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## ASSOCIATION BETWEEN SOCIOECONOMIC INDICATORS AND CHRONIC KIDNEY DISEASE IN RURAL-URBAN GHANA- THE RODAM STUDY

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## ASSOCIATION BETWEEN SOCIOECONOMIC INDICATORS AND CHRONIC KIDNEY DISEASE IN RURAL-URBAN GHANA-THE RODAM STUDY

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## Abstract

**Objectives** Studies from high income countries suggest higher prevalence of Chronic Kidney Disease (CKD) among individuals in low socio economic groups. However, some studies from low and middle-income countries (LMICs) show the reverse pattern among those in high socioeconomic groups. It is unknown which pattern applies to individuals living in rural and urban Ghana. We therefore assessed the association between Socio-Economic Status (SES) indicators and CKD in rural and urban Ghana and to what extent the higher SES of people in urban areas of Ghana could account for differences in CKD between rural and urban populations.

**Setting:** We used baseline data from multi-centre Research on Obesity and Diabetes among African Migrants (RODAM) study.

**Participants:** A sample of 2492 adults (Rural Ghana, 1043, Urban Ghana, 1,449 aged 25 to 70 years living in Ghana).

**Outcomes & Measurements** Three CKD outcomes were considered using the 2012 KDIGO (Kidney Disease: Improving Global Outcomes) severity of CKD classification: albuminuria (albumin-creatinine ratio  $\geq 3$  mg/mmol (category  $\geq$  A2)); reduced glomerular filtration rate (eGFR  $< 60$  mL/min/1.73 m<sup>2</sup> (category  $\geq$  G3)) and high to very high CKD risk based on the combination of these two.

**Results** All three SES indicators were not associated with CKD in both rural and urban Ghana after age and sex adjustment except for rural Ghana where high wealth index was significantly associated with higher odds of reduced eGFR (AOR, 2.38; 95% C.I. 1.03-5.47). The higher rate of CKD observed in urban Ghana was not explained by the higher SES of that population.

**Conclusion** SES indicators were not associated with prevalence of CKD except for wealth index and reduced eGFR in rural Ghana. Consequently, the higher SES did not account for the increased rate of CKD among urban dwellers suggesting the need to identify other factors that may be driving this.

**Index Words:** Chronic kidney disease; socioeconomic status; health inequalities; risk factor; ethnic minority groups; migrants; RODAM study, Ghana

### Strengths and limitation of the study

- The use of well-standardized study protocols across rural and urban Ghana eliminated intra protocol variability.
- Our study is also the first in Africa to use all three categories of CKD definition (albuminuria, reduced eGFR and CKD risk) by KDIGO 2012 in assessing association of SES with CKD in rural and urban setting, this provides a more detailed information on CKD outcomes.
- The limitation of intra laboratory variability in earlier studies was eliminated using the same standard operating procedures in the same laboratory for running all samples for both rural and urban Ghana.
- The use of three constructs of SES (educational level, occupational level and wealth index) in this study also provides a much better holistic approach to assessing SES association with CKD. Also, the distribution of SES in our study reflect on the national data allowing for generalization of our findings.
- Our study was limited by the use of cross sectional design which prevented us from determining causality between predictors and CKD progression.

## Introduction

In general, individuals in lower socio-economic status (SES) groups have been shown to suffer more frequently from Chronic Kidney Disease (CKD), often progressing to End Stage Renal Disease (ESRD), and associated with inadequate dialysis treatment, reduced access to kidney transplantation and poor health outcomes<sup>1</sup>. Recent studies have consistently found low SES to be associated with higher risk of CKD among people of African origin<sup>2-5</sup>.

However, in some settings the well-known inverse association between SES and CKD seems to be absent, or even reversed. For example, Bryne et al. did not find an association between SES and End Stage Renal Disease<sup>6</sup>. Invariably, others studies have consistently found a positive association between SES and CKD<sup>7 8</sup>. Specifically, as SES improved, unhealthful lifestyle (unhealthy diet, physical inactivity, smoking and alcohol consumption) increased in China while that of the United States decreased with improved SES<sup>9</sup>. People with higher incomes, in these contexts, can afford a western lifestyle, which is more readily available in the urban areas than in the rural areas. There is therefore an interaction between individual SES and environmental factors, such as food and sedentary life style in such populations<sup>10-12</sup>. Consequently, in those settings, people with a higher SES might have higher CKD risk.

In urban areas, the population in general has a higher SES than in rural areas<sup>13</sup>. For example, individuals with higher educational level migrate from rural areas to find higher occupations matching their higher education to improve on their wealth. If indeed a positive association between SES and CKD is observed in LMICs, this might underlie the well-known health differences between urban and rural areas, with urban areas having an increased risk of CKD<sup>14</sup>. So far, it is unknown whether the reversed SES gradient (higher risk in high SES group) might explain the higher burden of CKD in urban areas as compared to rural areas in Africa.

In view of this, we assessed the association of SES with CKD in rural and urban Ghana and studied what extent the higher SES of people in urban areas could account for differences in CKD between rural and urban populations.

## Methods

### *Study population and study design*

In the present analyses, data used were from the RODAM (Research on Obesity & Diabetes among African Migrants) study, a multi-centre cross-sectional study, were used. The rationale, conceptual framework, design and methodology of the RODAM study have been described in detail elsewhere<sup>15 16</sup>. As the Healthy Life in an Urban Setting (HELIUS) study conducted among Ghanaian migrants living in Amsterdam did not find any associations between SES and CKD<sup>17</sup> the current study focused on rural and urban Ghana (Ashanti region of Ghana). The RODAM study was conducted from 2012 to 2015 and it comprised of individuals aged 25-70 years living in rural and urban Ghana and Ghanaian migrants in Europe. All participants below 25 and above 70 years were excluded in the present analyses. The present analysis was restricted to the rural and urban sites (n=2492) RODAM participants. Specifically, 1043 participants from rural Ghana and 1449 from urban Ghana were used in this study.

Data collection for the study was standardized across the sites. Written informed consent was obtained from each participant prior to enrolment in the study. The respective ethics committees in Ghana and the three European countries approved the study protocols before data collection began. The response rate was 76% in rural Ghana and 74% in urban Ghana. In Ghana, participants were randomly drawn from a list of 30 enumeration areas in the Ashanti region based on the 2010 population census using the multistage random sampling. These enumeration areas came from two purposively selected urban cities (Kumasi and Obuasi) and 15 randomly selected rural communities in the Ashanti region. Selected health and community authorities were first identified, notified of the study and letters were sent giving detailed explanation of the study. We sent team members to stay among the communities to familiarize with them and organize mini clinics in the field. This lasted between 1-2 weeks depending on the sampled population and responsiveness of respondents.

In Ghana, questionnaires administration and physical examination were done at the same day/time. The participants were instructed to fast from 10.00 pm the night before the physical examination. For the current study, 2566 participants with data available on both questionnaire data and physical measurements were used. We excluded (n=74) individuals outside the RODAM age range of 25-70 years resulting in a data set of 2492 for analysis. These comprised 1,449 Urban Ghana and 1043 Rural Ghana. For the final analysis, individuals with no data on CKD status (n=42) were excluded.

## Measurements

### *Demographic and lifestyle factors*

Information on demographics, educational level, occupational level, wealth index and lifestyle factors (smoking and physical activity) were obtained by questionnaire. Physical examinations were performed with validated devices per standardized operational procedures across all study sites. Weight was measured in light clothing and without shoes with SECA 877 scales to the nearest 0.1 kg. Height was measured without shoes with a portable stadiometer (SECA 217) to the nearest 0.1 cm. Body mass index (BMI) was calculated as weight (kg) divided by height squared ( $m^2$ ). Overweight was defined as BMI of  $\geq 25$  to  $< 30$   $kg/m^2$  and obesity as BMI  $\geq 30$   $kg/m^2$ <sup>18</sup>. Waist circumference was measured in cm at the midpoint between the lower rib and the upper margin of the iliac crest. Per participant all anthropometrics were measured twice by the same assessor and the average of the two measurements were used for analyses.

### **Covariates**

Socioeconomic indicators used in this study were educational level, occupational status and level of wealth index. Educational level was determined based on self-reported highest educational qualification accomplished based on the Ghanaian educational system. Occupational level was determined based on self-reported current occupation if still employed or/and last occupation before retirement or student. The reported occupations were further coded according to the International Standard Classification of Occupations scheme (ISCO-08). Wealth index was determined using the World Health Organization (WHO) standard of wealth index classification. Wealth index was based on data collected in the Household Questionnaire. The questionnaire comprised of questions on household's ownership of several consumer items such as television, car, flooring material, toilet facilities etc. Each household was assigned a standard score for each asset. Wealth index was then expressed in five quintiles. The five quintiles were further categorized into three quintiles by combining the second and third quintiles due to small numbers<sup>19</sup>. All three SES constructs were further classified as low, medium and high SES and their relationship to each other tested.

### **Outcome: CKD prevalence**

Participants were asked to bring an early morning urine sample for the analyses of albuminuria and creatinine levels. Urinary albumin concentration (in mg/L) was measured by an immunochemical turbidimetric method (Roche Diagnostics). Urinary creatinine concentration (in  $\mu mol/L$ ) was measured by a kinetic spectrophotometric method (Roche Diagnostics). Estimated glomerular filtration rate (eGFR)



was calculated using the CKDEPI (CKD Epidemiology Collaboration) creatinine equation<sup>20</sup>. Urinary albumin-creatinine ratio (ACR; expressed in mg/g) was calculated by taking the ratio between urinary albumin and urinary creatinine. eGFR and albuminuria were categorized according to the 2012 KDIGO (Kidney Disease: Improving Global Outcomes) classification<sup>21</sup>. eGFR was categorized as follows: G1,  $\geq 90$  mL/min/1.73 m<sup>2</sup> (normal kidney function); G2, 60 to 89 mL/min/1.73 m<sup>2</sup> (mildly decreased); G3a, 45 to 59 mL/min/1.73 m<sup>2</sup> (mildly to moderately decreased); G3b, 30 to 44 mL/min/1.73 m<sup>2</sup> (moderately to severely decreased); G4, 15 to 29 mL/min/1.73 m<sup>2</sup> (severely decreased); and G5,  $< 15$  mL/min/1.73 m<sup>2</sup> (kidney failure). Albuminuria categories were derived from ACR and were as follows: A1,  $< 3$  mg/mmol (normal to mildly increased); A2, 3 to 30 mg/mmol (moderately increased); and A3,  $> 30$  mg/mmol (severely increased). CKD status was categorized according to severity of kidney disease (green, low risk; yellow, moderately increased risk; orange, high risk; and red, very high risk) using the combination of eGFR (G1-G5) and albuminuria (A1-A3) levels defined by the 2012 KDIGO guideline<sup>22</sup>. Due to the small number of participants in the very high risk category of CKD, high and very high risk groups were combined. Reduced eGFR was defined as eGFR  $< 60$  mL/min/1.73 m<sup>2</sup>. Because of the small number of participants in the severely increased albuminuria category, we defined albuminuria as ACR  $\geq 3$  mg/mmol by combining the moderately increased (A2) and severely increased (A3) categories.

### ***Other variables***

Blood pressure (BP) was measured three times using a validated semi-automated device (The Microlife WatchBP home) with appropriate cuffs in a sitting position after at least 5 min rest. The mean of the last two BP measurements was used in the analyses. Hypertension was defined as systolic BP  $\geq 140$  mmHg, and/or diastolic BP  $\geq 90$  mmHg, and/or being on antihypertensive medication treatment, and/or self-reported hypertension. Trained research assistants in the two sites collected fasting venous blood samples. All the blood samples were processed and aliquoted immediately (within one hour to maximum three hours of the vena puncture) after collection per standard operation procedures, and then temporarily stored at the local research location at  $-20^{\circ}\text{C}$ . The separated samples were then transported to the local research centres laboratories, where they were checked, registered and stored at  $-80^{\circ}\text{C}$ . To avoid intra-laboratory variability, the stored blood samples from the local research centres were transported to Berlin, Germany for biochemical analyses. Fasting plasma glucose concentration was measured using an enzymatic method (hexokinase). Type 2 diabetes was defined according to the WHO diagnostic criteria (fasting glucose  $\geq 7.0$  mmol/L, and/or current use of medication prescribed to treat diabetes, and/or self-reported diabetes)<sup>23</sup>. Concentration of total cholesterol was assessed using colorimetric test kits. All biochemical analyses were performed using an ABX Pentra 400 chemistry analyzer (ABX Pentra; Horiba ABX, Germany). Hypercholesterolemia was defined as total cholesterol level  $\geq 6.22$  mmol/L. Serum

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3 creatinine concentration (in  $\mu\text{mol/L}$ ) was determined by a kinetic colorimetric spectrophotometric isotope  
4 dilution mass spectrometry–calibrated method (Roche Diagnostics). Biochemical analyses were subject to  
5 extensive quality checks including blinded serial measurements.  
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### 8 9 **Patient and Public Involvement**

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11 Community leaders were involved in the recruitment of patients. These comprised of religious  
12 communities (churches and mosques), endorsement from local key leaders and establishing relationships  
13 with healthcare organizations. We also provided information on the study by involving the local media  
14 (radio and television stations). We sent letters to all selected health and community authorities to notify  
15 participants of the study. Team members were sent to the various community to stay among the  
16 community and organize mini clinics for a period of 1-2 weeks. Results of the study were disseminated  
17 through seminars, durbars and via radio and television stations.  
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### 22 23 **Statistical methods**

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25 Participants' characteristics were expressed as absolute numbers and percentages for categorical variables  
26 and as means and standard deviations (SD) for continuous variables. CKD prevalence with 5% error bars  
27 were presented as bar graphs for each SES construct across rural and urban Ghana. Spearman's rank  
28 correlation was used to determine correlations between the three SES constructs. Odds ratios (ORs) and  
29 their corresponding 95% confidence intervals (CIs) were estimated by means of logistic regression  
30 analyses to study the odds of albuminuria ( $\text{ACR} > 3 \text{ mg/mmol}$ , A2-A3, moderately to severely increased  
31 albuminuria), reduced kidney function ( $\text{eGFR} < 60 \text{ mL/min/1.73 m}^2$ , G3-G5 moderately to severely  
32 decreased kidney function) and increased CKD risk (high and very high CKD risk), with adjustments for  
33 potential covariates (age and sex). These covariates were adjusted for to account for their impact in the  
34 pathway of CKD incidence, prevalence and progression<sup>24</sup>. Model 1 was age and sex adjusted. The  
35 analyses were performed for the total population (using low educational level, low occupational status  
36 and low level of wealth index as reference categories). Further analysis was conducted using rural Ghana  
37 as reference. Model 1 was adjusted for age and sex while model 2 was adjusted for age, sex and  
38 educational level. Model 3 was adjusted for age, sex and occupational status while model 4 was adjusted  
39 for age, sex and level of wealth index ( $p < 0.05$ ). Tolerance test and variance inflation factor (VIF) showed  
40 very small degree of collinearity among SES predictors thus we adjusted for each of SES variables  
41 separately. Complete case analysis approach was used. All data available were included in the age-  
42 adjusted models. All analyses were performed using STATA, version 14.0 (StataCorp LP).  
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### 54 55 **Results**

Table 1 shows characteristics of study participants. Participants in rural Ghana were slightly older than those in urban Ghana. Female preponderance was observed in both rural and urban Ghana, though higher proportions were observed in urban Ghana. Individuals living in rural Ghana were generally less educated compared with those living in urban Ghana. There were slightly more individuals with low occupational status in urban Ghana compared with their peers in rural Ghana. People in urban Ghana were wealthier than their rural counterparts. Rural Ghanaians were more physically active compared with their urban peers. Smoking was low among Ghanaians though rural Ghanaians were more likely to smoke compared with their urban peers. Hypercholesterolemia was more prevalent in urban Ghana than in rural Ghana. Hypertension and type 2 diabetes were more prevalent in urban Ghanaians compared with those living in rural Ghana. Urban Ghanaians were markedly more obese compared with their rural peers. Except for eGFR, albuminuria and CKD risk prevalence rates were higher in urban Ghana compared with rural Ghana.

**Table 1: Baseline characteristics by location**

	Rural Ghana	Urban Ghana
Number of participants, N (%)	1043 (41.9)	1449 (58.1)
Mean age, years (SD)	46.5 (12.6)	45.2 (11.4)
Females, N (%)	638 (61.2)	1034 (71.4)
Educational level n (%)		
Low	555 (56.9)	614 (43.9)
Middle	311 (31.9)	547 (39.1)
High	108 (11.8)	239 (17.0)
Occupational status, n (%)		
Low	250 (25.7)	374 (26.7)
Middle	628 (64.5)	818 (58.4)
High	96 (9.8)	209 (14.9)
Wealth index, n (%)		
Low	449 (46.5)	368 (26.6)
Middle	276 (28.6)	416 (30.0)
High	241 (24.9)	602 (43.4)
Low physical activity, n (%)	663 (47.22)	592 (60.7)
Smoking, n (%)	22 (2.3)	14 (1.0)
Hypercholesterolemia, n (%)	78 (7.6)	270 (18.7)
Hypertension, n (%)	306 (29.3)	531 (36.7)
Diabetes, n (%)	53 (5.1)	153 (10.6)

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Albuminuria, n (%)		
A1, Normal to mildly increased (ACR <3 mg/mmol)	930 (91.6)	1285 (89.1)
A2-A3, moderately to severely increased (ACR ≥ 3 mg/mmol)	85 (8.4)	158 (10.9)
eGFR, n (%)		
G1-G2 (≥ 60 mL/min/1.73m <sup>2</sup> )	989 (96.3)	1388 (96.3)
G3-G5 (<60 mL/min/1.73m <sup>2</sup> )	38 (3.7)	54 (3.7)
CKD risk, n (%)		
Low risk (green)	916 (90.5)	1281 (88.9)
Moderately increased to very high risk (yellow to red)	96 (9.5)	160 (11.1)

**Abbreviations:** N, number of respondents; SD, standard deviation; eGFR, estimated glomerular filtration rate; ACR, albumin creatinine ratio; CKD, Chronic kidney disease

Figure 1 shows prevalence of CKD by level of education in urban and rural Ghana. Prevalence of CKD decreased with increasing levels of education in rural Ghana. Higher prevalence of CKD was observed among individuals with low educational level compared with those with middle and high educational level. However, those with high educational level in urban Ghana had higher prevalence of CKD compared with those with middle level education. For occupational status, prevalence of CKD was higher among individuals with low occupational status in urban Ghana. Similar patterns were observed in rural Ghana, however, those with higher occupational status had higher prevalence of CKD compared with those with middle occupational status (Figure 2). Figure 3 shows prevalence of CKD by level of wealth index. CKD prevalence among the levels of wealth index varied between urban and rural Ghana. Those with middle level wealth index had higher prevalence of CKD compared with those with low or high CKD prevalence in both rural and urban Ghana. CKD prevalence rate for low and high level wealth index in urban Ghana was the same while that of rural Ghana was slightly different.

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In urban Ghana, high educational level was positively associated with high wealth index but inversely associated with occupation. In rural Ghana, high education was positively associated with high wealth index, but there was no significant association between education and occupation. High wealth index was inversely associated with high occupational status in both rural and urban Ghana (Table 2).

**Table 2: Relationship between SES constructs (educational, occupational level and wealth index) by urban rural Ghana**

<b>Correlation matrix</b>	<b>Educational level</b>	<b>Occupational level</b>	<b>Wealth index</b>	<b>SES</b>
<b>Urban Ghana</b>				
Educational level	1.000			
Occupational status	-0.115*	1.000		
Wealth Index	0.294*	-0.126*	1.000	
Composite SES	0.576*	-0.024	0.937*	1.000
<b>Rural Ghana</b>				
Educational level	1.000			
Occupational status	0.017	1.000		
Wealth Index	0.219*	-0.135*	1.000	
SES	0.504*	0.029	0.934*	1.000

**Significant at 1%, Spearman’s correlation**

Table 3 shows association between level of education, occupational status, level of wealth index and prevalence of CKD. After adjusting for age and sex, we observed no significant association between SES indicators (educational level, occupational status and wealth index) and CKD in urban Ghana. In rural Ghana, whereas educational level and occupational status were not associated with CKD prevalence, high wealth index was significantly associated with higher odds of reduced eGFR.

**Table 3: Association of SES indicators (educational level, occupational status and wealth index level) with albuminuria, reduced eGFR and CKD risk**

	Albuminuria (ACR $\geq$ 3 mg/mmol)		eGFR < 60 mL/min/1.73 m <sup>2</sup>		High to very high CKD risk (KDIGO, 2012)	
	n (%)	OR (95% CI) Model 1	n (%)	OR (95% CI) Model 1	n cases (%)	OR (95% CI) Model 1
<b>Education</b>						
<b>Urban Ghana</b>						
Low	612 (14.7)	1.00 (Reference)	612 (4.1)	1.00 (Reference)	612 (14.1)	1.00 (Reference)
Middle	546 (7.8)	0.51 (0.34-0.76)	546 (3.7)	1.12 (0.59-2.12)	545 (8.1)	0.59 (0.39-0.89)
High	238 (8.4)	0.53 (0.31-0.91)	238 (3.4)	0.91 (0.37-2.19)	238 (10.9)	0.83 (0.51-1.38)
<b>Rural Ghana</b>						
Low	540 (8.7)	1.00 (Reference)	548 (3.8)	1.00 (Reference)	538 (9.5)	1.00 (Reference)
Middle	301 (6.3)	0.89 (0.51-1.59)	303 (3.9)	1.69 (0.77-3.66)	300 (8.7)	1.33 (0.79-2.25)
High	105 (3.8)	0.66 (0.23-1.95)	107 (2.8)	1.28 (0.35-4.71)	105 (3.8)	0.69 (0.23-2.02)
<b>Occupational status</b>						
<b>Urban Ghana</b>						
Low	207 (10.1)	1.00 (Reference)	207 (6.8)	1.00 (Reference)	207 (12.1)	1.00 (Reference)
Middle	817 (11.1)	1.50 (0.88-2.83)	817 (3.6)	1.15 (0.56-2.35)	816 (11.6)	1.37 (0.84-2.56)
High	373 (11.0)	1.57 (0.89-2.53)	373 (2.7)	1.02 (0.41-2.52)	373 (9.7)	1.21 (0.68-2.14)
<b>Rural Ghana</b>						

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Low	95 (10.5)	1.00 (Reference)	96 (10.4)	1.00 (Reference)	95 (14.7)	1.00 (Reference)
Middle	610 (6.7)	0.65 (0.31-1.37)	619 (3.1)	0.37 (0.16-0.85)	608 (7.6)	0.55 (0.28-1.08)
High	241 (8.3)	0.99 (0.43-2.28)	243 (2.9)	0.51 (0.18-1.44)	240 (9.2)	0.94 (0.44-2.01)
<b>Wealth index</b>						
<b>Urban Ghana</b>						
Low	367 (11.2)	1.00 (Reference)	367 (3.5)	1.00 (Reference)	367 (10.1)	1.00 (Reference)
Middle	414 (12.3)	1.12 (0.73-1.74)	414 (3.9)	1.30 (0.61-2.80)	413 (13.1)	1.45 (0.93-2.27)
High	601 (9.8)	0.82 (0.55-1.25)	600 (3.8)	1.13 (0.55-2.31)	600 (10.8)	1.11 (0.72-1.71)
<b>Rural Ghana</b>						
Low	441 (7.9)	1.00 (Reference)	446 (3.1)	1.00 (Reference)	441 (8.4)	1.00 (Reference)
Middle	264 (8.7)	1.13 (0.65-1.98)	269 (3.7)	1.22 (0.52-2.84)	262 (10.3)	1.31 (0.77-2.25)
High	234 (5.6)	0.78 (0.40-1.53)	235 (5.1)	<b>2.38 (1.03-5.47)</b>	233 (7.7)	1.16 (0.63-2.14)

Model 1, adjusted for age and sex; Abbreviations: CI, confidence interval; ACR, albumin creatinine ration; eGFR, estimated glomerular filtration rate; CKD, chronic kidney disease; OR, odds ratio, n= total number of individuals in rural and urban Ghana among the various levels of SES constructs; %, proportion of individuals with CKD among the various levels of SES constructs in rural and urban Ghana.

Table 4 shows the contribution of all three SES constructs to rural and urban CKD prevalence differences. The odds of albuminuria and CKD risk was significantly higher in urban Ghana compared with rural Ghana. The higher rate of CKD observed in urban Ghana was not explained by the higher SES of that population as compared to their rural counterparts.

**Table 4: Contribution of SES indicators to rural-urban differences in albuminuria, reduced eGFR and CKD risk**

		OR (95% CI) Model 1	OR (95% CI) Model 2	OR (95% CI) Model 3	OR (95% CI) Model 4
<b>Albuminuria (ACR <math>\geq</math> 3 mg/mmol)</b>					
Sites	n cases (%)				
Urban Ghana	1,443 (10.9)	<b>1.37 (1.03-1.81)</b>	<b>1.70 (1.25-2.31)</b>	<b>1.55 (1.15-2.10)</b>	<b>1.62 (1.18-2.19)</b>
Rural Ghana	1,015 (8.4)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
<b>eGFR &lt; 60 mL/min/1.73 m<sup>2</sup></b>					
Sites	n cases (%)				
Urban Ghana	1,442 (3.7)	1.27 (0.82-1.97)	1.20 (0.76-1.89)	1.18 (0.79-1.86)	1.12 (0.70-1.78)
Rural Ghana	1,027 (3.7)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
<b>High to very high CKD risk</b>					
Sites	n cases (%)				
Urban Ghana	1,441 (11.1)	<b>1.23 (1.01-1.62)</b>	<b>1.44 (1.07-1.93)</b>	<b>1.38 (1.03-1.84)</b>	<b>1.36 (1.01-1.83)</b>
Rural Ghana	1,012 (9.46)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)

Model 1: adjusted for age and sex; Model 2: adjusted for age, sex and education level; Model 3: adjusted for age, sex and occupational status; Model 4: adjusted for age, sex and wealth index; Abbreviations: CI, confidence interval; ACR, albumin creatinine ration; eGFR, estimated glomerular filtration rate; CKD, chronic kidney disease; OR, odds ratio, n=number of participants. n= total number of individuals in rural and urban Ghana; %, proportion of individuals with CKD among urban and rural Ghana.



## Discussion

### *Key findings*

Our study findings show no association between all three SES constructs and the prevalence of CKD in both rural and urban Ghana except for wealth index in rural Ghana, with the risk of CKD being higher in the wealthier populations. The higher rate of CKD observed in urban Ghana could not be attributed to the higher SES of that population compared to their rural counterparts.

### Discussion of key findings

#### *Association of SES with CKD in rural and urban Ghana*

Our study did not find any significant associations between all three SES constructs and CKD among rural and urban Ghana except for wealth index in rural Ghana. The positive association observed between wealth index in rural Ghana may be due to a number of reasons. A comparison of the three SES constructs showed higher educational level to be associated with wealth index in both rural and urban Ghana but not occupational level. This seems to suggest that occupational level may not be adequately capturing the SES status of individuals living in these settings in relation to CKD. For example, Masthi et al, compared different SES scales in rural and urban India and concluded that Standard of Living Index (SLI) scale was more accurate for classification of SES in urban and rural setting<sup>25</sup>. Our finding is consistent with other studies<sup>6 26</sup> which reported no association between SES and CKD in high-income countries and LMICs, but in contrast with other studies<sup>2-4 27</sup> that found positive associations between SES and CKD. The reasons for our current finding are unclear. However, it has been suggested that these inconsistent associations may be due to the varying pathways through which the effect of SES on health status is mediated. For example, at a given educational level marked ethnic differences have been reported. Additionally, similar differences were observed for wealth status at a given income level<sup>28-30</sup>.

#### *Contribution of SES to observed CKD risk differences between rural and urban Ghana*

We observed higher rates of CKD in urban Ghana compared with rural Ghana, as expected. The observed higher rates of CKD in our study were not explained by the higher SES of that population as compared to their rural counterparts. Our results indicate that this is due to the lack of a clear difference in the SES distribution of rural and urban Ghana observed in this study, as well as to the lack of associations between SES and CKD. Consistent with our findings, in a study conducted in Northern Tanzania SES did not explain increased risk of CKD in urban Tanzania<sup>26</sup>. The lack of associations between SES and CKD

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3 could probably partly be explained by the process of epidemiological transition in relation to the  
4 “diffusion theory” of ischemic heart disease mortality. This theory attributes the commencement of  
5 ischemic heart disease to individuals in the high SES group due to their ability to afford behaviours  
6 (smoking, alcohol and sedentary lifestyles) which increased risk of ischemic heart disease. The lower SES  
7 groups were later affected partially because of improved living standards, imitation and urbanization. The  
8 higher SES groups were the first to embrace behavioural changes required to decrease the risk of ischemic  
9 heart disease and this resulted in reversing the gradient <sup>31</sup>. The rapid urbanization of some rural  
10 communities in the Ashanti region of Ghana and the imitation of urban lifestyle could account for our  
11 finding. Also, it could be that whereas the high SES group in urban Ghana has already embraced  
12 favourable behavioural changes, those in rural Ghana are yet to do so <sup>32</sup>. This explains the observed  
13 association of wealth index with CKD in rural Ghana but not in urban Ghana. The complexities of  
14 influence of SES on prevalence and progression of CKD and the differential prevalence of established  
15 risk factors (diabetes, obesity and hypertension) in rural and urban Ghana may also contribute to the  
16 different associations of SES with CKD prevalence observed in rural and urban Ghana. In our study, the  
17 prevalence rates of hypercholesterolemia, hypertension and type 2 diabetes were substantially higher in  
18 urban Ghana compared with that of rural Ghana. Also, the interplay of other less understood or researched  
19 factors (e.g., exposure to nephrotoxins, herbal medications, sepsis) may be influencing the pathway in  
20 which SES influences CKD prevalence and progression.  
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### 32 ***Strength and limitation***

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35 Our study presents several strengths. First, we used well-standardized study protocols across rural and  
36 urban Ghana. Our study is also the first in Africa to use all three categories of CKD definition  
37 (albuminuria, reduced eGFR and CKD risk) by KDIGO 2012 in assessing association of SES with CKD  
38 in rural and urban setting, this provides a more detailed information on CKD outcomes. The limitation of  
39 intra laboratory variability in earlier studies was eliminated using the same standard operating procedures  
40 in the same laboratory for running all samples for both rural and urban Ghana. The use of three constructs  
41 of SES in this study also provides a much better holistic approach to assessing SES. Also, the distribution  
42 of SES in our study reflect on the national data allowing for generalization of our findings. Our study was  
43 limited by the use of cross sectional design which prevented us from determining causality between  
44 predictors and CKD progression.  
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## Conclusion

All three SES constructs appear not to be associated with prevalence of CKD in urban and rural Ghana except for wealth index in rural Ghana. The observed higher prevalence of CKD in urban Ghana was not explained by the higher SES in urban Ghana. Our study seems to suggest that other non-traditional factors such as nephrotoxins, herbal medications and misuse of over the counter drugs may play a role and underscores the need to further explore these factors.

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## Contributors

My co-authors have all contributed substantially to this manuscript and approve of this submission. Research idea and study design: DNA, CA, KS, DA, EB, KM, JA; data acquisition and curation: DNA, CA, EB, KM, data analysis/interpretation: DNA, CA, KS, DA, EB, KM, LS, JA, EOD, KKB, FPM, ID, JS, SB, ADA; statistical analysis: DNA, CA, KS. DNA, CA, KS, DA, EB, KM, LS, JA, EOD, KKB, FPM, ID, JS, SB, ADA contributed important intellectual content during manuscript drafting or revision and accepts accountability for the overall work by ensuring that questions pertaining to the accuracy or integrity of any portion of the work are appropriately investigated and resolved. DNA and CA takes responsibility that this study has been reported honestly, accurately, and transparently; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained.

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10 **Competing interest:** I have communicated with all my co-authors and obtained their full  
11 disclosures. My co-authors and I declare no conflicts of interest.  
12  
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14 **Patient Consent:** None declared  
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16 **Ethics approval:** IRBs at each participating site.  
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19 **Data sharing statement:** Data are available from the RODAM research cohort, a third party. Dr.  
20 Eric Beune affiliated with the RODAM research cohort and a co-author of this paper in  
21 accordance with the RODAM requirements for collaboration. Dr. Beune is the Data Collection  
22 Coordinator of RODAM and may be contacted with further questions (e.j.beune@amc.uva.nl).  
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24 Additionally, researchers interested in further collaboration with RODAM may see the following  
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### Legend for figures

Figure 1: Prevalence of chronic kidney disease (CKD) across level of education among urban and rural participants. Definitions according to 2012 KDIGO (Kidney Disease: Improving Global Outcomes) guideline. CKD was defined as being in moderately increased risk, high-risk, or very high-risk groups.

Figure 2: Prevalence of chronic kidney disease (CKD) across occupational status among urban and rural participants. Definitions according to 2012 KDIGO (Kidney Disease: Improving Global Outcomes) guideline. CKD was defined as being in moderately increased risk, high-risk, or very high-risk groups.

Figure 3: Prevalence of chronic kidney disease (CKD) across wealth index categories among urban and rural participants. Definitions according to 2012 KDIGO (Kidney Disease: Improving Global Outcomes) guideline. CKD was defined as being in moderately increased risk, high-risk, or very high-risk groups.

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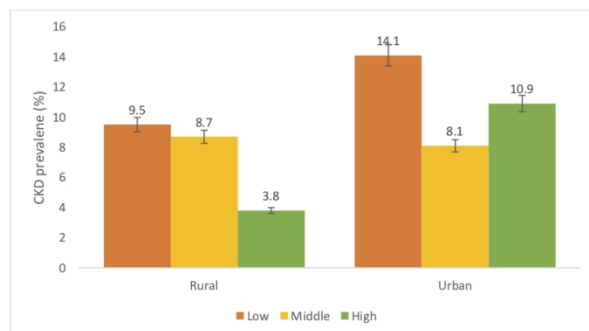


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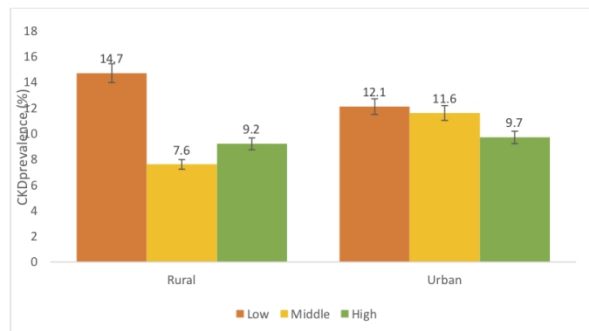


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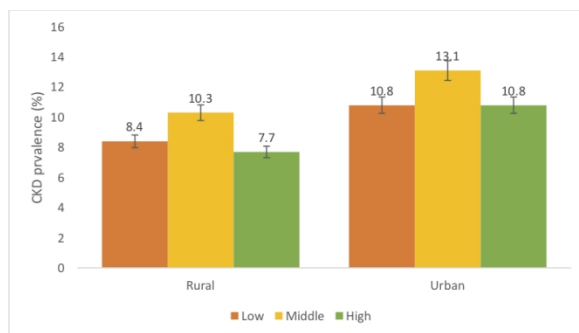


Figure 3: Prevalence of chronic kidney disease (CKD) across wealth index categories among urban and rural participants. Definitions according to 2012 KDIGO (Kidney Disease: Improving Global Outcomes) guideline. CKD was defined as being in moderately increased risk, high-risk, or very high-risk groups

Figure 3: Prevalence of chronic kidney disease (CKD) across wealth index categories among urban and rural participants. Definitions according to 2012 KDIGO (Kidney Disease: Improving Global Outcomes) guideline. CKD was defined as being in moderately increased risk, high-risk, or very high-risk groups

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# BMJ Open

## A CROSS-SECTIONAL STUDY OF ASSOCIATION BETWEEN SOCIOECONOMIC INDICATORS AND CHRONIC KIDNEY DISEASE IN RURAL-URBAN GHANA-THE RODAM STUDY

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<b>Primary Subject Heading</b>:	Epidemiology
Secondary Subject Heading:	Public health, Epidemiology
Keywords:	Chronic Kidney Disease, Socioeconomic status, Health inequalities, RODAM study, rural, urban

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**A CROSS SECTIONAL STUDY OF ASSOCIATION BETWEEN SOCIOECONOMIC INDICATORS AND CHRONIC KIDNEY DISEASE IN RURAL-URBAN GHANA-THE RODAM STUDY**

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## Abstract

**Objectives:** Studies from high income countries suggest higher prevalence of Chronic Kidney Disease (CKD) among individuals in low socio economic groups. However, some studies from low and middle-income countries (LMICs) show the reverse pattern among those in high socioeconomic groups. It is unknown which pattern applies to individuals living in rural and urban Ghana. We therefore assessed the association between Socio-Economic Status (SES) indicators and CKD in rural and urban Ghana and to what extent the higher SES of people in urban areas of Ghana could account for differences in CKD between rural and urban populations.

**Methods:** We used baseline data from multi-centre Research on Obesity and Diabetes among African Migrants (RODAM) study. A sample of 2492 adults (Rural Ghana, 1043, Urban Ghana, 1,449) aged 25 to 70 years living in Ghana. Three CKD outcomes were considered using the 2012 KDIGO (Kidney Disease: Improving Global Outcomes) severity of CKD classification: albuminuria (albumin-creatinine ratio  $\geq 3$  mg/mmol (category  $\geq$  A2)); reduced glomerular filtration rate (eGFR  $< 60$  mL/min/1.73 m<sup>2</sup> (category  $\geq$  G3)) and high to very high CKD risk based on the combination of these two.

**Results:** All three SES indicators were not associated with CKD in both rural and urban Ghana after age and sex adjustment except for rural Ghana where high wealth index was significantly associated with higher odds of reduced eGFR (AOR, 2.38; 95% C.I. 1.03-5.47). The higher rate of CKD observed in urban Ghana was not explained by the higher SES of that population.

**Conclusion:** SES indicators were not associated with prevalence of CKD except for wealth index and reduced eGFR in rural Ghana. Consequently, the higher SES did not account for the increased rate of CKD among urban dwellers suggesting the need to identify other factors that may be driving this.

**Index Words:** Chronic kidney disease; socioeconomic status; health inequalities; risk factor; ethnic minority groups; migrants; RODAM study, Ghana

## Strengths and limitation of the study

- The use of well-standardized study protocols across rural and urban Ghana eliminated intra protocol variability.
- **Our study is also the first in Africa to use all three categories of CKD definition (albuminuria, reduced eGFR and CKD risk) by KDIGO 2012 in assessing association of SES with CKD in rural and urban setting. This provides a more detailed information on CKD outcomes.**
- The limitation of intra laboratory variability in earlier studies was eliminated using the same standard operating procedures in the same laboratory for running all samples for both rural and urban Ghana.
- The use of three constructs of SES (educational level, occupational level and wealth index) in this study also provides a much better holistic approach to assessing SES association with CKD.
- Our study was limited by the use of cross sectional design which prevented us from determining causality between predictors and CKD progression.

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4 129 **Introduction**

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6 131 In general, individuals in lower socio-economic status (SES) groups have been shown to suffer more  
7 132 frequently from Chronic Kidney Disease (CKD), often progressing to End Stage Renal Disease (ESRD),  
8 133 and associated with inadequate dialysis treatment, reduced access to kidney transplantation and poor  
9 134 health outcomes<sup>1</sup>. Recent studies have consistently found low SES to be associated with higher risk of  
10 135 CKD among people of African origin<sup>2-5</sup>.

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15 136 However, in some settings the well-known inverse association between SES and CKD seems to be absent,  
16 137 or even reversed. For example, Bryne et al. did not find an association between SES and End Stage Renal  
17 138 Disease<sup>6</sup>. Other studies have found a positive association between SES and CKD<sup>7 8</sup>. Specifically, as  
18 139 SES improved, unhealthful lifestyle (unhealthy diet, physical inactivity, smoking and alcohol  
19 140 consumption) increased in China while that of the United States decreased with improved SES<sup>9</sup>. People  
20 141 with higher incomes, in these contexts, can afford a western lifestyle, which is more readily available in  
21 142 the urban areas than in the rural areas. There is therefore an interaction between individual SES and  
22 143 environmental factors, such as food and sedentary life style in such populations<sup>10-12</sup>. Consequently, in  
23 144 those settings, people with a higher SES might have higher CKD risk.

24 145 In urban areas, the population in general has a higher SES than in rural areas<sup>13</sup>. For example, individuals  
25 146 with higher educational level migrate from rural areas to find higher occupations matching their higher  
26 147 education to improve on their wealth. If indeed a positive association between SES and CKD is observed  
27 148 in LMICs, this might underlie the well-known health differences between urban and rural areas, with  
28 149 urban areas having an increased risk of CKD<sup>14</sup>. So far, it is unknown whether the reversed SES gradient  
29 150 (higher risk in high SES group) might explain the higher burden of CKD in urban areas as compared to  
30 151 rural areas in Africa.

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43 153 In view of this, we assessed the association of SES with CKD in rural and urban Ghana and studied what  
44 154 extent the higher SES of people in urban areas could account for differences in CKD between rural and  
45 155 urban populations.

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## 162 163 **Methods**

### 164 165 *Study population and study design*

166 In the present analyses, data from the RODAM (**R**esearch on **O**besity & **D**iabetes among **A**African  
167 **M**igrants) study, a multi-centre cross-sectional study were used. The rationale, conceptual framework,  
168 design and methodology of the RODAM study have been described in detail elsewhere<sup>15 16</sup>. As the  
169 Healthy Life in an Urban Setting (HELIUS) study conducted among Ghanaian migrants living  
170 in Amsterdam did not find any associations between SES and CKD<sup>17</sup> the current study focused on  
171 rural and urban Ghana (Ashanti region of Ghana). The RODAM study was conducted from 2012 to 2015  
172 and it comprised of individuals aged 25-70 years living in rural and urban Ghana and Ghanaian migrants  
173 in Europe. All participants below 25 and above 70 years were excluded in the present analyses. The  
174 present analysis was restricted to the rural and urban sites (n=2492) RODAM participants. Specifically,  
175 1043 participants from rural Ghana and 1449 from urban Ghana were used in this study.

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177 Data collection for the study was standardized across the sites. Written informed consent was obtained  
178 from each participant prior to enrolment in the study. The respective ethics committees in Ghana and the  
179 three European countries approved the study protocols before data collection began. Specifically, we  
180 obtained ethical clearance in Ghana from (School of Medical Sciences/Komfo Anokye Teaching Hospital  
181 Committee on Human Research, Publication & Ethical Review Board, in the Netherlands, (Institutional  
182 Review Board of the AMC, University of Amsterdam), in Germany, (Ethics Committee of Charite-  
183 Universitätsmedizin) and the UK (London School of Hygiene and Tropical Medicine Research Ethics  
184 Committee) before data collection began in each country.

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186 The response rate was 76% in rural Ghana and 74% in urban Ghana. In Ghana, participants were  
187 randomly drawn from a list of 30 enumeration areas in the Ashanti region based on the 2010 population  
188 census using the multistage random sampling. These enumeration areas came from two purposively  
189 selected urban cities (Kumasi and Obuasi) and 15 randomly selected rural communities in the Ashanti  
190 region. Selected health and community authorities were first identified, notified of the study and letters  
191 were sent giving detailed explanation of the study. We sent team members to stay among the communities  
192 to familiarize with them and organize mini clinics in the field. This lasted between 1-2 weeks depending  
193 on the sampled population and responsiveness of respondents.

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194 In Ghana, questionnaires administration and physical examination were done at the same day/time. The  
195 participants were instructed to fast from 10.00 pm the night before the physical examination. For the  
current study, 2566 participants with data available on both questionnaire data and physical measurements

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3 196 were used. We excluded (n=74) individuals outside the RODAM age range of 25-70 years resulting in a  
4 197 data set of 2492 for analysis. These comprised 1,449 Urban Ghana and 1043 Rural Ghana. For the final  
5 198 analysis, individuals with no data on CKD status (n=42) were excluded.

## 9 199 **Measurements**

## 11 200 **Covariates**

### 13 201 *Demographic and lifestyle factors*

16 202 Information on demographics, educational level, occupational level, wealth index and lifestyle factors  
17 203 (smoking and physical activity) were obtained by questionnaire. Physical examinations were performed  
18 204 with validated devices per standardized operational procedures across all study sites. Weight was  
19 205 measured in light clothing and without shoes with SECA 877 scales to the nearest 0.1 kg. Height was  
20 206 measured without shoes with a portable stadiometer (SECA 217) to the nearest 0.1 cm. Body mass index  
21 207 (BMI) was calculated as weight (kg) divided by height squared (m<sup>2</sup>). Overweight was defined as BMI of  
22 208  $\geq 25$  to  $< 30$  kg/m<sup>2</sup> and obesity as BMI  $\geq 30$  kg/m<sup>2</sup><sup>18</sup>. Per participant all anthropometrics were measured  
23 209 twice by the same assessor and the average of the two measurements were used for analyses.

### 29 210 *Predictor: SES*

32 211 Socioeconomic indicators used in this study were educational level, occupational status and level of  
33 212 wealth index. Educational level was determined based on self-reported highest educational qualification  
34 213 accomplished based on the Ghanaian educational system. Occupational level was determined based on  
35 214 self-reported current occupation if still employed and/or last occupation before retirement or student. The  
36 215 reported occupations were further coded according to the International Standard Classification of  
37 216 Occupations scheme (ISCO-08). Where 'high' (professionals, managers, clerical support staff, higher  
38 217 grade routine non-manual employees service and sales-related occupations) and 'low' (craft and related  
39 218 trades workers, elementary occupations and farmers) and the rest were categorize into the 'middle'.  
40 219 Wealth index was determined using the World Health Organization (WHO) standard of wealth index  
41 220 classification. Wealth index was based on data collected in the Household Questionnaire. The  
42 221 questionnaire comprised of questions on household's ownership of several consumer items such as  
43 222 television, car, flooring material, toilet facilities etc. Each household was assigned a standard score for  
44 223 each asset. Wealth index was then expressed in five categories. The five categories were further  
45 224 categorized into three categories by combining the second and third category due to small numbers<sup>19</sup>. All  
46 225 three SES constructs were further classified as low, medium and high SES and their relationship to each

226 other tested. A composite SES variable (SES) was generated based on the three SES constructs using the  
227 EGEN group command in STATA. This was also categorized into 3 categories (low, medium and high).

### 228 *Co-morbidity factors*

229 Blood pressure (BP) was measured three times using a validated semi-automated device (The Microlife  
230 WatchBP home) with appropriate cuffs in a sitting position after at least 5 min rest. The mean of the last  
231 two BP measurements was used in the analyses. Hypertension was defined as systolic BP  $\geq$  140 mmHg,  
232 and/or diastolic BP  $\geq$  90 mmHg, and/or being on antihypertensive medication treatment, and/or self-  
233 reported hypertension. Trained research assistants in the two sites collected fasting venous blood samples.  
234 All the blood samples were processed and aliquoted immediately (within one hour to maximum three  
235 hours of the vena puncture) after collection per standard operation procedures, and then temporarily  
236 stored at the local research location at  $-20^{\circ}\text{C}$ . The separated samples were then transported to the local  
237 research centres laboratories, where they were checked, registered and stored at  $-80^{\circ}\text{C}$ . To avoid intra-  
238 laboratory variability, the stored blood samples from the local research centres were transported to Berlin,  
239 Germany for biochemical analyses. Fasting plasma glucose concentration was measured using an  
240 enzymatic method (hexokinase). Type 2 diabetes was defined according to the WHO diagnostic criteria  
241 (fasting glucose  $\geq$ 7.0 mmol/L, and/or current use of medication prescribed to treat diabetes, and/or self-  
242 reported diabetes)<sup>20</sup>. Concentration of total cholesterol was assessed using colorimetric test kits. All  
243 biochemical analyses were performed using an ABX Pentra 400 chemistry analyzer (ABX Pentra; Horiba  
244 ABX, Germany). Hypercholesterolemia was defined as total cholesterol level  $\geq$  6.22 mmol/L. Serum  
245 creatinine concentration (in  $\mu\text{mol/L}$ ) was determined by a kinetic colorimetric spectrophotometric isotope  
246 dilution mass spectrometry-calibrated method (Roche Diagnostics). Biochemical analyses were subject to  
247 extensive quality checks including blinded serial measurements.

### 248 **Outcome: CKD prevalence**

249 Participants were asked to bring an early morning urine sample for the analyses of albuminuria and  
250 creatinine levels. Urinary albumin concentration (in mg/L) was measured by an immunochemical  
251 turbidimetric method (Roche Diagnostics). Urinary creatinine concentration (in  $\mu\text{mol/L}$ ) was measured by  
252 a kinetic spectrophotometric method (Roche Diagnostics). Estimated glomerular filtration rate (eGFR)  
253 was calculated using the CKDEPI (CKD Epidemiology Collaboration) creatinine equation<sup>21</sup>. Urinary  
254 albumin-creatinine ratio (ACR; expressed in mg/g) was calculated by taking the ratio between urinary  
255 albumin and urinary creatinine. eGFR and albuminuria were categorized according to the 2012 KDIGO  
256 (Kidney Disease: Improving Global Outcomes) classification<sup>22</sup>. eGFR was categorized as follows: G1,  $\geq$   
257 90 mL/min/1.73 m<sup>2</sup> (normal kidney function); G2, 60 to 89 mL/min/1.73 m<sup>2</sup> (mildly decreased); G3a, 45

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3 258 to 59 mL/min/1.73 m<sup>2</sup> (mildly to moderately decreased); G3b, 30 to 44 mL/min/1.73 m<sup>2</sup> (moderately to  
4 259 severely decreased); G4, 15 to 29 mL/min/1.73 m<sup>2</sup> (severely decreased); and G5, < 15 mL/min/1.73 m<sup>2</sup>  
5 260 (kidney failure). Albuminuria categories were derived from ACR and were as follows: A1, < 3mg/mmol  
6 261 (normal to mildly increased); A2, 3 to 30 mg/mmol (moderately increased); and A3, > 30mg/mmol  
7 262 (severely increased). CKD status was categorized according to severity of kidney disease (green, low risk;  
8 263 yellow, moderately increased risk; orange, high risk; and red, very high risk) using the combination of  
9 264 eGFR (G1-G5) and albuminuria (A1-A3) levels defined by the 2012 KDIGO guideline<sup>23</sup>. Due to the  
10 265 small number of participants in the very high risk category of CKD, high and very high risk groups were  
11 266 combined. Reduced eGFR was defined as eGFR < 60 mL/min/1.73 m<sup>2</sup>. Because of the small number of  
12 267 participants in the severely increased albuminuria category, we defined albuminuria as ACR ≥3 mg/mmol  
13 268 by combining the moderately increased (A2) and severely increased (A3) categories.

## 21 269 **Patient and Public Involvement**

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24 270 Community leaders were involved in the recruitment of patients. These comprised of religious  
25 271 communities (churches and mosques), endorsement from local key leaders and establishing relationships  
26 272 with healthcare organizations. We also provided information on the study by involving the local media  
27 273 (radio and television stations). We sent letters to all selected health and community authorities to notify  
28 274 participants of the study. Team members were sent to the various community to stay among the  
29 275 community and organize mini clinics for a period of 1-2 weeks. Results of the study were disseminated  
30 276 through seminars, durbars and via radio and television stations.

## 35 277 **Statistical methods**

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38 278 Participants' characteristics were expressed as absolute numbers and percentages for categorical variables  
39 279 and as means and standard deviations (SD) for continuous variables. CKD prevalence with 5% error bars  
40 280 were presented as bar graphs for each SES construct across rural and urban Ghana. Spearman's rank  
41 281 correlation was used to determine correlations between the three SES constructs. Odds ratios (ORs) and  
42 282 their corresponding 95% confidence intervals (CIs) were estimated by means of logistic regression  
43 283 analyses to study the odds of albuminuria (ACR>3 mg/mmol, A2-A3, moderately to severely increased  
44 284 albuminuria), reduced kidney function (eGFR< 60 mL/min/1.73 m<sup>2</sup>, G3-G5 moderately to severely  
45 285 decreased kidney function) and increased CKD risk (high and very high CKD risk) by SES, with  
46 286 adjustments for potential covariates (age and sex). These covariates were adjusted for to account for their  
47 287 impact in the pathway of CKD incidence, prevalence and progression<sup>24</sup>. The analyses were performed  
48 288 for the total population (using low educational level, low occupational status and low level of wealth  
49 289 index as reference categories). Further analysis was conducted using rural Ghana as reference. Model 1

290 was adjusted for age and sex while model 2 was adjusted for age, sex and educational level. Model 3 was  
 291 adjusted for age, sex and occupational status while model 4 was adjusted for age, sex and level of wealth  
 292 index. Model 5 was adjusted for age, sex, educational level, occupational level and wealth index ( $p < 0.05$ ).  
 293 Tolerance test and variance inflation factor (VIF) showed very small degree of collinearity among SES  
 294 predictors thus we adjusted for each of SES variables separately. Complete case analysis approach was  
 295 used. All data available were included in the age-adjusted models. All analyses were performed using  
 296 STATA, version 14.0 (StataCorp LP).

## 297 Results

298  
 299 Table 1 shows characteristics of study participants. Participants in rural Ghana were slightly older than  
 300 those in urban Ghana. Female preponderance was observed in both rural and urban Ghana, though higher  
 301 proportions were observed in urban Ghana. Individuals living in rural Ghana were generally less educated  
 302 compared with those living in urban Ghana. There were slightly more individuals with low occupational  
 303 status in urban Ghana compared with their peers in rural Ghana. People in urban Ghana were wealthier  
 304 than their rural counterparts. Rural Ghanaians were more physically active compared with their urban  
 305 peers. Smoking was low among Ghanaians though rural Ghanaians were more likely to smoke compared  
 306 with their urban peers. Hypercholesterolemia was more prevalent in urban Ghana than in rural Ghana.  
 307 Hypertension and type 2 diabetes were more prevalent in urban Ghanaians compared with those living in  
 308 rural Ghana. Urban Ghanaians were markedly more obese compared with their rural peers. Except for  
 309 eGFR, albuminuria and CKD risk prevalence rates were higher in urban Ghana compared with rural  
 310 Ghana.

311 **Table 1: Baseline characteristics by location**

	Rural Ghana	Urban Ghana
Number of participants, N (%)	1043 (41.9)	1449 (58.1)
Mean age, years (SD)	46.5 (12.6)	45.2 (11.4)
Females, N (%)	638 (61.2)	1034 (71.4)
Educational level n (%)		
Low	555 (56.9)	614 (43.9)
Middle	311 (31.9)	547 (39.1)
High	108 (11.2)	239 (17.0)
Occupational status, n (%)		
Low	250 (25.7)	374 (26.7)
Middle	628 (64.5)	818 (58.4)

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High	96 (9.8)	209 (14.9)
Wealth index, n (%)		
Low	449 (46.5)	368 (26.6)
Middle	276 (28.6)	416 (30.0)
High	241 (24.9)	602 (43.4)
BMI (kg/m <sup>2</sup> )		
< 25	794 (76.3)	579 (39.9)
25-29.9	189 (18.2)	495 (34.2)
≥ 30	58 (5.5)	374 (25.9)
Low physical activity, n (%)	663 (47.22)	592 (60.7)
Smoking, n (%)	22 (2.3)	14 (1.0)
Hypercholesterolemia, n (%)	78 (7.6)	270 (18.7)
Hypertension, n (%)	306 (29.3)	531 (36.7)
Diabetes, n (%)	53 (5.1)	153 (10.6)
Albuminuria, n (%)		
A1, Normal to mildly increased (ACR <3 mg/mmol)	930 (91.6)	1285 (89.1)
A2-A3, moderately to severely increased (ACR ≥ 3 mg/mmol)	85 (8.4)	158 (10.9)
eGFR, n (%)		
G1-G2 (≥ 60 mL/min/1.73m <sup>2</sup> )	989 (96.3)	1388 (96.3)
G3-G5 (<60 mL/min/1.73m <sup>2</sup> )	38 (3.7)	54 (3.7)
CKD risk, n (%)		
Low risk (green)	916 (90.5)	1281 (88.9)
Moderately increased to very high risk (yellow to red)	96 (9.5)	160 (11.1)

**Abbreviations:** N, number of respondents; SD, standard deviation; eGFR, estimated glomerular filtration rate; ACR, albumin creatinine ratio; CKD, Chronic kidney disease

Figure 1 shows prevalence of CKD by level of education in urban and rural Ghana. Prevalence of CKD decreased with increasing levels of education in rural Ghana. Higher prevalence of CKD was observed among individuals with low educational level compared with those with middle and high educational level. However, those with high educational level in urban Ghana had higher prevalence of CKD compared with those with middle level education. For occupational status, prevalence of CKD was higher among individuals with low occupational status in urban Ghana. Similar patterns were observed in rural Ghana, however, those with higher occupational status had higher prevalence of CKD compared with those with middle occupational status (Figure 2). Figure 3 shows prevalence of CKD by level of wealth index. CKD prevalence among the levels of wealth index varied between urban and rural Ghana. Those with middle level wealth index had higher prevalence of CKD compared with those with low or high CKD prevalence in both rural and urban Ghana. CKD prevalence rate for low and high level wealth index in urban Ghana was the same while that of rural Ghana was slightly different.

329 Among the whole group, educational level was positively associated with wealth index ( $p<0.01$ ) and composite SES ( $P<0.01$ ). Occupational level  
 330 was also inversely associated with educational level ( $p<0.01$ ) and wealth index ( $p<0.01$ ). In urban Ghana, high educational level was positively  
 331 associated with high wealth index but inversely associated with occupation ( $p<0.01$ ). In rural Ghana, high education was positively associated with  
 332 high wealth index ( $p<0.01$ ), but there was no significant association between education and occupation. High wealth index was inversely  
 333 associated with high occupational status in both rural and urban Ghana ( $p<0.01$ ) (Table 2).

334 **Table 2: Relationship between SES constructs (educational, occupational level and wealth index) by urban rural Ghana**

Correlation matrix	Educational level	Occupational level	Wealth index	SES
<b>Whole group</b>				
Educational level	1.000			
Occupational status	<b>-0.060</b>	1.000		
	<b>0.004</b>			
Wealth Index	0.282	<b>-0.121</b>	1.000	
	0.001	<b>0.001</b>		
SES	<b>1.000</b>	<b>-0.059</b>	<b>0.282</b>	1.000
	<b>0.003</b>	<b>0.006</b>	<b>0.001</b>	
<b>Urban Ghana</b>				
Educational level	1.000			
Occupational status	<b>-0.115</b>	1.000		
	<b>0.001</b>			
Wealth Index	<b>0.294</b>	<b>-0.126</b>	1.000	

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		<b>0.001</b>	<b>0.001</b>		
SES		<b>1.000</b>	<b>-0.024</b>	<b>0.937</b>	1.000
		<b>0.002</b>	<b>0.001</b>	<b>0.001</b>	
<b>Rural Ghana</b>					
Educational level		1.000			
Occupational status		0.017	1.000		
		0.589			
Wealth Index		<b>0.219</b>	<b>-0.135</b>	1.000	
		<b>0.001</b>	<b>0.001</b>		
SES		<b>0.504</b>	0.017	<b>0.934</b>	1.000
		<b>0.001</b>	0.587	<b>0.001</b>	

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Table 3 shows association between level of education, occupational status, level of wealth index and prevalence of CKD. After adjusting for age and sex for the whole group, albuminuria was associated with middle level education ( $p < 0.01$ ). After adjusting for age and sex, we observed no significant association between SES indicators (educational level, occupational status and wealth index) and CKD in urban Ghana. However, middle and higher level education was associated with reduced albuminuria in urban Ghana ( $p < 0.01$ ). Whereas educational level and occupational status were not associated with CKD prevalence, high wealth index was significantly associated with higher odds of reduced eGFR ( $p < 0.01$ ).

**Table 3: Association of SES indicators (educational level, occupational status and wealth index level) with albuminuria, reduced eGFR and CKD risk**

	Albuminuria (ACR $\geq$ 3 mg/mmol)		eGFR < 60 mL/min/1.73 m <sup>2</sup>		High to very high CKD risk (KDIGO, 2012)	
	n (%)	OR (95% CI) Model 1	n (%)	OR (95% CI) Model 1	n cases (%)	OR (95% CI) Model 1
<b>Education</b>						
<b>Whole group</b>						
Low	1,152 (11.89)	1.00 (Reference)	1,160 (3.97)	1.00 (Reference)	1,150 (11.91)	1.00 (Reference)
Middle	847 (7.32)	<b>0.66 (0.48-0.91)</b>	849 (3.77)	1.36 (0.83-2.22)	845 (8.28)	0.82 (0.59-1.12)
High	343 (7.00)	0.67 (0.42-1.07)	345 (3.19)	1.11 (0.55-2.29)	343 (8.75)	0.96 (0.62-1.49)
<b>Urban Ghana</b>						
Low	612 (14.7)	1.00 (Reference)	612 (4.1)	1.00 (Reference)	612 (14.1)	1.00 (Reference)
Middle	546 (7.8)	<b>0.51 (0.34-0.76)</b>	546 (3.7)	1.12 (0.59-2.12)	545 (8.1)	<b>0.59 (0.39-0.89)</b>
High	238 (8.4)	<b>0.53 (0.31-0.91)</b>	238 (3.4)	0.91 (0.37-2.19)	238 (10.9)	0.83 (0.51-1.38)
<b>Rural Ghana</b>						
Low	540 (8.7)	1.00 (Reference)	548 (3.8)	1.00 (Reference)	538 (9.5)	1.00 (Reference)
Middle	301 (6.3)	0.89 (0.51-1.59)	303 (3.9)	1.69 (0.77-3.66)	300 (8.7)	1.33 (0.79-2.25)
High	105 (3.8)	0.66 (0.23-1.95)	107 (2.8)	1.28 (0.35-4.71)	105 (3.8)	0.69 (0.23-2.02)
<b>Occupational status</b>						
<b>Whole group</b>						
Low	614 (9.93)	1.00 (Reference)	616 (2.76)	1.00 (Reference)	613 (9.46)	1.00 (Reference)

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3	Middle	1,427 (9.25)	0.82 (0.59-1.14)	1,436 (3.34)	0.93 (0.52-1.66)	1,424 (9.90)	0.89 (0.65-1.24)
4	High	302 (10.26)	0.76 (0.47-1.22)	303 (7.92)	1.33 (0.67-2.62)	302 (12.91)	0.90 (0.57-1.42)
5							
6	<b>Urban Ghana</b>						
7	Low	207 (10.1)	1.00 (Reference)	207 (6.8)	1.00 (Reference)	207 (12.1)	1.00 (Reference)
8	Middle	817 (11.1)	1.50 (0.88-2.83)	817 (3.6)	1.15 (0.56-2.35)	816 (11.6)	1.37 (0.84-2.56)
9	High	373 (11.0)	1.57 (0.89-2.53)	373 (2.7)	1.02 (0.41-2.52)	373 (9.7)	1.21 (0.68-2.14)
10							
11	<b>Rural Ghana</b>						
12	Low	95 (10.5)	1.00 (Reference)	96 (10.4)	1.00 (Reference)	95 (14.7)	1.00 (Reference)
13	Middle	610 (6.7)	0.65 (0.31-1.37)	619 (3.1)	<b>0.37 (0.16-0.85)</b>	608 (7.6)	0.55 (0.28-1.08)
14	High	241 (8.3)	0.99 (0.43-2.28)	243 (2.9)	0.51 (0.18-1.44)	240 (9.2)	0.94 (0.44-2.01)
15							
16	<b>Wealth index</b>						
17							
18	<b>Whole group</b>						
19	Low	808 (9.65)	1.00 (Reference)	813 (3.32)	1.00 (Reference)	808 (9.16)	1.00 (Reference)
20	Middle	678 (10.91)	1.18 (0.84-1.66)	683 (3.81)	1.30 (0.74-2.28)	675 (12.0)	1.43 (1.02-2.01)
21	High	835 (8.62)	0.93 (0.66-1.31)	835 (4.19)	1.55 (0.91-2.64)	833 (9.96)	1.21 (0.86-1.69)
22							
23	<b>Urban Ghana</b>						
24	Low	367 (11.2)	1.00 (Reference)	367 (3.5)	1.00 (Reference)	367 (10.1)	1.00 (Reference)
25	Middle	414 (12.3)	1.12 (0.73-1.74)	414 (3.9)	1.30 (0.61-2.80)	413 (13.1)	1.45 (0.93-2.27)
26	High	601 (9.8)	0.82 (0.55-1.25)	600 (3.8)	1.13 (0.55-2.31)	600 (10.8)	1.11 (0.72-1.71)
27							
28	<b>Rural Ghana</b>						
29	Low	441 (7.9)	1.00 (Reference)	446 (3.1)	1.00 (Reference)	441 (8.4)	1.00 (Reference)
30	Middle	264 (8.7)	1.13 (0.65-1.98)	269 (3.7)	1.22 (0.52-2.84)	262 (10.3)	1.31 (0.77-2.25)
31	High	234 (5.6)	0.78 (0.40-1.53)	235 (5.1)	<b>2.38 (1.03-5.47)</b>	233 (7.7)	1.16 (0.63-2.14)
32							

Model 1, adjusted for age and sex; Abbreviations: CI, confidence interval; ACR, albumin creatinine ration; eGFR, estimated glomerular filtration rate; CKD, chronic kidney disease; OR, odds ratio, n= total number of individuals in the whole group, rural and urban Ghana among the various levels of SES constructs; %, proportion of individuals with CKD among the various levels of SES constructs in rural and urban Ghana.

Table 4 shows the contribution of all three SES constructs to rural and urban CKD prevalence differences. The odds of albuminuria and CKD risk was significantly higher in urban Ghana compared with rural Ghana. The higher rate of CKD observed in urban Ghana was not explained by the higher SES of that population as compared to their rural counterparts.

**Table 4: Contribution of SES indicators to rural-urban differences in albuminuria, reduced eGFR and CKD risk**

		OR (95% CI) Model 1	OR (95% CI) Model 2	OR (95% CI) Model 3	OR (95% CI) Model 4	OR (95% CI) Model 5
<b>Albuminuria (ACR <math>\geq</math> 3 mg/mmol)</b>						
Sites	n cases (%)					
Urban Ghana	1,443 (10.9)	<b>1.37 (1.03-1.81)</b>	<b>1.70 (1.25-2.31)</b>	<b>1.55 (1.15-2.10)</b>	<b>1.62 (1.18-2.19)</b>	<b>1.74 (1.27-2.38)</b>
Rural Ghana	1,015 (8.4)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
<b>eGFR &lt; 60 mL/min/1.73 m<sup>2</sup></b>						
Sites	n cases (%)					
Urban Ghana	1,442 (3.7)	1.27 (0.82-1.97)	1.20 (0.76-1.89)	1.18 (0.79-1.86)	1.12 (0.70-1.78)	1.07 (0.67-1.72)
Rural Ghana	1,027 (3.7)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
<b>High to very high CKD risk</b>						
Sites	n cases (%)					
Urban Ghana	1,441 (11.1)	<b>1.23 (1.01-1.62)</b>	<b>1.44 (1.07-1.93)</b>	<b>1.38 (1.03-1.84)</b>	<b>1.36 (1.01-1.83)</b>	<b>1.40 (1.04-1.91)</b>
Rural Ghana	1,012 (9.46)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)

Model 1: adjusted for age and sex; Model 2: adjusted for age, sex and education level; Model 3: adjusted for age, sex and occupational status; Model 4: adjusted for age, sex and wealth index; Model 5: adjusted for age, sex, educational level, occupational status and wealth index; Abbreviations: CI, confidence interval; ACR, albumin creatinine ratio; eGFR, estimated glomerular filtration rate; CKD, chronic kidney disease; OR, odds ratio, n=number of participants. n= total number of individuals in rural and urban Ghana; %, proportion of individuals with CKD among urban and rural Ghana.

## 375 **Discussion**

### 376 ***Key findings***

377 Our study findings show no association between all three SES constructs and the prevalence of CKD in  
378 both rural and urban Ghana except for wealth index in rural Ghana, with the risk of CKD being higher in  
379 the wealthier populations. The higher rate of CKD observed in urban Ghana could not be attributed to the  
380 higher SES of that population compared to their rural counterparts.

381

### 382 **Discussion of key findings**

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#### 384 ***Association of SES with CKD in rural and urban Ghana***

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386 Our study did not find any significant associations between all three SES constructs and CKD among  
387 rural and urban Ghana except for wealth index in rural Ghana. The positive association observed between  
388 wealth index in rural Ghana may be due to a number of reasons. A comparison of the three SES  
389 constructs showed higher educational level to be associated with wealth index in both rural and urban  
390 Ghana but not occupational level. This seems to suggest that occupational level may not be adequately  
391 capturing the SES status of individuals living in these settings in relation to CKD. For example, Masthi et  
392 al, compared different SES scales in rural and urban India and concluded that Standard of Living Index  
393 (SLI) scale was more accurate for classification of SES in urban and rural setting <sup>25</sup>. Our finding is  
394 consistent with other studies, <sup>6 26</sup> which reported no association between SES and CKD in high-income  
395 countries and LMICs, but in contrast with other studies <sup>2-4 27</sup> that found positive associations between  
396 SES and CKD. The reasons for our current finding are unclear. However, it has been suggested that these  
397 inconsistent associations may be due to the varying pathways through which the effect of SES on health  
398 status is mediated. For example, at a given educational level marked ethnic differences have been  
399 reported. Additionally, similar differences were observed for wealth status at a given income level <sup>28-30</sup>.

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#### 401 ***Contribution of SES to observed CKD risk differences between rural and urban Ghana***

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403 We observed higher rates of CKD in urban Ghana compared with rural Ghana, as expected. The observed  
404 higher rates of CKD in our study were not explained by the higher SES of that population as compared to  
405 their rural counterparts. Our results indicate that this is due to the lack of a clear difference in the SES  
406 distribution of rural and urban Ghana observed in this study, as well as to the lack of associations between  
407 SES and CKD. Consistent with our findings, in a study conducted in Northern Tanzania SES did not  
408 explain increased risk of CKD in urban Tanzania <sup>26</sup>. The lack of associations between SES and CKD  
409 could probably partly be explained by the process of epidemiological transition in relation to the

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3 410 “diffusion theory” of ischemic heart disease mortality. This theory attributes the commencement of  
4 411 ischemic heart disease to individuals in the high SES group due to their ability to afford behaviours  
5 412 (smoking, alcohol and sedentary lifestyles) which increased risk of ischemic heart disease. The lower SES  
6 413 groups were later affected partially because of improved living standards, imitation and urbanization. The  
7 414 higher SES groups were the first to embrace behavioural changes required to decrease the risk of ischemic  
8 415 heart disease and this resulted in reversing the gradient<sup>31</sup>. The rapid urbanization of some rural  
9 416 communities in the Ashanti region of Ghana and the imitation of urban lifestyle could account for our  
10 417 finding. Also, it could be that whereas the high SES group in urban Ghana has already embraced  
11 418 favourable behavioural changes, those in rural Ghana are yet to do so<sup>32</sup>. This explains the observed  
12 419 association of wealth index with CKD in rural Ghana but not in urban Ghana. The complexities of  
13 420 influence of SES on prevalence and progression of CKD and the differential prevalence of established  
14 421 risk factors (diabetes, obesity and hypertension) in rural and urban Ghana may also contribute to the  
15 422 different associations of SES with CKD prevalence observed in rural and urban Ghana. In our study, the  
16 423 prevalence rates of hypercholesterolemia, hypertension and type 2 diabetes were substantially higher in  
17 424 urban Ghana compared with that of rural Ghana. Also, the interplay of other less understood or researched  
18 425 factors (e.g., exposure to nephrotoxins, herbal medications, sepsis) may be influencing the pathway in  
19 426 which SES influences CKD prevalence and progression.

### 427 428 ***Strength and limitation***

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430 Our study presents several strengths. First, we used well-standardized study protocols across rural and  
431 urban Ghana. Our study is also the first in Africa to use all three categories of CKD definition  
432 (albuminuria, reduced eGFR and CKD risk) by KDIGO 2012 in assessing association of SES with CKD  
433 in rural and urban setting, this provides a more detailed information on CKD outcomes. The limitation of  
434 intra laboratory variability in earlier studies was eliminated using the same standard operating procedures  
435 in the same laboratory for running all samples for both rural and urban Ghana. The use of three constructs  
436 of SES in this study also provides a much better holistic approach to assessing SES. Also, the distribution  
437 of SES in our study reflect on the national data allowing for generalization of our findings. Our study was  
438 limited by the use of cross sectional design, which prevented us from determining causality between  
439 predictors and CKD progression. Furthermore, there were more women than men in our study due to the  
440 higher response rate in women compared with men. However, this applied to both rural and urban Ghana.  
441 We therefore do not expect this to influence our results in a significant way.

### 442 443 444 ***Conclusion***

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3 446 All three SES constructs appear not to be associated with prevalence of CKD in urban and rural Ghana  
4 447 except for wealth index in rural Ghana. The observed higher prevalence of CKD in urban Ghana was not  
5 448 explained by the higher SES in urban Ghana. Our study seems to suggest that other non-traditional factors  
6 449 such as nephrotoxins, herbal medications and misuse of over the counter drugs may play a role and  
7 450 underscores the need to further explore these factors.  
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18 457 management and high-quality storage of collected samples.  
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25 460 **Contributors**  
26 461 My co-authors have all contributed substantially to this manuscript and approve of this  
27 462 submission. Research idea and study design: DNA, CA, KS, DA, EB, KM, JA; data acquisition  
28 463 and curation: DNA, CA, EB, KM, data analysis/interpretation: DNA, CA, KS, DA, EB, KM, LS,  
29 464 JA, EOD, KKB, FPM, ID, JS, SB, ADA; statistical analysis: DNA, CA, KS. DNA, CA, KS, DA,  
30 465 EB, KM, LS, JA, EOD, KKB, FPM, ID, JS, SB, ADA contributed important intellectual content  
31 466 during manuscript drafting or revision and accepts accountability for the overall work by  
32 467 ensuring that questions pertaining to the accuracy or integrity of any portion of the work are  
33 468 appropriately investigated and resolved. DNA and CA takes responsibility that this study has  
34 469 been reported honestly, accurately, and transparently; that no important aspects of the study have  
35 470 been omitted; and that any discrepancies from the study as planned have been explained.  
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3 479 **Competing interest:** I have communicated with all my co-authors and obtained their full  
4 480 disclosures. My co-authors and I declare no conflicts of interest.  
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7 482 **Patient Consent:** None declared  
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9 484 **Ethics approval:** IRBs at each participating site.  
10 485

11 486 **Data sharing statement:** Data are available from the RODAM research cohort, a third party. Dr.  
12 487 Eric Beune affiliated with the RODAM research cohort and a co-author of this paper in  
13 488 accordance with the RODAM requirements for collaboration. Dr. Beune is the Data Collection  
14 489 Coordinator of RODAM and may be contacted with further questions (e.j.beune@amc.uva.nl).  
15 490 Additionally, researchers interested in further collaboration with RODAM may see the following  
16 491 URL: <http://www.rod-am.eu/>  
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### Legend for figures

Figure 1: Prevalence of chronic kidney disease (CKD) across level of education among urban and rural participants Definitions according to 2012 KDIGO (Kidney Disease: Improving Global

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3 613 Outcomes) guideline. CKD was defined as being in moderately increased risk, high-risk, or very  
4 614 high-risk groups.  
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8 617 Figure 2: Prevalence of chronic kidney disease (CKD) across occupational status among urban  
9 618 and rural participants. Definitions according to 2012 KDIGO (Kidney Disease: Improving  
10 619 Global Outcomes) guideline. CKD was defined as being in moderately increased risk, high-risk,  
11 620 or very high-risk groups.  
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16 624 Figure 3: Prevalence of chronic kidney disease (CKD) across wealth index categories among  
17 625 urban and rural participants. Definitions according to 2012 KDIGO (Kidney Disease: Improving  
18 626 Global Outcomes) guideline. CKD was defined as being in moderately increased risk, high-risk,  
19 627 or very high-risk groups.  
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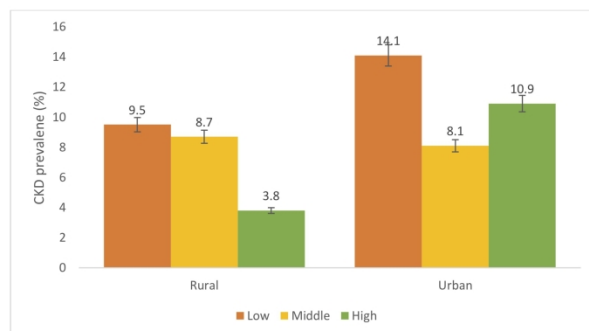


Figure 1: Prevalence of chronic kidney disease (CKD) across level of education among urban and rural participants Definitions according to 2012 KDIGO (Kidney Disease: Improving Global Outcomes) guideline. CKD was defined as being in moderately increased risk, high-risk, or very high-risk groups

Figure 1: Prevalence of chronic kidney disease (CKD) across level of education among urban and rural participants Definitions according to 2012 KDIGO (Kidney Disease: Improving Global Outcomes) guideline. CKD was defined as being in moderately increased risk, high-risk, or very high-risk groups.

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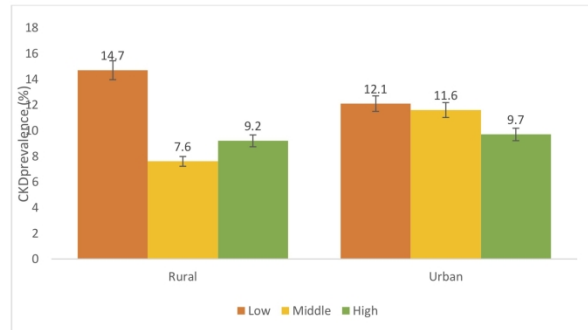


Figure 2: Prevalence of chronic kidney disease (CKD) across occupational status among urban and rural participants. Definitions according to 2012 KDIGO (Kidney Disease: Improving Global Outcomes) guideline. CKD was defined as being in moderately increased risk, high-risk, or very high-risk groups

Figure 2: Prevalence of chronic kidney disease (CKD) across occupational status among urban and rural participants. Definitions according to 2012 KDIGO (Kidney Disease: Improving Global Outcomes) guideline. CKD was defined as being in moderately increased risk, high-risk, or very high-risk groups.

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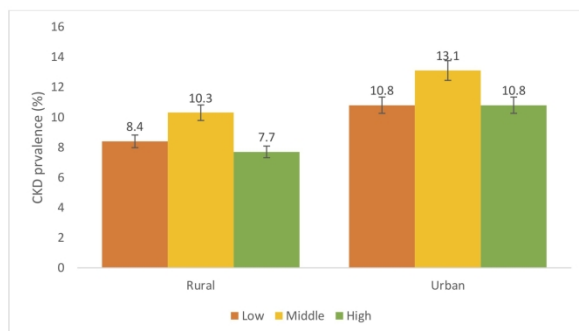


Figure 3: Prevalence of chronic kidney disease (CKD) across wealth index categories among urban and rural participants. Definitions according to 2012 KDIGO (Kidney Disease: Improving Global Outcomes) guideline. CKD was defined as being in moderately increased risk, high-risk, or very high-risk groups

Figure 3: Prevalence of chronic kidney disease (CKD) across wealth index categories among urban and rural participants. Definitions according to 2012 KDIGO (Kidney Disease: Improving Global Outcomes) guideline. CKD was defined as being in moderately increased risk, high-risk, or very high-risk groups.

279x361mm (300 x 300 DPI)

## STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No.	Recommendation	Page No.	Relevant text from manuscript
<b>Title and abstract</b>	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1,2	We have included a commonly used term in the title and abstract
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2	Our study did not find any associations between SES indicators and CKD in both rural and urban Ghana after age and sex adjustment except in rural Ghana where wealth index was associated with prevalence of CKD. Consequently, the higher SES did not account for the increased rate of CKD among urban dwellers suggesting the need to identify other factors that may be driving this.
<b>Introduction</b>				
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4	The theoretical and scientific background as well as the rationale for conducting the study have been provided in the introduction section.
Objectives	3	State specific objectives, including any prespecified hypotheses	4	We assessed the association of SES with CKD in rural and urban Ghana and studied what extent the higher SES of people in urban areas could account for differences in CKD between rural and urban populations
<b>Methods</b>				
Study design	4	Present key elements of study design early in the paper	5-6	Details given in the methods
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6	Rural or urban Ghana.

Participants	6	<p>(a) <i>Cohort study</i>—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up</p> <p><i>Case-control study</i>—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls</p> <p><i>Cross-sectional study</i>—Give the eligibility criteria, and the sources and methods of selection of participants</p>	6-8	A multi-centre cross-sectional study was conducted among Ghanaian adults (n=2492) aged 25-70 years residing in rural and urban Ghana.
		<p>(b) <i>Cohort study</i>—For matched studies, give matching criteria and number of exposed and unexposed</p> <p><i>Case-control study</i>—For matched studies, give matching criteria and the number of controls per case</p>		
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8	The main outcomes have been clearly defined.
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-8	We defined each variable of interest in the methods accordingly
Bias	9	Describe any efforts to address potential sources of bias	18	Potential sources of bias have discussed in the discussion section
Study size	10	Explain how the study size was arrived at	5	Given in the methods section and we have also referred to the RODAM study methods paper

Continued on next page

Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8-9	Please see methods
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	8-9	Please see methods
		(b) Describe any methods used to examine subgroups and interactions	8-9	Please see methods
		(c) Explain how missing data were addressed	8-9	
		(d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed	NA	We have reported non-response across sites
		(e) <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed		
		<i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy		
		(e) Describe any sensitivity analyses	NA	
<b>Results</b>				
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5	Non-response analysis was done to shed light on the differential response rates across sites
		(b) Give reasons for non-participation at each stage	5	
		(c) Consider use of a flow diagram	5	We have also referred to RODAM methods paper
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	5	We have also referred to RODAM methods paper
		(b) Indicate number of participants with missing data for each variable of interest	5	We have also referred to RODAM methods paper
		(c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	NA	
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time	NA	
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure	NA	
		<i>Cross-sectional study</i> —Report numbers of outcome events or summary measures	9-10	Summary measures are given in the results section and in tables and figures
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12-16	Unadjusted and adjusted estimates are given in the results section and in figures
		(b) Report category boundaries when continuous variables were categorized	12-16	We have provided mean and corresponding standard deviations for the continuous variables.



		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time	NA	
		Continued on next page		
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA	
<b>Discussion</b>				
Key results	18	Summarise key results with reference to study objectives	8	
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	18	Key limitations regarding study methods including differential response rates and sampling methods in the various study sites have been provided
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	17-18	Cautious overall interpretation of the key findings have been provided.
Generalisability	21	Discuss the generalisability (external validity) of the study results	17-18	
<b>Other information</b>				
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	19	The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).

# BMJ Open

## A CROSS-SECTIONAL STUDY OF ASSOCIATION BETWEEN SOCIOECONOMIC INDICATORS AND CHRONIC KIDNEY DISEASE IN RURAL-URBAN GHANA-THE RODAM STUDY

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**A CROSS SECTIONAL STUDY OF ASSOCIATION BETWEEN  
SOCIOECONOMIC INDICATORS AND CHRONIC KIDNEY DISEASE IN  
RURAL-URBAN GHANA-THE RODAM STUDY**

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## 8 40 **Abstract**

9 41  
10 42 **Objectives:** Studies from high income countries suggest higher prevalence of Chronic Kidney Disease  
11 43 (CKD) among individuals in low socio-economic groups. However, some studies from low and middle-  
12 44 income countries (LMICs) show the reverse pattern among those in high socioeconomic groups. It is  
13 45 unknown which pattern applies to individuals living in rural and urban Ghana. We therefore assessed the  
14 46 association between Socio-Economic Status (SES) indicators and CKD in rural and urban Ghana and to  
15 47 what extent the higher SES of people in urban areas of Ghana could account for differences in CKD  
16 48 between rural and urban populations.  
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18 50 **Methods:** We used baseline data from multi-centre Research on Obesity and Diabetes among  
19 51 African Migrants (RODAM) study. The sample consisted of 2492 adults (Rural Ghana, 1043, Urban  
20 52 Ghana, 1,449) aged 25 to 70 years living in Ghana. Three CKD outcomes were considered using the 2012  
21 53 KDIGO (Kidney Disease: Improving Global Outcomes) severity of CKD classification: albuminuria  
22 54 (albumin-creatinine ratio  $\geq 3$  mg/mmol (category  $\geq$  A2)); reduced glomerular filtration rate (eGFR  $< 60$   
23 55 mL/min/1.73 m<sup>2</sup> (category  $\geq$  G3)) and high to very high CKD risk based on the combination of these two.  
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26 57 **Results:** All three SES indicators were not associated with CKD in both rural and urban Ghana after age  
27 58 and sex adjustment except for rural Ghana where high wealth index was significantly associated with  
28 59 higher odds of reduced eGFR (AOR, 2.38; 95% C.I. 1.03-5.47). The higher rate of CKD observed in  
29 60 urban Ghana was not explained by the higher SES of that population.  
30 61

31 62 **Conclusion:** SES indicators were not associated with prevalence of CKD except for wealth index and  
32 63 reduced eGFR in rural Ghana. Consequently, the higher SES of did not account for the increased rate of  
33 64 CKD among urban dwellers suggesting the need to identify other factors that may be driving this.  
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37 67 **Index Words:** Chronic kidney disease; socioeconomic status; health inequalities; risk factor; ethnic  
38 68 minority groups; migrants; RODAM study, Ghana  
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### Strengths and limitation of the study

- The use of well-standardized study protocols across rural and urban Ghana eliminated intra protocol variability.
- Our study is also the first in Africa to use all three categories of CKD definitions (albuminuria, reduced eGFR and CKD risk) by KDIGO 2012 in assessing association of SES with CKD in rural and urban setting. This provides more detailed information on CKD outcomes.
- The limitation of intra laboratory variability in earlier studies was eliminated using the same standard operating procedures in the same laboratory for running all samples for both rural and urban Ghana.
- The use of three constructs of SES (educational level, occupational level and wealth index) in this study also provides a much better holistic approach to assessing SES associations with CKD.
- Our study was limited because of the use of cross sectional design which prevented us from determining causality between predictors and CKD progression.

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## Introduction

In general, individuals in lower socio-economic status (SES) groups have been shown to suffer more frequently from Chronic Kidney Disease (CKD), often progressing to End Stage Renal Disease (ESRD), and associated with inadequate dialysis treatment, reduced access to kidney transplantation and poor health outcomes<sup>1</sup>. Recent studies have consistently found low SES to be associated with higher risk of CKD among people of African origin<sup>2-5</sup>.

However, in some settings the well-known inverse association between SES and CKD seems to be absent, or even reversed. For example, Bryne et al. did not find an association between SES and End Stage Renal Disease<sup>6</sup>. Other studies have found a positive association between SES and CKD<sup>7 8</sup>. Specifically, as SES improved, unhealthful lifestyle (unhealthy diet, physical inactivity, smoking and alcohol consumption) increased in China while that of the United States decreased with improved SES<sup>9</sup>. People with higher incomes, in these contexts, can afford a western

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3 139 lifestyle, which is more readily available in the urban areas than in the rural areas.

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5 140 There is therefore an interaction between individual SES and environmental factors,

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8 141 such as food and sedentary life style in such populations <sup>10-12</sup>. Consequently, in those

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11 142 settings, people with a higher SES might have higher CKD risk.

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13 143 In urban areas, the population in general has a higher SES than in rural areas <sup>13</sup>. For example, individuals

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15 144 with higher educational level migrate from rural areas to find higher occupations matching their higher

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17 145 education to improve on their wealth. If indeed a positive association between SES and CKD is observed

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19 146 in LMICs, this might underlie the well-known health differences between urban and rural areas, with

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21 147 urban areas having an increased risk of CKD <sup>14</sup>. So far, it is unknown whether the reversed SES gradient

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23 148 (higher risk in high SES group) might explain the higher burden of CKD in urban areas as compared to

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25 149 rural areas in Africa.

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29 151 In view of this, we assessed the association of SES with CKD in rural and urban Ghana and studied what

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31 152 extent the higher SES of people in urban areas could account for differences in CKD between rural and

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33 153 urban populations.

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## 48 49 161 **Methods**

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### 52 53 163 *Study population and study design*

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55 164 In the present analyses, data from the RODAM (Research on Obesity & Diabetes

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57 165 among African Migrants) study, a multi-centre cross-sectional study were used. The

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59 166 rationale, conceptual framework, design and methodology of the RODAM study have

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167 been described in detail elsewhere <sup>15 16</sup>. As the Healthy Life in an Urban Setting



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3 168 (HELIUS) study conducted among Ghanaian migrants living in Amsterdam did not find any  
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5 169 associations between SES and CKD <sup>17</sup> the current study focused on rural and urban Ghana (Ashanti  
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7 170 region of Ghana). The RODAM study was conducted from 2012 to 2015 and it comprised  
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9 171 of individuals aged 25-70 years living in rural and urban Ghana and Ghanaian  
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11 172 migrants in Europe. All participants below 25 and above 70 years were excluded in  
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13 173 the present analyses. The present analysis was restricted to the rural and urban sites  
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15 174 (n=2492) RODAM participants. Specifically, 1043 participants from rural Ghana and  
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17 175 1449 from urban Ghana were used in this study.  
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22 177 Data collection for the study was standardized across all sites. Written informed  
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24 178 consent was obtained from each participant prior to enrolment in the study. The  
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26 179 respective ethics committees in Ghana and the three European countries approved the  
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28 180 study protocols before data collection began. Specifically, we obtained ethical clearance  
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30 181 in Ghana from School of Medical Sciences/Komfo Anokye Teaching Hospital  
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32 182 Committee on Human Research, Publication & Ethical Review Board. In the  
33  
34 183 Netherlands the Institutional Review Board of the AMC, University of Amsterdam gave  
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36 184 approval for the study. In Germany, approval for the study was obtained from the  
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38 185 Ethics Committee of Charite-Universitätsmedizin. The London School of Hygiene and  
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40 186 Tropical Medicine Research Ethics Committee gave approval for the study in the UK.  
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46 187 The response rate was 76% in rural Ghana and 74% in urban Ghana. In Ghana,  
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48 188 participants were randomly drawn from a list of 30 enumeration areas in the Ashanti  
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50 189 region based on the 2010 population census using the multistage random sampling.  
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52 190 These enumeration areas came from two purposively selected urban cities (Kumasi  
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54 191 and Obuasi) and 15 randomly selected rural communities in the Ashanti region.  
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3 192 Selected health and community authorities were first identified, notified of the study  
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6 193 and letters were sent giving detailed explanation of the study. We sent team members  
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8 194 to stay among the communities to familiarize with them and organize mini clinics in  
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10 195 the field. This lasted between 1-2 weeks depending on the sampled population and  
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12 196 responsiveness of respondents.

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16 197 In Ghana, questionnaires administration and physical examination were done at the  
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18 198 same day/time. The participants were instructed to fast from 10.00 pm the night before  
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20 199 the physical examination. For the current study, 2566 participants with data available  
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22 200 on both questionnaire data and physical measurements were used. We excluded  
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24 201 (n=74) individuals outside the RODAM age range of 25-70 years resulting in a data  
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26 202 set of 2492 for analysis. These comprised 1,449 Urban Ghana and 1043 Rural Ghana.  
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28 203 For the final analysis, individuals with no data on CKD status (n=42) were excluded.

## 204 **Measurements**

### 205 **Covariates**

#### 206 *Demographic and lifestyle factors*

207 Information on demographics, educational level, occupational level, wealth index and lifestyle factors  
208 (smoking and physical activity) were obtained by questionnaire. Physical examinations were performed  
209 with validated devices per standardized operational procedures across all study sites. Weight was  
210 measured in light clothing and without shoes with SECA 877 scales to the nearest 0.1 kg. Height was  
211 measured without shoes with a portable stadiometer (SECA 217) to the nearest 0.1 cm. Body mass index  
212 (BMI) was calculated as weight (kg) divided by height squared ( $m^2$ ). Overweight was defined as BMI of  
213  $\geq 25$  to  $< 30$   $kg/m^2$  and obesity as BMI  $\geq 30$   $kg/m^2$ <sup>18</sup>. Per participant, all anthropometrics were measured  
214 twice by the same assessor and the average of the two measurements were used for analyses.

#### 215 *Predictor: SES*

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3 216 Socioeconomic indicators used in this study were educational level, occupational status and level of  
4 217 wealth index. Educational level was determined based on self-reported highest educational qualification  
5 218 accomplished based on the Ghanaian educational system. Occupational level was determined based on  
6 219 self-reported current occupation if still employed and/or last occupation before retirement or student. The  
7 220 reported occupations were further coded according to the International Standard Classification of  
8 221 Occupations scheme (ISCO-08). Where 'high' (professionals, managers, clerical support staff, higher  
9 222 grade routine non-manual employees service and sales-related occupations) and 'low' (craft and related  
10 223 trades workers, elementary occupations and farmers) and the rest were categorized into the 'middle'.  
11 224 Wealth index was determined using the World Health Organization (WHO) standard of wealth index  
12 225 classification. Wealth index was based on data collected in the Household Questionnaire. The  
13 226 questionnaire comprised of questions on household's ownership of several consumer items such as  
14 227 television, car, flooring material, toilet facilities etc. Each household was assigned a standard score for  
15 228 each asset. Wealth index was then expressed in five categories. The five categories were further  
16 229 categorized into three categories by combining the second and third category due to small numbers<sup>19</sup>. All  
17 230 three SES constructs were further classified as low, medium and high SES and their relationship to each  
18 231 other tested. A composite SES variable (SES) was generated based on the three SES constructs  
19 232 (education, occupation and wealth index) using the EGEN group command in STATA. The codes were  
20 233 combined into numerical variables and their averages computed. The resultant values were recoded into  
21 234 three categories (low, medium and high).

### 235 *Co-morbidity factors*

236 Blood pressure (BP) was measured three times using a validated semi-automated device (The Microlife  
237 WatchBP home) with appropriate cuffs in a sitting position after at least 5 min rest. The mean of the last  
238 two BP measurements was used in the analyses. Hypertension was defined as systolic BP  $\geq$  140 mmHg,  
239 and/or diastolic BP  $\geq$  90 mmHg, and/or being on antihypertensive medication treatment, and/or self-  
240 reported hypertension. Trained research assistants in the two sites collected fasting venous blood samples.  
241 All the blood samples were processed and aliquoted immediately (within one hour to maximum three  
242 hours of the vena puncture) after collection per standard operation procedures, and then temporarily  
243 stored at the local research location at  $-20^{\circ}\text{C}$ . The separated samples were then transported to the local  
244 research centres laboratories, where they were checked, registered and stored at  $-80^{\circ}\text{C}$ . To avoid intra-  
245 laboratory variability, the stored blood samples from the local research centres were transported to Berlin,  
246 Germany for biochemical analyses. Fasting plasma glucose concentration was measured using an  
247 enzymatic method (hexokinase). Type 2 diabetes was defined according to the WHO diagnostic criteria  
248 (fasting glucose  $\geq$ 7.0 mmol/L, and/or current use of medication prescribed to treat diabetes, and/or self-

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3 249 reported diabetes)<sup>20</sup>. Concentration of total cholesterol was assessed using colorimetric test kits. All  
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5 250 biochemical analyses were performed using an ABX Pentra 400 chemistry analyzer (ABX Pentra; Horiba  
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7 251 ABX, Germany). Hypercholesterolemia was defined as total cholesterol level  $\geq 6.22$  mmol/L. Serum  
8  
9 252 creatinine concentration (in  $\mu\text{mol/L}$ ) was determined by a kinetic colorimetric spectrophotometric isotope  
10  
11 253 dilution mass spectrometry–calibrated method (Roche Diagnostics). Biochemical analyses were subject to  
12  
13 254 extensive quality checks including blinded serial measurements.

### 14 255 **Outcome: CKD prevalence**

15  
16 256 Participants were asked to bring an early morning urine sample for the analyses of albuminuria and  
17  
18 257 creatinine levels. Urinary albumin concentration (in mg/L) was measured by an immunochemical  
19  
20 258 turbidimetric method (Roche Diagnostics). Urinary creatinine concentration (in  $\mu\text{mol/L}$ ) was measured by  
21  
22 259 a kinetic spectrophotometric method (Roche Diagnostics). Estimated glomerular filtration rate (eGFR)  
23  
24 260 was calculated using the CKDEPI (CKD Epidemiology Collaboration) creatinine equation<sup>21</sup>. Urinary  
25  
26 261 albumin-creatinine ratio (ACR; expressed in mg/g) was calculated by taking the ratio between urinary  
27  
28 262 albumin and urinary creatinine. eGFR and albuminuria were categorized according to the 2012 KDIGO  
29  
30 263 (Kidney Disease: Improving Global Outcomes) classification<sup>22</sup>. eGFR was categorized as follows: G1,  $\geq$   
31  
32 264 90 mL/min/1.73 m<sup>2</sup> (normal kidney function); G2, 60 to 89 mL/min/1.73 m<sup>2</sup> (mildly decreased); G3a, 45  
33  
34 265 to 59 mL/min/1.73 m<sup>2</sup> (mildly to moderately decreased); G3b, 30 to 44 mL/min/1.73 m<sup>2</sup> (moderately to  
35  
36 266 severely decreased); G4, 15 to 29 mL/min/1.73 m<sup>2</sup> (severely decreased); and G5,  $< 15$  mL/min/1.73 m<sup>2</sup>  
37  
38 267 (kidney failure). Albuminuria categories were derived from ACR and were as follows: A1,  $< 3$  mg/mmol  
39  
40 268 (normal to mildly increased); A2, 3 to 30 mg/mmol (moderately increased); and A3,  $> 30$  mg/mmol  
41  
42 269 (severely increased). CKD status was categorized according to severity of kidney disease (green, low risk;  
43  
44 270 yellow, moderately increased risk; orange, high risk; and red, very high risk) using the combination of  
45  
46 271 eGFR (G1-G5) and albuminuria (A1-A3) levels defined by the 2012 KDIGO guideline<sup>23</sup>. Due to the  
47  
48 272 small number of participants in the very high risk category of CKD, high and very high risk groups were  
49  
50 273 combined. Reduced eGFR was defined as eGFR  $< 60$  mL/min/1.73 m<sup>2</sup>. Because of the small number of  
51  
52 274 participants in the severely increased albuminuria category, we defined albuminuria as ACR  $\geq 3$  mg/mmol  
53  
54 275 by combining the moderately increased (A2) and severely increased (A3) categories.

### 55 276 **Patient and Public Involvement**

56  
57 277 Community leaders were involved in the recruitment of patients. These comprised of religious  
58  
59 278 communities (churches and mosques), endorsement from local key leaders and establishing relationships  
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279 with healthcare organizations. We also provided information on the study by involving the local media  
280 (radio and television stations). We sent letters to all selected health and community authorities to notify

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3 281 participants of the study. Team members were sent to the various communities to stay among the  
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5 282 community and organize mini clinics for a period of 1-2 weeks. Results of the study were disseminated  
6  
7 283 through seminars, durbars and via radio and television stations.

## 8 9 284 **Statistical methods**

10  
11 285 Participants' characteristics were expressed as absolute numbers and percentages for categorical variables  
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13 286 and as means and standard deviations (SD) for continuous variables. CKD prevalence with 5% error bars  
14  
15 287 were presented as bar graphs for each SES construct across rural and urban Ghana. Spearman's rank  
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17 288 correlation was used to determine correlations between the three SES constructs. Odds ratios (ORs) and  
18  
19 289 their corresponding 95% confidence intervals (CIs) were estimated by means of logistic regression  
20  
21 290 analyses to study the odds of albuminuria (ACR>3 mg/mmol, A2-A3, moderately to severely increased  
22  
23 291 albuminuria), reduced kidney function (eGFR< 60 mL/min/1.73 m<sup>2</sup>, G3-G5 moderately to severely  
24  
25 292 decreased kidney function) and increased CKD risk (high and very high CKD risk) by SES, with  
26  
27 293 adjustments for potential confounders (age and sex).<sup>24</sup> In addition, the analyses were performed for the  
28  
29 294 total population (using low educational level, low occupational status and low level of wealth index as  
30  
31 295 reference categories). Further analysis was conducted to assess the contribution of SES  
32  
33 296 indicators to rural-urban differences in albuminuria, reduced eGFR and CKD risk using  
34  
35 297 rural Ghana as reference. Tolerance test and variance inflation factor (VIF) showed  
36  
37 298 very small degree of collinearity among SES predictors thus we therefore adjusted for  
38  
39 299 each of SES variables separately. Complete case analysis approach was used. All  
40  
41 300 data available were included in the age-adjusted models. All analyses were performed  
42  
43 301 using STATA, version 14.0 (StataCorp LP).

## 44 302 **Results**

45 303  
46  
47 304 Table 1 shows characteristics of study participants. Participants in rural Ghana were  
48  
49 305 slightly older than those in urban Ghana. Female preponderance was observed in both  
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51 306 rural and urban Ghana, though higher proportions were observed in urban Ghana.  
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54 307 Individuals living in rural Ghana were generally less educated compared with those  
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308 living in urban Ghana. There were slightly more individuals with low occupational  
 309 status in urban Ghana compared with their peers in rural Ghana. People in urban  
 310 Ghana were wealthier than their rural counterparts. Rural Ghanaians were more  
 311 physically active compared with their urban peers. Smoking was low among Ghanaians  
 312 though rural Ghanaians were more likely to smoke compared with their urban peers.  
 313 Hypercholesterolemia was more prevalent in urban Ghana than in rural Ghana.  
 314 Hypertension and type 2 diabetes were more prevalent in urban Ghanaians compared  
 315 with those living in rural Ghana. Urban Ghanaians were markedly more obese  
 316 compared with their rural peers. Except for eGFR, albuminuria and CKD risk  
 317 prevalence rates were higher in urban Ghana compared with rural Ghana.

318 **Table 1: Baseline characteristics by location**

	Rural Ghana	Urban Ghana
Number of participants, N (%)	1043 (41.9)	1449 (58.1)
Mean age, years (SD)	46.5 (12.6)	45.2 (11.4)
Females, N (%)	638 (61.2)	1034 (71.4)
Educational level n (%)		
Low	555 (56.9)	614 (43.9)
Middle	311 (31.9)	547 (39.1)
High	108 (11.2)	239 (17.0)
Occupational status, n (%)		
Low	250 (25.7)	374 (26.7)
Middle	628 (64.5)	818 (58.4)
High	96 (9.8)	209 (14.9)
Wealth index, n (%)		
Low	449 (46.5)	368 (26.6)
Middle	276 (28.6)	416 (30.0)

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4	High	241 (24.9)	602 (43.4)
5	BMI (kg/m <sup>2</sup> )		
6			
7	< 25	794 (76.3)	579 (39.9)
8	25-29.9	189 (18.2)	495 (34.2)
9			
10	≥ 30	58 (5.5)	374 (25.9)
11			
12	Low physical activity, n (%)	663 (47.22)	592 (60.7)
13	Smoking, n (%)	22 (2.3)	14 (1.0)
14			
15	Hypercholesterolemia, n (%)	78 (7.6)	270 (18.7)
16			
17	Hypertension, n (%)	306 (29.3)	531 (36.7)
18			
19		53	
20	Diabetes, n (%)	(5.1)	153 (10.6)
21			
22	Albuminuria, n (%)		
23			
24		930 (91.6)	
25	A1, Normal to mildly increased (ACR <3 mg/mmol)	85	1285 (89.1)
26	A2-A3, moderately to severely increased (ACR ≥ 3 mg/ (8.4)		158 (10.9)
27			
28	eGFR, n (%)		
29			
30	G1-G2 (≥ 60 mL/min/1.73m <sup>2</sup> )	989 (96.3)	1388 (96.3)
31			
32	G3-G5 (<60 mL/min/1.73m <sup>2</sup> )	38 (3.7)	54 (3.7)
33			
34	CKD risk, n (%)		
35	Low risk (green)	916 (90.5)	1281 (88.9)
36			
37	Moderately increased to very high risk		
38	(yellow to red)	96 (9.5)	160 (11.1)
39			

320

321 **Abbreviations:** N, number of respondents; SD, standard deviation; eGFR, estimated glomerular filtration rate; ACR, albumin  
 322 creatinine ratio; CKD, Chronic kidney disease

323

324 Figure 1 shows prevalence of CKD by level of education in urban and rural Ghana.

325 Prevalence of CKD decreased with increasing levels of education in rural Ghana.

326 Higher prevalence of CKD was observed among individuals with low educational level

327 compared with those with middle and high educational level. However, those with high

328 educational level in urban Ghana had higher prevalence of CKD compared with those

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3 329 with middle level education. For occupational status, prevalence of CKD was higher  
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6 330 among individuals with low occupational status in urban Ghana. Similar patterns were  
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8 331 observed in rural Ghana; however, those with higher occupational status had higher  
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10 332 prevalence of CKD compared with those with middle occupational status (Figure 2).  
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12 333 Figure 3 shows prevalence of CKD by level of wealth index. CKD prevalence among  
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15 334 the levels of wealth index varied between urban and rural Ghana. Those with middle  
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17 335 level wealth index had higher prevalence of CKD compared with those with low or  
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19 336 high CKD prevalence in both rural and urban Ghana. CKD prevalence rate for low and  
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22 337 high level wealth index in urban Ghana was the same while that of rural Ghana was  
23  
24 338 slightly different.



339 Among the whole group, educational level was positively associated with wealth index ( $p < 0.01$ ) and composite SES  
 340 ( $P < 0.01$ ). Occupational level was also inversely associated with educational level ( $p < 0.01$ ) and wealth index ( $p < 0.01$ ). In  
 341 urban Ghana, high educational level was positively associated with high wealth index but inversely associated with  
 342 occupation ( $p < 0.01$ ). In rural Ghana, high education was positively associated with high wealth index ( $p < 0.01$ ), but there  
 343 was no significant association between education and occupation. High wealth index was inversely associated with high  
 344 occupational status in both rural and urban Ghana ( $p < 0.01$ ) (Table 2).

346 **Table 2: Relationship between SES constructs (educational, occupational level and wealth index) by urban**  
 347 **rural Ghana**

Correlation matrix	Educational level	Occupational level	Wealth index	SES
<b>Whole group</b>				
Educational level	1.000			
Occupational status	<b>-0.060</b>	1.000		
	<b>0.004</b>			
Wealth Index	0.282	<b>-0.121</b>	1.000	
	0.001	<b>0.001</b>		
SES	<b>1.000</b>	<b>-0.059</b>	<b>0.282</b>	1.000
	<b>0.003</b>	<b>0.006</b>	<b>0.001</b>	

**Urban Ghana**

Educational level	1.000			
Occupational status	<b>-0.115</b>	1.000		
	<b>0.001</b>			
Wealth Index	<b>0.294</b>	<b>-0.126</b>	1.000	
	<b>0.001</b>	<b>0.001</b>		
SES	<b>1.000</b>	<b>-0.024</b>	<b>0.937</b>	1.000
	<b>0.002</b>	<b>0.001</b>	<b>0.001</b>	

**Rural Ghana**

Educational level	1.000			
Occupational status	0.017	1.000		
	0.589			
Wealth Index	<b>0.219</b>	<b>-0.135</b>	1.000	
	<b>0.001</b>	<b>0.001</b>		
SES	<b>0.504</b>	0.017	<b>0.934</b>	1.000
	<b>0.001</b>	0.587	<b>0.001</b>	

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361 Table 3 shows association between level of education, occupational status, level of wealth index and prevalence of  
 362 CKD. After adjusting for age and sex for the whole group, albuminuria was associated with middle level education ( $p<0.01$ ). After adjusting for  
 363 age and sex, we observed no significant association between SES indicators (educational level, occupational status and wealth index) and CKD in  
 364 urban Ghana. However, middle and higher level education was associated with reduced albuminuria in urban Ghana ( $p<0.01$ ). Whereas  
 365 educational level and occupational status were not associated with CKD prevalence, high wealth index was significantly associated with higher  
 366 odds of reduced eGFR ( $p<0.01$ ).

367

368 **Table 3: Association of SES indicators (educational level, occupational status and wealth index level) with albuminuria, reduced eGFR and CKD risk**

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Albuminuria (ACR $\geq$ 3 mg/mmol)		eGFR < 60 mL/min/1.73 m <sup>2</sup>		High to very high CKD risk (KDIGO, 2012)	
	OR (95% CI)		OR (95% CI)		OR (95% CI)
n (%)	Model 1	n (%)	Model 1	n (%)	Model 1

<b>Education</b>						
<b>Whole group</b>						
Low	1,152 (11.89)	1.00 (Reference)	1,160 (3.97)	1.00 (Reference)	1,150 (11.91)	1.00 (Reference)
Middle	847 (7.32)	<b>0.66 (0.48-0.91)</b>	849 (3.77)	1.36 (0.83-2.22)	845 (8.28)	0.82 (0.59-1.12)
High	343 (7.00)	0.67 (0.42-1.07)	345 (3.19)	1.11 (0.55-2.29)	343 (8.75)	0.96 (0.62-1.49)
<b>Urban Ghana</b>						
Low	612 (14.7)	1.00 (Reference)	612 (4.1)	1.00 (Reference)	612 (14.1)	1.00 (Reference)
Middle	546 (7.8)	<b>0.51 (0.34-0.76)</b>	546 (3.7)	1.12 (0.59-2.12)	545 (8.1)	<b>0.59 (0.39-0.89)</b>
High	238 (8.4)	<b>0.53 (0.31-0.91)</b>	238 (3.4)	0.91 (0.37-2.19)	238 (10.9)	0.83 (0.51-1.38)
<b>Rural Ghana</b>						
Low	540 (8.7)	1.00 (Reference)	548 (3.8)	1.00 (Reference)	538 (9.5)	1.00 (Reference)
Middle	301 (6.3)	0.89 (0.51-1.59)	303 (3.9)	1.69 (0.77-3.66)	300 (8.7)	1.33 (0.79-2.25)
High	105 (3.8)	0.66 (0.23-1.95)	107 (2.8)	1.28 (0.35-4.71)	105 (3.8)	0.69 (0.23-2.02)
<b>Occupational status</b>						
<b>Whole group</b>						
Low	614 (9.93)	1.00 (Reference)	616 (2.76)	1.00 (Reference)	613 (9.46)	1.00 (Reference)
Middle	1,427 (9.25)	0.82 (0.59-1.14)	1,436 (3.34)	0.93 (0.52-1.66)	1,424 (9.90)	0.89 (0.65-1.24)
High	302 (10.26)	0.76 (0.47-1.22)	303 (7.92)	1.33 (0.67-2.62)	302 (12.91)	0.90 (0.57-1.42)
<b>Urban Ghana</b>						
Low	207 (10.1)	1.00 (Reference)	207 (6.8)	1.00 (Reference)	207 (12.1)	1.00 (Reference)
Middle	817 (11.1)	1.50 (0.88-2.83)	817 (3.6)	1.15 (0.56-2.35)	816 (11.6)	1.37 (0.84-2.56)
High	373 (11.0)	1.57 (0.89-2.53)	373 (2.7)	1.02 (0.41-2.52)	373 (9.7)	1.21 (0.68-2.14)
<b>Rural Ghana</b>						
Low	95 (10.5)	1.00 (Reference)	96 (10.4)	1.00 (Reference)	95 (14.7)	1.00 (Reference)
Middle	610 (6.7)	0.65 (0.31-1.37)	619 (3.1)	<b>0.37 (0.16-0.85)</b>	608 (7.6)	0.55 (0.28-1.08)
High	241 (8.3)	0.99 (0.43-2.28)	243 (2.9)	0.51 (0.18-1.44)	240 (9.2)	0.94 (0.44-2.01)
<b>Wealth index</b>						
<b>Whole group</b>						

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Low	808 (9.65)	1.00 (Reference)	813 (3.32)	1.00 (Reference)	808 (9.16)	1.00 (Reference)
Middle	678 (10.91)	1.18 (0.84-1.66)	683 (3.81)	1.30 (0.74-2.28)	675 (12.0)	1.43 (1.02-2.01)
High	835 (8.62)	0.93 (0.66-1.31)	835 (4.19)	1.55 (0.91-2.64)	833 (9.96)	1.21 (0.86-1.69)
<b>Urban Ghana</b>						
Low	367 (11.2)	1.00 (Reference)	367 (3.5)	1.00 (Reference)	367 (10.1)	1.00 (Reference)
Middle	414 (12.3)	1.12 (0.73-1.74)	414 (3.9)	1.30 (0.61-2.80)	413 (13.1)	1.45 (0.93-2.27)
High	601 (9.8)	0.82 (0.55-1.25)	600 (3.8)	1.13 (0.55-2.31)	600 (10.8)	1.11 (0.72-1.71)
<b>Rural Ghana</b>						
Low	441 (7.9)	1.00 (Reference)	446 (3.1)	1.00 (Reference)	441 (8.4)	1.00 (Reference)
Middle	264 (8.7)	1.13 (0.65-1.98)	269 (3.7)	1.22 (0.52-2.84)	262 (10.3)	1.31 (0.77-2.25)
High	234 (5.6)	0.78 (0.40-1.53)	235 (5.1)	<b>2.38 (1.03-5.47)</b>	233 (7.7)	1.16 (0.63-2.14)

Model 1, adjusted for age and sex; Abbreviations: CI, confidence interval; ACR, albumin creatinine ration; eGFR, estimated glomerular filtration rate; CKD, chronic kidney disease; OR, odds ratio, n= total number of individuals in the whole group, rural and urban Ghana among the various levels of SES constructs; %, proportion of individuals with CKD among the various levels of SES constructs in rural and urban Ghana.

Table 4 shows the contribution of all three SES constructs to rural and urban CKD prevalence differences. The odds of albuminuria and CKD risk was significantly higher in urban Ghana compared with rural Ghana. The higher rate of CKD observed in urban Ghana was not explained by the higher SES of that population as compared to their rural counterparts.

**Table 4: Contribution of SES indicators to rural-urban differences in albuminuria, reduced eGFR and CKD risk**

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OR (95% CI)    OR (95% CI)    OR (95% CI)    OR (95% CI)    OR (95% CI)

		Model 1	Model 2	Model 3	Model 4	Model 5
<b>Albuminuria (ACR ≥ 3 mg/mmol)</b>						
	n cases					
Sites	(%)					
	1,443	<b>1.37 (1.03-</b>	<b>1.70 (1.25-</b>	<b>1.55 (1.15-</b>	<b>1.62 (1.18-</b>	<b>1.74 (1.27-</b>
Urban Ghana	(10.9)	<b>1.81)</b>	<b>2.31)</b>	<b>2.10)</b>	<b>2.19)</b>	<b>2.38)</b>
		1.00	1.00	1.00	1.00	1.00
Rural Ghana	1,015 (8.4)	(Reference)	(Reference)	(Reference)	(Reference)	(Reference)
<b>eGFR &lt; 60 mL/min/1.73 m<sup>2</sup></b>						
	n cases					
Sites	(%)					
		1.27 (0.82-	1.20 (0.76-	1.18 (0.79-	1.12 (0.70-	1.07 (0.67-
Urban Ghana	1,442 (3.7)	1.97)	1.89)	1.86)	1.78)	1.72)
		1.00	1.00	1.00	1.00	1.00
Rural Ghana	1,027 (3.7)	(Reference)	(Reference)	(Reference)	(Reference)	(Reference)
<b>High to very high CKD risk</b>						
	n cases					
Sites	(%)					
	1,441	<b>1.23 (1.01-</b>	<b>1.44 (1.07-</b>	<b>1.38 (1.03-</b>	<b>1.36 (1.01-</b>	<b>1.40 (1.04-</b>
Urban Ghana	(11.1)	<b>1.62)</b>	<b>1.93)</b>	<b>1.84)</b>	<b>1.83)</b>	<b>1.91)</b>
	1,012	1.00	1.00	1.00	1.00	1.00 (Reference)
Rural Ghana	(9.46)	(Reference)	(Reference)	(Reference)	(Reference)	(Reference)

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384 Model 1#: adjusted for age and sex; Model 2: adjusted for age, sex and education level; Model 3: adjusted for age, sex and occupational status;  
385 Model 4: adjusted for age, sex and wealth index; Model 5: adjusted for age, sex, educational level, occupational status and wealth index;  
386 Abbreviations: CI, confidence interval; ACR, albumin creatinine ratio; eGFR, estimated glomerular filtration rate; CKD, chronic kidney disease; OR, odds ratio, n= total number  
387 of individuals in rural and urban Ghana; %, proportion of individuals with CKD among urban and rural Ghana.

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3 388 **Discussion**

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6 389 ***Key findings***

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8 390 Our study findings show no association between all three SES constructs and the  
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10 391 prevalence of CKD in both rural and urban Ghana except for wealth index in rural  
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12 392 Ghana, with the risk of CKD being higher in the wealthier populations. The higher rate  
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14 393 of CKD observed in urban Ghana could not be attributed to the higher SES of that  
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16 394 population compared to their rural counterparts.  
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22 396 **Discussion of key findings**

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26 398 ***Association of SES with CKD in rural and urban Ghana***

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30 400 Our study did not find any significant associations between all three SES constructs  
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32 401 and CKD among rural and urban Ghana except for wealth index in rural Ghana. The  
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34 402 positive association observed between wealth index in rural Ghana may be due to  
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36 403 several reasons. A comparison of the three SES constructs showed higher educational  
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38 404 level to be associated with wealth index in both rural and urban Ghana but not  
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40 405 occupational level. This seems to suggest that occupational level may not be  
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42 406 adequately capturing the SES status of individuals living in these settings in relation to  
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44 407 CKD. For example, Masthi et al, compared different SES scales in rural and urban  
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46 408 India and concluded that Standard of Living Index (SLI) scale was more accurate for classification  
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48 409 of SES in urban and rural settings<sup>25</sup>. Our finding is consistent with other studies,<sup>6 26</sup> which  
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50 410 reported no association between SES and CKD in high-income countries and LMICs,  
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52 411 but in contrast with other studies<sup>2-4 27</sup> that found positive associations between SES  
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3 412 and CKD. The reasons for our current finding are unclear. However, it has been  
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6 413 suggested that these inconsistent associations may be due to the varying pathways  
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8 414 through which the effect of SES on health status is mediated. For example, at a given  
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10 415 educational level marked ethnic differences have been reported. Additionally, similar  
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13 416 differences were observed for wealth status at a given income level <sup>28-30</sup>.

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17 418 ***Contribution of SES to observed CKD risk differences between rural and***  
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19 419 ***urban Ghana***

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22 421 We observed higher rates of CKD in urban Ghana compared with rural Ghana, as expected. The observed  
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24 422 higher rates of CKD in our study were not explained by the higher SES of that population as compared to  
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26 423 their rural counterparts. Our results indicate that this is due to the lack of a clear difference in the SES  
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28 424 distribution of rural and urban Ghana observed in this study, as well as to the lack of associations between  
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30 425 SES and CKD. Consistent with our findings, in a study conducted in Northern Tanzania SES did not  
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32 426 explain increased risk of CKD in urban Tanzania <sup>26</sup>. The lack of associations between SES and CKD  
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34 427 could probably partly be explained by the process of epidemiological transition in relation to the  
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36 428 “diffusion theory” of ischemic heart disease mortality. This theory attributes the commencement of  
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38 429 ischemic heart disease to individuals in the high SES group due to their ability to afford behaviours  
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40 430 (smoking, alcohol and sedentary lifestyles) which increased risk of ischemic heart disease. The lower SES  
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42 431 groups were later affected partially because of improved living standards, imitation and urbanization. The  
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44 432 higher SES groups were the first to embrace behavioural changes required to decrease the risk of ischemic  
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46 433 heart disease and this resulted in reversing the gradient <sup>31</sup>. The rapid urbanization of some rural  
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48 434 communities in the Ashanti region of Ghana and the imitation of urban lifestyle could  
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50 435 account for our finding. Also, it could be that whereas the high SES group in urban  
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52 436 Ghana has already embraced favourable behavioural changes, those in rural Ghana  
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54 437 are yet to do so <sup>32</sup>. This explains the observed association of wealth index with CKD in rural Ghana  
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56 438 but not in urban Ghana. Also, the interplay of other less understood or researched factors

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3 439 (e.g., exposure to nephrotoxins, herbal medications, sepsis, psychosocial factors) may  
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6 440 be influencing the pathway in which SES influences CKD prevalence and progression.  
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10 442 ***Strength and limitation***

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12 444 Our study presents several strengths. First, we used well-standardized study protocols across rural and  
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14 445 urban Ghana. Our study is also the first in Africa to use all three categories of CKD definition  
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16 446 (albuminuria, reduced eGFR and CKD risk) by KDIGO 2012 in assessing association of SES with CKD  
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18 447 in rural and urban setting, this provided more detailed information on CKD outcomes. The limitation of  
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20 448 intra laboratory variability in earlier studies was eliminated using the same standard operating procedures  
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22 449 in the same laboratory for running all samples for both rural and urban Ghana. The use of three constructs  
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24 450 of SES in this study also provides a much better holistic approach to assessing SES. Also, the distribution  
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26 451 of SES in our study reflects on the national data allowing for generalization of our findings. Our study  
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28 452 was limited by the use of cross sectional design, which prevented us from determining causality between  
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30 453 predictors and CKD progression. Furthermore, there were more women than men in our study due to the  
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32 454 higher response rate in women compared with men. However, this applied to both rural and urban Ghana.  
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34 455 We therefore do not expect this to influence our results in a significant way.

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36 457

37 458 ***Conclusion***

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39 460 All three SES constructs appear not to be associated with prevalence of CKD in urban  
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41 461 and rural Ghana except for wealth index in rural Ghana. The observed higher  
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43 462 prevalence of CKD in urban Ghana was not explained by the higher SES in urban  
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45 463 Ghana. Our study seems to suggest that other non-traditional factors such as  
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47 464 nephrotoxins, herbal medications, psychosocial stressors and misuse of over the  
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49 465 counter drugs may play a role and underscores the need to further explore these  
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51 466 factors.  
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## 468 **Acknowledgement**

469 The authors are very grateful to the research assistants, interviewers and other staff of the five research  
470 locations who took part in gathering the data and the Ghanaian volunteers in all the participating RODAM  
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472 RODAM study methods and the Academic Medical Centre Biobank for their support in biobank  
473 management and high-quality storage of collected samples.

474

475

## 476 **Contributors**

477 My co-authors have all contributed substantially to this manuscript and approve of this  
478 submission. Research idea and study design: DNA, CA, KS, DA, EB, KM, JA; data acquisition  
479 and curation: DNA, CA, EB, KM, data analysis/interpretation: DNA, CA, KS, DA, EB, KM, LS,  
480 JA, EOD, KKG, FPM, ID, JS, SB, ADA; statistical analysis: DNA, CA, KS. DNA, CA, KS, DA,  
481 EB, KM, LS, JA, EOD, KKG, FPM, ID, JS, SB, ADA contributed important intellectual content  
482 during manuscript drafting or revision and accepts accountability for the overall work by  
483 ensuring that questions pertaining to the accuracy or integrity of any portion of the work are  
484 appropriately investigated and resolved. DNA and CA take responsibility that this study has been  
485 reported honestly, accurately, and transparently; that no important aspects of the study have been  
486 omitted; and that any discrepancies from the study as planned have been explained.

487

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489

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494 (German Center for cardiovascular research) and the Berlin Institute of Health (BIH).

495 **Competing interest:** I have communicated with all my co-authors and obtained their full  
496 disclosures. My co-authors and I declare no conflicts of interest.

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3 498 **Patient Consent:** None declared

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7 500 **Ethics approval:** IRBs at each participating site.

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10 502 **Data sharing statement:** Data are available from the RODAM research cohort, a third

11  
12 503 party. Dr. Eric Beune affiliated with the RODAM research cohort and a co-author of this paper

13  
14 504 in accordance with the RODAM requirements for collaboration. Dr. Beune is the Data Collection

15  
16 505 Coordinator of RODAM and may be contacted with further questions (e.j.beune@amc.uva.nl).

17  
18 506 Additionally, researchers interested in further collaboration with RODAM may see the following

19 507 URL: <http://www.rod-am.eu/>

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### 22 630 **Legend for figures**

23 631  
24 632 **Figure 1:** Prevalence of chronic kidney disease (CKD) across level of education among urban  
25 633 and rural participants. Definitions according to 2012 KDIGO (Kidney Disease: Improving Global  
26 634 Outcomes) guideline. CKD was defined as being in moderately increased risk, high-risk, or very  
27 635 high-risk groups.  
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30 638  
31 639 **Figure 2:** Prevalence of chronic kidney disease (CKD) across occupational status among urban  
32 640 and rural participants. Definitions according to 2012 KDIGO (Kidney Disease: Improving  
33 641 Global Outcomes) guideline. CKD was defined as being in moderately increased risk, high-risk,  
34 642 or very high-risk groups.  
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37 645  
38 646 **Figure 3:** Prevalence of chronic kidney disease (CKD) across wealth index categories among  
39 647 urban and rural participants. Definitions according to 2012 KDIGO (Kidney Disease: Improving  
40 648 Global Outcomes) guideline. CKD was defined as being in moderately increased risk, high-risk,  
41 649 or very high-risk groups.  
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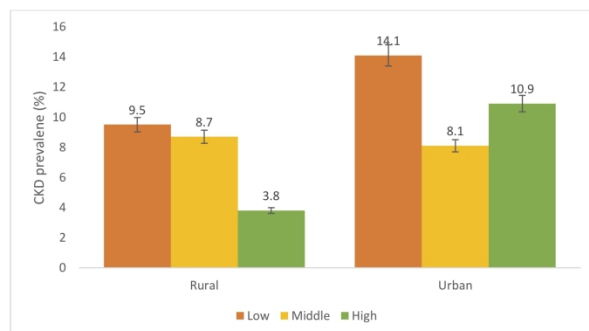


Figure 1: Prevalence of chronic kidney disease (CKD) across level of education among urban and rural participants Definitions according to 2012 KDIGO (Kidney Disease: Improving Global Outcomes) guideline. CKD was defined as being in moderately increased risk, high-risk, or very high-risk groups

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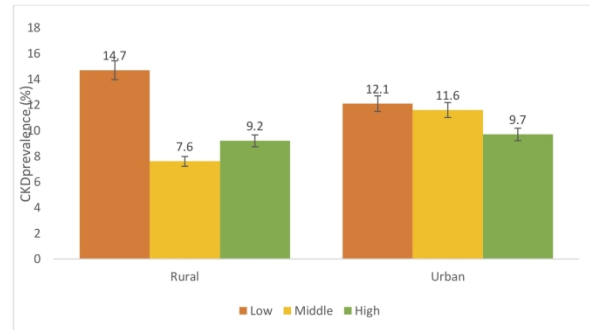


Figure 2: Prevalence of chronic kidney disease (CKD) across occupational status among urban and rural participants. Definitions according to 2012 KDIGO (Kidney Disease: Improving Global Outcomes) guideline. CKD was defined as being in moderately increased risk, high-risk, or very high-risk groups

Figure 2: Prevalence of chronic kidney disease (CKD) across occupational status among urban and rural participants. Definitions according to 2012 KDIGO (Kidney Disease: Improving Global Outcomes) guideline. CKD was defined as being in moderately increased risk, high-risk, or very high-risk groups.

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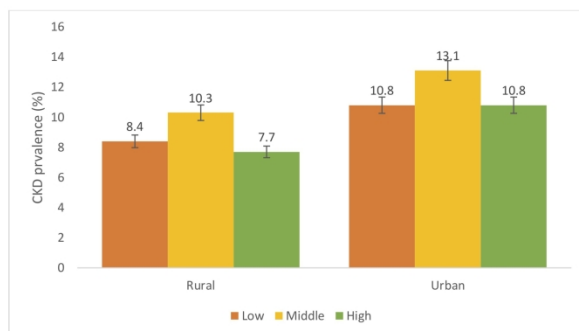


Figure 3: Prevalence of chronic kidney disease (CKD) across wealth index categories among urban and rural participants. Definitions according to 2012 KDIGO (Kidney Disease: Improving Global Outcomes) guideline. CKD was defined as being in moderately increased risk, high-risk, or very high-risk groups

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## STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No.	Recommendation	Page No.	Relevant text from manuscript
<b>Title and abstract</b>	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1,2	We have included a commonly used term in the title and abstract
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2	Our study did not find any associations between SES indicators and CKD in both rural and urban Ghana after age and sex adjustment except in rural Ghana where wealth index was associated with prevalence of CKD. Consequently, the higher SES did not account for the increased rate of CKD among urban dwellers suggesting the need to identify other factors that may be driving this.
<b>Introduction</b>				
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4	The theoretical and scientific background as well as the rationale for conducting the study have been provided in the introduction section.
Objectives	3	State specific objectives, including any prespecified hypotheses	4	We assessed the association of SES with CKD in rural and urban Ghana and studied what extent the higher SES of people in urban areas could account for differences in CKD between rural and urban populations
<b>Methods</b>				
Study design	4	Present key elements of study design early in the paper	5-6	Details given in the methods
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6	Rural or urban Ghana.

Participants	6	<p>(a) <i>Cohort study</i>—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up</p> <p><i>Case-control study</i>—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls</p> <p><i>Cross-sectional study</i>—Give the eligibility criteria, and the sources and methods of selection of participants</p>	6-8	A multi-centre cross-sectional study was conducted among Ghanaian adults (n=2492) aged 25-70 years residing in rural and urban Ghana.
		<p>(b) <i>Cohort study</i>—For matched studies, give matching criteria and number of exposed and unexposed</p> <p><i>Case-control study</i>—For matched studies, give matching criteria and the number of controls per case</p>		
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8	The main outcomes have been clearly defined.
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-8	We defined each variable of interest in the methods accordingly
Bias	9	Describe any efforts to address potential sources of bias	18	Potential sources of bias have discussed in the discussion section
Study size	10	Explain how the study size was arrived at	5	Given in the methods section and we have also referred to the RODAM study methods paper

Continued on next page

Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8-9	Please see methods
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	8-9	Please see methods
		(b) Describe any methods used to examine subgroups and interactions	8-9	Please see methods
		(c) Explain how missing data were addressed	8-9	
		(d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy	NA	We have reported non-response across sites
		(e) Describe any sensitivity analyses	NA	
<b>Results</b>				
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5	Non-response analysis was done to shed light on the differential response rates across sites
		(b) Give reasons for non-participation at each stage	5	
		(c) Consider use of a flow diagram	5	We have also referred to RODAM methods paper
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	5	We have also referred to RODAM methods paper
		(b) Indicate number of participants with missing data for each variable of interest	5	We have also referred to RODAM methods paper
		(c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	NA	
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time	NA	
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure	NA	
		<i>Cross-sectional study</i> —Report numbers of outcome events or summary measures	9-10	Summary measures are given in the results section and in tables and figures
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12-16	Unadjusted and adjusted estimates are given in the results section and in figures
		(b) Report category boundaries when continuous variables were categorized	12-16	We have provided mean and corresponding standard deviations for the continuous variables.

		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time	NA	
		Continued on next page		
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA	
<b>Discussion</b>				
Key results	18	Summarise key results with reference to study objectives	8	
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	18	Key limitations regarding study methods including differential response rates and sampling methods in the various study sites have been provided
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	17-18	Cautious overall interpretation of the key findings have been provided.
Generalisability	21	Discuss the generalisability (external validity) of the study results	17-18	
<b>Other information</b>				
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	19	The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).

# BMJ Open

## A CROSS-SECTIONAL STUDY OF ASSOCIATION BETWEEN SOCIOECONOMIC INDICATORS AND CHRONIC KIDNEY DISEASE IN RURAL-URBAN GHANA: THE RODAM STUDY

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2018-022610.R3
Article Type:	Research
Date Submitted by the Author:	15-Feb-2019
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<b>Primary Subject Heading</b>:	Epidemiology
Secondary Subject Heading:	Public health, Epidemiology
Keywords:	Chronic Kidney Disease, Socioeconomic status, Health inequalities, RODAM study, rural, urban

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**A CROSS-SECTIONAL STUDY OF ASSOCIATION BETWEEN  
SOCIOECONOMIC INDICATORS AND CHRONIC KIDNEY DISEASE IN  
RURAL-URBAN GHANA: THE RODAM STUDY**

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3 **85 Abstract**  
4 **86**

5 **87 Objectives:** Studies from high income countries suggest higher prevalence of Chronic Kidney Disease  
6 **88 (CKD)** among individuals in low socio-economic groups. However, some studies from low and middle-  
7 **89 income** countries (LMICs) show the reverse pattern among those in high socioeconomic groups. It is  
8 **90 unknown** which pattern applies to individuals living in rural and urban Ghana. We assessed the  
9 **91 association** between Socio-Economic Status (SES) indicators and CKD in rural and urban Ghana and to  
10 **92 what** extent the higher SES of people in urban areas of Ghana could account for differences in CKD  
11 **93 between** rural and urban populations.  
12 **94**

13 **95 Setting:** The study was conducted in Ghana (Ashanti region). We used baseline data from a  
14 **96 multi-centre** Research on Obesity and Diabetes among African Migrants (RODAM)  
15 **97 study.**  
16 **98**

17 **99 Participants:** The sample consisted of 2492 adults (Rural Ghana, 1043, Urban Ghana, 1,449) aged 25 to  
18 **100 70** years living in Ghana.  
19 **101**

20 **102 Exposure:** Educational level, occupational level and wealth index.  
21 **103**

22 **104 Outcome:** Three CKD outcomes were considered using the 2012 KDIGO (Kidney Disease: Improving  
23 **105 Global** Outcomes) severity of CKD classification: albuminuria, reduced glomerular filtration rate and  
24 **106 high** to very high CKD risk based on the combination of these two.  
25 **107**

26 **108 Results:** All three SES indicators were not associated with CKD in both rural and urban Ghana after age  
27 **109 and** sex adjustment except for rural Ghana where high wealth index was significantly associated with  
28 **110 higher** odds of reduced eGFR (AOR, 2.38; 95% C.I. 1.03-5.47). The higher rate of CKD observed in  
29 **111 urban** Ghana was not explained by the higher SES of that population.  
30 **112**

31 **113 Conclusion:** SES indicators were not associated with prevalence of CKD except for wealth index and  
32 **114 reduced** eGFR in rural Ghana. Consequently, the higher SES of urban Ghana did not account for the  
33 **115 increased** rate of CKD among urban dwellers suggesting the need to identify other factors that may be  
34 **116 driving** this.  
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36 **118 Index Words:** Chronic kidney disease; socioeconomic status; health inequalities; risk factor; ethnic  
37 **119 minority** groups; migrants; RODAM study, Ghana  
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### Strengths and limitation of the study

- The use of well-standardized study protocols across rural and urban Ghana eliminated intra protocol variability.
- Our study is also the first in Africa to use all three categories of CKD definitions (albuminuria, reduced eGFR and CKD risk) by KDIGO 2012 in assessing association of SES with CKD in rural and urban setting. This provides more detailed information on CKD outcomes.
- The limitation of intra laboratory variability in earlier studies was eliminated using the same standard operating procedures in the same laboratory for running all samples for both rural and urban Ghana.
- The use of three constructs of SES (educational level, occupational level and wealth index) in this study also provides a much better holistic approach to assessing SES associations with CKD.
- Our study was limited because of the use of cross sectional design which prevented us from determining causality between predictors and CKD progression.

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## Introduction

In general, individuals in lower socio-economic status (SES) groups have been shown to suffer more frequently from Chronic Kidney Disease (CKD), often progressing to End Stage Renal Disease (ESRD), and associated with inadequate dialysis treatment, reduced access to kidney transplantation and poor health outcomes <sup>1</sup>. Recent studies have consistently found low SES to be associated with higher risk of CKD among people of African origin <sup>2-5</sup>.

However, in some settings the well-known inverse association between SES and CKD seems to be absent, or even reversed. For example, Bryne et al. did not find any association between SES and End Stage Renal Disease <sup>6</sup>. Other studies have found a positive association between SES and CKD <sup>7 8</sup>. Specifically, as SES improved, unhealthful lifestyle (unhealthy diet, physical inactivity, smoking and alcohol consumption) increased in China while that of the United States decreased with

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4 189 improved SES<sup>9</sup>. People with higher incomes, in these contexts, can afford a western  
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6 190 lifestyle, which is more readily available in the urban areas than in the rural areas.  
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8 191 There is therefore an interaction between individual SES and environmental factors,  
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11 192 such as food, alcohol, smoking and sedentary life style in such populations<sup>10-12</sup>.  
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14 193 Consequently, in those settings, people with a higher SES might have higher CKD  
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16 194 risk.

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18 195 In urban areas, the population in general has higher SES than in rural areas<sup>13</sup>. For example, individuals  
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20 196 with higher educational level migrate from rural areas to find higher occupations matching their higher  
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22 197 education to improve on their wealth. If indeed a positive association between SES and CKD is observed  
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24 198 in LMICs, this might underlie the well-known health differences between urban and rural areas, with  
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26 199 urban areas having an increased risk of CKD<sup>14</sup>. So far, it is unknown whether the reversed SES gradient  
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28 200 (higher risk in high SES group) might explain the higher burden of CKD in urban areas as compared to  
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30 201 rural areas in Africa.

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32 203 In view of this, we assessed the association of SES with CKD in rural and urban Ghana and studied the  
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34 204 extent to which the higher SES of people in urban areas could account for differences in CKD between  
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36 205 rural and urban populations.

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## 43 212 **Methods**

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### 45 214 *Study population and study design*

46 215 In the present analyses, data from the RODAM (Research on Obesity & Diabetes  
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48 216 among African Migrants) study, a multi-centre cross-sectional study were used. The  
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3 217 rationale, conceptual framework, design and methodology of the RODAM study have  
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6 218 been described in detail elsewhere<sup>15 16</sup>. As the Healthy Life in an Urban Setting  
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8 219 (HELIUS) study conducted among Ghanaian migrants living in Amsterdam did not find any  
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10 220 associations between SES and CKD<sup>17</sup> the current study focused on rural and urban Ghana (Ashanti  
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12 221 region of Ghana). The RODAM study was conducted from 2012 to 2015 and it comprised  
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14 222 of individuals aged 25-70 years living in rural and urban Ghana and Ghanaian  
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16 223 migrants in Europe. All participants below 25 and above 70 years were excluded in  
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18 224 the present analyses. The present analysis was restricted to the rural and urban sites  
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20 225 (n=2492) RODAM participants. Specifically, 1043 participants from rural Ghana and  
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22 226 1449 from urban Ghana were used in this study.  
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27 228 Data collection for the study was standardized across all sites. Written informed  
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29 229 consent was obtained from each participant prior to enrolment in the study. The  
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31 230 respective ethics committees in Ghana and the three European countries approved the  
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33 231 study protocols before data collection began. Specifically, we obtained ethical clearance  
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35 232 in Ghana from School of Medical Sciences/Komfo Anokye Teaching Hospital  
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37 233 Committee on Human Research, Publication & Ethical Review Board. In the  
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39 234 Netherlands, the Institutional Review Board of the AMC, University of Amsterdam gave  
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41 235 approval for the study. In Germany, approval for the study was obtained from the  
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43 236 Ethics Committee of Charite-Universitätsmedizin. The London School of Hygiene and  
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45 237 Tropical Medicine Research Ethics Committee gave approval for the study in the UK.  
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51 238 The response rate was 76% in rural Ghana and 74% in urban Ghana. In Ghana,  
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53 239 participants were randomly drawn from a list of 30 enumeration areas in the Ashanti  
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3 240 region based on the 2010 population census using the multistage random sampling.  
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6 241 These enumeration areas came from two purposively selected urban cities (Kumasi  
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8 242 and Obuasi) and 15 randomly selected rural communities in the Ashanti region.  
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10 243 Selected health and community authorities were first identified, notified of the study  
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12 244 and letters were sent giving detailed explanation of the study. We sent team members  
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15 245 to stay among the communities to familiarize with them and organize mini clinics in  
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17 246 the field. This lasted between 1-2 weeks depending on the sampled population and  
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20 247 responsiveness of respondents.  
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23 248 In Ghana, questionnaires administration and physical examination were done at the  
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25 249 same day/time. The participants were instructed to fast from 10.00pm the night before  
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27 250 the physical examination. For the current study, 2566 participants with data available  
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30 251 on both questionnaire data and physical measurements were used. We excluded  
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32 252 (n=74) individuals outside the RODAM age range of 25-70 years resulting in a data  
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34 253 set of 2492 for analysis. These comprised 1,449 Urban Ghana and 1043 Rural Ghana.  
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37 254 For the final analysis, individuals with no data on CKD status (n=42) were excluded.  
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## 39 255 **Measurements**

## 40 256 **Covariates**

### 41 257 *Demographic and lifestyle factors*

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44 258 Information on demographics, educational level, occupational level, wealth index and lifestyle factors  
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47 259 (smoking and physical activity) were obtained by questionnaire. Physical examinations were performed  
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50 260 with validated devices per standardized operational procedures across all study sites. Weight was  
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52 261 measured in light clothing and without shoes with SECA 877 scales to the nearest 0.1 kg. Height was  
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54 262 measured without shoes with a portable stadiometer (SECA 217) to the nearest 0.1cm. Body mass index  
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56 263 (BMI) was calculated as weight (kg) divided by height squared (m<sup>2</sup>). Overweight was defined as BMI of  
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3 264  $\geq 25$  to  $< 30$  kg/m<sup>2</sup> and obesity as BMI  $\geq 30$  kg/m<sup>2</sup> <sup>18</sup>. Per participant, all anthropometrics were measured  
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5 265 twice by the same assessor and the average of the two measurements were used for analyses.  
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7 266 ***Predictor: SES***  
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10 267 Socioeconomic indicators used in this study were educational level, occupational status and level of  
11 268 wealth index. Educational level was determined based on self-reported highest educational qualification  
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13 269 accomplished based on the Ghanaian educational system. Occupational level was determined based on  
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15 270 self-reported current occupation if employed and/or last occupation before retirement or student. The  
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17 271 reported occupations were further coded according to the International Standard Classification of  
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19 272 Occupations scheme (ISCO-08). Where ‘high’ (professionals, managers, clerical support staff, higher  
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21 273 grade routine non-manual employees service and sales-related occupations) and ‘low’ (craft and related  
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23 274 trades workers, elementary occupations and farmers) and the rest were categorized into the ‘middle’.  
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25 275 Wealth index was determined using the World Health Organization (WHO) standard of wealth index  
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27 276 classification. Wealth index was based on data collected in the Household Questionnaire. The  
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29 277 questionnaire comprised of questions on household’s ownership of several consumer items such as  
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31 278 television, car, flooring material, toilet facilities etc. Each household was assigned a standard score for  
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33 279 each asset. Wealth index was then expressed in five categories. The five categories were further  
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35 280 categorized into three categories by combining the second and third as well as fourth and fifth categories  
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37 281 due to small numbers <sup>19</sup>. All three SES constructs were further classified as low, medium and high SES  
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39 282 and their relationship to each other tested. A composite SES variable (SES) was generated based on the  
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41 283 three SES constructs (education, occupation and wealth index) using the EGEN group command in  
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43 284 STATA. The codes were combined into numerical variables and their averages computed. The resultant  
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45 285 values were recoded into three categories (low, medium and high).  
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47 286 ***Co-morbidity factors***  
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49 287 Blood pressure (BP) was measured three times using a validated semi-automated device (The Microlife  
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51 288 WatchBP home) with appropriate cuffs in a sitting position after at least 5 min rest. The mean of the last  
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53 289 two BP measurements was used in the analyses. Hypertension was defined as systolic BP  $\geq 140$  mmHg,  
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55 290 and/or diastolic BP  $\geq 90$  mmHg, and/or being on antihypertensive medication treatment, and/or self-  
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57 291 reported hypertension. Trained research assistants in the two sites collected fasting venous blood samples.  
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59 292 All the blood samples were processed and aliquoted immediately (within one hour to maximum three  
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293 hours of the vena puncture) after collection per standard operation procedures, and then temporarily  
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295 stored at the local research location at  $-20^{\circ}\text{C}$ . The separated samples were then transported to the local  
research centres laboratories, where they were checked, registered and stored at  $-80^{\circ}\text{C}$ . To avoid intra-

laboratory variability, the stored blood samples from the local research centres were transported to Berlin, Germany for biochemical analyses. Fasting plasma glucose concentration was measured using an enzymatic method (hexokinase). Type 2 diabetes was defined according to the WHO diagnostic criteria (fasting glucose  $\geq 7.0$  mmol/L, and/or current use of medication prescribed to treat diabetes, and/or self-reported diabetes) <sup>20</sup>. Concentration of total cholesterol was assessed using colorimetric test kits. All biochemical analyses were performed using an ABX Pentra 400 chemistry analyzer (ABX Pentra; Horiba ABX, Germany). Hypercholesterolemia was defined as total cholesterol level  $\geq 6.22$  mmol/L. Serum creatinine concentration (in  $\mu\text{mol/L}$ ) was determined by a kinetic colorimetric spectrophotometric isotope dilution mass spectrometry-calibrated method (Roche Diagnostics). Biochemical analyses were subject to extensive quality checks including blinded serial measurements.

### **Outcome: CKD prevalence**

Participants were asked to bring an early morning urine sample for the analyses of albuminuria and creatinine levels. Urinary albumin concentration (in mg/L) was measured by an immunochemical turbidimetric method (Roche Diagnostics). Urinary creatinine concentration (in  $\mu\text{mol/L}$ ) was measured by a kinetic spectrophotometric method (Roche Diagnostics). Estimated glomerular filtration rate (eGFR) was calculated using the CKDEPI (CKD Epidemiology Collaboration) creatinine equation <sup>21</sup>. Urinary albumin-creatinine ratio (ACR; expressed in mg/g) was calculated by taking the ratio between urinary albumin and urinary creatinine. eGFR and albuminuria were categorized according to the 2012 KDIGO (Kidney Disease: Improving Global Outcomes) classification <sup>22</sup>. eGFR was categorized as follows: G1,  $\geq 90$  mL/min/1.73 m<sup>2</sup> (normal kidney function); G2, 60 to 89 mL/min/1.73 m<sup>2</sup> (mildly decreased); G3a, 45 to 59 mL/min/1.73 m<sup>2</sup> (mildly to moderately decreased); G3b, 30 to 44 mL/min/1.73 m<sup>2</sup> (moderately to severely decreased); G4, 15 to 29 mL/min/1.73 m<sup>2</sup> (severely decreased); and G5,  $< 15$  mL/min/1.73 m<sup>2</sup> (kidney failure). Albuminuria categories were derived from ACR and were as follows: A1,  $< 3$  mg/mmol (normal to mildly increased); A2, 3 to 30 mg/mmol (moderately increased); and A3,  $> 30$  mg/mmol (severely increased). CKD status was categorized according to severity of kidney disease (green, low risk; yellow, moderately increased risk; orange, high risk; and red, very high risk) using the combination of eGFR (G1-G5) and albuminuria (A1-A3) levels defined by the 2012 KDIGO guideline <sup>23</sup>. Due to the small number of participants in the very high risk category of CKD, high and very high risk groups were combined. Reduced eGFR was defined as eGFR  $< 60$  mL/min/1.73 m<sup>2</sup>. Because of the small number of participants in the severely increased albuminuria category, we defined albuminuria as ACR  $\geq 3$  mg/mmol by combining the moderately increased (A2) and severely increased (A3) categories.

### **Patient and Public Involvement**

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3 328 Community leaders were involved in the recruitment of patients. These comprised of religious  
4 329 communities (churches and mosques), endorsement from local key leaders and establishing relationships  
5 330 with healthcare organizations. We also provided information on the study by involving the local media  
6 331 (radio and television stations). We sent letters to all selected health and community authorities to notify  
7 332 participants of the study. Team members were sent to the various communities to stay among the  
8 333 community and organize mini clinics for a period of 1-2 weeks. Results of the study were disseminated  
9 334 through seminars, durbars and via radio and television stations.

### 15 335 **Statistical methods**

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17 336 Participants' characteristics were expressed as absolute numbers and percentages for categorical variables  
18 337 and as means and standard deviations (SD) for continuous variables. CKD prevalence with 5% error bars  
19 338 were presented as bar graphs for each SES construct across rural and urban Ghana. Spearman's rank  
20 339 correlation was used to determine correlations between the three SES constructs. Odds ratios (ORs) and  
21 340 their corresponding 95% confidence intervals (CIs) were estimated by means of logistic regression  
22 341 analyses to study the odds of albuminuria (ACR>3 mg/mmol, A2-A3, moderately to severely increased  
23 342 albuminuria), reduced kidney function (eGFR< 60 mL/min/1.73 m<sup>2</sup>, G3-G5 moderately to severely  
24 343 decreased kidney function) and increased CKD risk (high and very high CKD risk) by SES, with  
25 344 adjustments for potential confounders (age and sex).<sup>24</sup> In addition, the analyses were performed for the  
26 345 total population (using low educational level, low occupational status and low level of wealth index as  
27 346 reference categories). Further analysis was conducted to assess the contribution of SES  
28 347 indicators to rural-urban differences in albuminuria, reduced eGFR and CKD risk using  
29 348 rural Ghana as reference. Tolerance test and variance inflation factor (VIF) showed  
30 349 very small degree of collinearity among SES predictors thus we therefore adjusted for  
31 350 each of SES variables separately. Complete case analysis approach was used. All  
32 351 data available were included in the age-adjusted models. All analyses were performed  
33 352 using STATA, version 14.0 (StataCorp LP).

### 50 353 **Results**

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3 355 Table 1 shows characteristics of study participants. Participants in rural Ghana were  
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6 356 slightly older than those in urban Ghana. Female preponderance was observed in both  
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8 357 rural (61.2%) and urban (71.4%) Ghana, though higher proportions were observed in  
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10 358 urban Ghana. Individuals living in rural Ghana were generally less educated (56.9%)  
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12 359 compared with those living in urban (43.9%) Ghana. There were slightly more  
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14 360 individuals with low occupational status in urban Ghana compared with their peers in  
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16 361 rural Ghana. People in urban Ghana (43.4%) were wealthier than their rural (24.9%)  
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18 362 counterparts. Rural Ghanaians (47.2%) were more physically active compared with their  
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20 363 urban peers. Smoking was low among Ghanaians though rural Ghanaians were more  
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22 364 likely to smoke compared with their urban peers. Hypercholesterolemia was more  
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24 365 prevalent in urban Ghana than in rural Ghana. Hypertension (36.7%) and type 2  
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26 366 diabetes (10.6%) were more prevalent in urban Ghanaians compared with those living  
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28 367 in rural Ghana. Urban Ghanaians were markedly more obese compared with their rural  
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30 368 peers. Except for eGFR, albuminuria and CKD risk prevalence rates were higher in  
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32 369 urban Ghana compared with rural Ghana.  
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**Table 1: Baseline characteristics by location**

	Rural Ghana	Urban Ghana
Number of participants, N (%)	1043 (41.9)	1449 (58.1)
Mean age, years (SD)	46.5 (12.6)	45.2 (11.4)
Females, N (%)	638 (61.2)	1034 (71.4)
Educational level n (%)		
Low	555 (56.9)	614 (43.9)
Middle	311 (31.9)	547 (39.1)
High	108 (11.2)	239 (17.0)
Occupational status, n (%)		
Low	250 (25.7)	374 (26.7)
Middle	628 (64.5)	818 (58.4)
High	96 (9.8)	209 (14.9)
Wealth index, n (%)		
Low	449 (46.5)	368 (26.6)
Middle	276 (28.6)	416 (30.0)
High	241 (24.9)	602 (43.4)
BMI (kg/m <sup>2</sup> )		
< 25	794 (76.3)	579 (39.9)
25-29.9	189 (18.2)	495 (34.2)
≥ 30	58 (5.5)	374 (25.9)
Low physical activity, n (%)	663 (47.2)	592 (60.7)

Smoking, n (%)	22 (2.3)	14 (1.0)
Hypercholesterolemia, n (%)	78 (7.6)	270 (18.7)
Hypertension, n (%)	306 (29.3)	531 (36.7)
	53	
Diabetes, n (%)	(5.1)	153 (10.6)
Albuminuria, n (%)		
	930 (91.6)	
A1, Normal to mildly increased (ACR <3 mg/mmol)	85	1285 (89.1)
A2-A3, moderately to severely increased (ACR ≥ 3 mg/ (8.4)		158 (10.9)
eGFR, n (%)		
G1-G2 (≥ 60 mL/min/1.73m <sup>2</sup> )	989 (96.3)	1388 (96.3)
G3-G5 (<60 mL/min/1.73m <sup>2</sup> )	38 (3.7)	54 (3.7)
CKD risk, n (%)		
Low risk (green)	916 (90.5)	1281 (88.9)
Moderately increased to very high risk (yellow to red)	96 (9.5)	160 (11.1)

**Abbreviations:** N, number of respondents; SD, standard deviation; eGFR, estimated glomerular filtration rate; ACR, albumin creatinine ratio; CKD, Chronic kidney disease

Figure 1 shows prevalence of CKD by level of education in urban and rural Ghana. Prevalence of CKD decreased with increasing levels of education in rural Ghana. Higher prevalence of CKD was observed among individuals with low educational level compared with those with middle and high educational level. However, those with high educational level in urban Ghana had higher prevalence of CKD compared with those with middle level education. For occupational status, prevalence of CKD was higher among individuals with low occupational status in urban Ghana. Similar patterns were observed in rural Ghana; however, those with higher occupational status had higher prevalence of CKD compared with those with middle occupational status (Figure 2). Figure 3 shows prevalence of CKD by level of wealth index. CKD prevalence among

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3 404 the levels of wealth index varied between urban and rural Ghana. Those with middle  
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6 405 level wealth index had higher prevalence of CKD compared with those with low or  
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8 406 high CKD prevalence in both rural and urban Ghana. CKD prevalence rate for low and  
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10 407 high level wealth index in urban Ghana was the same while that of rural Ghana was  
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12 408 slightly different.  
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3 409 Among the whole group, educational level was positively associated with wealth index ( $p<0.01$ ) and composite SES  
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6 410 ( $P<0.01$ ). Occupational level was also inversely associated with educational level ( $p<0.01$ ) and wealth index ( $p<0.01$ ). In  
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8 411 urban Ghana, high educational level was positively associated with high wealth index but inversely associated with  
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10 412 occupation ( $p<0.01$ ). In rural Ghana, high education was positively associated with high wealth index ( $p<0.01$ ), but there  
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12 413 was no significant association between education and occupation. High wealth index was inversely associated with high  
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14 414 occupational status in both rural and urban Ghana ( $p<0.01$ ) (Table 2).  
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20 416 **Table 2: Relationship between SES constructs (educational, occupational level and wealth index) by urban**  
21 417 **rural Ghana**  
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Correlation matrix	Educational level	Occupational level	Wealth index	SES
<b>Whole group</b>				
Educational level	1.000			
Occupational status	<b>-0.060</b>	1.000		
	<b>0.004</b>			
Wealth Index	0.282	<b>-0.121</b>	1.000	
	0.001	<b>0.001</b>		
SES	<b>1.000</b>	<b>-0.059</b>	<b>0.282</b>	1.000
	<b>0.003</b>	<b>0.006</b>	<b>0.001</b>	



**Urban Ghana**

Educational level	1.000			
Occupational status	<b>-0.115</b>	1.000		
	<b>0.001</b>			
Wealth Index	<b>0.294</b>	<b>-0.126</b>	1.000	
	<b>0.001</b>	<b>0.001</b>		
SES	<b>1.000</b>	<b>-0.024</b>	<b>0.937</b>	1.000
	<b>0.002</b>	<b>0.001</b>	<b>0.001</b>	

**Rural Ghana**

Educational level	1.000			
Occupational status	0.017	1.000		
	0.589			
Wealth Index	<b>0.219</b>	<b>-0.135</b>	1.000	
	<b>0.001</b>	<b>0.001</b>		
SES	<b>0.504</b>	0.017	<b>0.934</b>	1.000
	<b>0.001</b>	0.587	<b>0.001</b>	

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431 Table 3 shows association between level of education, occupational status, level of wealth index and prevalence of  
 432 CKD. After adjusting for age and sex for the whole group, albuminuria was associated with middle level education (AOR=0.66, 0.48-0.91,  
 433 p<0.01). After adjusting for age and sex, we observed no significant association between SES indicators (educational level, occupational status and  
 434 wealth index) and CKD in urban Ghana. However, middle (AOR=0.51, 0.34-0.76, <0.01) and higher (AOR=0.53, 0.31-0.91, p<0.01) level  
 435 education was associated with reduced albuminuria in urban Ghana. Whereas educational level and occupational status were not associated with  
 436 CKD prevalence, high wealth index was significantly associated with higher odds of reduced eGFR in rural Ghana (AOR=2.38, 1.03-5.47,  
 437 P<0.01).

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439 **Table 3: Association of SES indicators (educational level, occupational status and wealth index level) with albuminuria, reduced eGFR and CKD risk**

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Albuminuria (ACR ≥ 3 mg/mmol)	eGFR < 60 mL/min/1.73 m2	High to very high CKD risk (KDIGO, 2012)
OR (95% CI)	OR (95% CI)	OR (95% CI)

	n (%)	Model 1	n (%)	Model 1	n (%)	Model 1
<b>Education</b>						
<b>Whole group</b>						
Low	1,152 (11.89)	1.00 (Reference)	1,160 (3.97)	1.00 (Reference)	1,150 (11.91)	1.00 (Reference)
Middle	847 (7.32)	<b>0.66 (0.48-0.91)</b>	849 (3.77)	1.36 (0.83-2.22)	845 (8.28)	0.82 (0.59-1.12)
High	343 (7.00)	0.67 (0.42-1.07)	345 (3.19)	1.11 (0.55-2.29)	343 (8.75)	0.96 (0.62-1.49)
<b>Urban Ghana</b>						
Low	612 (14.7)	1.00 (Reference)	612 (4.1)	1.00 (Reference)	612 (14.1)	1.00 (Reference)
Middle	546 (7.8)	<b>0.51 (0.34-0.76)</b>	546 (3.7)	1.12 (0.59-2.12)	545 (8.1)	<b>0.59 (0.39-0.89)</b>
High	238 (8.4)	<b>0.53 (0.31-0.91)</b>	238 (3.4)	0.91 (0.37-2.19)	238 (10.9)	0.83 (0.51-1.38)
<b>Rural Ghana</b>						
Low	540 (8.7)	1.00 (Reference)	548 (3.8)	1.00 (Reference)	538 (9.5)	1.00 (Reference)
Middle	301 (6.3)	0.89 (0.51-1.59)	303 (3.9)	1.69 (0.77-3.66)	300 (8.7)	1.33 (0.79-2.25)
High	105 (3.8)	0.66 (0.23-1.95)	107 (2.8)	1.28 (0.35-4.71)	105 (3.8)	0.69 (0.23-2.02)
<b>Occupational status</b>						
<b>Whole group</b>						
Low	614 (9.93)	1.00 (Reference)	616 (2.76)	1.00 (Reference)	613 (9.46)	1.00 (Reference)
Middle	1,427 (9.25)	0.82 (0.59-1.14)	1,436 (3.34)	0.93 (0.52-1.66)	1,424 (9.90)	0.89 (0.65-1.24)
High	302 (10.26)	0.76 (0.47-1.22)	303 (7.92)	1.33 (0.67-2.62)	302 (12.91)	0.90 (0.57-1.42)
<b>Urban Ghana</b>						
Low	207 (10.1)	1.00 (Reference)	207 (6.8)	1.00 (Reference)	207 (12.1)	1.00 (Reference)
Middle	817 (11.1)	1.50 (0.88-2.83)	817 (3.6)	1.15 (0.56-2.35)	816 (11.6)	1.37 (0.84-2.56)
High	373 (11.0)	1.57 (0.89-2.53)	373 (2.7)	1.02 (0.41-2.52)	373 (9.7)	1.21 (0.68-2.14)
<b>Rural Ghana</b>						
Low	95 (10.5)	1.00 (Reference)	96 (10.4)	1.00 (Reference)	95 (14.7)	1.00 (Reference)
Middle	610 (6.7)	0.65 (0.31-1.37)	619 (3.1)	<b>0.37 (0.16-0.85)</b>	608 (7.6)	0.55 (0.28-1.08)
High	241 (8.3)	0.99 (0.43-2.28)	243 (2.9)	0.51 (0.18-1.44)	240 (9.2)	0.94 (0.44-2.01)
<b>Wealth index</b>						

**Whole group**

Low	808 (9.65)	1.00 (Reference)	813 (3.32)	1.00 (Reference)	808 (9.16)	1.00 (Reference)
Middle	678 (10.91)	1.18 (0.84-1.66)	683 (3.81)	1.30 (0.74-2.28)	675 (12.0)	1.43 (1.02-2.01)
High	835 (8.62)	0.93 (0.66-1.31)	835 (4.19)	1.55 (0.91-2.64)	833 (9.96)	1.21 (0.86-1.69)

**Urban Ghana**

Low	367 (11.2)	1.00 (Reference)	367 (3.5)	1.00 (Reference)	367 (10.1)	1.00 (Reference)
Middle	414 (12.3)	1.12 (0.73-1.74)	414 (3.9)	1.30 (0.61-2.80)	413 (13.1)	1.45 (0.93-2.27)
High	601 (9.8)	0.82 (0.55-1.25)	600 (3.8)	1.13 (0.55-2.31)	600 (10.8)	1.11 (0.72-1.71)

**Rural Ghana**

Low	441 (7.9)	1.00 (Reference)	446 (3.1)	1.00 (Reference)	441 (8.4)	1.00 (Reference)
Middle	264 (8.7)	1.13 (0.65-1.98)	269 (3.7)	1.22 (0.52-2.84)	262 (10.3)	1.31 (0.77-2.25)
High	234 (5.6)	0.78 (0.40-1.53)	235 (5.1)	<b>2.38 (1.03-5.47)</b>	233 (7.7)	1.16 (0.63-2.14)

Model 1, adjusted for age and sex; Abbreviations: CI, confidence interval; ACR, albumin creatinine ration; eGFR, estimated glomerular filtration rate; CKD, chronic kidney disease; OR, odds ratio, n= total number of individuals in the whole group, rural and urban Ghana among the various levels of SES constructs; %, proportion of individuals with CKD among the various levels of SES constructs in rural and urban Ghana.

Table 4 shows the contribution of all three SES constructs to rural and urban CKD prevalence differences. The odds of albuminuria and CKD risk was significantly higher in urban Ghana compared with rural Ghana (p<0.01). The higher rate of CKD observed in urban Ghana was not explained by the higher SES of that population as compared to their rural counterparts.

**Table 4: Contribution of SES indicators to rural-urban differences in albuminuria, reduced eGFR and CKD risk**

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OR (95% CI)    OR (95% CI)    OR (95% CI)    OR (95% CI)    OR (95% CI)

		Model 1	Model 2	Model 3	Model 4	Model 5
<b>Albuminuria (ACR ≥ 3 mg/mmol)</b>						
	n cases					
<b>Sites</b>	(%)					
	1,443	<b>1.37 (1.03-</b>	<b>1.70 (1.25-</b>	<b>1.55 (1.15-</b>	<b>1.62 (1.18-</b>	<b>1.74 (1.27-</b>
Urban Ghana	(10.9)	<b>1.81)</b>	<b>2.31)</b>	<b>2.10)</b>	<b>2.19)</b>	<b>2.38)</b>
		1.00	1.00	1.00	1.00	1.00
Rural Ghana	1,015 (8.4)	(Reference)	(Reference)	(Reference)	(Reference)	(Reference)
<b>eGFR &lt; 60 mL/min/1.73 m<sup>2</sup></b>						
	n cases					
<b>Sites</b>	(%)					
		1.27 (0.82-	1.20 (0.76-	1.18 (0.79-	1.12 (0.70-	1.07 (0.67-
Urban Ghana	1,442 (3.7)	1.97)	1.89)	1.86)	1.78)	1.72)
		1.00	1.00	1.00	1.00	1.00
Rural Ghana	1,027 (3.7)	(Reference)	(Reference)	(Reference)	(Reference)	(Reference)
<b>High to very high CKD risk</b>						
	n cases					
<b>Sites</b>	(%)					
	1,441	<b>1.23 (1.01-</b>	<b>1.44 (1.07-</b>	<b>1.38 (1.03-</b>	<b>1.36 (1.01-</b>	<b>1.40 (1.04-</b>
Urban Ghana	(11.1)	<b>1.62)</b>	<b>1.93)</b>	<b>1.84)</b>	<b>1.83)</b>	<b>1.91)</b>
	1,012	1.00	1.00	1.00	1.00	1.00 (Reference)
Rural Ghana	(9.46)	(Reference)	(Reference)	(Reference)	(Reference)	

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455 Model 1#: adjusted for age and sex; Model 2: adjusted for age, sex and education level; Model 3: adjusted for age, sex and occupational status;  
456 Model 4: adjusted for age, sex and wealth index; Model 5: adjusted for age, sex, educational level, occupational status and wealth index;  
457 Abbreviations: CI, confidence interval; ACR, albumin creatinine ratio; eGFR, estimated glomerular filtration rate; CKD, chronic kidney disease; OR, odds ratio, n= total number  
458 of individuals in rural and urban Ghana; %, proportion of individuals with CKD among urban and rural Ghana.

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6 460 **Discussion**7  
8 461 ***Key findings***

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10 462 Our study findings show no association between all three SES constructs and the  
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12 463 prevalence of CKD in both rural and urban Ghana except for wealth index in rural  
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14 464 Ghana, with the risk of CKD being higher in the wealthier populations. The higher rate  
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16 465 of CKD observed in urban Ghana could not be attributed to the higher SES of that  
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18 466 population compared to their rural counterparts.  
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24 468 **Discussion of key findings**25  
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29 470 ***Association of SES with CKD in rural and urban Ghana***30  
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32 472 Our study did not find any significant associations between all three SES constructs  
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34 473 and CKD among rural and urban Ghana except for wealth index in rural Ghana. The  
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36 474 positive association observed between wealth index in rural Ghana may be due to  
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38 475 several reasons. A comparison of the three SES constructs showed higher educational  
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40 476 level to be associated with wealth index in both rural and urban Ghana but not  
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42 477 occupational level. This seems to suggest that occupational level may not be  
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44 478 adequately capturing the SES status of individuals living in these settings in relation to  
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46 479 CKD. For example, Masthi et al, compared different SES scales in rural and urban  
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48 480 India and concluded that Standard of Living Index (SLI) scale was more accurate for classification  
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50 481 of SES in urban and rural settings<sup>25</sup>. Our finding is consistent with other studies,<sup>6 26</sup> which  
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52 482 reported no association between SES and CKD in high-income countries and LMICs,  
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4 483 but in contrast with other studies <sup>2-4 27</sup> that found positive associations between SES  
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6 484 and CKD. The reasons for our current finding are unclear. However, it has been  
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8 485 suggested that these inconsistent associations may be due to the varying pathways  
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10 486 through which the effect of SES on health status is mediated. For example, at a given  
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12 487 educational level marked ethnic differences have been reported. Additionally, similar  
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14 488 differences were observed for wealth status at a given income level <sup>28-30</sup>.

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20 490 ***Contribution of SES to observed CKD risk differences between rural and***  
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22 491 ***urban Ghana***

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24 493 We observed higher rates of CKD in urban Ghana compared with rural Ghana, as expected. The observed  
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26 494 higher rates of CKD in our study were not explained by the higher SES of that population as compared to  
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28 495 their rural counterparts. Our results indicate that this is due to the lack of a clear difference in the SES  
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30 496 distribution of rural and urban Ghana observed in this study, as well as to the lack of associations between  
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32 497 SES and CKD. Consistent with our findings, in a study conducted in Northern Tanzania SES did not  
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34 498 explain increased risk of CKD in urban Tanzania <sup>26</sup>. The lack of associations between SES and CKD  
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36 499 could probably and partly be explained by the process of epidemiological transition in relation to the  
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38 500 “diffusion theory” of ischemic heart disease mortality. This theory attributes the commencement of  
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40 501 ischemic heart disease to individuals in the high SES group due to their ability to afford behaviours  
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42 502 (smoking, alcohol and sedentary lifestyles) which increased risk of ischemic heart disease. The lower SES  
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44 503 groups were later affected partially because of improved living standards, unhealthy life style imitation  
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46 504 and urbanization. The higher SES groups were the first to embrace behavioural changes required to  
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48 505 decrease the risk of ischemic heart disease and this resulted in reversing the gradient <sup>31</sup>. The rapid  
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50 506 urbanization of some rural communities in the Ashanti region of Ghana and the  
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52 507 imitation of urban lifestyle could account for our finding. Also, it could be that whereas  
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54 508 the high SES group in urban Ghana has already embraced favourable behavioural  
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56 509 changes, those in rural Ghana are yet to do so <sup>32</sup>. This explains the observed association of  
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58 510 wealth index with CKD in rural Ghana but not in urban Ghana. Also, the interplay of other less



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3 511 understood or researched factors (e.g., exposure to nephrotoxins, herbal medications,  
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5 512 sepsis, psychosocial factors) may be influencing the pathway in which SES influences  
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8 513 CKD prevalence and progression.  
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### 11 515 ***Strength and limitation***

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15 517 Our study presents several strengths. First, we used well-standardized study protocols across rural and  
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17 518 urban Ghana. Our study is also the first in Africa to use all three categories of CKD definition  
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19 519 (albuminuria, reduced eGFR and CKD risk) by KDIGO 2012 in assessing association of SES with CKD  
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21 520 in rural and urban setting, this provided more detailed information on CKD outcomes. The limitation of  
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23 521 intra laboratory variability in earlier studies was eliminated using the same standard operating procedures  
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25 522 in the same laboratory for running all samples for both rural and urban Ghana. The use of three constructs  
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27 523 of SES in this study also provides a much better holistic approach to assessing SES. Also, the distribution  
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29 524 of SES in our study reflects on the national data allowing for generalization of our findings. Our study  
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31 525 was limited by the use of cross sectional design, which prevented us from determining causality between  
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33 526 predictors and CKD progression. Furthermore, there were more women than men in our study due to the  
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35 527 higher response rate in women compared with men. However, this applied to both rural and urban Ghana.  
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37 528 We therefore do not expect this to influence our results in a significant way.

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### 40 531 ***Conclusion***

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43 533 All three SES constructs appear not to be associated with prevalence of CKD in urban  
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45 534 and rural Ghana except for wealth index in rural Ghana. The observed higher  
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47 535 prevalence of CKD in urban Ghana was not explained by the higher SES in urban  
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49 536 Ghana. Our study seems to suggest that other non-traditional factors such as  
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51 537 nephrotoxins, herbal medications, psychosocial stressors and misuse of over the  
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53 538 counter drugs may play a role and underscores the need to further explore these  
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55 539 factors.  
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19 549 **Contributors**

20 550 My co-authors have all contributed substantially to this manuscript and approve of this  
21 551 submission. Research idea and study design: DNA, CA, KS, DA, EB, KM, JA; data acquisition  
22 552 and curation: DNA, CA, EB, KM, data analysis/interpretation: DNA, CA, KS, DA, EB, KM, LS,  
23 553 JA, EOD, KKG, FPM, ID, JS, SB, ADA; statistical analysis: DNA, CA, KS. DNA, CA, KS, DA,  
24 554 EB, KM, LS, JA, EOD, KKG, FPM, ID, JS, SB, ADA contributed important intellectual content  
25 555 during manuscript drafting or revision and accepts accountability for the overall work by  
26 556 ensuring that questions pertaining to the accuracy or integrity of any portion of the work are  
27 557 appropriately investigated and resolved. DNA and CA take responsibility that this study has been  
28 558 reported honestly, accurately, and transparently; that no important aspects of the study have been  
29 559 omitted; and that any discrepancies from the study as planned have been explained.

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3 570 **Patient Consent:** None declared  
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7 572 **Ethics approval:** IRBs at each participating site.  
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10 574 **Data sharing statement:** Data are available from the RODAM research cohort, a third  
11  
12 575 party. Dr. Eric Beune affiliated with the RODAM research cohort and a co-author of this paper  
13  
14 576 in accordance with the RODAM requirements for collaboration. Dr. Beune is the Data Collection  
15  
16 577 Coordinator of RODAM and may be contacted with further questions (e.j.beune@amc.uva.nl).  
17  
18 578 Additionally, researchers interested in further collaboration with RODAM may see the following  
19  
20 579 URL: <http://www.rod-am.eu/>  
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Figure 1: Prevalence of chronic kidney disease (CKD) across level of education among urban and rural participants. Definitions according to 2012 KDIGO (Kidney Disease: Improving Global Outcomes) guideline. CKD was defined as being in moderately increased risk, high-risk, or very high-risk groups.

Figure 2: Prevalence of chronic kidney disease (CKD) across occupational status among urban and rural participants. Definitions according to 2012 KDIGO (Kidney Disease: Improving Global Outcomes) guideline. CKD was defined as being in moderately increased risk, high-risk, or very high-risk groups.

Figure 3: Prevalence of chronic kidney disease (CKD) across wealth index categories among urban and rural participants. Definitions according to 2012 KDIGO (Kidney Disease: Improving Global Outcomes) guideline. CKD was defined as being in moderately increased risk, high-risk, or very high-risk groups.

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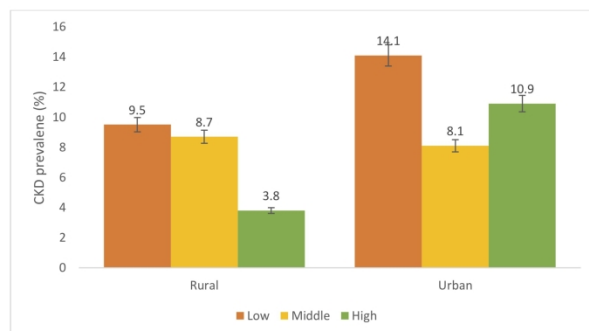


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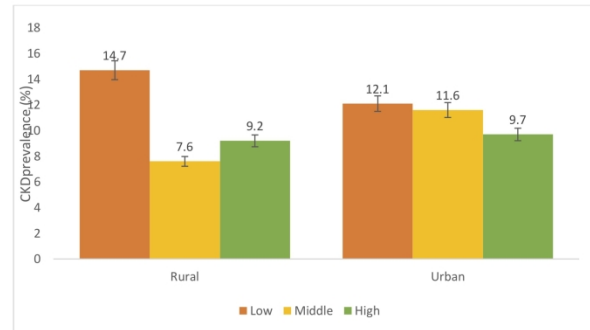


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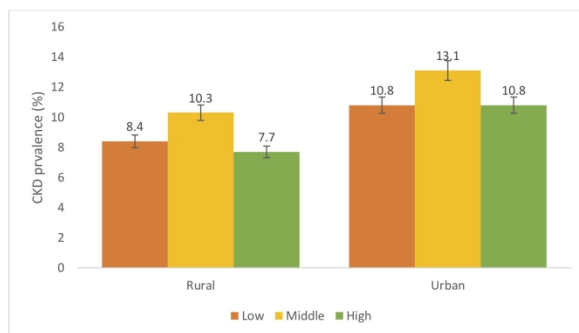


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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No.	Recommendation	Page No.	Relevant text from manuscript
<b>Title and abstract</b>	1	(a) Indicate the study’s design with a commonly used term in the title or the abstract	1,2	We have included a commonly used term in the title and abstract
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2	Our study did not find any associations between SES indicators and CKD in both rural and urban Ghana after age and sex adjustment except in rural Ghana where wealth index was associated with prevalence of CKD. Consequently, the higher SES did not account for the increased rate of CKD among urban dwellers suggesting the need to identify other factors that may be driving this.
<b>Introduction</b>				
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4	The theoretical and scientific background as well as the rationale for conducting the study have been provided in the introduction section.
Objectives	3	State specific objectives, including any prespecified hypotheses	4	We assessed the association of SES with CKD in rural and urban Ghana and studied what extent the higher SES of people in urban areas could account for differences in CKD between rural and urban populations
<b>Methods</b>				
Study design	4	Present key elements of study design early in the paper	5-6	Details given in the methods
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6	Rural or urban Ghana.

Participants	6	<p>(a) <i>Cohort study</i>—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up</p> <p><i>Case-control study</i>—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls</p> <p><i>Cross-sectional study</i>—Give the eligibility criteria, and the sources and methods of selection of participants</p>	6-8	A multi-centre cross-sectional study was conducted among Ghanaian adults (n=2492) aged 25-70 years residing in rural and urban Ghana.
		<p>(b) <i>Cohort study</i>—For matched studies, give matching criteria and number of exposed and unexposed</p> <p><i>Case-control study</i>—For matched studies, give matching criteria and the number of controls per case</p>		
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8	The main outcomes have been clearly defined.
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-8	We defined each variable of interest in the methods accordingly
Bias	9	Describe any efforts to address potential sources of bias	18	Potential sources of bias have discussed in the discussion section
Study size	10	Explain how the study size was arrived at	5	Given in the methods section and we have also referred to the RODAM study methods paper

Continued on next page

Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8-9	Please see methods
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	8-9	Please see methods
		(b) Describe any methods used to examine subgroups and interactions	8-9	Please see methods
		(c) Explain how missing data were addressed	8-9	
		(d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy	NA	We have reported non-response across sites
		(e) Describe any sensitivity analyses	NA	
<b>Results</b>				
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5	Non-response analysis was done to shed light on the differential response rates across sites
		(b) Give reasons for non-participation at each stage	5	
		(c) Consider use of a flow diagram	5	We have also referred to RODAM methods paper
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	5	We have also referred to RODAM methods paper
		(b) Indicate number of participants with missing data for each variable of interest	5	We have also referred to RODAM methods paper
		(c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	NA	
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time	NA	
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure	NA	
		<i>Cross-sectional study</i> —Report numbers of outcome events or summary measures	9-10	Summary measures are given in the results section and in tables and figures
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12-16	Unadjusted and adjusted estimates are given in the results section and in figures
		(b) Report category boundaries when continuous variables were categorized	12-16	We have provided mean and corresponding standard deviations for the continuous variables.

		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time	NA	
		Continued on next page		
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA	
<b>Discussion</b>				
Key results	18	Summarise key results with reference to study objectives	8	
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	18	Key limitations regarding study methods including differential response rates and sampling methods in the various study sites have been provided
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	17-18	Cautious overall interpretation of the key findings have been provided.
Generalisability	21	Discuss the generalisability (external validity) of the study results	17-18	
<b>Other information</b>				
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	19	The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).