Recent trends in the prevalence of chronic kidney disease: not the same old song

Raymond K. Hsu and Neil R. Powe

Purpose of review
We aim to review recent updates on the epidemiology of chronic kidney disease (CKD).

Recent findings
Recent analyses from the National Health and Nutritional Examination survey describe the temporal trend in CKD prevalence in US adults. The overall prevalence of estimated glomerular filtration rate less than 60 ml/min/1.73 m$^2$ increased from 4.8% in 1988–1994 to 6.9% in 2003–2004, but has since stabilized at 6.4–6.9% up to 2011–2012. Prevalence of CKD stages 1–4 has also stabilized at ~14% of adults since 2003–2004. The prevalence of diabetic kidney disease – defined as estimated glomerular filtration rate less than 60 ml/min/1.73 m$^2$ and/or microalbuminuria among adults with diabetes – has similarly plateaued since the early to mid-2000s at ~26–27%. There is continued rise in CKD and diabetic kidney disease prevalence among blacks and Mexican-Americans, however, in the last decade. Worldwide, a similar pattern of stable prevalence of CKD since the early 2000s is seen in England, Norway, and Korea. Despite these optimistic findings, there are several emerging at-risk populations. Rapid increases in diabetes and hypertension in China may signal an impending growth in CKD. In parts of Central America, there is emergence of very high CKD prevalence among agricultural workers – suspected to be due to occupational and environmental exposures.

Summary
Collective efforts to undermine risk factors, such as better control of hypertension and diabetes, have likely helped to abate the growth in CKD in several developed countries within the last decade. More worldwide high-quality and geographically granular data collection on CKD would help to monitor the epidemiology of CKD and potentially assist in identifying impactful interventions.

Keywords
chronic kidney disease, epidemiology, prevalence, temporal trends

INTRODUCTION
Chronic kidney disease (CKD) is associated with major adverse outcomes, including progression toward end-stage renal disease (ESRD), acute kidney injury, cardiovascular events, reduced quality of life, death, and increased healthcare costs [1,2]. Since the advent of consensus definitions for CKD in 2002 by the National Kidney Foundation Kidney Disease Outcomes Quality Initiative classification system [3], there has been tremendous advances in the research and understanding of the epidemiology of CKD. One of the most highlighted data sources to estimate the prevalence of CKD on a population level has been the National Health and Nutrition Examination Survey (NHANES) [4] in the United States. Analyses of NHANES data [5–7] showing a rise in CKD prevalence in the past few decades have led to CKD being characterized as an ‘epidemic’ [8]. A recent study projecting the future burden of CKD in the United States estimates that the prevalence of CKD (here defined as CKD stages 1–4) among those aged 30 years or older will increase from 13.2% in 2010 to 16.7% in 2030 [9]. However, there are more recent emerging data from both the United States and other developed countries that the CKD prevalence may have stabilized. We review two recent publications in 2016 with the most updated trends in overall CKD prevalence and diabetic kidney disease.
There are several populations around the world with disease prevalence in the United States, along with several updates in the temporal trend in CKD prevalence in other developed countries. We will also point out emerging threats in the global burden of CKD.

**Update in Chronic Kidney Disease Prevalence in the United States**

In a study published in 2016, Murphy et al. [10**] examined temporal trends in CKD in the United States using data from NHANES [4], a health examination survey that uses a probability sampling design to select participants representative of the US civilian population and involves a combination of in-person interviews, physical examinations, and laboratory data. The investigators analyzed data from NHANES III (conducted in 1988–1994) through NHANES 2011–2012 and limited the study to participants aged 20 years or older with available serum creatinine measurements. CKD was defined in this study as estimated glomerular filtration rate (eGFR) less than 60 ml/min/1.73 m², determined using serum creatinine measurements and the CKD Epidemiology Collaboration (CKD-EPI) creatinine equation [11]. Consistent with older analyses of US CKD prevalence using NHANES [5,6,12], the investigators excluded those with eGFR less than 15 ml/min/1.73 m² due to the relatively small sample size and inability to differentiate from ESRD (i.e., whether those individuals were receiving maintenance dialysis). They performed a secondary analysis using an expanded definition of CKD to also include those with eGFR at least 60 ml/min/1.73 m² and a one-time urine albumin-to-creatinine ratio (ACR) at least 30 mg/g. Diabetes status in this study was defined as self-reported physician diagnosis, use of glucose-lowering medication (oral hypoglycemic medication or insulin), or a laboratory-measured hemoglobin A1c (HbA1c) level of at least 6.5%.

The crude prevalence of CKD (eGFR < 60 ml/min/1.73 m²) increased from 4.8% in 1998–1994 to 6.9% in 2003–2004, but largely stabilized thereafter to 6.9% in 2011–2012 (Table 1) [5–7,12–17,18**,19]. This stability in trend was seen despite a significant increase in prevalence of diabetes (7.4% in 1988–1994 to 11.5% in 2011–2012) and an overall increase in age (mean 44.8 years in 1988–1994 to 47.3 years in 2011–2012). In subgroup analysis, prevalence of CKD was consistently higher in older age groups. For example, among persons aged 65–79 years, CKD prevalence increased from 19.4% in 1988–1994 to 25.1% in 2003–2004, then stabilized/decreased to 21.7% in 2011–2012. In analysis adjusted for age, sex, race/ethnicity, and diabetes status, there was also no significant increase in CKD prevalence after the early 2000s (P for interaction = 0.26). Figure 1 summarizes the temporal trend in crude prevalence of CKD (eGFR < 60 ml/min/1.73 m²) in the United States (along with international comparisons as discussed below) [10**,20**,21**,22]. In their secondary analysis using an expanded definition of CKD to include those with microalbuminuria, the investigators also found little change in crude CKD prevalence after the early 2000s (prevalence of 14.0% in 2003–2004 to 14.2% in 2011–2012, Table 1).

Notably, among all subgroups examined, only non-Hispanic blacks had a progressive increase in CKD prevalence throughout the study period, including from the early 2000s through 2011–2012. Crude CKD prevalence (eGFR < 60 ml/min/1.73 m²) among non-Hispanic blacks increased from 3.7% in 1998–1994 to 4.9% in 2003–2004 to 6.2% by 2011–2012 [10**]. This steady increase in CKD prevalence among non-Hispanic blacks persisted in both adjusted analysis and in secondary analysis using the expanded definition of CKD.

These latest results from Murphy et al. [10**] suggest a reversal in the temporal trend in overall CKD prevalence in several previous NHANES analyses, starting with an analysis by the same research group that showed a significant increase in CKD prevalence (eGFR < 60 ml/min/1.73 m²) from 2.0% in 1976–1980 to 2.5% in 1988–1994, a mean change in prevalence by +1.7% per year [5]. Subsequent analyses [6,12] comparing overall CKD prevalence from the NHANES III (1988–1994)
<table>
<thead>
<tr>
<th>Study</th>
<th>CKD definition</th>
<th>Disease prevalence during time period</th>
<th>Change in prevalence per year</th>
<th>GFR estimating equation</th>
<th>Filtration marker calibration and alignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hsu Annals 2004 [5]</td>
<td>eGFRcr &lt; 60</td>
<td>2.0%&lt;sup&gt;a&lt;/sup&gt; 2.5%&lt;sup&gt;a&lt;/sup&gt;</td>
<td>+1.7% per year&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4-variable MDRD study equation [13]</td>
<td>For both time periods, Cleveland Clinic calibrated Cr = Cr – 0.23</td>
</tr>
<tr>
<td>Coresh JASN 2005 [12]</td>
<td>CKD stages 1–4</td>
<td>8.8% 9.4% (1999–2000)</td>
<td>+0.8% per year</td>
<td>4-variable MDRD study equation [13]</td>
<td>1988–1994: Cleveland Clinic calibrated Cr = Cr – 0.23 1999–2000: Cleveland Clinic calibrated Cr = Cr + 0.13</td>
</tr>
<tr>
<td>Grams AJKD 2013 [7]</td>
<td>eGFRcys &lt; 60</td>
<td>5.5% 8.7% (1999–2002)</td>
<td>+4.9% per year&lt;sup&gt;b&lt;/sup&gt;</td>
<td>CKD-EPI Cystatin C 2012 [17]</td>
<td>1988–1994: standardized cystatin C = 1.12 × [0.022 + 0.80 × (cystatin C)] 1999–2002: standardized cystatin C = 1.12 × (cystatin C – 0.12)</td>
</tr>
<tr>
<td></td>
<td>eGFRcr–cys &lt; 60</td>
<td>4.4% 7.1% (1999–2002)</td>
<td>+5.0% per year&lt;sup&gt;b&lt;/sup&gt;</td>
<td>CKD-EPI Cr–cystatin C 2012 [17]</td>
<td>1988–1994: standardized cystatin C = 1.12 × [0.022 + 0.80 × (cystatin C)] 1999–2002: standardized cystatin C = 1.12 × (cystatin C – 0.12)</td>
</tr>
<tr>
<td>Latest studies</td>
<td>CKD definition</td>
<td>Disease prevalence during time period</td>
<td>Change in prevalence per year</td>
<td>GFR estimating equation</td>
<td>Filtration marker calibration and alignment</td>
</tr>
<tr>
<td>----------------</td>
<td>----------------</td>
<td>----------------------------------------</td>
<td>-------------------------------</td>
<td>-------------------------</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td>Murphy Annals</td>
<td>eGFRcr &lt; 60</td>
<td>4.8%</td>
<td>5.3%</td>
<td>6.7%</td>
<td>+2.9% per year</td>
</tr>
<tr>
<td>2016 [10**]</td>
<td>(primary analysis)</td>
<td>6.4%</td>
<td>6.5%</td>
<td>6.9%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CKD stages 1–4</td>
<td>11.8%</td>
<td>13.2%</td>
<td>14.0%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(eGFRcr and ACR)</td>
<td>13.6%</td>
<td>14.1%</td>
<td>12.7%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>6.9%</td>
<td>14.0%</td>
<td>14.2%</td>
<td>14.2% per year</td>
</tr>
<tr>
<td>Alkaiar JAMA</td>
<td>Diabetic CKD</td>
<td>28.4%</td>
<td>27.3%</td>
<td>27.1%</td>
<td>No significant trend</td>
</tr>
<tr>
<td>2016 [18**]</td>
<td>(eGFRcr and ACR among those with diabetes)</td>
<td>26.2%</td>
<td>26.2%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>eGFRcr &lt; 60</td>
<td>9.2%</td>
<td>11.6%</td>
<td>11.8%</td>
<td>+2.1% per year</td>
</tr>
<tr>
<td>(among those with diabetes)</td>
<td>20.8%</td>
<td>18.9%</td>
<td>14.1%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Albuminuria (ACR ≥ 30 mg/g; among those with diabetes)</td>
<td>17.9%</td>
<td>15.9%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ACR, albumin-to-creatinine ratio; AJKD, American Journal of Kidney Diseases; Annals, Annals of Internal Medicine; CIASN, Clinical Journal of the American Society of Nephrology; CKD, chronic kidney disease; CKD-EPI, Chronic Kidney Disease Epidemiology Collaboration; Cr, creatinine (in mg/dl); CysC, cystatin C; eGFRcr, creatinine-based estimated GFR; eGFRcys, creatinine, and cystatin C-based estimated GFR; eGFRcys; cystatin C-based estimated GFR; GFR, glomerular filtration rate; IDMS, isotope-dilution mass spectrometry; JAMA, Journal of the American Medical Association; JASN, Journal of the American Society of Nephrology; MDRD, Modification of Diet in Renal Diseases; NHANES, National Health and Nutrition Examination Surveys.

*For blacks and whites aged 20–74 years only.

aStatistically significant trend in the original study.

bPrevalence accounting for persistence in lab values meeting definition, rather than one-time laboratory value.

Adapted from [19].
Recent trends in the prevalence of chronic kidney disease [estimated glomerular filtration rate < 60 ml/min/1.73 m²] using nationally representative surveys. Recent publications using nationally representative surveys from several developed countries demonstrate stable prevalence of chronic kidney disease [estimated glomerular filtration rate < 60 ml/min/1.73 m²] since the early 2000s. Data from [10⁎, 20⁎, 21⁎, 22].

FIGURE 1. Temporal trends in the prevalence of chronic kidney disease [estimated glomerular filtration rate < 60 ml/min/1.73 m²] using nationally representative surveys. Recent publications using nationally representative surveys from several developed countries demonstrate stable prevalence of chronic kidney disease [estimated glomerular filtration rate < 60 ml/min/1.73 m²] since the early 2000s. Data from [10⁎, 20⁎, 21⁎, 22].

period with the early 2000s (1999–2004 period) have shown variable results in the temporal trend, depending on the definition of CKD employed and the method of calibration for creatinine, which was necessary to account for laboratory drift across those earlier NHANES cycles [23]. In one of these studies, Coresh et al. [6] reported a 3.5% annual increase in CKD prevalence (eGFR < 60 ml/min/1.73 m²) from 1988–1994 to 1999–2004 and a 2.6% annual increase in prevalence of eGFR less than 60 ml/min/1.73 m² or albuminuria in the same study period. Ensuing studies [7, 15] using serum cystatin C as an alternative filtration marker also showed discrepant temporal trends in CKD prevalence from the same era, with the latest study by Grams et al. [7] (employing the most updated eGFR cystatin C-estimating equation [17] and technique for cystatin C calibration) reporting a significant ~5.0% annual increase in CKD prevalence (eGFR < 60 ml/min/1.73 m²) from 1988–1994 to 1999–2004. Table 1 also summarizes these older published studies that used NHANES data.

Reasons for the stabilization in CKD prevalence in the United States in the most recent decade are not absolutely clear. Although Murphy et al. [10⁎] did not attempt to directly model any potential mediating factors for this current trend (due to the cross-sectional nature of the NHANES survey design), it has been well reported from other NHANES studies that blood pressure (BP) control among those with hypertension [24, 25] and glycemic control among those with diabetes [26] have improved over time. The use of renin–angiotensin system (RAS) inhibitors have also become more pervasive over time [27, 28], rendering a potential renoprotective effect. This latest update is strengthened by its large sample size generalizable to the US population, the use of NHANES recommended methods for serum creatinine calibrations, and the robustness of results in analyses adjusted for demographics and diabetes along with analyses using an expanded definition of CKD including albuminuria. In summary, this latest and most scientific rigorous update [10⁎] in CKD prevalence in the United States paints a favorable picture of overall stabilization of the epidemic of CKD. Despite an aging population and growing prevalence of diabetes and obesity, we should be cautiously optimistic that our collective efforts at preventing and treating CKD and its associated risk factors have likely helped to abate the CKD ‘epidemic’ overall in the United States within the last 10–15 years.

UPDATE IN DIABETIC KIDNEY DISEASE PREVALENCE IN THE UNITED STATES

In a second well publicized study in 2016, Afkarian et al. [18⁎] similarly used NHANES data (from 1988 to 2014) to specifically address the temporal trend in prevalence of diabetic kidney disease (DKD), defined as having albuminuria (urine ACR ≥ 30 mg/g) and/or eGFR less than 60 ml/min/1.73 m² (estimated with CKD-EPI creatinine equation [11]) among individuals with diabetes. In this study, diabetes status was defined as use of glucose-lowering medications or a laboratory-measured HbA1c level of at least 6.5%; the authors did not use self-reported history of diabetes due to concern that secular changes in diabetes screening and diagnosis could lead to biased estimates of the overall diabetic population (the denominator of interest). Using this strict definition of diabetes, Afkarian et al. found that the prevalence of diabetes in the United States increased from 6% in 1988–1994 to 9.8% in 2009–2014. There was a higher proportion of diabetic patients who self-identified as Mexican-American over time (from 6.6% in 1988–1994 to 10.4% in 2009–2014).

Among US adults with diabetes, the overall crude prevalence of DKD (albuminuria and/or eGFR < 60 ml/min/1.73 m²) did not change significantly during the study period (from 28.4% in 1988–1994 to 26.2% in 2009–2014) [18⁎]. These prevalence rates took into account persistence of abnormal eGFR and ACR measurements rather than relying on one-time measurements (a technique
that is different from the study by Murphy and other prior NHANES analyses). However, the prevalence of reduced eGFR (<60 ml/min/1.73 m$^2$) increased from 9.2 to 14.1%, whereas the prevalence of albuminuria decreased from 20.8 to 15.9% (Table 1). The decline in albuminuria prevalence among people with diabetes appeared to be largely driven by those younger than 65 years and non-Hispanic whites, as older subgroups and racial-ethnic minority subgroups did not demonstrate a decline in albuminuria prevalence.

The study by Afkarian et al. [18**] updated the same research group’s previous study on DKD prevalence in the United States [29] by extending analyses through 2014 and importantly illustrated less-favorable trends for albuminuria in older and racial-ethnic minority subgroups. Notably, the authors directly showed that although mean BP, HbA1c, and cholesterol levels decreased over time in the overall US diabetic population and in all racial-ethnic subgroups, the achieved levels of BP, HbA1c, and LDL cholesterol were higher (i.e., less optimal) in racial-ethnic minorities (Fig. 2). The proportion of adults with diabetes taking glucose-lowering medications, renin–angiotensin–aldosterone system (RAAS) inhibitors, and statins increased over time, but blacks and Mexican-Americans were less likely than non-Hispanic whites to be taking these medications throughout all periods (Fig. 2). Therefore, it is postulated that the decline in albuminuria among younger and white subgroups may be attributable to higher rates of prescribed diabetes therapies, whereas less-frequent use of these proven therapies may underlie the less-favorable trends in albuminuria in blacks and Mexican-Americans. It is not clear why the prevalence of reduced eGFR less than 60 ml/min/1.73 m$^2$ among people with diabetes increased over time [18**] (a finding in contrast with the stable prevalence of eGFR <60 ml/min/1.73 m$^2$ in the overall US population [10**]). The authors postulated that although an aging population is unlikely the reason (as this trend persisted after adjustment for demographics), it is possible that hemodynamic effects of RAAS inhibitors and improved BP control could have contributed to lower eGFR.
INTERNATIONAL UPDATES IN TEMPORAL TRENDS IN CHRONIC KIDNEY DISEASE PREVALENCE

Several countries with established health examination survey systems have also updated their CKD prevalence trends in recent years. Below, we review studies with nationally representative data similar to NHANES published within the last 3 years. Figure 1 illustrates the trends in prevalence across these international populations [10**,20**,21**,22].

England

Aitken et al. [20**] recently reported the temporal trend in CKD prevalence in England from 2003 to 2010. Using data from the Health Surveys for England (HSEs) – a nationally representative survey of individuals aged 16 years or more – the investigators found a national prevalence of CKD (defined as CKD-EPI [11] derived eGFR < 60 ml/min/1.73 m²) to be 5.7% in 2003 and 5.2% in 2009–2010 (Fig. 1). The prevalence of CKD fell in all age and sex subgroups with the exception of men aged 65–74 years in whom there was a slight increase in prevalence. This slight decline in national prevalence of CKD occurred despite a concurrent increase in prevalence of obesity and diabetes, and persisted after adjustment for demographic and clinical factors. Hypertension prevalence decreased, and BP control improved during the period, but these factors did not appear to fully explain the fall in CKD prevalence. The lack of albuminuria measurements from the 2003 HSE precluded the comparison of CKD prevalence defined using both albuminuria and eGFR [20**].

Norway

In a study published in 2016, Hallan et al. [21**] reported the trend in prevalence of CKD in a demographically stable county representative of Norway. Using the cross-sectional Nord-Trøndelag Health Study survey data from two periods about a decade apart, the investigators found a stable prevalence of CKD stages 1 through 5 (11.3% in 1995–1997 and 11.1% in 2006–2008, P = 0.42). There was a slight increase in the prevalence of eGFR less than 60 ml/min/1.73 m² from 4.5% in 1995–1997 to 4.8% in 2006–2008 (P = 0.033) (Fig. 1) but a slight decrease in prevalence of albuminuria (ACR ≥ 30 mg/g) from 7.9 to 7.4%. With analysis of potential risk factors acting as modifiers of CKD prevalence, the authors found that lowered BP over time was the most significant modifier of the lowered CKD prevalence over time. More specifically, it was postulated that better hypertension control and greater use of RAS-inhibitors are factors that probably contributed to the decrease in prevalence of albuminuria but increase in prevalence of eGFR less than 60 ml/min/1.73 m² [30]. Despite an increase in the prevalence of diabetes and obesity during this decade, the proportion of diabetic patients with CKD decreased from 33.4 to 28.6% [21**].

Korea

Kang et al. [31**] recently reported the temporal trend in CKD prevalence in adults in South Korea using multiple phases of the nationally representative Korean NHANES. In men, the prevalence of eGFR less than 60 ml/min/1.73 m² was 1.0% in 1998, 5.4% in 2001, 3.1% in 2005, and 2.6% in 2007–2009; in women, prevalence of eGFR less than 60 ml/min/1.73 m² was 3.4% in 1998, 9.7% in 2001, 10.2% in 2005, and 4.6% in 2007–2009. Using only urine dipstick measurements to assess proteinuria and defining CKD as eGFR less than 60 ml/min/1.73 m² or dipstick proteinuria at least 1+, there was a similar trend of decreased CKD prevalence since 2001 for men and since 2005 for women. This study was limited by the lack of more quantitative proteinuria measurements and the lack of explanation for potential in serum creatinine assay drift. Figure 1 includes data points from an earlier Korean study [22] comparing the overall prevalence in eGFR less than 60 ml/min/1.73 m² showing declining overall prevalence from the 2005–2007 surveys (as the more recent study by Kang et al. [31**] only provided sex-specific prevalence rates).

EMERGING THREATS

In many parts of the developing world, the epidemiology of CKD is not well elucidated, due to the lack of resources for large-scale health examination surveys and the inconsistent quality of data and application of methods for assessing kidney disease [32]. Another barrier is that GFR-estimating equations have not been well validated in many of these populations. In low-income and middle-income countries, the burden of CKD may be growing as a result of rapid urbanization, exposure to environmental toxins, infectious disease burdens, and increasing rates of noncommunicable diseases such as hypertension and diabetes [32*].

In China, the most populous country in the world with an estimated 1.4 billion population, there have been a few recent ominous snapshots on the epidemiology of CKD. Zhang et al. [33**] performed the first comprehensive study exploring prevalence of CKD in China using a multistage, stratified survey sampling methodology involving
adults from 13 provinces in China, allowing for nationally representative inferences to be made. GFR was estimated using a modified version [34] of the Modification of Diet in Renal Disease equation adapted for the Chinese population. The study reported an overall prevalence of CKD (defined as eGFR < 60 ml/min/1.73 m² or ACR ≥ 30 mg/g) of 10.8% (equivalent to nearly 120 million individuals) during the survey period of 2009–2010. Interestingly, most of the patients classified as having CKD in China were diagnosed because of the presence of albuminuria (adjusted prevalence 9.4%), whereas relatively fewer were diagnosed because of diminished eGFR less than 60 ml/min/1.73 m² (1.7% prevalence). This suggests that the reported results may represent the onset of an evolving CKD boom, with later stages of CKD (including ESRD) expected to increase in the years to come [35]. In a more recent analysis [36], the same research group reported that CKD related to diabetes has become more common than CKD related to glomerulonephritis in both the general population and in a hospitalized urban population. The findings from these large population studies in China, coupled with a well described rise in the prevalence of diabetes in China [37,38], signal a strong forewarning of a growing epidemic of CKD to come in China in the upcoming years to decades, perhaps analogous to trends seen in the United States from the 1980s to early 2000s [5].

Lastly, in the coastal pacific regions of Central America, an alarmingly epidemic of CKD and ESRD has emerged among rural agricultural communities within the past 2 decades [39,40]. Young male agricultural workers – particularly sugarcane cutters – in these coastal regions of Nicaragua, El Salvador, and to some extent Costa Rica and Guatemala have exhibited high rates of progressive CKD that were disproportionate to known risk factors such as diabetes and hypertension [39,40]. Community-based cross-sectional surveys have reported prevalence rates of CKD (decreased eGFR of <60 ml/min/1.73 m²) to be upward of more than 15–20% range among young agricultural male workers [41–44]. This entity, now named Mesoamerican nephropathy [39,40] or chronic interstitial nephritis in agricultural communities [45], is characterized by tubulointerstitial nephritis on kidney biopsy and is hypothesized to be triggered by occupational and environmental toxins in these agricultural communities, along with heat stress and repeated episodes of dehydration.

CONCLUSION

Nation-level health examination surveys that include measurements of kidney function and albuminuria have allowed for tracking of the prevalence of CKD in recent decades in the United States and several other countries. Recent updates in the prevalence of CKD in the United States using NHANES suggest stable overall prevalence of CKD and stable prevalence of DKD since the 1999–2004 period [10,18]. The United States prevalence of eGFR less than 60 ml/min/1.73 m² is estimated to be 6.9% in 2011–2012, whereas the prevalence of CKD stages 1–4 was 14.2% in the same period [10]. Several other developed countries such as Norway, England, and Korea have also seen a plateau (or downtrend in the case of Korea) in the prevalence of CKD since the early 2000s [20,21,22,30,31]. Although it is conceivable that this stability in CKD prevalence could be due to an increase in mortality rates among persons with CKD in the more recent years, to our knowledge there are no data to suggest that mortality rates among persons with CKD have worsened over time.

These findings underscore that strong efforts at treating risk factors for CKD such as lowering of BP, use of RAS-inhibitors, and improving glycemic control in those with diabetes have likely contributed to this reversal in the CKD epidemic [19,30]. Whether there are changes in the avoidance of use of nephrotoxins (e.g., radiographic contrast media, nonsteroidal anti-inflammatory agents, and other medication) in persons with CKD is unknown. The implication that better BP management may be modifying the disease prevalence of CKD is especially notable in light of the recently shifting, and somewhat uncertain targets, for hypertension treatment for CKD. The most recent 2014 Joint National Committee (JNC) 8 Hypertension Guidelines [46] recommended a relaxation in BP targets for those with CKD and diabetes (compared with the JNC 7 Guidelines [47]), whereas trial data from Systolic Blood Pressure Intervention Trial [48] suggested mortality and cardiovascular disease benefit with intensive control to SBP less than 120 mmHg in high cardiovascular risk patients (but with a potentially detrimental effect in loss of GFR in patients without baseline CKD with intensive BP control). Another common thread is that the stability of CKD prevalence occurred in the most recent decade despite an ongoing increase in the prevalence of diabetes and obesity across many populations, a sign that perhaps certain interventions that increased over time (i.e., glucose-lowering medications, improved glycemic control, and statin use) may overcome the initiation of CKD by these two risk factors.

Although these results are encouraging, a worrisome signal from the two recent US updates was that the burden of CKD continues to rise among racial-ethnic minorities (non-Hispanic blacks for
overall CKD prevalence [10**]; non-Hispanic blacks and Mexican-Americans for DKD prevalence [18**]), with data from Afkarian et al. [18**] suggesting that less-optimal care with regard to BP, diabetes, and lipid control may be playing a role. More aggressive efforts are necessary to better understand the complex interplay among biological, genetic, socioeconomic, and health system-level factors that contribute to this racial-ethnic disparity in trends.

Not all countries have well established surveillance systems to estimate and track CKD prevalence, but we have some glimpses at high-risk populations in some developing countries. In China, recent data from newly established population survey representative of its entire adult population showed overall CKD prevalence of 10% in 2009–2010 [33**], a figure expected to rise due to the disproportionately low rates of stage 3 and above CKD compared with CKD stages 1–2 during the surveyed period. The development of accelerated CKD among young agricultural workers in parts of Central America illustrates the importance of identifying nontraditional risk factors such as occupational and environmental exposures in geographic regions where CKD is particularly endemic out of proportion to the rest of the population.

It would be helpful to develop better systematic and high-quality data collection worldwide on CKD and more granular data in local communities and healthcare systems. This would help to better monitor trends in the overall epidemic and among subgroups of the most vulnerable persons. Most importantly, such efforts would help identify the most promising strategies to disrupt rising trends in CKD prevalence or progression.

Acknowledgements
None.

Financial support and sponsorship
R.K.H. was supported by grant K23DK100468 from the National Institutes of Health.

Conflicts of interest
R.K.H. has consulted for Retrophin; no financial relationships are relevant to this manuscript. N.R.P. declares no conflicts of interest.

REFERENCES AND RECOMMENDED READING
Papers of particular interest, published within the annual period of review, have been highlighted as: of special interest or of outstanding interest

11. The US study showed that overall prevalence of chronic kidney disease (CKD), defined as estimated glomerular filtration rate (eGFR) less than 60 ml/min/1.73 m

Copyright © 2017 Wolters Kluwer Health, Inc. All rights reserved. www.co-nephrolhypertens.com 195

Copyright © 2017 Wolters Kluwer Health, Inc. All rights reserved.

1062-4821 Copyright © 2017 Wolters Kluwer Health, Inc. All rights reserved.
Epidemiology and prevention

32. Stanley JW, Muñu A, Jafar TH, Patel UD. Chronic kidney disease in low- and middle-income countries. Nephrol Dial Transplant 2016; 31:868–874. This review highlights the emergence of populations from low-income and middle-income countries at risk for growth in CKD.
33. Zhang L, Wang F, Wang L, et al. Prevalence of chronic kidney disease in China: a cross-sectional survey. Lancet 2012; 379:815–822. This is the first study attempting to estimate the prevalence of CKD in China using a multistage stratified survey sampling design; and the study reported an overall prevalence of CKD (defined as eGFR < 60 ml/min/1.73 m² or albumin-to-creatinine ratio > 30 mg/g) of 10.8% (equivalent to nearly 120 million individuals) during the survey period of 2009–2010.