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CKD Awareness Among US Adults by Future Risk of Kidney Failure

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Abstract

Rationale & Objective: Persons with chronic kidney disease (CKD) are often unaware of their disease status. Efforts to improve CKD awareness may be most impactful if focused on persons at highest risk of progression to kidney failure.

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Authors' Contributions:

research idea and study design: CDC, TB, MEP, NRB, BWG, RS, MGS, DST, NRP; data acquisition: CDC; data analysis/ interpretation: CDC, CEM, DST; statistical analysis: CDC, CEM, DST; supervision or mentorship: DST, NRP. Each author contributed important intellectual content during manuscript drafting or revision, accepts personal accountability for the author's own contributions, and agrees to ensure that questions pertaining to the accuracy or integrity of any portion of the work are appropriately investigated and resolved.

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Study Design: Serial cross-sectional surveys.

Setting & Participants: Non-pregnant adults (age ≥20 years) with CKD glomerular filtration rate categories 3–4 (G3-G4) who participated in the National Health and Nutrition Examination Survey from 1999–2016 (n=3,713).

Predictor: 5-year kidney failure risk, estimated by the Kidney Failure Risk Equation (KFRE). Predicted risk was categorized as minimal (<2%), low (2%-<5%), intermediate (5%-<15%), or high (≥15%).

Outcome: CKD awareness, defined by answering "yes" to the question, "Have you ever been told by a doctor or other health professional that you had weak or failing kidneys?".

Analytical Approach: Prevalence of CKD awareness was estimated within each risk group using complex sample survey methods. Associations between KFRE risk and CKD awareness were assessed using multivariable logistic regression. CKD awareness was compared with awareness of hypertension and diabetes over the same time period.

Results: In 2011–2016, unadjusted CKD awareness was 9.6%, 22.6%, 44.7%, and 49.0% in the minimal, low, intermediate, and high risk groups respectively. In adjusted analyses, these proportions did not change over time. Awareness of CKD, including among the highest risk group, remains consistently below that of hypertension and diabetes and awareness of these conditions did increase over time.

Limitations: Imperfect sensitivity of the "weak or failing kidneys" question for ascertaining CKD awareness.

Conclusions: Among adults with CKD G3-G4 who have 5-year estimated risks of kidney failure of 5%- <15% and ≥15%, approximately half were unaware of their kidney disease, a gap that has persisted nearly two decades.

Keywords

chronic kidney disease (CKD); CKD awareness; public health; estimated glomerular filtration rate (eGFR); urinary albumin-creatinine ratio (UACR); albuminuria; renal function; renal insufficiency; kidney failure prevention; disease management; patient empowerment; self care; health literacy; nationally representative survey

Introduction

Chronic kidney disease (CKD) affects approximately 15% of the U.S. adult population, and nine out of ten adults with the disease are not aware of having it.[1,2] While there is some suggestion that patient awareness of CKD may have increased among persons with CKD stage 4 from 2009 to 2016[1], numerous studies have found low overall CKD awareness across racially/ethnically and geographically diverse populations.[3–8] It is generally assumed that awareness of disease is an important stimulus for early preventive care, including minimizing nephrotoxic medications and guiding treatments to slow kidney disease progression.[9,10] To date, studies examining this assumption have failed to show robust associations between CKD awareness and blood pressure control, glycemic control, non-

steroidal anti-inflammatory drug (NSAID) avoidance, and general CKD self-management knowledge and behaviors.[11–15]

While these data may temper enthusiasm surrounding diagnostic disclosure of CKD, patient awareness remains an important component of CKD management and preventive care. One argument is that all patients should be aware of all their diagnoses, no matter how consequential, unless they specifically indicate otherwise—and that withholding the diagnosis could represent a paternalistic practice.[16] In addition, knowledge of CKD diagnosis can reinforce adherence to lifestyle changes and treatments for shared cardiovascular and kidney-related risk factors; patient counseling may be framed in the context of decreasing the risk of worsening kidney function and forestalling or preventing the need for dialysis.

Controversy surrounding the value of CKD awareness is largely due to the uncertainty of whether CKD progression from early to late stages would be prevented if CKD awareness were greater. While it would be ideal for all persons with CKD to be aware of their condition, CKD awareness is almost certainly most relevant to those at greatest risk for CKD-specific complications, including need for kidney replacement therapy (KRT). The objectives of this study were to estimate CKD awareness in a nationally representative population sample according to risk of progression to kidney failure, and to determine whether awareness has changed over time among those with highest risk of progression to kidney failure.

Methods

Study Design

The National Health and Nutrition Examination Survey (NHANES) is a nationally representative cross-sectional survey of noninstitutionalized U.S. civilian residents that has been conducted continuously since 1999 by the Centers for Disease Control and Prevention's National Center for Health Statistics. The survey obtains cross-sectional prevalence estimates and, when combined over multiple years, can identify national trends in disease prevalence. NHANES consists of an interview component, a physical examination component, and a laboratory testing component. The NHANES protocol was approved by the National Center for Health Statistics Research Ethics Review Board (protocol #98–12, #2005–06, #2011–17), and informed consent was obtained from all study participants. We examined data from NHANES from 1999 to 2016.[17]

Study Population

Of the 92,062 NHANES participants 1999 to 2016, our study population included survey participants age 20 years or older and who were not pregnant (remaining n = 48,026). For analyses of CKD awareness, we excluded participants with missing data on age, sex, race, serum creatinine, or urinary albumin-creatinine ratio (UACR), as this information is required for calculation of estimated glomerular filtration rate (eGFR) and estimation of kidney failure risk (remaining n = 42,106). We excluded participants who did not have CKD GFR categories 3 or 4 (G3-G4), as defined by eGFR ≥15 and <60 mL/min/1.73m^2 (remaining n =

3,728). Participants with eGFR <15 mL/min/1.73m^2 were excluded due to low sample size (n = 97) and an inability to differentiate reliably those on dialysis from those with advanced but non-KRT-requiring CKD. Finally, we excluded participants who did not answer "Yes" or "No" to the question on awareness of CKD (final n for CKD awareness analysis = 3,713).

Definitions

CKD G3-G4 was defined by eGFR ≥15 and <60 ml/min/1.73m^2, as calculated using the CKD-EPI equation.[18] The 5-year risk of kidney failure was estimated using the 4-variable Kidney Failure Risk Equation (KFRE), which uses age, sex, eGFR, and UACR to predict risk of kidney failure over time (Item S1).[19] The KFRE is a publicly available risk prediction model initially developed and validated in a retrospective cohort of Canadian CKD patients; it has demonstrated excellent discriminatory performance in subsequent validation studies using diverse multinational cohorts.[20,21] We categorized KFRE-predicted risk into four levels: minimal risk (<2%), low risk (2 to <5%), moderate risk (5 to <15%), and high risk (15% or greater). These cutoffs were selected to represent clinically meaningful risk delineations suggested by prior studies.[19,22,23]

CKD awareness was defined among those with CKD as a "yes" answer to the interview question "Have you ever been told that you have weak or failing kidneys? Do not include kidney stones, bladder infections, or incontinence."

For comorbidities, hypertension was defined as either systolic blood pressure ≥140 mmHg, diastolic blood pressure ≥90 mmHg, or current use of antihypertensive medication.[24] If more than one blood pressure reading was measured, the mean systolic value and mean diastolic value across all readings were used. Diabetes was defined by hemoglobin A1c ≥6.5% or current use of diabetes medication.[25]

Statistical Methods

Combining all survey years 1999–2016, the proportion of persons aware of CKD was estimated within each risk group. To assess for temporal trends, we examined CKD awareness during three consecutive six-year intervals: 1999–2004, 2005–2010, and 2011–2016. Multiple survey years were aggregated to ensure sufficient cell sizes for analysis within each time interval and KFRE risk group. The unadjusted prevalence of CKD awareness was estimated during each time interval, by KFRE risk group. Temporal trends in CKD awareness were assessed by fitting logistic regression models using time interval as a categorical predictor, then using contrasts to test for linear trends in the corresponding coefficients.[26]

The association between KFRE risk and CKD awareness was examined using multivariable logistic regression, adjusting for demographic variables and comorbidities previously associated with CKD awareness. Because the question of whether CKD definition should use an age-adapted eGFR is an issue of current interest,[27–29] we also examined whether the association between KFRE risk and CKD awareness varied by age. For this analysis, age was categorized as 20–64, 65–74, and ≥75 years. Using logistic regression with an interaction term for age and KFRE risk, marginal predictions of CKD awareness were obtained for each KFRE risk group according to age category.

As a secondary analysis, we compared awareness of CKD to awareness of other common chronic conditions, namely, hypertension and diabetes. For this analysis, hypertension awareness was defined as either self-reported hypertension (defined by answering “yes” to the question “Have you ever been told by a doctor or other health professional that you had hypertension, also called high blood pressure?”) or self-reported use of prescription medication for high blood pressure, among persons with hypertension. Diabetes awareness was defined as either self-reported diabetes (defined by answering “yes” to the question “Other than during pregnancy, have you ever been told by a doctor or health professional that you have diabetes or sugar diabetes?”) or self-reported insulin or diabetic pill use, among persons with diabetes.

Analyses were performed using Stata/IC version 15.1 (StataCorp, College Station, Texas, USA). Adjustments were made to account for historical laboratory creatinine calibration issues according to NHANES analytical guidelines (Item S2). All estimates in NHANES were weighted to the U.S. population using the appropriate sample weights with variance computed accounting for strata and primary sampling units. All reported estimates were based on >8 degrees of freedom, and all had relative standard error <30%, in accordance with NHANES analytic guidelines and the National Center for Health Statistics Data Presentation Standards for Proportions.[30]

Results

Participant Characteristics

Baseline characteristics of NHANES participants with CKD G3-G4 (n = 3,713) are described in Table 1. Higher KFRE risk was more common among men, persons of non-white race/ethnicity, persons with diabetes, and persons with hypertension. The mean eGFR ranged from 52 mL/min/1.73m^2 in the minimal KFRE risk group to 26 mL/min/1.73m^2 in the highest risk group; median UACR ranged from 9 mg/g to 934 mg/g across these groups of KFRE risk. The proportion of persons with any type of health insurance was high at approximately 96% and was similar across all risk groups, although in higher risk groups, Medicaid was more common (14.4% in the highest risk group versus 6.6% in the lowest) and private insurance was less common (48.9% versus 61.2%, respectively).

Proportion Aware of CKD

Among adults with CKD G3-G4 and <2% KFRE risk, 7.0% (95% CI, 5.9%−8.3%) were aware of their CKD; among those with 2%-<5% KFRE risk, 18.7% (95% CI, 14.0% −23.4%) were aware; among those with 5%-<15% KFRE risk, 43.4% (95% CI, 36.4% −50.5%) were aware; and among those with ≥15% KFRE risk, 49.6% (95% CI, 41.1% −58.2%) were aware.

Consistently over time, crude prevalence of CKD awareness was higher with higher KFRE risk group (Figure 1, panel A). In analyses of awareness over time, unadjusted analyses showed a borderline statistically significant trend only among those at minimal KFRE risk (6.3% [95% CI, 4.3%−8.3%] in 1999–2004 and 9.6% [95% CI, 7.4%−11.8% in 2011–2016]; p_{trend} = 0.03). In other KFRE risk groups, no statistically significant trends were

found: CKD awareness estimates in the 2%-<5% KFRE risk group were numerically higher in 2011–2016 (22.6%; 95% CI, 14.7%−30.4%) than in 1999–2004 (14.6%; 95% CI, 6.6% −22.5%) but this was not statistically significant (p_{trend} = 0.2); awareness in higher risk groups ranged from 42% to 50% (p_{trend} = 0.8 and 0.9, respectively).

Similar results were obtained when analyses were conducted for direct age-standardized CKD awareness (Figure 1, panel B), and then with adjustment for sex, age, race/ethnicity, presence of hypertension, and presence of diabetes (Figure 1, panel C). No statistically significant trends were observed in any KFRE risk groups in either age-standardized or adjusted analyses.

Association of Kidney Failure Risk with CKD Awareness

The association between KFRE risk and CKD awareness was examined using multivariable logistic regression (Table 2). In both unadjusted and adjusted models, the odds of CKD awareness were greater with each category of higher KFRE risk. Odds of CKD awareness were similar in the two highest risk groups (5%-<15% and ≥15%). Associations between CKD awareness and each KFRE risk group were all statistically significant (p <0.01 for each).

Figure 2 shows unadjusted and adjusted CKD awareness by KFRE risk and age categories. Findings were overall similar between unadjusted and adjusted analyses. CKD awareness was greater with increasing kidney failure risk, except among the highest risk group in the 20–64 age category. The ≥75 age category consistently had the lowest awareness across the all risk groups. Of note, interpretation of these interactions is limited due to wide confidence intervals, and p values for interaction were nonsignificant in both unadjusted and adjusted analyses.

Comparison of Awareness of CKD, Hypertension, and Diabetes

Figure 3 shows trends in awareness of diabetes and hypertension over the study time period, compared to CKD (all CKD G3-G4) and high-risk CKD (CKD with ≥15% risk of kidney failure at 5 years as determined by the KFRE). From 1999–2016, hypertension and diabetes awareness were both consistently higher than CKD awareness in all CKD G3-G4 and in high-risk CKD. During this period, both hypertension and diabetes exhibited an increase in prevalence of disease awareness (p_{trend} < 0.001 for both).

Discussion

In this nationally representative sample of U.S. adults, we found that while CKD awareness was higher among persons with higher 5-year kidney failure risk, approximately half of the participants with ≥15% risk of developing kidney failure within 5 years were unaware of having kidney disease. Additionally, no statistically significant trends over time were observed in CKD awareness for any risk groups except among those with minimal risk CKD, but this trend was not significant in adjusted analyses. After adjustment for demographic factors and comorbidities, we found that higher predicted kidney failure risk was associated with increased odds of CKD awareness.

Our findings that CKD awareness is markedly lower for persons with CKD, even those at the highest levels of risk for kidney failure, compared to all persons with hypertension or diabetes regardless of their future risk for adverse events underscores the need for the Public Awareness Initiative for Advancing American Kidney Health launched by the National Kidney Foundation, American Society of Nephrology, and the U.S. Department of Health and Human Services.[30a] This initiative aims to elevate kidney disease awareness and includes an accompanying Kidney Risk Campaign. Additionally, both diabetes and hypertension awareness demonstrate an increase over time with statistically significant ptrend values. The trend in awareness for CKD G3-G4 was not significant in adjusted analyses; furthermore, no statistically significant trends were observed in the high-risk CKD group—a group for whom the practical implications of CKD are potentially most clinically relevant.

There are several possible factors contributing to low CKD awareness. In one study of audio-taped primary care encounters, CKD was less commonly discussed compared to hypertension or diabetes, and most CKD discussions were limited to technical discussion of laboratory results, rather than on risk factors, prevention, or complications.[31] Other possible contributing factors may be provider under-recognition, lack of CKD knowledge or familiarity on the part of primary care providers, and fear of overwhelming patients, as compared to hypertension or diabetes.[32]

A somewhat surprising finding was the similarity in CKD awareness between the intermediate risk (5%-<15% KFRE risk at 5 years) and the high risk (≥15%) groups. Both categories of risk were associated with approximately 9 times odds of awareness compared to the minimal risk group. The decision not to disclose CKD to patients has been, at least in part, attributed to the view that there is little benefit to CKD disclosure when kidney disease is mild, has no immediate treatment implications, and is likely to cause undue anxiety in patients who are worried they will need dialysis or kidney transplantation.[33] If clinicians' efforts to notify and educate patients about CKD are related to kidney disease severity, then similar rates of awareness between intermediate and high levels of risk would suggest that clinicians are failing to discriminate between these levels of risk in patients with CKD. While persons in the highest risk group had a mean eGFR that was 7 ml/min/1.73m^2 lower than those in the intermediate risk group (33 versus 26 ml/min/1.73m^2), they had substantially more albuminuria (median UACRs of 934 vs 63 mg/g). Prior studies have shown proteinuria to be an uncommon reason for nephrology referral, suggesting that a possible reason why clinicians fail to recognize high risk kidney disease may be a relative underappreciation of the prognostic significance of albuminuria compared to eGFR for predicting renal and cardiovascular outcomes.[8,22] Risk assessment using KFRE would reinforce the importance of albuminuria measurement and allow clinicians to assess risk more effectively and objectively for patients with CKD. KFRE utilization in primary care could help risk stratify patients with CKD and inform appropriate counseling, as well as next steps in workup and referral.[22,34,35]

We found no statistically significant effect modification of age on the association between KFRE risk and CKD awareness. Except in the highest KFRE risk group, CKD awareness was higher in younger age groups. Of the multiple provider-level factors (recognition,

disclosure) and patient-level factors (e.g., health literacy, denial) that may affect awareness, the observed findings are suggestive of several possibilities.[10] One possible provider-level factor would be a higher threshold for disclosure for mild CKD at older age. This may be due to a view that kidney disease is a part of normal aging, and that labeling or disclosure may lead to undue anxiety and stigma for otherwise well patients.[33,36,37] This behavior, whether intentional or not, is much in keeping with the recent conversation surrounding whether the eGFR-based definition of CKD should be age-adapted, based on physiologic age-related kidney function decline as well as examination of age-dependent differences in mortality risk associated with eGFR.[27–29] In particular, it has been suggested that the threshold eGFR for CKD definition should be higher with younger age (75 ml/min/1.73m^2 for age <45) and lower with older age (45 ml/min/1.73m^2 for age >65). Another possibility is if providers are under-recognizing CKD in older age groups, which is plausible if older individuals are more likely to have creatinine tested for reasons other than kidney health, thereby leading to incidental detection of CKD. Additional study would be needed to discern the extent to which age-related differences in provider recognition versus disclosure (versus patient-level factors) lead to different rates of CKD awareness. However, these findings should be interpreted with caution given the uncertainty associated with awareness estimates due to small sample sizes in higher KFRE risk groups.

This study benefits from capturing a nationally representative population over an extended time period spanning 18 years. It also represents a use of the KFRE as a method to stratify our analysis based on each person's risk for a meaningful clinical outcome, rather than stratifying by disease definitions such as CKD stage or albuminuria, which are not as directly patient-centered. Our study examined the CKD population through a lens of predicted risk rather than observed outcomes, providing a more coherent and actionable framework for guiding CKD awareness efforts and focusing on persons at high risk of kidney failure. By directly showing low awareness among persons with high predicted kidney failure risk, we define a discrete population—identifiable based on presently obtainable laboratory and demographic information—in which awareness efforts may be intensified. As the basis for risk-based care, this helps further underscore the importance of albuminuria testing for risk stratification to guide referral, counseling, and treatment decisions.

The primary limitation of this study was the imperfect sensitivity of the question used in NHANES for ascertaining awareness of kidney disease. Ascertainment of CKD awareness among persons with laboratory-defined CKD can differ according to how the question is asked, with the NHANES question referring to "weak or failing kidneys" being relatively less sensitive compared to different phrases to describe CKD.[38,39] Clinicians may describe CKD to patients in a variety of ways (e.g., weak kidneys, kidney disease, poor kidney function, protein in the urine), and the best question to ascertain CKD awareness has not been conclusively established; a study has shown that a compound question or combining multiple questions may increase the yield.[38] However, the present question remains the most readily available way to obtain consistent, nationally representative estimates of trends in CKD awareness. Given that improving awareness of kidney disease has been announced in 2019 as a priority of the Advancing American Kidney Health initiative, better validated tools are needed for improved measurement and national surveillance of CKD awareness.

Additional limitations included small numbers of persons with advanced CKD, which precluded more precise estimation and analysis of CKD awareness in higher risk groups. Because of the cross-sectional nature of NHANES, the diagnosis of CKD was based on a single measurement of creatinine and albuminuria, whereas the gold standard definition requires two abnormal laboratory parameters separated by at least three months.[40] Similarly, hypertension and diabetes diagnoses may be subject to misclassification due to definitions based on a single timepoint. Finally, the cross-sectional design does not allow any inference with respect to whether or how kidney failure risk might lead to CKD awareness.

In summary, we found in a nationally representative sample that approximately half of persons with CKD and high risk of progression to kidney failure (≥15% within 5 years) were unaware of having kidney disease, and among those with minimal (<2%) risk, less than 10% were aware. The heterogeneity of kidney failure risk also likely contributes to difficulty in demonstrating the effects of CKD awareness in the overall CKD population. Future studies of CKD awareness should present risk-stratified results, as this may better direct public health efforts. While there may be some debate about the disclosure of CKD diagnosis for those with milder degrees of CKD and low risk of progression, the finding that such a large proportion of persons with the highest risk of needing dialysis or kidney transplantation within 5 years are unaware of having kidney disease is highly concerning, particularly as awareness in this group remains below that of hypertension and diabetes, and has not changed with time. Despite broadly directed efforts by many organizations to raise overall awareness of kidney disease over the years, CKD awareness has remained largely unchanged for 18 years. The 2019 executive order on Advancing American Kidney Health initiative was an unprecedented step in garnering nationwide attention surrounding kidney disease, bringing it directly into the national spotlight. The subsequent announcement of the Public Awareness Initiative, which is to include a nationwide Kidney Risk Campaign, is an exciting and welcome step we should all look forward to with great anticipation.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Support:

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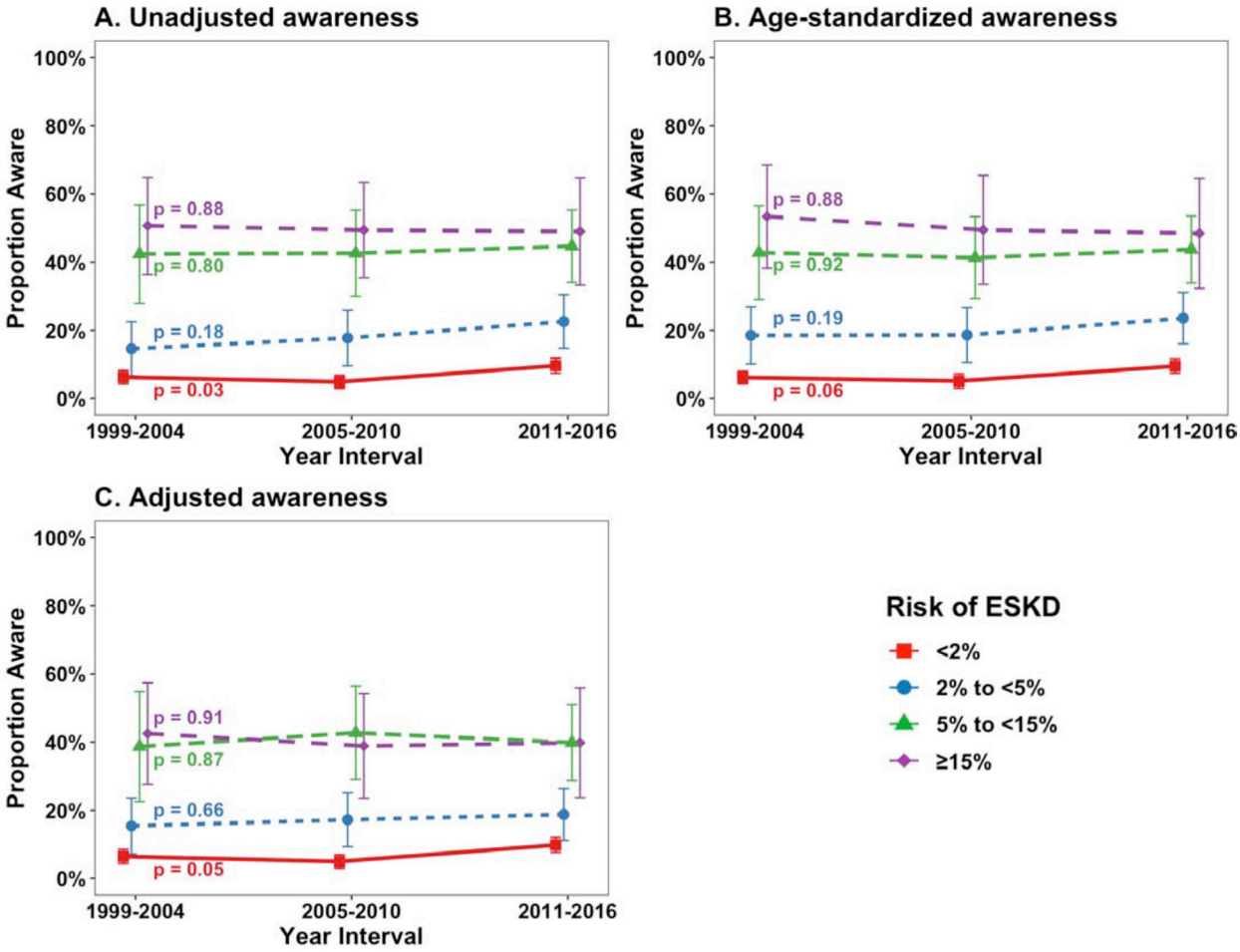

Figure 1: CKD awareness by 5-year Kidney Failure Risk, NHANES 1999–2016.

P values reported are for linear trends. ESKD risk is the estimated 5-year risk of dialysis or kidney transplant, calculated using the 4-variable Kidney Failure Risk Equation. In panel B, estimates are standardized to the 1999–2004 age distribution. In panel C, adjustment is for sex, race/ethnicity, presence of diabetes, and presence of hypertension. CKD = chronic kidney disease; NHANES = National Health and Nutrition Examination Survey; ESKD = end-stage kidney disease.

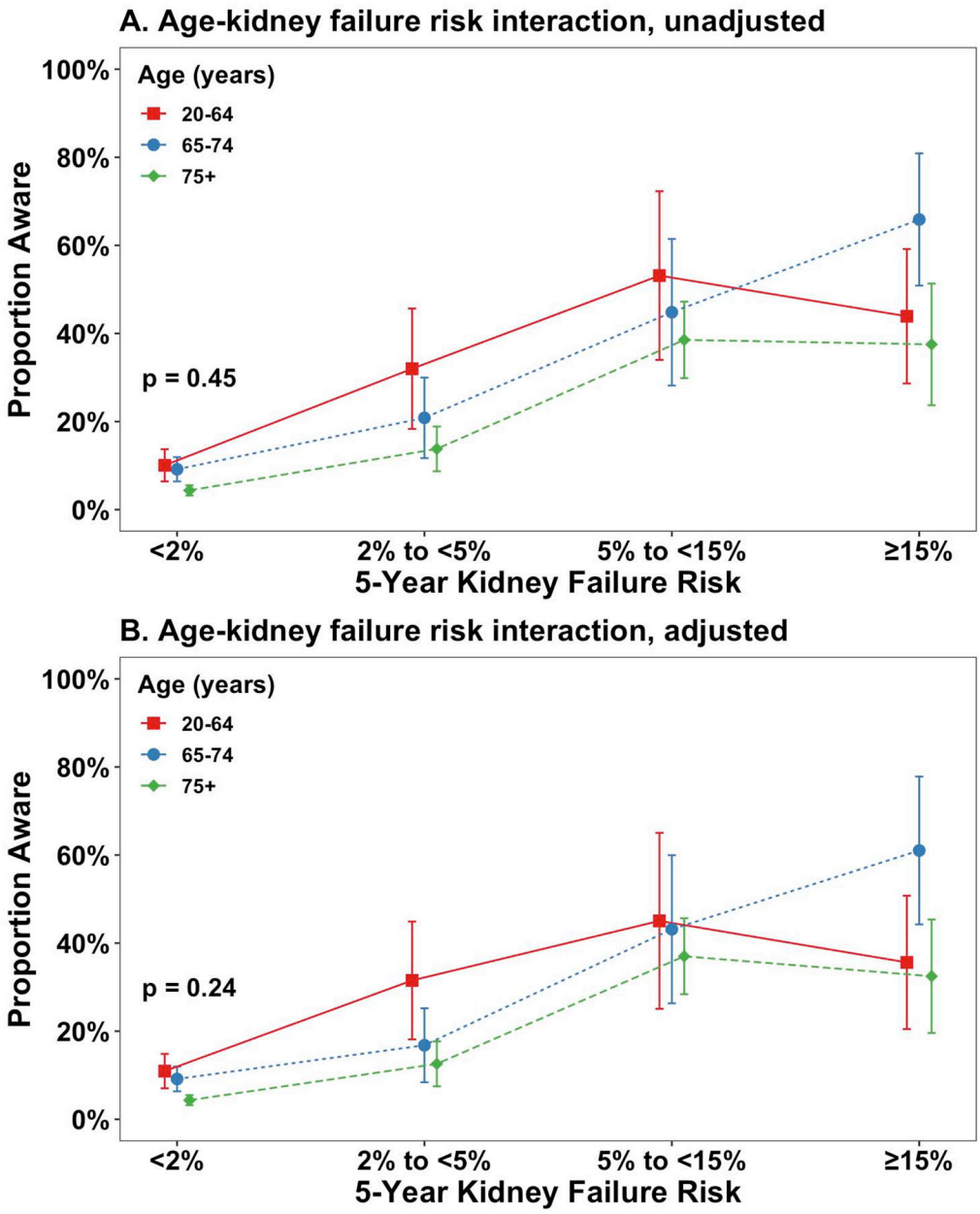

Figure 2: CKD Awareness by Age and Kidney Failure Risk

ESKD risk is the estimated 5-year risk of dialysis or kidney transplant, calculated using the 4-variable Kidney Failure Risk Equation. In panel B, adjustment is for sex, race/ethnicity, presence of hypertension, and presence of diabetes. P values reported are for tests for interaction. CKD = chronic kidney disease.

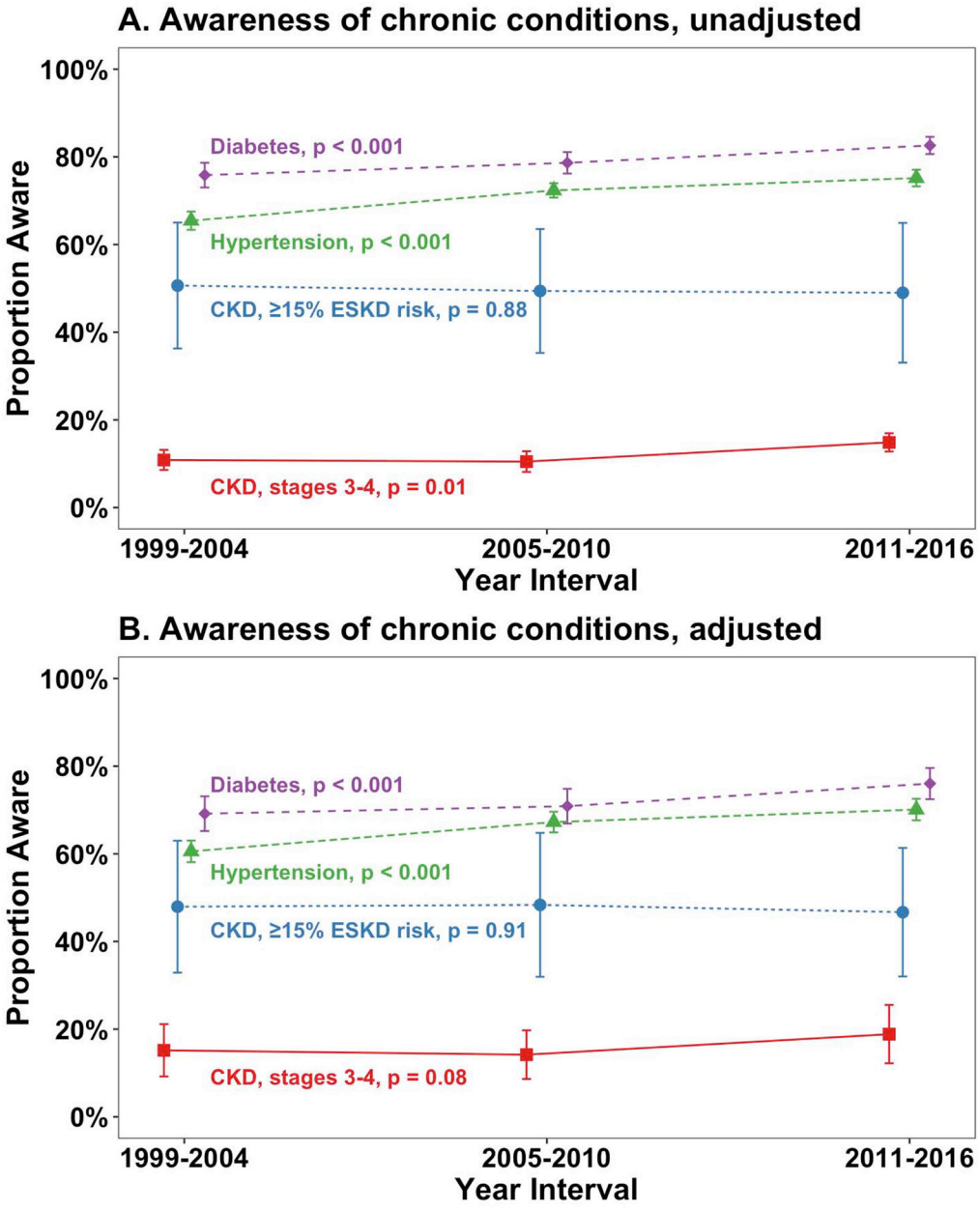

Figure 3: Comparative Awareness of CKD, Hypertension, and Diabetes, NHANES 1999–2016

P values reported are for linear trends. Diabetes awareness was defined as self-reported diabetes, insulin use, or diabetic pill use among persons with glycohemoglobin A1c ≥ 6.5% or documented diabetes medication use. Hypertension awareness was defined as self-reported hypertension or high blood pressure medication use among persons with systolic blood pressure ≥140 mmHg, diastolic blood pressure ≥90 mmHg, or documented antihypertensive medication use. CKD awareness was defined as reporting having been told by a health provider one had "weak or failing kidneys", among persons with estimated glomerular filtration rate 15 to <60 ml/min/1.73m^2 (defining CKD stages 3–4) or ≥15% 5-year risk of dialysis or kidney transplant, calculated using the 4-variable Kidney Failure Risk Equation (defining CKD with ≥15% ESKD risk) respectively. In panel B, adjustment is for

age, sex, race/ethnicity, presence of diabetes, and presence of hypertension. CKD = chronic kidney disease, ESKD = end-stage kidney disease.

Table 1:

Characteristics of U.S. adults with CKD by estimated 5-year kidney failure risk, NHANES 1999–2016.

Characteristic	estimated 5-year kidney failure risk				P
	<2%	2%<5%	5%–<15%	≥15%	
No. of participants	2,818	423	258	214	
Mean Age	71 (71, 72)	73 (71, 74)	71 (69, 73)	67 (64, 69)	0.2
Women	60.4 (58.3, 62.5)	58.6 (53.1, 64.2)	50.5 (44.0, 57.0)	46.7 (38.1, 55.1)	<0.001
Race/ethnicity					<0.001
Non-Hispanic white	84.0 (81.9, 86.0)	74.9 (70.2, 79.6)	71.9 (65.5, 78.2)	57.8 (48.8, 66.8)	
Non-Hispanic black	7.6 (6.4, 8.8)	12.1 (9.1, 15.1)	13.3 (9.2, 17.5)	20.4 (14.5, 26.3)	
Mexican-American	2.0 (1.4, 2.6)	3.9 (2.4, 5.3)	4.9 (2.1, 7.7)	8.9 (4.9, 12.8)	
Other Hispanic	3.0 (1.8, 4.2)	2.6 (1.0, 4.1)	3.7 (1.6, 5.9)	3.9 (1.2, 6.6)	
Other	3.5 (2.6, 4.3)	6.6 (3.0, 10.2)	6.2 (2.4, 10.1)	9.0 (2.2, 15.8)	
Health insurance, any	96.3 (95.3, 97.2)	95.5 (92.5, 98.5)	95.3 (92.6, 98.0)	95.0 (90.9, 99.0)	0.8
Private insurance	61.2 (58.3, 64.2)	58.0 (51.7, 64.5)	49.0 (41.2, 56.9)	48.9 (40.4, 57.3)	0.002
Medicare	70.9 (68.3, 73.6)	75.6 (69.9, 81.4)	72.9 (65.5, 80.4)	68.2 (59.9, 76.6)	0.4
Medicaid	6.6 (5.4, 7.8)	11.7 (7.9, 15.4)	12.5 (6.9, 18.0)	14.4 (8.6, 20.3)	<0.001
Reported a routine site of care	96.8 (96.0, 97.6)	96.0 (93.6, 98.5)	97.9 (96.2, 99.7)	98.6 (97.0, 100.0)	0.4
High school education or above	75.3 (73.0, 77.7)	67.0 (61.3, 72.7)	63.4 (57.5, 70.4)	66.0 (58.6, 73.5)	<0.001
Current smoker	18.7 (15.8, 21.6)	22.6 (15.8, 29.4)	20.3 (11.4, 29.2)	26.4 (16.2, 36.6)	0.3
Obesity	36.2 (34.3, 38.1)	41.7 (34.4, 49.1)	49.5 (41.3, 57.8)	52.0 (43.1, 61.0)	<0.001
Family history of diabetes	39.6 (37.2, 41.9)	43.6 (37.6, 49.7)	43.3 (35.5, 51.0)	61.9 (53.6, 70.2)	<0.001
Diabetes	22.6 (20.7, 24.5)	37.8 (31.6, 44.1)	46.4 (39.5, 53.3)	55.6 (46.2, 65.0)	<0.001
Hypertension	80.3 (77.9, 82.6)	92.4 (88.6, 96.2)	94.8 (91.9, 97.8)	92.9 (87.9, 98.0)	<0.001
Coronary artery disease	12.5 (10.9, 14.0)	18.7 (14.0, 23.5)	22.3 (16.0, 28.6)	27.6 (19.5, 35.7)	<0.001
Congestive heart failure	10.6 (9.1, 12.1)	17.1 (13.0, 21.2)	24.2 (18.2, 30.2)	27.8 (19.9, 35.8)	<0.001
CKD GFR category					<0.001
G3a	84.8 (83.4, 86.3)	19.5 (15.1, 24.0)	7.4 (3.5, 11.2)	0	
G3b	15.2 (13.7, 16.6)	69.0 (63.1, 74.9)	54.6 (47.3, 61.8)	34.2 (25.7, 42.7)	
G4	0	11.5 (7.3, 15.7)	38.1 (31.1, 45.1)	65.8 (57.3, 74.3)	
eGFR (ml/min/1.73m^2) *	52 (6)	39 (8)	33 (8)	26 (8)	<0.001
UACR (mg/g) **	9 (5, 22)	41 (13, 135)	63 (34, 330)	934 (322, 2763)	<0.001

Values in parentheses are 95% confidence intervals.

* Mean +/− standard deviation

** median [interquartile range]

Reported figures are adjusted for complex survey design used by NHANES to estimate nationally representative results.

Obesity defined as body mass index ≥30 kg/m^2.

CKD = chronic kidney disease; NHANES = National Health and Nutrition Examination Survey; SD = standard deviation; eGFR = estimated glomerular filtration rate, calculated by Chronic Kidney Disease-Epidemiology Collaboration (CKD-EPI) equation; UACR = urinary albumin-creatinine ratio

Table 2:

Association of Kidney Failure Risk and CKD Awareness by Multivariable Logistic Regression among U.S. Adults with CKD G3-G4 Based on NHANES 1999–2016.

Kidney Failure Risk Group	Unadjusted OR (95% CI)	Adjusted OR (95% CI)	
		Model 1*	Model 2**
<2%	1.00 (reference)	1.00 (reference)	1.00 (reference)
2%–<5%	3.02 (2.11–4.33)	3.14 (2.22–4.43)	2.76 (1.90–4.01)
5%–<15%	10.10 (7.11–14.34)	10.19 (7.04–14.74)	9.36 (6.30–13.90)
≥15%	12.96 (8.76–19.16)	11.20 (7.42–16.92)	9.24 (5.97–14.31)

* Adjusted for age, sex, and race/ethnicity.

** Adjusted for age, sex, race/ethnicity, hypertension status, and diabetes status.

Kidney failure risk was 5-year risk, determined using the 4-variable Kidney Failure Risk Equation.

CKD = chronic kidney disease; NHANES = National Health and Nutrition Examination Survey; OR = odds ratio; CI = confidence interval.