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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.

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 majoirty of studies in Africa, the bias introduced from the heterogeneity between studies, analytical and methodological issues, sample size, and study population selection.

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

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.[4] 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.[5]

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.[6] 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.[7] 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.[8] 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.[9] 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).[10]

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.[11] 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,[12–14] 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 into details in previous methodology reviews dealing with clinical trials,[15] diagnostic studies[16] and observational studies.[17] 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.[18] 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

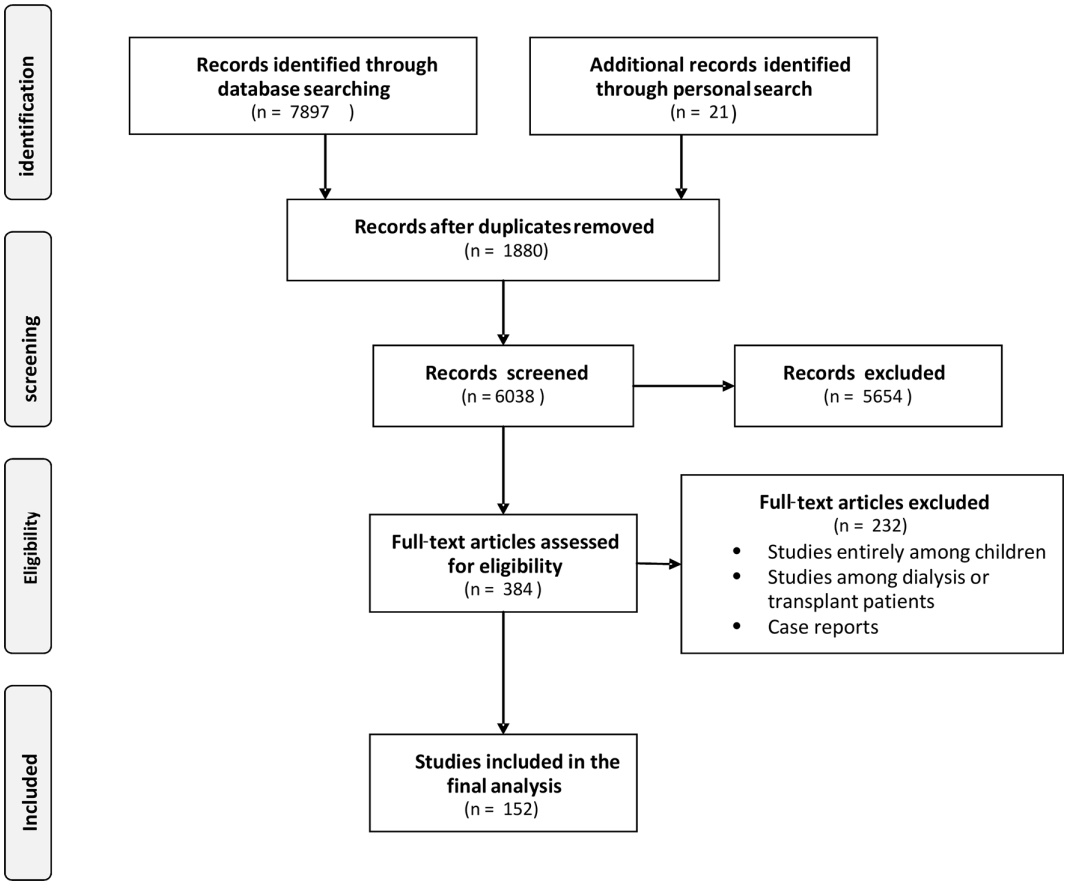

Figure 1 Flow diagram of the study selection.

Table 1 Characteristics of the study population included in the analysis

Study population	Studies (n)	Study characteristics
General population	29	n=30 169, age ranging from 12 to 95 years; 48% male
Patients with diabetes	18	n=9082, age ranging from 14 to 90 years; 43% male
Patients with hypertension	9	n=4123, age ranging from 19 to 90 years; 43% male
Patients with HIV	42	n=67 432, age ranging from 13 to 74 years; 36% male
Occupational group	2	n=153, age ranging from 22 to 59 years; one study only enrolled women and the other principally enrolled men
Family practice patients	7	n=3250, age ranging from 20 to 74 years; 44% male
Patients with lupus	1	n=43, age ranging from 16 to 55 years; 7% male
Rheumatoid arthritis	1	n=233, age ranging from 40 to 70 years; 17.2% male
Sickle cell anaemia	1	n=194, age ranging from 12 to 40 years; 43.3% male
Patients with chronic kidney disease	42	n=34 236, age ranging from 12 to 90 years; 58% male

(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 wa-s 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 3), 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,[19] one study in patients with rheumatoid arthritis,[20] one study among patients with sickle cell anaemia,[21] two in specific occupational settings (silica exposure[22] and exposure to the nephrotoxic hair-dye, paraphenylenediamine[23]) and seven studies in family practice[24–26] or hospital-based[27–30] surveys. Forty-two studies were conducted among patients with CKD (online supplementary table 2).[31–72]

The studies that were included covered all regions of Africa. The highest number of the studies came from the Western macro-area (n=54), followed by the Eastern macro-area (n=32) and Southern macro-area (n=25). Twenty studies were retrieved from Northern Africa, and eight studies from each of the Central macro-area and the Central-Western macro-area. Three studies were conducted in both the Eastern and Southern regions and two studies in the sub-Saharan region.

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.[21 24 26 29 73–96] Twenty studies used dipstick with confirmation by quantitative methods, nine of which used dipsticks to identify proteinuria/albuminuria with confirmation by 24-hour proteinuria,[25 97–104] whereas 11 studies used dipstick with confirmation by the protein-to-creatinine ratio or albumin-to-creatinine ratio.[105–115] 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.[19 27 28 30 116–140] In one study, the method of proteinuria assessment was not mentioned.[141]

Serum creatinine was measured in 95 studies (86%). The Jaffe assay was used in 30 studies,[29 30 76 80 82 83 86 90 95 97 102 105 111 113 124 126 130 131 136 142–152] whereas the isotope dilution mass spectrometry (IDMS)-calibrated method was used in 15 studies.[12 14 21 26 115 117 132–134 141 153–157] In nine studies, both the Jaffe assay and the calibrated serum creatinine were used.[13 20 25 91 98 99 106 112 158] The remaining 41 studies provided no information on the method of creatinine measurement.[19 24 27 28 78 79 81 84 85 87–89 93 94 96 100 101 104 109 114 116 118–122 125 127 135 137–139 159–167] With respect to the formula used for estimating GFR, the MDRD equation was used in 30 studies[24–26 28 29 94–97 105 106 111 113 116 117 121 122 126 130 133 134 136 141 146 149 153 154 158 159 164] and the CG equation was used in 18.[19 76 81 86–88 93 100 102 114 119 124 138 143 145 150 162 167] The other 14 studies used both the CG and the MDRD equations,[78–80 83–85 98 99 101 144 147 152 161 163] whereas 15 studies estimated GFR by the CG, MDRD and the CKD-EPI methods.[12–14 20 82 90 91 109 112 115 139 142 155 156 160] Six studies used MDRD and CKD-EPI[131 132 137 148 151 157] and two studies used CKD-EPI.[21 166] In other two studies the formula was not mentioned.[30 135]

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,[12 14 20 80 93–96 111 117 119 139 146 148–159 161–164 166 167] with chronicity confirmed by repeated testing in four other studies.[142–145] 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.[21 24 26 76 78]

Table 2 Studies on CKD among the general population

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[169]	2013, Sudan, Northeast	All village inhabitants	389	Age (years): 41±15 Male gender: 16.2 % Hypertension: 39.6 %; DM: 17 % BMI category (kg/m ^{2}) < 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[73]	2011, Nigeria, West	Market population	286	Age (years): 49.5±5.7 Male gender: 9.8% Hypertension: 37.7% BMI (kg/m^2): 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[74]	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[12]	2013, South Africa, South	Bellville town inhabitants	1202	Age (years): 52.9±14.8 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[97]	2014, Senegal, West	Two-stage cluster sampling of urban and rural inhabitants of Saint-Louis	1037	Age (years): 48.0±16.9 Male gender: 40% Hypertension: 39.1% DM: 12.7% BMI: 26.3±6.8 kg/m^2	KDOQI	Albuminuria by urinary strips; positive samples were confirmed by 24-hour albuminuria, eGFR by 186 MDRD	5.3% albuminuria >1 g/L	Total prevalence: 6.1%	High	
Pruijm[116]	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	Not mentioned	11.4% microalbuminuria, 0.7% macroalbuminuria	Total prevalence: 15.3% Prevalence of stages 3–4 CKD: 3.2%	High
Sumaili[98]	2009, Congo, Central	Multistage sampling of residents of Kinshasa	500	Age (years): 38.6±14.4 Male gender: 41% Hypertension: 27.6% DM: 11.7% BMI category (kg/m^2) 25–29.9: 20.3% =30: 14.9%	KDOQI	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% Stage 2: 2.4% Stage 3: 7.8% Stage 4: 0% Stage 5: 0.2%	High

Continued

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
Matsha[159]	2014, South Africa, South	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/m^2 Mean eGFR at baseline: 68.6±16.7 mL/min/1.73 m^2	eGFR<60 mL/min/ 1.73 m^2	eGFR: 186 MDRD (four variables)	Not mentioned	Not measured	Total prevalence: 28.9% Prevalence by categories eGFR >90 mL/min/1.73 m^2: 9.4% eGFR60 90 mL/min/1.73 m^2: 58.7% eGFR30 60 mL/min/1.73 m^2: 28.1% eGFR <30 mL/min/1.73 m^2: 0.9%	Medium
Sumaili[75]	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
Egbi[76]	2014, Nigeria, West	All civil servants in Bayelsa	179	Age (years): 45.2±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 m^2 and/ or presence of proteinuria of at least +1 on dipstick urinalysis	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
Oluyombo[105]	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, negative cases were estimated for albumin-to-creatinine ratio, 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[13]	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/m^2	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	

Continued

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
Gouda[117]	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/m^2	eGFR <60 mL/min/1.73 m^2	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
Ayodele[77]	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/m^2	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-Aisha[78]	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 m^2 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: 4.7% Stage 3: 2.6% Stage 4: 0% Stage 5: 0.4%	Medium
Gharbi[106]	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 m^2 or macroalbuminuria or dipstick abnormalities (proteinuria =++1 or haematuria =++1) or diabetes type 1 associated with microalbuminuria	175 MDRD, microalbuminuria and proteinuria by urinary strip and ACR	Kinetic Jaffe and IDMS	Microalbuminuria (30–299 mg/L): 5.26%	Total prevalence 2.90%	High
Odenigbo[153]	2014, Nigeria, West	All attendees to lectures of the Ebreime Foundation for the elderly	170	Age (years): 68.1±7.7 Male gender: 67.1%	eGFR <60 mL/min/1.73 m^2	175 MDRD	IDMS-calibrated		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%	Low
Booysen[155]	2016, South Africa, South	Participants from families of black African descent	1221	Age (years): 44.1±18.4 Male gender: 34.9% BMI (kg/m^2): 29.5±8.0 Hypertension: 45% DM: 25.2%	eGFR <60 mL/min/1.73 m^2	eGFR by CG, four variables MDRD, CKD-EPI	IDMS-calibrated	Not measured	Total prevalence: 6.3%	High

Continued

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
Kalyesubula[90]	2017, Uganda, East	Community-based survey among all households of Wakiso District	955	Age (years): 31 (IQR: 24–42) Male gender: 33% BMI (kg/m^2) categories Underweight: 5.5% Normal: 56.9% Overweight: 24.2% Obese: 13.4% 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[91]	2015, Cameroon, Central-West	Population of the Littoral region	500	Age (years): 45.3±13.2 Male gender: 53.4% BMI (kg/m^2): 27.1±5.3 DM: 2.8% Hypertension: 12.2%	Any albuminuria and/or eGFR<60 mL/min/1.73 m^2	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[112]	2015, Cameroon, Central-West	Population of the Western region	439	Age (years): 47±16.1 Male gender: 42.1% Hypertension: 10.7% DM: 5.9%	Albuminuria and/or eGFR <60 mL/min confirmed 3 months later	Albuminuria by dipstick and ACR and eGFR by CG, MDRD, CKD-EPI	Kinetic Jaffe and IDMS	12.1% had albuminuria	Total prevalence (CKD-EPI): 27.6% (38.5% by CG, 27.3% MDRD) Prevalence by gender Female: 15.4% Male: 10.2%	High
Laurence[130]	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/m^2) Male: 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 m^2	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[92]	2016, Uganda, East	Urban residents of Kampala	141	Age (years): 64% in age group of 18–39 Male gender: 43% BMI (kg/m^2): 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[131]	2015, South Africa, South	Household residents of BellVille	902	Age (years): 55±15 Male gender: 23% BMI(kg/m^2): 29.9±7.2 Hypertension: 49.8% Diabetes mellitus: 27.9%	eGFR <60 mL/min/1.73 m^2 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: 16.6%	Medium

Continued

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
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 gender: 45.7% BMI (kg/m^2) categories Underweight: 10.5% Normal: 71% Overweight: 11.8% Obese: 6.6% DM: 0.9% Hypertension: 17.3%	eGFR <60 mL/min/1.73 m^2	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[132]	2016, Tanzania, East	Stratified, cluster-designed, cross-sectional household	481	Age (years): 46.9±15.1 Male gender: 74.4% DM: 9.4% Hypertension: 31%	Presence of albuminuria (=30 mg/dL; confirmed by repeat assessment) and/or a reduction in eGFR =60 mL/min/1.73 m^2	Quantitative assessment of albuminuria and eGFR by MDRD and CKD-EPI	IDMS	6.8%	Total prevalence: 11.9%	High
Stanifer[133]	2015, Tanzania, East	Randomly selected adults	481	Age (years): 45 (IQR 35–59) Male gender: 25.6% DM: 12.7% Hypertension: 28%	eGFR <60 mL/min/1.73 m^2 and/or persistent albuminuria	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
Stanifer[134]	2016, Tanzania, East	Stratified, cluster-designed, cross-sectional survey	606	Age (years): 45.5±15.5 Male gender: 24.6% DM: 10.1% Hypertension: 23.7%	Presence of albuminuria (=30 mg/dL confirmed by repeat assessment) and/or a once-measured eGFR =60 mL/min/1.73 m^2	Quantitative assessment of albuminuria and eGFR by MDRD	IDMS	Not mentioned	Total prevalence: 8% Prevalence by age 18–39 years: 6.4% 40–59 years: 9.3% 60+ years: 10.5% Prevalence by gender Female: 7.2% Male: 11.4%	High
Wachukwu[93]	2015, Nigeria, West	Adult volunteers in a university	259	Age (years):28.3±9.7 Male gender: 52.1% SBP (mm Hg): 117.3±15.5 DBP (mm Hg): 75.7±11.7	eGFR <60 mL/min/1.73 m^2	Proteinuria by dipstick and eGFR by CG	Not mentioned	12.4%	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	Definition of CKD	Methods of outcome assessment	Creatinine assay	Proteinuria	CKD prevalence	Quality assessment
Wkba[142]	2013, Ghana, West	ART clinic at the regional hospital	442	HIV (276 HAART-naïve patients 166 on HAART)	Age (years): HAART-naïve (33.42±0.88), on HAART (36.91±0.77) Male gender: HAART-naïve (28.3%), on HAART (22.3%)	eGFR <60 mL/min/1.73 m^2 for >3 months	CG, 186 MDRD, CKD-EPI	Kinetic Jaffe	Not measured	Total prevalence (CKD-EPI): 10.2% HAART-naïve: 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-naïve (7.5%), HAART (14%) Male: HAART-naïve (11.5%), HAART (8.1%)	Low
Stöhr[143]	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/m^2	eGFR <60 mL/min/1.73 m^2 on ≥2 consecutive visits 80 days apart or confirmed 25% decrease if eGFR <60 mL/min/1.73 m^2 at baseline	CG	Kinetic Jaffe	Not measured	Total prevalence: 7.2%	Medium
Stöhr[144]	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 <18.5 kg/m^2: 18% 18.5 to <25 kg/m^2: 66% 25 to <30 kg/m^2: 12% ≥30 kg/m^2: 4%	eGFR <60 mL/min 1.73 m^2 on ≥2 consecutive occasions >80 days apart or confirmed 25% decrease if eGFR <60 mL/min/1.73 m^2 at baseline	186 MDRD, CG	Kinetic Jaffe	Not measured	Total prevalence (MDRD): 3.1% CG: 7.4%	Medium
Cailhol[79]	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/m^2	KDOQI	Proteinuria by urinary strip, CG, 186 MDRD	Not mentioned	6.10%	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
Masimango[107]	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±3.8 kg/m^2	Proteinuria ≥+1 by urinary strip or albuminuria ≥30 mg/dL	Proteinuria by urinary strip and ACR	Not measured	Proteinuria ≥+1: 41.3%	Total prevalence (based on proteinuria): 41.3%	Low

Continued

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
Reid[145]	2008, Uganda, Zimbabwe, East and South	Three centres in Uganda and Zimbabwe	3316	HIV-infected, ART-naïve adults with CD4+ cell counts of <200 cells/mm^3	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/m^2	eGFR <60 mL/min 1.73 m^2 on ≥2 consecutive occasions >80 days apart or confirmed 25% decrease if eGFR <60 mL/min/1.73 m^2 at baseline	CG	Kinetic Jaffe	Not measured	Total prevalence: 7%	Medium
Fabian[108]	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[154]	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 m^2	MDRD	IDMS-calibrated	Not measured	Total prevalence among HIV-positive: 0.7%	Medium
Jao[160]	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/m^2	CrCl <50 mL/min	CG, 186 MDRD, CKD-EPI	Not mentioned	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[99]	2012, Congo, Central	Consecutive patients with HIV from clinic	300	HIV-infected (ART treated=264) (ART-naïve=36)	Age (years): 43±9 Male gender: 23% Hypertension: 13% BMI: 24±5 kg/m^2	eGFR <60 mL/min/1.73 m^2 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 m^2 by MDRD	Low
Sarfo[109]	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/m^2	eGFR <60 mL/min/1.73 m^2, or proteinuria ≥+1 (confirmed by uPCR >45 mg/mmol)	Proteinuria by urinary strip, ACR, PCR, eGFR by CG, MDRD, CKD-EPI	Not mentioned		Total prevalence (CKD-EPI): 13.8%	Low

Continued

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[161]	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 <60 mL/min/1.73 m^2	CG, MDRD	Not mentioned		Total prevalence (MDRD): 9.4% CG: 20.2% Prevalence by gender Female: 79.1%	Medium
Ekat[146]	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% BMI: 20.31 (IQR: 17.97–22.89) kg/m^2	eGFR <60 mL/min/1.73 m^2	186 MDRD	Kinetic Jaffe	Not measured	Total prevalence: 8.5%	Low
Wools-Kaloustian[80]	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) mm/Hg	CrCl <60 mL/min/1.73 m^2	Proteinuria by urinary strip, CG, full and abbreviated MDRD	Kinetic assay	6.2% (proteinuria ≥1+)	Total prevalence: 11.50%	Low
Emem[81]	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 <19.0 kg/m^2: 59.2% 19–25 kg/m^2: 37.5% >25 kg/m^2: 3.3%	Albuminuria +1 on at least two occasions (4 weeks apart) and/or serum creatinine >1.5 mg/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% Among patients, 8.8% had CrCl <15 mL/min.	Medium
Wyatt[82]	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: HIV-positive: 4.8%/HIV-negative: 8.3% BMI (kg/m^2): HIV-positive: 20.9 (IQR: 19.0–23.3)/HIV-negative: 20.5 (IQR: 18.5–23.3)	eGFR <60 mL/min/1.73 m^2 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 <60 mL/min/1.73 m^2 CKD prevalence among HIV-negative: 7.2% 1.5% had eGFR <60 mL/min/1.73 m^2	Medium
FolefackKaze[83]	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 <60 mL/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<60 mL/min/1.73 m^2.	Low

Continued

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
Struik[84]	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 (≥+1) with renal dysfunction (eGFR <60 mL/min/1.73 m^2), 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% Among patients with proteinuria, 5.3% had CrCl <60 mL/min.	Low
Attolou[118]	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%	Total prevalence: 27.16%	Low
Agaba[170]	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)	Total prevalence among AIDS group: 51.80% CKD prevalence among control group: 12.2%	Low
Fana[100]	2011, Zimbabwe, South	Outpatient clinics	159	HIV-infected patients naïve to ART		CrCl <60 mL/min, proteinuria ≥+1 and/or PCR >20 mg/mg	Proteinuria by urinary strip and 24-hour proteinuria, eGFR by CG	Not mentioned	45.90%	Total prevalence: 45.9% Among patients, 7.50% had CrCl <60 mL/min	Low
Han[101]	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	Microalbuminuria > urinary protein 30 and 300 mg/24 hours A cut-off serum creatinine level of 250 mmol/L was used to exclude those patients with advanced nephropathy.	Proteinuria by urinary strip and 24-hour proteinuria, CG and MDRD	Not mentioned	6%	Total prevalence (based on proteinuria): 6%	Low
Peters[147]	2008, Uganda, East	Home-based AIDS care	508	Patients with HIV starting HAART	Age (years): 39 (median) Male gender: 41%	CrCl of 25–50 mL/min	CG, 175 MDRD	Kinetic Jaffe	Not measured	Total prevalence: 20%	Low

Continued

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
Jao[110]	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/g)	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[85]	2011, Tanzania, East	Outpatient clinics	355	HIV-infected patients naïve to ART	Age (years): 36.1±7.9 Male gender: 35% BMI (kg/m^2): 21.3±3.8	KDOQI	Proteinuria and albuminuria by urinary strip eGFR by CG, MDRD	Not mentioned	36% proteinuria ≥+1	Total prevalence: 85.6%	Low
Myer[162]	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%	CrCl <60 mL/min	Absolute SCr and CG	Not mentioned	Not measured	Total prevalence: 5.8%	Low
Mulenga[163]	2008, Zambia, South	Clinic	25 249	HIV-infected, ART-naïve adults initiating treatment	Age (years): normal CrCl, 33.7±7.9, decreased CrCl, 38.5±9.9 Male gender: 39.7%	CrCl <60 mL/min	Absolute SCr, eGFR by CG and MDRD	Not mentioned	Not measured	Total prevalence (MDRD): 3.2%	Medium
Adedeji[158]	2015, Nigeria, West	The University of Ilorin Teaching Hospital	183	Newly diagnosed HIV-infected ART-naïve patients	Age (years): 37.9+10.5 Male gender: 42.6% BMI (kg/m^2): 20.88+3.56	eGFR <60 mL/min/1.73 m^2	Absolute SCr, eGFR by MDRD	Kinetic Jaffe and IDMS	Not measured	Total prevalence: 24%	Low
Anyabolu[135]	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): 38.84±10.65 Male gender: 28% BMI categories <18.50.0 kg/m^2: 7% 18.5–24.9 kg/m^2: 35% 25–29.9 kg/m^2: 32% ≥30 kg/m^2: 23%	24-hour urine protein ≥0.300 g and/or GFR <60 mL/min	Quantitative assessment of protienuira, SCr and eGFR	Not mentioned	Not mentioned	Total prevalence among HIV-positive patients: 22.9% Prevalence among HIV-negative: 8.1%	Low

Continued

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
Ayokunle[113]	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/m^2): 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 ≥30 mg/g and/or eGFR <60 mL/mL/1.73 m^2	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
Chadwick[114]	2015, Ghana, West	Komfo Anokye Teaching Hospital	330	Patients with HIV on ART	Age (years): 39 (IQR: 35–46) Male gender: 25% BMI (kg/m^2): 22.9 (IQR: 20.5–26.6)	Proteinuria or CrCl <60 mL/min	Proteinuria (dipsticks, PCR and ACR) and GFR by CG	Not mentioned	37% by dipstick and 12% by PCR	Total prevalence (proteinuria): 37% CrCl <60 mL/min among 7%	Low
Edwards[166]	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 <60 mL/min	eGFR by CKD-EPI	Not mentioned	Not measured	Total prevalence: 12.1% HIV-positive: 17% HIV-negative: 11%	Medium
Glaser[14]	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 <60 mL/min	eGFR by CG, MDRD and CKD-EPI with and without correction factor	IDMS-calibrated creatinine and cystatin-C	Not measured	Total prevalence among HIV-positive (creatinine-based CKD-EPI): 1.9%	Medium
Glaser[115]	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/m^2): 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

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
Kamkuemah[167]	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% Prevalence by age <29 years: 17% 29–34 years: 28% 34–41 years: 5% >41 years: 50% Prevalence by gender Male: 28% Female: 72%	Medium
Nsagha[149]	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 per 1.73 m^2	eGFR by MDRD	Kinetic Jaffe	Not measured	Total prevalence: 8%	Low
Odongo[94]	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/m^2)<18: 33%	eGFR <60 mL/min/1.73 m^2	Proteinuria by dipstick and eGFR by MDRD	Not mentioned	Proteinuria ≥+1: 52%	Total prevalence: 14.4% Prevalence by gender Female: 16.5% Male: 10.4%	Low
Okafor[136]	2016, Nigeria, West	University of Benin Teaching Hospital	383	HIV-infected naïve patients	Age (years): 36.03±9.08 Male gender: 41%	eGFR <60 mL/min/1.73 m^2 and/or evidence of kidney injury as detected when the PCR (mg/g) was ≥200	Quantitative assessment of proteinuria by PCR and eGFR by MDRD	Kinetic Jaffe	Not mentioned	Total prevalence: 53.5%	Low
Seape[156]	2016, South Africa, South	Medical inpatients at the Chris Hani Baragwanath Hospital	100	HIV-infected naïve patients	Age (years): 37.0±9.6 Male gender: 60% BMI (kg/m^2): 20.9±5.1	eGFR <60 mL/min/1.73 m^2	eGFR by CG, MDRD, CKD-EPI	IDMS	Not measured	Total prevalence: 16%	Low
Wensink[137]	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 m^2	Albuminuria by ACR and eGFR by MDRD and CKD-EPI	Not mentioned	21%	Total prevalence (albuminuria): 21% 2% had eGFR<60 mL/min/1.73 m^2	Medium
Zachor[157]	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 m^2	eGFR by MDRD and CKD-EPI	IDMS	Not measured	Total prevalence: 2%	Medium

Continued

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
Mekuria[150]	2016, Ethiopia, East	Jimma University Specialised Hospital	446	223 HAART-naïve and 223 HAART-experienced	Age (years): HAART-naïve: 38.25±10.8, HAART-positive: 35.14±9.2 Male gender: 37% BMI (kg/m^2): HAART-naïve: 20.7±3.2, HAART-positive: 21.6±3.5 Hypertension: 3.36% DM: 21.4%	eGFR <60 mL/min/1.73 m^2	eGFR by CG	Kinetic Jaffe	Not measured	Total prevalence: 18.2%	Medium

ACR, albumin to creatinine ratio; ART, antiretroviral therapy; BMI, body mass index; CG, Cockroft-Gault; CKD, chronic kidney disease; CKD-EPI, Chronic Kidney Disease-Epidemiology; CrCl, creatinine clearance; DBP, diastolic blood pressure; DM, diabetes mellitus; DOTS, directly observed treatment short course; eGFR, estimated glomerular filtration rate; ESRD, end stage renal disease; HAART, highly active antiretroviral therapy; IDMS, isotope dilution mass spectrometry; KDOQI, Kidney Disease Outcome Quality Initiative; MDRD, Modification of Diet in Renal Disease; SBP, systolic blood pressure; SCr, serum creatinine; uPCR, urinary protein to creatinine ratio.

[82–84 86 91 99 100 105 106 109 112–114 121 130–137 141] Proteinuria/albuminuria was used alone to identify CKD in 14 studies.[73–75 77 87 92 107 108 110 123 128 129 138 140] KDOQI staging[168] of CKD was used in 13 studies.[13 25 29 79 85 90 97 98 115 116 122 124 126] 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.[89 104 120 165] 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 m^2.[19 27 28 30 81 88 101–103 118 125 127 147 160 169 170]

Paper quality

Paper quality was high in 16 studies.[13 25 75 90 91 97 98 105 106 112 116 132–134 148 155] Thirty-five studies were of medium quality.[12 14 26 29 73 74 77–79 81 82 96 110 111 115 117 128 130 131 137 141 143–145 150–152 154 157 159–161 163 166 167] 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 m^2 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[86]	2013, Tanzania, East	Diabetes mellitus clinic of Bugando Medical Centre in Mwanza	369	Consecutive patients with diabetes	Age (years): 54 (IQR: 45–62) Male gender: 46.6% Hypertension: 57.5% BMI (kg/m^2): 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 m^2 or evidence of kidney damage (microalbuminuria or overt proteinuria)	Microalbuminuria, proteinuria by urinary strips, eGFR by CG	Kinetic Jaffe	Overt proteinuria (34.1%), microalbuminuria (45.8%)	Total prevalence: 83.7%	Low
Wanjohi[87]	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: 50% BMI (kg/m^2): 27.8±6.0 Duration of DM (months): 10.3±7.5	Albuminuria >20 mg/ L	Albuminuria by urinary strip, CG	Not mentioned	26% had albuminuria	Total prevalence (based on albuminuria): 26%	Low
Bouzid[119]	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/m^2): 28.8±5.5	eGFR <60 mL/min	CG, 24-hour proteinuria	Not mentioned	10.1% macroalbuminuria, 13% microalbuminuria	Total prevalence: 19.8%	Low
Choukem[88]	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% BMI (kg/m^2): 28.5±5.2 Duration of DM (years): 4 (IQR: 1–9)	Presence of positive proteinuria with or without low CrCl <90 mL/min/1.73 m^2	Proteinuria by urinary strip/eGFR by CG	Not mentioned		Total prevalence: 31%	Low
Keeton[120]	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/m^2): (31±6) Duration of DM (years): 17 (range: 14–33)	Double SCr level	Proteinuria by PCR and serum creatinine	Not mentioned		Total prevalence: 66.1%	Low
Bouaziz[121]	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/m^2): 30.5±0.7 Duration of DM (years): 10.6±1	Microalbuminuria (defined as <2.8 g/mmol for women and <2.3 for men) and eGFR ≤60 mL/min/1.73 m^2	Measurement of microalbuminuria, eGFR by MDRD	Not mentioned		Total prevalence: 11%	Low
Katchunga[122]	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/m^2): 25.2±4.7 Duration of DM (years): 17.3±8.5	KDOQI	Microalbuminuria (>20 mg/L and <200 mg/L) eGFR by MDRD	Not mentioned		Total prevalence: 66%	Low

Continued

Table 4 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
Djrolo[123]	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
Balogun[102]	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
Mafundikwa[103]	2007, Zimbabwe, South	Diabetic clinic	75	Consecutive insulin-dependent 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
Lutale[124]	2007, Tanzania, East	Outpatient diabetic clinic	204	91 patients with type 1 and 153 type 2 diabetes	45% type 1 DM 55% type 2 DM Age (years): type 1, 21 (14–44.8), type 2, 53 (23.5–85) Male gender: 55% hypertension: 42% BMI (kg/m^2): 19.3±3.8 (type 1), 27.8±4.8 (type 2) Duration of DM (years): 3(Range: 0–25)	KDOQI	Quantitative assessment of albuminuria, CrCl 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% 4.6% of type 1 patients and 22% of type 2 had eGFR <60 mL/min/1.73 m^2	Low
Gill[125]	2008, Ethiopia, East	Diabetic clinic at Mekelle Hospital	105	All patients with diabetes	Age (years): 41±16 Male gender: 70% Hypertension: 5% BMI (kg/m^2): 20.6±5.4 Duration of DM (years): 7±6	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
Makulo[111]	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±13.4 BMI (kg/m^2): 22.6±5.2	eGFR of <60 mL/min/1.73 m^2	Urinary albumin by urinary strip and ACR, eGFR by 186 MDRD	Kinetic Jaffe	29.6%	Total prevalence: 29.6% 10% of the patients had eGFR <60 mL/min/1.73 m^2	Medium
Adebamowo[151]	2016, Nigeria, Ghana, Kenya (sub-Saharan)	University medical centres and surrounding communities	4815	2208 cases of type 2 DM and 2607 controls free from DM	Age (years): 48±15 Male gender: 41% Hypertension: 68.3% of type 2 DM and 35.3% of diabetic-free BMI (kg/m^2): 26.9±5.4 (patients with diabetes), 25.5±5.7 (non-diabetics)	eGFR of <60 mL/min/1.73 m^2	eGFR by MDRD and CKD-EPI	Kinetic Jaffe	Not measured	Total prevalence (MDRD): 9% 13.4% of type 2 DM and 4.8% of diabetic-free	Medium
Feteh[95]	2016, Cameroon, Central-West	Outpatient section of the endocrine unit of the Douala General Hospital	636	Cases of type 2 DM	Age (years): 56.5±10.6 Male gender: 53.1% BMI (kg/m^2): 29.3±14.7 Hypertension: 62.2%	eGFR of <60 mL/min/1.73 m^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

Continued

Table 4 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
Fiseha[152]	2014, Ethiopia, East	Follow-up clinic at Butajira Hospital	214	Patients with diabetes	Age (years): 45±14.5 Male gender: 57.5% SBP (mm Hg): 121±17 DBP (mm Hg): 79±10 BMI (kg/m^2): 25.26±4.35	eGFR of <60 mL/min/1.73 m^2	eGFR by CG and 186 MDRD	Kinetic Jaffe	Not measured	Total prevalence (MDRD): 18.2% Prevalence (CG): 23.8%	Medium
Pillay[96]	2016, South Africa, South	All patients seen at Edendale Hospital Diabetic Clinic	653	Patients with diabetes with or without HIV (149 DM and HIV; 504 DM without HIV)	Among patients with diabetes with HIV: Age (years): 50–70 Male gender: 32% Among patients with diabetes without HIV Age (years): 51–60	eGFR of <60 mL/min/1.73 m^2	Proteinuria by dipstick and eGFR by 186 MDRD	Kinetic Jaffe	18%	Total prevalence: 18.8%	Medium
Eghan[138]	2007, Ghana, West	Outpatient diabetic clinic of the Department of Medicine at Komfo Anokye Teaching Hospital	109	Patients with diabetes	Age (years): 54.1±10.9 Male gender: 28% Hypertension: 39% BMI (kg/m^2): 26.3±4.4	Microalbuminuria if urine albumin excretion was 30–300 mg/day	Albuminuria by urine albumin excretion and eGFR by CG	Not mentioned	43.1%	Total prevalence (based on microalbuminuria): 43.1% Prevalence by gender: male: 31.9%	Low

ACR, albumin to creatinine ratio; BMI, body mass index; CG, Cockroft-Gault; CKD, chronic kidney disease; CKD-EPI, Chronic Kidney Disease-Epidemiology Collaboration; CrCl, creatinine clearance; 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; SCr, serum creatinine.

macro-areas, which ranged from 9% to 39% (pooled estimate: 11.6%), and the East macro-areas, where the prevalence ranged from 1% to 46% (pooled estimate: 11.2%), had seemingly similar figures, which were higher than in the South (3.5%) macro-areas. Based on the treatment status, the prevalence of renal dysfunction ranged from 1% to 47% (pooled prevalence: 9.9%; 95% CI 9.4% to 10.4%) among patients with HIV not receiving treatment, while it ranged from 7% to 33% (pooled prevalence: 5.2%; 95% CI 5.0% to 5.4%) among patients with HIV on antiretroviral therapy. The prevalence was reported to be 5.7% (range: 3.1%–7.2%) among the three studies done in both the East and South macro-areas and 2.5% from the study done in the sub-Saharan area. According to the definition, the prevalence of CKD ranged from 1% to 18% (pooled estimate: 4.7%) in studies that defined CKD as eGFR <60 mL/min. In studies that defined CKD as eGFR <60 mL/min/1.73 m^2 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, 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.

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/1.73 m^2 and/or the presence of proteinuria or albuminuria. When CKD was defined based on proteinuria/albuminuria, CKD prevalence ranged from 26% to 51% (pooled estimate: 36.3%). In patients with diabetes who had CKD based on eGFR <60 mL/min/1.73 m^2, the prevalence ranged from 13% to 30% (pooled estimate: 16.6%). When KDOQI was used to define CKD, the prevalence of CKD ranged from 19% to 66% (pooled estimate: 34.2%). 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

Table 5 Studies on CKD among patients with hypertension

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[126]	2011, Ghana, West	Four polyclinics	712	Patients with hypertension	Age (years): 59 (range, 19–90) Male gender: 21.3% DM: 14.7% SBP (mm Hg): 150 (range, 100–280) DBP (mm Hg): 90 (range, 60–160) BMI (kg/m^2): 29.7 (range, 12.2–67.4) BMI categories (kg/m^2) <25: 22.3% 25–29.9: 26% >30: 45.7%	KDOQI	Proteinuria by PCR (men >0.3, women >0.2 mg/mg) eGFR by MDRD	Kinetic Jaffe	28.90%	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%	Low
Ajayi[164]	2014, Nigeria, West	Tertiary health centre	628	Records of patients with hypertension and diabetes	Age (years): 49.71±13.22 Male gender: 49% DM: 8.6% SBP (mm Hg): 135.9±27.4 DBP (mm Hg): 87.0±16.3 BMI (kg/m^2): 27.8±8.7	eGFR <60 mL/min/1.73 m^2	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%	Low
Lengani[127]	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 ≥650 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%	Low
Nwankwo[165]	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	Not measured	Total prevalence: 45.50%	Low
Rayner[128]	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	Not measured	21.3% microalbuminuria, 4.1% macroalbuminuria	Total prevalence (based on albuminuria): 25.4%	Medium
Plange-Rhule[89]	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±27.8 DBP (mm Hg): 101.9±17.9	Plasma creatinine ≥140 mol/L	Proteinuria by urinary strips and serum creatinine	Not mentioned	25.50%	Total prevalence: 30.2%	Low
Addo[141]	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/m^2): 27.5±5.4	Persistent proteinuria on urinalysis in the absence of urinary tract infection and/or impaired GFR <60 mL/min/1.73 m^2	Proteinuria and eGFR by MDRD	Enzymatic assessment	13.4%	Total prevalence: 13.4% 4.1% had eGFR <60 mL/min/1.73 m^2	Medium

Continued

Table 5 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
Aryee[139]	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/m^2): patients with hypertension (on antihypertensive therapy: 29.52±0.39, no antihypertensive therapy: 29.8±0.71), control (29.36±0.65)	eGFR <60 mL/min/1.73 m^2	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
Nabbaale[140]	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 299 mg/dL	Quantitative assessment of albumin in urine	Not measured	39.5%	Total prevalence (based on microalbuminuria): 39.5%	Low

BMI, body mass index; CG, Cockroft-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, estimtaed glomerular filtration rate; ACR, albumin to creatinine ratio.

Table 6 Studies on CKD among other populations

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
Ka[19]	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 ElHafeez[29]	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% DM: 11.5% BMI (kg/m^2): 28.5±5.89	KDOQI	Proteinuria by urinary strips, 186 MDRD	Kinetic Jaffe	21.3%	Total prevalence: 57% Prevalence by stage Stage 1: 9% Stage 2: 44% Stage 3: 4% Stage 4: 0.3%	Medium
Raji[28]	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/m^2): first-degree relatives: 25.5±5.3, controls: 23.8±4.0 SBP (mm Hg): first-degree relatives: 116.5±22.5, controls: 112.1±18.1 DBP (mm Hg): first-degree relatives: 74.9±12.7, controls: 71.4±10.5	Reduced eGFR	Albuminuria by ACR and eGFR by MDRD	Not mentioned	46%	Total prevalence: 4%	Low
Elsharif[24]	2013, Sudan, East	Primary healthcare	252	Patients attending the primary healthcare facilities	Age (years): 43.35±12.80 Male gender: 16% Hypertension: 10% DM: 5.95% BMI (kg/m^2): 28.67±6.43 BMI categories (kg/m^2) <18: 2.38% >25.13: 71.83	eGFR of <60 mL/ min/1.73 m^2 with or without proteinuria	Proteinuria by urinary strip and eGFR by MDRD	Not mentioned	24.21%	Total prevalence: 10.32%	Low
Afolabi[26]	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% 32% elevated SBP, 30% elevated DBP DM: 6% Obesity: 32%	Persistently abnormal ACR irrespective of GFR level or persistent eGFR <60 mL/ min/1.73 m^2 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% 10.4% had persistent eGFR <60 mL/min/1.73 m^2	Medium
Sumaili[25]	2009, Congo, Central	Primary and secondary healthcare	527	At-risk population randomly selected	Age (years): 53.9±15.5 Male gender: 43% Hypertension: 58.2% DM: 54.5% Obesity: 16%	KDOQI	Proteinuria by urinary strip, 24-hour proteinuria, 175 MDRD	Kinetic Jaffe	19%	Total prevalence: 36% Prevalence by stage Stage 1: 4.2% Stage 2: 6.1% Stage 3: 18.3% Stage 4: 1.9% Stage 5: 5.7%	High
Anyabolu[30]	2016, Nigeria, West	Federal Medical Centre	136	Subjects from medical outpatient department of the hospital	Age (years): 38.58±11.79 Male gender: 27.9% BMI (kg/m^2): 25.51±6.47	Proteinuria as 24-hour protein ≥0.300 g and impaired renal filtration function as CrCl <90mL/min	Proteinuria by quantitative assessment and SCr	Kinetic Jaffe	14.1% had proteinuria	Total prevalence: 14.1%	Low

Continued

Table 6 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
Dessein[20]	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/m^2): 27.4±6.0 Hypertension: 57.5% DM: 12.5%	eGFR <60 mL/min/1.73 m^2	eGFR by CG, MDRD, CKD-EPI	Kinetic Jaffe and IDMS-calibrated	Not measured	Total prevalence: 39%	Low
Ephraim[21]	2015, Ghana, West	Tema General Hospital	194	Patients with sickle cell anaemia	Age (years): 23.25±12.04 Male gender: 43.3% SBP (mm Hg): 110.06±8.27 DBP (mm Hg): 67.16±8.23 BMI (kg/m^2): 18.85±11.19	eGFR<60 mL/min/1.73 m^2 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 Rensburg[27]	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 >3.5 g/dL	Total prevalence: 37.9%	Low
Hamdouk[104]	2011, Sudan, East	Hairdressing saloons	72	Hairdressers	Age (years): 40±8 Male gender: 0% Hypertension: 19.4%	SCr level ≥2 mg/dL	Proteinuria by urinary strip and 24-hour SCr measurement and renal biopsy	Not mentioned	26.4% had albuminuria	Total prevalence: 26.4% 14% had SCr ≥2 mg/dL	Low
EL-Safty[129]	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 Workers (29 non-silicotics, 24 silicotics and 28 referent)	Age (years): 39.83±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; 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; ESRD, end stage renal disease; ACR, albumin to creatine ratio.

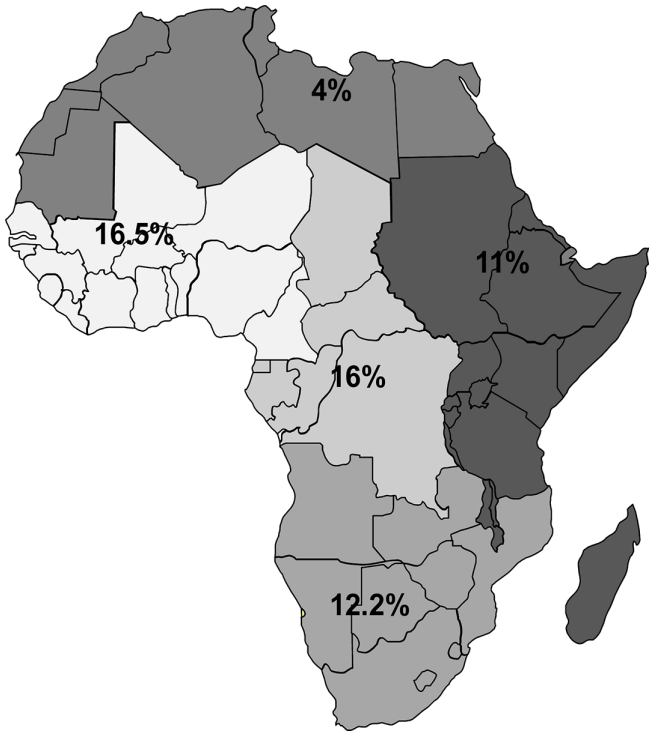

Figure 2 Prevalence of chronic kidney disease among the entire general population. Estimates from this figure should be presented with caution as it is bound to be imprecise and inaccurate due to its tentative way of estimation.

age 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 m^2, 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: 40.3%). 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.[19] Hospital-based surveys revealed that (the calculation was based on the total prevalence reported from all studies including three of high-medium quality and four of low quality in the same table) more than one-third of patients attending either primary care centres or tertiary hospitals had CKD (range: 11%–57%, pooled prevalence: 36%, 95% CI 34.4% to 37.7%). In hospital-based studies, when CKD was defined as eGFR <60 mL/min/1.73 m^2 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: 45.1%) when CKD was defined according KDOQI. CKD was prevalent among almost 39% of patients with rheumatoid arthritis[20] or sickle cell.[21] The study (low quality) conducted among hairdressers exposed to paraphenylenediamine[104] reported that 26.4% of these subjects had renal impairment. Of note, 100% of silica-exposed workers experienced proteinuria (reported from low-quality study).[129]

Causes of CKD

Forty-two studies were conducted specifically to clarify the underlying cause of CKD[31–72] (online supplementary table 2). The diagnosis was biopsy-proven in 17 studies.[33 39 41 43–45 48 54 55 58 60 63 67–70 72] 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 period[171] and most Jaffe assays overestimate serum creatinine.[172] 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,[173] 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.[174] 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

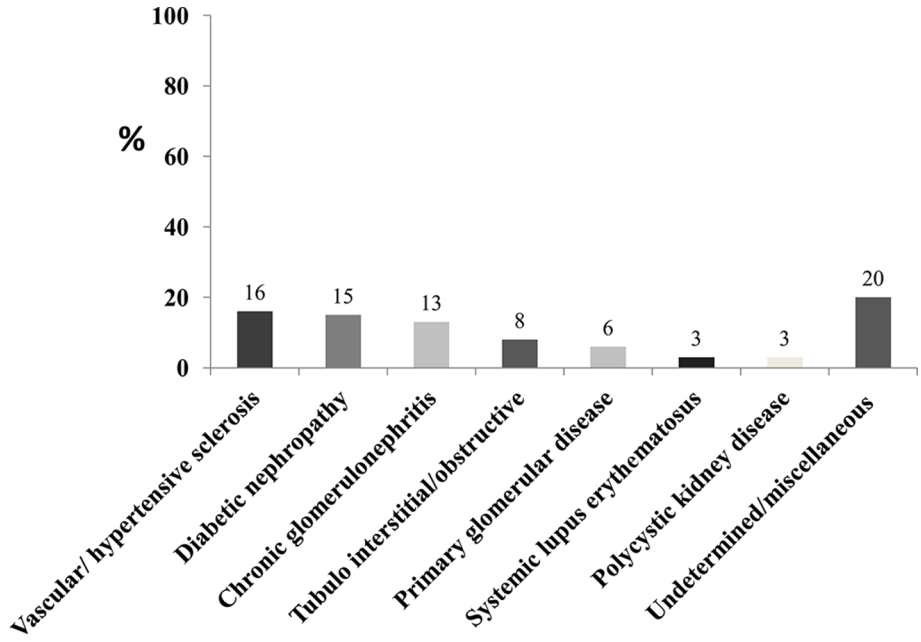

Figure 3 Main causes of chronic kidney disease.

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.[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.[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[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.[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 *et al*[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.[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%.[179] In sub-Saharan Africa in Stanifer *et al*'s meta-analysis, the prevalence of CKD was 13.2%,[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.[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.[181] CKD prevalence in some Asian countries was higher than the estimates in the USA and in Europe, being 17.5% in Thailand,[182] 15% in India,[183] 13% in Japan,[184] 11.9% in Taiwan[185] and 9.9% in China.[186] Overall, the estimated prevalence of CKD at

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%).[187]

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.[188]

In Africa, infectious diseases such as HIV, bilharziasis, malaria, hepatitis B and C represent an almost unique cluster of risk factors responsible for CKD.[189] HIV/AIDS is pandemic in Africa, with a prevalence ranging from 0.5% in Senegal[190] to 27.4% in Swaziland.[191] 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.[192] Up to 50% of kidney diseases in HIV-infected persons result from a wide array of non-HIV-associated nephropathy pathologies, ranging from glomerulonephritis to diabetic nephropathy.[193] 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.[194–198] 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.[199] Furthermore, differences in HIV clades or strains in African patients[200] and genetic factor[201] may influence the replication capacities within the isolated renal reservoir and thus lead to a diversity in clinical presentations.[80]

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.[19] This isolated figure is higher than that reported in other countries.[202–204] More than one-third (39%) of patients with rheumatoid arthritis had CKD,[20] which is higher than that reported from Taiwan.[205]

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,[206] and CKD was principally caused by chronic glomerulonephritis and hypertension in East and Tropical Africa.[207 208] Today, the spectrum of causes of CKD in Africa is dominated by diabetes mellitus and hypertension.[209] 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[9], 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.[210] 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 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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