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Prevalence and Awareness of CKD Among African Americans: The Jackson Heart Study

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Abstract

Background—Chronic kidney disease (CKD) leads to End Stage Renal Disease (ESRD) and is a growing epidemic throughout the world. In the United States, African Americans have an incidence of ESRD four times that of Whites.

Study Design—Cross Sectional to examine the prevalence and awareness of CKD in African Americans

Setting & Participants—Observational Cohort in the Jackson Heart Study (JHS)

Predictor—CKD was defined as estimated glomerular filtration rate < 60 ml/min/1.73 m², presence of albuminuria, or being on dialysis

Outcomes and Measurements—Data from the Jackson Heart Study (JHS) were analyzed. Medical history including disease awareness and drug therapy, anthropometric measurements, serum, and urine samples were obtained from JHS participants at the baseline visit. Associations between CKD prevalence and awareness and selected demographic, socioeconomic, healthcare access, and disease status parameters were assessed utilizing logistic regression models.

Results—The prevalence of CKD in the JHS was 20%; CKD awareness was only 15.8%. Older participants had higher prevalence but were also more aware of CKD. Hypertension, diabetes, cardiovascular disease (CVD), hypercholesterolemia, hypertriglyceridemia, increasing age and waist circumference as well as being single or less physically active were associated with CKD. Only advancing of CKD stage was associated with awareness.

Limitations—Cross-sectional assessment, single urine measurement

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Conclusions—The JHS has a high prevalence and low awareness of CKD, especially those with less severe disease status. This emphasizes the need for earlier diagnosis and increased education of health care providers and the general population.

Keywords

renal insufficiency; proteinuria; African American; chronic disease; epidemiology; population

Introduction

Recent studies show that prevalence and incidence of end-stage renal disease (ESRD) and chronic kidney disease (CKD) have reached epidemic proportions in the US and worldwide. An estimated 50 million people are affected, with ~1 million receiving renal replacement therapy^{1,2}. In the most recent NHANES (National Health and Nutrition Examination Survey) report, Coresh and Levey calculated estimates of 8 million in the US with Stage 3 CKD (eGFR < 60 ml/min/1.73 m²) and 12 million with microalbuminuria³. Together, this places greater than 6% of the US population at risk for the complications of ESRD. The prevalence of CKD among adults in the NHANES was almost 17% during 1999–2004, 16% higher than during 1988–1994⁴. The 2006 Annual US Renal Data System report demonstrates that a large proportion of the CKD population has the co-morbidities of diabetes and hypertension⁵. While recent ESRD incident rates have leveled off at ~340 per million, the high rates of hypertension and diabetes in the younger, employed population likely signify an upturn in the incidence rate since 70% of all persons with ESRD have these diseases as their primary diagnosis⁵. Older African-Americans (60+) in the US have incident rates of ESRD of ~1500 per million, over three times their white counterparts; younger African Americans have similar increased incident rates⁵. Because the personal, social, and economic costs of ESRD are high⁶, there is a global challenge to prevent or slow the progression of CKD⁷.

The most serious consequences of untreated CKD include hypertension, CVD, and ESRD which leads to dialysis and kidney transplantation, thus resulting in decreased quality of life, increased health-care cost, and premature death^{1,6}. There is evidence that these outcomes of CKD can be prevented or delayed, with timely diagnosis and treatment^{8–11}. Because of the increased risk of CKD progression to ESRD in the African American population, it was important to examine the prevalence of CKD, disease awareness, and the degree of treatment in a large cohort such as the Jackson Heart Study (JHS) versus factors such as diabetes, hypertension, obesity, level of physical activity, hypercholesterolemia, social status, income, and education.

Methods

Study Design, Participants, and Measurements

The JHS is a single-site, longitudinal population-based study designed to prospectively explore the determinants (both individual and environmental) and genetic linkages that influence the development of CVD among African Americans. The sample consists of 5,302 women and men selected between 2000 and 2004 from a tri-county area of Mississippi: Hinds, Madison, and Rankin Counties. The rationale for the study stems from the large disparity in cardiovascular mortality between Mississippi African Americans and Mississippi Whites or African Americans from other parts of the US^{12,13}. Current findings have demonstrated high prevalence of hypertension (~60%) and diabetes (~20%)¹⁴ as well the metabolic syndrome (~40%)¹⁵. Overviews of the JHS¹⁶ including the sampling and recruitment¹⁷, sociocultural¹⁸, and laboratory methods¹⁹ have been described previously.

The baseline examination consisted of a home interview, self-administered questionnaires, and a clinic visit. Medications taken in the prior 2 weeks were brought to clinic and transcribed verbatim with subsequent coding by a pharmacist using the Medispan dictionary with classification according to the Therapeutic Classification System. After an overnight fast, anthropometric and seated blood pressure measurements were obtained and venipuncture/urine collection was performed in accordance with the National Committee for Clinical Laboratory Standards published in 1999^{20–22}. Waist circumference (cm) at the umbilicus, height (cm) and weight (to 0.1 kg) were measured, and the body mass index (BMI) was computed using these last two measurements (kg/m^2). Blood pressure was measured by trained technicians using a Hawksley random zero manometer and determined by the arithmetic average of two readings taken 1 minute apart after a five-minute rest. Based on the physical activity questions, four index scores, Active Living, Work, Sport, and Home and Family Life, were obtained with values for each ranging from one to five and summed to calculate the total physical activity score.

All baseline participants were requested to contribute a 24-hour urine collection. Because some participants did not agree to the 24-hour urine collection, spot urine collections were later added to the protocol. Participants were provided with a sterile container and instructions for obtaining a clean catch sample²¹. Urine albumin and creatinine concentrations were obtained for each collection method. Urine albumin was measured using a human albumin kit (Dade Behring, Newark, Delaware) on a Dade Behring BN II nephelometer. Biochemical testing for serum and urine creatinine was performed at the University of Mississippi Medical Center Laboratory Reading Center using a multi-point enzymatic spectrophotometric assay (Vitros CREA dry reaction slides on a Vitros 950 Ortho-Clinical Diagnostics analyzer, Raritan, New Jersey)¹⁹. Creatinine values were biochemically calibrated to Cleveland Clinic-equivalent Minnesota Beckman CX3 assay for analysis purposes.

Variables

CKD was defined as presence of albuminuria, reduced glomerular filtration rate (eGFR) <60 $\text{ml}/\text{min}/1.73 \text{ m}^2$ or being on dialysis and classified into five stages according to the National Kidney Foundation (NKF) guidelines²³. Presence of albuminuria was determined by urine albumin to urine creatinine ratio (ACR) based on spot or 24-hour urine values ($\text{ACR} > 30 \text{ mg}/\text{g}$)²⁴, and eGFR was calculated based on serum creatinine values using the IDMS-traceable, 4-variable MDRD Study equation [$\text{GFR} = 186.0 \cdot (\text{serum creatinine})^{-1.154} \cdot \text{age}^{-0.203} \cdot (0.742 \text{ if female}) \cdot (1.21 \text{ if African American})$]. CKD stages corresponded to ranges of GFR ($\text{mL}/\text{min}/1.73\text{m}^2$): Stage 1: $\text{GFR} \geq 90$ with presence of albuminuria; Stage 2: $\text{GFR} 60\text{--}89$ with presence of albuminuria; Stage 3: $\text{GFR} 30\text{--}59$; Stage 4: $\text{GFR} 15\text{--}29$; and Stage 5: $\text{GFR} < 15$. Participants whose CKD status could not be determined based on available data, i.e., if they had no serum creatinine or urinary protein values or had only one normal value without the other measure, were excluded from the analyses. While some studies define CKD based solely on eGFR²⁵, microalbuminuria has been clearly associated with progressive decline of kidney function, particularly in diabetic individuals²⁶. With the abundant evidence that early intervention (CKD stages 1–2) with angiotensin converting enzyme inhibitors (ACE inhibitors) or angiotensin receptor blockers (ARBs) slows the progression of disease, a broader definition of CKD is warranted.

Awareness of CKD was defined by a “yes” response to the question: “Have you ever been told by a doctor or health care professional that you have kidney disease?” and/or self-report of being on dialysis. Awareness of hypertension and diabetes was determined by a positive response to ever having been told of the diagnosis by a health care provider or a self-reported treatment for the condition. As CKD was not included as a possible reason for taking medication on the questionnaire, any use of ACE inhibitors or ARBs was attributed to

hypertension treatment though they may have been dually used to slow or prevent CKD. Therefore, individuals with CKD receiving such medications were considered as potentially treated for kidney disease in addition to treatment of hypertension; this likely overestimates the true number under treatment for CKD.

Select sociodemographic factors including age, sex, and marital status, socioeconomic status (SES) (education and family income level) and health care access (insurance status, preventive health care), lifestyle behaviors (smoking and physical activity), CVD status and CVD-related risk factors (waist circumference, presence of obesity, hypertension, diabetes, low high-density lipoprotein (HDL) cholesterol, hypercholesterolemia, or hypertriglyceridemia) were included to examine the relationship with CKD. CVD was defined as presence of coronary heart disease [electrocardiogram (ECG)-determined myocardial infarction (MI) or self-reported history of MI or angioplasty] or cerebrovascular disease [self-reported history of stroke or carotid endarterectomy or angioplasty]. Hypertension was defined as a measured blood pressure $\geq 140/90$ mmHg and/or use of antihypertensive medications. Presence of Type 2 diabetes mellitus (diabetes) was determined by a measured fasting glucose of ≥ 126 mg/dl or use of anti-diabetic agents. Presence of hypercholesterolemia was defined as an elevated fasting total cholesterol (≥ 200 mg/dl), low-density lipoprotein [LDL] cholesterol (≥ 160 mg/dl), and/or use of lipid-lowering medications. Hypertriglyceridemia was defined as elevated triglyceride levels (≥ 150 mg/dl) or/and treatment by Fenofibrate or Gemfibrozil while sex-specific limits (<50 mg/dl for women and <40 mg/dl for men) were used to define low HDL cholesterol levels¹⁵.

Statistical Methods

Participant characteristics were summarized descriptively (with means and standard deviations for continuous variables and counts and percentages for categorical variables). Logistic regression models were utilized to identify baseline characteristics associated with CKD prevalence and awareness. First, association between CKD prevalence and each socioeconomic, healthcare access, lifestyle, CVD, and CVD risk factor parameter described above was tested using logistic regression models controlling for age and sex. Association between CKD awareness and each of the above-listed parameters as well as CKD stage was tested using logistic regression models controlling for age. Factors that were statistically significant ($p < 0.05$) as well as sex were then included in the full model adjusting for potential confounders. Logistic regression analysis with backward stepwise elimination was performed to obtain the most parsimonious models. The odds ratios (OR) and 95% confidence intervals (CI) were estimated for each model. Only the data from JHS participants meeting study inclusion criteria age 35–84 were utilized in regression analyses as participants outside that age range ($n=266$) were included in the original sample only to maximize the size of the participating families in the family study component²⁷. The analyses were performed using SAS[®] Version 9.1 (SAS Institute, NC). For comparison purposes, NHANES data released since 1999 were aggregated into a combined data set (1999–2004) and estimates were adjusted to the JHS sex-specific age, education and income distribution (JHS-NHANES) using SUDAAN[®] (RTI International, NC) to account for the complex sampling design.

Results

Descriptive Data

After excluding participants with restricted consent ($n=23$) or without sufficient serum ($N=56$) or urine data ($n=1792$) to determine their CKD status, a total of 3431 participants (2,154 women and 1,277 men) were used in these analyses. Among included participants, 1015 had 24-hour and 2255 had spot urine collections; an additional 161 participants with missing urine data were classified as having CKD because of low eGFR or being on dialysis. Table 1 displays the

baseline characteristics of the JHS by CKD status for the overall population and men and women. Participants with CKD reported lower income, lower level of education, and had notably higher rates of CVD, diabetes, hypertension, hypercholesterolemia, and hypertriglyceridemia. They also tended to be older, more obese, and less physically active and less likely to be married or drink heavily but were not different with respect to smoking than those without CKD. Nearly equal proportions of participants with and without CKD had insurance, but a smaller proportion of those without CKD used preventive care. Characteristics of included participants were very similar to those of participants with eGFR alone (data not shown).

Outcome Data

Figure 1 displays the prevalence of CKD for men and women in specific age groups. The overall prevalence of CKD was 20.0%. Figure 2 provides analogous data for albuminuria and low eGFR. The age group of 60 years and older had the highest prevalence of albuminuria (~19%) and low eGFR (~11%).

Table 2 details the CKD stages by eGFR for men and women and for different age groups. There were no large differences between men and women, but the 60+ age group was not only the largest group but also had the highest percentage within Stages 3 (20%) and 4/5 (3%). For the overall study cohort, there were more individuals in Stage 3 (9.6%) than in any other stage.

Main Results

As illustrated in Tables 2 and 3, a very small percentage (15.8%) of those with CKD were aware of their disease, and there were no sex differences in awareness rates. Though awareness was reasonably high among those in Stage 4/5 (65.9%), it was still lower than overall awareness of hypertension or diabetes. Among those with mild to moderate CKD, awareness was minimal with only 17.6% of those in Stage 3 aware of their condition. Assuming that treatment with ACE inhibitors or ARBs equals implied therapy for CKD, just over one-half (52%) were on antihypertensive medication recommended for CKD compared to treatment rates over 80% for hypertension (83.2%) and diabetes (85.4%); as noted in the methods, this assumption likely overestimates those treated for CKD.

Tables 4–5 display the results of logistic regression analyses of CKD prevalence and awareness, respectively. In the sex- and age-adjusted analysis, the odds of CKD increased with hypertension, diabetes, CVD, hypercholesterolemia, hypertriglyceridemia, low HDL, abdominal girth (waist circumference), and lower physical activity levels and decreased with higher levels of education and income as well as being married and having insurance.

The results from the fully adjusted and the most parsimonious model were consistent. Presence of hypertension, diabetes, CVD, hypertriglyceridemia, and hypercholesterolemia, lower physical activity score, increasing waist girth and age were independently associated with CKD. Only CKD severity was associated with awareness compared to those in Stages 1/2. A subgroup analysis of participants with eGFR alone yielded essentially the same results with the exception of odds of CKD being higher for women than men, as expected (data not shown).

Discussion

The findings of this cross-sectional cohort of African American adults enrolled in the JHS further confirm the rising national epidemic of CKD, particularly among non-Hispanic African Americans, with prevalence estimates similar to the most current national estimates of 16.8% for the whole population reported by the Centers for Disease Control (CDC) from analyses of the 1999–2004 NHANES data⁴. Older participants (60+ years) in both the NHANES (39.4%)

and the JHS (31.7%) had a higher prevalence. The CDC analyses demonstrated that persons with albuminuria ($\text{ACR} \geq 17 \text{ mg/g}$ for men and $\geq 25 \text{ mg/g}$ for women, $\text{eGFR} > 59$) made up 11.1% of the cohort and those with $\text{eGFR} < 60$ made up 5.8%. Similar to those analyses, there was a disparity in the JHS participants in Stage 1 and 2 CKD with proteinuria and relatively normal kidney function from those in CKD Stage 3, which is often used as the definition of “CKD”. In the JHS, the more conservative NKF criteria were used to define albuminuria ($> 30 \text{ mg/day}$), while NHANES employed the lower sex-specific cut points. A more recent analysis of the NHANES data (courtesy of NHLBI), adjusted to the JHS age and sex distribution with the same criteria as this study (Figure 3) demonstrated overall CKD prevalence of 22.2% in NHANES African Americans compared to 20% in the JHS. The cross-sectional nature of our data precludes any causal inferences, but it is interesting to note this lower than national prevalence of CKD corresponds with a higher than national rate of blood pressure control among JHS hypertensives at baseline¹⁴.

Analyses of the data demonstrate medical and socioeconomic factors are associated with CKD. As with other population studies^{4,28,29}, hypertension, diabetes, CVD, hypercholesterolemia, hypertriglyceridemia, abdominal obesity, and increasing age were strongly associated with CKD. As expected, the odds of having CKD progressively declined with the increase in annual income, education level beyond primary school, and an increasing activity score. A recent analysis of NHANES III also demonstrated that African Americans had increased odds of albuminuria (OR 1.41 for non-diabetic individuals and 1.85 for those with diabetes) and low eGFR (OR 2.18 for non-diabetic individuals and 2.78 for those with diabetes) than whites after adjusting for baseline characteristics (such as age, sex, education, marital status, income, blood pressure, etc.)²⁴. These findings underscore the importance of earlier diagnosis in this population.

While the disease prevalence was high in the cohort, the awareness of the disease was quite low, varying from ~13% in the 21–39 year olds to 17% in 60+ year olds. Older participants were not only more aware but were more likely to be treated for CKD (Table 3). For comparison, analogous data can be derived from the National Kidney Foundation’s Kidney Early Evaluation Program (KEEP), which consists of screenings of targeted populations with chronic diseases. In a report published in 2003³⁰, only 2.6% of the 6,071 participants (43% of the cohort were African American) reported pre-existing kidney disease, while 24.7% reported having diabetes and 51.8% reported being hypertensive. Within this KEEP cohort, 34% were in CKD stage 0–1, 50% in Stage 2, and 16% in stages 3–5³⁰. New conditions identified through the screening were: diabetes, 2%; hypertension, 35%; and kidney disease, 42% ($\text{eGFR} < 60$ or microalbuminuria). 86% of these participants had health insurance coverage and had seen their physician within one year, which compares to the JHS insured percentage of 87% and 73% of the study cohort receiving preventive care in the past year. These data demonstrated remarkably low rates of awareness in the JHS, which were similar for men and women and increased with age and stage of CKD. This was in sharp contrast to JHS participant awareness of other major conditions, such as diabetes, hypertension and hypercholesterolemia, which ranged from 60% to 84% exceeding that of CKD by 44–68%¹⁴. Figure 3 compared CKD awareness in the JHS with age- and sex-adjusted data from NHANES (courtesy of NHLBI) and demonstrated low numbers in both studies. This lack of awareness highlights inadequate public awareness and health care provider education for CKD.

Worldwide, awareness of CKD is likely low. A recent study carried out in 6,001 participants in Taiwan³¹ demonstrated awareness rates of 8% in CKD stage 3, 25% in stage 4, and 71% in stage 5. The prevalence of CKD stages 3–5 was 6.9% of the cohort, similar to the JHS. This directs attention to the international challenge of education of patients and health care providers concerning CKD.

Based on the assumptions that treatment with an ACE inhibitor or ARB constituted a drug targeted to CKD, the treatment of all age groups in the JHS was much better than the awareness of the underlying disease. The assumption may not be true if studied carefully. Primary care physicians in Mississippi are just now receiving information on CKD stages (personal communication, Mississippi State Department of Health) and the need to carefully examine and treat “at risk” patients. Therefore, the treatment of hypertension with ACE inhibitors or ARBs may be serendipitous. Despite this, the vast majority of the JHS cohort, who had insurance and at least a high school education, did not know that they have CKD and were not being properly treated.

This study is not without limitations. Data for this analysis were cross-sectional with a single urine collection. As in other epidemiological studies that employ two parameters to define CKD, there could be slight bias toward prevalence due to incomplete laboratory studies. The use of estimated GFR using the MDRD Study equation has come under criticism in recent years because the equation was developed for kidney disease patients and not validated in a general population. Our definition of CKD depends on both albuminuria (with normal function) and eGFR, and therefore may differ from earlier studies that used only a low eGFR as the defining criteria. However, analyses of participants with GFR only (data shown in appendix) showed very similar results to Table 4. Our measure of awareness differed from that used in NHANES in that it asked about “kidney disease” rather than “weakened or failing kidneys.” Interviewers were carefully instructed to exclude answers that implied bladder infections and other urinary tract issues that would not indicate chronic problems of the kidney. Though the item was used previously in the ARIC study, there was no pretesting among persons with known CKD to determine how well it was understood or discriminated. Despite these limitations, the question does provide an approximate assessment of this population and should be validated against other awareness questions to develop a standard item for use in epidemiological surveys of this type. Given the low overall response, errors would likely be in the direction of overestimating awareness. We were limited in our ability to fully examine several potential factors (smoking, alcohol) because of the small number of participants engaging in these behaviors. The strengths of the study are that it is the largest single-site study of African Americans, with extensive phenotypic data utilizing actual pharmacist-coded medication information rather than self-reported medication use.

Despite those limitations, it is clear that CKD is a looming national and international problem on par with diabetes with consequences that are as severe and costly. It is imperative that new approaches be implemented to increase awareness, diagnosis, and treatment – for both the health care provider and the patient. African Americans are known to have a rate of ESRD four times that of whites³². The high prevalence of CKD in the JHS further emphasizes the nature of the CKD threat to African Americans and the need for sustained, integrated, population-based programs to prevent, delay progression of, and treat CKD. We are on the cusp of a large national public health campaign to provide education to the general public and primary care providers. Our data strongly support the necessity of this kind of national effort coupled with localized efforts to enhance screening and awareness in high-risk populations.

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Figure 1.
CKD Prevalence by Sex and Age Group. Solid bars: Men; Open bars: Women.

Figure 2.

Prevalence of albuminuria and low estimated GFR (eGFR) by sex and age group: Solid bars: albuminuria in men; Open bars: albuminuria in women; Horizontal stripes: low eGFR in men; Vertical stripes: low eGFR in women.

Figure 3. Age- and sex-adjusted comparison of the Jackson Heart Study (JHS) and National Health and Nutrition Examination Survey (NHANES) of: A. CKD prevalence and B. Awareness. Solid bars: JHS; Open bars: NHANES.

Table 1
Baseline Characteristics of the Jackson Heart Study Participants by CKD Status

Characteristics	Overall		Men		Women	
	No CKD (N=2746)	CKD (N=685)	No CKD (N=1049)	CKD (N=228)	No CKD (N=1697)	CKD (N=457)
Sex (% Women)	61.8	66.7				
Education (% >=HS)	86.9	71.8	86.8	73.3	86.9	71.1
Income (% >=\$50,000)	39.6	22.9	53.1	29.6	31.1	19.5
Marital Status (% Married)	56.8	47.9	71.4	67.8	47.8	38.0
Insured (%)	87.0	88.2	86.8	87.6	87.1	88.5
Preventive Care (%)	71.2	78.3	60.6	73.0	77.7	80.9
Current Smoker (%)	11.6	11.6	15.0	15.6	9.5	9.6
Heavy Drinker (%)	2.6	1.8	5.8	4.5	0.6	0.4
Type 2 Diabetes (%)	12.9	39.7	9.4	44.7	15.1	37.2
Hypercholesterolemia (%)	57.0	87.5	54.2	86.2	58.7	88.1
Low HDL Cholesterol (%)	38.1	42.3	33.8	37.6	40.8	44.5
Hypertriglyceridemia (%)	14.7	26.6	18.3	35.4	12.3	22.3
Hypertension (%)	30.2	47.1	30.9	44.4	29.8	48.3
CVD (%)	7.6	22.0	8.6	25.4	6.9	20.2
Age (years) [Mean (SD)]	52.7 (12.6)	61.1 (12.7)	51.6 (12.7)	60.3 (12.9)	53.3 (12.5)	61.5 (12.7)
BMI (kg/m ²) [Mean (SD)]	31.4 (6.9)	33.0 (7.6)	29.5 (5.7)	31.7 (7.4)	32.5 (7.4)	33.7 (7.7)
Waist (cm) [Mean (SD)]	99.4 (15.8)	105.0 (16.7)	100.1 (14.5)	106.6 (16.4)	98.9 (16.6)	104.2 (16.8)
Physical Activity Score [Mean (SD)]	8.6 (2.5)	7.2 (2.5)	8.9 (2.5)	7.2 (2.6)	8.4 (2.5)	7.1 (2.5)
Creatinine (mg/dL) [Mean (SD)]	1.0 (0.2)	1.5 (1.3)	1.1 (0.1)	1.7 (1.4)	0.9 (0.1)	1.4 (1.3)
eGFR (ml/min/1.73 m ²) [Mean (SD)]	89.6 (15.2)	67.6 (27.2)	90.5 (14.7)	71.3 (27.2)	89.1 (15.6)	65.8 (27.0)

Abbreviations: HS, high school; CKD, chronic kidney disease; HDL, high-density lipoprotein; CVD, cardiovascular disease; BMI, body mass index; eGFR, estimated glomerular filtration rate. Note: eGFR in mL/min/1.73m² may be converted to mL/s/1.73m² by multiplying by 0.01667.

Table 2

CKD Prevalence and Awareness by Stage

	All CKD n (%)	Stage 1 n (%)	Stage 2 n (%)	Stage 3 n (%)	Stages 4/5 n (%)
All	685 (20.0)	148 (5.1)	186 (6.3)	291 (9.6)	41 (1.5)
Women	457 (21.2)	83 (4.7)	120 (6.6)	213 (11.2)	28 (1.6)
Men	228 (17.9)	65 (5.8)	66 (5.9)	78 (6.9)	13 (1.2)
21–39	47 (10.1)	29 (6.5)	10 (2.3)	3 (0.7)	1 (0.2)
40–59	228 (13.6)	73 (4.8)	68 (4.5)	67 (4.4)	13 (0.9)
60+	410 (31.7)	46 (4.9)	108 (10.9)	221 (20.0)	27 (3.0)
Aware*	107 (15.8)	4 (2.7)	15 (8.2)	51 (17.6)	27 (65.9)

* For awareness, percentages are calculated based on the stage totals.

Note: For all with CKD, percentages are calculated of those whose CKD status could be determined based on urine or serum data. For CKD stages, percentages are calculated excluding 19 individuals with missing estimated glomerular filtration rate values.

Table 3
Awareness and Treatment of CKD, Type 2 Diabetes, Hypertension, and Hypercholesterolemia

	CKD		Diabetes		Hypertension		Hypercholesterolemia	
	Awareness %	Treatment [#] %	Awareness %	Treatment %	Awareness %	Treatment %	Awareness %	Treatment %
All	15.8	52.0	84.4	85.4	82.7	83.2	60.3	43.4
Women	15.2	53.2	85.2	86.4	86.0	87.4	63.8	44.2
Men	16.8	49.8	82.8	83.2	76.5	75.1	54.3	42.1
21–39	13.0	33.3	84.9	81.8	69.6	65.2	36.0	16.3
40–59	14.1	49.1	80.6	82.1	79.8	78.3	59.1	36.1
60+	17.0	55.9	87.1	88.0	86.5	89.2	64.3	52.7

[#] Receiving ACE Inhibitors or/and Angiotensin Receptor Antagonists alone or in combination with other agents was considered as hypertension treatment possibly targeting CKD.

Note: Awareness was defined as a self-report of being informed of the condition by a doctor or a healthcare professional. Those with CKD who reported being on dialysis were also considered as aware of their condition.

Abbreviations: ACE, angiotensin-converting enzyme.

Table 4
Baseline Characteristics and CKD Presence Main Cohort (Age 35–84)

	Age and sex-adjusted model*		Multivariable model		Most parsimonious model	
	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
Sex (Ref: Men)	1.13 (0.94,1.37)	0.2	1.06 (0.81,1.38)	0.7		
Education (Ref: < HS)	0.71 (0.59,0.86)	< 0.001	1.01 (0.77,1.33)	0.9		
Income (Ref: Lower)	0.64 (0.53,0.79)	< 0.001	0.82 (0.63,1.08)	0.2	0.77 (0.60,0.98)	0.04
Marital Status (Ref: Married)	1.32 (1.10,1.59)	0.003	1.2 (0.93,1.54)	0.2		
Insured (Ref: No)	0.74 (0.56,0.97)	0.03	0.89 (0.60,1.32)	0.6		
Hypertension (Ref: No)	3.9 (2.99,5.08)	< 0.001	3.19 (2.26,4.51)	< 0.001	3.21 (2.28,4.53)	< 0.001
Type 2 Diabetes (Ref: No)	3.52 (2.88,4.30)	< 0.001	1.91 (1.43,2.53)	< 0.001	1.91 (1.44,2.54)	< 0.001
CVD (Ref: No)	2.38 (1.87,3.04)	< 0.001	1.74 (1.24,2.43)	0.001	1.72 (1.24,2.40)	0.001
Hypercholesterolemia (Ref: No)	1.6 (1.32,1.94)	< 0.001	1.37 (1.08,1.76)	0.011	1.39 (1.09,1.77)	0.008
Low HDL Cholesterol (Ref: No)	1.36 (1.12,1.66)	0.002	1.01 (0.78,1.30)	0.9		
Hypertriglyceridemia (Ref: No)	1.93 (1.53,2.43)	< 0.001	1.48 (1.10,1.99)	0.009	1.47 (1.11,1.96)	0.008
Waist (per 5 cm)	1.12 (1.09,1.15)	< 0.001	1.05 (1.01,1.09)	0.01	1.05 (1.01,1.09)	0.01
Physical Activity (per SD)	0.69 (0.62,0.76)	< 0.001	0.81 (0.70,0.92)	0.002	0.81 (0.70,0.92)	0.001
Age (per 5 years)	1.33 (1.28,1.38)	< 0.001	1.13 (1.06,1.21)	< 0.001	1.13 (1.06,1.20)	< 0.001

* Sex was adjusted only for age. Abbreviations: HS, high school; CVD, cardiovascular disease; HDL, high-density lipoprotein.

Table 5
Baseline Characteristics and CKD Awareness Main Cohort (Age 35–84)

	Age-adjusted model*		Multivariable model		Most parsimonious model	
	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
Sex (Ref: Men)	0.9 (0.57,1.41)	0.6	0.91 (0.52,1.59)	0.7		
CKD Stage (Ref: Stages 1/2)		<0.001		<0.001		<0.001
Stage 3	3.45 (1.88,6.32)		3.85 (1.98,7.47)		3.77 (2.07,6.84)	
Stage 4/5	31.10 (14.00,73.28)		29.33 (11.8,72.72)		31.50 (13.2,75.17)	
Education (Ref: < HS)	0.54 (0.34,0.87)	0.01	0.62 (0.35,1.09)	0.1		
CVD (Ref: No)	2.10 (1.30,3.39)	0.002	1.30 (0.73,2.33)	0.4		
Physical Activity (per SD)	0.63 (0.48,0.82)	<0.001	0.84 (0.63,1.13)	0.3		
Age (per 5 years)	1.09 (0.99,1.20)	0.08	0.91 (0.79,1.05)	0.2		

Abbreviations: HS, high school; CVD, cardiovascular disease.

Table A1

Baseline Characteristics for Participants with GFR and CKD Status

Characteristic	Non-missing CKD Status	Non-missing GFR
Sex (% Women)	62.8	63.3
Education (% ≥HS)	83.9	81.7
Income (% ≥\$50,000)	36.4	34.2
Marital Status (% Married)	55.1	54.7
Insured (%)	87.2	86.7
Preventive Care (%)	72.6	72.5
Current Smoker (%)	11.6	13.2
Heavy Drinker (%)	2.4	2.9
BMI (% Obese)	53.0	53.2
Type 2 Diabetes (%)	18.2	18.5
Hypercholesterolemia (%)	63.1	62.9
Hypertension (%)	33.3	32.8
CVD (%)	10.4	10.3
Age (year) [Mean (SD)]	54.3 (13.1)	54.9 (12.8)
BMI (Kg/m ²) [Mean (SD)]	31.7 (7.1)	31.7 (7.2)
Waist (cm) [Mean (SD)]	100.5 (16.2)	100.7 (16.1)
Physical Activity Score [Mean (SD)]	8.3 (2.6)	8.3 (2.6)
Creatinine (mg/dL) [Mean (SD)]	1.1 (0.6)	1.0 (0.5)
eGFR (mL/min/1.73 m ²) [Mean (SD)]	85.3 (20.2)	86.1 (18.6)

Abbreviations: eGFR, estimated glomerular filtration rate; CKD, chronic kidney disease; HS, high school; BMI, body mass index; CVD, cardiovascular disease.

Note: Creatinine in mg/dL may be converted to $\mu\text{mol/L}$ by multiplying by 88.4; eGFR in mL/min/1.73m² to mL/s/1.73m² by multiplying by 0.01667.

Table A2
Baseline Characteristics and Presence of Low GFR Main Cohort (Age 35–84)

Characteristic	Age- & sex-adjusted model*		Multivariable model		Most parsimonious model	
	Odds Ratio (95% CI)	p-value	Odds Ratio (95% CI)	p-value	Odds Ratio (95% CI)	p-value
Sex (Ref: Men)	1.46 (1.13,1.89)	0.004	1.46 (1.03,2.06)	0.03	1.46 (1.03,2.06)	0.03
Education (Ref: < HS)	0.92 (0.72,1.17)	0.5	N/A			
Income (Ref: Low)	0.85 (0.65,1.11)	0.2	N/A			
Marital Status (Ref: Married)	1.32 (1.03,1.69)	0.03	1.37 (1.01,1.86)	0.04	1.37 (1.01,1.86)	0.04
Insured (Ref: No)	1.26 (0.79,2.01)	0.3	N/A			
Hypertension (Ref: No)	5.51 (3.38,8.97)	< 0.001	3.12 (1.82,5.33)	<0.001	3.12 (1.82,5.33)	<0.001
Type 2 Diabetes (Ref: No)	2.73 (2.14,3.48)	< 0.001	1.43 (1.04,1.98)	0.03	1.43 (1.04,1.98)	0.03
CVD (Ref: No)	3.29 (2.52,4.31)	< 0.001	2.54 (1.82,3.54)	<0.001	2.54 (1.82,3.54)	<0.001
Hypercholesterolemia (Ref: No)	1.79 (1.39,2.32)	< 0.001	1.46 (1.09,1.96)	0.01	1.46 (1.09,1.96)	0.01
Low HDL (Ref: No)	1.47 (1.12,1.91)	0.005	1.1 (0.81,1.49)	0.6	1.1 (0.81,1.49)	0.6
Hypertriglyceridemia (Ref: No)	2.23 (1.67,2.99)	< 0.001	1.68 (1.20,2.36)	0.003	1.68 (1.20,2.36)	0.003
Waist (per 5 cm)	1.08 (1.04,1.12)	< 0.001	1.03 (0.98,1.08)	0.3	1.03 (0.98, 1.08)	0.3
Physical Activity (per SD)	0.70 (0.59,0.81)	< 0.001	0.81 (0.70,0.95)	0.01	0.81 (0.70,0.95)	0.01
Age (per 5 years)	1.56 (1.47,1.65)	< 0.001	1.42 (1.31,1.55)	<0.001	1.42 (1.31,1.55)	<0.001

Abbreviations: HS, high school; GFR, glomerular filtration rate; CVD, cardiovascular disease; HDL, high-density lipoprotein; N/A, ***.