.01 (kg/m² per year). Abbreviations: ESRD, end-stage renal disease; BMI, body mass index; kg, kilogram; m, meter.

Hispanic veterans comprised only 6% of veterans transitioning to ESRD between 10/1/2007 and 3/31/2015, but of the 6,412 who had data on mean BMI level at transition, the mean was 28.6 kg/m². Higher levels of mean BMI for Hispanic veterans (Figure 9.29) were seen in Alaska (38.6 kg/m²), Indiana (31.6 kg/m²), and Montana (30.8 kg/m²), as well as in New Mexico, Minnesota, Kansas, Missouri, Arkansas, Virginia, and Massachusetts. Lower BMI levels for Hispanic veterans transitioning to ESRD were observed in Vermont (23.9 kg/m²), Delaware (24.9 kg/m²), and Alabama (25.7 kg/m²), as well as in Hawaii, Wyoming, West Virginia, Tennessee, South Carolina, and Maryland. No information on mean BMI for Hispanic veterans was available for veterans in Maine.

vol 1 Figure 9.29 Distribution of mean body mass index (BMI) levels at transition to ESRD among 6,412 Hispanic incident ESRD veterans across the United States, 10/1/2007-3/31/2015

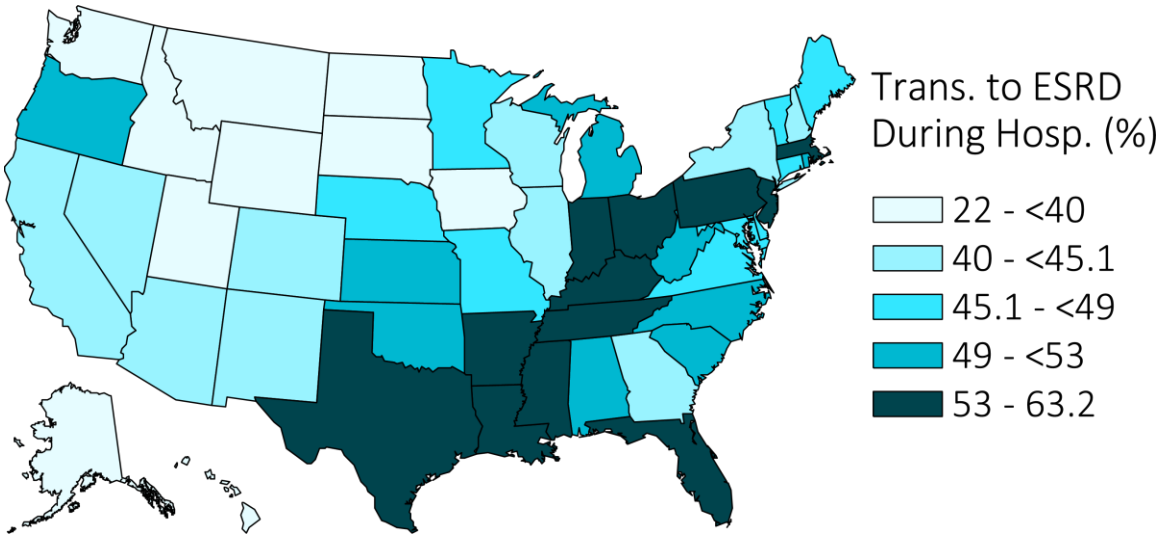


Data source: USRDS ESRD Database. Abbreviations: ESRD, end-stage renal disease; BMI, body mass index; kg, kilogram; m, meter.

HOSPITALIZATIONS DURING TRANSITION, INITIAL ACCESS TYPE AND ACUTE KIDNEY INJURIES IN THE YEAR PRIOR TO TRANSITION AMONG VETERANS WHO TRANSITIONED TO ESRD

In the 2017 ADR, we showed that 50% (n=50,786) of the 102,477 U.S. veterans who transitioned to ESRD between 10/1/2007 and 3/31/2015 transitioned to ESRD during a hospitalization admission. This year, we show the proportion of veterans per state who transitioned to ESRD during a hospitalization admission (Figure 9.30). There were higher proportions of transition during hospitalization in states in the South and the East, including Florida (63%), Louisiana (60%), Massachusetts (60%), Texas, Arkansas, Mississippi, Tennessee, Kentucky, Indiana, Ohio, Pennsylvania, and New Jersey. States in the North had lower proportions of patients transitioning to ESRD during a hospitalization. States with the lowest proportions of veterans transitioning to ESRD during a hospitalization admission included Utah (22%), Alaska (27%), Idaho (29%), Hawaii, Washington, Wyoming, Montana, North and South Dakota, and Iowa.

vol 1 Figure 9.30. Distribution of proportion of veterans transitioning to ESRD during a Hospitalization Admission among 102,477 incident ESRD veterans across the United States, 10/1/2007-3/31/2015

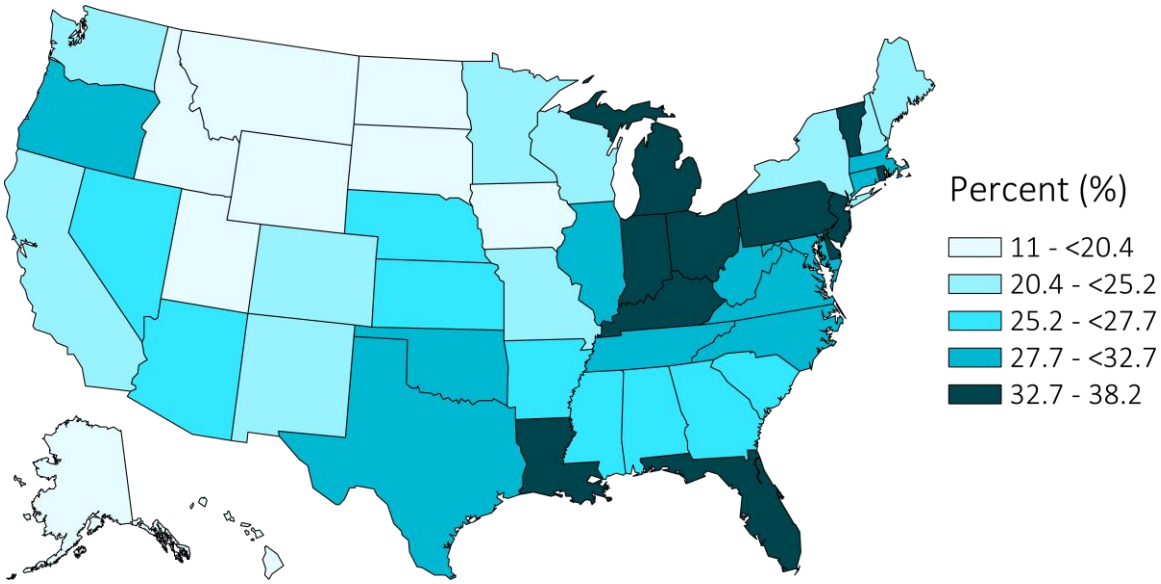


Data source: VHA, CMS, and USRDS ESRD Databases. Abbreviations: ESRD, end-stage renal disease; Trans., transition; Hosp., hospitalization.

Secular trends in the proportion of veterans transitioning to ESRD during a hospitalization appeared to decrease for most states, although Washington, DC, increased and Wyoming remained constant over the 7.5 year period (map not shown).

In the 2017 ADR, we showed that the most commonly listed cause of hospital admission for patients that were hospitalized during transition to ESRD was acute kidney injury (AKI). We found that of the 84,799 U.S. veterans in the year prior to ESRD, there were 24,500 (29%) U.S. veterans who had at least one hospitalization for AKI in the year prior to transition. Across the United States, higher proportions of patients with an AKI hospitalization in the year prior to ESRD transition were seen in the East, including Florida (38%), Rhode Island (37%), Vermont (36%), Ohio, New Jersey, Michigan, Kentucky, Indiana, Pennsylvania, and Louisiana , while lower proportions were seen in Utah (11%), Alaska (13%), and Idaho (16%), as well as Hawaii, and some northern states including North Dakota, Montana, South Dakota, Iowa, and Wyoming (Figure 9.31).

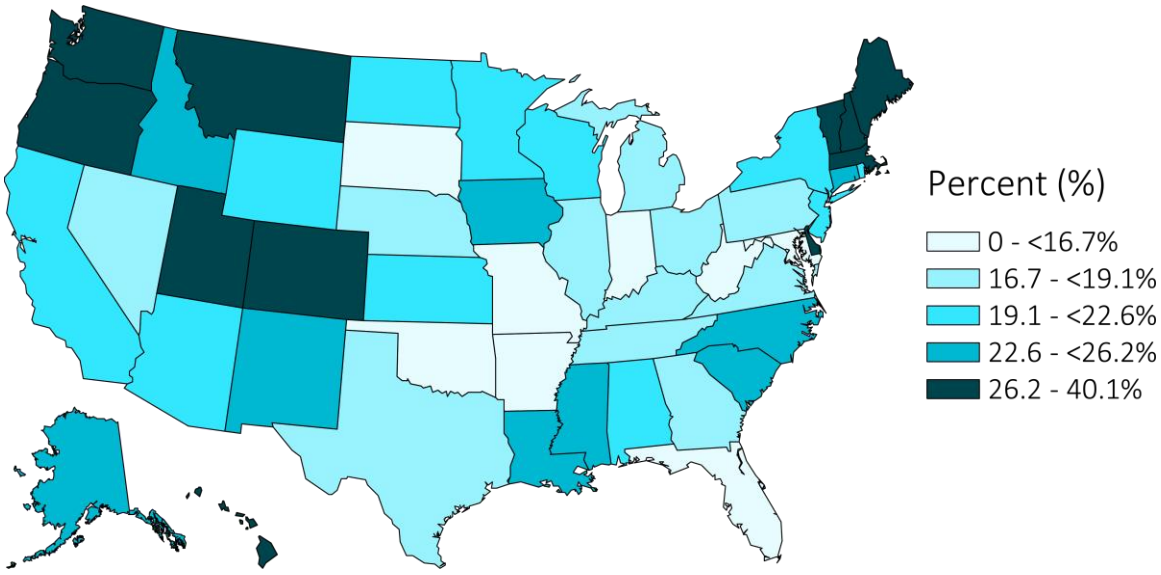
vol 1 Figure 9.31 Distribution of proportion of veterans with a hospitalization for acute kidney injury in the year prior to transition across the United States among 84,799 incident ESRD veterans with information in the year prior to transition, 10/1/2007-3/31/2015



Data source: VHA, CMS, and USRDS ESRD Databases. Abbreviation: ESRD, end-stage renal disease.

Information on initial access type at transition can shed light on U.S. veteran patient pre-transition care and preparation for transition to ESRD. As shown in Table 9.1, 20% (n=18,122) of U.S. veterans transitioned to ESRD between 10/1/2007 and 3/31/2015 with an AV fistula as an initial access type, which was a greater percentage than for the total USRDS population (15%) (Table 9.1). The percentage of TC-CKD U.S. veterans with AV graft as an initial access type is similar to that of the USRDS population, but the percentage of U.S. veterans with central venous catheter (CVC) as an initial access type is lower. New Hampshire (40%), Maine (30%), and Hawaii (30%) had the highest proportion of patients with AV fistula as an initial access type. Higher proportions were also seen in Oregon, Washington, Delaware, Montana, Colorado, Utah, Vermont, and Massachusetts. The lowest proportions were in the District of Columbia (9%), Arkansas (13%), and South Dakota (14%) (Figure 9.32).

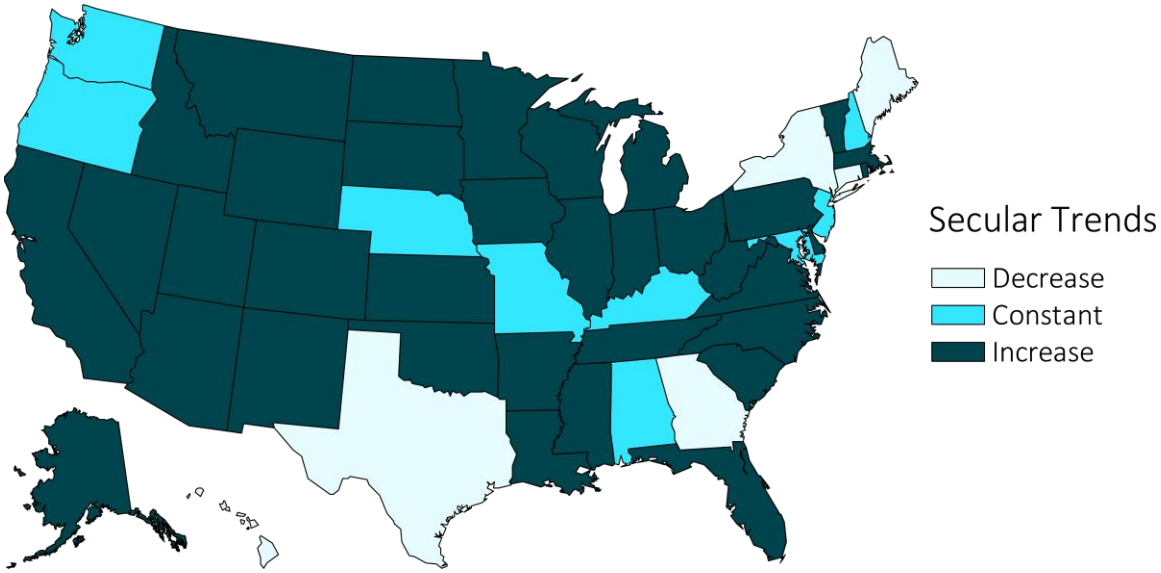
vol 1 Figure 9.32 Distribution of proportion of veterans with an AV fistula as initial access type across the United States among 102,477 incident ESRD veterans, 10/1/2007-3/31/2015



Data source: USRDS ESRD Database. Abbreviations: ESRD, end-stage renal disease; AV, arteriovenous.

Between 10/1/2007 and 3/31/2015, most states saw an increase in the proportion of patients with AV fistula as an initial access type, with a few states that remained constant, but New York, Connecticut, Hawaii, Texas, Georgia, and Maine had a decrease over time (Figure 9.33).

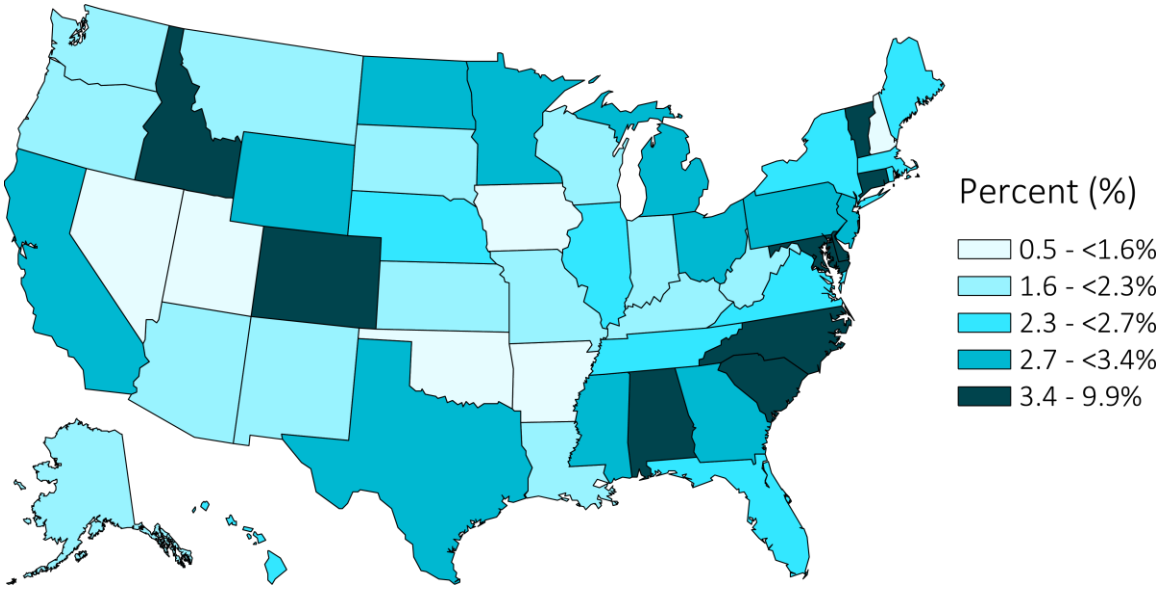
vol 1 Figure 9.33 Secular trends in the proportion of veterans with an AV fistula as initial access type across the United States among 102,477 incident ESRD veterans, between 10/1/2007-3/31/2015



Data source: USRDS ESRD Database. Decrease: ≤-0.01; Constant: <-0.01 to ≤0.01; Increase: >0.01 (% per year). Abbreviations: ESRD, end-stage renal disease; AV, arteriovenous.

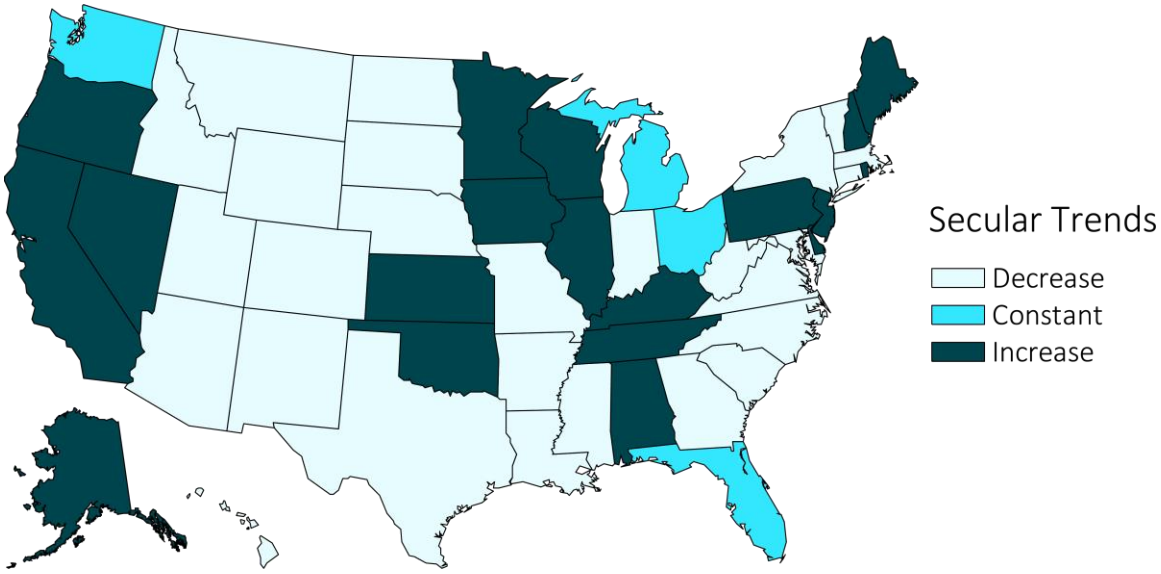
Only 3% of U.S. veterans transitioning to ESRD between 10/1/2007 and 3/31/2015 had an AV graft as initial access type. However, some states across the U.S. showed higher proportions of patients with an AV graft as the initial access type. These included the District of Columbia (10%), Alabama (6%), and Maryland (4%). Idaho, Colorado, Vermont, North Carolina, South Carolina, and Connecticut were also among the states with the higher proportions of veterans with an AV graft as the initial access type (Figure 9.34). Across the years, pockets including, California, Nevada, Alaska, and Oregon, Minnesota, Iowa, Illinois, and Wisconsin, as well as Oklahoma and Kansas, Kentucky, Tennessee, and Alabama, and Pennsylvania, Rhode Island, Delaware, New Jersey, and New Hampshire, and Maine, showed an increase in the proportion of U.S. veterans transitioning to ESRD with an AV graft as the initial access type (Figure 9.35).

vol 1 Figure 9.34 Distribution of proportion of veterans with an AV graft as initial access type across the United States among 102,477 incident ESRD veterans, 10/1/2007-3/31/2015



Data source: USRDS ESRD Database. Abbreviations: ESRD, end-stage renal disease; AV, arteriovenous.

vol 1 Figure 9.35 Secular trends in the proportion of veterans with an AV graft as initial access type across the United States among 102,477 incident ESRD veterans, between 10/1/2007-3/31/2015



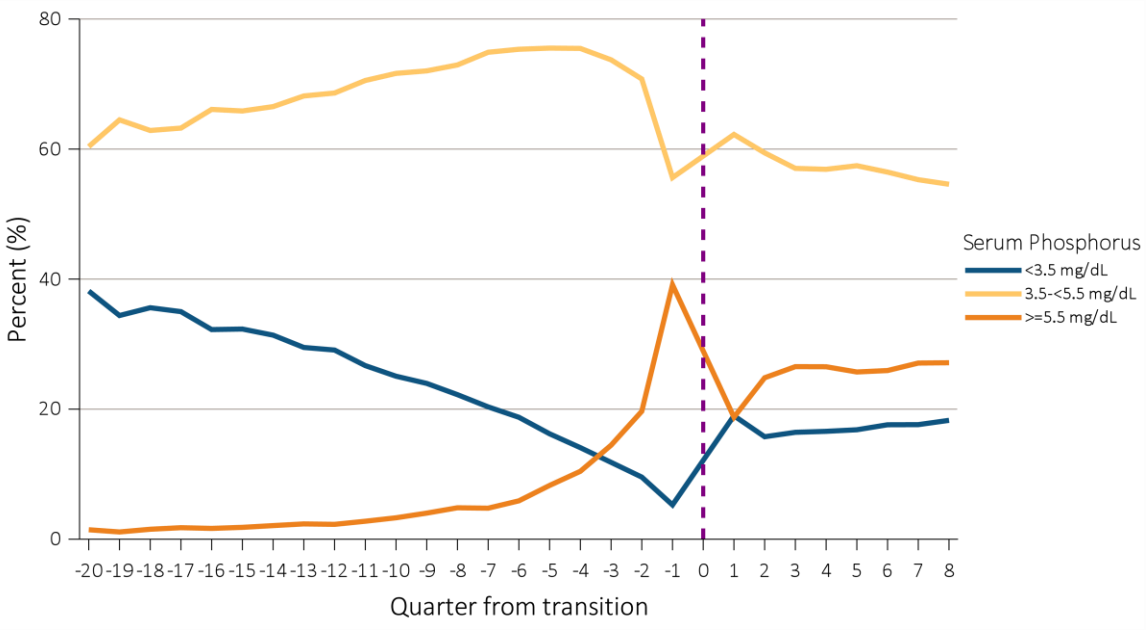
Data source: USRDS ESRD Database. Decrease: ≤-0.01; Constant: <-0.01 to ≤0.01; Increase: >0.01 (% per year). Abbreviations: ESRD, end-stage renal disease; AV, arteriovenous.

COMPARING LABORATORY TRENDS DURING PRELUDE (PRIOR TO ESRD TRANSITION) AND VINTAGE PERIODS (AFTER ESRD TRANSITION)

The significance of changes in clinical and laboratory values when a patient with non-dialysis dependent (NDD) CKD transitions to renal replacement therapy is still unclear. In the previous ADR 2017, we showed averaged laboratory measurements for up to 5 years (20 quarters) prior and 2 years post-ESRD transition. In this year's ADR, we sought to examine the change over time in the proportion of patients within ranges of laboratory measures. It can be useful to see how patients' laboratory values fall within and out of target ranges across the period before and after ESRD transition.

In the previous ADR (2017), we showed that the mean phosphorous level increased over 36 months from 4 to above 5.5 mg/dL immediately prior to transition to ESRD. Figure 9.36 shows the trend in serum phosphorus categories in 36,621 veterans. In all measurements and throughout the entire time period, the majority of patients achieved the target range of serum phosphorous between 3.5-<5.5 mg/dL. As patients moved closer to transition, the proportion of patients with lower serum phosphorous (<3.5 mg/dL) and serum phosphorus within target range decreased, while the proportion of patients with higher serum phosphorous (≥5.5 mg/dL) gradually increased. In the quarter immediately prior to transition, there was a sharp increase in the proportion of patients with serum phosphorous ≥5.5 mg/dL; however, by the first quarter post-ESRD transition the proportion of patients with a phosphorous level in target range or lower increased again and remained relatively stable after the 3rd quarter post-transition.

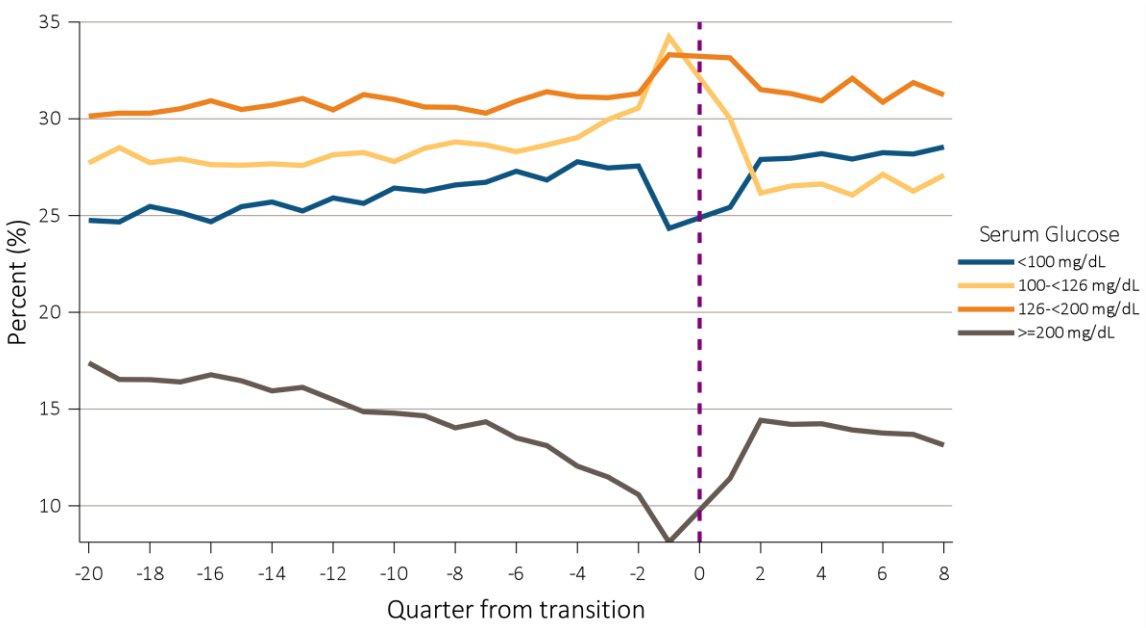
vol 1 Figure 9.36 Trend in serum phosphorus level categories up to 5 years prior and 2 years post-transition in 36,621 veterans who transitioned to ESRD during 10/1/2007-3/31/2015



Data source: VHA data. Abbreviations: ESRD, end-stage renal disease; mg/dL, milligrams per deciliter.

Figure 9.37 shows the trends in serum glucose across ESRD transition in 61,730 veterans. For most measurements and throughout most of the time period, the majority of patients had serum glucose between 126-200 mg/dL. The proportion of patients with elevated glucose ≥200 mg/dL decreased over the prelude period, with the largest drop in the quarter prior to transition; however, this proportion increased after the first two quarters of transition to ESRD. The other middle range groups, including those with glucose 100-<126 and 126-<200 mg/dL are relatively stable for most of the period prior to transition, but increased in proportion in the quarter prior to ESRD, and then declined after transition. While the proportion of patients with low serum glucose of <100 mg/dL gradually increased over the time prior to ESRD transition, the proportion dipped lower in the two quarters surrounding transition, but recovered and remained stable throughout the post-transition period. From the previous ADR, we have learned that large drops in serum glucose level prior to transition in this veteran population is mostly seen in patients with diabetes as the primary cause of ESRD.

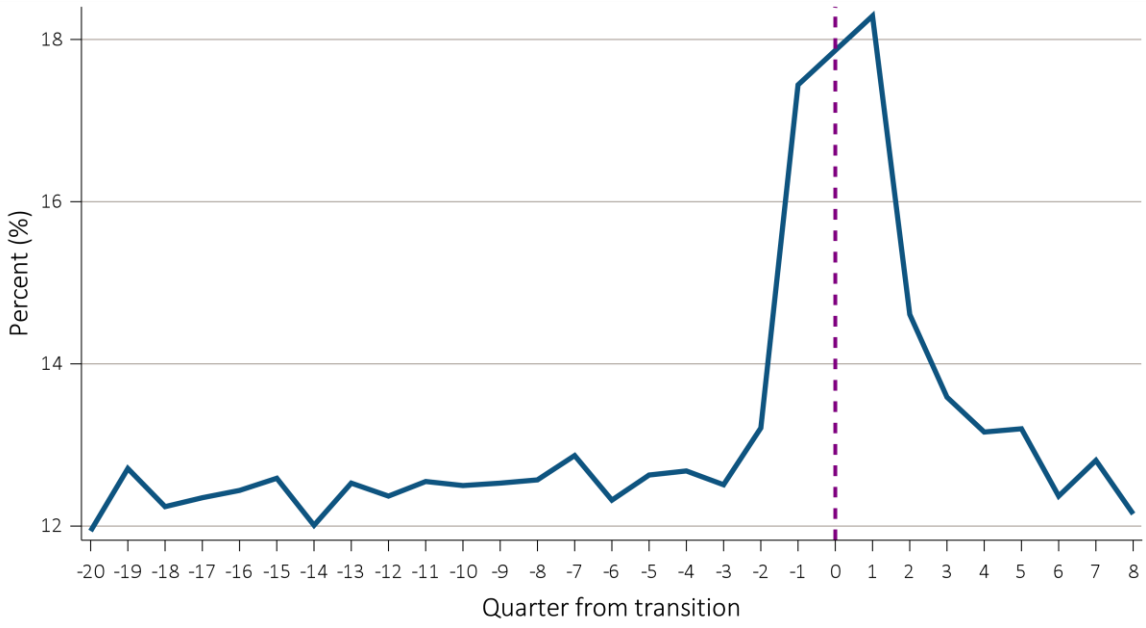
vol 1 Figure 9.37 Trend in serum glucose level categories up to 5 years prior and 2 years post-transition in 61,730 veterans who transitioned to ESRD during 10/1/2007-3/31/2015



Data source: VHA data. Abbreviations: ESRD, end-stage renal disease; mg/dL, milligrams per deciliter.

For most of the period prior to ESRD transition, approximately 12% of patients in each quarter had an elevated white blood cell count >10 x10^3/µL. In the previous ADR, we showed that mean white blood cell levels remained steady at 7.5 x10^3/µL in the earlier pre-transition period. However, from this year's results, in the quarter before and lasting until the quarter after transition, the proportion of patients with an elevated white blood cell count swelled to 18%. Yet, by the 2nd quarter post-transition, this proportion began to decline and leveled to pre-ESRD levels at the 6th quarter post-transition (Figure 9.38).

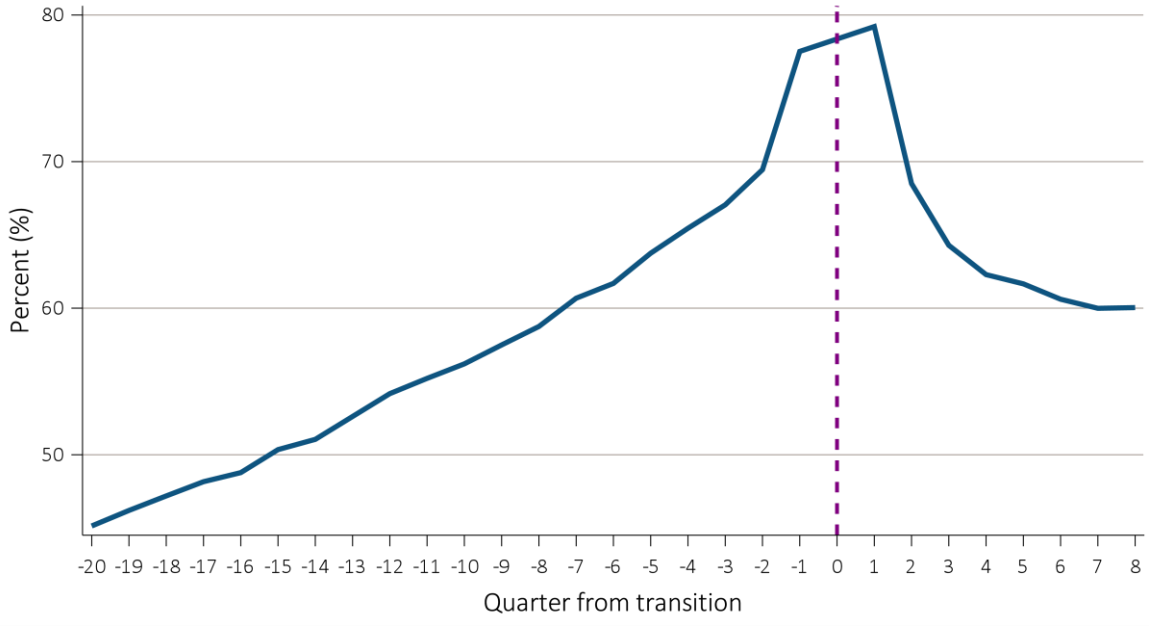
vol 1 Figure 9.38 Trend in proportion of U.S. veteran patients with serum white blood cell count >10 x 10^3/µL up to 5 years prior and 2 years post-transition in 60,036 veterans who transitioned to ESRD during 10/1/2007-3/31/2015



Data source: VHA data. Abbreviations: ESRD, end-stage renal disease; µL, microliter.

Conversely, the proportion of patients with lower serum albumin <3.8 g/dL gradually increased from 45% to nearly 80% through the period prior to ESRD transition (Figure 9.39) Higher proportions of patients had lower serum albumin up to the quarter following ESRD transition, and then abruptly declined over the 3rd and 4th quarters following transition. Thereafter, approximately 60% of patients had lower serum albumin levels <3.8 g/dL for the remainder of the post-transition period. In the previous ADR, we showed that the mean albumin levels declined from 3.8 g/dL to less than 3.4 g/dL over the prelude period (-20 quarters), and then increased to almost 3.6 g/dL in the vintage period (+4 quarters).

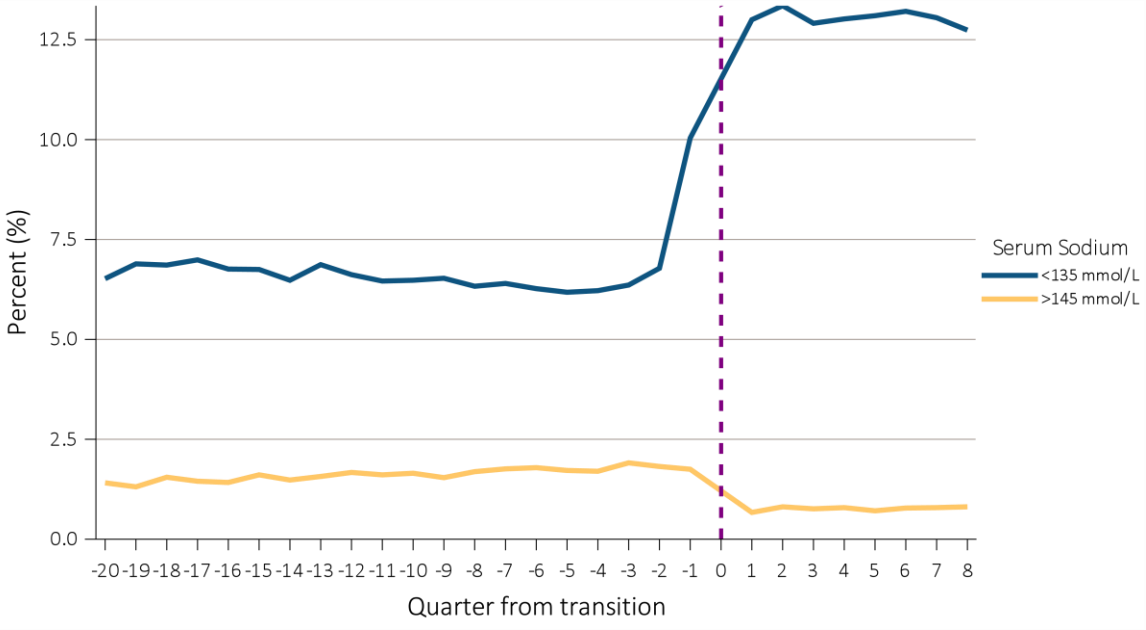
vol 1 Figure 9.39 Trend in proportion of U.S. veteran patients with serum albumin <3.8 g/dL up to 5 years prior and 2 years post-transition in 58,854 veterans who transitioned to ESRD during 10/1/2007-3/31/2015



Data source: VHA data. Abbreviations: ESRD, end-stage renal disease; g/dL, grams per deciliter.

Figure 9.40 shows the pre- and post-ESRD trends in the proportion of patients across serum sodium categories (<135, 135-145, >145 mEq/L) among veterans who transitioned to ESRD during 10/1/2007-3/31/2015 (figure only shows serum sodium <135 and >145 mEq/L). Less than 7% of patients had a serum sodium <135 mEq/L during the time prior to ESRD transition. However, in the quarter prior to ESRD transition, the proportion of patients with low sodium rose to 10%, and then rose even higher to 13% in the quarter after transition. Thereafter, the proportion of patients with lower serum sodium remains higher at 13% throughout the rest of the post-transition period. Conversely, the proportion of patients with serum sodium >145 mEq/L gradually rose between 1.5 to 2% of patients throughout the pre-ESRD period, but this proportion dropped to 0.7% after ESRD transition and remained low thereafter. The proportion of patients in the target range of 135-145 mEq/L was relatively stable throughout the prelude period, but begins to drop two quarters prior to transition and then continues to drop after transition to ESRD. In the previous ADR, we showed that the mean sodium levels remained relatively steady at around 139 g/dL over the prelude period (-20 quarters), and then dropped to 138 g/dL in the vintage period (+4 quarters).

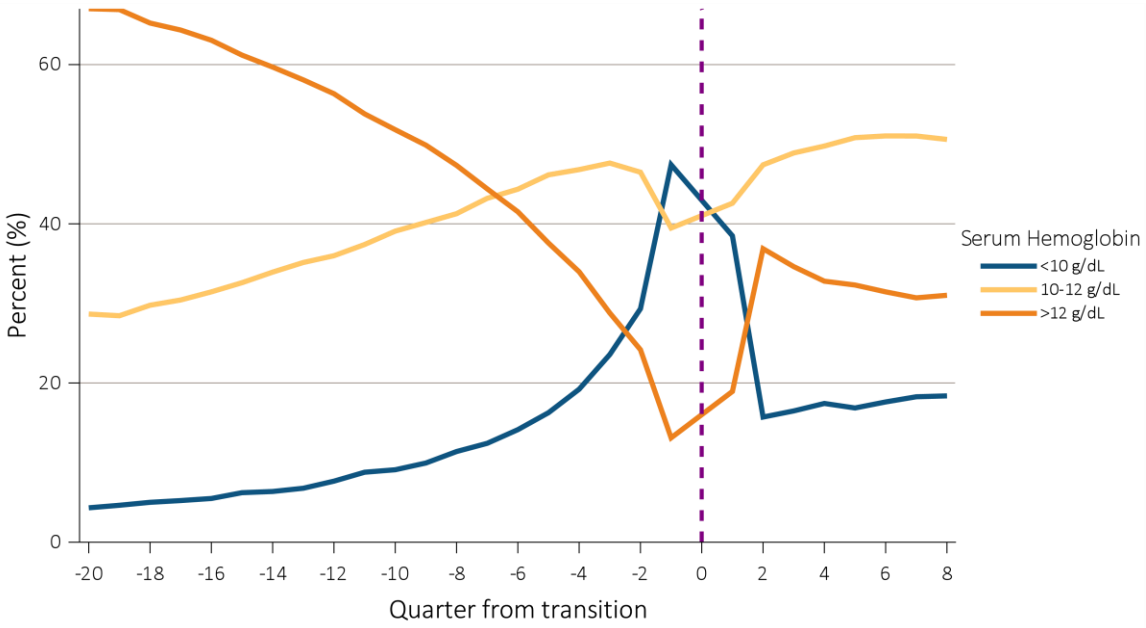
vol 1 Figure 9.40 Trend in serum sodium categories up to 5 years prior and 2 years post-transition in 61,990 veterans who transitioned to ESRD during 10/1/2007-3/31/2015



Data source: VHA data. Abbreviations: ESRD, end-stage renal disease; mmol/L, millimoles per liter.

Figure 9.41 shows the pre- and post-ESRD trends in the proportion of patients across a range of hemoglobin categories among U.S. veterans who transitioned to ESRD during 10/1/2007-3/31/2015. Early in the prelude period, most patients (approximately 67%) had a hemoglobin >12 g/dL. However, as CKD progressed toward ESRD transition, the proportion of patients with higher hemoglobin declined rapidly to 12% in the quarter prior to transition. After transition to ESRD, the proportion of patients with higher hemoglobin >12 g/dL increased to 37%, and modestly declined in the next few quarters, but remained stable at approximately 30% of patients thereafter. Conversely, the proportion of patients with hemoglobin <10 g/dL was below 5% in patients with lab measures five years prior to ESRD transition; however, that proportion rapidly rose to 46% in the quarter prior to transition and quickly dropped, but only to above 15% in the 2nd quarter post-transition. Thereafter, it slightly increased but remained below 16% throughout the remainder of the 2 year post-transition period. The proportion of patients in the target range of 10-12 g/dL steadily increased from 29% prior to transition to 51% in quarter 4 post-transition. In the previous ADR, we showed that mean blood hemoglobin dropped from 13 g/dL to almost 10 g/dL over the prelude period (-20 quarters), then increased from above 10 g/dL to less than 12 g/dL over the vintage period (+4 quarters).

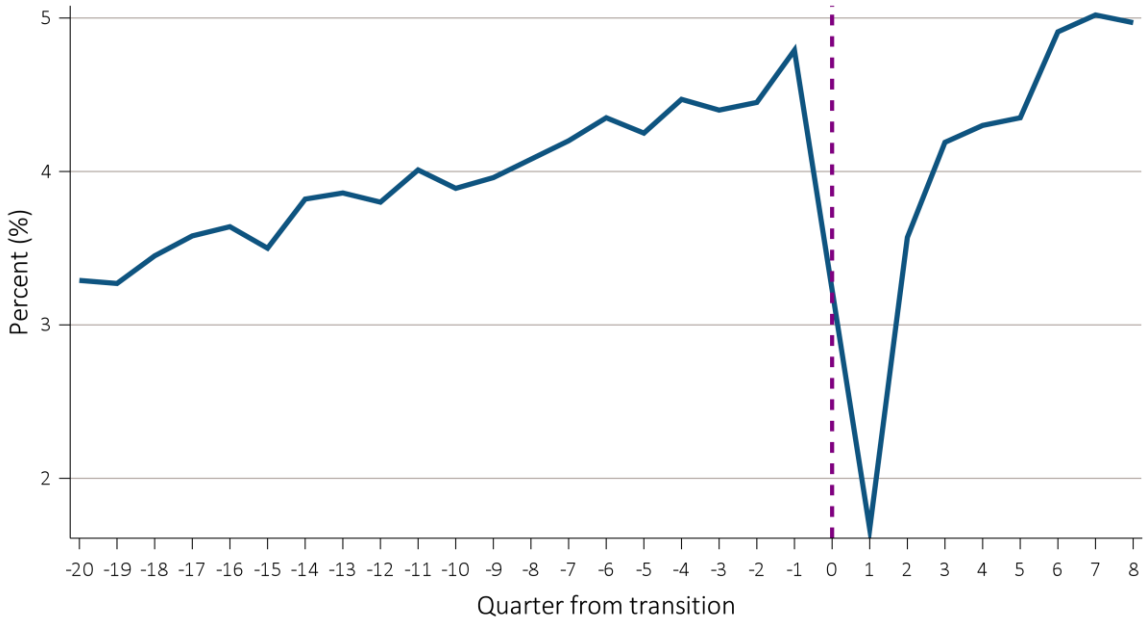
vol 1 Figure 9.41 Trend in serum hemoglobin categories up to 5 years prior and 2 years post-transition in 59,946 veterans who transitioned to ESRD during 10/1/2007-3/31/2015



Data source: VHA data. Abbreviations: ESRD, end-stage renal disease; g/dL, grams per deciliter.

In this year's ADR chapter, we also wanted to examine the proportion of patients with hyperkalemia (serum potassium ≥5.5 mEq/L) throughout transition, in pre- and post-ESRD periods (Figure 9.42). Over the course of the pre-transition period, the proportion of patients with higher serum potassium (≥5.5 mEq/L) rose from 3.2% to a peak of 4.8% in the quarter prior to ESRD transition. After transition to ESRD, that proportion sharply declined to less than 2% in the first post-transition quarter, but then rose to above 4% by the 4th quarter and rose to 5% in the 7th and 8th quarters after transition to ESRD.

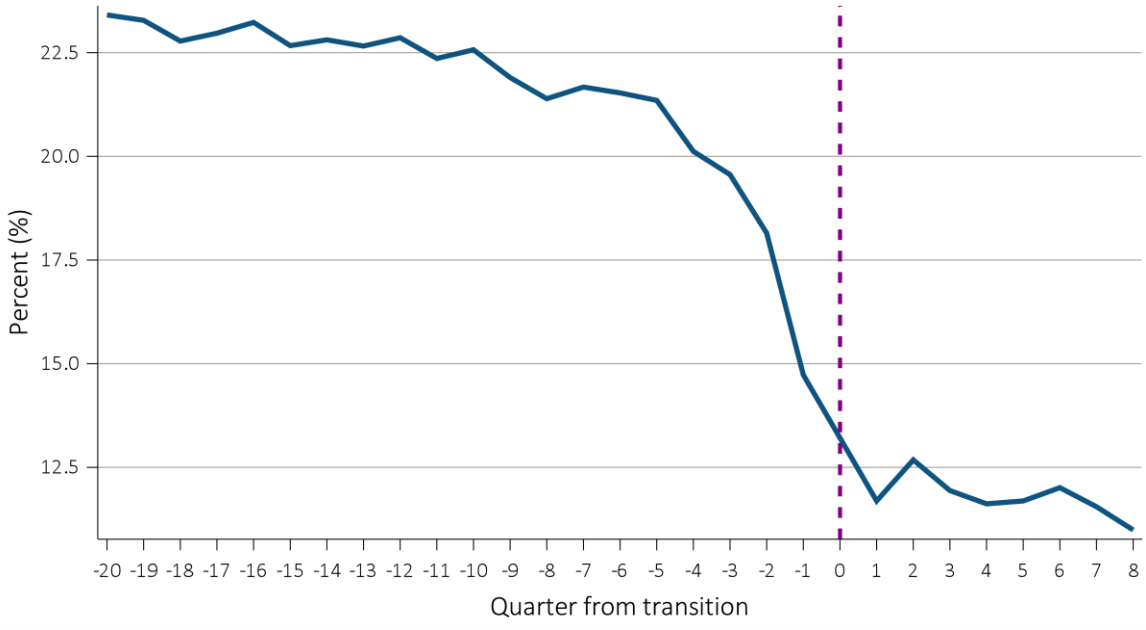
vol 1 Figure 9.42 Trend in proportion of U.S. veteran patients with serum potassium ≥5.5 mEq/L for up to 5 years prior and 2 years post-transition in 61,934 veterans who transitioned to ESRD during 10/1/2007-3/31/2015



Data source: VHA data. Abbreviations: ESRD, end-stage renal disease; mEq/L, milliequivalent per liter.

In patients with available serum cholesterol measurements 20 quarters prior to ESRD transition, more than 23% had a cholesterol level of ≥200 mg/dL (Figure 9.43). However, over the next 16 quarters, that proportion dropped gradually to 20% of patients. Thereafter, the proportion of patients with elevated cholesterol sharply declined over the next year and until the quarter following ESRD transition. Although there was a slight increase in the 2nd quarter after transition to ESRD, the proportion of patients with elevated cholesterol remained low (around 12%) for the remainder of the two-year post-ESRD transition period.

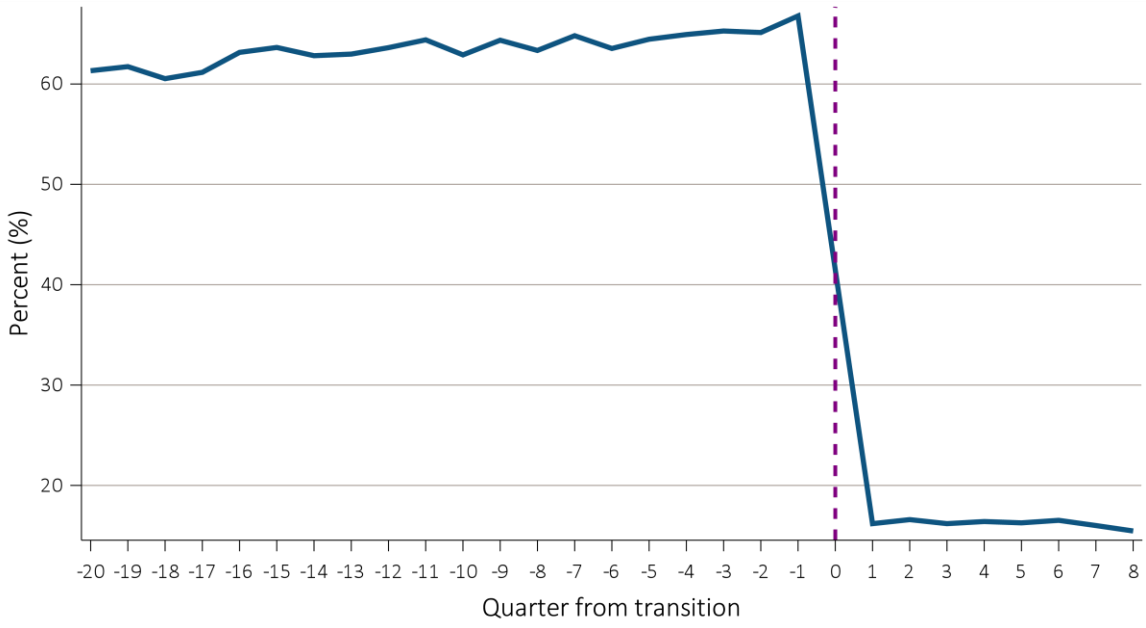
vol 1 Figure 9.43 Trend in proportion of U.S. veteran patients with serum cholesterol ≥200 mg/dL for up to 5 years prior and 2 years post-transition in 59,562 veterans who transitioned to ESRD during 10/1/2007-3/31/2015



Data source: VHA data. Abbreviations: ESRD, end-stage renal disease; mg/dL, milligrams per deciliter.

Throughout the period of NDD-CKD and over the 20 quarters prior to ESRD transition, between 61 and 65% of patients had a uric acid level >7 mg/dL, with a peak of 67% in the quarter prior to ESRD transition (Figure 9.44). In the quarter after ESRD transition, that percentage dropped to 16% of patients. However, there was a very slight increase in the 2nd quarter. For the remainder of the two-year post-ESRD transition, the proportion of patients with higher uric acid remained low at approximately 17%.

vol 1 Figure 9.44 Trend in proportion of U.S. veteran patients with uric acid >7 mg/dL for up to 5 years prior and 2 years post-transition in 31,276 veterans who transitioned to ESRD during 10/1/2007-3/31/2015

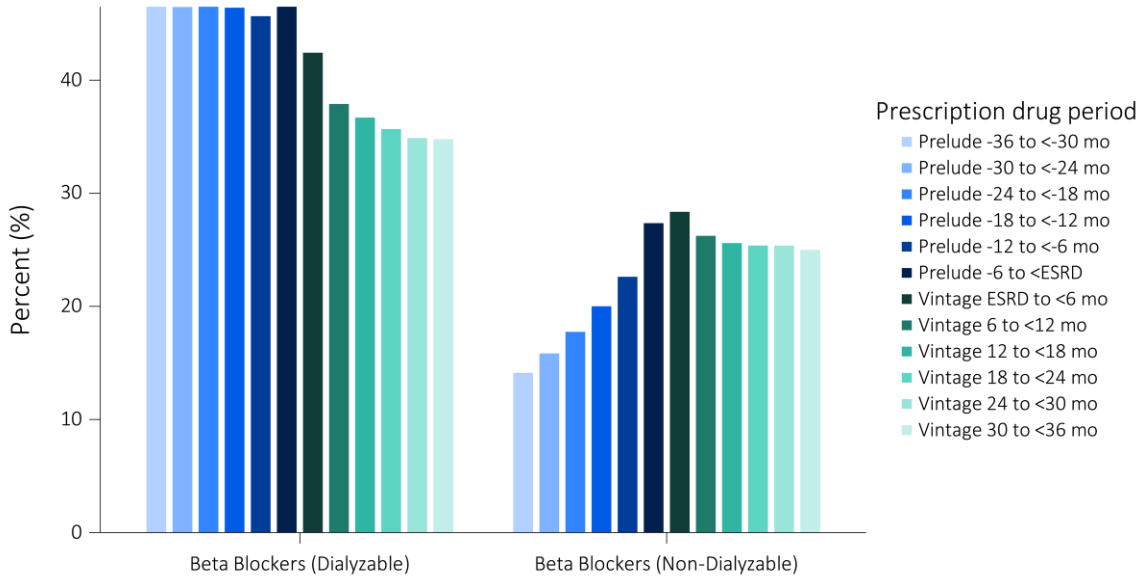


Data source: VHA data. Abbreviations: ESRD, end-stage renal disease; mg/dL, milligrams per deciliter.

Beta Blocker Use during Prelude (prior to ESRD Transition) and Vintage Periods (after ESRD Transition)

In the previous year's ADR chapter, we characterized the proportion of patients using various medications before and after ESRD transition. Beta blocker use gradually increased from 60% of patients to 65% over the course of the prelude period, and then began to decline to below 60% over the post-ESRD or vintage period. In this year's ADR, we sought to further characterize the use of beta blockers across transition to ESRD, by dialyzable versus non-dialyzable beta blockers (Figure 9.45). In this more granular examination, we see that increases in beta blocker prescriptions prior to ESRD were mostly attributed to increases in prescriptions for non-dialyzable beta blockers, while prescriptions for dialyzable beta blockers remained consistently higher at approximately 45% of patients throughout the prelude period. Post-transition, declines in beta blocker prescriptions appear to be attributed to the decline in prescriptions of dialyzable beta blockers, as the proportion of patients prescribed non-dialyzable beta blockers remained relatively stable at approximately 25% throughout the vintage period.

vol 1 Figure 9.45 Prescribed dialyzable (a) and non-dialyzable (b) beta blockers to incident ESRD veterans who transitioned to ESRD during 10/1/2007-3/31/2015, with data up to -36 months prior to transition (prelude) and up to +36 months after transition (vintage) (data were abstracted from 84,004 veterans)

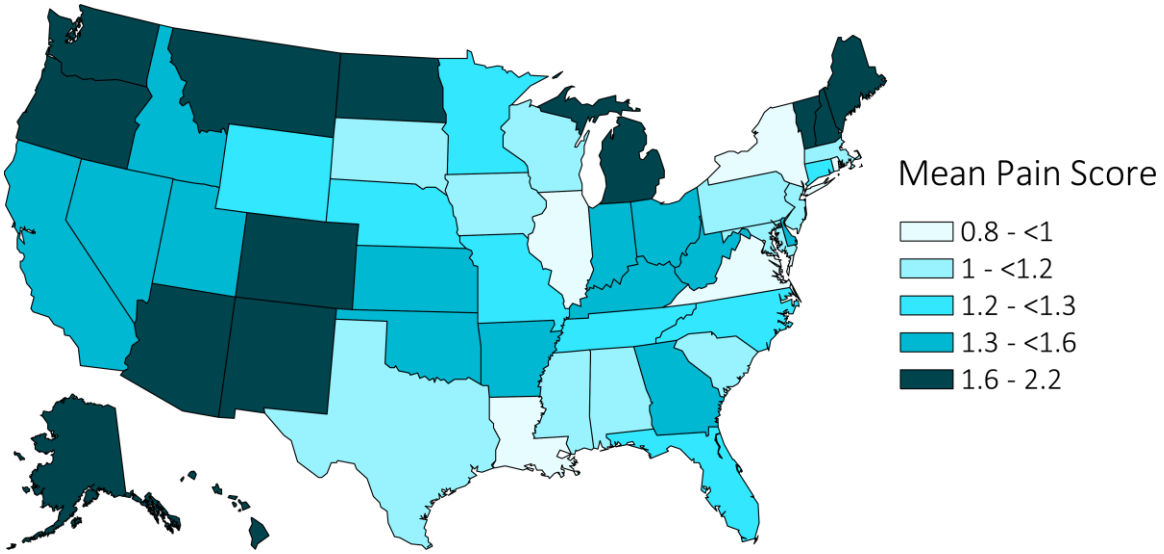


Data source: VHA data, CMS Medicare Inpatient and Outpatient data. Abbreviations: ESRD, end-stage renal disease; mo, months.

PAIN AND OPIOID USE IN U.S. VETERANS TRANSITIONING TO ESRD

CKD patients often report having pain as their disease progresses and while on dialysis. In this year's ADR, we wanted to further characterize pain scores and use of opioids in U.S. veterans transitioning to ESRD. U.S. veterans are asked to provide a pain score between 1 and 10 during any clinical encounter. In the 44,903 U.S. veterans who transitioned to ESRD between 10/1/2007-3/31/2015, and had a pain score available in the 6 months prior to ESRD, the mean ± standard deviation pain score was 1.2±2.3 out of 10. The highest mean reported pain score per state was in Colorado (2.2) (Figure 9.46). Other higher reported mean pain scores per state were more likely to be in the northern states such as Alaska (2.0), Oregon (2.0), Washington, Montana, North Dakota, Michigan, Vermont, New Hampshire, and Maine, as well as Arizona, New Mexico, and Hawaii; while Rhode Island (0.76), Illinois (0.82), Louisiana (0.85), and Virginia (0.89) had the lowest mean pain scores per state.

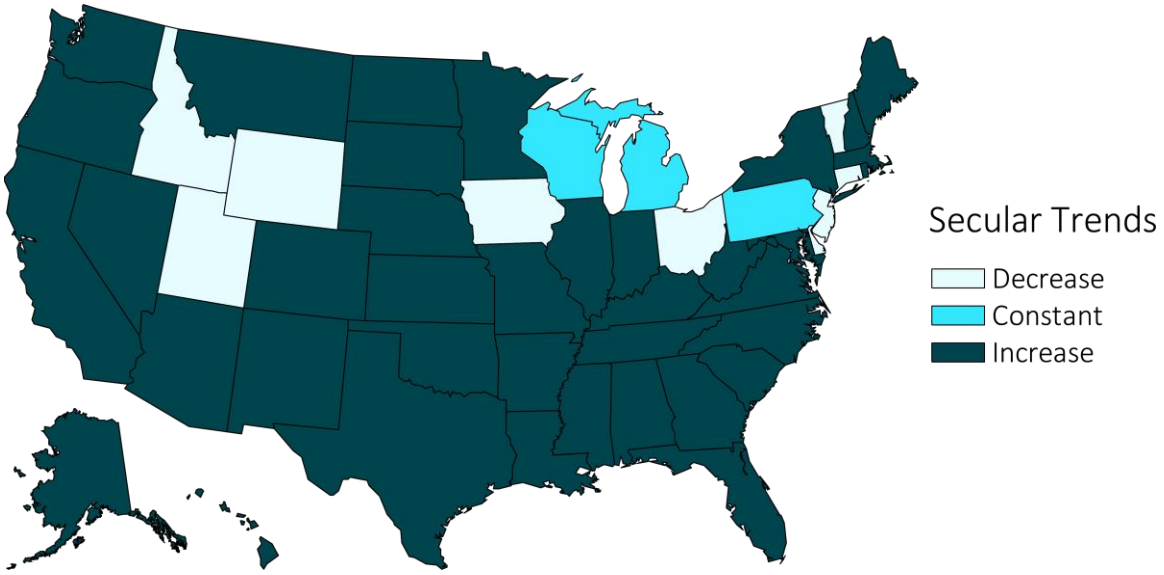
vol 1 Figure 9.46 Distribution in the mean pain score across the United States among 44,903 incident ESRD veterans, 10/1/2007-3/31/2015



Data source: VHA data. Abbreviation: ESRD, end-stage renal disease.

Over the 7.5 year period studied, the mean score reported for patients in the 6 months prior to transition increased from 1.0 in 2007 to 1.4 in 2015. There were 3% of patients reporting a pain score of >7 (severe pain) in the 6 months prior to ESRD transition in 2007, and 4% in 2015. Most states had an increase in mean pain score between 10/1/2007-3/31/2015 (Figure 9.47). While mean pain scores decreased in Connecticut, Delaware, Iowa, Idaho, New Jersey, Ohio, Vermont, Wyoming, and Utah, they remained constant in Pennsylvania, Michigan, District of Columbia, and Wisconsin.

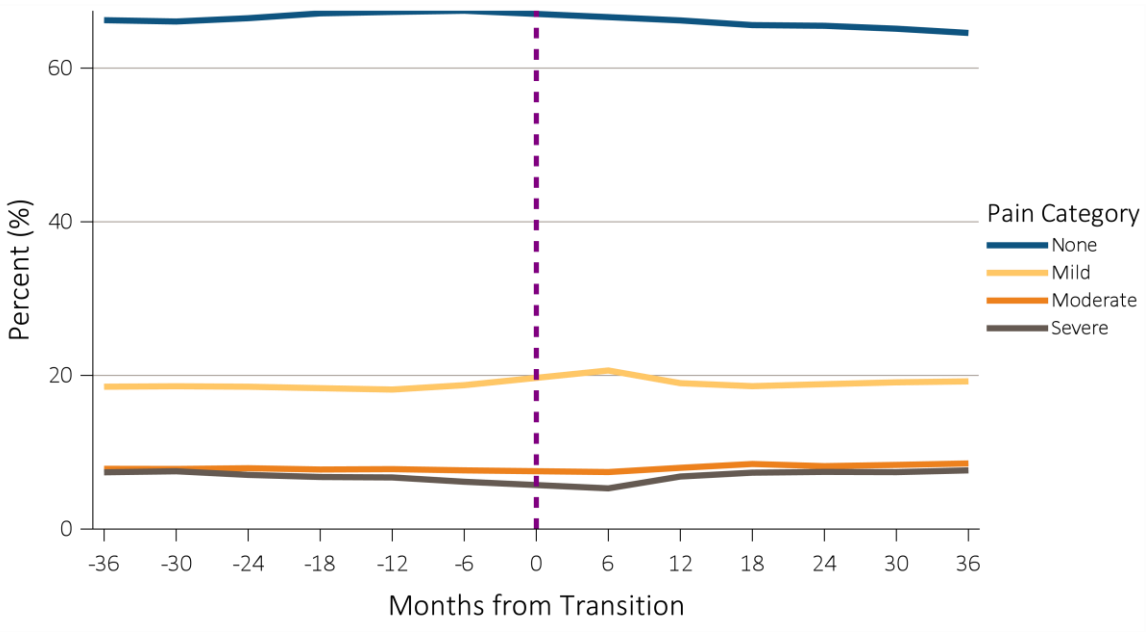
vol 1 Figure 9.47 Secular trends in the mean pain score across the United States among 44,903 incident ESRD veterans, 10/1/2007-3/31/2015



Data source: USRDS ESRD Database. Decrease: ≤-0.01; Constant: <-0.01 to ≤0.01; Increase: >0.01 (score per year). Abbreviation: ESRD, end-stage renal disease.

Proportion of patients in pain score categories did not vary widely across quarters before and after transition (Figure 9.48) in 66,042 patients who transitioned to ESRD between 10/1/2007-3/31/2015. There was a very slight increase in mild pain reported starting in the 6 months prior to transition and lasting to 6 months post-ESRD transition, but then declines and stabilizes thereafter.

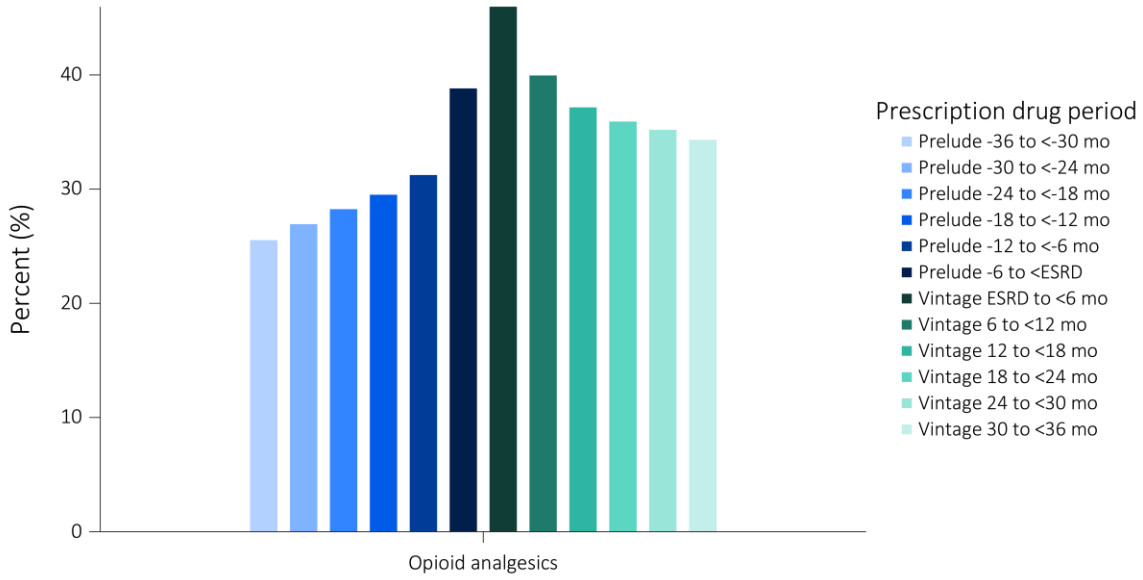
vol 1 Figure 9.48 Trend in proportion of patients in pain score categories with data up to -36 months prior to transition (prelude) and up to +36 months after transition (vintage) in 66,042 veterans who transitioned to ESRD during 10/1/2007-3/31/2015



Data source: VHA data. Abbreviation: ESRD, end-stage renal disease.

Conversely, prescriptions of opioid in U.S. veterans varied more markedly across periods surrounding transition to ESRD. In the prelude (pre-ESRD) period, the proportion of patients ever prescribed an opioid rose from 25% in the 30-36 month prelude period, up to 39% in the 6 months prior to ESRD transition (Figure 9.49). Immediately after ESRD transition, in the first 6 months vintage, over 46% of patients were prescribed an opioid. That proportion dropped to less than 40% in the following 6 months and slowly declined but remained higher than 34% through the 30-36 month vintage period.

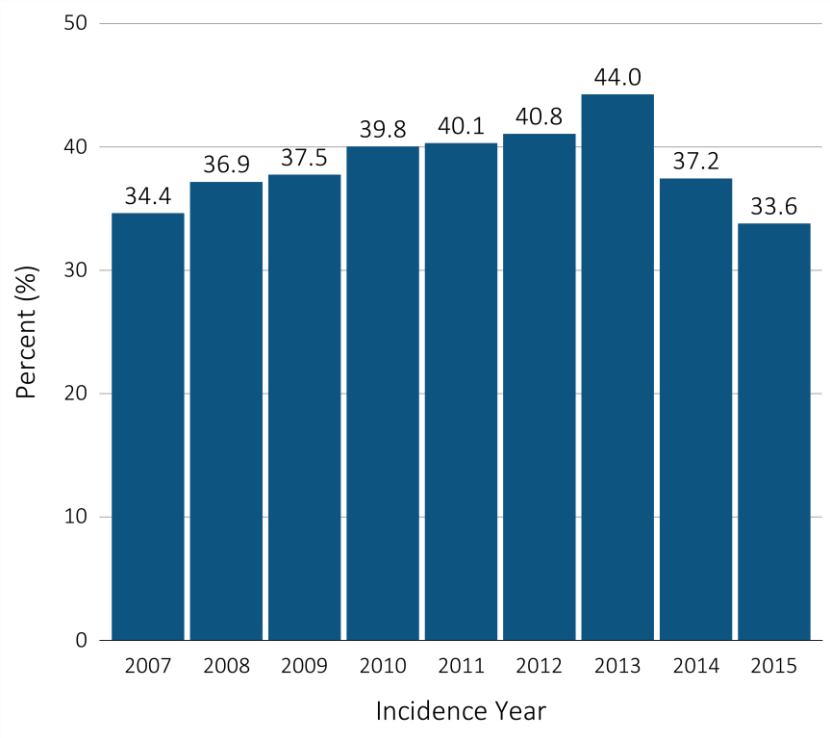
vol 1 Figure 9.49 Prescribed opioids in incident ESRD veterans who transitioned to ESRD during 10/1/2007-3/31/2015, with data up to -36 months prior to transition (prelude) and up to +36 months after transition (vintage) (data were abstracted from 84,004 veterans)



Data source: VHA data, CMS Medicare Inpatient and Outpatient data. Abbreviations: ESRD, end-stage renal disease; mo, months.

Between 2007 and 2013, the proportion of patients with an opioid prescription within 6 months prior to transition increased from 34% to 44% (Figure 9.50). However, in 2014 that proportion declined to 37% of patients and then further declined to 34% in the following year.

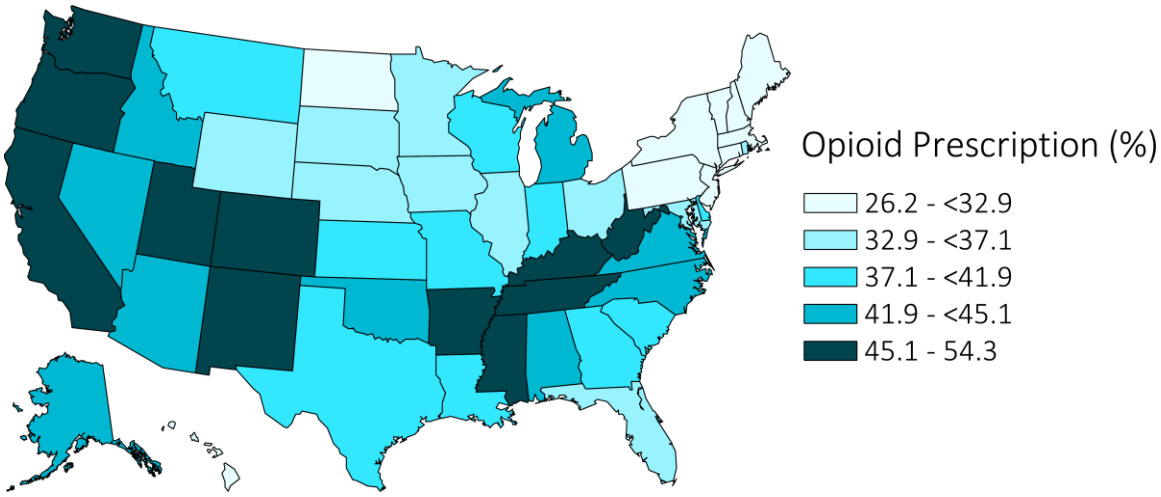
vol 1 Figure 9.50 Secular trends in proportion of patients with an opioid prescription in the 6 months prior to ESRD transition in incident ESRD veterans who transitioned to ESRD during 10/1/2007-3/31/2015



Data source: CMS and VHA ESRD Databases. Abbreviation: ESRD, end-stage renal disease.

The proportion of patients with an opioid prescription in the 6 months prior to ESRD varied across states (Figure 9.51). The highest proportions of opioid prescriptions were in Utah (54%), Oregon (54%), and West Virginia (50%). Other states within the highest quintile of proportion of veteran patients prescribed an opioid within 6 months prior to ESRD were in California, Washington, Colorado, New Mexico, as well as in Mississippi, Kentucky, Tennessee, and Arkansas. The states with the lowest proportion of veterans receiving an opioid within 6 months prior to ESRD transition were in the upper East of the United States, including New Jersey (26%), Connecticut (29%), and New Hampshire (30%), Massachusetts, Vermont, Maine, New York, Pennsylvania, as well as Hawaii and North Dakota.

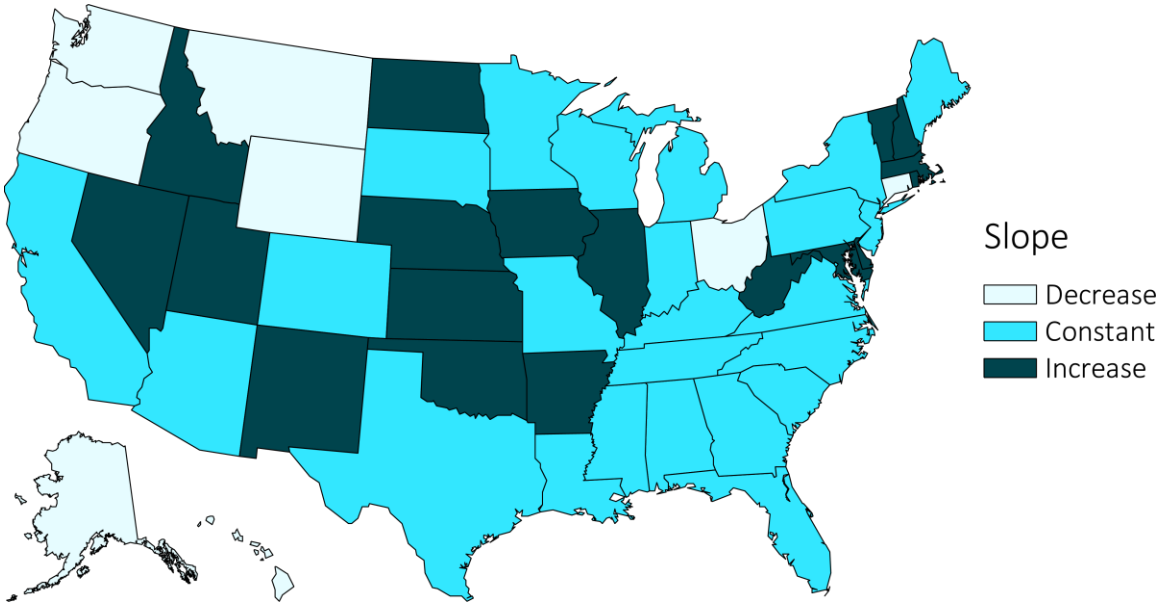
vol 1 Figure 9.51 Proportion of patients with an opioid prescription in the 6 months prior to ESRD transition across the United States in incident ESRD veterans who transitioned to ESRD during 10/1/2007-3/31/2015



Data source: VHA data, CMS Medicare Inpatient and Outpatient data. Abbreviation: ESRD, end-stage renal disease.

Most states had an increase or remained constant with regard to the proportion of patients with a prescription for opioids in the 6 months prior to transition over the 7.5 year period for patients transitioning to ESRD between 10/1/2007-3/31/2015 (Figure 9.52). However, Washington, Oregon, Montana, Wyoming, Alaska, Hawaii, Ohio, and Connecticut showed a decline over this time span.

vol 1 Figure 9.52 Secular trends in the proportion of patients with an opioid prescription in the 6 months prior to ESRD transition across the United States in incident ESRD veterans who transitioned to ESRD during 10/1/2007-3/31/2015



Data source: USRDS ESRD Database. Decrease: ≤-0.01; Constant: <-0.01 to ≤0.01; Increase: >0.01 (% per year). Abbreviation: ESRD, end-stage renal disease.

Data from Kaiser Permanente Southern California

California is the most populous (39.8 million) and racially/ethnically diverse U.S. state. Southern California is the most populous mega-region of California with almost 23 million people (58% of California's population), and bears two of the top 10 most populated cities in the nation (Los Angeles and San Diego). It encompasses the Los Angeles Metropolitan region, including the >17 million people in Los Angeles, San Diego, and Orange Counties combined, and is the fifteenth largest economy in the world. In addition to substantial socioeconomic diversity, Southern California has remarkable racial/ethnic diversity that is reflected among the Kaiser Permanente Southern California member population.

Kaiser Permanente Southern California (KP-SC), the largest Kaiser Permanente region, is an integrated health care system that provides comprehensive health services for over 4.4 million members. Table 9.6 displays demographic characteristics of the KP-SC member population compared to the 2010 U.S. census and California populations. The KP-SC member population, like the California-specific total population, has greater racial/ethnic diversity as compared to the nation. The proportion of Hispanic members at KP-SC matches that of the California-specific total population. KP-SC also has a larger proportion of non-Hispanic Black, and a smaller proportion of non-Hispanic Asian members than the California-specific total population. The proportion of males to females and distribution by age is similar to both the U.S. census and California populations.

vol 1 Table 9.6 Demographic characteristics of the Kaiser Permanente Southern California member population compared to the 2010 U.S. census and California populations

	KPSC (%)	U.S. census 2010 (%)	California 2010 (%)
Sex			
Male	48.2	49.2	49.7
Female	51.8	50.8	50.3
Age			
Under 5 years	5.8	6.5	6.8
5-17 years	19.1	17.5	18.6
18 to 24 years	8.7	9.9	10.5
25 to 44 years	26.1	26.6	28.2
45 to 64 years	28.2	26.4	24.9
65 years and over	12.1	13.0	11.4
Ethnicity			
Hispanic	37.6	16.3	37.6
Non-Hispanic	53.0	83.7	62.4
Unknown	9.4	^	^
Race			
White	47.7	76.2	40.1
Black/African American	9.8	14.6	5.8
American Indian/Alaska Native	0.4	0.9	0.4
Asian	9.1	5.6	12.8
Native Hawaiian/Pacific Islander	1.0	0.2	0.3
Other/Multirace	5.1	2.5	2.8
Unknown	26.3	^	^

Data source: Kaiser Permanente Southern California Electronic Health Records, U.S. Census Bureau. Active KPSC Members (all medical centers) on June 30, 2010. Abbreviation: KPSC, Kaiser Permanente Southern California. ^Data not available.

TRANSITION TO ESRD IN KAISER PERMANENTE SOUTHERN CALIFORNIA

The Kaiser Permanente transition to ESRD (TC-CKD) database is maintained by the KP-SC Renal Business Group, in which all members undergoing dialysis or transplantation are tracked through the health system's Renal Program, and regularly reconciled with internal dialysis unit census and outside claims. Patients' demographic information—including race, ethnicity, sex, and zip code—are linked to the KP-SC Membership and Benefit Research Data Warehouse created by the Research and Evaluation (R&E) Department. This mainly relies on four KP systems: the Operational Data Store (ODS), HealthConnect (HC), the Enhanced Prenatal Services System (PSS), and the Membership Extract Enrollment Management (MXEM) files. Other data such as socioeconomic information (education and household income) are collected from the KP-SC Geocoding database created by the R&E Department, in which three sources, including the U.S. Census, Claritas (i.e. Nielsen), and American Community Survey (ACS) five-year summary are combined.

Mortality data of the ESRD population were obtained from the KP-SC Mortality database, which combines multiple data sources, including the California State Death Master Files, California State Multiple Cause of Death Master Files (MCOD), Social Security Administration (SSA) Death Master Files, KP-SC Hospital and Emergency Room (ER) records, KP-SC Membership System, Perinatal Data Mart (PDM), and Outside Claims Processing System (OCPS).

Over the 10 years between 01/1/2007 and 12/31/2016, 12,242 KP-SC members transitioned to ESRD, i.e. dialysis and transplant patients. Crude and adjusted incidence rates are shown in Table 9.7. KP-SC incidence rates were lower than the U.S. general population, likely due to several different factors. These include an earlier and more standardized comprehensive delivery of care for the CKD population, and a population that may have been comprised of a larger proportion of people who were healthier and employed. KP-SC members were 62.5 ± 14.7 years old (mean ± SD) and included 7,116 (58.1%) men and 5,126 (41.9%) women. Race/ethnic groups included non-Hispanic Whites (3,567, 29.1%), Blacks (2,467, 20.2%), Asians (1,290, 10.6%), Hispanics (4,555, 37.2%), American Indians or Alaska Natives (27, 0.2%), Native Hawaiians or Pacific Islanders (173, 1.4%), and those of other race/ethnicity or unknown (109, 0.9%). According to KP-SC Renal Program records, the primary causes of ESRD were diabetes in 6,276 (51.3%) patients and hypertension in 2,142 (17.5%).

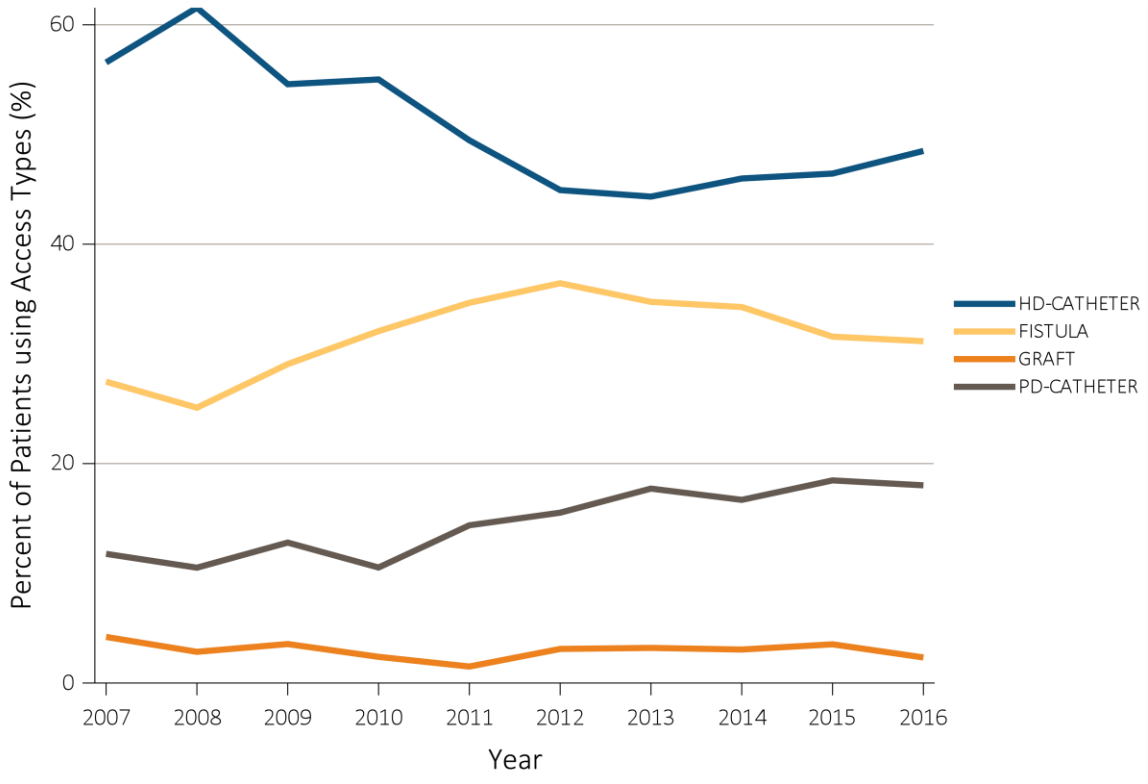
vol 1 Table 9.7 Crude and age- and sex-adjusted incidence rates among Kaiser Permanente Southern California members who transitioned to ESRD between 1/1/2007 and 12/31/2016

Incidence Year	Number of incident ESRD patients	Number of KP-SC members	Crude incidence/ 1,000,000 person years	Age-, Sex-adjusted incidence/1,000,000 person years
2007	1,144	3,183,804	359.3	386.1
2008	1,109	3,200,101	346.6	364.8
2009	1,253	3,216,209	389.6	404.8
2010	1,255	3,247,766	386.4	393.6
2011	1,168	3,387,552	344.8	349.2
2012	1,125	3,485,161	322.8	320.9
2013	1,188	3,551,617	334.5	324.2
2014	1,276	3,667,316	347.9	331.6
2015	1,359	3,908,399	347.7	331.2
2016	1,365	4,080,091	334.6	315.4

Data source: Kaiser Permanente Southern California Electronic Health Records, U.S. Census Bureau. The 2010 U.S. Census was used as the standard population. Abbreviations: ESRD, end-stage renal disease; KP-SC, Kaiser Permanente Southern California.

Of the 12,242 patients who transitioned to ESRD, 10,196 (83.3%) started on hemodialysis (HD), 1,731 (14.1%) started on peritoneal dialysis (PD) (continuous ambulatory PD and continuous cycling PD), and 315 (2.6%) underwent preemptive transplant. Among the 11,927 incident dialysis patients, 5,991 (50.2%) used HD-catheters, 1,750 (14.7%) used PD-catheters, 3,755 (31.5%) used arteriovenous (AV)fistulas, and 351 (2.9%) used AV grafts for initial dialysis access. Figure 9.53 displays the trend for access type among the incident dialysis patients. There was a marked decrease in the use of HD-catheters and an increase in the use of AV fistulas and PD-catheters between 2010 and 2012. HD-catheter was the most common access type of dialysis over time; while AV grafts remained the least common access type.

vol 1 Figure 9.53 Trend of initial dialysis access type used among the 11,927 KP-SC incident dialysis patients who transitioned to ESRD during 1/1/2007-12/31/2016

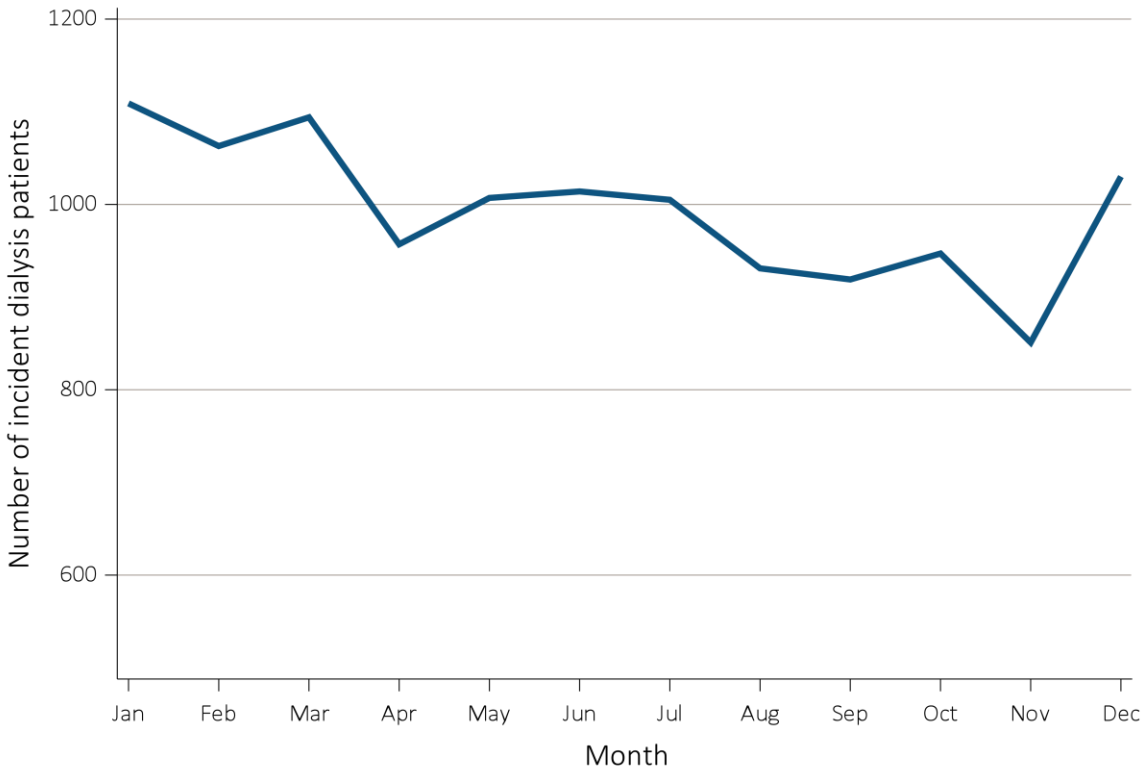


Data source: Kaiser Permanente Southern California Electronic Health Records. Abbreviations: KP-SC, Kaiser Permanente Southern California; ESRD, end-stage renal disease; HD, hemodialysis; PD, peritoneal dialysis.

SEASONAL TREND AMONG KAISER PERMANENTE SOUTHERN CALIFORNIA INCIDENT DIALYSIS PATIENTS WHO TRANSITIONED TO ESRD

The seasonal trend of the 11,927 incident dialysis patients who transitioned to ESRD is shown in Figure 9.54. A greater number of patients transitioned to ESRD in the winter months of January, February, and March, compared to the rest of the year. The fewest incident dialysis patients, less than 900, transitioned to ESRD in the month of November.

vol 1 Figure 9.54 Seasonal trend among 11,927 KP-SC incident dialysis patients who transitioned to ESRD during 1/1/2007-12/31/2016

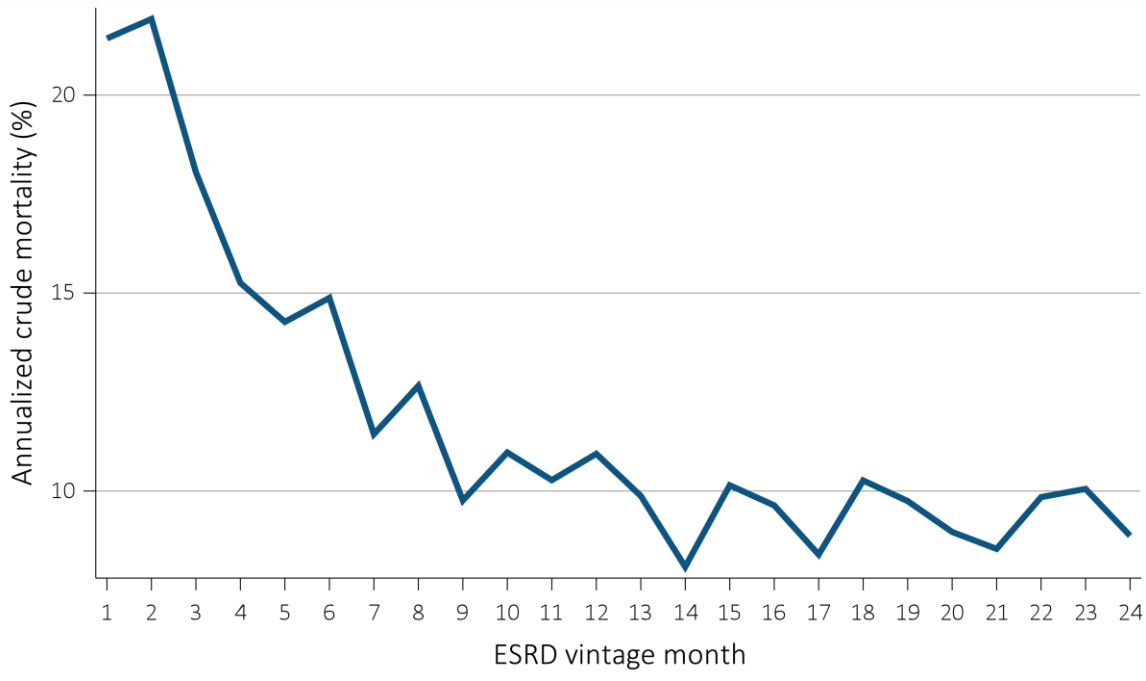


Data source: Kaiser Permanente Southern California Electronic Health Records. Abbreviations: KP-SC, Kaiser Permanente Southern California; ESRD, end-stage renal disease; Jan, January; Feb, February; Mar, March; Apr, April; Jun, June; Jul, July; Aug, August; Sep, September; Oct, October; Nov, November; Dec, December.

MORTALITY IN 24 MONTHS AND UTILIZATION COMPARISON AMONG KAISER PERMANENTE SOUTHERN CALIFORNIA INCIDENT DIALYSIS PATIENTS WHO TRANSITIONED TO ESRD

Annualized mortality rates among 11,927 KP-SC incident dialysis patients over the first 24 months of the vintage period are depicted in Figure 9.55. The higher mortality rates in the first several months bear resemblance to rates observed among veterans with incident ESRD, and the U.S. ESRD population overall. During the first three months, 600 (5.0%) of incident dialysis patients died.

vol 1 Figure 9.55 Annualized unadjusted mortality of the 11,927 KP-SC incident dialysis patients who transitioned to ESRD during 1/1/2007-12/31/2016 and were followed for up to 24 months



Data source: Kaiser Permanente Southern California Electronic Health Records. Abbreviations: ESRD, end-stage renal disease; KP-SC, Kaiser Permanente Southern California.

Table 9.8 displays the number of incident dialysis patients who were hospitalized during pre-transition and post-transition. Of the 8,019 incident dialysis patients who were hospitalized prior to ESRD transition, 4,956 (61.8%) were hospitalized post-transition. Of the 3,908 who were not hospitalized pre-transition, over a third (35.6%) were hospitalized post-transition. Table 9.9 compares hospitalizations for heart failure (HF) and acute kidney injury (AKI) and early mortality. Among patients dying two months after ESRD transition, 38.6% were hospitalized for AKI six months prior to ESRD transition, compared to 19.4% who survived at least 12 months. Congestive heart failure was a primary cause of hospitalization six months prior to ESRD transition among the 28.6% of patients who died at two months compared to 11.1% who were alive more than 12 months.

vol 1 Table 9.8 Number of hospitalizations pre- and post-transition among the 11,927 KP-SC incident dialysis patients during 1/1/2007-12/31/2016

Hospitalization pre-transition	Hospitalization post-transition
Yes N=8,019 (73.1%)	Yes N=4,956 (61.8%)
	No N=3,063 (38.2%)
No N=3,908 (26.9%)	Yes N=1,391 (35.6%)
	No N=2,517 (64.4%)

Data source: Kaiser Permanente Southern California Electronic Health Records. Abbreviation: KP-SC, Kaiser Permanente Southern California.

vol 1 Table 9.9 Comparison of hospitalizations for heart failure and acute kidney injury for KP-SC incident dialysis patients who died at two months vs. alive more than 12 months after ESRD transition

	Patients died at two months (N=427)	Patients died between 2 months and 12 months (N=1,174)	Patients survived more than 12 months (N=10,326)
	N (%)	N (%)	N (%)
Hospitalization in 6 months prior to ESRD transition	382 (89.5)	1,006 (85.7)	6,013 (58.2)
Primary cause of hospitalization in 6 months prior to ESRD transition			
Heart failure	122 (28.6)	275 (23.4)	1,142 (11.1)
Acute kidney injury	165 (38.6)	380 (32.4)	2,004 (19.4)
Hospitalization related diagnosis in 6 months prior to ESRD transition			
Heart failure	235 (55.0)	589 (50.2)	2,724 (26.4)
Acute kidney injury	327 (76.6)	802 (68.3)	4,019 (38.9)

Data source: Kaiser Permanente Southern California Electronic Health Records. Abbreviations: KP-SC, Kaiser Permanente Southern California; ESRD, end-stage renal disease.

TC-CKD COMORBIDITY DATA PRIOR TO ESRD TRANSITION AT KAISER PERMANENTE SOUTHERN CALIFORNIA

The comorbidity data for the prelude period were created from the KP-SC utilization database, which stores comprehensive patient diagnosis and procedure information from 1981 to the present. Pre-existing co-morbidities were determined by ICD-9-CM documentation in records from inpatient or outpatient settings in the three years prior to transition to ESRD. Among the top five comorbid conditions seen in Figure 9.56.a, more than 70% of the 11,927 incident dialysis patients at KP-SC had DM with or without complications; over a third of the ESRD patients had myocardial infarction, and 22% had cancer.

A macro originally developed at Manitoba Centre for Health Policy (MCHP) website was used to estimate Charlson Comorbidity Index (CCI) scores as shown in Figure 9.56.b. A revised, weighted CCI score that excluded renal disease was calculated according to the formula below:

CCI = 1* Myocardial Infarction + 1* Heart Failure + 1* Peripheral Vascular Disease + 1* Cerebrovascular Disease + 1* Dementia + 1* Chronic Pulmonary Disease + 1* Rheumatic Disease + 1* Peptic Ulcer Disease + 1* Mild Liver Disease + 1* Diabetes without chronic complications

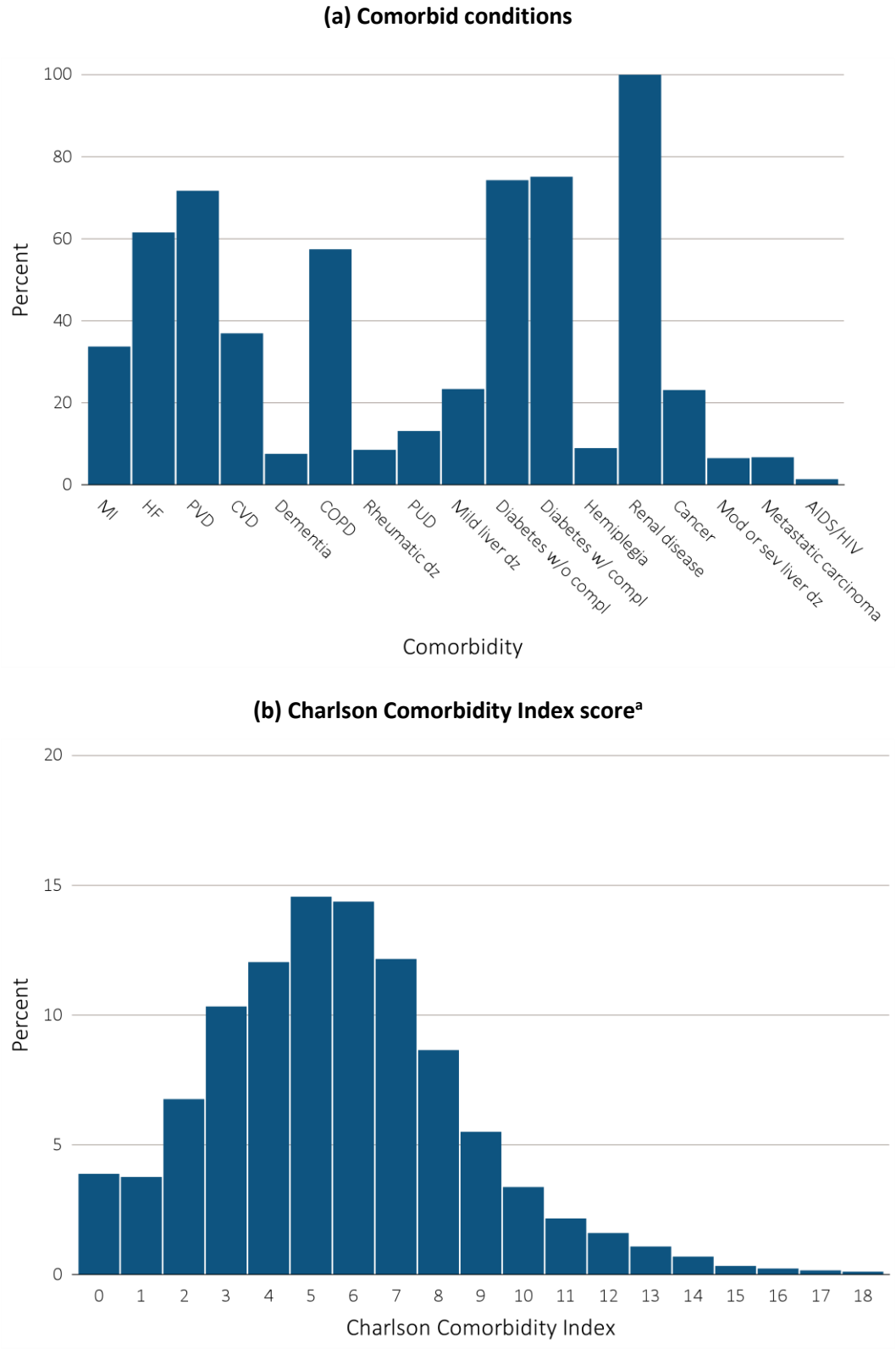
+ 2* Diabetes with chronic complications + 2* Paraplegia or Hemiplegia + 2* Any Cancer

+ 3* Moderate or Severe Liver Disease

+ 6* Metastatic Carcinoma + 6*AIDS/HIV

The mean CCI, excluding renal disease, was 4.2 ± 2.1, and 0.3% had a CCI of 10 or greater. The mean weighted CCI was slightly greater, 5.6 ± 2.9, and 8.9% of the persons with weighted CCI had a CCI of 10 or greater.

vol 1 Figure 9.56 Selected (a) comorbid conditions for calculation of the (b) Charlson Comorbidity Index, prior to transition to ESRD in 11,927 KP-SC incident dialysis patients during 1/1/2007-12/31/2016

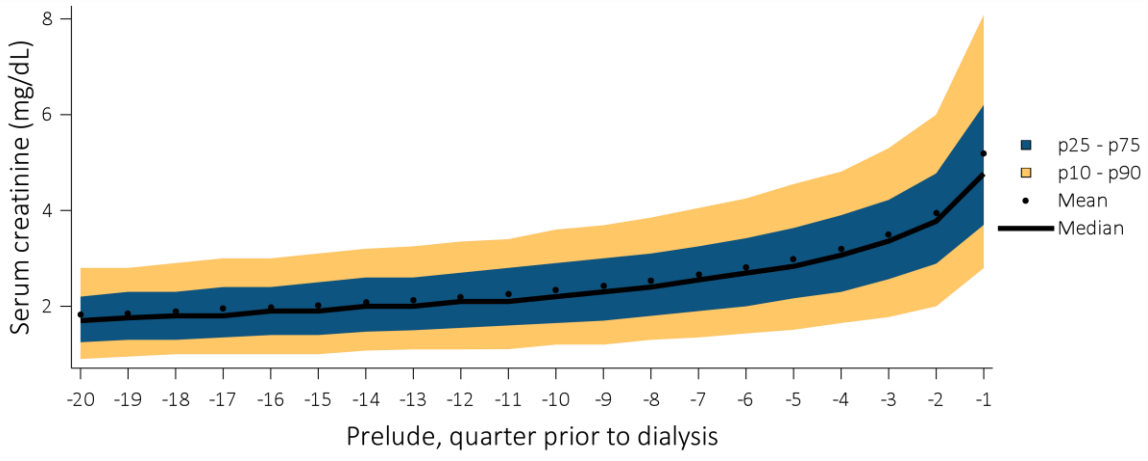


Data source: Kaiser Permanente Southern California Electronic Health Records. [a]Excludes renal disease (not ESRD). Abbreviations: AIDS, acquired immunodeficiency virus; compl, complications; COPD, chronic obstructive pulmonary disease; CVD, cerebrovascular disease; dz, disease; ESRD, end-stage renal disease; HF, heart failure; HIV, human immunodeficiency virus; Kaiser Permanente Southern California; MI, myocardial infarction; Mod, moderate; PVD, peripheral vascular disease; PUD, peptic ulcer disease; sev, severe.

PRELUDE AND VINTAGE LABORATORY TRENDS OF TC-CKD DATA IN KAISER PERMANENTE SOUTHERN CALIFORNIA

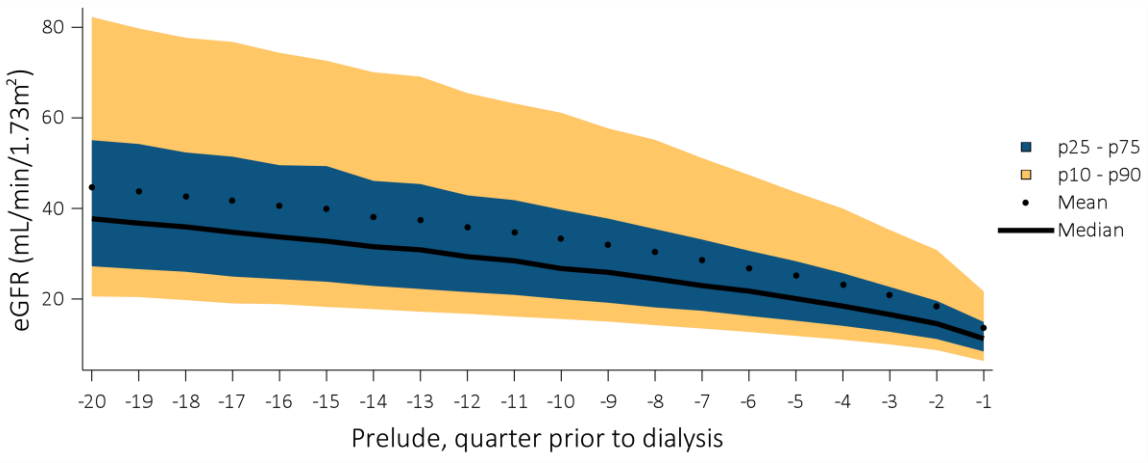
Data spanning over 20 years were extracted from the KP-SC Laboratory database that tracks inpatient and outpatient laboratory orders and results. Figures 9.57 and 9.58 show prelude variables (including serum creatinine and eGFR) averaged by 91-day quarters (n=20 quarters) among the 11,927 patients who transitioned to dialysis. In the 90 days immediately prior to transition, serum creatinine levels remarkably increased and eGFR levels decreased. Furthermore, the age-stratified eGFR trend over 20 quarters shows that older CKD patients had a slower progression rate than younger patients (Figure 9.59). Examining the eGFR trend by cause of ESRD in Figure 9.60, we find that those with diabetes had a faster progression rate than those with hypertension or other causes for most of the prelude quarters.

vol 1 Figure 9.57 Trend in serum creatinine level during the prelude (pre-ESRD) period over 20 quarters among 11,927 KP-SC patients who transitioned to dialysis during 1/1/2007-12/31/2016



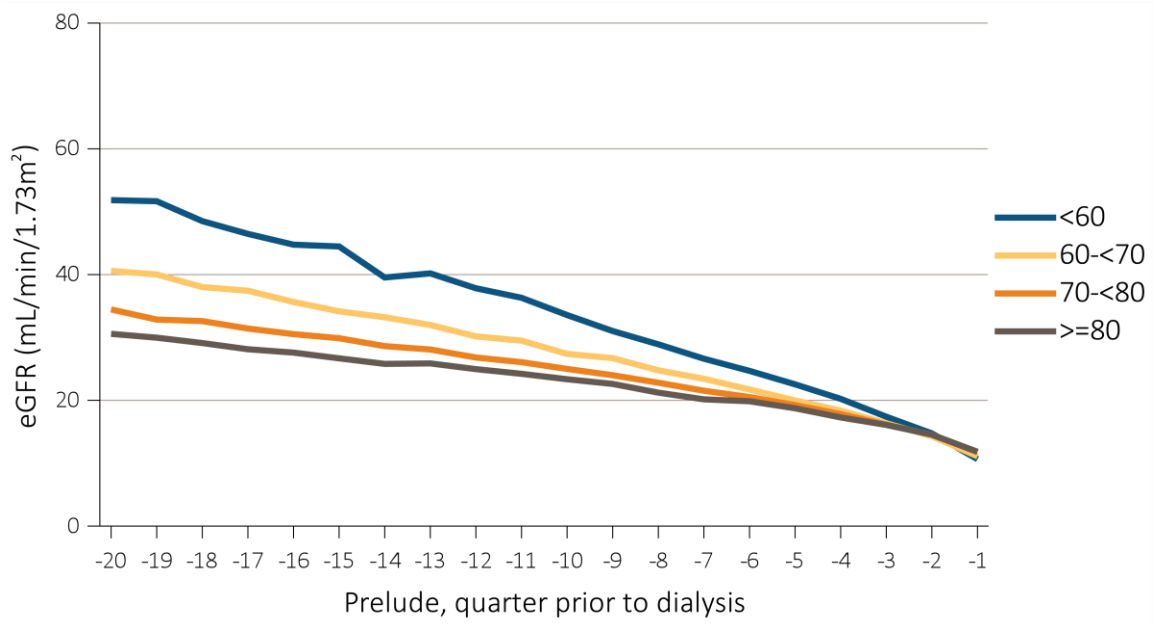
Data source: Kaiser Permanente Southern California Electronic Health Records. Abbreviations: ESRD, end-stage renal disease; KP-SC, Kaiser Permanente Southern California; mg/dL, milligrams per deciliter; p, percentile.

vol 1 Figure 9.58 Trend in eGFR during the prelude (pre-ESRD) period over 20 quarters among 11,927 KP-SC patients who transitioned to dialysis during 1/1/2007-12/31/2016



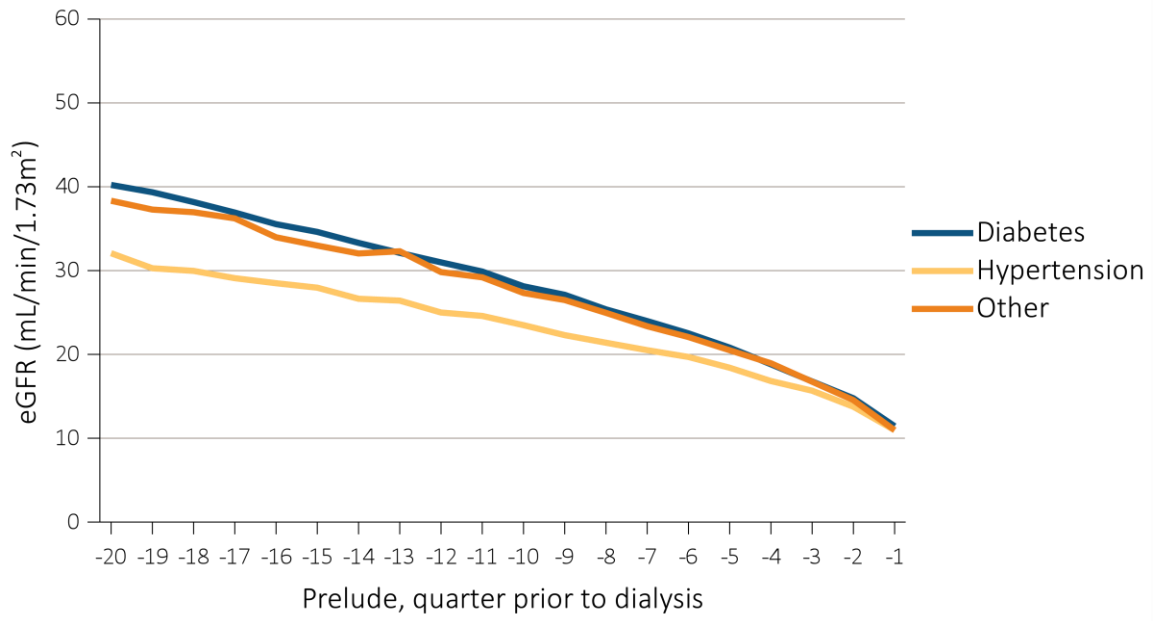
Data source: Kaiser Permanente Southern California Electronic Health Records. Abbreviations: eGFR; estimated glomerular filtration rate; ESRD, end-stage renal disease; KP-SC, Kaiser Permanente Southern California; mL/min/1.73m², milliliter per minute per 1.73 meters squared; p, percentile.

vol 1 Figure 9.59 Trends in eGFR[a] during the prelude (pre-ESRD) period over 20 quarters among 11,927 KP-SC patients who transitioned to dialysis during 1/1/2007-12/31/2016, stratified by age-at-incidence



Data source: Kaiser Permanente Southern California Electronic Health Records. [a]Median eGFR. Abbreviations: eGFR; estimated glomerular filtration rate; ESRD, end-stage renal disease; KP-SC, Kaiser Permanente Southern California; mL/min/1.73m², milliliter per minute per 1.73 meters squared.

vol 1 Figure 9.60 Trends in eGFR[a] during the prelude (pre-ESRD) period over 20 quarters among 11,927 KP-SC patients who transitioned to dialysis during 1/1/2007-12/31/2016, stratified by cause of ESRD

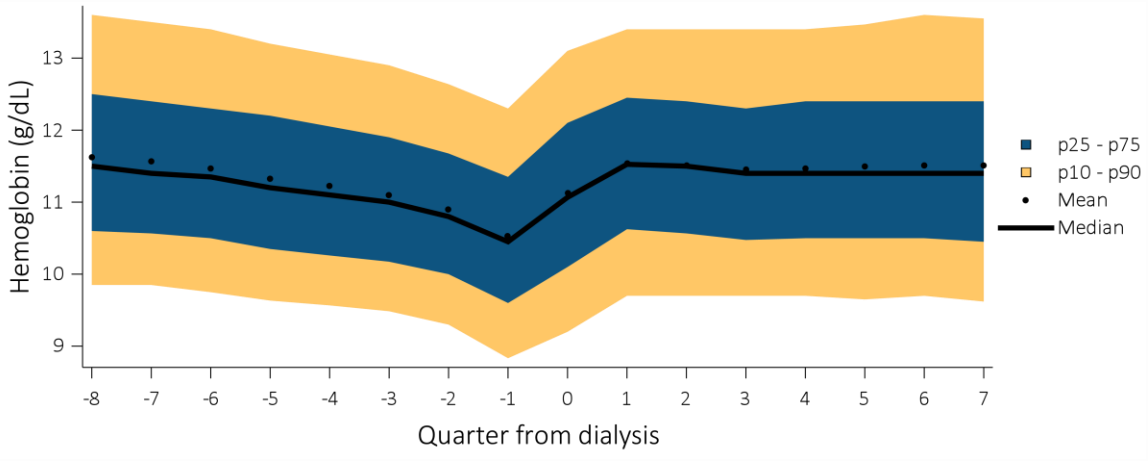


Data source: Kaiser Permanente Southern California Electronic Health Records. [a]Median eGFR. Abbreviations: eGFR; estimated glomerular filtration rate; ESRD, end-stage renal disease; KP-SC, Kaiser Permanente Southern California; mL/min/1.73m², milliliter per minute per 1.73 meters squared.

For the 11,927 patients who transitioned to ESRD, we show selected KP-SC laboratory data for hemoglobin, hemoglobin A1C, phosphorus, parathyroid hormone, and albumin levels over eight prelude (quarters -8 to -1) and eight vintage (quarters 0 to +7) quarters (Figures 9.61, 9.62, 9.63, 9.64, and 9.65).

Mean hemoglobin levels gradually decreased from 11.6 g/dL to a nadir of 10.5 g/dL in the prelude period of progression from CKD to ESRD. Immediately after transition to ESRD, a slight increase in mean hemoglobin to 11.1 g/dL was observed in the first quarter (quarter 0), followed by a rise to a peak of 11.5 g/dL in the second quarter (quarter 1). Subsequent mean hemoglobin levels decreased in vintage quarter 3 and later stabilized (Figure 9.61).

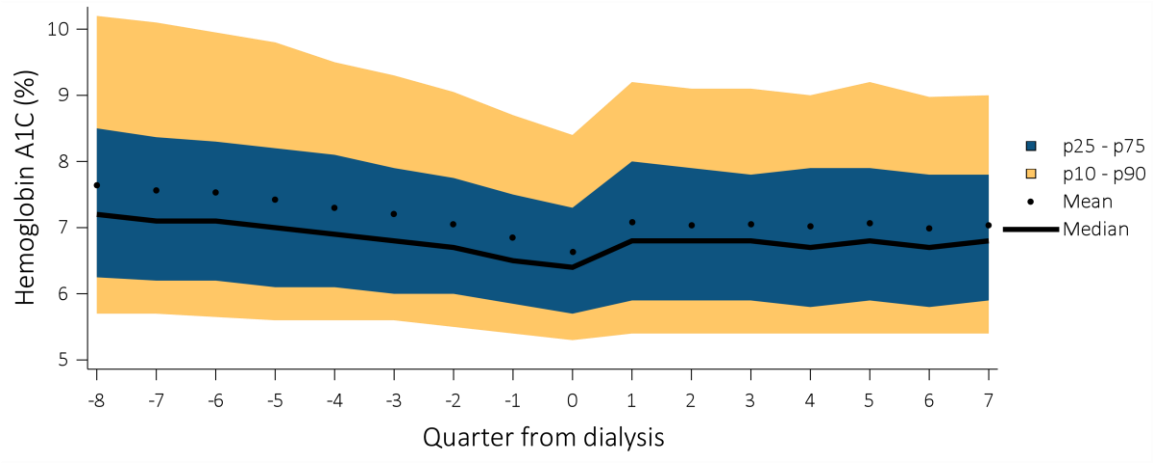
vol 1 Figure 9.61 Trend in hemoglobin levels (g/dL) over 8 quarters each in the prelude (pre-ESRD) and vintage (post-ESRD) periods among 11,927 KP-SC patients who transitioned to dialysis during 1/1/2007-12/31/2016



Data source: Kaiser Permanente Southern California Electronic Health Records. Abbreviations: ESRD, end-stage renal disease; KP-SC, Kaiser Permanente Southern California; HGB, hemoglobin; g/dL, grams per deciliter; p, percentile.

In Figure 9.62, mean hemoglobin A1C levels dropped from 7.6% to 6.8% in the prelude period, then slightly decreased even further to 6.6% immediately after transition to ESRD. In the second quarter, post-transition (quarter 1), mean hemoglobin A1C levels rose to 7.1% and remained stable afterwards in the vintage period.

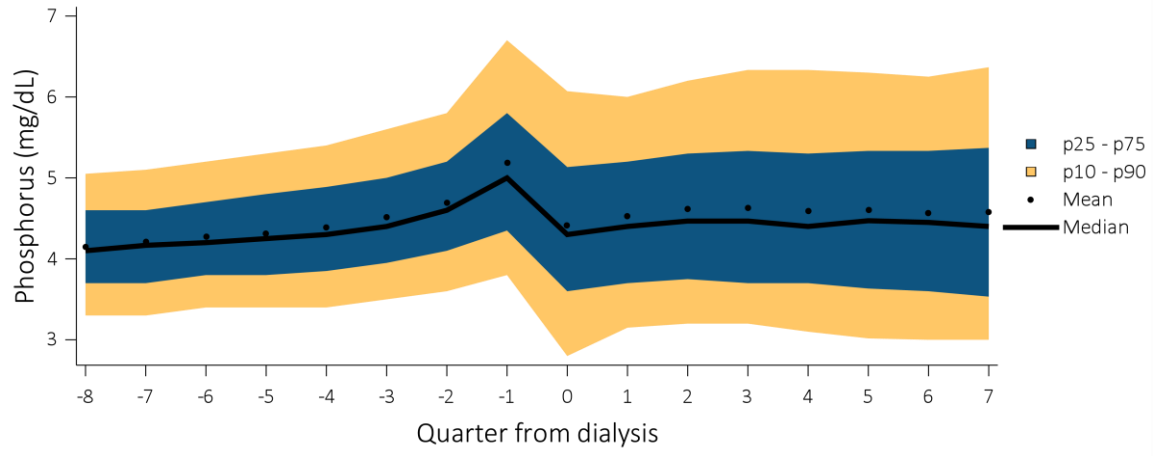
vol 1 Figure 9.62 Trend in hemoglobin A1C levels (%) over 8 quarters each in the prelude (pre-ESRD) and vintage (post-ESRD) periods among 11,927 KP-SC patients who transitioned to dialysis during 1/1/2007-12/31/2016



Data source: Kaiser Permanente Southern California Electronic Health Records. Abbreviations: ESRD, end-stage renal disease; KP-SC, Kaiser Permanente Southern California; Hgb, hemoglobin; p, percentile.

Mean phosphorus levels increased in the prelude period from 4.2 mg/dL to 5.2 mg/dL (Figure 9.63). Immediately after transition to ESRD, mean phosphorus decreased to 4.4 mg/dL. In the third quarter post-transition (quarter 2), mean phosphorus increased to 4.6 mg/dL and remained stable in the vintage period.

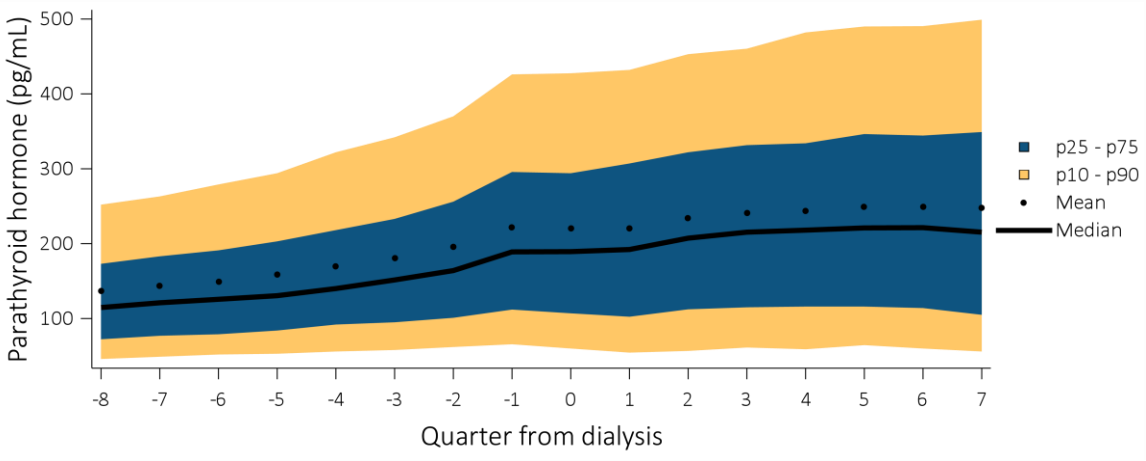
vol 1 Figure 9.63 Trend in phosphorus levels (mg/dL) over 8 quarters each in the prelude (pre-ESRD) and vintage (post-ESRD) periods among 11,927 KP-SC patients who transitioned to dialysis during 1/1/2007-12/31/2016



Data source: Kaiser Permanente Southern California Electronic Health Records. Abbreviations: ESRD, end-stage renal disease; KP-SC, Kaiser Permanente Southern California; mg/dL, milligrams per deciliter; p, percentile.

Figure 9.64 shows mean parathyroid hormone levels steadily increasing over the prelude and vintage periods from 136.2 pg/mL to 248.0 pg/mL. Transition to ESRD did not appear to modify the trajectory of increasing parathyroid hormone levels over time.

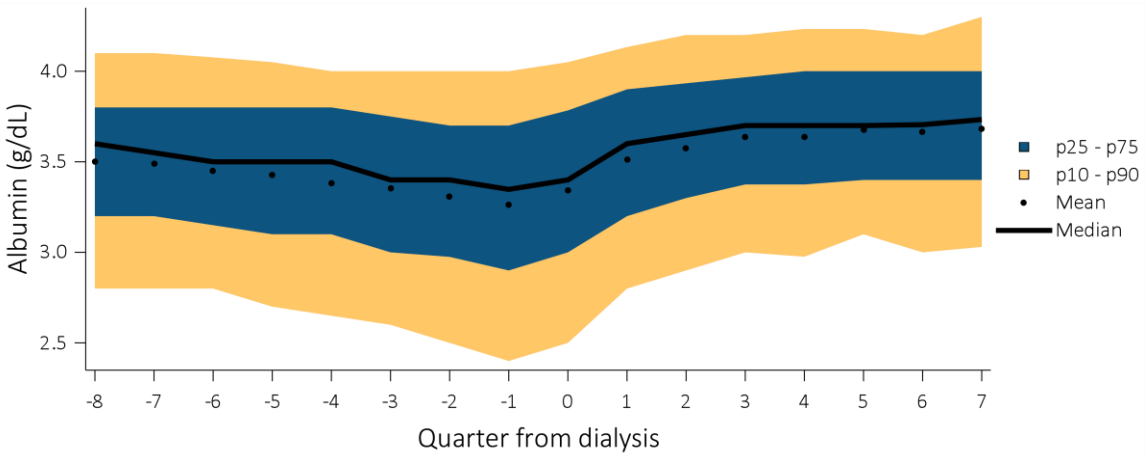
vol 1 Figure 9.64 Trend in parathyroid hormone levels (pg/mL) over 8 quarters each in the prelude (pre-ESRD) and vintage (post-ESRD) periods among 11,927 KP-SC patients who transitioned to dialysis during 1/1/2007-12/31/2016



Data source: Kaiser Permanente Southern California Electronic Health Records. Abbreviations: ESRD, end-stage renal disease; KP-SC, Kaiser Permanente Southern California; PTH, parathyroid hormone; pg/dL, picograms per deciliter; p, percentile.

Mean albumin levels dropped from 3.5 g/dL to 3.3 g/dL over the prelude period. Immediately after transition to ESRD, mean albumin increased to 3.4 g/dL in the first quarter to 3.7 g/dL in the fourth quarter (quarter 3) of the vintage period, and subsequently remained stable (Figure 9.65).

vol 1 Figure 9.65 Trend in albumin levels (g/dL) over 8 quarters each in the prelude (pre-ESRD) and vintage (post-ESRD) periods among 11,927 KP-SC patients who transitioned to dialysis during 1/1/2007-12/31/2016



Data source: Kaiser Permanente Southern California Electronic Health Records. Abbreviations: ESRD, end-stage renal disease; KP-SC, Kaiser Permanente Southern California; g/dL, grams per deciliter; p, percentile.

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Volume 1: CKD Analytical Methods

Contents

Introduction

In this chapter, we describe the data sources, preparation and management, variable definitions, and analytical methods used to produce the statistics presented in Volume 1 of the 2018 USRDS Annual Data Report (ADR), which focuses on chronic kidney disease (CKD) prior to end-stage renal disease (ESRD). For information regarding the datasets and methods used for ESRD analyses, see the *ESRD Analytical Methods* chapter in Volume 2. This CKD Methods chapter does not address Volume 1, *Chapter 9: Transition of Care in Chronic Kidney Disease*, which is the product of a USRDS Special Study Center. Relevant methods are included within that chapter.

Data Sources

The USRDS uses several data sources to describe kidney disease not requiring treatment by dialysis or kidney transplantation in the U.S. These contain data regarding patient diagnoses, demographic characteristics, healthcare procedures, prescription drug plan participation, and filled prescriptions. Data on the non-institutionalized, general population are from the National Health and Nutrition Examination Survey (NHANES) and the Behavioral Risk Factor Surveillance System (BRFSS). For patients with CKD, acute kidney injury (AKI) and related comorbidities, data from three healthcare systems are used: the standard Centers for Medicare & Medicaid Services (CMS) Medicare 5% sample, the Optum Clinformatics™ Data Mart Database of people with commercial health insurance and Medicare Advantage plans, and the Veterans Health Administration (VHA) beneficiary data.

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 U.S. In 1999, NHANES became a continuous, annual survey to provide for more timely and regular estimates; public-use data files are released every two years.

NHANES 1999–2016 are nationally-representative, cross-sectional surveys with a complex, stratified, multi-stage probability cluster sampling design that includes the selection of primary sampling units (counties), household segments within the counties, and sample persons from selected households (Ingram et al., 2018). Survey participants are interviewed in their homes and/or receive standardized medical examinations in mobile examination centers. African Americans, Mexican Americans, and individuals aged 60 or older are over-sampled to improve the estimates for these subgroups.

Behavioral Risk Factor Surveillance System

The BRFSS is a series of telephone-based surveys of health-related risk behaviors, chronic health conditions, and use of preventive services; BRFSS sampling is designed to provide state-specific estimates (CDC, 2018). Like NHANES, it is also conducted by the CDC through NCHS. BRFSS began in 1984 with 15 states, and expanded nationwide in 1993. As of 2011, in addition to traditional landline subscribers, cell phone users are included in the sample frame. A question regarding kidney health was added starting in 2012—specifically, respondents are asked, *"Has a doctor, nurse, or other health professional ever told you have kidney disease? Do NOT include kidney stones, bladder infection or incontinence (Incontinence is not being able to control urine flow)."* Allowable responses were "yes", "no", and "not sure", with additional coding for "refused to answer" and "missing/not asked." The response rate for this question was very good. Of the 475,687 respondents in 2012, for example, only 202 respondents refused to answer (0.04%), three were missing, and 1,322 answered "not sure" (0.28%). Data from 2012-2016 are used in the 2018 ADR.

Optum Clinformatics™ Data Mart Database (OptumInsight, Eden Prairie, MN)

The Optum Clinformatics™ Data Mart provides paid medical and prescription claims and enrollment information for participants in the commercial insurance plans and Medicare Advantage plans of a large U.S.

managed-care health insurance company. Included plan members are enrolled in both a medical and a prescription plan, and the sample represents all areas of the country.

In 2018, OptumInsight delivered a refreshed dataset for the years 2005-2016, which included more claims for earlier years. In addition, the death data was also refreshed with increased death ascertainment, especially for older years. Claims for encounters that are not billed separately, such as follow-up visits after a surgery, were newly added to the dataset this year. The physical structure of the data files also changed; instead of 25 diagnoses on each claim, the data set now had observations with one diagnosis code and each claim had up to 25 observations. In data analysis terms, the dataset went from wide to long. The inpatient procedure codes were also restructured this way. This had no effect on the identification of diseases or procedures. The data refreshment process, however, did results in some differences in trends this year compared to last year.

The Optum Clinformatics™ data license requires that their data not be merged with any other data files, so we are unable to match these individuals with the USRDS ESRD databases to comprehensively identify ESRD patients. Therefore, we assign these individuals a first service date for ESRD as the earliest date of either the first claim with a diagnosis of ESRD, a procedure code for outpatient dialysis, or a diagnosis related group (DRG) code for a kidney transplant surgery. See Table 10.1 for specific code values.

We present Optum Clinformatics™ data from 2006 through 2016 in the 2018 ADR. To comply with the Health Insurance Portability and Accountability Act of 1996 (HIPAA) and prevent the re-identification of individuals in the database, certain combinations of sensitive data elements are not allowed. OptumInsight provides the data as different 'views', each containing a limited amount of sensitive data. For this report, we use the Date of Death (DOD) view—detailed geographic and socio-economic data are not available in the files, but date of death (month/year) is included. The other available data views do not contain date of death. Enrollment and member information, such as year of birth, sex, race/ethnicity, state of residence, and plan participation are contained in the DOD_MEMBER_REVISED data table.

All services for both inpatient and outpatient care are located in the MED_<YEAR> claims data table, with the confinement ID (*conf_id*) variable indicating inpatient institutional claims. We create admission and discharge dates from the med_<year> file using the earliest date of a service performed for a *conf_id* as the admission date and discharge from the latest claim with the *conf_id*. We validate this approach by comparing the confinement IDs that were in both the MED_<YEAR> and CONF_<YEAR> tables and check for matching admission and discharge dates. We do this because in our initial look at the data, we identified more hospitalizations *(conf_id)* in the MED_<YEAR> than in the CONF_<YEAR> table. We then use these dates to identify all institutional and non-institutional medical services performed for the patient during that time.

vol 1 Table 10.1 ICD diagnosis, CPT procedure, and DRG codes used to define ESRD in the Optum Clinformatics™ and VHA datasets throughout Volume 1 of the ADR

Type of Code		Code Values
ICD-9-CM Diagnosis codes		585.6, 996.81, V42.0, V45.1, V56.0, V56.1, V56.2, V56.3, V56.31, V56.32, V56.8, E879.1
ICD-10-CM Diagnosis codes		N18.9, T86.10-T86.13, T86.19
HCPCS codes		90935, 90937,90940, 90945, 90947, 90951-90970, 90989, 90993, 90997, 90999; *codes from earlier years:* 90918-90925
DRG Codes	**Prior to FY2007:**	302,512
	FY2007-present:	652,008

Abbreviations: CPT, current procedural terminology; DRG, diagnosis related group; ESRD, end-stage renal disease; FY, fiscal year (10/1/yy to 9/30/yy); HCPCS, Healthcare Common Procedure Coding System; ICD-9/10-CM, International Classification of Diseases, Ninth/Tenth Revision, Clinical Modification.

The DOD_MEMBER_REVISED table was processed to create an enrollment table by deleting observations with data inconsistencies, and combining enrollment periods with a non-coverage gap of less than one month. Enrollment observations were dropped if (1) the year of birth variable, *yrdob*, was missing or zero, (2) the year of the plan coverage effective date, *eligeff*, was before the year of birth, (3) the year of plan coverage effective date was after the year of the death date, (4) the coverage ending date, *eligend*, was the same as or earlier than the coverage start date, or (5) the member had more than one year of birth reported and they differ by more than one year.

Observations from DOD_MEMBER_REVISED with overlapping enrollment periods (defined as *eligeff* through *eligend*) are combined into one. Observations where the gap between the end date (*eligend*) of the first period (i.e. observation) and the start (*eligeff*) of the second period is less than one month are also combined, as beneficiaries with brief coverage lapses do not present as significantly different than those with continuous coverage.

Date of death information is provided as month and year only, not as a specific date. We have set all deaths to the first day of the reported month to create a specific death date from the month and year combination. Insurance claims do not have information on death unless the death occurred during a covered inpatient stay as identified through the discharge status (*dstatus*). The insurance company may only be informed that the member's coverage has ended. However, Optum augments information in the Clinformatics™ Data Mart with data from the Social Security Death Master File (SSDMF). In November of 2011, some states stopped reporting death information to the SSDMF, causing a 30% drop in the number of death records contained in the database (OptumInsight, 2015). This may overstate the survival statistics, as more deaths will go undetected. For this reason, we do not present analysis of mortality rates for the Optum Clinformatics™ dataset, although other chapters do use date of death to censor time to event analyses.

Information on Optum Clinformatics™ expenditures is given in real dollars with Optum providing cost factors and cost basis year for researchers to adjust across years and across cost basis years. To account for differences in pricing across health plans and provider contracts, OptumInsight applies standard pricing algorithms to the claims data in the Optum Clinformatics™ Data Mart. These algorithms are designed to create standard prices that reflect allowed payments across all provider services. Standard pricing amounts are included in the MED_<YEAR> and the PHARM_<YEAR> claims tables. Standard prices are determined for each service (CPT code) and are applied to every claim, regardless of

whether actual payment was made for that service. This resulted in the addition of encounter claims. One needs to exclude these claims prior to summing up cost data to represent actual expenditures by the insurance company. The encounters are mostly health care services that are bundled with a more extensive procedure, like follow-up visits after surgery. They are paid within the payment for the surgery, but also added to the medical claims to document that a visit happened even though it was not billed for individually.

CENTERS FOR MEDICARE & MEDICAID SERVICES MEDICARE 5% SAMPLE

These files contain billing data from final action claims on behalf of Medicare beneficiaries; all adjustments have been resolved, and submitted to Medicare by healthcare providers for reimbursement. CMS and its contractors produce the 5% datasets by selecting all final action claims for Medicare beneficiaries whose CMS Health Insurance Claim (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 creates a built-in longitudinal panel dataset as well as a nationally representative, yearly cross-section sample. 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. Since 2015, the USRDS Coordinating Center has received the data files from the Medicare Chronic Conditions Warehouse contractor. The files, described below, are collectively referred to in the ADR as the Medicare 5% files. The 2018 ADR includes all claims for care occurring up to December 31, 2016, that were submitted and processed by June of 2017.

ENROLLMENT DATA (DENOMINATOR FILE)

Since 2015, we have received two data files from the Master Beneficiary Summary File—one for Medicare Parts A and B (MBSF_AB_SUMMARY; formerly called the Denominator file) and another for Part D (MBSF_D_CMPNTS). The files provide 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]).

MEDICARE PARTS A AND B CLAIMS FILES

Claims files for Medicare Parts A and B are divided into two groups based on the type of healthcare provider—institutional or non-institutional (physician/supplier and durable medical equipment). Institutional claims are divided into five sets of files based on the type of medical service: INPATIENT, OUTPATIENT, and HHA (home health agency), HOSPICE, and SNF (skilled nursing facility) care. For each type of medical service we receive six files corresponding to different parts of the claim: (<*type of service*>_BASE_CLAIMS_J (the base claim file), <*type of service*>_REVENUE_CENTER_J (revenue center file), <*type of service*>_CONDITION_CODES (condition code file), <*type of service*>_OCCURRNCE_CODE (occurrence code file), <*type of service*>_SPAN_CODES (span code file), and <*type of service*>_VALUE_CODES (value code file).

Physician and supplier claims (also referred to as carrier claims) are received in one set for durable medical equipment (DME) and another for all other Part B covered services (BCARRIER). For each of these, we receive two files corresponding to different parts of the claim (<*type of service*>_CLAIMS_J (the base claim file) and <*type of service*>_LINE_J (the line item file).

MEDICARE PART D FILES

For Part D, we receive files on beneficiary information and prescription drug events (records of each prescription fill and refill, similar to a claim), as well as information about plan characteristics and premiums. The MBSF_D_CMPNTS file, mentioned above, contains monthly enrollment information for Part D program participation, type of plan, creditable coverage, eligibility for cost sharing and low-income subsidies, and additional information. The Part D Events (PDE) file contains all events related to final action claims for prescription drugs submitted by pharmacies on behalf of the Part D beneficiary. This dataset contains details about the drug (name, days supplied, dose, strength, quantity, etc.) and payment

amounts. In addition to these beneficiary and beneficiary-prescription fill level datasets, we also receive files containing data about the Part D plan, prescribers, and pharmacies. For the 2018 ADR, we use the Plan Characteristics file (PLAN_CHAR) to report on the coverage gap.

VETERANS HEALTH ADMINISTRATION DATA

In the 2018 ADR, we update analyses of Veterans Health Administration (VHA) data (first introduced in 2016) on kidney disease and present new tabulations. Data are primarily from the VHA Corporate Data Warehouse (CDW) supplemented by laboratory results from the Managerial Cost Accounting (MCA, formerly Decision Support System, DSS) National Data Extract LAR file. Data is accessed through and stored in the VA Informatics and Computing Infrastructure (VINCI). Data in the CDW is refreshed nightly from the VHA's electronic medical record, and the analyses in the 2018 ADR are based on a cohort created by the VINCI data manager on January 18, 2018. Our basic cohort is defined as all patients with at least one outpatient encounter (a record in the VISIT table in the OUTPAT domain) during calendar year 2016. Age, sex, race, and date of death are taken from the PATIENT_PATIENT table, and race is taken from the PATSUB_PATIENTRACE table. Ethnicity is taken from PATSUB_PATIENTETHNICITY.

In the CDW, various types of inpatient care provided by the VHA are included in the INPAT_INPATIENT table. These include the stays at short-term hospitals that are commonly thought of when referring to hospital care, but also admissions to rehabilitation hospitals, long-term care facilities, and the VA's Domiciliary Residential Rehabilitation Treatment Programs, among others. We identified short-term hospital stays by requiring the *medical_service* variable to have one of the following values: medicine, surgery, psychiatry, spinal cord injury, intermediate medicine, or neurology. Additionally, the specialty variable must also have had a value related to the type of care provided in short-term hospitals[1].

Serum creatinine laboratory test results are obtained from the MCA_LAR file. The variable *dsslarno* denotes the type of laboratory test result in each observation; a value of '31' denotes serum creatinine. Lab results are categorized using the result date variable (*res_date*) rather than the order date, collection time, or date of the visit associated with the lab order. Records with text in the result field (such as COMMENT, CANC, PENDING, etc.) are dropped, as are those with values less than 0.4 mg/dL or greater than 15.0 mg/dL for the CKD analyses (20.0 mg/dL for the AKI analyses).

ESRD MEDICAL EVIDENCE FORM (CMS 2728)

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, we search the USRDS ESRD databases for the beneficiaries in the Medicare 5% files. The date of ESRD is determined from the ESRD Medical Evidence form (CMS 2728), the official form for registering ESRD patients, which dialysis or transplant providers must submit within 45 days of ESRD initiation. First service date for ESRD is reported on this form; for analyses in Volume 2, this is used as the date when ESRD began. See Volume 2, *ESRD Analytical Methods* for additional information on how the Medical Evidence form was used in analyses of ESRD patients.

ESRD DEATH NOTIFICATION FORM (CMS 2746)

The Master Beneficiary Summary File delivered with the Medicare 5% 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% file who experienced 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, dialysis or transplant providers must submit this form within 30 days of a patient's death.

[1] Contact usrds@usrds.org to request a detailed listing of all specialty variable values.

Race and Ethnicity

Throughout the ADR, race and ethnicity categorizations are limited by the distinctions available in the original data sources. The race variables for the CKD volume are different from those available in the ESRD volume, so we are unable to replicate the new race/ethnicity categories implemented in the 2017 ADR. Table 10.2 shows the categories included in the original data files. For the Medicare 5% files and Optum Clinformatics™ Data Mart, we were unable to consider ethnicity as separate from race or to separate Pacific Islanders from other categories (Asian or Other). Additionally, we cannot identify Native Americans in the Optum Clinformatics™ data. The NHANES, BRFSS, and VHA data report two variables, one with race categories, and a second designating Hispanic ethnicity. These categories are combined for some analyses due to the small sample sizes in some datasets.

vol 1 Table 10.2 Race and ethnicity variables in Volume 1 data sources

Race/ethnicity variables	NHANES	BRFSS	Medicare 5% data	Clinformatics™ Data Mart	Veterans Health Administration
Separate variable for Hispanic?	X	X			X
Race Variable Categories					
White	X	X	X	X	X
Black/African American	X	X	X	X	X
Hispanic	Separate	Separate	X	X	Separate
Native American	X	X	X		X
Asian	X	X	X	X	X
Pacific Islander/Native Hawaiian	X	X			X
Other	X	X	X		X
Unknown/missing/refused	X	X	X	X	X

Abbreviations: NHANES, National Health and Nutrition Examination Survey; BRFSS, Behavioral Risk Factor Surveillance System.

General Methods for Health Insurance Claims Data Files

For the purpose of analysis, several restrictions are applied to the claims data files to create a sample cohort. The individual restrictions that are used for each figure and table are detailed in the chapter-specific sections of this chapter. The general rationale and explanation of these restrictions apply to all analyses with the health system data files and are detailed here. It is important to remember that the primary purpose of the data collection underlying these datasets is to reimburse healthcare providers for services performed for beneficiaries. Information that is not necessary to facilitate payment for services, such as results of lab tests, family medical history, or health behaviors such as smoking, generally is not available in the dataset.

Plan Participation

Medicare currently provides medical benefits through four programs commonly 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 (including physician services, durable medical equipment, ambulance, radiology, and laboratory services), Part C is for enrollment in managed care plans (which provide all Part A and Part B services), and Part D provides prescription drug coverage (CMS, 2014).

Part A coverage is free to Medicare beneficiaries, while other parts require premiums to be paid by the beneficiary and are optional. Beneficiaries are also allowed to switch between Original Medicare (fee-for-service) and 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% 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 the Optum Clinformatics™ Data Mart, plan enrollment intervals are provided in the MEMBER_DETAIL table with a start date (*eligeff*) and an end date (*eligend*). In some analyses for both datasets, the cohort is limited to patients who meet these plan participation requirements on a certain date, such as January 1 of the reported year. In other cases the sample may have been limited to beneficiaries who meet those enrollment requirements during the entire calendar year.

In most analyses limited to patients with a certain disease or disorder, such as CKD, Medicare beneficiaries must be enrolled in Parts A and B and not Part C for the year prior to the reported year (the entry period or 'year one'), while Optum Clinformatics™ patients must be enrolled in their plan for the year. This ensures that each patient has 12 months of 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 use claims during the reported year (the typical year two) to determine the presence of the disorder.

Medicare Reason for Entitlement

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

ESRD

As the focus of this volume is on patients who do not have ESRD, Medicare patients under age 65 who were only eligible for Medicare due to ESRD are excluded. The Optum Clinformatics™ Data Mart cannot be linked to the USRDS ESRD database due to licensing restrictions, so the identification of ESRD patients is from diagnosis and procedure codes from claims. Most analyses for both data sources restrict the sample to beneficiaries/plan members who 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, readmission, time to the performance of a laboratory test) often censor a patient at the start of ESRD. Censoring also often occurs at death, upon change in plan enrollment (for Medicare beneficiaries, the disenrollment from Parts A and B of Medicare or when switching to a Medicare Advantage plan, and for Optum Clinformatics™ patients at the end of plan participation as reported by the *eligend* variable). The start of ESRD is the date of first service from the CMS 2728 form for Medicare patients and the date of the first claim with an ESRD diagnosis, outpatient dialysis procedure, or transplant hospitalization for Optum Clinformatics™ plan members (starting in 2004 through the most recent year).

Identification of Major Comorbidities

We employ a previously validated method (Herbert et al., 1999) to identify diabetic patients through Medicare claims. A patient is considered diabetic if, within a one-year observation period, he or she had a qualifying ICD-9-CM or ICD-10-CM diagnosis code of diabetes mellitus (DM) on one or more Part A institutional claims (inpatient, skilled nursing facility, or home health

agency), or on two or more institutional outpatient claims and/or Part B physician/supplier claims. 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. This same algorithm is also applied to the claims data in the Optum Clinformatics™ Data Mart with the inpatient/outpatient determination made by determining if the service date fell within an inpatient confinement identified by the confinement ID (admission and discharge dates calculated from the first and last date of the claims with a specific confinement ID). Tables 10.3 and 10.4 list these conditions and the ICD-9-CM and ICD-10-CM diagnostic codes used to define them. Additionally, the overall grouping of cardiovascular disease (CVD) includes patients with at least one of these individual conditions: coronary artery disease (formerly called atherosclerotic heart disease), heart failure (HF; formerly called congestive heart failure), cerebrovascular accident/transient ischemic attack, peripheral vascular disease, dysrhythmias, or other cardiac conditions. Analyses within individual chapters also define additional conditions using the same algorithmic structure, as described in the chapter-specific sections below.

vol 1 Table 10.3 ICD-9-CM and ICD-10-CM diagnosis codes used to define chronic kidney disease in the health insurance claims data files throughout Volume 1 of the ADR

	ICD-9-CM codes	ICD-10-CM codes
Chronic kidney disease (CKD)	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; 581-583; 585-588; 591; 642.1; 646.2; 753.12-753.19; 753.2; 794.4	A18.11, A52.75, B52.0, C64.x, C68.9, D30.0x, D41.0x-D41.2x, D59.3, E08.2x, E09.2x, E10.2x, E10.65, E11.2x, E13.2x, E74.8, I12.xx, I13.0, I13.1x, I13.2, K76.7, M10.3x, M32.14, M32.15, N01.x-N08.x, N13.1, N13.1x-N13.39, N14.x,N15.0, N15.8, N15.9, N16, N17.x, N18.1-N18.5, N18.8, N18.9, N19, N25.xx, N26.1, N26.9, O10.4xx, O12.xx, O26.83x, O90.89, Q61.02, Q61.1x-Q61.8, Q26.0-Q26.39, R94.4
Staging of chronic kidney disease		
Stage 1	585.1	N18.1
Stage 2	585.2	N18.2
Stage 3	585.3	N18.3
Stage 4	585.4	N18.4
Stage 5	585.5 or 585.6 with no CMS 2728 form	N18.5 of N18.6 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; 581-583; 585.9; 586-588; 591; 642.1; 646.2; 753.12-753.19; 753.2; 794.4	Patient has no claims with codes N18.1-N18.6 but has: A18.11, A52.75, B52.0, C64.x, C68.9, D30.0x, D41.0x-D41.2x, D59.3, E08.2x, E09.2x, E10.2x, E10.65, E11.2x, E13.2x, E74.8, I12.xx, I13.0, I13.1x, I13.2, K76.7, M10.3x, M32.14, M32.15, N01.x-N08.x, N13.1, N13.1x-N13.39, N14.x,N15.0, N15.8, N15.9, N16, N18.8, N18.9, N19, N25.xx, N26.1, N26.9, O10.4xx, O12.xx, O26.83x, O90.89, Q61.02, Q61.1x-Q61.8, Q26.0-Q26.39, R94.4

Source: ICD-9/10-CM, International Classification of Diseases, Ninth/Tenth Revision, Clinical Modification. ICD-9-CM diagnosis codes can have up to five digits with a decimal point between the 3rd and 4th digits, while ICD-10-CM codes have seven digits. 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 10.4 ICD-9-CM and ICD-10-CM diagnosis codes used to define medical conditions in the health insurance claims data files throughout Volume 1 of the ADR

Condition name	ICD-9-CM codes	ICD-10-CM codes
Anemia	280-285	D50.0-D64.9
Cancer	140-172; 174-208; 230-231; 233-234	C00.0-C43.9; C45.0-C75.9; C76.0-D03.9; D05.00-D09.9
Cardiac, other	420-421, 423-424; 429; 785.0-785.3; V42.2; V43.3	A18.84; I25.10; I31-I39; I51.0-I52; I97.0-I97.191; M32.11; M32.12; R00.0; R00.2-R01.2; Z95.2-Z95.4
Cerebrovascular accident (CVA) / transient ischemic attack (TIA)	430-438	G45.0-G45.2; G45.4-G46.8; I60.00-I66.9; I67.1; I67.2; I67.4-I67.82; I67.841-I69.998
Chronic obstructive pulmonary disorder (COPD)	491-494; 496; 510	J41.0-J47.9; J86.0; J86.9
Coronary artery disease (CAD)	410-414; V45.81; V45.82	I12.00-I22.9; I24.0-I25.9; Z95.1; Z95.5; Z98.61
Diabetes mellitus (DM)	250; 357.2; 362.0; 366.41	E08.311-E08.36; E08.40; E08.42; E09.311-E09.36; E09.40; E09.42; E10.10-E13.9
Dysrhythmia	426-427; V45.0; V53.3	I44.0-I49.9; R00.1; Z45.0-Z45.09; Z95.0; Z95.810; Z95.818; Z95.9
Gastrointestinal bleeding disorders (GI)	456.0-456.2; 530.7; 531-534; 569.84-569.85; 578	I85.00-I85.11; K22.6; K25.0-K28.9; K55.20; K55.21; K56.60; K92.0-K92.2
Heart failure (HF)	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	A18.84; I09.81; I11.0; I13.0; I13.2; I40.0-I43; I50.1-I50.9; Z48.21; Z48.280; Z94.1; Z94.3
Hypertension (HTN)	362.11; 401-405; 437.2	H35.031-H35.039; I10-I13.2; I15.0-I15.9; I67.4; N26.2
Liver disease	570-571; 572.1, 572.4; 573.1-573.3; V42.7	B25.1; K70.0-K72.01; K73.0-K74.69; K77; Z48.23; Z94.4
Peripheral vascular disease (PVD)	440-444; 447; 451-453; 557	E08.51; E08.52; E09.51; E09.52; E10.51; E10.52; E11.51; E11.52; E13.51; E13.52; I67.0; I70.0-I74.9; I77.0-I77.9; I79.0-I82.91; K55.0; K55.1; K55.8; K55.9; M31.8; M31.9

Source: ICD-9/10-CM, International Classification of Diseases, Ninth/Tenth Revision, Clinical Modification. ICD-9-CM diagnosis codes can have up to five digits with a decimal point between the 3rd and 4th digits, while ICD-10-CM codes have seven digits. Codes listed with three digits include all existing 4th and 5th digits, and those listed with four digits include all existing 5th digits.

The U.S. federal government changed from using the International Classification of Diseases, Ninth Revision (ICD-9) coding system to using the ICD-10 coding system at the start of fiscal year 2016, which was October 1, 2015. In calendar year 2016, all claims use the ICD-10-CM code frame. To identify the ICD-10 codes that indicated the chronic conditions previously identified by ICD-9 codes, we used the CMS General Equivalence Mapping (GEM) dataset. There is not a one-to-one match between ICD-9 and ICD-10 codes in the GEM, but rather a one-to-many match in both directions; an ICD-9 code can match to multiple ICD-10 codes and an ICD-10 code can match to multiple ICD-9 codes. We then looked at counts and percentages for each comorbidity for 2013, 2014, and 2015 to note any changes in the monthly pattern starting in October 2015. While the overall numbers reasonably matched the results from prior years, a detailed review of the ICD-10-CM codes will be performed in the coming year.

Chapter 1: CKD in the General Population

Analyses in *Volume 1,* *Chapter 1: CKD in the General Population* 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 (Ingram et al., 2018). Starting in 1999-2000, the NHANES has collected data continuously, releasing public-use data files in two-year cycles. Data for *Volume 1, Chapter 1* represents participants 20 years and older in four clusters of NHANES continuous cycle years 2001-2004, 2005-2008, 2009–2012, and 2013-2016. *Note*: Data from NHANES III (1988-1994) and the first two years of continuous NHANES (1999-2001) can be found in previous Annual Data Reports (ADR).

The statistical software package SAS® was used to analyze all NHANES data, incorporating the sampling weights and survey design through its survey procedures.

In *Volume 1, Chapter 1*, age is defined as the participant's age at the time of the NHANES household interview, categorized into age groups: 20 to 39, 40 to 59, or 60 and older and as a dichotomous under age 60 or age 60 or higher. Race and ethnicity are self-reported and categorized as non-Hispanic White, non-Hispanic Black/African American, Mexican-American, other Hispanic, and other non-Hispanic. The identification of CKD is based on the 2012 guidelines from the Kidney Disease: Improving Global Outcomes (KDIGO) CKD Work Group (KDIGO, 2013), which was 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 m^2, calculated 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). With NHANES data we use the urine albumin creatinine ratio (uACR) to measure albuminuria, but there is no 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 uACR, so we cannot address the three-month persistence criteria for defining CKD; the implications of this are discussed in detail in the chapter.

The eGFR (measured in ml/min/1.73 m^2) was calculated using the CKD-EPI equation, based on the NCHS-recommended standardized creatinine values (Selvin et al., 2007).

The CKD-EPI equation is:

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

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 if otherwise

AGE is measured in years. The uACR 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 in 2002 through the National Kidney Foundation's Kidney Disease Outcomes and Quality Improvement Guidelines (NKF, 2002). Following these guidelines, we define stages of CKD 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 <29
- Stage 5: eGFR <15, not ESRD

NHANES respondents are also asked, *"Have you ever been told by a doctor or other health professional that you had weak or failing kidneys? Do not include kidney stones, bladder infections, or incontinence."* When a respondent endorses CKD as measured above, we call this question awareness of kidney disease. Those answering "yes" are aware of their CKD.

Participants with diabetes mellitus (DM) include 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) glycosylated hemoglobin (HgbA1c) ≥7%. 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). Participants answering "borderline" are classified as non-diabetic. Control of DM is assessed as HgbA1c less than 7%.

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 reported currently taking a prescription medication to control HTN, and as in control of their HTN if their blood pressure at time of medical examination was ≤140/≤90 (≤130/≤80 for CKD or SR DM).

Participants who self-reported any of the following diseases are considered to have self-reported cardiovascular disease (SR CVD): angina, myocardial infarction, stroke, coronary heart disease, or heart failure (HF; formerly called 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 were classified as current smokers if they give an affirmative answer to the question *"Do you now smoke cigarettes?"* and former smokers if they respond negatively to the previous question, but affirmatively to the question *"Have you smoked at least 100 cigarettes in your life?"*

Since the 2017 ADR, the examination of CKD by socioeconomic variables and additional health-related behaviors is reported. Three socioeconomic variables were added in 2017: health insurance status, annual family income, and education. First, health insurance as a yes/no variable is determined by the answer to the question, *"Are you covered by health insurance or some kind of healthcare plan? [Include health insurance obtained through employment or purchased directly as well as government programs like Medicare and Medicaid that provide medical care or help pay medical bills]."* The category private insurance is determined by a "yes" answer to *"Are you covered by private insurance?"* Medicare coverage is a "yes" answer to *"Are you covered by Medicare?"* Other government coverage is defined by a "yes" answer to having coverage through Medigap, Medicaid, State Child Health Insurance Program (SCHIP), military healthcare, Indian Health Service, or other government insurance. Answers to these questions are categorized as private only, Medicare only, other government insurance only, private and any government (Medicare or other government insurance), and other/unknown.

Income was total annual family income (*indfminc*) in the 1999-2006 NHANES, reported in ranges of $5,000 increments up to a top range of "$75,000 and over". In 2007-2008 the variable *indfmin2* contained annual family income with two additional categories on the upper end of the distribution—$75,000 to $99,999 and $100,000 and over. We collapsed reported income levels into categories of less than $10,000, $10,000-$24,999, $25,000-$44,999, $45,000-$74,999, and $75,000 or more.

Education was derived from the question, *"What is the highest grade or level of school you have completed or the highest degree you have received?"* Valid answers are less than 9th grade, 9th-11th grade (including 12th grade with no diploma), high school grad/GED (general educational development) or equivalent, some college or AA (associate) degree, and college graduate or above. We collapse these categories into less than high school, high school grad/GED, and at least some college.

Physical activity was defined using several questions from the NHANES survey. For the 1999-2001 and 2001-2002 NHANES, vigorous activity was defined as a "yes" answer to the question, *"Over the past 30 days, did you do any vigorous activities for at least 10 minutes that caused heavy sweating, or large increases in breathing or heart rate? Some examples are running, lap swimming, aerobics classes or fast bicycling"*. Moderate activity is a "yes" answer to *"Over the past 30 days, did you do any moderate activities for at least 10 minutes that caused only light sweating, or a slight to moderate increase in breathing or heart rate? Some examples are brisk walking, bicycling for pleasure, golf, and dancing"*. Starting with the 2007-2008 NHANES, different questions are asked about physical activity; separate questions ask about work (paid, unpaid, volunteer, house and yardwork), transportation (walking or using a bicycle) and recreational activities. The questions are phrased similarly to the previous NHANES questions but with reference to work and recreation. Vigorous activity in the ADR was defined as answering "yes" to either work or recreational vigorous activity, with moderate activity defined the same way. The final physical activity categorical variable was defined in a hierarchical manner; if a person reported both vigorous and moderate activity, they are classified as "vigorous" activity level. Sedentary was defined as having neither vigorous nor moderate activity.

Sleep is another health behavior that was introduced in 2017. Sleep amount was determined by the answer to the question, *"How much sleep do you usually get at night on weekdays or workdays?"* Valid answers were one to 11 or "12 hours or more". A categorical variable was then made with ranges of less than six hours, six hours, seven to eight hours, and nine or more hours.

New in the 2018 ADR is the presentation of the intake of macronutrients from the dietary interview. NHANES collects extensive information on the foods consumed and the portion sizes of respondents through a dietary recall. The USDA's Food and Nutrient Database for Dietary Studies is used to calculate nutrient values for different foods. Macronutrients are shown by CKD status across time (CDC, 2018).

Figure 1.1 shows the weighted percentage of NHANES respondents with each stage of CKD,

defined as above, for four time periods, 2001-2004, 2005-2008, 2009-2012, and 2013-2016. The whisker bars show the 95% confidence interval around each estimate of fraction with each stage of kidney disease in the U.S. civilian, noninstitutionalized population. The test for trends noted in the text is a logistic regression with appropriate accounting for survey design elements, including weights, with the four time periods forming a continuous variable with values 1 to 4 in order of calendar time. Figure 1.2.a shows the distribution of estimated eGFR for all NHANES respondents, and Figure 1.2.b shows the distribution for those aged 60 and over. These figures are box plots. The structure of the box is as follows:

vol 1 Figure 10.1 Interpretation of a box plot

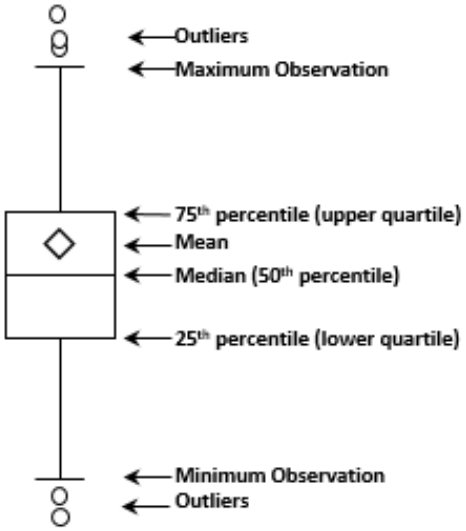

Figure 1.3 shows the urine albumin creatinine ratio (uACR) for NHANES respondents in four categories: less than 10 mg/g, 10 to 29 mg/g, 30-300 mg/g (also known as microalbuminuria), and greater than 300 (macroalbuminuria) for the four periods used in Figure 1.1. Figure 1.4 shows the percent of NHANES respondents with uACR of 30 mg/g or higher by level of eGFR and time period. Table 1.1.a shows updated statistics for Figure 1.8: Definition and Classification of CKD of the KDIGO 2012 Clinical Practice Guideline for CKD Evaluation and Management (KDIGO, 2013) using data for 2013-2016. Table 1.1.b summarizes the results by the risk categories shown in Table 1.1.a—low risk, moderately high risk, high risk and very high risk, over the four time periods.

Table 1.2 shows demographic variables (age, race/ethnicity, sex) and clinical risk factors and consequences of CKD (DM, SR DM, HTN, SR HTN, SR CVD, and obesity) by three definitions of CKD—the standard definition using eGFR and uACR (All CKD), using reduced eGFR alone (<60 ml/min/1.73m^2), and using the albuminuria criterion alone (uACR $\geq$ 30 mg/g). This table shows what percent of the group described by the row label has CKD; for example, 32.2% of those aged 60 or older in 2013-2016 had CKD by the eGFR and uACR criteria combined. The test for trends noted in the text is a logistic regression with appropriate accounting for survey design elements, including weights, with the four periods forming a continuous variable with values 1 to 4 in order of calendar time. Figure 1.5 shows the distribution of the following markers of CKD: reduced eGFR only, elevated uACR only, or both reduced eGFR and elevated uACR, among each risk factor group.

Adjusted odds ratios in Figures 1.6-1.8 are calculated using logistic regression, incorporating the sampling weight and survey design. In Figures 1.6 and 1.8 the results of seven logistic models are shown. Figure 1.7 splits the model into two panels for ease of reading due to the differences in scale for the odds ratios for age compared to the other risk factors. The associations for age are shown in panel a, and other CKD risk factors in panel b. The model includes the following variables: age (20 to 39/40 to 59/60 and older), 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) include age (20 to 39/40 to 59/60 and older), sex (male/female), race (White/Black/other) and presence of the risk factor shown (yes vs. no). Ninety-five percent confidence intervals are displayed and results shown for the four periods.

Table 1.3 shows the distribution of three socioeconomic variables among those with and without CKD— either the standard definition, reduced eGFR, or elevated uACR—for the four periods. The column percentages of not insured and insured add up to 100%, the types of insurance add up to the percentage insured, and the income and education categories each add up to 100%. Table 1.4

shows the distribution of health risk behaviors in a manner similar to Table 1.3. Sleep amount and self-reported special diet are not available for the 2001-2003 period.

Macronurients are shown in Table 1.4 and include energy (total calories), fat, carbohydrates, protein, total sugars, sodium and potassium. The means are presented in Table 1.4.

Figure 1.9 shows the percent of NHANES respondents who are physically active (defined as moderate or vigorous activity) by CKD definition/components and the four periods.

Table 1.5 shows the distribution of several measures of treatment, and control for the CKD risk factors of HTN, high cholesterol, and DM. Again, these column percentages sum to 100% within each panel. Figure 1.10 shows the percent of NHANES respondents whose blood pressure at the medical exam was at the target level at 140/90 (1.10.a) and at 130/80 (1.10.b) by CKD definition/components and the four periods. Figure 1.11 shows the percentage with cholesterol levels within target range, and Figure 1.12 shows the percentage with HgbA1c within target range or exceeding the target, <7% in 1.11.a and 8% or higher in 1.11.b.

Figure 1.13 shows the percent of NHANES respondents that report having a health professional tell them they had kidney disease, which we define as being aware of their kidney disease, across the four periods. Figure 1.13.a is among people with CKD (low eGFR or presence of albuminuria); 1.13.b shows awareness for those with low eGFR only, with uACR>30 only, and with both; 1.13.c shows awareness by diabetes and hypertension status – neither DM or HTN, DM only, HTN only and both DM and HTN – and 1.13.d by age group.

Figure 1.14 tabulates responses to the 2013-2016 Behavioral Risk Factor Surveillance System question, *"Has a doctor, nurse, or other health professional ever told you have kidney disease?"* by U.S. state for each of the past four years of available data.

Chapter 2: Identification and Care of Patients with CKD

All of the analyses in the *Volume 1, Chapter 2* sections, *Patients Characteristics across Datasets, Comparison of CKD Prevalence across Datasets, and Longitudinal Change in CKD Status and Outcomes, Based on Diagnosis Codes,* include point prevalent patients who survived all of the reported year (2016 for most of the figures and tables) and who did not have or develop ESRD during the reported year. Medicare analyses also required the beneficiary to be continuously enrolled in Medicare Parts A and B in the reported year, not enrolled in a Medicare Advantage plan (Part C), and aged 65 or older as of January 1 of the reported year. Optum Clinformatics™ analyses additionally required the plan member to be enrolled for the entire reported year. The sections, *Laboratory Testing of Patients with and without CKD* and *Physician Visits after a 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 were then censored in the analysis if they died, developed ESRD, switched to a Medicare Advantage plan (Part C), or disenrolled from Parts A and B during year two.

Table 2.1 presents demographic and comorbidity characteristics of individuals in the Medicare 5% sample (aged 65 and older), the Optum Clinformatics™ dataset (aged 22 and older), and the VHA (aged 22 and older). Comorbidities included diabetes mellitus (DM), hypertension (HTN), and cardiovascular disease (CVD). CVD was defined as the presence of any of the following comorbidities: cerebrovascular accident, peripheral vascular disease, coronary artery disease (formerly called atherosclerotic heart disease), heart failure, dysrhythmia, or other cardiac comorbidities. Each comorbidity was defined by at least one inpatient or two outpatient medical 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 10.3 and 10.4 for a list of ICD-9-CM and ICD-10-CM codes used.

Table 2.2 presents the prevalence of coded CKD, DM, and CVD in the fee-for-service, age-eligible Medicare population, and patients aged 22 to 64 in the Optum Clinformatics™ and VHA datasets. Table 2.2.a shows the sample counts and percent of all patients with the condition, for each condition separately. Table 2.2.b shows the interaction between all three conditions, identifying those with all combinations of the conditions, plus the number and percentage who had at least one or at least two comorbidities.

Table 2.3 shows a comparison of the percent of patients with CKD by demographic characteristics, in different datasets. The survey-based NHANES data (see the Data Sources section on *NHANES* in this chapter for methods) include the 2013-2016 survey years and are restricted to participants aged 65 or older. CKD is determined by eGFR<60 ml/min/1.73m^2. In the claims-based datasets of Optum Clinformatics™ (2016) and the Medicare 5% sample (2016), CKD is determined by ICD-9-CM or ICD-10-CM diagnosis codes. In the claims- and lab-based VHA dataset (2016) patients are considered to have CKD via either a diagnosis or eGFR<60 ml/min/1.73m^2, as determined by routine blood testing for serum creatinine.

Table 2.4 shows the 2016 unadjusted prevalence of diagnosed CKD by age, sex (male/female), race (White/Black/Native American/Asian/Hispanic [Optum Clinformatics™ only]/Other/Unknown), and comorbidity for the Medicare 5% sample, Optum Clinformatics™, and the VHA. Comorbidities include DM with or without HTN and HTN without DM.

Figure 2.1 has two map panels: (a) the Medicare 5% sample (aged 65+) and (b) the Optum Clinformatics™ dataset (aged 22+), showing the prevalence of diagnosed CKD across the United States in 2016.

Figure 2.2 illustrates the prevalence of CKD over time in the fee-for-service, age-eligible Medicare population—overall (any code) and by CKD stage-specific codes.

Table 2.5 shows progression of kidney disease by CKD stage, end-stage renal disease (ESRD), or death in 2015-2016 for the fee-for-service, age-eligible Medicare population of 2011. The analysis cohort required patients to be alive and eligible for Medicare Parts A and B with no HMO coverage for all of 2011. Death and ESRD status were examined yearly between 2012 and 2016, and carried forward if present. The ESRD and death information were combined to create three categories: ESRD-alive, ESRD-death, and Death without ESRD. For patients who did not progress to death or ESRD by 2016 the last CKD diagnosis claim in 2016 was used; if this was not available, the last CKD diagnosis claim from 2015 was used. Lost to follow-up status represents the patients who were not enrolled in Medicare Part A and B during 2015 or 2016 and who had no indication of death or ESRD.

Figures 2.3–2.4 show the proportion of patients tested for urine albumin from 2006-2016, for patients with (Figure 2.4) and without (Figure 2.3) CKD by the comorbidities of DM without HTN, HTN without DM, both DM and HTN, or neither. For these analyses, a one-year period was used to define comorbid conditions (year one) and laboratory testing was assessed in the following year (year two, the year reported in the figures). Patients must have been enrolled in their plan (for Medicare, Parts A and B coverage, and no Medicare Advantage plans), not have ESRD, and 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. For each figure, panel a shows the Medicare 5% sample, and panel b the Optum Clinformatics™ data.

Table 2.6 examines physician visits in the year after a diagnosis of CKD. Similar to the laboratory testing, the sample included patients who were alive, without ESRD, did not have a Medicare Advantage plan, and had both Parts A and B coverage for all of 2015. The date of the earliest CKD claim (any CKD or Stage 3/4/5 [585.3–585.6, N18.3-N18.6) in 2015 was used as the date of CKD diagnosis, and claims were then searched for services provided by primary care physicians, nephrologists, and cardiologists for the 365 days following that date. Primary care visits were defined based on a physician specialty code of 01, 08, or 11. Cardiologist visits were defined based on specialty code 06, and nephrology

visits based on specialty code 36.

Figure 2.5 presents the proportion of CKD patients in the fee-for-service, age-eligible Medicare population in 2016 (based on diagnostic code) who were tested for urine albumin in 2016, according to whether they saw a primary care physician, a nephrologist, or neither in 2015. The analysis cohort required patients to be alive and eligible for all of 2016 with a CKD diagnosis claim in 2015.

Chapter 3: Morbidity and Mortality in Patients with CKD

The analyses in *Volume 1, Chapter 3: Morbidity & Mortality in Patients with CKD* used a one-year entry period to determine disease conditions prior to hospitalization, referred to as 'year one'. Patients were required to be alive, aged 65 or older on January 1, without ESRD, and enrolled in their plan (for Medicare, covered by Parts A and B with no Medicare Advantage plan (Part C)) for all of year one. Claims from year one were then searched for diagnoses as described in the *Identification of Major Comorbidities* section of this chapter. Additionally, patients were required to meet the above criteria and to be aged 66 or older on January 1 of the following year (year two). We then determined patient mortality and/or hospitalization for the period January 1 to December 31 of year two. Analyses were 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 began on January 1 of year two, and was censored at the earliest of the date of death, start of ESRD, disenrollment from their plan (for Medicare, Parts A or B or a switch to a Medicare Advantage plan), or December 31 of year two. The analyses of Optum Clinformatics™ data employed similar selection criteria, except patients must have been enrolled in their Optum Clinformatics™ plan for all of year one and January 1 of year two.

MORTALITY

The date of death was 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 is found in the integrated data from the ESRD Death Notification form CMS 2746. Figure 3.1 shows trends in unadjusted and adjusted all-cause mortality rates by CKD status from 2004 to 2016, and Figure 3.2 shows rates for 2016 by CKD status and stage. We calculated unadjusted mortality as the number of deaths divided by the number of patient-years at risk, and express this as "per 1,000 patient-years." In Figures 3.1-3.6 adjusted mortality was based on a Cox regression model and adjusted for age (66 to less than 70, 70 to less than 75, 75 to less than 85, or 85 years and older), race (White, Black/African American, or Other), and sex (male or female). We have applied this modified set of adjustment covariates since the 2014 ADR—prior year hospitalization and comorbidities are no longer included. These adjustment covariates differ from those used in prior ADRs through the 2013 ADRs. Therefore, differences between adjusted rates in the ADRS since 2014 and rates in ADRs prior to 2014 may be notable.

All patients in 2016 formed the standard cohort for Table 3.1 and Figures 3.1-3.6. Optum Clinformatics™ data were not used in mortality analyses as the date of death determination is now limited to information from the Social Security Death Master file. In 2011, the Social Security Administration stopped releasing death dates derived from state sources. The number of deaths reported has dropped by over 30%, indicating artificially low mortality rates.

HOSPITALIZATION

For the hospitalization analyses, additional processing was performed on the inpatient claims data. A patient's inpatient claims were ordered by date and compared to identify (1) overlapping claims (two claims covering the same time frame), (2) consecutive claims (one claim's admission date on the day following the previous claim's discharge date), (3) transfers (patient discharge status of 02 on the claim), and (4) interim claims (claim sequence number, the third digit of the 'type of bill' code, of 2, 3, or 4). In such cases, the claims were consolidated into one claim, with dates, diagnoses, and procedures combined. Analyses excluded 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).

We calculated unadjusted admission rates as the number of hospitalizations divided by the number of patient-years at risk, and express this as "per 1,000 patient-years." Adjusted admission rates included the following variables as adjustments: age (66 to less than 70, 70 to less than 75, 75 to less than 85, or 85 years or older), race (White, Black/African American, or Other), and sex (male or female). As with mortality, a different set of adjustment covariates were applied starting with the 2014 ADR. Adjusted rates in this ADR may thus differ from the adjusted rates in ADRs prior to 2014. A model-based adjustment method was used with a generalized linear model using a Poisson distribution and log link function. The sample included data from the current and previous two years, with respective weights of 1.0, 0.25 and 0.125 applied. Adjusted rates reflect the distribution of a reference cohort, as specified below in the discussion of the specific figures. With this method, the parameter estimates from the model were used to calculate an estimated admission rate for each patient in the standard cohort. Overall adjusted rates were then computed as the weighted average of these individual rates, using the time at risk of each patient in the standard cohort as the weight.

Table 3.2 and Figures 3.7 and 3.8 show adjusted all-cause admission rates for fee-for-service Medicare patients aged 66 and older and Optum Clinformatics™ patients aged 22 and older. Table 3.2 and Figure 3.7 also show the unadjusted rates. As mentioned above, DM and CVD were ascertained in 2015 for the analysis of hospital admissions in 2016, as described in the *Identification of Major Comorbidities* section of this chapter. All Medicare patients in the cohort were 66 years and older (22 and older for Optum Clinformatics™), did not have ESRD on 1/1/2016, had Medicare Part A and B coverage (for Optum Clinformatics™, plan enrollment) for all of 2015, and did not participate in a Medicare Advantage plan from 1/1/2015 through 1/1/2016. Rates presented by one factor were adjusted for the other covariates. The standard cohort for Medicare analyses included all 2016 Medicare patients aged 66 and older. The standard cohort for Optum Clinformatics™ analyses includes all patients in 2016.

vol 1 Table 10.5 ICD-9-CM and ICD-10-CM diagnosis codes used to define cause of hospitalization

Cause of hospitalization	Principle diagnosis for hospital stay	
	ICD-9-CM diagnosis codes	ICD-10-CM diagnosis codes
Cardiovascular diseases	276.6; 394-398; 401-405; 410-438; 440-459	A18.84; E08.51; E08.52; E09.51; E09.52; E10.51; E10.52; E11.51; E11.52; E13.51; E13.52; G45.0-G46.8; I05.0-I09.1; I09.81-I67.82; I67.841-I87.9; I89.0-I97.2; I99.8; I99.9; K64.0-K64.9; M30.0-M31.9; M32.11; M32.12; N26.2; R00.0; R58; T80.0XXA; T81.72XA; T82.817A; T82.818A
Infections	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	A00.0-A32.9; A35-B99.9; D86.0-D86.9; E32.1; E83.2; G00.0-G04.02; G04.2-G09; G14; G37.4; G92; G93.7; H00.011-H10.9; H16.251-H16.269; H32; H66.001-H66.43; H67.1-H67.9; H70.001-H70.93; H75.00-H75.83; H83.01-H83.09; H92.10-H92.13; H95.00-H95.199; I00-I02.9; I09.2; I32; I33.0; I39-I40.8; I41; I67.3; J00-J18.1; J18.8-J21.9; J31.0-J32.9; J35.01-J35.03; J36; J37.0; J37.1; J39.0-J39.2; J40; J41.1; J47.0-J47.9; J85.0-J85.2; J86.0-J92.9; J94.0-J94.9; J95.02; K04.6; K04.7; K11.3; K12.2; K35.2-K37; K50.014; K50.114; K50.814; K50.914; K51.014; K51.214; K51.314; K51.414; K51.514; K51.814; K51.914; K57.00; K57.01; K57.20; K57.21; K57.40; K57.41; K57.80; K57.81; K61.0-K61.4; K63.0; K65.0-K65.9; K67-K68.9; K71.0-K71.9; K75.0-K75.3; K75.81-K75.9; K76.4; K77; K81.0-K81.9; K90.81; L01.0-L08.9; L44.4; L70.2; L88; L92.8; L94.6; L98.0; L98.3; M00.00-M01.X9; M02.10-M02.19; M02.30-M02.89; M35.2; M46.20-M46.39; M86.00-M86.9; M90.80-M90.89; N10-N12; N13.6; N15.1; N15.9; N16; N28.84-N28.86; N30.0-N30.31; N30.80; N30.81; N34.0-N34.3; N35.111-N35.12; N37-N39.0; N41.0-N41.9; N45.1-N45.4; N47.6; N48.1-N48.29; N49.0-N49.9; N51; N61; N70.01-N74; N75.1; N76.0-N76.4; N77.1; N98.0; O85; O86.12; O86.81; O86.89; R09.1; R11.11; R78.81; T80.211A-T80.29A; T81.4XXA; T82.6XXA; T82.7XXA; T83.51xXA-T83.6XXA; T84.50XA-T84.7XXA; T85.71XA-T85.79XA; T86.842; T87.40-T87.44; T88.0XXA
Other causes	All codes, except those in cardiovascular or infection.	All codes, except those in cardiovascular or infection.

Source: ICD-9/10-CM, International Classification of Diseases, Ninth/Tenth Revision, Clinical Modification. ICD-9-CM diagnosis codes can have up to five digits with a decimal point between the 3rd and 4th digits, while ICD-10-CM codes have seven digits. Codes listed with three digits include all existing 4th and 5th digits, and those listed with four digits include all existing 5th digits.

Figures 3.9-3.15 show adjusted, cause-specific admission rates by CKD status and stage for Medicare and Optum Clinformatics™ patients. Cause-specific rates reflect hospital admissions for the purpose of treating the specified condition—cardiovascular or infectious—and are identified using the principal ICD-9-CM or ICD-10-CM diagnosis code on the claim. Code values are shown in Table 10.5. The 'other cause' of hospitalization is a residual category consisting of all hospitalizations other than those for cardiovascular or infectious conditions.

HOSPITAL READMISSION

Analyses of readmissions focus on the 30 days following discharge from a hospitalization in year two, the year reported in the figure. As for all the analyses in *Volume 1, Chapter 3: Morbidity & Mortality in Patients with CKD*, 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 were identified; the latter date (12/1) was

chosen as a cutoff to allow a 30-day follow-up period after discharge to evaluate readmission. The unit of analysis was a hospital discharge rather than a patient. Hospital stays were 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 were at risk of death or readmission for the entire 30-day period, so results are presented as percentages.

Since death and readmission are competing risks, outcomes were presented as: (1) the percent of hospital discharges where the patient both returned to the hospital and died within 30 days, (2) the percent where the patient was readmitted within 30 days but remained alive on day 30, and (3) the percent where the patient died within 30 days without a readmission. Table 3.3 shows the unadjusted percentage who were readmitted (both alive and dead on day 30) for age, sex, and race groups, plus the composite death and readmission outcomes described above by CKD status and stage. Figure 3.16 adds a fourth category to the three described above for those who did not have a readmission and were still alive at day 30. This figure shows the adjusted percentages for the four readmission and death outcomes across time from 2004 to 2016. Live hospital discharges from January 1 to December 1 of each year were included. Rates were adjusted for age, sex, and race using direct adjustment, with a reference group of discharges in 2011. Figure 3.17 shows the unadjusted percentage of patients readmitted to the hospital within 30 days of discharge for 2016 patients with and without CKD before an all-cause index hospitalization, while Figures 3.18-3.20 show this for cardiovascular, infection, and other cause-specific index hospitalizations. Figure 3.21 illustrates this by age group, Figure 3.22 by sex, and Figure 3.23 by race.

Chapter 4: Cardiovascular Disease in Patients with CKD

Volume 1, Chapter 4: Cardiovascular Disease in Patients with CKD describes the prevalence of cardiovascular comorbidities and selected cardiovascular procedures in fee-for-service, age-eligible Medicare enrollees. Cardiovascular comorbidities include coronary artery disease (CAD; formerly referred to as atherosclerotic heart disease, ASHD), acute myocardial infarction (AMI), heart failure (HF; formerly congestive heart failure, CHF), valvular heart disease (VHD), cerebrovascular accident/transient ischemic attack (CVA/TIA), peripheral artery disease (PAD), atrial fibrillation (AFIB), sudden cardiac arrest and ventricular arrhythmias (SCA/VA), and venous thromboembolism and pulmonary embolism (VTE/PE). The same algorithm described in the *Identification of Major Comorbidities* section of this chapter (one inpatient or two outpatient claims with the specific diagnosis) was used to define these cardiovascular conditions. Code values are shown in Table 10.6. The presence of CKD, CKD staging, and comorbidities such as diabetes mellitus (DM) and hypertension (HTN) were also defined as described in the *Identification of Major Comorbidities* section of this chapter and shown in Tables 10.3 and 10.4.

Cardiovascular procedures include revascularization – percutaneous coronary interventions (PCI), revascularization – coronary artery bypass graft (CABG), the placement of implantable cardioverter defibrillators (ICD) and cardiac resynchronization therapy with defibrillator (CRT-D), and carotid artery stenting and carotid endarterectomy (CAS/CEA). Procedures required only one claim with the procedure code. The presence of PAD was determined by the diagnosis or a claim for a procedure. Table 10.7 shows the codes and type of claims used to identify each procedure.

vol 1 Table 10.6 ICD-9-CM and ICD-10-CM diagnosis codes used to define cardiovascular disorders in Volume 1, Chapter 4 of the ADR

Condition	ICD-9-CM diagnosis codes	ICD-10-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	A18.84; E08.51 E08.52; E09.51; E09.52; E10.51; E10.52; E11.51; E11.52; E13.51; E13.52; G45.0-G45.2; G45.4-G46.8; I09.81; I11.0; I12.00-I22.9; I13.0; I13.2; I21.01-I22.9; I24.0-I25.9; I25.2; I34.0-I39; I40.0-I43; I46.2-I47.0; I47.2; I48.0-I48.92; I49.01; I49.02; I49.3; I49.49; I50.1-I50.9; I60.00-I66.9; I67.0; I67.1; I67.2; I67.4-I67.82; I67.841-I69.998; I70.0-I74.9; I77.0-I77.9; I79.0-I79.8; I81-I82.91; K55.0; K55.1; K55.8; K55.9; M31.8; M31.9; M32.11; Z48.21; Z48.280; Z94.1; Z94.3; Z95.1; Z95.5; Z98.61
Acute myocardial infarction (AMI)	410; 412	I21.01-I22.9; I25.2
Atrial fibrillation (AFIB)	427.3	I48.0-I48.92
Cerebrovascular accident/transitory ischemic attack (CVA/TIA)	430–438	G45.0-G45.2; G45.4-G46.8; I60.00-I66.9; I67.1; I67.2; I67.4-I67.82; I67.841-I69.998
Coronary artery disease (CAD)	410-414; V45.81; V45.82	I12.00-I22.9; I24.0-I25.9; Z95.1; Z95.5; Z98.61
Heart failure (HF)	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]	A18.84; I09.81; I11.0; I13.0; I13.2; I40.0-I43; I50.1-I50.9; Z48.21; Z48.280; Z94.1; Z94.3
Systolic or both systolic & diastolic	428.2, 428.4	I50.20-I50.23; I50.40-I50.43
Diastolic only	428.3	I50.30-I50.33
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]	A18.84; I09.81; I11.0; I13.0; I13.2; I40.0-I43; I50.1; I50.9; Z48.21; Z48.280; Z94.1; Z94.3
Peripheral arterial disease (PAD)	440–444; 447; 557	E08.51; E08.52; E09.51; E09.52; E10.51; E10.52; E11.51; E11.52; E13.51; E13.52; I67.0; I70.0-I74.9; I77.0-I77.9; I79.0-I79.8; K55.0; K55.1; K55.8; K55.9; M31.8; M31.9
Sudden cardiac arrest/ventricular arrhythmias (SCA/VA)	427.1, 427.4, 427.41, 427.42, 427.5, 427.69	I46.2-I47.0; I47.2; I49.01; I49.02; I49.3; I49.49
Valvular heart disease (VHD)	424	A18.84; I34.0-I39; M32.11
Venous thromboembolism and pulmonary embolism (VTE/PE)	452-453.9	I81-I82.91

Source: ICD-9/10-CM, International Classification of Diseases, Ninth/Tenth Revision, Clinical Modification. ICD-9-CM diagnosis codes can have up to five digits with a decimal point between the 3rd and 4th digits, while ICD-10-CM codes have seven digits. 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.

vol 1 Table 10.7 Procedure codes (ICD-9/10-CM and HCPCS) and claims files used to define cardiovascular procedures in Volume 1, Chapter 4 of the ADR

Data Sources (Claims files searched)	Values
Peripheral arterial disease (PAD)	
ICD-9-CM Procedure codes (IP, OP, SN)	39.25, 39.26, 39.29; 84.0, 84.1, 84.91
ICD-10-CM Procedure codes (IP, OP, SN)	All of: 0312090-031309K; 0315091-031G0ZG; 031K09J-031N0ZK; 0414093-041N4ZS; 051707Y-051V4ZY; 061307Y-061V4ZY; 061307Y-0X6W0Z3; 0Y620ZZ-0Y6Y0Z3. All except xxxxxx3, xxxxxx4, xxxxxx5: 0410090-04104ZR; All except xxxxxxM, xxxxxxN: 03130J0-03140ZK; All except xxxxxxG: 031H09J-031J0ZK.
HCPCS codes (PB, OP-revenue)	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 (IP, OP, SN)	00.66; 36.01, 36.02, 36.05, 36.06, 36.07
ICD-10-CM Procedure codes (IP, OP, SN)	02703ZZ; 02704ZZ; 02713ZZ; 02714ZZ; 02723ZZ; 02724ZZ; 02733ZZ; 02734ZZ
HCPCS codes (PB, OP-revenue)	92980-92982, 92984, 92995-92996, G0290, G0291
Coronary artery bypass graft (CABG)	
ICD-9-CM Procedure codes (IP)	36.1
ICD-10-CM Procedure code (IP, OP, SN)	All of: 0210083-02100ZF; 0210483-02104ZF; 211088-021108C; 021208C; 021208W; 021209C; 021209W; 02120AC; 02120AW; 02120JC; 02120JW; 02120KC; 02120KW; 02120ZC; 021248C; 021248W; 021249C; 021249W; 02124AC; 02124AW; 02124JC; 02124JW; 02124KC; 02124KW; 02124ZC; 021308C; 021308W; 021309C; 021309W; 02130AC; 02130AW; 02130JC; 02130JW; 02130KC; 02130KW; 02130ZC; 021348C; 021348W; 021349C; 021349W; 02134AC; 02134AW; 02134JC-02134JW; 02134KC; 02134KW; 02134ZC; All except xxxxxxF, xxxxxx3, xxxxxx4: 211088-02110ZC; 211488-02114ZC;
Implantable cardioverter defibrillators & cardiac resynchronization therapy with defibrillator (ICD/CRT-D)	
ICD-9-CM Procedure codes (IP, OP, SN)	00.51; 37.94
ICD-10-CM Procedure code (IP, OP, SN)	02H60KZ; 02H63KZ; 02H64KZ; 02H70KZ; 02H73KZ; 02H74KZ; 02HK0KZ; 02HL3KZ; 02HL4KZ; 02PA0MZ; 02PA3MZ; 02PA4MZ; 02PAXMZ; 0JH608Z; 0JH609Z; 0JH638Z; 0JH639Z; 0JH808Z; 0JH809Z; 0JH838Z; 0JH839Z; 0JPT0PZ; 0JPT3PZ
Carotid artery stunting and carotid endarterectomy (CAS/CEA)	
ICD-9-CM Procedure codes (IP, OP, SN)	00.61; 00.62; 00.63; 00.64; 00.65; 17.53; 17.54; 38.11; 38.12; 38.31; 38.32; 38.41; 38.42; 39.74
ICD-10-CM Procedure codes (IP, OP, SN)	037x34Z, 037x3DZ, 037x3ZZ, 037x44Z, 037x4DZ, 037x4ZZ, for x=G to Q, except I & O; 03Bx0ZZ, 03Bx4ZZ, for x=G to V, except I & O; 03CG0ZZ, 03CG3Z6, 03CG3ZZ, 03CG4Z6, 03CG4ZZ, 03Cx0ZZ, 03Cx3ZZ, 03Cx4Z6, 03Cx4ZZ for x=H to V, except I & 0; 03Cx3Z6 for x=R to V; 03RG07Z-03RV4KZ; 057L3DZ, 057L4DZ, 057M3DZ, 057M4DZ, 057N3DZ, 057N4DZ, 057P3DZ, 057P4DZ,057Q3DZ, 057Q4DZ, 057R3DZ, 057R4DZ, 057S3DZ, 057S4DZ, 057T3DZ, 057T4DZ, 05Bx0ZZ, 05BLx4ZZ for x=L to V, except O. 05RL07Z-05RV4KZ; 06R307Z-06R34KZ
HCPCS codes (PB, OP-revenue)	37215, 37216

Source: ICD-9/10-CM, International Classification of Diseases, Ninth/Tenth 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, while ICD-10-CM codes have seven 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.

CARDIOVASCULAR DISEASE PREVALENCE AND OUTCOMES IN CKD

For Figure 4.1, the study cohort included Medicare enrollees who were alive, aged 66 and older, were residents of the 50 states, the District of Columbia, Puerto Rico, or the U.S. territories, did not have ESRD on December 31, 2016, and who were continuously enrolled in Medicare Parts A and B but not in a Medicare Advantage plan for all of 2016. Cardiovascular conditions, CKD, and CKD staging were determined from claims in 2016.

Table 4.1.a presents the Figure 4.1 prevalence data by age, race, sex, and CKD status, and Table 4.1.b presents data on cardiovascular procedures performed in 2016. The cohort was the same as that used for Figure 4.1. However, the denominator for each cardiovascular procedure was not "all patients in the cohort", which was the denominator for the prevalence statistics. The percent with PCI or CABG in Table 4.1.b was only of the cohort members with CAD, the percent with ICD/CRT-D was of cohort members with HF, and the percent with CAS/CEA was of the cohort members with CAD, CVA, or PAD.

Figures 4.2 and 4.3 present the two-year survival probability of patients with cardiovascular conditions (Figure 4.2) or cardiovascular procedures (Figure 4.3), adjusted for age and sex using Cox regression models. We assessed conditions in a baseline year (2014), the origin for survival time was January 1 of the following year (1/1/2015), and there was no attempt to isolate incident diagnoses. Procedures used the same algorithm as in the past.

To form the study cohort for each condition in Figure 4.2, we searched 2014 Medicare claims for the diagnoses (and procedure codes for PAD) specified in Tables 10.6 and 10.7. To be retained in the analysis cohort, the patient must have been alive, without ESRD, aged 66 and older on 1/1/2015, residing in the 50 states, the District of Columbia, Puerto Rico, or the U.S. territories, and enrolled in Medicare Parts A and B, but not enrolled in a Medicare Advantage plan for all of 2014. Patients were then followed from 1/1/2015 until the earliest of date of death, ESRD diagnosis, or December 31, 2016. The Kaplan-Meier method was used to estimate survival. Table 4.2 shows the numeric values for two-year survival for each condition by CKD status and stage.

To form the study cohort for each procedure in Figure 4.3, Medicare claims from 1/1/2013 through 12/31/2016 were searched for the procedure codes specified in Tables 10.7, and the date of the first claim with a specified code was considered the index date. To be retained in the analysis cohort, on the index date, the patient must have been aged 66 or older, residing in the 50 states, the District of Columbia, Puerto Rico, or the U.S. territories, and enrolled in Medicare Parts A and B, but not enrolled in a Medicare Advantage plan. Patients with ESRD on or before the index date were excluded. The patient's claims from the 365 days preceding the index date were then searched for a prior occurrence of the given condition/procedure. Patients were excluded from the analysis. CKD status and stage were also determined from the patient's claims in the 365 days prior to the index date. Patients were then followed from the index date until the earliest of date of death, two years after the index date, ESRD diagnosis, or December 31, 2016. The Kaplan-Meier method was used to estimate survival. Table 4.3 shows the numeric values for two-year survival for each procedure by CKD status and stage.

CARDIOVASCULAR DISEASE AND PHARMACOLOGICAL TREATMENTS

This section of the chapter uses data from the Medicare Part D program, which include enrollment information and claims for prescription fills and refills for medication prescribed by a healthcare professional and filled through Part D insurance (the prescription drug event, PDE, file). Enrollees are not required to fill all of their medications through Part D, and may pay out of pocket for some. Use of over the counter medications is not included in the Part D data; therefore, we have no information on such medication use.

Creation of the cohort for Table 4.4 begins with the cohort described for Table 4.1 and then excludes patients who are not enrolled in a Part D prescription plan for all of the reported calendar year (2016). All drugs in the PDE file were matched to a therapeutic category according to the American Hospital Formulary Service (AHFS) Pharmacologic-Therapeutic Classification©. Claims for 2016 were searched for each drug class and a patient was defined as having a medication in a given drug class if they had a claim for at least one filled or refilled medication in the drug classes during 2016. The prescription must be part of the AHFS Classification group and have a generic name as specified in Table 10.8.

Table 10.8 Drug classes used in Volume 1, Chapter 4 of the ADR

Drug class	AHFS classification	Generic drug name
Beta blockers	242400	*<no restriction>*
Statins	240608	*<no restriction>*
P2Y$_{12}$ inhibitors	201218	prasugrel, ticagrelor, or clopidogrel
Warfarin	201204	warfarin
Direct oral anticoagulants	201204	apixaban, rivaroxaban, dabigatran
Angiotensin converting enzyme inhibitors (ACEs) or angiotensin II receptor blockers (ARBs)	243204, 243208	*<no restriction>*

Abbreviations: AHFS, American Hospital Formulary Service; P2Y12, a group of antiplatelet medications.

HEART FAILURE AND CHRONIC KIDNEY DISEASE

The type of heart failure (HF) for the calendar year was determined by frequency of diagnoses and a hierarchy. The presence of systolic (ICD-9: 428.2x, 428.4; ICD-10: I50.2, I50.4), diastolic (ICD-9: 428.3x; ICD-10: I50.3) and unspecified diagnoses (all other HF diagnosis codes listed in Table 10.6) was determined by searching all reported diagnoses on all claims for a given calendar day. Each day was 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 numbers of days with systolic, diastolic, and unspecified diagnoses were then summed for the calendar year. The patient's predominant type of HF for the year was then determined by a hierarchy similar to that applied for each calendar day. If the patient had any systolic HF and no diastolic-only heart failure, he/she was classified as systolic heart failure; if the patient had diastolic HF and no systolic, he/she was classified as diastolic heart failure; and if the patient had only unspecified heart failure, he/she was classified as unspecified heart failure. When a patient had both systolic and diastolic-only diagnosis days during the year, he/she was assigned the HF type that was most frequent during the year.

Figure 4.4 shows the distribution of type by CKD status in 2016. The study cohort included Medicare enrollees who were alive, aged 66 and older, residents of the 50 states, the District of Columbia, Puerto Rico, or the U.S. territories, who did not have ESRD on December 31, 2016, and who were continuously enrolled in Medicare Parts A and B and not enrolled in a Medicare Advantage plan for all of 2015. The denominators were the total numbers of patients in each CKD status or stage group, and the numerators were the numbers of patients with the given HF type within that CKD status or stage group.

Figure 4.5 presents the adjusted, two-year survival probability of patients with and without CKD and HF. The adjusted probability of survival was calculated using the results of a Cox model, in which significant factors included age group, sex, race, diabetic (DM) status, hypertension (HTN) status, and a four-category variable summarizing HF and CKD status. We determined heart failure, CKD, DM, and HTN statuses from 2014 claims data. The study cohort included Medicare enrollees who were alive and aged 66 or older on December 31, 2014, residents of the 50 states, the District of Columbia, Puerto Rico, or the U.S. territories, and continuously enrolled in Medicare Parts A and B, but not enrolled in a Medicare Advantage plan for all of 2014. Patients with ESRD on or before December 31, 2014 were excluded. Follow-up began on 1/1/2015 and continued until death or 12/31/2016. Type of HF was determined by the same procedure as the previous figures, using claims from 2014. Codes used to define DM and HTN are listed in Table 10.4 of this chapter. Age was defined as of 12/31/2014. As the interaction between HF status and CKD status was significant in the Cox model, adjusted survival curves were created for the four combination groups of HF status and CKD status (no CKD and no HF, CKD and no HF, HF and no CKD, and CKD with

HF). The survival curves were adjusted for the other significant factors in the model listed above.

ATRIAL FIBRILLATION AND CHRONIC KIDNEY DISEASE

Table 4.5 presents the prevalence of AFIB by CKD stage, age, race, sex, diabetic status, HTN status, and HF status for 2016. This table uses the same cohort as Figure 4.1.

Chapter 5: Acute Kidney Injury

Three data sources were used for Volume 1, *Chapter 5: Acute Kidney Injury*: the Medicare 5% sample, Optum Clinformatics™ Data Mart, and the VHA data. The Medicare and Optum Clinformatics™ datasets only contain diagnosis code information on AKI, and no laboratory measurements. For these two sources, a hospitalization with AKI was defined as an inpatient stay with any diagnosis code for AKI, not necessarily as the primary diagnosis. The VHA data contain serum creatinine measurements for both routine outpatient visits and inpatient stays, but not urine output measurements. This allowed for calculation of the serum creatinine criteria of the KDIGO consensus definition of AKI, and for episodes to be classified by stage (KDIGO 2012). Diagnosis codes are also available in the VHA data. As in prior ADRs, this chapter only examined AKI as identified during an inpatient hospital stay.

In the Optum Clinformatics™ dataset, inpatient stays were identified by a non-missing confinement ID variable (*conf_id*) in the MEDICAL claims data table. Previously, we identified more patients with at least one or more inpatient stays from the MEDICAL claims data table than from the CONFINEMENT data table, so we continued to use the MEDICAL claims data table. Admission and discharge dates are not available in the MEDICAL claims data table and must be generated. We created the admission date as the minimum "claim from" date (*fst_dt*) and the discharge date as the maximum "claim through" date (*lst_dt*) for all claims with a given *patid-conf_id* combination. Review of inpatient stays that were included in the CONFINEMENT data table verified that this process created appropriate dates.

Dialysis during the hospitalization with AKI is defined from the Medicare 5% sample using diagnosis, procedure, and revenue center codes. For the Medicare 5% sample, the inpatient claims file was searched for ICD-9-CM diagnosis codes V45.1, V56.0, and V56.1, ICD-10-CM diagnosis codes Z49.01, Z49.31, Z91.15, and Z99.2, ICD-9-CM procedure codes 39.95 and 54.98, ICD-10-CM procedure codes 5A1D00Z, 5A1D60Z, and 3E1M39Z, and Medicare revenue center codes 0800–0809. Additionally, physician and supplier claims were searched for HCPCS codes 90935, 90937, 90945, and 90947, with service dates that corresponded to the patient's inpatient stay. In the Clinformatics™ Data Mart, we searched for both inpatient and outpatient dialysis procedures in the DIAG_<YEAR>, PROC_<YEAR>, and MED_<YEAR> claims data tables that were performed between the admission and discharge dates of the inpatient stay. Similarly, the VHA dataset was searched for dialysis procedures during the time frame of the inpatient stay. Patients with ESRD prior to the inpatient stay were not considered to have AKI.

CHARACTERISTICS OF PATIENTS WITH AKI

The cohort for Figures 5.1, 5.3.a, 5.3.b, 5.4.a, 5.4.b, 5.5.a, 5.5.b, and Table 5.1 (Medicare) included all patients who were 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 of the reported year. The Optum Clinformatics™ cohort for Figures 5.2, 5.3.c, 5.4.c, 5.5.c, and Table 5.1 (Optum Clinformatics™) included all patients who were alive, aged 22 or older, enrolled in their plan, and without ESRD on January 1 of the reported year. The comorbidities of CKD and diabetes mellitus (DM) were determined as described in the *Identification of Major Comorbidities* section of this chapter (and Tables 10.3 and 10.4), using claims from a one-year entry period (year one, the calendar year *before* the year in which hospitalization was assessed for AKI). Hospitalization was then assessed in the following year (year two, the year reported in the figures and tables). Figures 5.1 and 5.2 and Table 5.1 show statistics on people who had at least one hospitalization with an AKI diagnosis anywhere on the claim. Information specific to the AKI hospitalization used the first AKI hospitalization in the calendar year. Each calendar year

formed a separate cohort, so that a patient can have a "first" AKI hospitalization in multiple years. This process was used for both the Medicare and Optum Clinformatics™ datasets. For the 2018 ADR, Figures 5.3, 5.4, and 5.5 show the rate of all AKI hospitalizations, or AKI requiring dialysis, with an individual allowed to have more than one AKI during the calendar year. The denominator was the same as in previous years, with time at risk calculated for each person.

Figures 5.1.a and 5.2 illustrate similar statistics, but Figure 5.1.a uses Medicare data and 5.2 uses Optum Clinformatics™ (Figure 5.2) data. Figures 5.1.a and 5.2 show the fraction of the entire cohort (described in the previous paragraph) that had a hospitalization with a diagnosis of AKI (in any position on the claim) in each year, and by whether the hospitalization with the AKI diagnosis contained a stay in the ICU. Figure 5.1.b, however, uses the numerator of Figure 5.1.a as its denominator, showing the fraction of cohort patients with at least one hospitalization with AKI, who received a dialysis procedure during that hospitalization, and whether that hospitalization contained a stay in the ICU. ICU stays were determined by revenue center codes falling between 0200 and 0204, or between 0207 and 0209. We could not determine ICU stays for Optum Clinformatics™ beneficiaries. Figure 5.1.c uses the same denominator as 5.1.b, showing the percent of patients with nephrology consultation during AKI hospitalization.

The nephrology consultation during the AKI hospitalization was defined from Part B physician/supplier claims by searching provider specialty code 39 and HCPCS codes (99218-99226, 99231-99236, 90935, 90937, 90945, 90947, 99251- 99255) between the AKI admission and discharge dates.

Note that these percentages do not take into account each patient's individualized time at risk—for example, a patient who died in February was still included in the denominator for the entire year, even though he/she was 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 experienced an AKI hospitalization during the year?" Table 5.1 also uses the total number of cohort patients with at least one hospitalization with AKI as the denominator, and presents the distribution of age, sex, race, DM, and CKD for those with AKI for Medicare and Optum Clinformatics™.

Table 5.2 shows data from the VHA. Data are from fiscal year 2016 (October 1, 2015 through September 30, 2016) as retrieved from the Corporate Data Warehouse. Short-term hospital stays were isolated from the INPAT_INPATIENT table for discharges within the fiscal year (see *Veterans Health Administration Data* earlier in this chapter). All outpatient serum creatinine (SCR) measurements within the 365 days prior to the admission date were obtained from the MCA (formerly DSS) national data extract of laboratory results (LAR file; *dsslarno*=31 and *in_out*="O"). SCR results containing text ("CANC", "N.A.", etc.) and those with values greater than 20.0 mg/dL or less than 0.4 mg/dL were set to missing. Each patient was assigned a baseline SCR by this hierarchy: (1) the mean of all outpatient SCR measurements collected between seven and 365 days prior to admission, or (2) if the patient had no outpatient SCR values before seven days prior to admission, they were assigned the outpatient SCR value within seven days of admission, using the one farthest from admission if more than one measure was available, or (3) if no outpatient SCR values were available within the year before the AKI hospitalization, the first inpatient SCR was assigned as the baseline SCR. Patients without at least one inpatient SCR measurement were excluded from the analysis. Serum creatinine measurements within the inpatient stay were then compared to the baseline SCR and each other, to identify episodes of AKI and to stage those episodes. We did not distinguish multiple episodes of AKI within one inpatient stay, only whether there was any or no AKI. Table 10.9 shows the criteria for AKI from the KDIGO guidelines.

vol 1 Table 10.9 KDIGO definition and staging of acute kidney injury (AKI)

Definition of AKI		
An increase in serum creatinine (SCR) by ≥0.3 mg/dL (≥26.5 µmol/l) within 48 hours; or an increase in SCR to ≥1.5 times baseline, which is known or presumed to have occurred within the prior 7 days; or urine volume <0.5 ml/kg/h for 6 hours.		
Stage	**Serum creatinine**	**Urine output**
1	1.5–1.9 times baseline OR ≥0.3 mg/dL (≥26.5 µmol/l) increase	<0.5 ml/kg/h for 6-12 hours
2	2.0–2.9 times baseline	<0.5 ml/kg/h for ≥12 hours
3	3.0 times baseline OR increase in SCR to ≥4.0 mg/dL (≥353.6 µmol/l) OR initiation of renal replacement therapy OR, in patients <18 years, decrease in eGFR to <35 ml/min/1.73m^2	<0.3 ml/kg/h for ≥24 hours OR anuria for ≥12 hours

Adapted from KDIGO (2012). Abbreviations: eGFR, estimated glomerular filtration rate; SCR, serum creatinine. This is also Table A in Volume 1, Chapter 5.

The consensus SCR criteria in the KDIGO guidelines contain two conditions to identify AKI. One is a rise by 0.3 mg/dL within 48 hours, and the second is an increase to 1.5 times baseline within seven days. To identify a hospitalization with AKI, a patient's first SCR measurement on the day of admission was compared to their baseline SCR. If the patient's first SCR measurement on the day of admission was 0.3 mg/dL or 1.5 times higher than baseline, the patient was said to have AKI. If not, the second inpatient SCR measurement was examined. If the second SCR measurement occurred within two days of the admission, and if the second SCR was 0.3 mg/dL or 1.5 times higher than the baseline or first inpatient measurement, the patient was said to have AKI. If not, this process continued. When an SCR measurement was taken more than 48 hours from admission, it was compared to all previous SCR measurements that occurred within the last 48 hours, rather than to the patient's baseline.

We present the following scenario to illustrate the 48-hour increase assessment. Let us suppose that a patient with a baseline SCR of 0.8 mg/dL is admitted on January 1st, and has a first inpatient SCR of 0.8 mg/dL, then another on January 2nd measuring 0.7 mg/dL, another on January 4th of 0.9 mg/dL, and then 1.5 mg/dL on January 5th. The January 5th measurement is compared to the January 4th measurement, where it meets the criteria for AKI. The January 5th measurement would not be compared to those from January 1st or 2nd, nor would the January 5th measurement be compared to the baseline to determine whether the 0.3 mg/dL increase condition is satisfied. Similarly, when assessing for an SCR increase to 1.5 times baseline over seven days, each SCR measurement is compared to all other SCR measurements within seven days of its date. If a patient experiences either the 48 hour increase or the seven day increase, he or she is said to have had a hospitalization with AKI.

Once the patient was determined to have experienced an AKI based on SCR changes, the hospitalization as a whole was used to assign the stage of AKI. The highest SCR during the hospitalization was compared to the baseline. If the difference was greater than three times the baseline, the highest SCR was greater than 4.0 mg/dL, or renal replacement therapy was used during the stay, that hospitalization was classified as Stage 3. If the AKI episode was not Stage 3 and the difference between the maximum SCR and baseline was more than two times baseline but less than three, the hospitalization was classified as Stage 2. If the AKI episode was not Stage 2 or 3, it was Stage 1, i.e. an increase of at least 0.3 mg/dL but less than two times baseline.

Figures 5.3-5.5 used the entire analysis cohort as the denominator to calculate rates of AKI per 1,000 patient-years at risk for Medicare (panel a) and Optum Clinformatics™ (panel c) beneficiaries, and to calculate rates of AKI requiring dialysis per 1,000 patient-years at risk for Medicare (panel b) beneficiaries. Each hospitalization with an AKI diagnosis (any position on the claim) for a patient was

counted as an event. Years at risk were calculated for each patient as the time during the reported year (year two), censored at the development of ESRD, disenrollment from their plan (for Medicare, disenrollment from Parts A and B, or a switch to a Medicare Advantage plan), at death, or December 31 of year two. Age was determined on January 1 of year two, while CKD and DM status were determined by claims in year one. For the 2018 ADR, a Poisson model was used to model the number of AKI events, and the denominator was the sum of the time at risk of every cohort member.

Readmission associated with an AKI Episode

Figures 5.6 (Medicare beneficiaries) and 5.7 (Optum Clinformatics™ beneficiaries) show the probability of having a second hospitalization with AKI within 24 months of the first hospitalization with AKI. The samples for these figures began with the 2014 Medicare and Optum Clinformatics™ cohorts identified in the *Characteristics of Patients with AKI* section above—patients alive, aged 66+ years in the Medicare data or 22+ years in the Optum Clinformatics™ data, without ESRD, and enrolled in their plan (for Medicare, Part A and B coverage with no Medicare Advantage plan) on 1/1/2014. The first hospitalization with AKI in 2013 was identified. Age was determined as of 1/1/2014, and comorbidities were defined by searching claims one year prior to the AKI admission date. The search period was determined as follows: admission date – (minus) 365 (days), through one day before admission. Within this customized date range, CKD and DM status were defined according to the algorithm and codes described in the *Identification of Major Comorbidities* section and Tables 10.3 and 10.4 of this chapter. The final cohorts for Figures 5.6 and 5.7 included only those patients with at least one hospitalization with AKI in 2014 who were discharged alive. Follow-up began on the date of discharge listed on the claim for the hospitalization with AKI and continued until the earlier of a second hospitalization with AKI, death, ESRD, disenrollment from their plan (for Medicare, Parts A and B or a switch to a Medicare Advantage plan), or 730 days following the first AKI discharge. Kaplan Meier methods were used to estimate survival, with the cumulative probability of a recurrent hospitalization with AKI defined as (1-survival).

Patient Care and Outcomes

Figure 5.8.a shows the outcomes of death or ESRD within one year of a live discharge from a hospitalization with AKI for Medicare beneficiaries; Figure 5.8.b presents this data for the Optum Clinformatics™ beneficiaries. To increase the precision of these estimates, we created cohorts that included Medicare or Optum Clinformatics™ patients with a first hospitalization with AKI in 2014 or 2015. Patients were alive, aged 66 or older in the Medicare data or 22 years or older in the Optum Clinformatics™ data, without ESRD, and enrolled in their plan (for Medicare, Parts A and B coverage with no Medicare Advantage plan) on January 1 of the year of their first hospitalization with AKI. Patients discharged alive from their hospitalization with AKI were 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 was calculated from the date of discharge of the hospitalization with AKI to the earliest date of ESRD, death, disenrollment from their plan (for Medicare, Parts A or B or a switch to a Medicare Advantage program), or 365 days following discharge. Note that, starting with the 2017 ADR, the mortality model was not censored at the start of ESRD. For the mortality model, survival time was calculated from the date of discharge from the first hospitalization with AKI to the earliest of death, disenrollment from their plan (for Medicare, Parts A or B or a switch to a Medicare Advantage program), or 365 days following discharge.

Figure 5.9 presents the probability of a nephrology clinic visit within the first six months after a live discharge from a hospitalization with AKI. Claims were searched for services provided by nephrologists for 180 days following the discharge date of the hospitalization with AKI. In the Medicare data (Figure 5.9.a), visits with a nephrologist have the provider specialty code 36, while in the Optum Clinformatics™ data (Figure 5.9.b), visits are identified by a provider category code for nephrologist (PROVCAT 0597-0604). Time to visit begins on the date of discharge listed on the claim for the hospitalization with AKI and

continues until the earliest date of occurrence of the following: the follow-up visit, death, ESRD, disenrollment from their plan (for Medicare, Parts A and B or a switch to a Medicare Advantage plan), or 180 days following the first AKI discharge. Kaplan Meier methods were used to estimate survival with the cumulative probability of a nephrology visit defined as (1-survival).

Figures 5.10.a and 5.10.b show renal status after one year for Medicare and Optum Clinformatics™ patients discharged alive from their first hospitalization with AKI. To increase the precision of the estimates, we created a cohort for this figure of patients who had a first hospitalization with AKI in 2014 or 2015. Patients were alive, aged 66 or older in the Medicare data or 22 years or older in the Optum Clinformatics™ data, without ESRD, with plan coverage (for Medicare, Parts A and B coverage with no Medicare Advantage plan) on January 1 of the year of their hospitalization with AKI, and did not have any claims with a diagnosis of CKD in the 365 days prior to that admission. Renal status after AKI was determined from claims occurring between discharge from the hospitalization with AKI and 365 days after discharge. CKD stage was determined by the 585.x or N18.x claim closest to 365 days after discharge, while ESRD determination used the first service date on the ESRD Medical Evidence form.

Figure 5.11 shows discharge status following a first hospitalization for Medicare beneficiaries in 2016. Figure 5.11.a shows patients whose hospitalization contained an AKI episode while 5.11.b shows those whose hospital stay did not. The cohort includes all patients who experienced a hospitalization during 2016 and were alive, aged 66 or older, enrolled in Medicare Parts A and B but not in a Medicare Advantage program, and without ESRD on January 1, 2016. For Medicare patients admitted to an 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) were 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 were those whose 'patient discharge status' was 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 was 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: CKD among Children and Adolescents

The analyses in *Volume 1, Chapter 6: CKD among Children and Adolescents* are based on the Optum Clinformatics™ Data Mart cohort, a dataset of participants in the commercial insurance plans of a large U.S. managed-care health insurance company.

The definition of CKD typically includes the presence of structural or functional kidney damage over a minimum period of three months. Functional damage is often characterized by sustained reduction in estimated glomerular filtration rate (eGFR), persistent elevations in urinary albumin excretion or a combination thereof (KDIGO, 2012). The presence of a structural abnormality of the kidney also fulfills the criteria for CKD. Documentation of the presence of chronic structural or functional abnormalities of the kidney in medical claims may include traditional CKD codes or may only include a more precise structural or functional diagnosis. Consequently, a pediatric code set using ICD-9 and ICD-10 codes is utilized for *Volume 1, Chapter 6: CKD among Children and Adolescents*. Table 10.10 provides this set of CKD-related ICD-9-CM and ICD-10-CM codes.

Table 10.10 ICD-9-CM and ICD-10-CM diagnosis codes used to define chronic kidney disease (CKD) in pediatric patients in Volume 1, Chapter 6 of the ADR

Condition name	ICD-9-CM codes	ICD-10-CM codes
Chronic kidney disease (CKD)	189.0, 250.4-250.43,255.13, 283.11, 285.21, 403, 404, 446.21, 446.4, 580.4, 556.9, 581-582, 583.81, 585-588, 590.01, 593.3, 593.5, 596.4, 593.71-597.73, 593.81, 753.0-753.36, 753.9, 756.71, 886.81, V10.52, V13.03, V42.0, V44.52, V45.11, V45.73	A02.25, A18.11, A36.84, A52.75, B52.0, B58.83, C64.1, C64.2, C64.9, C68.9, D30.0x, D41.0x-D41.2x, D59.3, E08.22, E08.29, E09.21, E09.22, E09.29, E10.21, E10.22, E10.29, E10.331, E10.339, E11.2x, E13.2x, E26.81, E31.21, E72.01, E72.03, E72.04, E72.53, E83.31, E85.8, I12.x, I13.0, I13.1x, I13.2, M10.3x, M13.722, M31.0, M3101, M31.31, M31.7, M31.7, M32.14, M32.15, M35.04, N01.x-N08.x, N11.0, B11.1, N11.8, N11.9, N13.1, N13.1x-N13.6, N13.70, N13.721, N13.729, N13.8-N13.9, N14.x, N15.0, N15.8, N15.9, N16, N17.x, N18.1-N18.5, N18.8, N18.9, N19, N25.xx, N26.1-N28.9, N31.2, N31.9, Q27.1, Q60.x-Q62.69, Q63-Q64.33, Q64.4-Q64.9, Q79.4, Q79.51, Q71.81, Q80.0, Q80.1, Q80.8, Q83.9, R94.4, Z85.520, Z85.528, Z87.441, Z90.5, Z93.52
Staging of chronic kidney disease		
Stage 1	585.1	N18.1
Stage 2	585.2	N18.2
Stage 3	585.3	N18.3
Stage 4	585.4	N18.4
Stage 5	585.5 or 585.6 with no CMS 2728 form	N18.5 or N18.6 with no CMS 2728 form
Stage unknown or unspecified	Patient has no claims with codes 585.1-585.6 but has: 189.0, 250.4-250.43,255.13, 283.11, 285.21, 403, 404, 446.21, 446.4, 580.4, 556.9, 581-582, 583.81, 586-588, 590.01, 593.3, 593.5, 596.4, 593.71-597.73, 593.81, 753.0-753.36, 753.9, 756.71, 886.81, V10.52, V13.03, V42.0, V44.52, V45.11, V45.73	Patient has no claims with codes N18.1-N18.6 but has: A02.25, A18.11, A36.84, A52.75, B52.0, B58.83, C64.1, C64.2, C64.9, C68.9, D30.0x, D41.0x-D41.2x, D59.3, E08.22, E08.29, E09.21, E09.22, E09.29, E10.21, E10.22, E10.29, E10.331, E10.339, E11.2x, E13.2x, E26.81, E31.21, E72.01, E72.03, E72.04, E72.53, E83.31, E85.8, I12.x, I13.0, I13.1x, I13.2, M10.3x, M13.722, M31.0, M3101, M31.31, M31.7, M31.7, M32.14, M32.15, M35.04, N01.x-N08.x, N11.0, B11.1, N11.8, N11.9, N13.1, N13.1x-N13.6, N13.70, N13.721, N13.729, N13.8-N13.9, N14.x, N15.0, N15.8, N15.9, N16, N17.x, N18.8, N18.9, N19, N25.xx, N26.1-N28.9, N31.2, N31.9, Q27.1, Q60.x-Q62.69, Q63-Q64.33, Q64.4-Q64.9, Q79.4, Q79.51, Q71.81, Q80.0, Q80.1, Q80.8, Q83.9, R94.4, Z85.520, Z85.528, Z87.441, Z90.5, Z93.52

Source: ICD-9/10-CM, International Classification of Diseases, Ninth/Tenth Revision, Clinical Modification. Abbreviation: CKD, chronic kidney disease.

Tables 6.1 and 6.2 include point prevalent patients under 22 years old who survived all of the reported year (2016) and who did not have or develop ESRD during the reported year. Additionally, for the Optum Clinformatics™ analysis, the plan member is required to be enrolled for the entire reported year.

Table 6.1 presents demographic and comorbidity characteristics of children and adolescents in the Optum Clinformatics™ dataset. Comorbidities included diabetes mellitus (DM), hypertension (HTN), and cardiovascular disease (CVD). CVD was defined as the presence of any of the following comorbidities: cerebrovascular accident, peripheral vascular disease, coronary artery disease (formerly called atherosclerotic heart disease), heart failure, dysrhythmia, or other cardiac comorbidities. Each comorbidity was defined as described in the *Identification of Major Comorbidities* section of this chapter by at least one inpatient or two outpatient medical claims during the reported year.

Table 6.2 presents the prevalence of coded CKD, DM, and CVD in Optum Clinformatics™. Table 6.2.a shows the sample counts and percent of all patients with the condition, for each condition separately. Table 6.2.b shows the interaction between all three conditions, identifying those with all combinations of the conditions, plus the number and percentage who had at least one or at least two comorbidities.

The hospitalization analyses follow a similar approach as the hospitalization section in *Volume 1, Chapter 3: Morbidity and Mortality*.

Table 6.3 and Figure 6.1 show adjusted all-cause admission rates for Optum Clinformatics™ patients under 22 years old. Table 6.3 also shows the unadjusted rates. All Optum Clinformatics™ patients in the cohort were under 22 years old, did not have ESRD on or before 1/1/2016, had plan enrollment for all of 2015, and were alive on January 1, 2016. Adjusted analysis is adjusted for age/sex/race. Rates presented by one factor were adjusted for the others. The standard cohort for Optum Clinformatics™ analyses includes all patients in 2011.

Figure 6.2 shows adjusted, cause-specific admission rates for CKD Optum Clinformatics™ patients under 22 years old. Cause-specific rates reflect hospital admissions for the purpose of treating the specified condition—cardiovascular or infectious—and are identified using the principal ICD-9-CM or ICD-10-CM diagnosis code on the claim. Code values are shown in Table 10.5, however, those hospitalizations with the following diagnosis codes were reclassified from 'other cause' to cardiovascular:

Q20.3, Q21.0-Q21.3, Q22.1, Q22.2, Q23.1, Q13.3, Q24.5, Q24.8, Q24.9, Q25.9, Q26.1, R00.0, R01.0, R01.1, Z94.5

The 'other cause' of hospitalization is a residual category consisting of all hospitalizations other than those for cardiovascular or infectious conditions. Each cause is using an individual model adjusted for age/sex/race. Rates presented by one factor were adjusted for the others. The standard reference cohort for Optum Clinformatics™ analyses includes all patients in 2011.

Figure 6.3 shows per person per year commercial spending ($, in thousands) for Optum Clinformatics™ patients under 22 years old by comparing CKD patients and non-CKD patients from 2006 to 2016. The analysis follows a similar approach as *Volume 1, Chapter 7: Health Care Expenditures for Persons with CKD*.

Chapter 7: Health Care Expenditures for Persons with CKD

Volume 1, Chapter 7: Health Care Expenditures for Persons with CKD used a cohort that continued the methodology introduced in the 2010 ADR, where we only tabulated CKD costs for patients with CKD diagnoses (minimum of one inpatient and/or two outpatient) among their claims in the year prior to the reported year (year one). For example, the total costs of CKD for 2015 (year two) included all costs incurred by patients with a CKD diagnosis in 2014 (year one). Prior to the 2010 ADR, patients newly diagnosed with CKD during year two were also included in the total expenditures.

The data we received from the Optum Clinformatics™ Data Mart this year included a complete refresh of all years from 2006 to 2016. This lead to changes in some of the trends using the

Optum cost data. Additionally, Optum added encounter claims. These are claims that the insurance company did not pay for outright but were bundled as part of a larger procedure, such as follow-up visits after surgery. While these claims may be useful for researchers studying surgeries who may want to track patients' adherence to the follow-up regimen, these claims are tricky for cost analysis. Since Optum sets a standard price for each CPT code/ICD procedure code, the encounter claims show a standard price even though the insurance company paid nothing. As we are interested in how much the payer spends on various patient groups, we limited the claims to those with a claim type of P for paid, whereas in the past, when there were no encounter claims, we summed all claims.

The same general point prevalent cohort was used to create all the Medicare tables and figures, and a similar cohort was created for the Optum Clinformatics™ tables and figures. Each year's Medicare cohorts included patients aged 65 and older who were alive and without ESRD on January 1 of the reported year (year two). Cohort members were continuously enrolled in their plan (for Medicare, Medicare Parts A and B and not enrolled in a Medicare Advantage plan) for all of year one (the one-year entry period prior to the year in which costs were assessed). Costs were then aggregated for the reported year (year two). Patient-years at risk were 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 their plan (for Medicare, Parts A or B or a switch to a Medicare Advantage program), or December 31 of year two. Per-person-per-year (PPPY) costs are produced by dividing the total cost amount by the number of patient-years at risk. Since total costs and the numbers of patients for Medicare were based on the 5% Medicare files, we multiplied counts and expenditures by 20 in order to represent 100% of Medicare fee-for-service Part A, B, and D expenditures. These were age-eligible patients who were continuously enrolled in Parts A and B, and not enrolled in a Medicare Advantage plan, for all of the previous year (year one). The Optum Clinformatics™ data represents 100% of their beneficiaries, thus there was no need to weight the data to population totals.

Since the 2017 ADR, we no longer attribute only a fraction of claims that span the calendar year to each year. Instead, we place the entire payment for a claim spanning a calendar year in the year corresponding to the admission date.

The disease conditions of CKD, heart failure (HF), diabetes mellitus (DM), and the stage of CKD were determined from the claims in the year prior to the reported year (year one) using the algorithm described in the *Identification of Major Comorbidities* section of this chapter and the diagnosis codes listed in Tables 10.3 and 10.4. Age was determined as of December 31 of year one. With rows representing all combinations of the disease conditions of CKD, HF, and DM, Table 7.1 shows the total Medicare population aged 65 and older, total spending, per-patient per-year spending, the fraction of the total Medicare population with the given disease condition(s), and the fraction of total Medicare spending for the given disease condition(s). Table 7.2 shows the Optum Clinformatics™ data for members aged 65 and older covered by their commercial insurance and Medicare Advantage plans. For each plan type, the per-patient per-year spending is shown, as is the fraction of the total plan members with each given condition, and the fraction of total plan spending for each condition. Tables 7.3 and 7.4 show the same statistics for beneficiaries and members who were under the age of 65. Figure 7.1 shows the information in Table 7.1 graphically, along with the same information for the previous year.

Table 7.5 shows two years of per-person per-year spending for overall CKD (any stage) and by CKD stage for Medicare fee-for-service coverage, and Table 7.6 shows this data for Optum Clinformatics™ commercial insurance and Optum Clinformatics™ Medicare Advantage plans. Costs and conditions were determined as in Tables 7.1 and 7.2 and Figure 7.1, while race and sex were provided by the Master Beneficiary Summary File. Figure 7.2 displays this information graphically for four years. Table 7.7 shows data similar to Table 7.5, but for those with CKD and DM. Table 7.8 shows the same statistics as Table 7.7 but for Optum Clinformatics™ Medicare Advantage and commercial insurance enrollees. Table 7.9 repeats Table 7.7, but for those with CKD and HF rather than DM. Table 7.10 presents the same results as Table 7.9,

but for the Optum Clinformatics™ Medicare Advantage and commercial insurance enrollees.

The focus of Figures 7.3-7.6 is expenditure trends. Figure 7.3 shows the spending on fee-for-service Parts A, B, and D for all Medicare patients and for Medicare patients with CKD (7.3.a), patients with DM (7.3.b), and patients with HF (7.3.c). Figure 7.4 shows Medicare spending for fee-for-service enrollees with CKD by the type of Medicare claim, which corresponds to the type of medical service delivered. The categories include inpatient institutional claims (billed by the hospital or other facility), outpatient claims billed by facilities, physician/supplier claims (services from non-institutional providers, mostly covered under Part B), skilled nursing facilities (Medicare covers short term stays for rehabilitation after medical procedures or surgery but not long-term care), home health agencies (another service provided following medical procedures or surgeries), hospice care, and Part D prescription drug claims. Figure 7.5 shows inpatient institutional costs by the cause of hospitalization, which was determined using the same methods as in *Volume 1, Chapter 3: Morbidity and Mortality in Patients with CKD*, using the codes displayed in Table 10.5. Figure 7.6 shows per-person per-year (PPPY) spending by a combination of chronic conditions. We included all patients regardless of condition—those without DM and HF, those with CKD and DM, CKD and HF, and those with all three (CKD, DM, and HF). Figure 7.6.a shows Medicare fee-for-service spending, 7.6.b shows Optum Clinformatics™ commercial insurance plan members, and 7.6.c shows Optum Clinformatics™ Medicare Advantage spending. Table 7.11 shows the overall percentage of CKD expenditures for Medicare, Medicare Advantage, and managed care beneficiaries aged 65 and older by CKD stage and year.

Chapter 8: Prescription Drug Coverage in Patients with CKD

Volume 1, Chapter 8: Prescription Drug Coverage in Patients with CKD describes prescription drug coverage and usage. Since the 2017 ADR, we show prescription drug utilization from the Optum Clinformatics™ dataset for both those in Medicare Advantage plans and those in commercial plans, as well as Medicare 5% sample beneficiaries. CKD was determined as described in the *Identification of Major Comorbidities* section of this chapter and in Table 10.3, using claims from a one-year entry period (year one, the calendar year before the year in which prescription drug coverage participation and utilization was assessed). Prescription drug utilization and enrollment (for Part D coverage only) were assessed in the following year (year two, the year reported in the figures and tables), while ESRD was determined by the ESRD first service date. In the chapter Prescription Drug Coverage in Patients with CKD in Volume 1, both the General Medicare cohort and the CKD cohort had the same inclusion criteria, representing a change from the 2013 and earlier ADRs. This also differs from the sample used to describe General Medicare patients in *Volume 2, Chapter 10: Prescription Drug Coverage in Patients with ESRD*, which does not apply restrictions based on year-one Medicare participation.

In *Volume 1, Chapter 8*, beneficiaries must have been enrolled in their plan (for Medicare, Parts A and B, and not enrolled in a Medicare Advantage plan) for all of year one, and must have been alive, without ESRD, and enrolled in their plan on January 1 of year two. Note that those with a Medicare Advantage plan in January of year two were not specifically excluded; if a beneficiary was not in a Medicare Advantage plan for all of year one, but switched to Medicare Advantage for year two, they were still included in the analysis cohort. These criteria were necessary to enable CKD identification in the Medicare cohort, as diagnosis codes were only available for those with fee-for-service Medicare. To have an appropriate comparison for the CKD cohort, the same exclusion criteria were applied to the General Medicare group. Unlike the other chapters in Volume 1, *Chapter 8* includes all beneficiaries aged 20 years and older. For inclusion in the Medicare cohort, those under age 65 must have been eligible for Medicare through participation in federal disability programs (Social Security Disability Insurance or Supplemental Security Income) or their entitlement was related to amyotrophic lateral sclerosis, and thus should not be viewed as representative of the U.S. general population under age 65. On the other hand, the

Optum Clinformatics™ dataset represents those of prime working age in the country and is representative of younger age groups.

Figures 8.1-8.3 summarize the prescription drug insurance coverage for Medicare beneficiaries by source, comparing the General Medicare and CKD populations, showing results overall and by age and race categories. The sources of coverage across the calendar year are combined into mutually exclusive and exhaustive categories in a hierarchical manner. Enrollment in a Part D plan is determined by the first digit of the Part D Plan Contract Number variable (one for each month) being "E" (an employer direct plan, a valid value starting in 2007), "H" (a managed care organization other than a regional preferred provider organization (PPO)), "R" (a regional PPO), or "S" (a stand-alone prescription drug plan). A beneficiary was considered to be enrolled in a Part D plan for the year if he or she was enrolled for one month or more of the analysis year.

If a beneficiary was enrolled in a Part D plan and received a low-income subsidy (LIS) in at least one month, he or she was classified as "Part D with LIS", and as "Part D without LIS" otherwise. The receipt of a low-income subsidy was determined by the monthly Cost Sharing Group Code values "01" through "08."

For beneficiaries not enrolled in a Part D plan, there are several options for non-Medicare prescription drug coverage, as reported to the Medicare program. Beneficiaries were classified as having a "Retiree Drug Subsidy" if they were not enrolled in a Part D plan but had at least one month with a Part D Retiree Drug Subsidy Indicator value of "Y" (yes), indicating he or she was enrolled in an employer-sponsored prescription drug plan that qualified for Part D's retiree drug subsidy.

In prior deliveries of the Medicare 5% sample there was a variable called Creditable Coverage Switch with a value of "1", indicating another form of drug coverage that was at least as generous as the Part D benefit. For data year 2016 (used in the 2018 ADR), the Creditable Coverage Switch variable was no longer available on the files we received from the Chronic Conditions Warehouse, and it cannot be derived from other variables on the file.

Figure 8.1 presents the distribution of sources of prescription drug coverage without the category of other creditable coverage for the General Medicare and CKD cohorts described above.

Table 8.1 shows the percent of beneficiaries with Part D coverage for the past six years in the General Medicare and CKD cohorts. Table 8.2 is an adaptation of data presented in the 2016 Medicare Outlook section of the *www.q1medicare.com* website and does not include USRDS analyses. Figure 8.2 shows the categories of prescription drug coverage (described above for Figure 7.1) by age groups (20 to 44, 45 to 64, 65 to 74, and 75 and older) for General Medicare (Figure 8.2.a) and CKD (Figure 8.2.b) cohorts, while Figure 8.3 shows the coverage categories by race groups (White, Black or African American, Asian, and Other.)

Table 8.3 is limited to beneficiaries who were enrolled in Part D prescription plans for at least one month of the analysis year. Part D plan enrollment and receipt of LIS were determined as described for Figure 8.1. Table 8.3 shows the percent of Part D enrollees with LIS within each race group ("all ages" row) and by age groups within the race group (also defined as above) for the General Medicare cohort and the CKD cohort. Figure 8.4 is limited to those enrolled in a Part D plan with LIS and shows the different types of LIS, as determined by the values of the Cost Sharing Group Code, for the General Medicare and CKD cohorts.

Table 8.4 and Figure 8.5 present data on Medicare spending for Part D benefits. The Part D benefit expenditure for a prescription drug event (PDE) is the sum of the amount of cost sharing for the drug that is paid by the Part D low-income subsidy (LIS Amount) and the net amount that the Part D plan pays for the PDE (Covered Part D Plan Paid Amount). Table 8.4 shows the total Medicare Part D benefit expenditures and the per-person per-year spending for the General Medicare and CKD cohorts (defined above) for beneficiaries enrolled in stand-alone Part D plans (i.e. spending for Medicare Advantage prescription drug plans is not included). These cost numbers are therefore comparable to the statistics presented in *Volume 1, Chapter 7: Healthcare Expenditures for Persons with CKD*, which show Medicare spending on Parts A and B benefits for those not in Medicare Advantage plans.

Figure 8.5.a shows spending and patient out-of-pocket costs per-person per-year (PPPY) for the General Medicare members and CKD cohorts for those in fee-for-service Part D plans, Optum Clinformatics™ Medicare Advantage plans, and Optum Clinformatics™ commercial insurance plans. Out-of-pocket cost is the sum of the amounts the patient pays without being reimbursed by a third party (for fee-for-service Medicare, the Patient Payment Amount), which includes all copayments, coinsurance, deductible, or other patient payment amounts. For fee-for-service Medicare, this includes the amount of any payment made by other third-party payers that reduced the beneficiary's liability for the PDE or prescription claim (Other True Out-of-Pocket Amount). Two examples of this are payments by qualified state pharmacy assistance programs or charities. Figure 8.5.b breaks out these costs by whether the patient received any low income subsidies. Table 8.5.a shows PPPY spending by age, sex, and race for the General and CKD cohorts by fee-for-service Medicare with LIS and fee-for-service Medicare without LIS. Table 8.5.b provides the same information for patients with Optum Clinformatics™ Medicare Advantage plans and Optum Clinformatics™ commercial insurance plans.

All drugs in the PDE file and Optum Clinformatics™ PHARM_<YEAR> table were matched to a therapeutic category according to the American Hospital Formulary Service (AHFS) classification system. The Medicare cohort for Tables 8.6.a and 8.7.a was limited to those in the CKD cohort who had stand-alone Part D prescription drug coverage. Each therapeutic category in Tables 8.6-8.7 was summarized and the percent of patients with CKD who filled at least one prescription for a drug in the given class was calculated, as well as the total amount spent by Medicare or the plans in the Optum Clinformatics™ dataset on each drug class and its percentage of total prescription drug plan expenditures. Table 8.6 shows the top 15 drug classes ranked by the highest percent of CKD patients with at least one prescription filled in that class for fee-for-service Medicare (Table 8.6.a), Optum Clinformatics™, Medicare Advantage (Table 8.6.b), and Optum Clinformatics™ commercial insurance (Table 8.6.c). Table 8.7 shows the top 15 drug classes ranked by spending. The column following the drug class shows the total amount spent by Medicare (Table 8.7.a), Optum Clinformatics™ Medicare Advantage (Table 8.7.b), and Optum Clinformatics™ commercial insurance (Table 8.7.c) on each drug class for CKD patients. The next column shows that drug class' cost as a percentage of all plan expenditures for these patients.

Since the 2017 ADR, the chapter Prescription Drug Coverage in Patients with CKD has shown data on analgesic drugs. Analgesics were identified as members of the AHFS classes 280804 – nonsteroidal anti-inflammatory agents (NSAIDs), 280808 – opiate agonists, and 280812 – opiate partial agonists. The cohort used for Figures 8.6-8.7 was the same as the Medicare cohort used in Tables 8.6-8.7; it excluded those with Medicare Advantage Part D plans, as we are unable to identify CKD in those patients. Analgesic use in patients with CKD was defined as the patient having filled or refilled at least one prescription of a drug in the drug classes listed above. The state of residence was obtained from the Medicare Beneficiary Summary File. Figure 8.6 tabulates the use of NSAIDs (yes/no) by state, divides the states by quintiles, and shows the results in a map. Figure 8.7 does the same with the use of opiates.

The special focus of the 2018 ADR is antiviral medication use in the general Medicare population and the CKD population. Figure 8.8.a shows the prevalence of Human Immunodeficiency Virus (HIV) and Figure 8.8.b shows Hepatitis C virus (HCV) in patients with CKD. Diagnosis codes for HIV are 042 (ICD-9) and all of B20 (ICD-10). For HCV, the codes were 070.54 (ICD-9) and B18.2x (ICD-10) – all of the codes beginning with B18.2.

The antiviral class of drugs was defined as AHFS class 0818. We focused on antiretrovirals (081808), nucleosides and nucleotides (0818320), and protease inhibitors (081840). Figure 8.9 shows the utilization of these drugs over time, and Figure 8.10 shows per-patient per-year spending on these drugs by the Medicare program.

Reference Tables

CKD Reference Tables

Downloadable CKD Reference Tables are found on this page: *https://www.usrds.org/reference.aspx*

Reference Table B: Prevalence

Reference Tables B.1–B.6 present estimated point prevalent (December 31) counts of the Medicare non-ESRD population, based on the 5% Medicare sample, for adults aged 20 and older rather than the age-eligible (aged 65 and older) cohort presented in *Volume 1, Chapter 2: Identification and Care of Patients with CKD*. Each year's cohort included all patients alive and without ESRD, who were continuously enrolled in Medicare Parts A and B, and not enrolled in a Medicare Advantage program for the entire year. Age was calculated as of December 31 of the reported year. Race and sex were provided by the Master Beneficiary Summary File. The disease conditions of CKD, heart failure (HF), and diabetes mellitus (DM) and the stage of CKD were determined from 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 10.3 and 10.4. Counts were multiplied by 20 to represent 100% of the Medicare population meeting the cohort definition.

Reference Tables B.7-B.10 were based on NHANES data (see the NHANES methods description in the *Chapter 1: CKD in the General Population* section, above). For Table B.8, CKD was defined as an 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). We estimated eGFR 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 a three-month period, but only one measurement of each is available in NHANES. Therefore, the resulting numbers may 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, diabetes mellitus (DM) is defined as in *Volume 1, Chapter 1: CKD in the General Population*, and eGFR and ACR are described as in Table B.8. Table B.10 presents results for heart failure (HF), 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*?"

Reference Table K: Healthcare Expenditures

In Tables K.1–K.5 we present estimates of the per-person per-year Parts A, B, and D Medicare expenditures for point prevalent (December 31) general Medicare patients, also derived from the 5% Medicare sample. Methods for these tables were the same as those described in the *Chapter 7: Health Care Expenditures for Persons with CKD* section of this chapter. Reference Table K includes all adult patients aged 20 and older, while *Volume 1, Chapter 7* presents these costs only for those age-eligible for Medicare (aged 65 or older).

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Notes