USRDS
UNITED STATES RENAL DATA SYSTEM

Chapter 1: CKD in the General Population

- This year we introduce an examination of the socioeconomic factors of health insurance status, income, and education level among individuals with chronic kidney disease (CKD; Table 1.3).
- Overall prevalence of CKD (Stages 1-5) in the United States (U.S.) adult general population was 14.8% in 2011-2014. CKD Stage 3 (6.6%) was the most prevalent (Figure 1.2 and Table 1.2).
- Roughly, 40% of individuals with CKD also had diabetes (DM), 32% had hypertension (HTN), and 40% had self-reported cardiovascular disease (SR CVD; Table 1.2).
- In the general U.S. population, the prevalence of a urinary albumin-to-creatinine ratio (ACR) with >10mg/g of creatinine was 32%, including 8.5% with ACR 30–300 mg/g and 1.4% with ACR >300 mg/g (Figure 1.4).
- Approximately 20% of individuals had urinary ACR 10-29 mg/g, which although below the threshold for albuminuria, has shown evidence of prognostic significance (Figure 1.4).
- Age was the best correlate of low estimated glomerular filtration rate (eGFR; <60 ml/min/1.73m^2), while HTN was the greatest predictor of albuminuria (Figures 1.7 & 1.8).
- In a comparison of four cohorts of NHANES participants (1999-2002, 2003-2006, 2007-2010, and 2011-2014), the percentage of individuals at target blood pressure of <140/90 (Figure 1.10) and the percentage with normal cholesterol levels (Figure 1.11) increased over time.
- Only minimal changes in self-reported physical activity occurred over time (Figure 1.9).
- Following a 1999-2002 initial increase in the percentage of diabetics with glycosylated hemoglobin <7%, this rate fell steadily over the subsequent three time periods (Figure 1.12 & Table 1.5).
- Comparing these same four NHANES cohorts, there was little improvement in the percentage of individuals with CKD who were aware of their disease, especially among those in Stages 1 to 3. Individuals with Stage 4 CKD reported a small increase in disease awareness (Figure 1.13).
- The prevalence of self-reported CKD was very low in the U.S. general population, as indicated in a large representative telephone-based survey (BRFSS). Reports ranged from 1.8% in Virginia to 4.0% in Arizona. 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 U.S., through analysis of data from the National Health and Nutrition Examination Survey (NHANES; CDC, 2015a) and from the Behavioral Risk Factors Surveillance System (BRFSS; CDC, 2015b), 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—1999-2002, 2003-2006, 2007-2010, and 2011-2014. These years include all data from the beginning of the “continuous” NHANES data collection. In previous Annual Data Reports (ADRs) NHANES III (1988-1994) data were also included; we refer readers to the past ADRs for this information. New data available for this year’s ADR is limited to the 2013-2014 information on CKD, which became available in February of 2017.

The Behavioral Risk Factors Surveillance System (BRFSS; CDC, 2015b), 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 2015.

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. Therefore, as repeated measures are not available for a large number of individuals in these cohorts, using such data to determine rates of CKD is subject to bias-by-indication.

While it is possible that a second data point from repeat testing may result in lower estimates of prevalence of kidney disease than those calculated from single values, it is equally possible that the values obtained in these two settings under stable conditions are acceptable for purposes of public health surveillance. This is especially likely given that the variability of repeat serum creatinine measurements in individuals is based on a number of factors (diet, physical activity, state of hydration, etc.) and also because the potential fluctuations in urine albumin excretion can be influenced by posture, exercise, early morning specimen vs. random urine specimen, etc. Furthermore, and especially at higher levels of kidney function (GFR ≥60 ml/min/1.73m^2), the estimating equations currently in use are known to be increasingly imprecise, and have not been validated for use in the very elderly, in those with poor muscle mass, or at the extremes of body size.

Given the considerations above, although the potential for imprecise prevalence estimates from a single serum creatinine or urine albumin measurement is real, an estimate for CKD prevalence based on just two readings may also result in under- or over-estimates. Therefore on balance, and for public health purposes alone, when samples have been obtained in a stable, community-based setting such as the NHANES survey, we believe that the estimate based on a single random sample from the non-institutionalized population is sufficient and realistic at the population level. Further, NHANES does not collect data on the institutionalized populations who are mostly elderly and likely to skew the overall prevalence estimate.

With the above caveat, we used the KDIGO 2012 Clinical Practice Guideline for the Evaluation and Management of Chronic Kidney Disease (KDIGO, 2012) to identify CKD. Our working definition differs from that of KDIGO in that data available in NHANES are not longitudinal in nature, and therefore information on the persistence of poor kidney function for three months is not available.

In clinical practice, diagnosis of CKD typically requires multiple assessments of kidney function and urine albumin (or total protein) over weeks or months. Instead, we rely on a single, cross-sectional sample available for all participants in the four cohorts to estimate the prevalence of CKD in the U.S. adult population, and to determine CKD trends over time. Thus, the estimates of CKD reported in this chapter may be higher (or lower) than would be the case if measures of eGFR and ACR were repeated over time to fulfill the KDIGO criteria of 'persistence for three months or longer' for the clinical diagnosis of CKD.

Consistent with the assessment of the prevalence of other medical conditions in NHANES, both eGFR and ACR measures are based on laboratory specimens collected at a single point in time. We evaluated kidney function by eGFR as calculated using the CKD-EPI creatinine equation (Levey et al., 2009). Individuals with eGFR <60 ml/min/1.73m² 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/1.73m² or ACR ≥30 mg/g. Staging of kidney disease follows the Kidney Disease Outcomes and Quality Improvement (KDOQI) CKD guidelines (Table A; NKF, 2002).

It is important to note that 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 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, OPTUM Clinformatics™, and Veterans Health Administration (VHA) data, providing information on morbidity, interventions, and costs.

Methods

Two nationally representative data sources are included in the analyses for this chapter: NHANES (1999-2014) and BRFSS (2012-2015).

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.

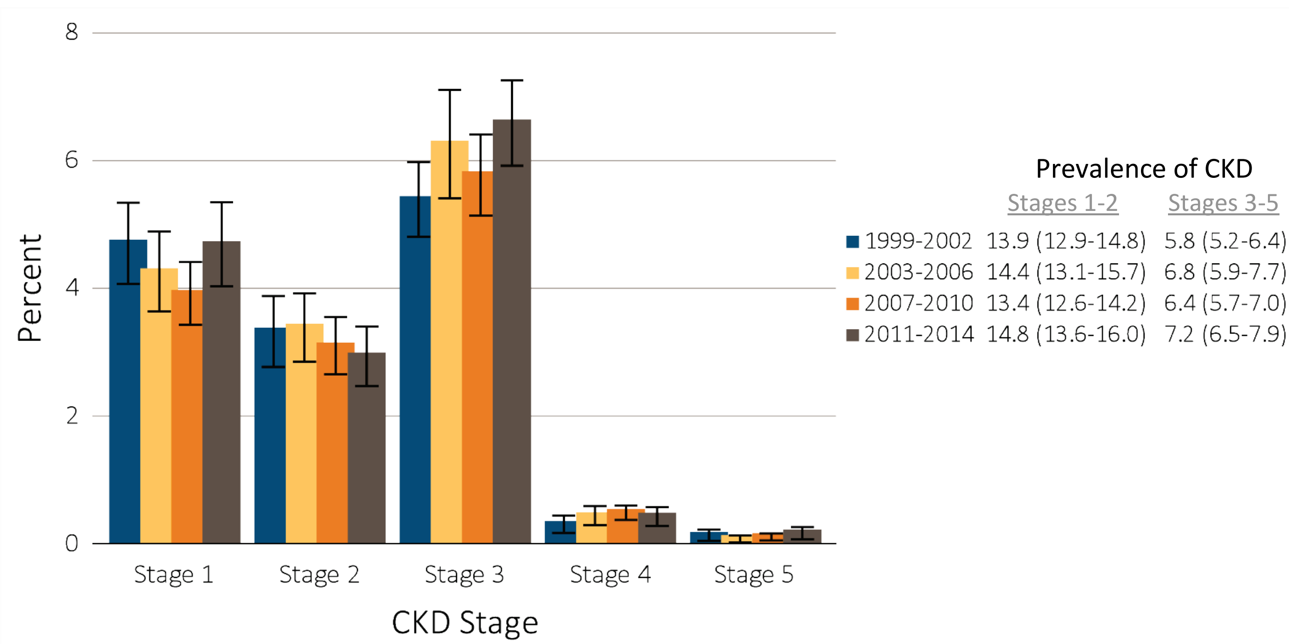
Figure 1.14 employs data from the Behavioral Risk Factor Surveillance System (BRFSS) to illustrate the geographic distribution by state of self-reported kidney disease. These data are also a sample of the U.S. general population, but respondents answer survey questions during a phone interview, and there is no medical examination. However, the sample size is larger 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 Chapter 1, 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.

Prevalence of CKD

Figure 1.1 presents the U.S. prevalence of CKD, over four periods from 1999 to 2014. The largest increase occurred in Stage 3 CKD, which rose from 5.4% to 6.6% over the four periods. The percent of individuals in Stages 1 and 2 decreased from 1999-2010; Stage 2 continued to decrease but Stage 1 reverted to initial levels in the most recent time frame. The trend in increasing prevalence for Stages 3-5 (non-ESRD) was statistically significant (OR=1.06 per each more recent cohort, p=0.01), although some of the increase is explained by age (OR=1.03, p=0.25). The U.S. population experienced a population age shift during the included years, primarily resulting from an influx of the "baby boomer" population aging into retirement. Because of the large effect of age on CKD prevalence, higher rates are understandable.

vol 1 Figure 1.1 Prevalence of CKD by stage among NHANES participants, 1999-2014



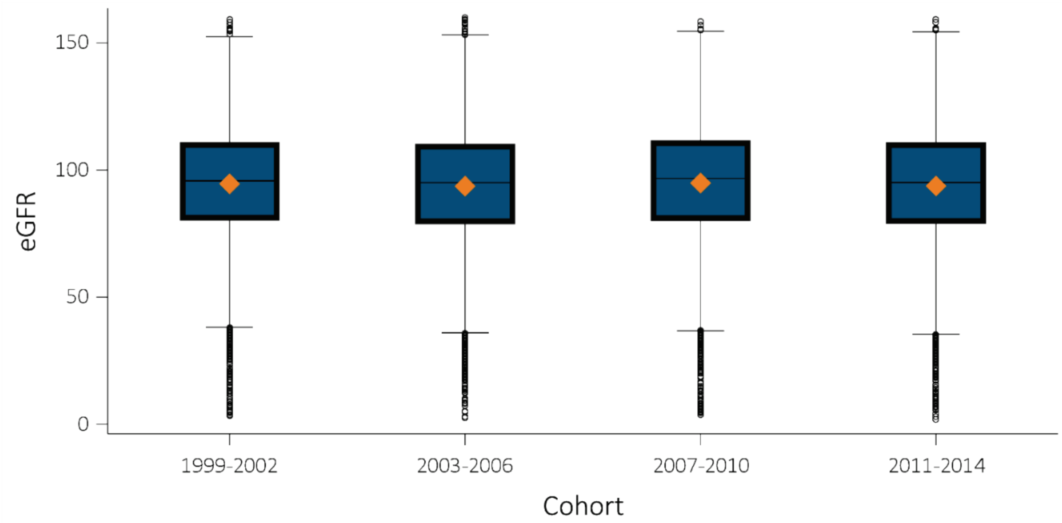
Data Source: National Health and Nutrition Examination Survey (NHANES), 1999-2002, 2003-2006, 2007-2010 & 2011–2014 participants aged 20 & older. Whisker lines indicate 95% confidence intervals. Abbreviation: CKD, chronic kidney disease.

Figure 1.2 provides the density distributions of eGFR in NHANES 1999-2002, 2003-2006, 2007-2010, and 2011-2014. 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 the individuals over 60 years was approximately 25 ml/min/1.72m², lower than for the complete sample (Figure 1.2.b).

vol 1 Figure 1.2 eGFR distribution among NHANES participants, 1999-2014

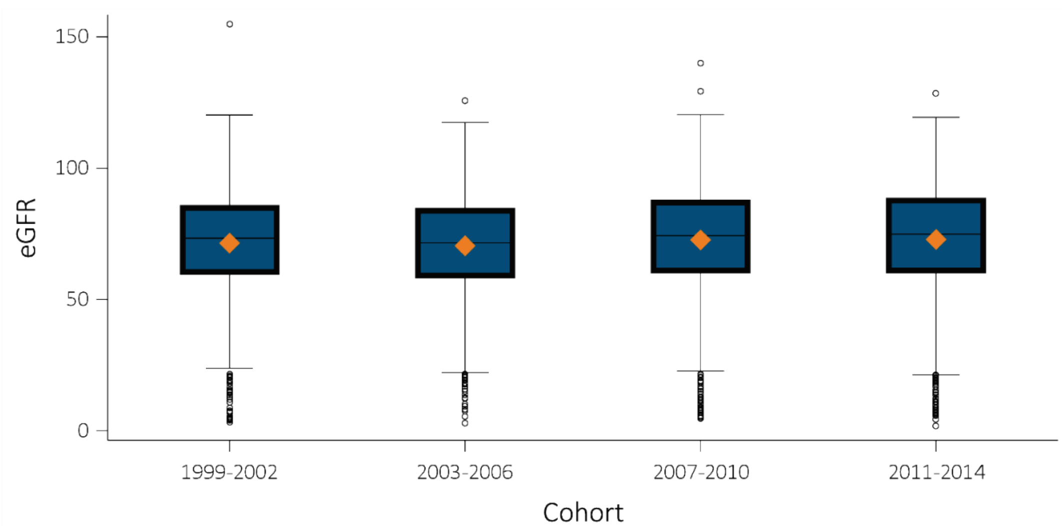
(a) All Individuals

Cohort	Mean	SE
1999-2002	94.9	0.46
2003-2006	93.8	0.63
2007-2010	95.0	0.55
2011-2014	94.0	0.45



(b) Individuals 60+ years

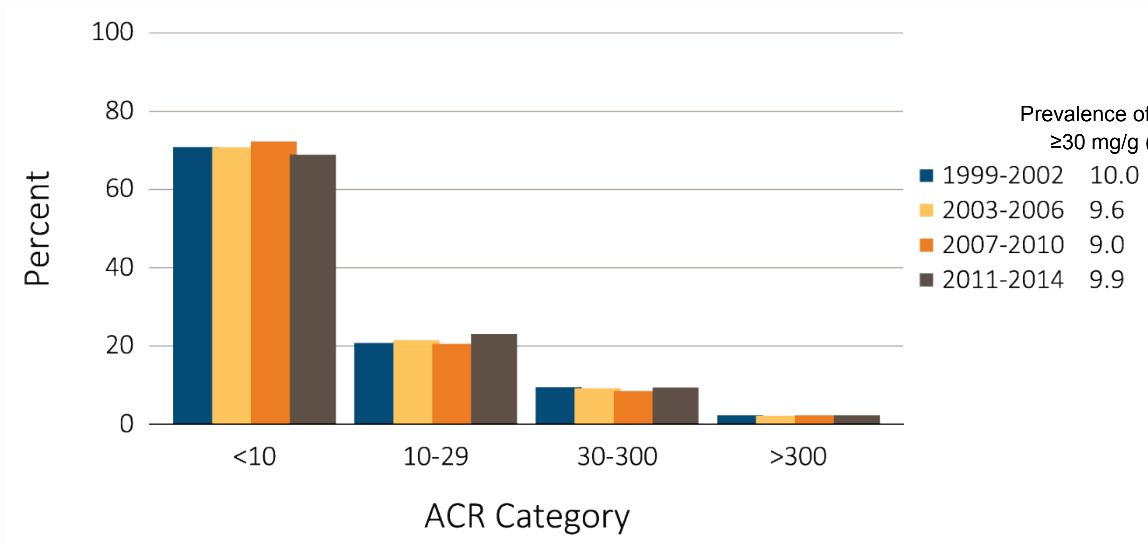
Cohort	Mean	SE
1999-2002	71.9	0.52
2003-2006	70.8	0.52
2007-2010	72.9	0.36
2011-2014	73.2	0.38



Data Source: National Health and Nutrition Examination Survey (NHANES), 1999-2014 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.

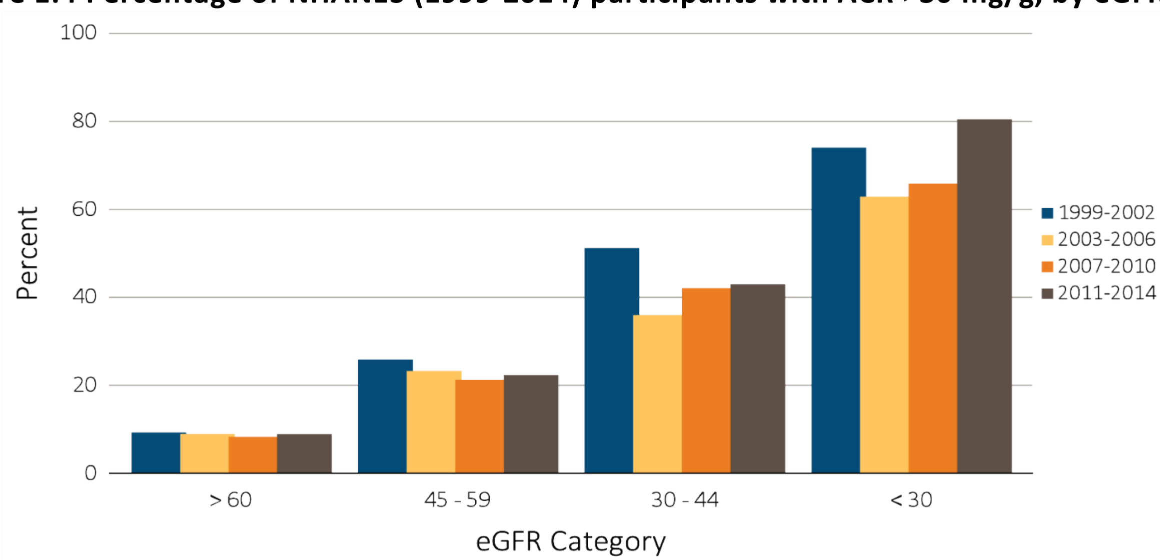
Figure 1.3, with corresponding findings for ACR, shows little change over time in the distribution patterns of individuals with ACR >300 mg/g. However, comparison of the groups with ACR 10-29 mg/g and 30-300 shows a slight increase, with a corresponding decrease in the proportions of individuals with either 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, 1999-2014



Data Source: National Health and Nutrition Examination Survey (NHANES), 1999-2014 participants aged 20 & older. Single-sample estimates of ACR. Abbreviation: ACR, urine albumin (mg)/creatinine (g) ratio.

vol 1 Figure 1.4 Percentage of NHANES (1999-2014) participants with ACR >30 mg/g, by eGFR category



Data Source: National Health and Nutrition Examination Survey (NHANES), 1999-2014 participants aged 20 & older. Single-sample estimates of eGFR. Abbreviation: ACR, urine albumin (mg)/creatinine (g) ratio; eGFR, estimated glomerular filtration rate.

When assessing the joint distribution of eGFR and ACR, we observed higher prevalence of albuminuria with lower kidney function. For example, in the 2011 to 2014 NHANES sample, 6.5% of persons with normal kidney function (>90 eGFR ml/min/1.73m²) had some evidence of albuminuria (Table 1.1). This rose to 9.4% among individuals with an eGFR of 60-90, 22.2% for those with an eGFR of 45-59, and 46.7% for those with an eGFR of 30-44. Of individuals with Stage 4 CKD (eGFR <30 ml/min/1.73m²), over half had evidence of albuminuria.

vol 1 Table 1.1 Percentage of NHANES 2011-2014 participants, in the various CKD (eGFR and albuminuria) risk categories (KDIGO 2012)

(a) Percentage in each category (2011-2014)

				Albuminuria categories		
				A1	**A2**	**A3**
				Normal to mildly increased	Moderately increased	Severely increased
				<30 mg/g <3 mg/mmol	30-300 mg/g 3-30 mg/mmol	>300 mg/g >30 mg/mmol
GFR categories ($ml/min/1.73\ m^2$)	**G1**	Normal to high	≥90	54.7	4.3	0.4
	G2	Mildly decreased	60-89	30.4	2.6	0.3
	G3a	Mildly to moderately decreased	45-59	3.9	0.9	0.2
	G3b	Moderately to severely decreased	30-44	1.0	0.5	0.2
	G4	Severely decreased	15-29	0.1	0.1	0.2
	G5	Kidney failure	<15	<0.001	0.001	0.01

(b) Summary of prevalence in each risk category, by cohort (1999-2014)

	1999-2002		**2003-2006**		**2007-2010**		**2011-2014**	
Low risk		86.1		85.5		86.5		85.1
Moderately high risk	13.9	10.4	14.5	10.6	13.5	9.6	14.9	10.8
High risk		2.2		2.7		2.5		2.6
Very high risk		1.3		1.2		1.4		1.5

Data source: National Health and Nutrition Examination Survey (NHANES), 1999-2002, 2003-2006, 2007-2010 & 2011–2014 participants aged 20 and older. Single-sample estimates of eGFR and ACR; eGFR calculated using the CKD-EPI equation. Abbreviations: ACR, urine albumin/creatinine ratio; CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate; GFR, glomerular filtration rate; KDIGO, Kidney Disease: Improving Global Outcomes CKD Work Group. Low risk: eGFR ≥60 ml/min/1.73 m^2 and ACR <30 mg/g; moderately high risk: eGFR 45-59 ml/min/1.73 m^2 or eGFR ≥60 ml/min/1.73 m^2 and ACR 30-300 mg/g; high risk: eGFR 30-44 ml/min/1.73 m^2 or eGFR 45-59 ml/min/1.73 m^2 and ACR 30-300 mg/g or eGFR ≥60 ml/min/1.73 m^2 and ACR >300 mg/g; very high risk: eGFR <30 ml/min/1.73 m^2 or eGFR 30-44 ml/min/1.73 m^2 and ACR 30-300 mg/g or eGFR ≥60 ml/min/1.73 m^2 and ACR >300 mg/g.

Demographic Characteristics and Biological 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/m^2; BMI) are associated with CKD. Data showing the percentage of adult NHANES participants with either eGFR <60 ml/min/1.73 m^2 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/m^2 (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.

Occurrences of eGFR <60 ml/min/1.73 m^2 and ACR ≥30 mg/g for adult NHANES participants are shown in Table 1.2. When CKD was defined as either eGFR <60 *or* ACR ≥30, prevalence estimates varied over time, with an overall rise from 13.9% to 14.8% (Figure 1.5). The largest relative increase in prevalence occurred among those with SR CVD, where estimates rose from 38.2% in 1999-2002 to 42.6% in 2011-2014. The prevalence of eGFR <60 rose from 5.8 to 7.2% (p=0.01) over the four periods, with the largest relative increase (1.7-fold) seen in those aged 40–59 (p=0.04). Prevalence for ACR ≥30 remained steady over this period, between 9-10%.

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 25.0% of the 2003-2006 participant cohort, compared to 0.1% of individuals aged 20 to 39 years and 2.3% of those aged 40 to 59 years. The prevalence of low eGFR also rose in all other comorbidity categories over these periods, especially for DM (15.1% to 20.7%). The prevalence of eGFR <60 increased for both sexes and for all races, although more so for non-Hispanic whites (6.6% to 8.5%), as shown in Table 1.2.

The prevalence of ACR ≥30 mg/g decreased over the four periods among individuals with DM, SR DM, HTN, SR HTN, and higher BMI. Prevalence was higher in the older age groups, but less markedly than for eGFR <60.

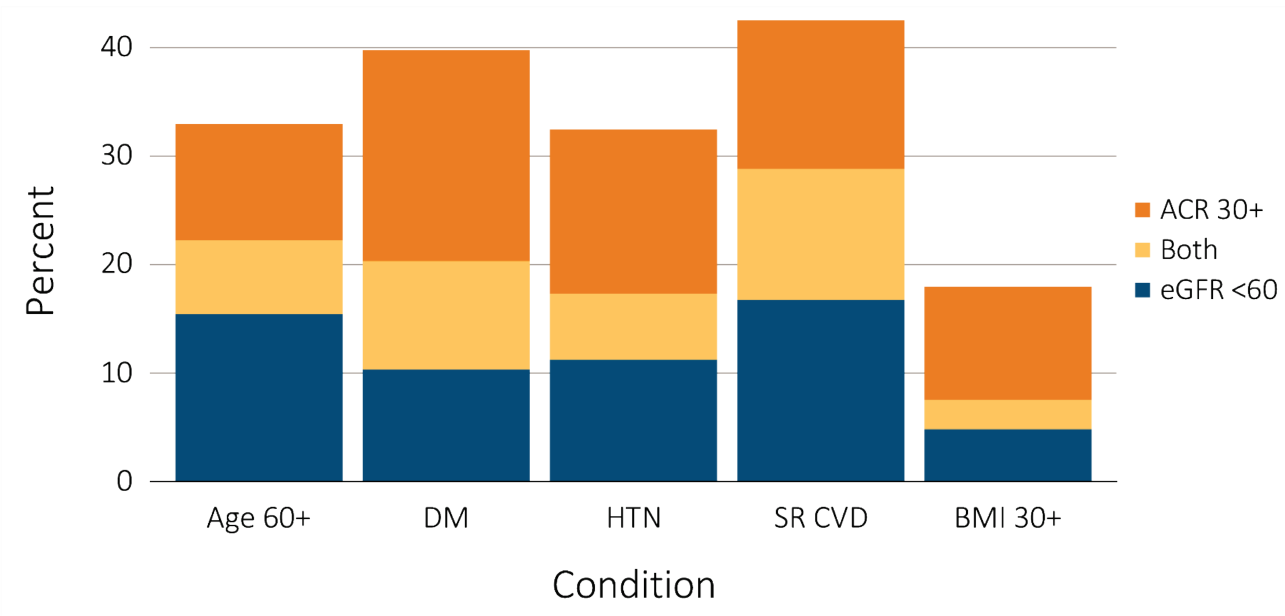
vol 1 Table 1.2 Prevalence (%) of CKD in NHANES population within age, sex, race/ethnicity, & risk factor categories, 1999-2014

	All CKD				eGFR <60 ml/min/1.73m^2				ACR ≥30 mg/g			
	1999-2002	2003-2006	2007-2010	2011-2014	1999-2002	2003-2006	2007-2010	2011-2014	1999-2002	2003-2006	2007-2010	2011-2014
Age												
20-39	6.0	5.9	5.4	6.6	0.4	0.1	0.3	0.3				
40-59	10.0	9.8	8.5	10.6	1.9	2.3	2.0	3.3	5.9	5.8	5.3	6.4
60+	36.9	37.1	33.6	32.6	24.0	25.8	22.9	22.6	8.6	8.2	7.0	8.5
Sex												
Male	12.0	12.6	11.7	13.0	4.8	5.7	5.2	6.4	9.1	8.9	8.4	8.8
Female	15.6	16.1	15.0	16.5	6.8	7.8	7.5	7.9	10.9	10.2	9.4	10.9
Race/Ethnicity												
Non-Hispanic White	13.9	14.3	13.8	15.2	6.6	7.9	7.5	8.5	9.3	8.5	8.4	9.0
Non-Hispanic Black/African American	15.1	15.8	14.8	16.9	5.3	5.2	5.8	6.2	12.7	13.0	11.2	13.5
Mexican American	11.6	11.6	11.8	12.5	1.4	1.6	2.3	2.5	10.4	10.9	10.5	11.2
Other Hispanic	13.8	15.5	11.4	12.8	3.6	3.5	3.3	4.3	11.7	13.3	9.5	10.5
Other Non-Hispanic	14.0	16.2	10.6	12.8	3.9	4.2	3.1	4.3	12.1	13.5	9.1	10.3
Risk Factor												
Diabetes	41.2	41.5	39.0	39.4	15.1	19.2	18.7	20.7	34.8	30.9	28.4	28.7
Self-reported diabetes	40.8	43.0	40.6	40.6	16.5	20.3	19.9	22.3	33.5	31.7	29.5	29.5
Hypertension	33.4	31.7	30.6	32.1	16.8	17.4	16.9	17.7	23.0	19.6	19.1	20.6
Self-reported hypertension	28.2	26.9	25.7	26.9	16.3	15.3	15.0	15.8	17.7	16.5	15.7	16.6
Self-reported cardiovascular disease	38.2	43.5	37.2	42.6	26.7	29.3	25.1	29.3	22.7	24.8	22.3	25.5
Obesity (BMI >30)	17.2	16.8	16.1	17.6	6.3	7.1	7.0	7.9	13.2	11.9	11.1	12.5
All	13.9	14.4	13.4	14.8	5.8	6.8	6.4	7.2	10.1	9.6	8.9	9.9

Data source: National Health and Nutrition Examination Survey (NHANES), 1999-2002, 2003-2006, 2007-2010 & 2011-2014 participants age 20 & older. Single-sample estimates of eGFR & ACR; eGFR calculated using the CKD-EPI equation. Diabetes defined as HbA1c >7 percent, self-reported (SR), or currently taking glucose-lowering medications. Hypertension defined as BP ≥130/≥80 for those with diabetes or CKD, otherwise BP ≥140/≥90, or taking medication for hypertension. Values in Figure 1.12 cannot be directly compared to those in Table 1.3 due to different survey cohorts. The table represents NHANES participants who are classified as hypertensive (measured/treated) but some of those are at target blood pressure. Abbreviations: ACR, urine albumin/creatinine ratio; BMI, body mass index; BP, blood pressure, CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate.

Figure 1.5 displays the prevalence of CKD markers (eGFR <60 ml/min/1.73 m² and ACR ≥30 mg/g) among adult NHANES 2011–2014 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 or older (22.6%) and those with SR CVD (29.2%), followed by those with DM (20.7%), HTN (17.7%), and higher BMI (9.9%). An ACR ≥30 was most common in those with DM (28.7%), followed by those with SR CVD (25.4%), with HTN (20.5%), aged 60 or older (16.8%), and of higher BMI (12.4%). The presence of both eGFR <60 and ACR ≥30 was most common with SR CVD, at 12.1%, followed by DM at 10.0%, those aged 60 years and older (6.8%), with HTN (6.1%), and with higher BMI (2.7%).

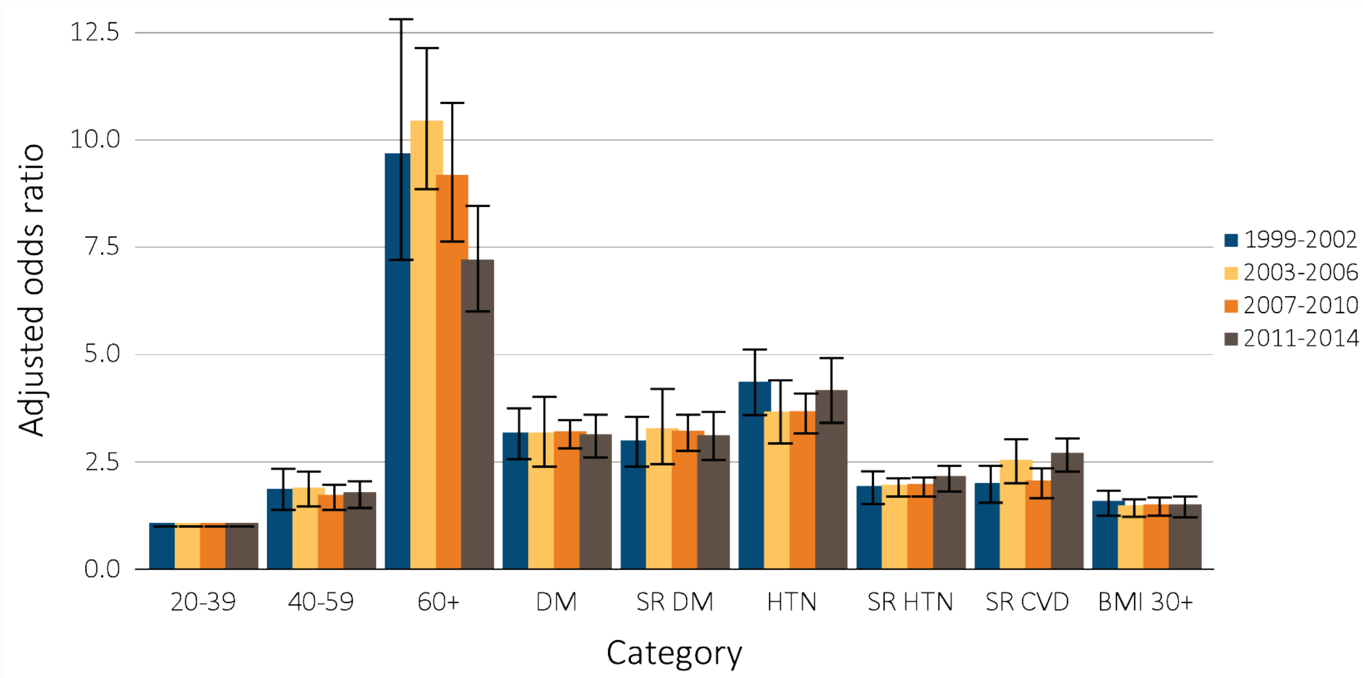
vol 1 Figure 1.5 Distribution of markers of CKD in NHANES participants with diabetes, hypertension, self-reported cardiovascular disease, & obesity, 2011–2014



Data Source: National Health and Nutrition Examination Survey (NHANES), 2011–2014 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, 1999-2014



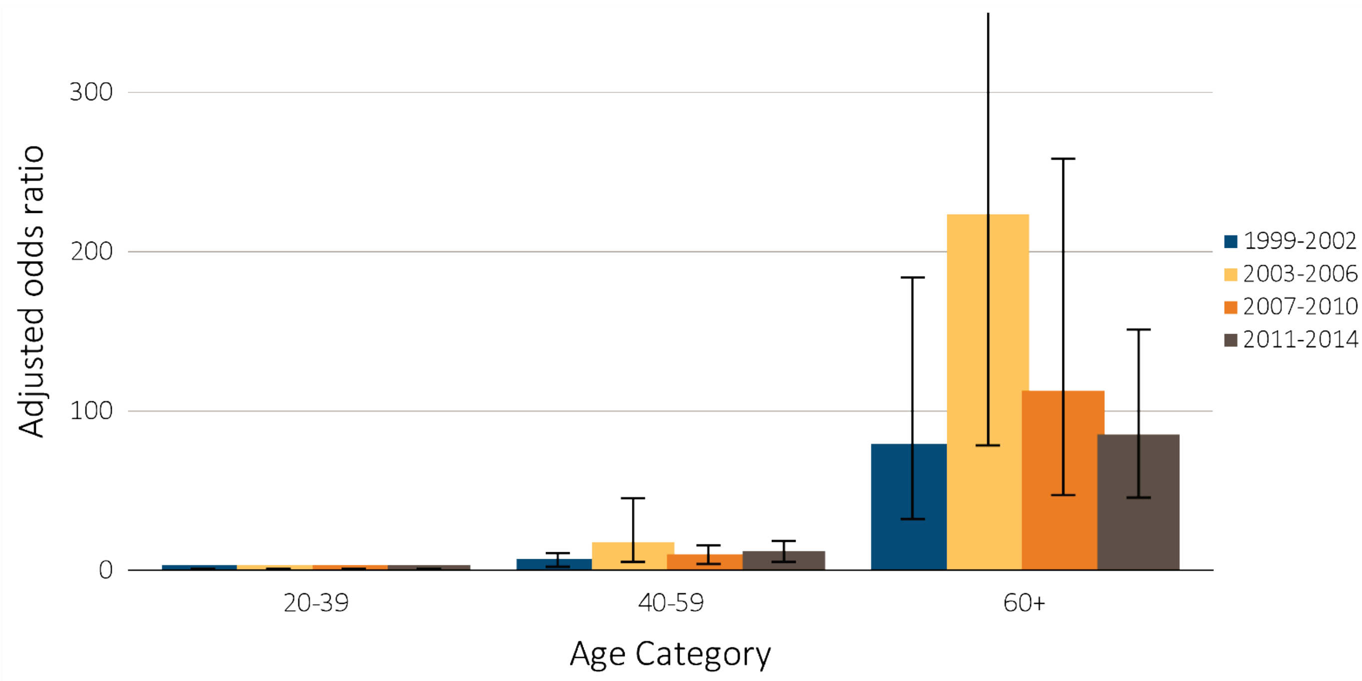
Data Source: National Health and Nutrition Examination Survey (NHANES), 1999–2002, 2003-2006, 2007-2010 & 2011–2014 participants age 20 & older; single-sample estimates of eGFR & ACR. Adj: age, sex, & race; eGFR calculated using the CKD-EPI equation. Whisker lines indicate 95% confidence intervals. Abbreviations: ACR, urine albumin/creatinine ratio; BMI, body mass index; CKD, chronic kidney disease; CVD, cardiovascular disease; DM, diabetes mellitus; eGFR, estimated glomerular filtration rate; HTN, hypertension; SR, self-report.

Adjusted odds ratios for presence of CKD (Figure 1.6) were generally lower in NHANES 2003-2006, 2007–2010, and 2011-2014 participants than during 1999–2002. This was true for each risk factor except SR HTN and SR CVD, where adjusted odds ratios rose from 1.86 to 2.09 and 1.93 to 2.63 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.

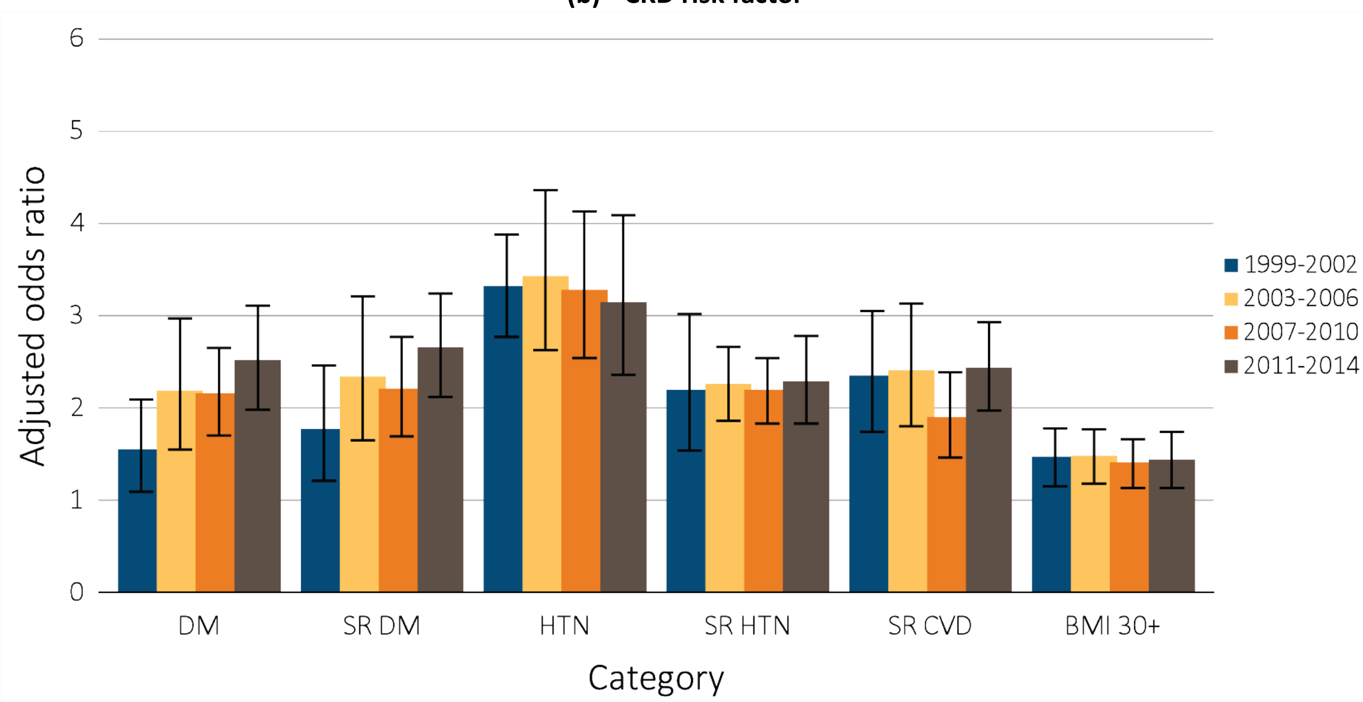
For eGFR <60 alone (Figure 1.7), adjusted odds ratios followed a similar pattern, except for DM and SR DM, where the odds increased from 1.6 to approximately 2.5 in both groups. Also, eGFR <60 showed a very strong association with age, with adjusted odds ratios in the 100 range. For ACR ≥30 alone (Figure 1.8), a substantial decline in the adjusted odds ratio was seen among both those with DM (from 4.08 to 3.69) and aged 60 or older (from 4.74 to 3.23), while a substantial increase in the adjusted odds ratio was seen for those with SR CVD (from 1.65 to 2.57).

vol 1 Figure 1.7 Adjusted odds ratios of eGFR <60 ml/min/1.73m^2 in NHANES participants, by age & risk factor, 1999-2014

(a) Age category

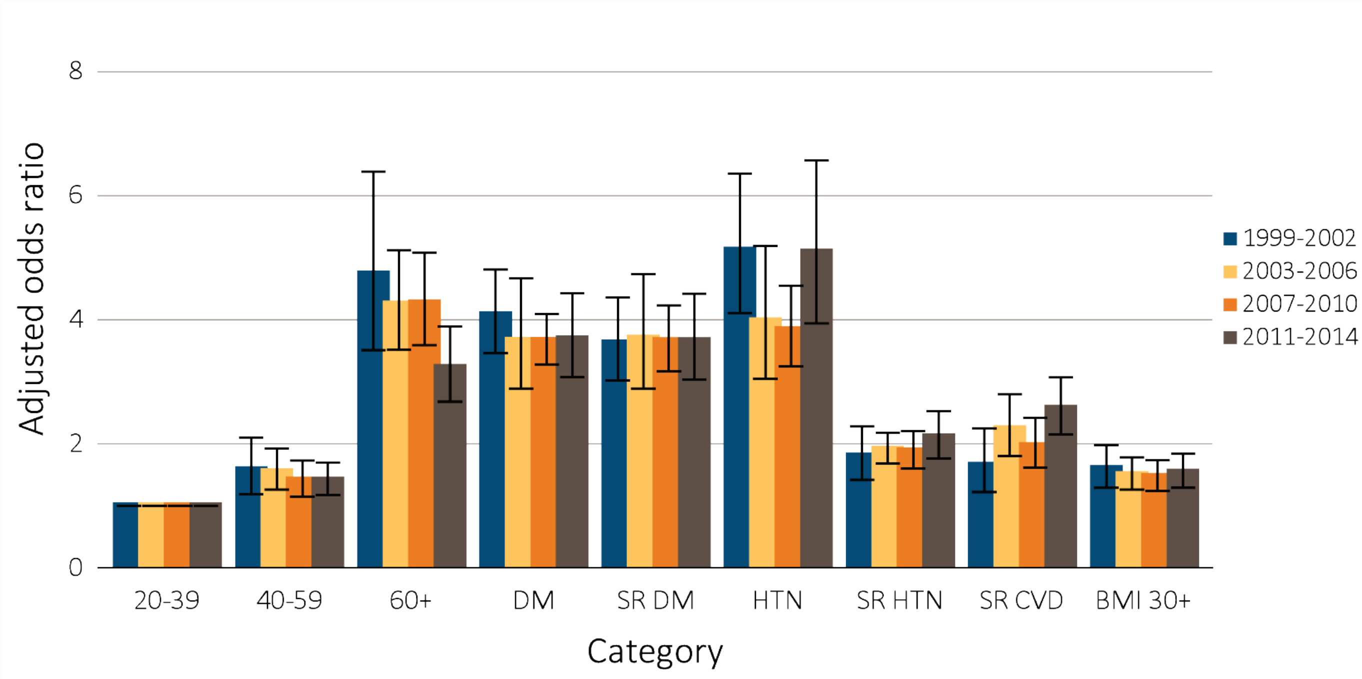


(b) CKD risk factor



Data Source: National Health and Nutrition Examination Survey (NHANES), 1999–2002, 2003-2006, 2007-2010 & 2011–2014 participants age 20 & older; single-sample estimates of eGFR & ACR. Adj: age, sex, & race; eGFR calculated using the CKD-EPI equation. Whisker lines indicate 95% confidence intervals. Abbreviations: ACR, urine albumin/creatinine ratio; BMI, body mass index; CKD, chronic kidney disease; CVD, cardiovascular disease; DM, diabetes mellitus; eGFR, estimated glomerular filtration rate; HTN, hypertension; SR, self-report.

vol 1 Figure 1.8 Adjusted odds ratios of urine albumin/creatinine ratio ≥30 mg/g in NHANES participants, by age & risk factor, 1999-2014



Data Source: National Health and Nutrition Examination Survey (NHANES), 1999–2002, 2003-2006, 2007-2010 & 2011–2014 participants age 20 & older; single-sample estimates of eGFR & ACR. Adjusted: age, sex, & race; eGFR calculated using the CKD-EPI equation. Whisker lines indicate 95% confidence intervals. Abbreviations: ACR, urine albumin/creatinine ratio; BMI, body mass index; CKD, chronic kidney disease; CVD, cardiovascular disease; DM, diabetes mellitus; eGFR, estimated glomerular filtration rate; HTN, hypertension; SR, self-report.

Socioeconomic Factors and CKD

New to this year's ADR we begin to examine the socioeconomic factors of health insurance status, income, and education level among individuals with CKD (Table 1.3). The overall proportion with health care coverage remained steady between approximately 86-90%. 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 coverages.

Income levels for these cohorts appear to have risen over time; approximately 22% of individuals with CKD reported an income of $75,000 or more in 2011-2014. 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).

Education levels also rose over time, especially among those with eGFR <60. The percentage of individuals with less than high school education decreased from 37.0% in 1999-2003 to 21.3% from 2011-2014, while the group with at least some college increased from 36.9% to 56.5% 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% in 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 as compared to males.

vol 1 Table 1.3 Socioeconomic factors among individuals with CKD, percent of NHANES participants, 1999-2014

	All CKD				eGFR <60 ml/min/1.73m^2				ACR ≥30 mg/g			
	1999-2002	2003-2006	2007-2010	2011-2014	1999-2002	2003-2006	2007-2010	2011-2014	1999-2002	2003-2006	2007-2010	2011-2014
Health Insurance Status												
Not Insured	11.4	10.1	11.4	13.8	3.9	3.3	4.2	3.9	14.7	13.2	14.8	18.9
Insured	88.6	89.9	88.6	86.2	96.1	96.7	95.8	96.1	85.3	86.8	85.2	81.1
Private Only	37.2	30.0	30.6	30.8	22.5	16.8	18.7	22.9	42.2	36.2	35.9	33.4
Medicare Only	17.4	17.4	15.6	15.9	23.8	23.9	20.9	23.0	16.2	14.4	13.3	12.3
Other Government Only	4.9	5.9	5.1	6.9	2.6	2.3	3.0	5.5	5.8	7.8	6.2	8.7
Private and any Government	21.7	26.8	28.6	22.9	36.6	41.1	44.0	34.2	14.6	19.3	21.1	17.1
Other/Unknown	7.4	9.8	8.7	9.7	10.6	12.6	9.2	10.5	6.5	9.1	8.7	9.6
Income												
Less than $10,000	14.5	7.5	6.8	8.0	13.8	6.1	4.6	5.9	16.3	8.2	8.3	9.4
$10,000 – $24,999	29.7	28.0	23.9	24.5	31.8	31.8	26.0	25.4	29.8	27.8	24.2	25.2
$25,000 – $44,999	18.8	23.2	23.4	19.8	22.6	24.7	24.3	21.2	17.2	21.0	22.6	19.3
$45,000 – $74,999	15.3	20.8	18.1	18.9	13.4	19.8	19.5	19.7	14.8	21.0	16.7	17.8
$75,000 or more	11.4	14.2	20.1	22.6	8.4	10.9	16.6	22.2	11.5	15.6	20.8	21.1
Missing	10.2	6.3	7.7	6.6	10.0	6.7	9.0	5.5	10.2	6.4	7.5	7.2
Education												
< High School	33.4	26.2	27.1	22.4	37.0	27.8	26.6	21.3	32.8	26.3	29.2	23.8
High School Graduate/GED	25.6	27.1	26.9	22.3	26.1	30.6	27.5	22.2	26.3	25.0	26.3	23.5
At least some College	41.0	46.7	46.0	55.3	36.9	41.4	45.9	56.5	40.9	48.6	44.5	52.7

Data Source: National Health and Nutrition Examination Survey (NHANES), 1999–2002, 2003-2006, 2007-2010 & 2011–2014 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.

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 types of diet. Little change has occurred in activity level across these cohorts, with almost half of individuals with CKD reporting a sedentary life-style. This is in contrast to individuals without CKD who have shown an increase in the percentage reporting physical activity (Figure 1.9).

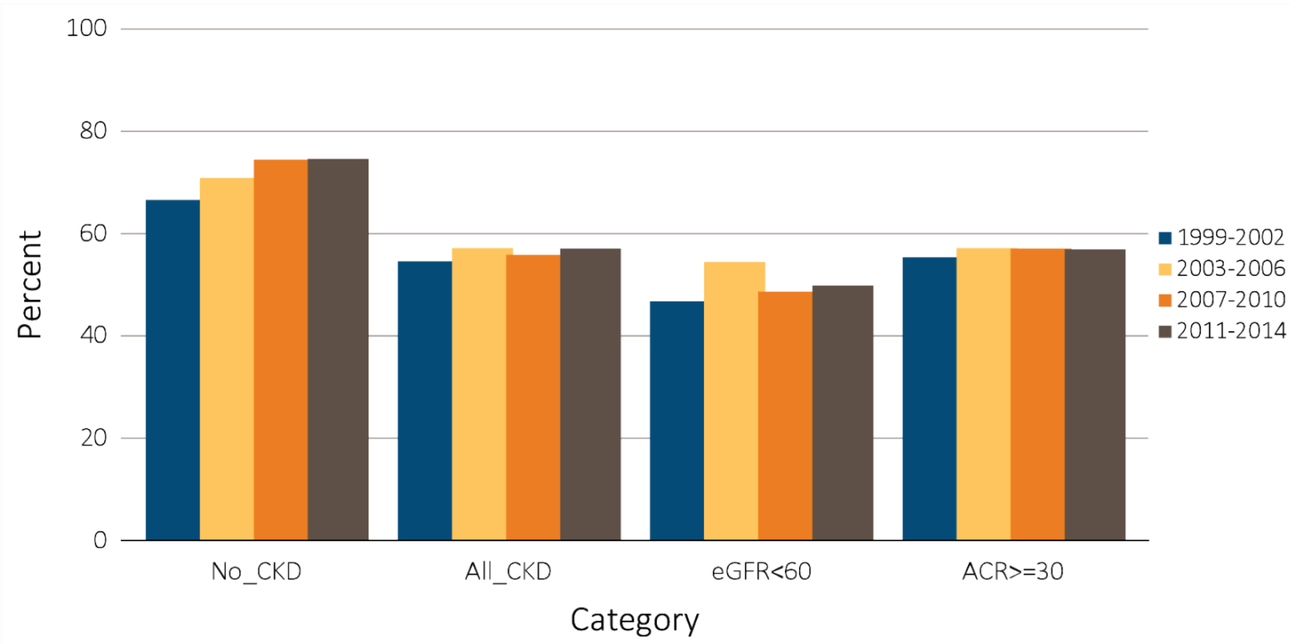
A moderate decrease in the percentage of individuals reporting current smoking was seen across the cohorts, primarily in the individuals with eGFR <60. The percentage of current smokers increased among those with albuminuria. Reported amount of sleep was lowest for those with albuminuria, while a higher percentage of those with eGFR <60 reported more than nine hours of sleep per night. A very low percentage of individuals in all cohorts reported following a special diet. The most common type reported by these participants was a “diabetic diet”, although the percentage endorsing this decreased slightly over time.

vol 1 Table 1.4 Health Risk Behaviors among individuals with CKD, percent of NHANES participants, 1999-2014

	All CKD				eGFR <60 ml/min/1.73m^2				ACR ≥30 mg/g			
	1999-2002	2003-2006	2007-2010	2011-2014	1999-2002	2003-2006	2007-2010	2011-2014	1999-2002	2003-2006	2007-2010	2011-2014
Physical Activity												
Vigorous	22.4	20.8	20.6	23.3	14.0	14.8	13.0	16.9	24.2	22.9	23.5	24.7
Moderate	31.5	35.7	34.6	33.1	32.0	39.0	35.0	33.9	30.5	33.6	32.9	31.6
Sedentary	46.1	43.5	44.8	43.6	53.9	46.2	52.0	49.2	45.3	43.5	43.6	43.7
Smoking												
Current	16.6	16.2	15.0	15.0	7.4	8.7	8.4	9.1	20.4	20.1	18.7	18.6
Former	31.6	31.8	31.6	33.3	39.2	38.1	39.0	39.8	28.7	29.3	28.9	30.6
Never	51.8	52.0	53.4	51.7	53.4	53.2	52.6	51.1	50.9	50.6	52.5	50.8
Amount of Sleep												
Less than 6 hours	-	15.2	15.5	13.5	-	8.9	12.6	12.4	-	18.8	17.6	14.6
6 hours	-	21.9	21.5	20.5	-	21.5	19.2	18.1	-	23.7	22.8	22.3
7-8 hours	-	55.4	53.2	54.9	-	60.8	55.4	53.0	-	51.3	51.2	54.8
9 hours or more	-	7.6	9.8	11.1	-	8.8	12.8	16.5	-	6.2	8.4	8.3
Self-Reported Special Diet												
Low fat/Low cholesterol	-	3.5	2.8	2.4	-	3.8	3.3	2.8	-	2.9	2.5	2.1
Low salt/Low sodium	-	2.5	3.5	3.6	-	3.1	4.7	5.3	-	2.6	3.6	3.1
Sugar free/Low sugar	-	2.0	1.1	0.4	-	2.5	1.5	0.3	-	1.6	1.1	0.5
Diabetic diet	-	6.6	5.2	5.1	-	6.8	5.4	6.9	-	7.4	5.2	5.5
Renal diet	-	-	0.3	0.6	-	-	0.7	1.2	-	-	0.5	0.8

Data Source: National Health and Nutrition Examination Survey (NHANES), 1999–2002, 2003-2006, 2007-2010 & 2011–2014 participants age 20 & older. Single-sample estimates of eGFR & ACR; eGFR calculated using the CKD-EPI equation. Abbreviations: ACR, urine albumin/creatinine ratio; CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate.

vol 1 Figure 1.9 NHANES participants physically active, 1999-2014



Data Source: National Health and Nutrition Examination Survey (NHANES), 1999-2002, 2003-2006, 2007-2010 & 2011–2014 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.

Treatment/Control of 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 m² 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 64.3% to 22.6% in those years. The proportion of hypertensive individuals who were aware, treated, and disease-controlled rose steadily from approximately 8% in the early cohorts to 28% in 2011-2014. In the subgroup with DM, glycemic control showed little improvement over time, with 57.1% remaining uncontrolled in 2011-2014. Participants reported no improvements in activity level or smoking status.

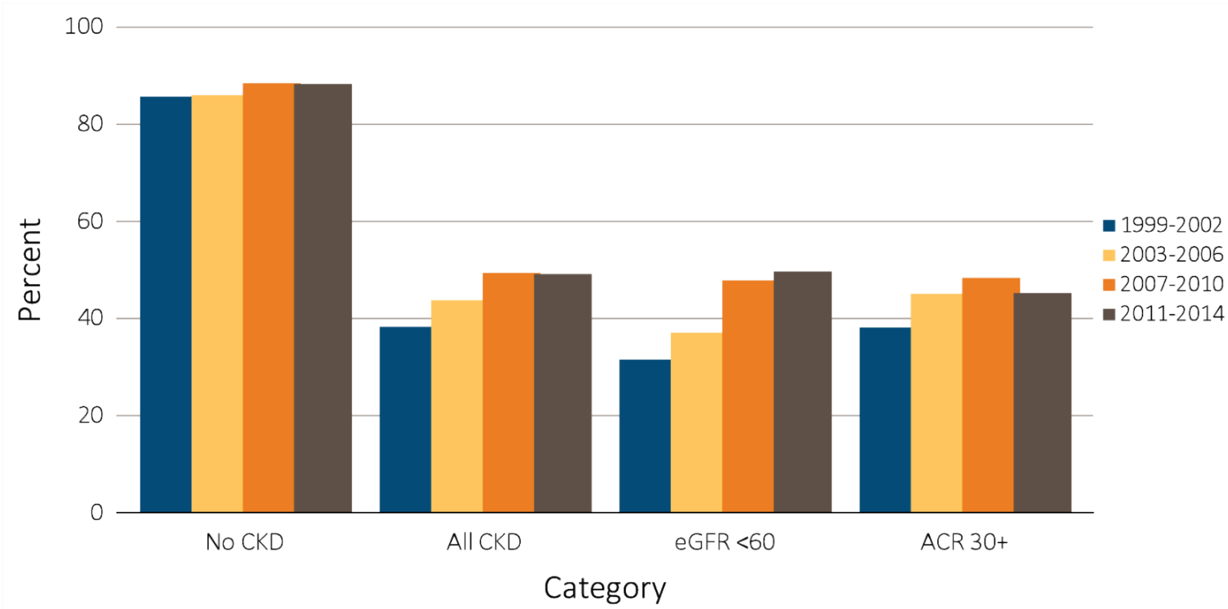
vol 1 Table 1.5 Awareness, treatment, & measures of control of CKD risk factors, percentage of NHANES participants, 1999-2014

	All CKD					eGFR <60 ml/min/1.73m^2					ACR ≥30 mg/g				
	1999-2002	2003-2006	2007-2010	2011-2014	Trend p-value	1999-2002	2003-2006	2007-2010	2011-2014	Trend p-value	1999-2002	2003-2006	2007-2010	2011-2014	Trend p-value
Hypertension, by current hypertensive status[a]															
Non-hypertensive status	26.9	25.8	26.8	26.1	0.87	14.8	14.6	15.6	17.0	0.20	29.7	30.3	31.1	28.6	0.75
Hypertensive	73.1	74.2	73.2	73.9		85.2	85.4	84.4	83.0		70.3	69.7	68.9	71.5	
Control of hypertension among hypertensive patients[b]															
Unaware	64.3	25.4	19.5	22.6	***<0.001***	58.1	21.0	17.0	13.1	***<0.001***	67.7	26.8	24.7	23.0	***<0.001***
Aware, not treated	5.6	8.4	9.7	5.8		3.2	5.2	2.5	4.3		6.6	10.3	8.2	12.6	
Aware, treated, uncontrolled	22.1	46.6	42.3	43.8		26.6	51.4	45.5	45.8		21.1	46.3	44.9	43.9	
Aware, treated, controlled	8.0	19.6	28.5	27.8		12.1	22.4	35.0	36.8		4.7	16.5	22.1	20.5	
Total cholesterol[c]															
<200 (desirable)	43.2	53.1	59.2	61.6	***<0.001***	40.7	56.6	62.6	64.3	***<0.001***	44.9	52.8	58.2	61.3	***<0.001***
200–239 (borderline high)	35.3	27.5	26.3	24.1		37.0	25.8	23.5	22.0		34.2	27.7	27.2	24.8	
240+ (high)	21.5	19.4	14.5	14.4		22.3	17.6	13.9	13.7		20.9	19.5	14.6	13.9	
Control of diabetes among patients with diabetes[d]															
Glycohemoglobin <7% (controlled)	32.8	51.1	46.9	42.9	0.20	45.6	62.5	55.9	49.3	0.57	28.8	45.3	40.1	36.8	0.37
Glycohemoglobin 7% or higher (uncontrolled)	67.2	48.9	53.1	57.1		54.4	37.5	44.1	50.7		71.2	54.7	59.9	63.2	

Data Source: National Health and Nutrition Examination Survey (NHANES), 1999–2002, 2003-2006, 2007-2010 & 2011–2014 participants age 20 & older. Single-sample estimates of eGFR & ACR; eGFR calculated using the CKD-EPI equation. Abbreviations: ACR, urine albumin/creatinine ratio; CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate. a. Hypertension defined as blood pressure ≥130/≥80 for those with CKD and diabetes; otherwise ≥140/≥90, or self-reported treatment for hypertension.
b. Awareness and treatment are self-reported. Control defined as <130/<80 for those with CKD and diabetes; otherwise <140/<90. c. Total cholesterol classified according to Adult Treatment Panel III blood cholesterol guidelines (ATP III). d. Glycohemoglobin classified according to American Diabetes Association guidelines.

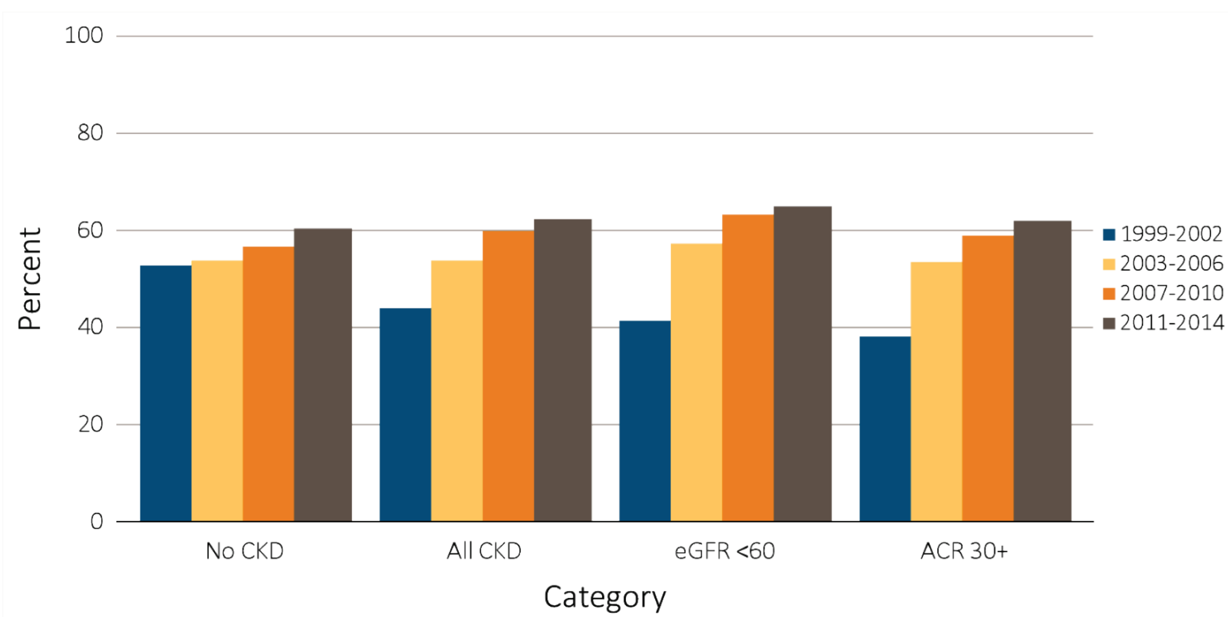
As illustrated by Figures 1.10-1.12, over the periods of 1999–2002, 2003-2006, 2007-2010, & 2011–2014, improvements in the management of HTN and cholesterol were observed, regardless of whether the criterion was eGFR, or ACR level. For comparison, these figures include estimates for individuals without CKD.

vol 1 Figure 1.10 NHANES participants at target blood pressure, 1999-2014



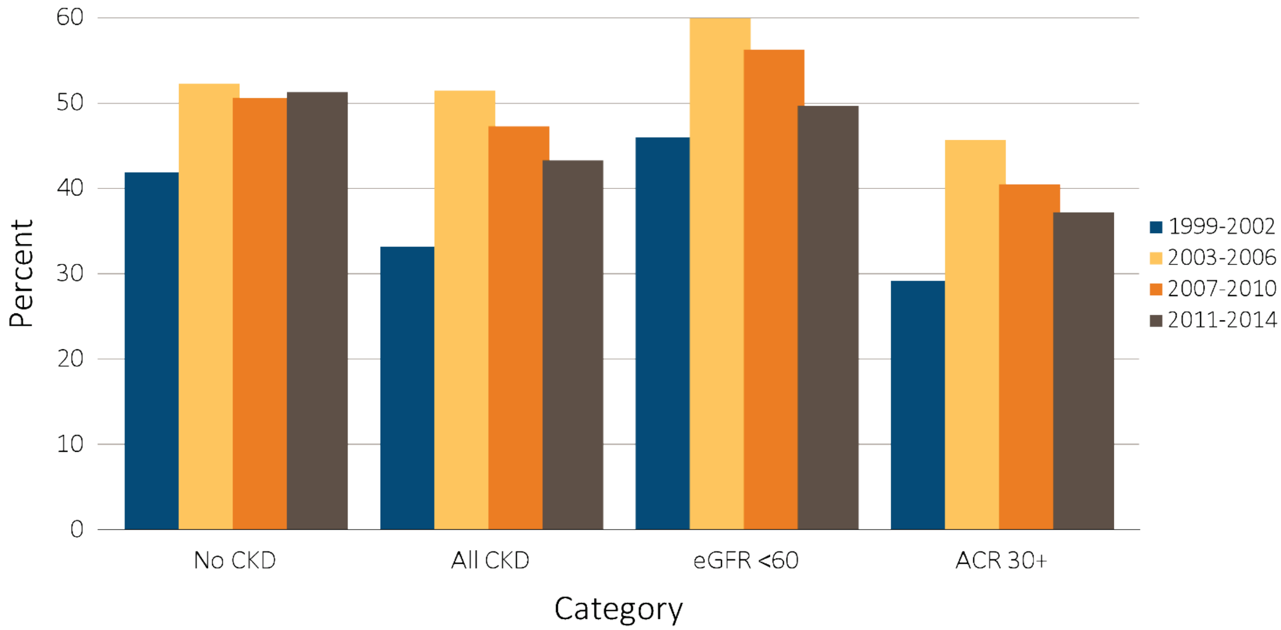
Data Source: National Health and Nutrition Examination Survey (NHANES), 1999-2002, 2003-2006, 2007-2010 & 2011–2014 participants aged 20 & older. Single-sample estimates of eGFR & ACR; eGFR calculated using the CKD-EPI equation. Figure represents all hypertensive participants including those who were 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 NHANES participants within cholesterol normal range, 1999-2014



Data Source: National Health and Nutrition Examination Survey (NHANES), 1999-2002, 2003-2006, 2007-2010 & 2011–2014 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 Diabetic NHANES participants with glycosylated hemoglobin <7%, 1999-2014



Data Source: National Health and Nutrition Examination Survey (NHANES), 1999-2002, 2003-2006, 2007-2010 & 2011–2014 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 1999-2014 (Figure 1.13). There was some suggestion of an improvement among individuals with Stage 4 CKD between 2003-2006 and 2007-2010, although this did not persist in the 2011-2014 cohort (note that this graphic is based on four-year cohorts). 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.

vol 1 Figure 1.13 NHANES participants with CKD aware of their kidney disease, 1999-2014

(a) By stage

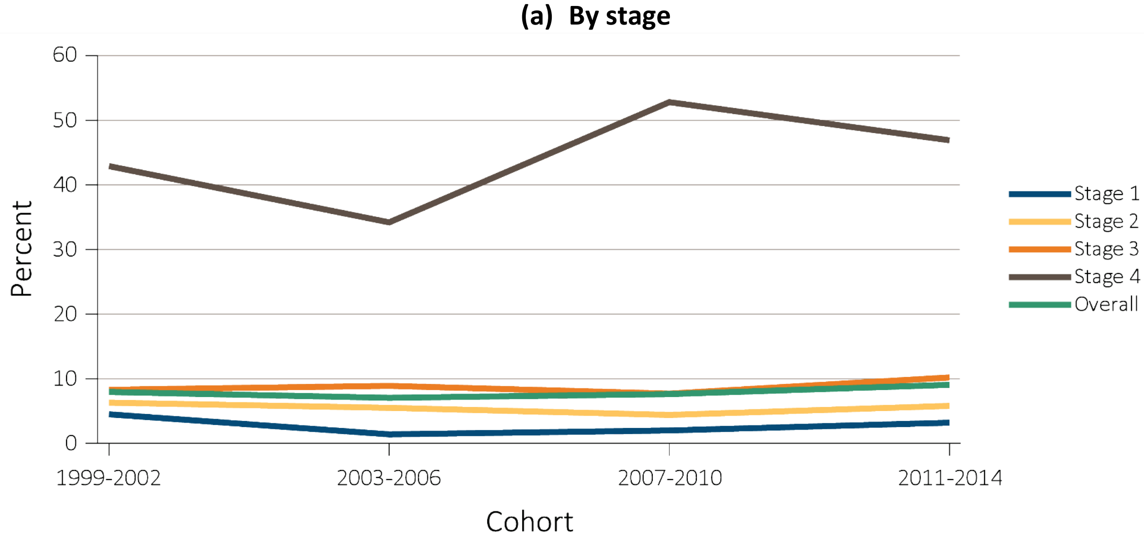
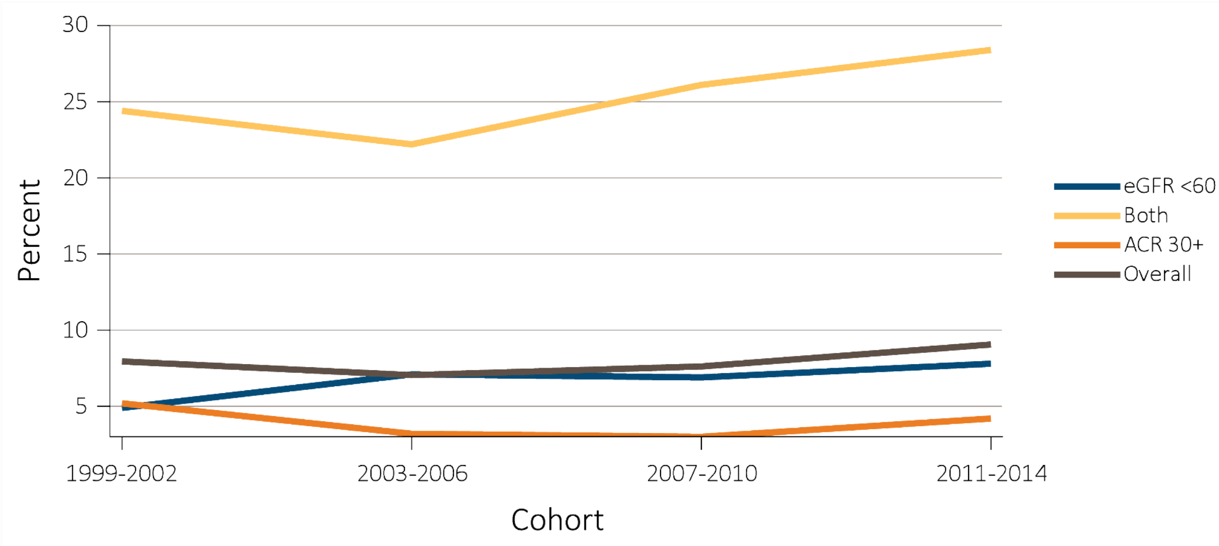


Figure 1.13 continued on next page.

vol 1 Figure 1.13 NHANES participants with CKD aware of their kidney disease, 1999-2014 (*continued*)

(b) By low eGFR and albuminuria status

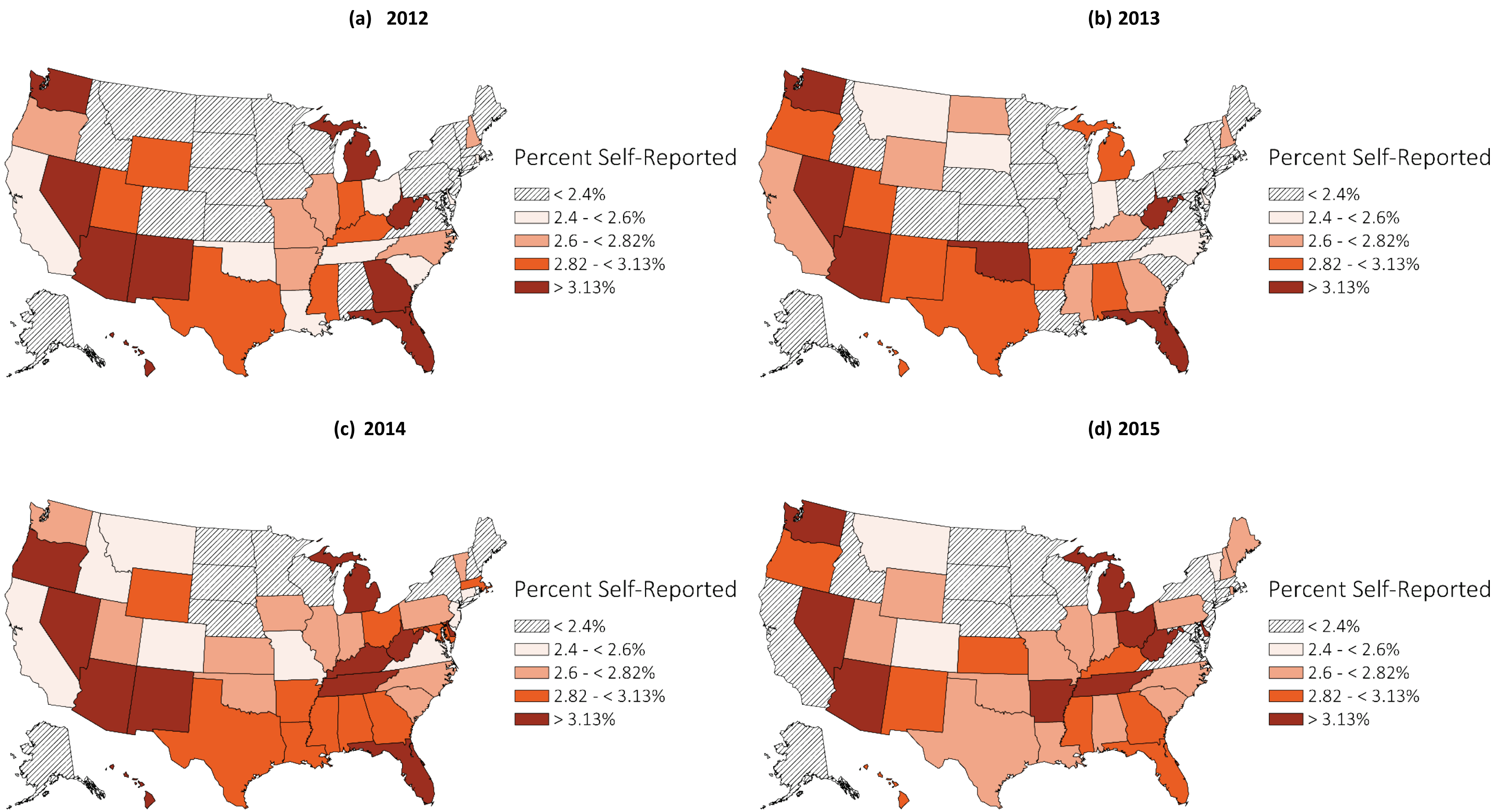


Data Source: National Health and Nutrition Examination Survey (NHANES), 1999-2014 participants aged 20 & older. Abbreviations: CKD, chronic kidney disease.

Figure 1.14 displays the state-specific proportions of individuals who reported being told they had 'kidney disease', based on the 2012 and 2014 BRFSS sample. The overall national averages were very low, at 2.7% in 2012 and 2.8% in 2014. 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 in both years who indicated that they had been informed that they had kidney disease included Hawaii, Arizona, Florida, New Mexico, Michigan, West Virginia, and Nevada. Conversely, the states with the lowest proportion of BRFSS participants reporting awareness of kidney disease included Wisconsin, North Dakota, and Minnesota. 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 U.S. state is unknown. Therefore, it is presently unclear whether higher prevalence of 'self-reported kidney disease' reflects actual higher prevalence of the disease, greater awareness among those who have the condition, or a combination of both.

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), 2012 participants aged 18 & older. 2012 (N=471,107), 2013 (N=491,777), 2014 (N=464,617), and 2015 (N=441,460).

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