Prevalence and burden of chronic kidney disease among the general population and high-risk groups in Africa: a systematic review

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ABSTRACT

Objectives While increasing attention is paid to the rising prevalence of chronic diseases in Africa, there is little focus on chronic kidney disease (CKD). This systematic review assesses CKD burden among the general population and high-risk groups on the entire African continent.

Design, setting and participants We searched Medline and PubMed databases for articles published between 1 January 1995 and 7 April 2017 by sensitive search strategies focusing on CKD surveys at the community level and high-risk groups. In total, 7918 references were evaluated, of which 7766 articles were excluded because they did not meet the inclusion criteria. Thus, 152 studies were included in the final analysis.

Outcome measurement The prevalence of CKD in each study group was expressed as a range and pooled prevalence rate of CKD was calculated as a point estimate and 95% CI. No meta-analysis was done. Data were presented for different populations.

Results In the community-level studies, based on available medium-quality and high-quality studies, the prevalence of CKD ranged from 2% to 41% (pooled prevalence: 10.1%; 95% CI 9.8% to 10.5%). The prevalence of CKD in the high-risk groups ranged from 1% to 46% (pooled prevalence: 5.6%; 95% CI 5.4% to 5.8%) in patients with HIV (based on available medium-quality and high-quality studies), 11%–90% (pooled prevalence: 24.7%; 95% CI 23.6% to 25.7%) in patients with diabetes (based on all available studies which are of low quality except four of medium quality) and 13%–51% (pooled prevalence: 34.5%; 95% CI 34.04% to 36%) in patients with hypertension (based on all available studies which are of low quality except two of medium quality).

Conclusion In Africa, CKD is a public health problem, mainly attributed to high-risk conditions as hypertension and diabetes. The poor data quality restricts the validity of the findings and draws the attention to the importance of designing future robust studies.

INTRODUCTION

Chronic kidney disease (CKD) is an emerging global public health problem.1 The disease is a component of a new epidemic of chronic conditions that replaced malnutrition and infection as leading causes of mortality during the 20th century.2 Age-standardised death rates due to CKD have increased during the last 23 years. CKD has shifted from the 36th cause of death in 1990 to the 19th cause in 2013.3 The worldwide increase in CKD and kidney failure—necessitating renal replacement therapy—and the high rate of cardiovascular mortality and morbidity attributable to CKD are poised to reach epidemic proportions over the next decade. CKD complications represent a considerable burden on global healthcare resources and only a small

Strengths and limitations of this study

► This systematic review assessed the chronic kidney disease (CKD) burden among the general population and high-risk groups on the entire African continent based on studies that covered all of Africa from 1 January 1995 until 7 April 2017.

► The quality of the included articles was assessed based on standard criteria dealing with clinical trials, diagnostic studies and observational studies. The articles were assessed based on the population sampling and precision, sampling technique, response rate and exclusion rate.

► No meta-analysis was conducted in this review due to the huge discrepancy in the definition used to identify CKD, the methods of creatinine measurement, urine protein assessment and in the quality of the reporting.

► There is paucity of information about CKD prevalence in age and gender groups, which affects the accuracy of the pooled prevalence estimated from each group.

► The prevalence of CKD reported in this review should be interpreted with caution due to the low quality of the majority of studies in Africa, the bias introduced from the heterogeneity between studies, analytical and methodological issues, sample size, and study population selection.
number of countries have sufficiently robust economies to meet the challenge posed by this disease. Socioeconomic differences in health exist and individuals of lower socioeconomic status (SES) have a higher risk for mortality and morbidity compared with those of higher SES. A change in the global approach to CKD from the treatment of end stage renal disease (ESRD) to intensive primary and secondary prevention is therefore considered an absolute public health priority.

Africa is the second largest continent in the world, with a population of over 1 billion; 961.5 million people live in sub-Saharan Africa and 195 million in Northern Africa. Africa now faces the dual challenge of infectious illnesses and chronic diseases. Africa’s chronic disease burden is secondary to various factors, including increased life expectancy, changing lifestyle practices, poverty, urbanisation and globalisation. The World Health Assembly advocated the Global Action Plan for the Prevention and Control of Non-Communicable Diseases 2013–2020. One of its targets is to reduce premature mortality from chronic diseases by 25% in 2025. These actions have the potential to make a significant impact on the burden of CKD. Unfortunately, CKD problem remains underestimated on the entire continent due to lack of epidemiological information from different African countries. There exists only a single systematic review conducted in sub-Saharan Africa, which concluded that CKD is a prevalent and potentially escalating disease across sub-Saharan Africa, with both communicable and non-communicable risk factors. Strategies aimed at managing CKD epidemics in Africa critically depend on a reliable assessment of the burden of the problem and the establishment of affordable early detection programmes. Previous studies reported the prevalence of CKD among the general population or the specific prevalence of this condition in diseases that are recognised as drivers of renal damage (eg, diabetes mellitus). These estimates have varied across studies due to differences in the methods of glomerular filtration rate (GFR) measurement, background risk (general population vs high-risk groups) or demographic characteristics (eg, age, gender).

With this background in mind, this review aimed to increase the systematic information on the burden of CKD in the general population and high-risk groups of the entire African continent and provide an estimate of the prevalence of CKD in different regions of Africa.

MATERIALS AND METHODS

Data source and search strategy

We followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. A systematic literature search was performed in the PubMed and Ovid Medline databases by two authors (DB and SA) to identify articles reporting epidemiology data on CKD in the adult population in any geographical area of the African continent. This employed focused, highly sensitive search strategies (online supplementary table 1). The search covered the time frame from 1 January 1995 to 7 April 2017. Papers without language and study design restrictions were located and screened. References from relevant studies were screened for supplementary articles.

Study selection and data extraction

Titles and abstracts were screened independently by two authors (SA and GD), who discarded studies that were not relevant to the topic. Case reports, reviews, editorials, letters and studies focusing on African–Americans not living on the African continent, conducted entirely among children, or dealing with acute kidney injury or kidney transplantation were excluded. Two authors (SA and ED) independently assessed the retrieved abstracts and the full texts of these studies to determine eligibility according to the inclusion criteria. Disagreements were resolved through discussion and consensus, or through consultation with a third reviewer (DB), who solved these differences based on study judgements. Furthermore, screening of reference lists of all of the retrieved studies was conducted to check for relevant articles, and a supplementary scan of the reference lists of the systematic reviews was performed to identify any additional studies. Data were extracted from full-text articles and registered using a specifically designed form. These data included study design, geographical area, sample size, the definition of CKD used, prevalence of CKD, age, gender, GFR measurement, type of creatinine assay, proteinuria, the method of outcome assessment, and associated comorbidities such as diabetes mellitus and hypertension. Data extraction was performed by one reviewer (SA) and independently verified by another reviewer (DB).

Data extraction and analysis

Studies were categorised according to the reference population as follows: (1) studies dealing with the general population and (2) studies focusing on particular diseases such as diabetes, hypertension, lupus and HIV, or settings, for example, hospital-based surveys and occupational studies.

Information on the assessment of kidney function was collected, including the equation adopted for GFR estimation (Cockroft-Gault (CG), Modification of Diet in Renal Disease (MDRD), Chronic Kidney Disease-Epidemiology Collaboration (CKD-EPI)), the type of creatinine assay (Jaffe, standardised or unknown), and the type of proteinuria or albuminuria assay used (semiquantitative assessment by urinary strips or quantitative in urine samples or 24-hour collection). When the study included two or three GFR equations, we defined the CKD prevalence based on the CKD-EPI equation whenever this information was provided. Otherwise, we considered the MDRD equation and lastly the CG equation. In the case of ethnicity correction, we included the equation that corrected for ethnicity. Information on the definition of CKD used in each study was also included (either the internationally accepted definition as Kidney Disease...
Outcome Quality Initiative (KDOQI), or other ways of defining CKD).

**Quality assessment**
Two independent authors (SA and DB) appraised each article independently and assessed its quality based on standard criteria described in detail in previous methodology reviews dealing with clinical trials, diagnostic studies, and observational studies. The articles were assessed based on the subject sampling and precision, sampling technique, response rate, method of assessment of kidney function and exclusion rate.

**Statistical analyses**
The principal demographic and clinical data for each study were summarised as the mean and SD or as absolute number and percentage, as appropriate. The age range in each study was also recorded. The range of the CKD prevalence for each study group was reported. The pooled prevalence rate of CKD was expressed as a point estimate and 95% CI. The prevalence from each study was weighed by the sample size, then the pooled prevalence was categorised by the African region. The inter-rater agreement for inclusion and quality assessment was determined using Cohen’s kappa (κ) coefficient. The percentage of the different causes of CKD was weighed by the sample size of each study done among patients with CKD. Then we simply summed the number of patients for each aetiological factor and divided it by the total sample size from the whole included studies. No meta-analysis was conducted in this study. Data were appropriately presented for different populations (general population and patients with CKD). Patients’ data were stratified by the type of underlying condition, that is, hypertension, diabetes mellitus, HIV or systemic lupus erythematosus. All calculations were conducted using SPSS for Windows V.21.

**RESULTS**

**Search results**
The flow diagram of the selection process is depicted in figure 1. In total, 7897 potentially relevant references were initially retrieved. Twenty-one additional citations were found through a personal search. By screening titles and abstracts, a total of 7534 citations were excluded because of search overlap, dealing with the wrong population (African–American, acute kidney injury (AKI), cancer or post-transplant patients) or not providing actual data on CKD. Review articles, case reports, editorials or letters were also excluded. Among the 384 studies selected for full-text examination, 232 were excluded because they dealt with a population different from that specifically targeted in this systematic review, such as paediatric populations (122 studies), transplant patients (n=44) or others.

![Flow diagram of the study selection](http://bmjopen.bmj.com/ BMJ Open: first published as 10.1136/bmjopen-2016-015069 on 10 January 2018. Downloaded from http://bmjopen.bmj.com/)

**Figure 1** Flow diagram of the study selection.
(n=46) (eg, Africans living in non-African countries), or because only narrative data were provided (n=20). A total of 152 articles were therefore reviewed in detail and included in the analysis. The main characteristics of these studies are summarised in table 1. The inter-rater agreement for inclusion was κ=0.90 and for the quality assessment was κ=0.85.

### Study characteristics

Among the 152 studies reviewed, 29 were general population studies (table 2). One hundred and twenty-three studies focused on selected groups, of which 42 included patients with HIV (table 4), 18 studied patients with diabetes (table 4), 9 included hypertensive subjects (table 5) and 12 were conducted in other populations (table 6), including one study in patients with lupus, one study in patients with rheumatoid arthritis, one study among patients with sickle cell anaemia, two in specific occupational settings (silica exposure and exposure to the nephrotoxic hair-dye, paraphenylenediamine) and seven studies in family practice or hospital-based surveys. Forty-two studies were conducted among patients with CKD (online supplementary table 2). Thirty-one studies defined the presence of CKD as an estimated glomerular filtration rate (eGFR) below 60 mL/min/1.73 m^2, whereas 11 studies used dipstick with confirmation by the protein-to-creatinine ratio or albumin-to-creatinine ratio. Quantitative methods for the assessment of proteinuria/albuminuria (24-hour proteinuria or albuminuria, Protein to Creatine Ratio (PCR), immunoassay or Albumin to Creatinine Ratio (ACR) were applied in 29 studies. In one study, the method of proteinuria assessment was not mentioned.

Serum creatinine was measured in 95 studies (86%). The Jaffe assay was used in 30 studies, whereas the isotope dilution mass spectrometry (IDMS)-calibrated method was used in 15 studies. Eight studies, both the Jaffe assay and the calibrated serum creatinine were used. In nine studies, both the Jaffe assay and the calibrated serum creatinine were used. With respect to the formula used for estimating GFR, the MDRD equation was used in 30 studies, and the CG equation was used in 18. The other 14 studies used both the CG and the MDRD equations.

### Assessment of kidney function impairment

Urinary markers for kidney disease were assessed in 78 (71%) among 110 studies conducted in the general population, high-risk groups, occupational or hospital-based studies. Proteinuria was assessed by a semi-quantitative method (urinary strips) in 28 studies. Twenty studies used dipstick with confirmation by quantitative methods, nine of which used dipsticks to identify proteinuria/albuminuria with confirmation by 24-hour proteinuria whereas 11 studies used dipstick with confirmation by the protein-to-creatinine ratio or albumin-to-creatinine ratio. Sixteen studies estimated GFR by the CG, MDRD and the CKD-EPI methods whereas 15 studies estimated GFR by the CG, MDRD and the CKD-EPI methods whereas 14 studies used both the CG and the MDRD equations. Six studies used MDRD and CKD-EPI and two studies used CKD-EPI. In other two studies the formula was not mentioned.

### Definition of CKD

Thirty-one studies defined the presence of CKD as an estimated glomerular filtration rate (eGFR) below 60 mL/min/1.73 m^2, with chronicity confirmed by repeated testing in four other studies. Moreover, 28 studies reported CKD prevalence based on eGFR below 60 mL/min/1.73 m^2 and/or the presence of proteinuria or albuminuria.
| Study ID | Year, country, region | Location | N   | Population characteristics | Definition of CKD | Method of outcome assessment | Type of creatinine assay | Proteinuria | CKD prevalence | Quality assessment |
|----------|-----------------------|----------|-----|----------------------------|-------------------|------------------------------|------------------------|-------------|----------------|--------------------|
| Abdelsatir | 2013, Sudan, Northeast 1 | All village inhabitants | 389 | Age (years): 41±15 Male gender: 16.2% Hypertension: 39.6%; DM: 17% BMI category (kg/m²) <18: 6.2% 18–24.9: 65.8% 25–29.9: 20.2% ≥30: 7.8% | Not identified, personal history | Personal history | Not mentioned | Not measured | Total prevalence (as reported): 6.40% | Low |
| Fatiu | 2011, Nigeria, West | Market population | 286 | Age (years): 49.5±5.7 Male gender: 9.8% Hypertension: 37.7% BMI (kg/m²): 26.76±5.28 <20: 7.4% 20–25: 33.4% >25: 59% | Proteinuria = +1 | Midstream urine sample was tested by urinary strip | Not measured | 29.70% | Total prevalence (based on proteinuria prevalence): 29.7% | Medium |
| Traore | 1998, Mali, West | All household population of the villages | 1098 | Age (years): 30±12 Male gender: 52% | Proteinuria = +1 | Microhaematuria and proteinuria by urinary strip | Not measured | 40.80% | Total prevalence (based on proteinuria prevalence): 40.80% | Medium |
| Matsha | 2013, South Africa, South | Bellville town inhabitants | 1202 | Age (years): 52±14.9 Male gender: 24.7% SBP: 125±20 DBP: 76±13 DM: 26.4% BMI: 29.9±7.2 | eGFR <60 mL/min | Four variables: MDRD, CG, CKD-EPI | Standardised creatinine assay | Not measured | Prevalence of stages 3–5: 7.4% (based on CKD-EPI with ethnicity correction) | Medium |
| Seck | 2014, Senegal, West | Two-stage cluster sampling of urban and rural inhabitants of Saint-Louis | 1037 | Age (years): 48±16.9 Male gender: 40% Hypertension: 39.1% BMI: 26.3±6.8 kg/m² | KDOQI Albuminuria by urinary strips; positive samples were confirmed by 24-hour albuminuria, eGFR by 186 MDRD | Albuminuria by urine strips; four variables confirmed by 24-hour albuminuria; eGFR by 186 MDRD | 5.3% albuminuria >1 g/L | Total prevalence: 6.1% | High |
| Pruim | 2008, Seychelles, East | A random sex-stratified and age-stratified sample inhabitants of Seychelles | 1255 | Age (years): range, 25–64 Male gender: 46% | KDOQI Quantitative microalbuminuria by ACR, eGFR using MDRD | Quantitative microalbuminuria and 24-hour albuminuria, eGFR using MDRD | Not mentioned | 11.4% microalbuminuria, 0.7% macroalbuminuria | Total prevalence: 15.3% Prevalence of stages 3–4 CKD: 3.2% | High |
| Sumaili | 2009, Congo, Central | Multistage sampling of residents of Kinshasa | 500 | Age (years): 38.6±14.4 Male gender: 41% Hypertension: 27.9% DM: 11.7% BMI category (kg/m²) <18: 20.3% 18–24.9: 20.3% ≥30: 14.9% | KDOQI Proteinuria by urinary strip and 24-hour proteinuria, eGFR by CG and 175 MDRD | Proteinuria by urinary strip and 24-hour proteinuria, eGFR by CG and 175 MDRD | Kinetic Jaffe and IDMS-calibrated | 18% proteinuria by dipstick 5% (>300 mg/day) | Total prevalence MDRD: 12.4% CG: 19% Prevalence by stage (MDRD) Stage 1: 2.2% Stage 2: 2.2% Stage 3: 2.2% Stage 4: 0% Stage 5: 0.2% | High |

Continued
| Study ID | Year, country, region | Location | N   | Population characteristics | Definition of CKD | Method of outcome assessment | Type of creatinine assay | Proteinuria | CKD prevalence | Quality assessment |
|---------|----------------------|----------|-----|-----------------------------|------------------|-----------------------------|------------------------|-------------|----------------|------------------|
| Matsha  | 2014, South Africa, South Town | All residents of Cape Town | 320 | Age (years): mean, 56.4 (95% CI 55.1 to 57.6) Male gender: 22% SBP: 124.7 (95% CI 122.8 to 126.7) mm Hg DBP: 75.5 (95% CI 74.2 to 76.7) mm Hg BMI: 31.9 (95% CI 31.2 to 32.7) kg/m² Mean eGFR at baseline: 68.6±16.7 mL/min/1.73 m² | eGFR<60 mL/min/1.73 m² | eGFR: 186 MDRD (four variables) | Not mentioned | Not measured | Total prevalence: 28.9% Prevalence by categories eGFR >90 mL/min/1.73 m²: 9.4% eGFR 60-90 mL/min/1.73 m²: 58.7% eGFR 30-60 mL/min/1.73 m²: 28.1% eGFR <30 mL/min/1.73 m²: 0.9% | Medium |
| Sumaili  | 2008, Congo, Central | All residents of Kinshasa | 3018 | Age (years): 44.3±15.3 Male gender: 59% Hypertension: 18% DM: 4% | Proteinuria =+1 | Proteinuria by urinary strip | Not assessed | 17.1% | Total prevalence (based on proteinuria prevalence): 17.1% Prevalence by age 12–21 years: 8.7% 22–31 years: 11.4% 32–41 years: 18.6% 42–51 years: 18.2% 52–61 years: 18.9% 62–71 years: 22.4% >72 years: 19.7% | High |
| Egb  | 2014, Nigeria, West | All civil servants in Bayelsa | 179 | Age (years): 45.5±10.3 Male gender: 53.1% SBP: 128.5±17.5 mm Hg DBP: 81.8±13.2 mm Hg | eGFR <60 mL/min/1.73 m² and/or presence of proteinuria of at least +1 on dipstick urinanalysis | Proteinuria by urinary strip, eGFR by CG equation standardised for body surface area | Kinetic Jaffe | 5.6% | Total prevalence: 7.8% Prevalence by stage Stage 1: 3.4% Stage 2: 2.2% Stage 3: 2.2% None in stage 4 or 5 | Low |
| Olayombo  | 2013, Nigeria, West | Multistage sampling of households of Ilie | 454 | Age (years): 45.8±19.0 Male gender: 43% Hypertension: 20.4% DM: 0.6% | eGFR <60 mL/min and/or macroalbuminuria (ACR >300 mg/g or dipstick proteinuria) | Proteinuria by urinary strip, eGFR by 186 MDRD | Kinetic Jaffe | Macroalbuminuria in 8.9% | Total prevalence: 18.8% Prevalence by stage Stage 1: 2.4% Stage 2: 4.1% Stage 3: 11.8% Stage 4: 0.5% | High |
| Eastwood  | 2010, Ghana, West | Inhabitants of 12 villages | 944 | Age (years): 54.7±11.2 Male gender: 38% SBP: 125.5±26.0 mm Hg DBP: 74.4±13.6 mm Hg DM: 4% BMI: 21.1±4.2 kg/m² | KDOQI | 175 MDRD, CG, CKD-EPI | Kinetic Jaffe and calibrated IDMS | Total prevalence (based on CKD-EPI and ethnicity correction): 1.7% MDRD: 1.6% (7.2% without ethnicity correction) CKD-EPI: 1.7% (4.7% without ethnicity correction) CG: 21.0% | High |

Table 2 Continued
| Study ID | Year, country, region | Location | N     | Population characteristics | Definition of CKD | Method of outcome assessment | Type of creatinine assay | Proteinuria | CKD prevalence | Quality assessment |
|----------|-----------------------|----------|-------|-----------------------------|-------------------|-------------------------------|----------------------------|--------------|-----------------|--------------------|
| Gouda17  | 2011, Egypt, North    | Community based in Al-Buhayrah governorate | 417   | Age (years): 39.12±14.29 Male gender: 43.2% Hypertension: 25.20% DM: 10.6% BMI: 29.96±6.18 kg/m² | eGFR <60 mL/min/1.73 m² | Quantitative assessment of urinary ACR, eGFR by 175 MDRD | IDMS-calibrated | 10.6% microalbuminuria | Total prevalence: 18% Prevalence by age 18–29 years: 0.8% 30–44 years: 6.1% 45–60 years: 19.6% >60 years: 40% Prevalence by gender Female: 9.6% Male: 12% | Medium |
| Ayodele17| 2011, Nigeria, West   | People at a major trade centre, the public servant secretariat and the state broadcasting station | 586   | Age (years): 42.4±11.2 Male gender: 61.4% Hypertension: 16.4% DM: 3.8% BMI: 25.9±5.4 kg/m² | Proteinuria = +1 | Proteinuria by urinary strip | Not assessed | 2.50% | Total prevalence (based on proteinuria): 2.50% Prevalence by gender Female: 1.7% Male: 3% | Medium |
| Abu-Aisha78| 2009, Sudan, East    | Pilot survey of police housing complex | 273   | Age (years): 34.3±12 Male gender: 49.1% Hypertension: 27% DM: 5.1% | eGFR <60 mL/min/1.73 m² and/or proteinuria | Proteinuria by urinary strip, 175 MDRD, CG | Not mentioned | 5.30% | Total prevalence (MDRD): 7.7% (11% by CG) Prevalence by stage Stage 1 or 2: 2.4% Stage 3: 2.6% Stage 4: 0% Stage 5: 0.4% | Medium |
| Gharbi106 | 2012, Morocco, North | Stratified random sampling of population in two towns | 10 524 | Age (years): range, 25–70 Male gender: 50% Hypertension: 16.7% | eGFR <60 mL/min/1.73 m² or microalbuminuria or dipstick abnormalities (proteinuria +++1 or haematuria ++1) or diabetes type 1 associated with microalbuminuria | Proteinuria by urinary strip and ACR | Kinetic Jaffe and IDMS | Microalbuminuria (30–299 mg/L): 5.26% | Total prevalence 2.90% | High |
| Odenigbo523 | 2014, Nigeria, West  | All attendees to lectures of the Ebereime Foundation for the elderly | 170   | Age (years): 68.1±7.7 Male gender: 67.1% | eGFR <60 mL/min/1.73 m² | Total prevalence: 43.50% (all cases were at stage 3) Prevalence by age =65 years: 49.1% >65 years: 40.7% Prevalence by gender Female: 64% Male: 33% | 175 MDRD, IDMS-calibrated | Not measured | Total prevalence: 6.3% | High |
| Booysen155 | 2016, South Africa, South | Participants from families of black African descent | 1221  | Age (years): 44.1±18.4 Male gender: 34.9% BMI (kg/m²): 29.3±8.0 Hypertension: 45% DM: 25.2% | eGFR <60 mL/min/1.73 m² | eGFR by CG, four variables MDRD, CKD-EPI | IDMS-calibrated | Not measured | Total prevalence: 6.3% | High |
| Study ID     | Year, country, region          | Location                              | N    | Population characteristics                                                                 | Definition of CKD                                                                 | Method of outcome assessment          | Type of creatinine assay | Proteinuria | CKD prevalence | Quality assessment |
|-------------|-------------------------------|---------------------------------------|------|-------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|--------------------------------------|-----------------------|--------------|-----------------|-------------------|
| Kalyesubula | 2017, Uganda, East            | Community-based survey among all households of Wakiso District | 955  | Age (years): 31 (IQR: 24–42) Male gender: 33% BMI (kg/m²): 27.1±5.3 Overweight: 24.2% Diabetics: 5.9% | KDOQI                                                                             | Proteinuria by dipstick and eGFR by CG, MDRD and CKD-EPI | Kinetic Jaffe          | 0.3%         | Total prevalence: 15.2% Prevalence by stage Stage 1: 6.2% Stage 2: 12.7% Stage 3: 2.4% Stage 4: 0% Stage 5: 0.1% | High |
| Kaze        | 2015, Cameroon, Central-West  | Population of the Littoral region     | 500  | Age (years): 45.3±13.2 Male gender: 53.4% BMI (kg/m²): 27.1±5.3 Hypertension: 12.2% | Albuminuria and/or eGFR <60 mL/min/1.73 m²                                      | Albuminuria by dipstick and eGFR by CG, MDRD, CKD-EPI | Kinetic Jaffe and IDMS    | 7.2%         | Total prevalence (CKD-EPI): 10% (14.2% by CG, 11% MDRD) Prevalence by gender Female: 9.8% Male: 10.1% | High |
| Kaze        | 2015, Cameroon, Central-West  | Population of the Western region      | 439  | Age (years): 47 ± 16.1 Male gender: 42.1% Hypertension: 10.7% DM: 9.9%                  | Albuminuria and/or eGFR <60 mL/min confirmed 3 months later                       | Albuminuria by dipstick and eGFR by CG, MDRD, CKD-EPI | Kinetic Jaffe and IDMS    | 12.1%        | Total prevalence (CKD-EPI): 27.6% (38.5% by CG, 27.3% MDRD) Prevalence by gender Female: 15.4% Male: 10.2% | High |
| Laurencis   | 2016, South Africa, South     | Teachers from public schools in in the urban area of the Metro South Education District | 489  | Age (years): 46.3±8.5 Male gender: 30% BMI (kg/m²): 29.1±4.8 Female: 32.4±1.7 Hypertension: 48.5% DM: 10.1% | Proteinuria =0.30 mg/mg or eGFR <60 mL/min/1.73 m²                               | Proteinuria by PCR and eGFR using MDRD | Kinetic Jaffe          | Not mentioned | Total prevalence: 10.4% Prevalence by gender Female: 10.9% Male: 9% | Medium |
| Lunyera     | 2016, Uganda, East            | Urban residents of Kampala             | 141  | Age (years): 64% in age group of 18–39 Male gender: 43% BMI (kg/m²): 25.9 (IQR 22.7–30.7) Hypertension: 38% Impaired fasting blood glucose: 13% | Proteinuria as urine protein of >1+ on dipstick in the absence of haematuria and leucocyturia | Proteinuria by dipstick               | Not measured                  | 13%          | Total prevalence (based on proteinuria): 13% Prevalence by age 18–39 years: 16% 40–59 years: 4% ≥60 years: 0% Prevalence by gender Female: 11% Male: 15% | Low  |
| Mogueo      | 2015, South Africa, South     | Household residents of Bellville       | 902  | Age (years): 55±15 Male gender: 23% BMI(kg/m²): 29.9±7.2 Hypertension: 49.8% Diabetes mellitus: 27.9% | eGFR <60 mL/min/1.73 m² or any nephropathy                                        | Albuminuria by ACR and eGFR by MDRD and CKD-EPI | Kinetic Jaffe          | 2.3%         | Total prevalence (CKD-EPI): 21.7% (prevalence by MDRD: 29.7%) Prevalence by gender Female: 23.3% Male: 16.8% | Medium |
Table 2

| Study ID | Year, country, region | Location | N | Population characteristics | Definition of CKD | Method of outcome assessment | Type of creatinine assay | Proteinuria | CKD prevalence | Quality assessment |
|----------|-----------------------|----------|---|---------------------------|------------------|-----------------------------|------------------------|-------------|----------------|-------------------|
| Peck 148 | 2016, Tanzania, East  | Stratified multistage sampling of adult population in Mwanza City, Geita and Kahama | 1043 | Age (years): 35.5±15.3 Male: 45.7% BMI (kg/m²) categories: Underweight: 10.5% Normal: 71% Overweight: 11.8% Obese: 6.8% DM: 0.9% Hypertension: 17.3% | eGFR <60 mL/min/1.73 m² | eGFR by MDRD and CKD-EPI | Kinetic Jaffe | Not measured | Total prevalence (CKD-EPI): 7% Prevalence by age: <25 years: 3.4% 25–34 years: 4.9% 35–44 years: 7.2% ≥45 years: 12.1% Prevalence by gender: Female: 6% Male: 7.3% | High |
| Stanifer 133 | 2015, Tanzania, East | Randomly selected adults | 481 | Age (years): 45 (IQR 35–59) Male: 25.6% DM: 12.7% Hypertension: 28% Presence of albuminuria (≥30 mg/dL confirmed by repeat assessment) and/or a reduction in eGFR to <60 mL/min/1.73 m² | Quantitative assessment of albuminuria and eGFR by MDRD | IDMS | Not mentioned | Total prevalence: 7% Prevalence by age: 18–39 years: 7.6% 40–59 years: 5.4% ≥60 years: 7.7% Prevalence by gender: Female: 6.2% Male: 7.9% | High |
| Wachukwu 19 | 2015, Nigeria, West | Adult volunteers in a university | 259 | Age (years): 28.3±9.7 Male: 52.1% SBP (mm Hg): 117.3±15.5 DBP (mm Hg): 75.7±11.7 Proteinuria by dipstick and eGFR by CG | Proteinuria by dipstick and eGFR by CG | Not mentioned | Total prevalence: 1.9% | Low |

ACR, albumin to creatinine ratio; BMI, body mass index; CG, Cockroft-Gault; CKD, chronic kidney disease; CKD-EPI, Chronic Kidney Disease-Epidemiology Collaboration; DBP, diastolic blood pressure; DM, diabetes mellitus; eGFR, estimated glomerular filtration rate; IDMS, isotope dilution mass spectrometry; KDOQI, Kidney Disease Outcome Quality Initiative; MDRD, Modification of Diet in Renal Disease; SBP, systolic blood pressure.
## Table 3  Studies on CKD among patients with HIV

| Author  | Year, country, region | Location | N  | Study group | Population characteristics | Methods of outcome assessment | Creatinine assay | Proteinuria | CKD prevalence | Quality assessment |
|---------|-----------------------|----------|----|-------------|-----------------------------|-------------------------------|-----------------|-------------|---------------|--------------------|
| Wkba142 | 2013, Ghana, West     | ART clinic at the regional hospital | 442 | HIV (276 HAART-naive patients 166 on HAART) | Age (years): HAART-naive (33.42±0.88), on HAART (36.91±0.77) Male gender: HAART-naive (28.3%), on HAART (22.3%) | eGFR <60mL/min/1.73m² for >3 months | CG, 186 MDRD, CKD-EPI | Not measured | Total prevalence (CKD-EPI): 10.2% HAART-naive: 8.7% CG, 9.1% MDRD, 8.7% CKD-EPI On HAART: 14.5% CG, 12.6% MDRD, 12.6% CKD-EPI Prevalence by gender Female: HAART-naive (7.5%), HAART (14%) Male: HAART-naive (11.5%), HAART (8.1%) | Low |
| Stöhr143 | 2011, Uganda, Zimbabwe, East and South | Three centres in Uganda and Zimbabwe | 3316 | HIV-infected patients initiating ART | Age (years): 36.8 (32–42.2) Male gender: 35% SBP: median: 110 (IQR: 100–120) mm Hg DBP: median: 70 (60–80) mm Hg BMI: 21.1 (19.1–23.6)kg/m² | eGFR <60mL/min/1.73m² on ≥2 consecutive visits 80 days apart or confirmed 25% decrease if eGFR <60mL/min/1.73m² at baseline | CG | Kinetic Jaffe | Not measured | Total prevalence: 7.2% | Medium |
| Stöhr144 | 2008, Uganda, Zimbabwe, East and South | Three centres in Uganda and Zimbabwe | 3316 | HIV-infected patients on ART | Age (years): 36.8 (32–42.2) Male gender: 35% SBP: median: 110 (IQR: 100–120) mm Hg DBP: median: 70 (60–80) mm Hg BMI categories: 18.5kg/m²: 18% 18.5 to <25kg/m²: 66% 25 to <30kg/m²: 12% ≥30kg/m²: 4% | eGFR <60mL/min/1.73m² on ≥2 consecutive occasions >80 days apart or confirmed 25% decrease if eGFR <60mL/min/1.73m² at baseline | 186 MDRD, CG | Kinetic Jaffe | Not measured | Total prevalence (MDRD): 3.1% CG: 7.4% | Medium |
| Cailhol79 | 2011, Burundi, East   | Outpatients HIV clinic | 300 | HIV-infected patients | Age (years): 40.1 (33–46.5) Male gender: 29.7% Hypertension: 2.7% DM: 2% BMI: median: 21.8 (19.3–24.2)kg/m² | KDOQI | Proteinuria by urinary strip, CG, 186 MDRD | Not mentioned | 6.1% | Total prevalence (MDRD): 45.7% CG: 46.5% Prevalence by stages (using MDRD) Stage 1: 30.2% Stage 2: 13.5% Stage 3: 2% Stages 4 and 5: no patients | Medium |
| Masimango107 | 2014, Congo, Central | Outpatient HIV clinic | 235 | HIV-infected patients | Age (years): 40.0±10.7 Male gender: 27.8% Hypertension: 46.8% DM: 1.7% BMI: 22.3±3.8kg/m² | Proteinuria ≥1+ by urinary strip or albuminuria ≥30mg/dL | Proteinuria by urinary strip and ACR | Not measured | Proteinuria ≥1+: 41.3% | Total prevalence (based on proteinuria): 41.3% | Low |

Continued
| Author       | Year, country, region | Location                                      | N     | Study group                                                                                                                                       | Population characteristics                                                                 | Definition of CKD                                                                                     | Methods of outcome assessment | Creatinine assay | Proteinuria | CKD prevalence | Quality assessment |
|-------------|-----------------------|-----------------------------------------------|-------|--------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|-------------------------------|------------------|---------------|----------------|---------------------|
| Abd ElHafeez S, et al. BMJ Open 2018;8:e015069. doi:10.1136/bmjopen-2016-015069 | 2008, Uganda, Zimbabwe, East and South    | Three centres in Uganda and Zimbabwe          | 3316  | HIV-infected, ART-naive adults with CD4+ cell counts of <200 cells/mm³                                                                         | Age (years): 36.8 (IQR: 32.0–42.2) Male gender: 35% SBP: median: 110 (IQR: 100–120) mm Hg DBP: median: 70 (IQR: 60–80) mm Hg BMI: median: 21.1 (IQR: 19.1–23.6) kg/m² | eGFR <60 mL/min/1.73 m² on ≥2 consecutive occasions >80 days apart or confirmed 25% decrease if eGFR <60 mL/min/1.73 m² at baseline | CG Kinetic Jaffe Not measured | Total prevalence: 7% Medium |
| Fabian[10]  | 2009, South Africa, South | HIV outpatient clinic at Johannesburg Hospital | 578   | HIV-infected naïve ART patients                                                                                                                  | Age (years): 37 (range 16–70 years) Male gender: 38% DM: 4.6% among group with microalbuminuria | Proteinuria ≥1+ by urinary strip or albuminuria ≥30 mg/dL                                      | Proteinuria by urinary strip and PCR Not measured | 43.7% had proteinuria | Total prevalence (based on proteinuria prevalence): 43.7% Low |
| Lucas[14]   | 2010, Uganda, East     | All consenting individuals residing in every household in 50 Rakai District communities | 1960  | 1202 HIV-infected patients and 664 HIV-negative age-matched and sex-matched controls                                                          | Age (years): HIV-negative: 28 (IQR: 24–35); HIV-positive: 30 (IQR: 25–36) Male gender: HIV-negative: 38.7%; HIV-positive: 36.4% | eGFR <60 mL/min/1.73 m²                                                                                 | MDRD IDMS-calibrated Not measured | Total prevalence among HIV-positive: 0.7% Medium |
| Jao[18]     | 2011, sub-Saharan       | Primary healthcare units                       | 2495  | HIV-infected patients before ART                                                                                                                  | Age (years): 30 (IQR: 27–35) Male gender: 30% BMI: 22.8 (IQR: 20.4–25.6) kg/m²                | CrCl <50 mL/min                                                                                       | CG, 186 MDRD, CKD-EPI Not measured | Not measured | Total prevalence (CKD-EPI with coefficient for black race): 2.5% CG: 3.4% (MDRD with coefficient for black race): 2.5% Prevalence by age <30 years: 29.8% 30–39 years: 57.1% ≥40 years: 13.1% Prevalence by gender Female: 66.7% Medium |
| Longo[9]    | 2012, Congo, Central    | Consecutive patients with HIV from clinic      | 300   | HIV-infected (ART treated=264) (ART-naive=36)                                                                                                    | Age (years): 43±9 Male gender: 23% Hypertension: 13% BMI: 24±5 kg/m²                                | eGFR <60 mL/min/1.73 m² or proteinuria defined as 1+ or greater                                     | Proteinuria by dipstick and 24-hour proteinuria, eGFR by MDRD, CG Kinetic Jaffe and IDMS | 20.50% | Total prevalence: 20.5% 3% of the patients had eGFR <60 mL/min/1.73 m² by MDRD Low |
| Sarfo[19]   | 2013, Ghana, West       | HIV clinic                                     | 3137  | HIV-infected patients starting ART                                                                                                               | Age (years): 38 (32–45) Male gender: 33% BMI: 20.3 (IQR: 17.6–22.7) kg/m²                       | eGFR <60 mL/min/1.73 m² or proteinuria ≥1 (confirmed by uPCR >45 mg/mmol)                              | Proteinuria by urinary strip, ACR, PCR, eGFR by CG, MDRD, CKD-EPI Not measured | Total prevalence (CKD-EPI): 13.8% Low |
### Table 3: Continued

| Author         | Year, country, region | Location                                                                 | N       | Study group                          | Population characteristics                                                                 | Definition of CKD | Methods of outcome assessment | Creatinine assay | Proteinuria | CKD prevalence | Quality assessment |
|----------------|-----------------------|---------------------------------------------------------------------------|---------|--------------------------------------|-------------------------------------------------------------------------------------------|--------------------|-----------------------------|-----------------|-------------|-----------------|--------------------|
| Gupta[^1]      | 2011, Cameroon, Central-West | Electronic medical records of patients from 18 sites throughout Western Kenya | 7383    | Patients with HIV without ART        | Age (years): 35.5 (29.3–44.0) Male gender: 26.9%                                                                                              | eGFR <60mL/min/1.73m² | CG, MDRD                   | Not mentioned   |             |                 | Medium            |
| Ekat[^2]       | 2013, Congo, Central   | Ambulatory treatment centre                                               | 562     | Newly diagnosed patients with HIV    | Age (years): 38.84 (IQR: 33.18–46.23) Male gender: 33.9% BM: 20.31 (IQR: 17.97–22.89)kg/m² | eGFR <60mL/min/1.73m² | 186 MDRD          | Kinetic Jaffe   | Not measured | Total prevalence: 8.5% | Low                |
| Woolf-Kaloustian[^3] | 2007, Kenya, East       | Academic Model for the Prevention and Treatment of HIV/AIDS clinic         | 373     | HIV-infected patients naïve to ART   | Age (years): 35.0 (range, 19–60) Male gender: 32.1% SBP: 104.7 (range, 80–140)mmHg          | CrCl <60mL/min/1.73m² | Proteinuria by urinary strip, CG, full and abbreviated MDRD | Kinetic assay     | 6.2% (proteinuria ≥1+) | Total prevalence: 11.50% | Low                |
| Emem[^4]       | 2008, Nigeria, West    | HIV/AIDS outpatient clinic                                                 | 400     | HIV-infected patients                | Age (years): 34.6±9.4 Male gender: 48.5% Hypertension: 13.2% BMI categories: <19.0kg/m²: 59.2%, 19–25 kg/m²: 37.5%, >25kg/m²: 3.3% | Albuminuria +1 on at least two occasions (4 weeks apart) and/or serum creatinine >1.5mg/dL | Proteinuria or albuminuria by urinary strip and 24-hour proteinuria, CG | Not mentioned | 38% proteinuria with dipstick, 21.9% nephrotic range proteinuria | Total prevalence: 38.8% | Medium            |
| Wyatt[^5]      | 2011, Rwanda, East     | Community-based                                                            | 891     | 677 HIV-infected and 214 HIV-uninfected | Age (years): 34 (IQR: 30–39) HIV-positive: 43 (IQR: 34–50), HIV-negative Male gender: 0 Hypertension: 4.8%/HIV-negative: 8.3% BMI (kg/m²): HIV-positive: 20.9 (IQR: 19.0–23.3)/HIV-negative: 20.5 (IQR: 18.5–23.3) | eGFR <60mL/min/1.73m² or proteinuria +1 or greater | Proteinuria by urinary strip, eGFR by MDRD, CKD-EPI, CG | Kinetic Jaffe (9% among HIV-positive and 7.2% among non-infected) | Total prevalence among HIV-positive: 9% | 2.7% had eGFR <60mL/min/1.73m² | CKD prevalence among HIV-negative: 7.2% | 1.5% had eGFR <60mL/min/1.73m² | Medium |
| FolefackKaze[^6] | 2013, Cameroon, Central-West | HIV clinic of Yaoundé General Hospital                                     | 104     | All newly diagnosed HIV-infected patients naïve to HAART | Age (years): 35±10.7 Male gender: 32% Presence of proteinuria +1 or more and eGFR <60mL/min based on the average of eGFR by two equations | Proteinuria by urinary strip, eGFR by CG, 175 MDRD | Kinetic Jaffe | 36% | Total prevalence: 36% | Among patients, 3% had eGFR<60mL/min/1.73m² | Low |
### Table 3 Continued

| Author | Year, country, region | Location | N | Study group | Population characteristics | Definition of CKD | Methods of outcome assessment | Creatinine assay | Proteinuria | CKD prevalence | Quality assessment |
|--------|-----------------------|----------|---|-------------|----------------------------|-------------------|-------------------------------|-----------------|-------------|-----------------|-------------------|
| Struijk \(^{14}\) | 2011, Malawi, East | ART clinic in a central hospital in Malawi | 526 | Consecutive newly referred HIV-infected patients on ART | Age (years): 34.3±9.3; Male gender: 43.5%; Hypertension: 11.2%; DM: 0.8% | Any proteinuria (≥+1), heavy proteinuria (≥+2), any proteinuria (≥+3) with renal dysfunction (eGFR <60 mL/min/1.73 m²), and heavy proteinuria (≥+2) with renal dysfunction (CrCl <60 mL/min) and the absence of any alternative cause for renal dysfunction or proteinuria | Proteinuria by urinary strip, eGFR by CG and MDRD | Not mentioned | 23.3% | Total prevalence: 23.3% | Low |
| Attolou \(^{18}\) | 1998, Benin, West | National Central Hospital | 92 | HIV-infected patients | Age (years): 22±4; Male gender: 68% | Proteinuria >0.5 g/24 hours and Scr >14 mg/L | Serum creatinine measurement and 24-hour proteinuria | Not mentioned | Proteinuria >0.5 g/24 hours in 23.33% | 27.16% | Total prevalence: 27.16% | Low |
| Agaba \(^{12}\) | 2003, Nigeria, West | Infections unit of the Jos University Teaching Hospital | 126 | Consecutive 79 patients with AIDS and 57 controls | Not known | Not known | Not known | 25% (AIDS group) | 25% (AIDS group) | Total prevalence among AIDS group: 51.80%; CKD prevalence among control group: 12.2% | Low |
| Fana \(^{10}\) | 2011, Zimbabwe, South | Outpatient clinics | 159 | HIV-infected patients naïve to ART | Not known | Not known | Not known | 45.90% | 45.90% | Total prevalence: 45.9%; Among patients, 7.50% had CrCl <60 mL/min | Low |
| Han \(^{10}\) | 2006, South Africa, South | Medical centre | 615 | Patients with HIV not on ART | Age (years): 31 (range, 13–63); Male gender: 25%; Proteinuria-negative: 117±14/70±9; Microalbuminuria: 121±15/81±10; Macroalbuminuria: 120±12/74±11 | Proteinuria >0.5 g/24 hours and/or PCR >20 mg/mg | Proteinuria by urinary strip and 24-hour proteinuria, eGFR by CG | Not mentioned | 6% | Total prevalence (based on proteinuria): 6% | Low |
| Peters \(^{14}\) | 2008, Uganda, East | Home-based AIDS care | 508 | Patients with HIV starting HAART | Age (years): 39 (median); Male gender: 41% | Proteinuria >0.5 g/24 hours and/or PCR >20 mg/mg | Proteinuria by urinary strip and 24-hour proteinuria, eGFR by CG | Not measured | 6% | Total prevalence: 20% | Low |

*Continued*
| Author     | Year, country, region | Location                     | N  | Study group                                           | Population characteristics                                                                 | Definition of CKD                                                                 | Methods of outcome assessment                                      | Creatinine assay | Proteinuria | CKD prevalence | Quality assessment |
|------------|-----------------------|------------------------------|----|-------------------------------------------------------|-------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|---------------------------------------------------------------|------------------|-------------|----------------|--------------------|
| Jao & al.  | 2011, Cameroon, Central-West | Clinics                     | 389| 199 HIV-positive and 190 HIV-negative pregnant women | Age (years): HIV-positive (27 (IQR: 24–31)) HIV-negative (27 (IQR: 22–31)) Male gender: 0 | Proteinuria (PCR >200 mg/L) Proteinuria by urinary strip and PCR | Not measured                                                 | HIV-positive: 39.2% HIV-negative: 20.9% | Total prevalence among HIV-positive (based on proteinuria): 39.2% | Medium             |
| Msango & al. | 2011, Tanzania, East | Outpatient clinics           | 355| HIV-infected patients naïve to ART                    | Age (years): 36.1±7.9 Male gender: 35% BMI (kg/m²): 21.3±3.8                            | KDOQI                                                                         | Proteinuria by urinary strip and albuminuria by urinary strip eGFR by CG, MDRD | Not mentioned | 36% proteinuria ≥+1 | Total prevalence: 35.6% | Low |
| Myer & al. | 2013, South Africa, South | Primary healthcare clinic    | 1861| Consecutive 238 pregnant women, 1014 non-pregnant, 609 men; HIV-infected patients eligible for ART | Age (years): pregnant, 28 (IQR: 25–32), men, 37 (IQR: 32–45), women, 33 (IQR: 28–39) Male gender: 33% | eGFR <60 mL/min eGFR by CG and MDRD | Not measured | Total prevalence: 84.6% | Low |
| Mulenga & al. | 2008, Zambia, South | Clinic                       | 25249| HIV-infected, ART-naive adults initiating treatment | Age (years): normal CrCl: 33.7±7.9, decreased CrCl: 38.5±9.9 Male gender: 33% | eGFR <60 mL/min | Absolute SCR and eGFR | Not measured | Total prevalence: 5.8% | Low |
| Adedeji & al. | 2015, Nigeria, West | The University of Ilorin Teaching Hospital | 183| Newly diagnosed HIV-infected ART-naive patients | Age (years): 37.9±10.5 Male gender: 42.6% BMI (kg/m²): 20.8±3.56 | eGFR <60 mL/min/1.73 m² | Absolute SCR, eGFR by CG and MDRD | Kinetic Jaffe and IDMS | Not measured | Total prevalence: 24% | Low |
| Anyabolu & al. | 2016, Nigeria, West | Federal Medical Centre       | 529| 393 newly diagnosed drug-naïve patients with HIV, 136 age-matched and sex-matched HIV-seronegative controls | Age (years): 38.8±10.65 Male gender: 28% BMI categories <18.50.0 kg/m²: 7% 18.5–24.9 kg/m²: 35% 25–29.9 kg/m²: 32% ≥30 kg/m²: 23% | 24-hour urine protein ≥0.300 g and/or GFR <80 mL/min | Absolute assessment of proteinuria, SCR and eGFR | Not mentioned | Not mentioned | Total prevalence among HIV-positive patients: 22.9% Prevalence among HIV-negative: 8.1% | Low |

Continued
| Author       | Year, country, region | Location                                                                 | N            | Study group                                                                                   | Population characteristics                                           | Definition of CKD                                                                 | Methods of outcome assessment                                                                 | Creatinine assay | Proteinuria | CKD prevalence | Quality assessment |
|-------------|-----------------------|--------------------------------------------------------------------------|--------------|-----------------------------------------------------------------------------------------------|-----------------------------------------------------------------------|-------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|------------------|--------------|-----------------|-------------------|
| Ayokunle113 | 2015, Nigeria, West   | Medical Out-patient Department of University of Ilorin Teaching Hospital  | 335          | 227 newly diagnosed, ART-naïve patients with HIV/AIDS, 108 age-matched and sex-matched control | Age (years): 40.3±10.3 Male gender: 44% BMI (kg/m²): 20.5±4.8 among patients with HIV, 26.7±5.3 among control group SBP (mm Hg): 111.9±1 among patients with HIV, 126.1±12.0 among control group DBP (mm Hg): 72.9±9.5 among patients with HIV, 80.6±6.8 among control group | Albuminuria ≥30mg/g and/or eGFR <60mL/m²/1.73m² | Proteinuria by dipstick, and ACR and eGFR by MDRD | Kinetic Jaffe | Not mentioned | Total prevalence among patients with HIV: 47.6% The prevalence among HIV-negative: 16.7% | Low               |
| Chadwick114 | 2015, Ghana, West     | Komfo Anokye Teaching Hospital                                           | 330          | Patients with HIV on ART                                                                        | Age (years): 39 (IQR: 35–46) Male gender: 25% BMI (kg/m²): 22.9 (IQR: 20.5–26.6) | Proteinuria or CrCl <60mL/min | Proteinuria (dipsticks, PCR and ACR) and GFR by CG | Not mentioned | 37% by dipstick and 12% by PCR | Total prevalence (proteinuria): 37% CrCl <60mL/min among 7% | Low               |
| Edwards166  | 2015, Kenya, East     | Two primary care clinics                                                | 2206         | 210 HIV-positive patients and 1996 HIV-negative                                                | Age (years): HIV-positive: 43 (IQR: 39–50), HIV-negative: 49 (IQR: 40–56) Male gender: HIV-positive: 31%, HIV-negative: 28.7% Hypertension: HIV-positive: 44%, HIV-negative: 33.2% DM: HIV-positive: 5%; HIV-negative: 15.2% | CrCl <60mL/min | eGFR by CKD-EPI | Not mentioned | Not measured | Total prevalence: 12.1% HIV-positive: 17% HIV-negative: 11% | Medium             |
| Glaser14    | 2016, Malawi, East    | Lighthouse Clinic                                                      | 363          | 116 HIV-positive ART-naïve patients and 247 HIV-negative patients                              | Age (years): 31 (IQR: 26–39) Male gender: 52%                         | eGFR <60mL/min | eGFR by CG, MDRD and CKD-EPI with and without correction factor | Not measured | IDMS-calibrated creatinine and cystatin-C | Total prevalence among HIV-positive (creatinine-based CKD-EPI): 1.9% | Medium             |
| Glaser115   | 2016, Malawi, East    | Lighthouse Clinic                                                      | 363          | 116 HIV-positive patients and 247 HIV-negative patients                                        | Age (years): 34.1±10.9 Male gender: 52% BMI (kg/m²): 23.2±4.8 Hypertension: 13.5% | KDOQI | Proteinuria by dipstick and ACR, eGFR by CG, MDRD and CKD-EPI | IDMS-calibrated creatinine and cystatin-C | 12.1% Total prevalence: 13% Prevalence among HIV-positive: 22% Prevalence among HIV-negative: 9% | Medium             |

Continued
| Author       | Year, country, region | Location                                      | N     | Study group                                      | Population characteristics | Definition of CKD | Methods of outcome assessment | Creatinine assay | Proteinuria | CKD prevalence | Quality assessment |
|--------------|-----------------------|-----------------------------------------------|-------|-------------------------------------------------|----------------------------|-------------------|--------------------------------|-----------------|-------------|----------------|------------------|
| Kamkuemah    | 2015, South Africa, South | Gugulethu Community Health Centre            | 1092  | HIV-infected patients initiated ART therapy     | Age (years): 34 (IQR: 29–41) Male gender: 38% | eGFR <60 mL/min          | eGFR by CG                      | Not mentioned     | Not measured | Total prevalence: 2% | Low              |
| Nsagha       | 2015, Cameroon, Central-West | Government hospitals                        | 200   | Patients with HIV on HAART, DOTS or on the combined therapy (HAART/ DOTS) | Age (years): 38.04±10.52 Male gender: 50.5% | eGFR <60 mL/min/1.73 m² | eGFR by MDRD                    | Kinetic Jaffe     | Not measured | Total prevalence: 8% | Low              |
| Odongo       | 2015, Uganda, East    | Infectious Diseases Clinic of Gulu Regional Referral Hospital | 361   | Newly diagnosed patients with HIV not receiving ART | Age (years): 31.4±9.5 Male gender: 36.3% BMI (kg/m²)<18: 33% | eGFR <60 mL/min/1.73 m² | Proteinuria by dipstick and eGFR by MDRD | Not mentioned     | Proteinuria ≥+1: 52% | Total prevalence: 14.4% | Low              |
| Okafor       | 2016, Nigeria, West   | University of Benin Teaching Hospital         | 383   | HIV-infected naive patients                     | Age (years): 36.03±9.08 Male gender: 41% | eGFR <60 mL/min/1.73 m² and/or evidence of kidney injury as detected when the PCR (mg/g) was ≥200 | Quantitative assessment of proteinuria by POR and eGFR by MDRD | Kinetic Jaffe     | Not mentioned | Total prevalence: 53.5% | Low              |
| Seape        | 2016, South Africa, South | Medical inpatients at the Chris Hani Baragwanath Hospital | 100   | HIV-infected naive patients                     | Age (years): 37.0±9.6 Male gender: 60% BMI (kg/m²): 20.9±5.1 | eGFR <60 mL/min/1.73 m² | eGFR by CG, MDRD, CKD-EPI       | IDMS             | Not measured | Total prevalence: 16% | Low              |
| Wensink      | 2015, South Africa, South | Rural Medical Centre                          | 903   | HIV-infected adult patients                     | Age (years): 40 (IQR: 34–48) Male gender: 31% DM: 4% Hypertension: 23% | Albuminuria or eGFR<60 mL/min/1.73 m² | Albuminuria by ACR and eGFR by MDRD and CKD-EPI | Not mentioned     | 21%         | Total prevalence (albuminuria): 21% | Medium           |
| Zachor       | 2016, South Africa, South | Outpatient infectious clinic at an academic hospital | 650   | HIV-infected patients initiating ART            | Age (years): 37.9±9.4 Male gender: 35.5% DM: 2.2% Hypertension: 7.8% | eGFR <60 mL/min/1.73 m² | eGFR by MDRD and CKD-EPI        | IDMS             | Not measured | Total prevalence: 2% | Medium           |
Proteinuria/albuminuria was used alone to identify CKD in 14 studies. KDOQI staging of CKD was used in 13 studies. The serum creatinine level (either doubling, or an increase above a certain threshold) was considered to be a marker of the presence of CKD in four studies. In 16 studies, the definition of CKD was either not mentioned or was defined in various ways, including personal history, creatinine clearance (CrCl) ≤50 mL/min, clinical manifestations, the presence of albuminuria, elevated serum creatinine and the average of two measurements of eGFR <90 mL/min/1.73 m².

Paper quality

Paper quality was high in 16 studies. Thirty-five studies were of medium quality. The rest of the studies were of low quality.

Prevalence of CKD

The included medium-quality/high-quality studies in the general population in Africa provided estimates of CKD prevalence by disparate criteria (table 2). The prevalence of CKD ranged from 2% to 41% (pooled prevalence: 10.1%; 95% CI 9.8% to 10.5%). The prevalence was reported to range from 2% to 41% (pooled estimate: 16.5%) in the West/Central-West, followed by the Central region where the prevalence ranged from 12% to 17% (pooled estimate: 16%), in the Southern where the CKD prevalence range was 6%–29% (pooled estimate: 12.2%), in Eastern where the prevalence ranged from 7% to 15% (pooled estimate: 11.0%), and in the North where the prevalence ranged from 3% to 13% (pooled estimate: 4%) (figure 2). In sub-Saharan Africa, the prevalence ranged from 2% to 14% (pooled prevalence: 14.02%; 95% CI 13.5% to 14.5%). In studies defining CKD as eGFR <60 mL/min, the prevalence of CKD ranged from 7% to 29% (pooled estimate: 13.2%), while in those who adopted the combined criterion GFR <60 mL/min/1.73 m² and/or the presence of proteinuria or albuminuria, the prevalence ranged from 3% to 22% (pooled estimate: 5.6%). When defined according to KDOQI, the prevalence ranged from 2% to 28% (pooled estimate: 10.8%). Finally, in studies reporting on proteinuria/albuminuria only, the prevalence ranged from 3% to 41% (pooled estimate: 18.9%). The CKD prevalence for each age or gender group was not reported in the majority of the studies. In online supplementary figure 1 we show graphically the relationship between gender and age and CKD prevalence in the medium-high-quality studies of this systematic review.

Among patients with HIV (table 3), the prevalence of CKD in the 18 medium-quality studies ranged from 1% to 46% (pooled prevalence: 5.6%; 95% CI 5.4% to 5.8%). The prevalence of CKD in the West/Central-West

82-84 86 91 99 100 105 106 109 112-114 121 130-137 141 Proteinuria/albu-
mminuria was used alone to identify CKD in 14 studies. KDOQI staging of CKD was used in 13 studies. The serum creatinine level (either doubling, or an increase above a certain threshold) was considered to be a marker of the presence of CKD in four studies. In 16 studies, the definition of CKD was either not mentioned or was defined in various ways, including personal history, creatinine clearance (CrCl) ≤50 mL/min, clinical manifestations, the presence of albuminuria, elevated serum creatinine and the average of two measurements of eGFR <90 mL/min/1.73 m².

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Paper quality was high in 16 studies. Thirty-five studies were of medium quality. The rest of the studies were of low quality.

Prevalence of CKD

The included medium-quality/high-quality studies in the general population in Africa provided estimates of CKD prevalence by disparate criteria (table 2). The prevalence of CKD ranged from 2% to 41% (pooled prevalence: 10.1%; 95% CI 9.8% to 10.5%). The prevalence was reported to range from 2% to 41% (pooled estimate: 16.5%) in the West/Central-West, followed by the Central region where the prevalence ranged from 12% to 17% (pooled estimate: 16%), in the Southern where the CKD prevalence range was 6%–29% (pooled estimate: 12.2%), in Eastern where the prevalence ranged from 7% to 15% (pooled estimate: 11.0%), and in the North where the prevalence ranged from 3% to 13% (pooled estimate: 4%) (figure 2). In sub-Saharan Africa, the prevalence ranged from 2% to 14% (pooled prevalence: 14.02%; 95% CI 13.5% to 14.5%). In studies defining CKD as eGFR <60 mL/min, the prevalence of CKD ranged from 7% to 29% (pooled estimate: 13.2%), while in those who adopted the combined criterion GFR <60 mL/min/1.73 m² and/or the presence of proteinuria or albuminuria, the prevalence ranged from 3% to 22% (pooled estimate: 5.6%). When defined according to KDOQI, the prevalence ranged from 2% to 28% (pooled estimate: 10.8%). Finally, in studies reporting on proteinuria/albuminuria only, the prevalence ranged from 3% to 41% (pooled estimate: 18.9%). The CKD prevalence for each age or gender group was not reported in the majority of the studies. In online supplementary figure 1 we show graphically the relationship between gender and age and CKD prevalence in the medium-high-quality studies of this systematic review.

Among patients with HIV (table 3), the prevalence of CKD in the 18 medium-quality studies ranged from 1% to 46% (pooled prevalence: 5.6%; 95% CI 5.4% to 5.8%). The prevalence of CKD in the West/Central-West
Table 4: Studies on CKD among patients with diabetes

| Study ID | Year, country, region | Location | N | Study group | Population characteristics | Definition of CKD | Methods of outcome assessment | Creatinine assay | Proteinuria | CKD prevalence | Quality assessment |
|----------|-----------------------|----------|---|-------------|---------------------------|-------------------|-------------------------------|----------------|------------|-----------------|-------------------|
| Janmohamed | 2013, Tanzania, East | Diabetes mellitus clinic of Bugando Medical Centre in Mwanza | 389 | Consecutive patients with diabetes | Age (years): 54 (IQR: 49-62) Male gender: 46.6% Hypertension: 57.5% BMI (kg/m²): 25.6 (IQR: 22.6-29.6) Duration of DM (years): 6 (3-11) 93.8% type 2 DM 6.2% type 1 DM | eGFR ≤60 mL/min/1.73 m² or evidence of kidney damage (microalbuminuria or overt proteinuria) | Microalbuminuria, proteinuria by urinary strips, eGFR by CG | Kinetic Jaffé | Overt proteinuria (34.1%), microalbuminuria (40.8%) | Total prevalence: 83.7% | Low |
| Wanjohi | 2002, Kenya, East | Outpatient diabetic clinic at Kenyatta National Hospital | 100 | Patients with type 2 diabetes | Age (years): 53.7±9.3 Male gender: 37% Hypertension: 56.0% BMI (kg/m²): 27.8±6.0 Duration of DM: 10.3±4.5 | Albuminuria >20 mg/L | Albuminuria by urinary strip, CG | Not mentioned | 26% had albuminuria | Total prevalence (based on albuminuria): 26% | Low |
| Bouzid | 2011, Tunis, North | Endocrinology centre at the National Institute of Nutrition | 689 | Patients with type 2 diabetes from computerised hospital database | Age (years): 60±11 Male gender: 39% Hypertension: 84.6% (renal insufficiency), 57.2% (no renal disease) Duration of DM (years): 11±8 BMI (kg/m²): 28.8±5.5 | eGFR <60 mL/min | CG, 24-hour proteinuria | Not mentioned | 10.1% macroalbuminuria, 13% microalbuminuria | Total prevalence: 19.8% | Low |
| Chouken | 2012, Cameroon, Central-West | Two main referral centres | 420 | Consecutive patients with type 2 diabetes | Age (years): 56.7±9.9 Male gender: 49% Hypertension: 50.1% BMI (kg/m²): 28.5±5.2 Duration of DM: 4 (IQR: 1-9) | Presence of positive proteinuria with or without low CrCl <90 mL/min/1.73 m² | Proteinuria by urinary strip, eGFR by CG | Not mentioned | Total prevalence: 31% | Low |
| Keeton | 2004, South Africa, South | Groote Schuur Hospital Outpatients Diabetic Clinic or the Somerset Hospital Outpatients | 59 | Patients with type 2 diabetes | Age (years): 62±9.4 Male gender: 36% BMI (kg/m²): 31±6 Duration of DM: 17 (range: 14-33) | Double SCr level | Proteinuria by PCR and serum creatinine | Not mentioned | Total prevalence: 66.1% | Low |
| Bouaziz | 2012, Tunisia, North | Basic Health Group of Sousse | 115 | 73 patients with type 2 diabetes and 42 healthy volunteers | Age (mean±SE in years): 59.3±1.1 Male gender: 35% SBP (mean±SE mm Hg): 136.3±3.1 DBP (mean±SE): 76.8±1.9 BMI (mean±SE in kg/m²): 30.5±0.7 Duration of DM (years): 10.6±1 | Microalbuminuria defined as <2.8 g/gm Cr for women and <2.3 for men) and eGFR ≤60 mL/min/1.73 m² | Measurement of microalbuminuria, eGFR by MDRD | Not mentioned | Total prevalence: 11% | Low |
| Katchunga | 2010, Congo, Central | Referral general hospital | 98 | Medical records of patients with type 2 diabetes | Age (years): 58±10.4 Male gender: 35.7% Hypertension: 59.2% BMI (kg/m²): 25.2±4.7 Duration of DM: 17.3±8.5 | KDOQI | Microalbuminuria (>20 mg/L and <200 mg/L) eGFR by MDRD | Not mentioned | Total prevalence: 66% | Low |

Continued
| Study ID | Year, country, region | Location | N | Study group | Population characteristics | Definition of CKD | Methods of outcome assessment | Creatinine assay | Proteinuria | CKD prevalence | Quality assessment |
|----------|----------------------|----------|---|-------------|-----------------------------|-------------------|-----------------------------|----------------|-------------|-----------------|-------------------|
| Djrolo123 | 2001, Benin, West | National University Hospital Centre | 152 | Patients with type 1 and 2 diabetes | Age (years): 53.3 (range, 21–90) Male gender: 65.8% Duration of DM (years): <1–16 or more | Presence of proteinuria | 24-hour proteinuria | Not measured | 28% | Total prevalence (based on proteinuria level): 28% | Low |
| Balogun122 | 2011, Nigeria, West | Tertiary hospital | 40 | Randomly selected patients with type 2 diabetes | Age (years): 59.4±11.25 Male gender: 37.5% Hypertension: 45% | Not mentioned | Proteinuria by urinary strip and 24-hours, eGFR by CG | Jaffe method | 82.5% macroalbuminuria | Total prevalence: 90% | Low |
| Mafundikwa123 | 2007, Zimbabwe, South | Diabetic clinic | 75 | Consecutive insulin-independent patients with diabetes | No available data | No available data | Proteinuria by urinary strips and 24-hour proteinuria | Overt proteinuria 21%, microalbuminuria 12% | Total prevalence: 33% | Low |
| Lutale124 | 2007, Tanzania, East | Outpatient diabetic clinic | 204 | 91 patients with type 1 and 153 type 2 diabetes | Age (years): 53.3 (range, 21–90) Male gender: 37.5% Hypertension: 45% Duration of DM (years): <1–16 or more | Presence of proteinuria | 24-hour proteinuria | Not measured | 28% | Total prevalence (based on proteinuria level): 28% | Low |
| Gill125 | 2008, Ethiopia, East | Diabetic clinic at Mekelle Hospital | 105 | All patients with diabetes | Age (years): 41±16 Male gender: 70% Hypertension: 5% | Nephropathy was considered present if the urinary ACR was >25.0 mg/mmol and retinopathy was present. Microalbuminuria was diagnosed if the ACR was >2.5 and <25.0 mg/mmol in men and >3.5 and <25.0 mg/mmol in women. | ACR, SCR | Not mentioned | 51% microalbuminuria | Total prevalence: 51% | Low |
| Makulo111 | 2010, Congo, Central | Community-based | 229 | 81 patients with diabetes and 148 with impaired fasting glucose | Age (years): 53.1±16.3 Male gender: 33% SBP (mm Hg): 128.0±5.7 DBP (mm Hg): 78.5±3.14 BMI (kg/m²): 22.6±5.2 Hypertension: 5% | Urinary albumin by urinary strip and ACR, eGFR by 186 MDRD and CKD-EPI | KDOQI Quantitative assessment of albuminuria, Q/Cl by CG | Kinetic Jaffe | Type 1: microalbuminuria was 12.1% and macroalbuminuria 1.1%. Type 2: microalbuminuria 9.8% Macroalbuminuria 7.2% | Total prevalence: 18.5% | Low |
| Adebanowo151 | 2016, Nigeria, Ghana, Kenya (sub-Saharan) | University medical centres and surrounding communities | 4815 | 2208 cases of type 2DM and 2607 controls free from DM | Age (years): 48±15 Male gender: 41% Hypertension: 68.3% of type 2DM and 35.3% of diabetic-free BMI (kg/m²): 26.9±5.4 (patients with diabetes), 25.5±6.7 (non-diabetics) | Proteinuria by dipsticks and eGFR by 186 MDRD | eGFR by MDRD and CKD-EPI | Not measured | 6.6% among patients with anaemia, 57.6% non-anaemic | Total prevalence: 6.6% | Low |
| Feteh95 | 2016, Cameroon, Central-West | Outpatient section of the endocrine unit of the Douala General Hospital | 636 | Cases of type 2DM | Age (years): 56.5±10.6 Male gender: 53.1% BMI (kg/m²): 29.3±4.7 Hypertension: 62.2% | Proteinuria by dipsticks and eGFR by 186 MDRD | Kinetic Jaffe | 68.4% among patients with anaemia, 57.6% non-anaemic | Total prevalence: 18.5% | Low |
Among patients with diabetes (table 4, all studies are of low quality except for four with medium quality), the prevalence of CKD ranged from 11% to 90% (pooled prevalence: 24.7%; 95% CI 23.6% to 25.7%). The highest prevalence was in the Eastern, which ranged from 18% to 84% (pooled estimate: 46.9%), followed by the Central, where the CKD prevalence ranged from 30% to 66% (pooled estimate: 40.8%). In the West/Central-West, CKD prevalence ranged from 18% to 90% (pooled estimate: 27.7%), while in the South the CKD prevalence ranged from 18% to 66% (pooled estimate: 23.0%), and in the North CKD prevalence ranged from 11% to 20% (pooled estimate: 18.9%). One study done in sub-Saharan reported that the prevalence was 13%. Among patients with diabetes, CKD prevalence ranged from 11% to 83% (pooled estimate: 51.8%) when CKD was defined as eGFR <60 mL/min. In studies that defined CKD as eGFR <60 mL/min/1.73 m² and/or the presence of proteinuria or albuminuria, the CKD prevalence ranged from 9% to 21% (pooled estimate: 5.6%). There are other four studies that defined CKD based on either the presence of proteinuria, KDOQI, CrCl <50 mL/min/1.73 m², CrCl <50 mL/min. In studies that defined CKD based on either the presence of proteinuria, KDOQI, CrCl <50 mL/min/1.73 m², CrCl <50 mL/min, or albuminuria and serum creatinine. In these four studies, the prevalence of CKD ranged from 3% to 46% (pooled estimate: 12.6%). The CKD prevalence for each age or gender group was not reported in the majority of the studies. In online supplementary figure 1 we show graphically the relationship between gender and age and CKD prevalence among patients with HIV in the medium-high-quality studies.
| Study ID | Year, country, region | Location | N | Study group | Population characteristics | Definition of CKD | Methods of outcome assessment | Creatinine assay | Proteinuria | CKD prevalence | Quality assessment |
|----------|-----------------------|----------|---|-------------|-----------------------------|-----------------|------------------------------|-----------------|-------------|----------------|---------------------|
| Osafo    | 2011, Ghana, West     | Four polyclinics | 712 | Patients with hypertension | Age (years): 59 (range, 19–90) Male gender: 21.3% DM: 14.1% SBP (mm Hg): 150 (range, 100–280) DBP (mm Hg): 90 (range, 60–160) BMI (kg/m²): 29.7 (range, 12.3–67.4) | KDOQI Proteinuria by PCR (men >0.3, women >0.2 mg/mg) eGFR by MDRD Kinetic Jaffe | Total prevalence: 46.90% Prevalence by stage Stages 1–2: 19.1% Stages 3–5: 27.8% Prevalence by gender Female: 46.6% Male: 48% |
| Ajayi    | 2014, Nigeria, West   | Tertiary health centre | 628 | Records of patients with hypertension and diabetes | Age (years): 49.7±13.22 Male gender: 49% DM: 8.6% SBP (mm Hg): 135.9±27.4 DBP (mm Hg): 87.0±16.3 BMI (kg/m²): 27.8±8.7 | eGFR <60 mL/min/1.73 m² eGFR by MDRD | Not mentioned | Not measured | Total prevalence: 38.5% Prevalence by age <20 years: 0.1% 21–40 years: 31.5% 41–60 years: 34.7% 61–75 years: 40% >75 years: 62.9% Prevalence by gender Female: 57% Male: 18.9% |
| Lengani  | 2000, Burkina Faso, West | Department of Cardiology or Internal Medicine | 342 | Patients with hypertension | Age (years): 50.6±13.8 Male gender: 58% | Serum creatinine ≥60 µmol/L and or blood urea ≥35 mL/L plus long history with clinical manifestations | Measurement of SCr, 24-hour proteinuria | Not mentioned | Total prevalence: 50.8% |
| Nwankwo | 2006, Nigeria, West   | University of Maiduguri Teaching Hospital | 185 | All hospitalised patients with hypertension | Age (years): 44.6±14.9 Male gender: 49% | SCr >135 µmol/L | Measurement of SCr | Not mentioned | Total prevalence: 45.0% |
| Rayner   | 2006, South Africa, South | 100 general practice centres | 1091 | Random patients with hypertension | Age (years): ≥35 years Male gender: 48.5% BMI: 23.6% of the patients had a normal BMI, 41.9% were overweight and 34.2% were frankly obese. | Albuminuria defined as (mg/mmol) microalbuminuria 3–30, macroalbuminuria >30 Quantitative assessment of albuminuria by ACR Proteinuria and eGFR by MDRD Proteinuria and eGFR by MDRD Enzymatic assessment | Not measured | 21.3% microalbuminuria, 4.1% macroalbuminuria Total prevalence (based on albuminuria): 25.4% |
| Plange-Rhule | 1999, Ghana, West | Komfo Anokye Teaching Hospital | 448 | Patients with hypertension | Age (years): 50.5±13.0 Male gender: 36% SBP (mm Hg): 165.0±27.6 DBP (mm Hg): 101.9±17.9 | Plasma creatinine ≥140 µmol/L | Proteinuria by urinary strips and serum creatinine | Not mentioned | 25.50% | Total prevalence: 30.2% |
| Addo     | 2009, Ghana, West     | Seven central government ministries in Accra | 219 | Patients with hypertension | Age (years): 50.4±6.6 Male gender: 64% SBP (mm Hg): 156.0±21.5 DBP (mm Hg): 95±13 BMI (kg/m²): 27.5±5.4 | Persistent proteinuria on urinalysis in the absence of urinary tract infection and/or impaired GFR <60 mL/min/1.73 m² | Proteinuria and eGFR by MDRD Enzymatic assessment | 13.4% | Total prevalence: 13.4% 4.1% had eGFR <60 mL/min/1.73 m² |

Continued
| Study ID | Year, country, region | Location | N | Study group | Population characteristics | Definition of CKD | Methods of outcome assessment | Creatinine assay | Proteinuria | CKD prevalence | Quality assessment |
|----------|------------------------|----------|---|-------------|-----------------------------|------------------|-----------------------------|----------------|-------------|----------------|---------------------|
| Aryee1** | 2016, Ghana, West | Komfo Anokye Teaching Hospital and the surrounding community | 242 | 180 non-diabetic patients with hypertension and 61 age-matched controls | Age (years): 22–87 Male gender: 37% SBP (mm Hg): patients with hypertension (on antihypertensive therapy: 155.46±1.82, no antihypertensive therapy: 152±3.27), control (117.38±0.96) DBP (mm Hg): patients with hypertension (on antihypertensive therapy: 101.46±0.94, no antihypertensive therapy: 100.50±1.34), control (73.28±0.77) BMI (kg/m²): patients with hypertension (on antihypertensive therapy: 29.52±0.39, no antihypertensive therapy: 29.8±0.71), control (29.36±0.65) | eGFR <60mL/min/1.73m² Urine albumin excretion, and eGFR by CG, 186 MDRD and CKD-EPI | Not mentioned | 30% | Total prevalence (CKD-EPI): 14.5% Prevalence by MDRD: 13.3% Prevalence by CG: 16.6% | Low |
| Nabbaale40 | 2015, Uganda, East | Outpatient hypertension clinic | 256 | Newly diagnosed eligible black adult patients with hypertension | Age (years): 54.3±6.2 Male gender: 36.7% | Microalbuminuria as a random urine albumin level between 30 and 299mg/dL | Quantitative assessment of albumin in urine | Not measured | 39.5% | Total prevalence (based on microalbuminuria): 39.5% | Low |

BMI, body mass index; CG, Cockcroft-Gault; CKD, chronic kidney disease; CKD-EPI, Chronic Kidney Disease-Epidemiology Collaboration; CrCl, creatinine clearance; DBP, diastolic blood pressure; DM, diabetes mellitus; GFR, glomerular filtration rate; IDMS, isotope dilution mass spectrometry; KDOQI, Kidney Disease Outcome Quality Initiative; MDRD, Modification of Diet in Renal Disease; SBP, systolic blood pressure; eGFR, estimated glomerular filtration rate; ACR, albumin to creatinine ratio.
| Study ID | Year, country, region | Location | N | Study group | Population characteristics | Definition of CKD | Methods of outcome assessment | Creatinine assay | Proteinuria | CKD prevalence | Quality assessment |
|----------|----------------------|----------|---|-------------|-----------------------------|------------------|-----------------------------|----------------|-------------|----------------|--------------------|
| Ka23     | 2013, Senegal, West   | Nephrology Department of the Aristide Le Dantec University Hospital Centre | 43 | Patients with lupus | Age (years): 32.9 Male gender: 7% Hypertension: 30% | Proteinuria >0.5 g/24 hours with or without haematuria/ renal insufficiency/ abnormal renal biopsy | 24-hour proteinuria and eGFR by CG | Not mentioned | 51% | Total prevalence: 72% | Low |
| Abd ElHafeez29 | 2009, Egypt, North | Nephrology Department at the Main Alexandria University Hospital | 400 | Relatives of ESRD patients | Age (years): 35.2±11.6 Male gender: 50.8% Hypertension: 60% | Proteinuria >0.5 g/24 hours with or without haematuria | KDOQI | Proteinuria by urinary strips, 186 MDRD | Kinetic Jaffe | 21.3% | Total prevalence: 57% | Medium |
| Raj28     | 2015, Nigeria, West   | Nephrology outpatient clinic at Lagos University Teaching Hospital | 469 | 230 first-degree relatives of patients with CKD and 230 age-matched and gender-matched controls with no personal or family history of CKD | Age (years): 33.49±12.0 BMI (kg/m²): 28.5±5.89 | Reduced eGFR | Albuminuria by ACR and eGFR by MDRD | Not mentioned | 46% | Total prevalence: 4% | Low |
| Elsharif24 | 2013, Sudan, East     | Primary healthcare | 252 | Patients attending the primary healthcare facilities | Age (years): 43.35±12.9 Male gender: 16% Hypertension: 10% | eGFR of <60 mL/min/1.73 m² with or without proteinuria | Proteinuria by urinary strip and eGFR by MDRD | Not mentioned | 24.21% | Total prevalence: 10.32% | Low |
| Abalab26  | 2009, Nigeria, West   | Family practice clinic | 250 | Newly registered patients who attended the Family Practice Clinic | Age (years): 50.52±13.03 Male gender: 27.2% | Persistently abnormal ACR irrespective of GFR level or persistent eGFR <60 mL/min/1.73 m² irrespective of the presence or absence of kidney damage after 3 months | Proteinuria by urinary strip, eGFR by MDRD | Standardised IDMS | 14.4% | Total prevalence: 14.4% | Medium |
| Sumail25  | 2009, Congo, Central  | Primary and secondary healthcare | 527 | At-risk population randomly selected | Age (years): 53.9±15.5 Male gender: 43% | Persistent abnormal ACR irrespective of GFR level or persistent eGFR <60 mL/min/1.73 m² irrespective of the presence or absence of kidney disease after 3 months | Proteinuria by urinary strip, 24-hour proteinuria, 175 MDRD | Kinetic Jaffe | 19% | Total prevalence: 36% | High |
| Anyabolu30 | 2016, Nigeria, West   | Federal Medical Centre | 136 | Subjects from medical outpatient department of the hospital | Age (years): 36.58±11.79 Male gender: 27.9% | Proteinuria as 24-hour urine dip ≥0.300 g and impaired renal filtration function as CrCl <90 mL/min | Proteinuria by quantitative assessment and SCr | Kinetic Jaffe | 14.1% had proteinuria | Total prevalence: 14.1% | Low |
| Study ID | Year, country, region | Location | N | Study group | Population characteristics | Definition of CKD | Methods of outcome assessment | Creatinine assay | Proteinuria | CKD prevalence | Quality assessment |
|----------|-----------------------|----------|---|-------------|-----------------------------|-------------------|-------------------------------|----------------|-------------|----------------|------------------|
| Dessein10 | 2015, South Africa, South Charlotte Maxeke Johannesburg and Milpark Hospitals | 233 | African patients with rheumatoid arthritis | Age (years): 57.1±10.8 Male gender: 17.2% BMI (kg/m²): 27.4±6.0 Hypertension: 57.5% DM: 12.5% | eGFR <60 mL/min/1.73m² | eGFR by CG, MDRD, CKD-EPI | Kinetic Jaffe and IDMS-calibrated | Not measured | Total prevalence: 39% | Low |
| Ephraim10 | 2015, Ghana, West Tema General Hospital | 194 | Patients with sickle cell anemia | Age (years): 23.2±12.04 Male gender: 43.3% SBP (mm Hg): 110.06±8.27 DBP (mm Hg): 67.16±8.23 BMI (kg/m²): 27.4±6.0 | eGFR<60mL/min/1.73m² or evidence of kidney damage as albuminuria or overt proteinuria | Proteinuria by dipstick and eGFR by CKD-EPI | IDMS | 13.4% | 39.2% | Low |
| van Rensburg27 | 2010, South Africa, South Tertiary hospital | 1216 | New patients referred to the renal unit | Age (years): 39.6±15.9 Male gender: 51.1% Hypertension: 13.2% DM: 10.8% | Elevated SCr (>130 μmol/L) and small kidneys on imaging without evidence of reversible causes | Proteinuria by quantitative assessment and SCr measurement | Not mentioned | 16.7% proteinuria ≥3.5g/dL | Total prevalence: 37.9% | Low |
| Hamdouk104 | 2011, Sudan, East Hairdressing saloons | 72 | Hairdressers | Age (years): 40±8 Male gender: 0% Hypertension: 19.4% | SCr level ≥2mg/dL | Proteinuria by urinary strip and 24-hour SCr measurement and renal biopsy | Not mentioned | 26.4% had albuminuria Total prevalence: 14% had SCr ≥2mg/dL | Total prevalence: 26.4% | Low |
| EL-Safty129 | 2003, Egypt, North Male workers attending the outpatient clinic of the Health Insurance Organisation | 81 | Male workers attending the outpatient clinic of the Health Insurance Organisation (29 non-silicotics, 24 silicotics and 28 referent) | Age (years): 39.8±7.27 Male gender: 100% Hypertension: 19.4% | Elevated proteinuria | Assessment of proteinuria quantitatively | Not measured 93% among non-silica-exposed 100% silica-exposed | Total prevalence (among those with silica exposure): 100% | Low |

BMI, body mass index; CG, Cockroft-Gault; CKD, chronic kidney disease; CKD-EPI, Chronic Kidney Disease-Epidemiology Collaboration; CRG, creatinine clearance; DBP, diastolic blood pressure; DM, diabetes mellitus; GFR, glomerular filtration rate; IDMS, isotope-dilution mass spectrometry; KDOQI, Kidney Disease Outcome Quality Initiative; MDRD, Modification of Diet in Renal Disease; SBP, systolic blood pressure; eGFR, estimated glomerular filtration rate; ESRD, end stage renal disease; ACR, albumin to creatinine ratio.
Hospital-based surveys revealed that (Abd ElHafeez S, et al. BMJ Open 2018;8:e015069. doi:10.1136/bmjopen-2016-015069)

... et al BMJ Open defined CKD as eGFR <60 mL/min/1.73 m² and/or the presence of proteinuria or albuminuria, the prevalence ranged from 10% to 14% (pooled estimate: 12.4%), while the prevalence ranged from 49% to 57% (pooled estimate: 51.5%) when CKD was defined according to KDOQI. CKD was prevalent among almost 39% of patients with rheumatoid arthritis²⁰ or sickle cell.²¹ The study (low quality) conducted among hairdressers exposed to paraphenylenediamine later reported that 26.4% of these subjects had renal impairment. Of note, 100% of silica-exposed workers experienced proteinuria (reported from low-quality study).²¹²

Causes of CKD

Forty-two studies were conducted specifically to clarify the underlying cause of CKD²¹³–²²² (online supplementary table 2). The diagnosis was biopsy-proven in 17 studies.²²² Vascular/hypertensive sclerosis was the main cause of CKD (16%), followed by diabetic nephropathy (15%), chronic glomerulonephritis (13%), tubulointerstitial/obstructive (8%), primary glomerular diseases (6%), systemic lupus erythematosus (3%) and polycystic kidney disease (3%). The causes of CKD were undetermined/miscellaneous causes in one-fifth of the patients (20%) (figure 3).

DISCUSSION

This systematic review focuses on the burden of CKD on the entire African continent. We assessed 152 papers published between 1 January 1995 and 7 April 2017 reporting the epidemiology of CKD in the general population and in specific chronic conditions in Africa. The CKD prevalence reported in our review should be interpreted with caution. Our estimates may be affected by the analytical heterogeneity used to measure creatinine and albuminuria. Serum creatinine concentrations are affected by intraindividual variability with over 20% changes within a 2-week period²¹⁷ and most Jaffe assays overestimate serum creatinine.²¹⁸ The resulting bias could vary according to the creatinine concentration, specific assay, manufacturer and calibration material used. Although the IDMS calibration standardisation has reduced the bias and improved the inter-laboratory comparability,²¹¹ the number of studies reported using IDMS was low in Africa. Moreover, CKD prevalence may additionally be influenced by albuminuria assays, which are affected by inter-laboratory differences.²¹⁴ The different equations used to estimate GFR could be a source of bias. The systematic underestimation of measured GFR at higher estimated GFR by the MDRD equation is well known, and may reflect higher creatinine generation in healthy and CKD prevalence among patients with diabetes in the included studies.

The prevalence of CKD among patients with hypertension (table 5, 9 studies; all of low quality except for two with medium quality) ranged from 13% to 51% (pooled prevalence: 34.5%; 95% CI 34.04% to 36%). The highest prevalence was reported from one study in the East macro-area (39.5%), followed by the West/Central-West, where the prevalence ranged from 13% to 51% (pooled estimate: 37.7%). In South Africa, the CKD prevalence reported from one study was 25.4%. No data were found for other African macro-areas. In studies that defined CKD as eGFR <60 mL/min/1.73 m², the prevalence of CKD ranged from 38.5% to 40% (pooled estimate: 38.9%). When serum creatinine was used to define CKD, the prevalence ranged from 30% to 51% (pooled estimate: 40.9%). When CKD was defined according to albuminuria/proteinuria, the prevalence of CKD ranged from 15% to 25% (pooled estimate: 23.6%). In one study, CKD was defined according to KDOQI criteria and it was prevalent among 47% of patients with hypertension. The CKD prevalence for each age or gender group was not reported in the majority of the studies. In online supplementary figure 1 we show graphically the relationship between gender and age and CKD prevalence among patients with diabetes in the included studies.

Among other patient populations (studies reported in table 6), almost three-quarters of patients with lupus had CKD (prevalence=72.0%) based on low-quality study.²⁰ Two with medium quality) ranged from 13% to 51% (pooled prevalence: 37.7%). In South Africa, the CKD prevalence ranged from 13% to 51% (pooled estimate: 37.7%). In hospital-based studies, when CKD was defined as eGFR <60 mL/min/1.73 m² and/or the presence of proteinuria or albuminuria, the prevalence ranged from 10% to 14% (pooled estimate: 12.4%), while the prevalence ranged from 49% to 57% (pooled estimate: 51.5%) when CKD was defined according to KDOQI. CKD was prevalent among almost 39% of patients with rheumatoid arthritis²⁰ or sickle cell.²¹ The study (low quality) conducted among hairdressers exposed to paraphenylenediamine later reported that 26.4% of these subjects had renal impairment. Of note, 100% of silica-exposed workers experienced proteinuria (reported from low-quality study).²¹²

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individuals compared with individuals with CKD in whom the MDRD equation was derived. This bias is reduced substantially, but not completely, by the CKD-EPI equation, which was derived from studies including people without CKD.\textsuperscript{175} In addition, differences in sample size, demographics and clinical characteristics are all significant limitations in this systematic review for making accurate estimates of the prevalence of CKD in African countries. Age and gender are well-known determinants of the risk of CKD development, progression and complication. While the prevalence of CKD tends to be higher in women, the disease is more severe in men, who also have a higher risk of all-cause and cardiovascular disease (CVD) mortality across different levels of renal function. However, the risk relationships of reduced eGFR and higher albuminuria with mortality were steeper in women than in men. Moreover, the risk of progression to ESRD at a given eGFR rate and urinary albumin-to-creatinine ratio seemed equivalent in men and women.\textsuperscript{176,177} The lack of information on the prevalence of CKD by age and gender in studies included in this systematic review—only 11\% of the included studies reported CKD prevalence by either age or gender groups—limits the value and the reliability of pooled estimates of CKD prevalence in Africa and in its macro-areas. To circumvent this limitation, we showed the prevalence of CKD in the various studies in relationship to the proportion of men and age in the same studies. However the number of studies is too small for reliably capturing the effect of age and gender on CKD prevalence in Africa. Furthermore, only five studies\textsuperscript{79,142-145} assessed the KDOQI chronicity criterion, which is a fundamental element of the current definition of CKD by this organisation. A single elevated serum creatinine, reduced eGFR or an abnormal urinalysis should initially be viewed as a screening test, and the diagnosis of CKD should be confirmed with repeated tests, additional work-up and clinical judgement.\textsuperscript{178} Thus, estimates in this review should be seen as a pragmatic attempt to evaluate the dimension of CKD as a public health issue on the African continent.

CKD is now considered to be an important component of the epidemic of non-communicable diseases in economically developed and low–income/middle-income countries alike. In a seminal meta-analysis published in 2014, Stanifer \textit{et al}\textsuperscript{9} for the first time drew attention to the public health relevance of CKD in the sub-Saharan Africa, a vast area comprising 85\% (947.4 million) of the whole African population.\textsuperscript{9} In the present systematic review, the lowest prevalence of CKD (4\%) was reported in the Northern Africa macro-area, including Egypt, Libya, Tunisia, Algeria, Morocco, the Western Sahara and Mauritania, and the highest (16.5\%) was observed in West/Central West Africa, which includes Benin, Burkina Faso, the island nation of Cape Verde, Gambia, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Liberia, Mali, Mauritania, Niger, Nigeria, Cameroon, the island of Saint Helena, Senegal, Sierra Leone, São Tomé and Príncipe and Togo. The average prevalence in the entire African continent was 10.1\%. The global CKD prevalence was reported to be 13.4\%.\textsuperscript{179} In sub-Saharan Africa in Stanifer \textit{et al}\textsuperscript{9}’s meta-analysis, the prevalence of CKD was 13.2\%,\textsuperscript{9} which is close to that reported in the same area in our review (14.02\%). Among the general population of economically developed countries, CKD has 13.6\% prevalence in the USA.\textsuperscript{180} In Europe, the reported prevalence is lower and more homogeneous, being 8.9\% in the Netherlands, 6.8\% in Italy, 5.2\% in Portugal, 4.7\% in Spain and 3.3\% in Norway.\textsuperscript{181} CKD prevalence in some Asian countries was higher than the estimates in the USA and in Europe, being 17.5\% in Thailand,\textsuperscript{182} 15\% in India,\textsuperscript{183} 13\% in Japan,\textsuperscript{184} 11.9\% in Taiwan\textsuperscript{185} and 9.9\% in China.\textsuperscript{186} Overall, the estimated prevalence of CKD at

![Figure 3](http://bmjopen.bmj.com/)  

**Figure 3**  Main causes of chronic kidney disease.
the general population level in African countries appears to be comparable and possibly even higher than that reported in other continents. This may be at least in part due to the low-quality data for the prevalence of CKD in Africa related to poor sampling techniques, unreliable kidney function measurements and the different definitions used.

In our review, the prevalence of CKD in surveys based on hospitals or primary care centres (36%) is close to that in Swiss primary care centres (36%).

Poverty-related factors such as infectious diseases secondary to poor sanitation, inadequate supply of safe water, environmental pollutants and high concentrations of disease-transmitting vectors continue to play an important role in the development of CKD in low-income countries. Although rates of diabetic nephropathy are rising, chronic glomerulonephritis and interstitial nephritis are among the principal causes of CKD in many countries.

In Africa, infectious diseases such as HIV, bilharziasis, malaria, hepatitis B and C represent an almost unique cluster of risk factors responsible for CKD. HIV/AIDS is pandemic in Africa, with a prevalence ranging from 0.5% in Senegal to 27.4% in Swaziland. The global success in bringing effective antiretroviral treatment (highly active antiretroviral therapy (HAART)) to HIV-infected patients in Africa has determined the emergence of chronic medical illnesses such as HIV-related CKD.

Up to 50% of kidney diseases in HIV-infected persons result from a wide array of non-HIV-associated nephropathies, ranging from glomerulonephritis to diabetic nephropathy. We found that 5.6% of patients with HIV complained of renal dysfunction. This figure is lower than that reported in economically developed countries such as France, USA, China, Spain and Brazil. CKD was higher among patients with HIV not receiving HAART compared with those on HAART. Variation in the proportion of patients with HIV affected by CKD depends on the heterogeneity in the definition used to determine renal dysfunction, the proportion of the study population on HAART, diverse ethnicities, the associated comorbidities and the nutritional status of the study population. Patients with HIV are more prone to nutritional deficiencies due to malabsorption, impaired oral intake and the wasting syndrome. Increased availability of HAART has led to some improvement of the nutritional status of patients. However, for certain individuals, undernutrition and weight loss persist despite therapy. Malnutrition exacerbates side effects, alters drug pharmacokinetics and impinges on adherence, thereby limiting the beneficial effects of the therapy. Furthermore, differences in HIV clades or strains in African patients and genetic factor may influence the replication capacities within the isolated renal reservoir and thus lead to a diversity in clinical presentations.

Regarding systemic autoimmune diseases such as lupus, a study conducted among patients with lupus from Senegal showed that almost three-quarters (71.0%) of the patients with this disease had evidence of renal involvement. This isolated figure is higher than that reported in other countries. More than one-third (39%) of patients with rheumatoid arthritis had CKD, which is higher than that reported from Taiwan.

Even though there are no sufficient data to precisely reconstruct historical trends, the profile of CKD causes has changed during the last decades. Interstitial nephritis and glomerulonephritis were the main causes of CKD in North Africa, and CKD was principally caused by chronic glomerulonephritis and hypertension in East and Tropical Africa. Today, the spectrum of causes of CKD in Africa is dominated by diabetes mellitus and hypertension. We found that the prevalence of vascular/hypertensive and diabetic nephropathies as a cause of CKD (16% and 15%, respectively) exceeded that caused by chronic glomerulonephritis (13%).

Our review has both strengths and limitations. The major strengths include a thorough systematic search of electronic databases and the inclusion of all comprehensive studies with a transparent assessment of CKD prevalence by two independent reviewers. The fact that our literature search was limited to PubMed and Ovid Medline but did not include the African Index Medicus, like it was done by Stanifer et al in the meta-analysis of CKD in sub-Saharan Africa, is a limitation of our study. Because there was a huge discrepancy in the definitions used to identify CKD, the methods of creatinine measurement, urine protein assessment and in the quality of the reporting, we decided to adopt an inclusive strategy. Our primary interest was to identify all studies conducted among different population groups in Africa providing information on CKD and to reconstruct a tentative scenario of the epidemiological dimension concerning disease in the entire African continent. Methodological limitations notwithstanding this review compiled estimates suggesting that the CKD burden in Africa is at least as concerning as that in economically developed countries. The lack of a consistent definition of CKD makes it difficult to compare the burden of CKD across studies in various countries. Moreover, the failure to demonstrate chronicity when defining CKD is a common limitation of studies investigating CKD prevalence in Africa. It was reported that a single test in time has an extremely poor positive predictive value for confirmation of CKD compared with repeated testing 3 months later. Failure to repeat testing may lead to a significant overestimation of CKD prevalence and underestimation of the burden of CVD in CKD. In addition, observational studies are subject to bias and residual confounding, which are difficult to account for and there are limitations due to the heterogeneity that arises from differences in age and sex distributions. This poor data quality reported in different studies is considered as a cumbersome problem limiting the accuracy in assessing the burden of CKD in Africa.

In conclusion, CKD in Africa appears to be at least as common as in other continents, and as such it constitutes a true public health priority with major cost burden...
to healthcare systems worldwide. Targeted screening of high-risk groups (including those patients with hypertension, diabetes mellitus and HIV, and persons with occupational exposures) should likely be instituted as the first step in kidney disease prevention whenever and wherever affordable and feasible. Education to increase awareness of CKD among healthcare workers and patients, and the promotion of healthy lifestyles, should be engrained in preventive programmes. The treatment of hypertension and diabetes mellitus is of obvious relevance. Nurses and other health workers should be trained to manage these conditions at the local level if we are to curb the incidence of CKD and to avert the added burden of CKD complications to diabetes, hypertension and infectious diseases, the deadly trio of risk factors underlying the CKD epidemic in Africa.

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