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Research Article

Silent Kidney Dysfunction in Contemporary U.S. Adults: Phenotype-Specific Awareness of Albuminuria and Reduced eGFR in NHANES 2021–2023

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Abstract

Background: Chronic kidney disease often develops without any symptoms, and the awareness in the population has not become so far despite advances in risk stratification and kidney-protective therapy. It is uncertain whether the contemporary U.S. population recognizes albuminuric and reduced-filtration phenotypes differently.

Methods: We examined data from the National Health and Nutrition Examination Survey (NHANES) conducted between August 2021 and August 2023 in adults aged ≥20 years with serum creatinine, urinary albumin to creatinine ratio (UACR), and kidney awareness questionnaire data. The 2021 CKD-EPI creatinine equation was used to estimate the eGFR. CKD-compatible abnormality in the laboratory was eGFR <60 mL/min/1.73 m2 and/or UACR ≥30 mg/g at the single NHANES examination. In this case, awareness was defined as personally reporting having been told by a health professional that the participant has weak or failing kidneys.

The weight for phlebotomy, cycle-specific, strata and primary sampling units determined survey analyses.

Results: Among 5298 adults, there were 918 laboratory abnormality; weighted prevalence was 14.0 % (95% CI, 12.5%–15.6%). Of the adults who had the disease, only 12.9% knew about it (95% CI, 9.9-16.0%), meaning 87.1% remained unrecognized. In isolated albuminuria, awareness was 3.1%, in isolated eGFR <60 it was 17.9%, while in both was 39.8%. In totally modified models, compared with isolated albuminuria, awareness was higher with isolated reduced eGFR (OR 7.42, 95% CI 2.85–19.30) and the merged phenotype (OR 27.63, 95% CI 11.19–68.21). Being in the A3 albuminuria category or having severe filtration impairment (eGFR <45) was independently associated with a higher awareness; however, even in the most severe combination, awareness was under 50%.

Conclusion: In contemporary US adults, kidney dysfunction remains mostly unrecognized, especially when the abnormality is albuminuria with preserved eGFR. Tests of serum creatinine will not close the gap, which is substantial, although dual assessment with eGFR and UACR needs to be more widespread.

Keywords: Chronic kidney disease, awareness, Albuminuria, eGFR, Screening, NHANES, Kidney disease detection

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Introduction

CKD is common, clinically significant, and often silent until considerable injury has taken place. Currently, the assessment of chronic kidney disease (CKD) is based on two complementary dimensions: glomerular filtration and albuminuria. It is known from the guidelines, as will be discussed in this chapter, that lower eGFR and higher UACR independently predict kidney failure, cardiovascular events, hospitalization and mortality. Thus, it's recommended to interpret them together. In other words, serum creatinine alone should not be treated as a complete kidney assessment [1,2].

The challenge lies in the fact that biologic detection isn't automatically patient identification. For more than two decades, surveys of the population of the U.S. have made it clear that many adults who meet laboratory criteria for kidney disease do not know it. The initial analyses of NHANES showed a very low awareness, especially in less advanced disease, while later analyses showed only modest improvement over time [3-5]. According to Gong et al. [6], CKD-prevalence was nearly 15% in U.S. adults in 2011-March 2020, as per estimation. Awareness was near 12%. Ozieh et al [7] reported similarly persistently low awareness over NHANES 1999–2020, as CKD care advanced.

The typical binary designation of "CKD present" or "CKD absent" may hide an important part of the awareness gap. Albuminuria does not necessarily co-occur with reduced eGFR. eGFR is a good indicator of overall kidney function for clinical diagnosis, but it may miss small vascular changes causing albuminuria. The biological differences of these phenotypes are important, but so are the differences of recognition due to clinical workflows. Serum creatinine is in routine chemistry panels and eGFR is generally reported automatically, while UACR requires urine and specific order. The National EHR data from Canada documents that UACR testing is underutilized even in a population of adults with conditions like diabetes or hypertension who are at high risk for CKD [8].

That distinction has practical outcomes. Routine blood testing can seem reassuring unless urine albumin is checked in a case of substantial albuminuria and normal eGFR in an adult. A low eGFR is likely to cause an abnormality recommended in the routine laboratory review. So, awareness is not only related to severity of the disease, but the abnormal kidney marker. The question is especially germane since sodium-glucose cotransporter-2 inhibitors and other kidney protective strategies are being guided more and more by e GFR and albuminuria risk [2].

The latest National Health and Nutrition Examination Survey (NHANES) cycle conducted from August 2021 till August 2023 will allow us to assess awareness about kidney among the population during the post-pandemic period, after the halt of data collection. Accordingly, we estimated the prevalence of laboratory abnormalities compatible with CKD, based on a single measurement. Secondly, we quantified patient-reported awareness. In addition, we compared awareness in albuminuric, reduced-eGFR and combined phenotypes. Finally, we examined whether the severity of filtration loss or albuminuria independently influenced awareness. We surmised that awareness would be minimal in case of isolated albuminuria and it would increase with increasing severity of kidney abnormalities or as both dimensions were involved.

Materials and Methods

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Study design and population

Between August 2021 and August 2023, public-use data were obtained from the cross-sectional study conducted by NCHS. The U.S. civilian noninstitutionalized population is represented through a complex multistage probability design by NHANES. This analysis included adults ≥20 years of age, not pregnant, who had the necessary information to calculate eGFR, classify albuminuria, and determine kidney-disease awareness The unique participant identifier was SEQN. Data were merged. There were 5,298 adults in the sample. Since serum creatinine and HbA1c are blood analytes, the analyses utilized the cycle-specific phlebotomy examination weight (WTPH2YR) with SDMVSTRA and SDMVPSU, as per NCHS guidance for the 2021–2023 cycle [9].

Kidney function and laboratory phenotypes

NHANES standard biochemistry profile was used to obtain serum creatinine. Using the 2021 CKD-EPI creatinine equation, eGFR was calculated to estimate GFR without a race coefficient [10]. The NHANES urinary albumin and creatinine measurements were used for UACR. A shortened eGFR <60 mL/min/1.73 m² considered as reduced filtration and UACR ≥30 mg/g was considered as albuminuria.

The participants were classified into four mutually exclusive laboratory phenotypes: (1) normal kidney markers, eGFR ≥60 and UACR <30 mg/g; (2) isolated albuminuria, eGFR ≥60 and UACR ≥30 mg/g; (3) isolated reduced eGFR, eGFR <60 and UACR <30 mg/g; and (4) combined abnormality, eGFR <60 and UACR ≥30 mg/g. Phenotypes 2-4 were judged as the "CKD-compatible laboratory abnormality" The choice of nomenclature was deliberate because NHANES measurements are derived in one examination. According to KDIGO [2], for the condition to be established as chronic, evidence of persistence is required for at least 3 months. Also, a single abnormal eGFR or UACR should not be identified as confirmed CKD [2].

Isolated albuminuria for severity analyses was segregated into A2 (UACR 30–299 mg/g) and A3 (UACR ≥300 mg/g). eGFR levels under 60 mL/min/1.73 m² are recognized as significant risk factors. The eGFR categories of 45-59 and <45 mL/min/1.73 m² were separated in the same way.

Kidney-disease awareness

The NHANES Kidney Condition–Urology Questionnaire was used to arrive at awareness. The participants were classified as alerted when they responded "yes" to the survey question informing them whether a doctor or other health professionals had ever told them they have weak or failing kidneys (except for kidney stones, bladder infections, and incontinence) [11]. The same wording has been used in earlier NHANES awareness studies which enhance comparison over time [5,6]. Only yes and no responses were included in the awareness analyses.

Covariates

Selection of covariates was determined before the study because of their ability to influence both kidey disease severity and recognition. Age, sex, race/ethnicity, body mass index (BMI), diabetes, hypertension, current smoking, educational attainment, and family poverty-to-income ratio were included. Diabetes was termed as prior diagnosis of diabetes or HbA1c ≥6.5%. An individual was classified as having hypertension if their mean measured blood pressure was greater than or equal to130/80 mmHg or if they had a previous diagnosis of hypertension. BMI was analyzed for every 5kg/m2 and age for every

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decade. For purposes of analysis, race and ethnicity were retained using the NHANES categories. Because the 2021–2023 cycle did not oversample race/ethnicity groups in the same manner as several earlier cycles, subgroup estimates should be interpreted cautiously.

Statistical analysis

The estimates by the survey weighted WTPH2YR strata and primary sampling units. By Taylor-series linearization analysis, the weighted prevalence estimates and 95% confidence intervals were calculated. The first descriptive outcomes were the prevalence of a CKD-compatible laboratory abnormality in U.S. adults. The second was the awareness of U.S. adults with the abnormality. The third was the total adult population with an abnormality and not aware.

Survey-weighted logistic regression analyzed awareness among adults with laboratory abnormality. The primary model considered isolated reduced eGFR and combination abnormality as phenotypic reference with isolated albuminuria while adjusting for age, sex, BMI, diabetes, hypertension, current smoking, poverty-to-income ratio, education, and race/ethnicity. The severity model used eGFR (less than) 45 mL/min/1.73 m² and albuminuria A3 instead of phenotype indicators. As the complete-case analysis was used for the full socioeconomic model, a sensitivity model without poverty-to-income ratio and education was performed to retain a larger analytical sample. Statistical significance was ascertained at $p<0.05$. It was thought associations rather than causal effects.

Results

Prevalence of laboratory kidney abnormalities and awareness

Of 5298 adults with complete data on kidney markers and awareness, 918 had eGFR <60 mL/min/1.73 m² and/or UACR ≥30 mg/g. The overall prevalence of this single-measurement CKD compatible abnormality was 14.0% (95% CI, 12.5%–15.6%). Of affected adults, only 12.9% (95% CI, 9.9%–16.0%) reported being told they had weak or failing kidneys. Thus, it can be said that 87% of adults with a lab abnormalities aren't aware of a kidney disease. About 12.2% of U.S. adults had a laboratory abnormality that was not previously recognized (Figure 1).

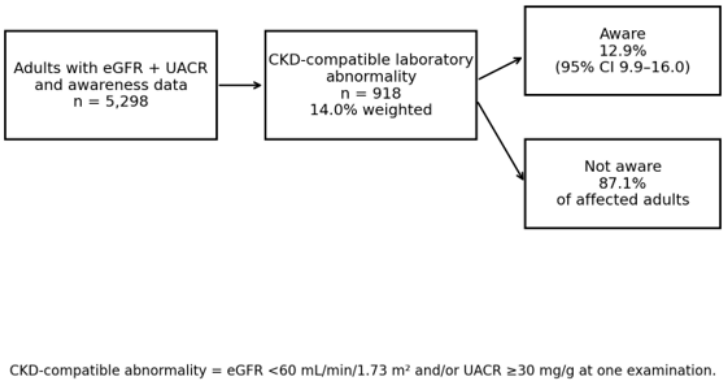


Figure 1. Contemporary kidney-dysfunction awareness cascade

Awareness by kidney phenotype

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Laboratory phenotype explains far greater variations than the overall 12.9% figure suggests. Among adults with isolated albuminuria, the pooled estimate dropped to only 3.1% (95% CI, 0.9%–5.4%), with the weighted median UACR in this group of approximately 59 mg/g. Awareness was 17.9% (95% CI 11.2%–24.5%) with isolated eGFR <60 and 39.8% (95% CI 28.1%–51.5%) with reduced filtration and albuminuria. Thus, the most easily not recognized phenotype is albuminuria with preserved filtration (Table 1), (Figure 2).

Phenotype	n	Weighted %	Age, y	Female, %	Diabetes, %	Hypertension, %	Aware, %	eGFR	Median UACR
Normal	4,380	86.0	46.7	50.6	9.8	46.5	1.1	98.8	6.6
Isolated albuminuria	467	7.8	55.7	51.4	41.0	70.2	3.1	95.6	59.4
Isolated low eGFR	308	4.2	70.6	59.9	28.6	74.0	17.9	51.6	8.8
Combined	143	2.1	68.1	44.4	49.1	90.6	39.8	44.4	83.6

Table 1. Weighted clinical profile according to kidney laboratory phenotype

Note: Weighted means/proportions except n and median UACR. eGFR in mL/min/1.73 m²; UACR in mg/g.

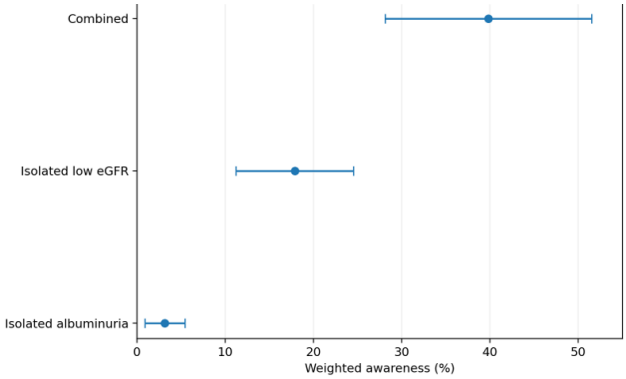


Figure 2. Kidney-disease awareness differs sharply by laboratory phenotype

Awareness rises with severity but remains incomplete

As the anomalies became much more severe, improvement in recognition was noted but large gaps still existed. Awareness was 2.4% in isolated A2 albuminuria and isolated A3 albuminuria significance a x 94%. According to the study, they reported 13.7% awareness in G3a, whereas G3b–G5 had 36.3% awareness. Even in the combined phenotype, awareness was, respectively, 32-3% when eGFR was 45-59 and 49-8% when eGFR was <45 mL/min/1.73 m². As such, approximately half the adults that fall in the most serious combined category still did not state they knew or had weak or failing kidneys (Table 2), (Figure 3).

Estimate / group	Unweighted N	Weighted %	95% CI
Objective abnormality	5,298	14.0	12.5–15.6
Awareness among objective	918	12.9	9.9–16.0
Unrecognized objective abnormality	5,298	12.2	10.8–13.6
Normal	4,380	1.1	0.7–1.5
Isolated albuminuria	467	3.1	0.9–5.4
Isolated low eGFR	308	17.9	11.2–24.5
Combined	143	39.8	28.1–51.5
Isolated albuminuria A2	422	2.4	0.4–4.5

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Isolated albuminuria A3	45	9.4	1.8–17.0
Isolated low eGFR G3a	250	13.7	7.9–19.4
Isolated low eGFR G3b-5	58	36.3	21.5–51.0
Combined G3a + A2/A3	74	32.3	15.4–49.3
Combined G3b-5 + A2/A3	69	49.8	38.5–61.0

Table 2. Weighted prevalence and kidney-disease awareness estimates

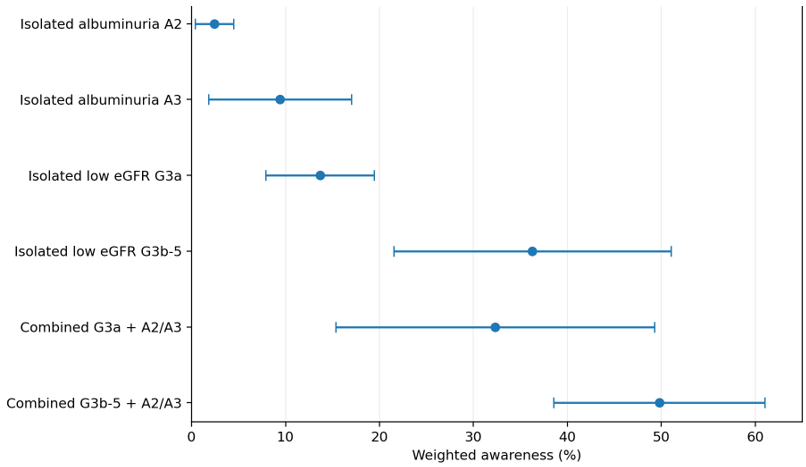


Figure 3. Awareness increases with laboratory severity but remains incomplete

Independent correlates of awareness

Even after adjusting for demographic, cardiometabolic, behavioral, and socioeconomic variables, the phenotype gradient remained quite striking. When isolated albuminuria is used as the reference phenotype, it has been found that isolated reduced eGFR is associated with approximately seven times higher odds of awareness (OR 7.42, 95% CI 2.85–19.30). Also, combined phenotype is associated with approximately twenty-eight times higher odds (OR 27.63, 95% CI 11.19–68.21). Having diabetes was independently associated with having more awareness (OR 1.79, 95% CI 1.03–3.12). In the comprehensive adjusted model, present smoking demonstrated a borderline connection. When the phenotype and other covariates were included, age, sex, BMI, hypertension, education, and poverty-to-income ratio were not independently associated with awareness. Specific coefficients adjusted for race/ethnicity suggest less awareness in comparison to non-Hispanic White adults; however, the confidence intervals and sample sizes of subgroups should be a word of caution, especially since the design for post-pandemic NHANES sampling did not oversample race/ethnicity groups as was done for several earlier cycles. We treat these findings as exploratory, rather than as the main message of the study (Table 3), (Figure 4).

Variable	Adjusted OR	95% CI	p value
Isolated low eGFR vs isolated albuminuria	7.42	2.85–19.30	<0.001
Combined vs isolated albuminuria	27.63	11.19–68.21	<0.001
Age, per 10 years	0.96	0.77–1.19	0.677
Female sex	1.24	0.74–2.06	0.389
BMI, per 5 kg/m²	0.96	0.81–1.13	0.604
Diabetes	1.79	1.03–3.12	0.041
Hypertension	1.69	0.57–4.94	0.318
Current smoking	2.05	1.00–4.22	0.051

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Table 3. Fully adjusted associations with kidney-disease awareness

Note: Model n=766; 15 design degrees of freedom. Model additionally adjusts for race/ethnicity, educational attainment, and poverty-to-income ratio. Isolated albuminuria is the phenotype reference.

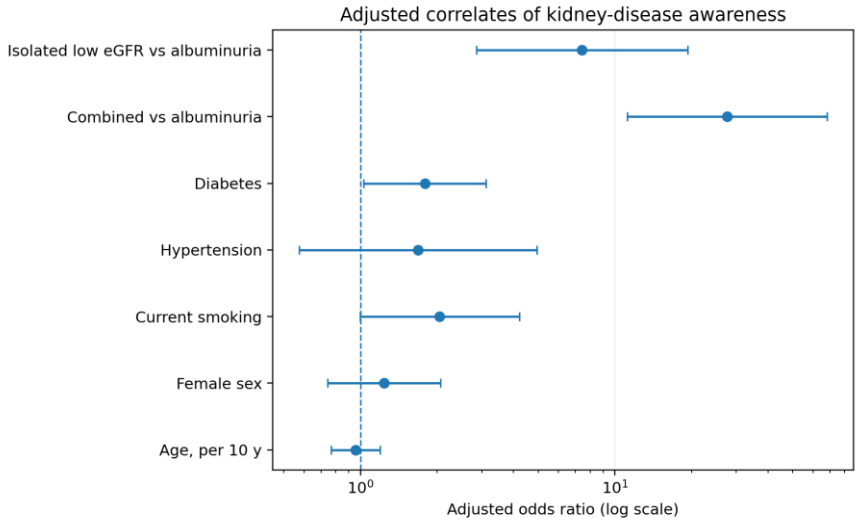


Figure 4. Adjusted correlates of kidney disease awareness

Severity model and sensitivity analysis

In a part of the severity model, the eGFR >45 mL/min/1.73 m² was linked to markedly greater awareness (OR 6.02, 95% CI 3.18–11.38); whereas, A3 albuminuria independently increased the odds of awareness (OR 2.98, 95% CI 1.08–8.18). The results suggest that both dimensions ultimately become more recognizable as they deteriorate. However, the amount of recognition was considerably greater for filtration loss. The exclusion of education and poverty-to-income ratio from the sensitivity model which included 901 affected adults yielded estimates that were similar to those of the primary model: OR isolated low eGFR=7.16 and combined phenotype=23.22 (Table 4).

Variable	Adjusted OR	95% CI	p value
eGFR <45 mL/min/1.73 m²	6.02	3.18–11.38	<0.001
A3 albuminuria (UACR ≥300 mg/g)	2.98	1.08–8.18	0.036
Diabetes	1.38	0.85–2.22	0.175
Hypertension	1.66	0.61–4.54	0.299
Current smoking	1.36	0.84–2.19	0.197

Table 4. Severity-based adjusted associations with awareness

Discussion

This contemporary national analysis demonstrates that the primary issue with kidney disease is not how many adults have abnormal kidney markers, but how rarely those abnormalities are translated into patient awareness. In the U.S., roughly 14% of adults have an abnormality in kidney function or damage. But only around 13% of the affected adults recall being told that they have weak or failing kidneys. Almost every seven out of eight adults who has a objective abnormality were unaware

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The outcome here is strikingly consistent with pre-2021 NHANES work showing that major therapeutic advances in nephrology so far have yet to translate into similar improvements in recognition [6,7].

This study's most significant contribution is the gradient specific to phenotypes. The occurrence of albuminuria with preserved eGFR only had a roughly 3% awareness, with isolated reduced eGFR having 18% and both occurring 40%. After extensive adjustments, adults with isolated low eGFR were 7 times more likely to report awareness than adults with isolated albuminuria, and those with both abnormalities were more than 20 times more likely. Essentially, how kidney disease is manifesting in routine care is a significant determinant of the route from biological disease to patient disease.

There is a simple clinical explanation. A majority of routine metabolic panels now embed serum creatinine, with eGFR usually automatically calculated and displayed. Unlike other markers of kidney damage albuminuria, requires a urine sample and dedicated test. Kidney Injury May Remain Invisible to Clinicians If UACR Is Never Ordered Even in Patients with Diabetes, Hypertension and Other High Risk Conditions A large sample of U.S. patients with CKD are not receiving UACR tests [8]. The population as a whole did not get tested, especially people with hypertension who were without diabetes. Up-to-date health write-ups frequently refer to the albuminuria tests as a concerning implementing gap [12]. Our very low estimate of awareness for isolated albuminuria is consistent with that testing problem.

Albuminuria is no trivial lab abnormality, and this matters. Data from a large number of cases show that increasing albuminuria provides independent prognostic information for kidney failure, cardiovascular disease, hospitalization and death across all eGFR categories [1]. The degree of albuminuria also changes risk stratification and can influence the use of kidney-protective therapies. Thus, a patient whose eGFR is in the normal range but is nonetheless has a UACR well above 30 mg/g may nevertheless have clinically important kidney and cardiovascular risk that is missed if kidney assessment stops at serum creatinine.

The analysis relating to severity adds more. As eGFR dropped and albuminuria attained A3, awareness rose, but it never became total. Less than half of adults who had limitations related to the most severe combined phenotype reported awareness. The result is consistent with earlier NHANES research, which found that even advanced disease usually goes unrecognized [5]. The continued presence of this gap in 2021-2023 indicates that enhanced laboratory detection must be accompanied by improved communication: patients cannot act on a diagnosis they have not been given or do not understand.

The severity examination adds another dimension. As eGFR declined and albuminuria progressed to A3, awareness improved but was not complete. No more than half of adults with the most severe combined phenotype reported awareness. The same issue was seen by Plantinga et al [5] in NHANES data which showed advanced disease is not recognized. The gap between laboratory results and access to therapeutic options continues to persist through 2021–2023. Therefore, one must not only improve laboratory detection but also communicate the result. If the result is diagnosed by the laboratory but not told to the patient or not understandable by the patient, then the patient cannot act on a diagnosis.

The results indicate a number of feasible interventions. First, clinical systems should treat eGFR and UACR as a paired kidney profile rather than as two optional tests. In addition, in a recent Kidney360 implementation study, researchers found that EHR-based care-gap tools and one-click kidney-profile ordering improved annual screening in adults with diabetes [13]. Third, the testing could be performed closer to the patients. According a 2026 study [14] home UACR testing using a

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smartphone significantly increased screening for albuminuria in adults with diabetes and hypertension. These strategies would directly meet the particular inadequacy which our data reveals: albuminuria may be prognostically meaningful but little noticed by the patient.

Not only testing but also awareness is a communication issue. The NHANES question asks whether they were told they had "weak or failing kidneys." This language may not be how clinicians define mild CKD, albuminuria, or reduced eGFR. Some patients have had an abnormal test mentioned to them without it being stated that the test was abnormal. Others may have been told of kidney disease in the past but then had a normal value at the NHANES exam. The 1.1% of objectively normal participants who nevertheless reported a prior diagnosis illustrates this bias. As a result, our outcome should be viewed as patient-reported awareness of kidney disease rather than being a gold standard for clinician diagnosis.

The study boasts multiple strengths. It uses first complete post-pandemic NHANES cycle, employs race-free 2021 CKD-EPI equation, incorporates filtration and albumin excretion, and uses cycle-specific phlebotomy weight. Separation of isolated albuminuria isolated low eGFR and combined abnormalities causes identification of a detection gap which an overall CKD-awareness estimate cannot identify. Data on measured blood pressure and HbA1c was also available for covariate classification.

Several limitations need emphasis. To begin with, the analysis is cross-sectional and must not be able to establish when an abnormality developed; when a clinician first recognized it; and whether awareness changes over time. In addition, CKD diagnosis cannot be made based on a single eGFR and UACR reading. The value of albuminuria varies from one individual to another and may be transient; abnormal measurements should be repeated to assess persistence [2,12]. Thirdly, eGFR creatinine based has known limitations related to muscle mass and other non-GFR determinants. The recognition question should use different terminology to make things clearer for clinicians.

The fifth aspect is that use of complete-case multivariable models reduced the size of the sample. Sensitivity analyses restricting by fewer socioeconomic covariates yielded similar effects on the phenotypes. In closing, caution should be exercised when interpreting findings for detailed race/ethnicity subgroups from the 2021–2023 sampling design; this analysis is exploratory in nature and should not be overgeneralized.

In brief, low awareness of CKD is a problem of detection by phenotype. The silent phenotype may not be the least prognostically important one. Patients with albuminuria, who had preserved filtration, were found to be common and often metabolically high risk but rarely recognized as the same. To close this gap, we will require regular urine testing, communication of abnormal results, and workflows treating albuminuria as part of kidney health rather than an optional extra.

Conclusions

According to NHANES 2021–2023, one in seven adults in America had a laboratory abnormality compatible with CKD with one measure, but only one in eight affected adults reported awareness. In terms of phenotype, awareness was extremely low with isolated albuminuria, higher with reduced eGFR, and greatest with both abnormalities present. About half of the affected adults were unaware of their severe combined abnormalities. The laboratory detection of kidney disease must lead to clear communication if advances in kidney-protective therapy are to reach the large population with currently silent disease.

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Declarations

Ethics approval: The protocols used by NHANES receive approval from the Research Ethics Review Board of National Center for Health Statistics. Moreover, each participant gives informed consent. The research was based on deindentified information that was publicly available. New participant contact was not made.

The public-use datasets and documentation from NHANES August 2021-2023 can be found on the U.S. Centers for disease control and prevention, National Center for Health Statistics.

Financial Sponsorship

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Conflict of Interest

No conflict of interest

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