Review Article

Chronic Kidney Disease among Human Immunodeficiency Virus Positive Patients on Antiretroviral Therapy in Sub-Saharan Africa: A Systematic Review and Meta-analysis

Habtamu Wondifraw Baynes¹, Markos Negash², Demeke Geremew², Zegeye Getaneh³

Departments of ¹Clinical Chemistry, ²Immunology and ³Immunohematology, School of Biomedical and Laboratory Sciences, College of Medicine and Health Science, University of Gondar, Gondar, Ethiopia

ABSTRACT. Human immunodeficiency virus (HIV)-infected patients are at risk for renal disease as a consequence of complications of antiretroviral treatment. Particularly, the complication of kidney disease is high in patients who switched to Tenofovir Disoproxil Fumarate. The treatment is associated with nephrotoxicity, decrease in glomerular filtration rate, leading to kidney disease. This review focused on assessing the effect of antiretroviral therapy (ART) on kidney function among HIV-positive patients. Initially, the study protocol was registered on Prospero and given a unique identification number of CRD42018087686. We then conducted a systematic search of PubMed, Google Scholar, the Cochrane library, and Google from 2008 to September 2018. We found 742 study results eligible for this review. After stringent filtration mechanism, 15 qualified studies were used for systematic review and meta-analysis process. Cross-sectional, cohort, randomized controlled trials, and prospective studies were eligible for inclusion in the study. The overall pooled prevalence found in this meta-analysis was 6.42% with high statistical heterogeneity ($I^2 = 96.7\%$). The highest subgroup prevalence was reported from Ghana, with subgroup prevalence of 13.65% without statistical heterogeneity ($I^2 = 0.0\%$). Majority of chronic kidney disease (CKD) was in stage 3 with subgroup prevalence of 6.78% and tolerable statistical heterogeneity ($I^2 = 66.7\%$). There was high pooled prevalence of CKD among HIV-positive patients on ART in Sub-Saharan Africa. The highest subgroup prevalence was reported from Ghana. Majority of CKD was reported in stage 3.

Correspondence to:
Mr. Habtamu Wondifraw Baynes,
Department of Clinical Chemistry, School of Biomedical and Laboratory Sciences, College of Medicine and Health Science, University of Gondar, Gondar, Ethiopia.
E-mail: habtamuw97@gmail.com

Introduction

Chronic kidney disease (CKD) is the impairment of kidney function which persists for more than three months.¹ It is becoming a major health problem as current researches indicating it as being underdiagnosed and undertreated.²,³ In 2017, an estimated 36.9
million people were living with human immunodeficiency virus (HIV). The vast majority of people living with HIV are located in low- and middle-income countries, with an estimated 66% (24.4 million) living in sub-Saharan Africa. Among this group, 19.6 million are living in East and Southern Africa. Of all persons living with HIV, 59% (44%–73%) had received antiretroviral therapy (ART) in 2017. In the WHO African Region, 60% (45%–73%) of people living with HIV were able to access life-saving medicines. The successful rollout of ART has resulted in the increased life of HIV-infected patients and decreased HIV-related mortality and morbidity. On the other hand, HIV-infected patients are at risk of developing comorbidities since HIV decreases the immune status of the patients which exposes them to different coinfections and, due to ART that impairs the normal metabolism process.

These HIV/AIDS-infected patients nowadays suffer from comorbidities such as heart disease, diabetes, stroke, kidney, and liver disease, which are found highly prevalent and lead to complications and then if untreated results in death. Particularly, HIV-infected patients are likely to develop kidney disease five times as compared to noninfected ones. Inevitable age-related degenerative changes (possibly accelerated in HIV infection), cumulative exposure to ART drug toxicities, effects of ongoing inflammation, progressive immune dysfunction, and long-term infection by the virus itself are postulated to drive these noncommunicable diseases in HIV. Particularly, the complication of kidney disease is increased in patients switched to Tenofovir Disoproxil Fumarate. The treatment is associated with nephrotoxicity, decrease in glomerular filtration rate finally leading to kidney disease.

Different studies from sub-Saharan Africa showed that there was a high prevalence of ART-associated kidney impairment in HIV-infected patients. People living in low-income countries, particularly in sub-Saharan Africa, estimated more than 70% for end-stage renal disease as of 2030. This estimation is from the view of the previous baseline point, that the global prevalence of maintenance dialysis patients has doubled since 1990. On the other hand, renal transplantation has been performed in 18 million people worldwide by 2004 and <5% of the population from sub-Saharan Africa have access to it. Because ART is massively used in developing countries, the status in Africa should be investigated in terms of how to use, the impact and attitude toward ART. Therefore, this review tried to see the burden of CKD on HIV-positive patients taking ART in sub-Saharan Africa.

### Methods

#### Search strategy and selection criteria

We searched for published articles after registering on Prospero and obtaining a unique identification number of CRD42018087686. The data were extracted by following the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines. We searched using PubMed, Google Scholar, the Cochrane library, and Google for studies published on CKD among HIV patients who took ART in Sub-Saharan Africa. Search for studies for this systematic review and meta-analysis was limited to studies conducted on human subjects and published in English up to September 30, 2018. We used the following search engines from PubMed “[ART (MeSH Terms) AND HIV patients (MeSH Terms) OR CKD (MeSH Terms) OR kidney failure (MeSH Terms) OR chronic kidney failure (MeSH Terms) AND Sub-Saharan Africa (MeSH Terms)].” The full version of data extraction method is presented in Figure 1.

Two reviewers assessed the articles independently for eligibility to the study. Consultation to the third person was also applied for disagreements. Titles, abstracts, and full documents were screened for eligibility using prior defined data extraction tool. The type of participants (human or animal), outcome of the study, study design, and country where the study was conducted were used as eligibility criteria of published articles for this systematic review and meta-analysis. Pharmacokinetics
studies, pilot studies, reviews, and case reports were excluded from this review. Published studies that used study design of cross-sectional, cohort, randomized controlled trials, and prospective were recruited to this systematic review and meta-analysis. The published articles that estimated the estimated glomerular filtration rate (eGFR) using Modification of Diet in Renal Disease (MDRD), CKD Epidemiology Collaboration (CKD-EPI) and Cockcroft Gault (CG), reported in prevalence were also recruited to the review.

Quality assessment and data extraction

The quality of included articles was assessed using the Joanna Briggs Institute Critical Appraisal Checklist. We assessed the feasibility between the outcome variables in each study based on the variables identified (year, design of the study, age of participants, methods of measurement, and cutoff values used). Two reviewers independently extracted the studies based on the preformulated extraction tool. The other two reviewers checked the extracted data for their accuracy. Data collected from each published study included the following: the authors involved in the study, year of study, country where the study conducted, study design, age in mean/median of the participants, method used for eGFR estimation, prevalence of CKD, and distribution of CKD in stages were gathered from each published study. CKD was defined by either kidney damage or GFR <60 mL/min/1.73 m² for ≥3 months, regardless of the cause. CKD stages were categorized based on the classification system established by the National Kidney Foundation – Kidney Disease Outcomes Quality Initiative classification.

Statistical Analysis

The extracted data from published studies were entered into Microsoft Excel and transferred to STATA version 11 (StataCorp LLC, Texas, USA) for analysis. Statistical heterogeneity between published studies was calculated using the index of heterogeneity ($I^2$)
CKD in HIV infection

I

for further scrutiny, 703 articles were excluded (57%).

The sensitivity analysis was also performed for the effect of each study on the overall prevalence. The risk of bias between studies was also evaluated using eggers test.

Results

Quantity of the articles available

We found a total of 738 results from PubMed and four studies from other sources with a total of 742 screened for eligibility in this review. On further scrutiny, 703 articles were excluded based on their unrelated title. Thus, 39 studies were further screened for their meeting of the target of this review, 19 studies were rejected following which, 20 studies were left. After following the stringent filtration mechanism, 15 qualified articles were included for systematic review and meta-analysis process (Figure 1).

Study characteristics

Fifteen studies were included in the meta-analysis process. Of these, seven studies were cross-sectional and the remaining eight were performed by cohort study design. Nine studies estimated the eGFR and CKD by using MDRD method of estimation, two studies used the CG method of estimation and the remaining three studies used CKD-EPI estimation method.

The published studies had a varied number of participants of which Mulenga et al, Sarfo et al, Kalayjian et al, De Waal et al, and Deckert et al conducted their studies with large number of study participants, in decreasing order. Owiredu et al and Peck et al performed their study with small number of participants. Some of the studies reported the age of participants by mean ± standard deviation (SD) while others used median. The studies reported the participants’ age by mean (±SD), which ranged from 33.13 (±12.3) to 41.4 (±9.2) years and in the studies reporting median age, it ranged from 33 (28–39) to 40.1 (33–46.5) years (Table I and Figure 2).

Renal outcome

The overall pooled prevalence of this review was 6.42%, 95% confidence interval (CI) (5.2, 7.59 mL/min/1.73 m²) with heterogeneity of (I² = 97.6 %). Two studies that were performed in Ethiopia had subgroup prevalence of 9.53%, 95% CI (5.61, 13.44 mL/min/1.73 m²). The statistical heterogeneity of this subgroup was low (I² = 57%). Another two studies that were performed in Ghana had 13.65% subgroup prevalence, 95% CI (12.47, 14.82) with heterogeneity of (I² = 00%). The remaining three studies and seven other studies were conducted in South Africa and Tanzania, respectively and had high statistical heterogeneity (Figure 3).

The overall prevalence of CKD stage 3 was 6.78 %, 95% CI % (3.58, 9.97) and (I² = 66.7%), stage 4, it was 0.69%, 95% CI (0.002, 1.36) and (I² = 29.5%) and stage 5 with 95% CI (-0.23, 1.55) and (I² = 00%) (Figure 4).

In the 15 studies involved, the CI did not lie within the pooled CI; therefore, the influential ability of each study over the total prevalence of CKD is minimal. The prevalence and confidence interval ranged from 5.1159449 (4.200563, 6.0313263) to 7.5550871 (5.2209311, 9.8892431) (Table 2). There was no significant bias among the articles with a variable number of sample sizes with meta-bias result of coefficient = 0.598 and P = 0.155. The funnel plot results of the articles showed that most of the articles lied on top of the funnel plot which indicates that the influential articles had a high probability of publishing, while some with small sample size articles were in the bottom of the right side from symmetrical line, indicating subjective judgment and presence of bias (Figure 5).
Table 1. Characteristics of the study participants included in the systematic review and meta-analysis from studies in sub-Saharan Africa.

| Author          | Design     | Method   | Age       | Albuminuria | Regimens used                                | Incident | Average duration in month |
|-----------------|------------|----------|-----------|-------------|----------------------------------------------|----------|--------------------------|
| Cailhhol et al  | Cross-sectional | MDRD    | 40.1 (33-46.5) | 112 (45.7%) | NRTI: 3TC, AZT, d4T, TDF, AB, DDI NNRTIs: NVP, EFV Pls: IDV | NS       | 12                       |
| Mekuria et al   | Cross-sectional | Cockcroft-Gault | 35.14 (±9.2) | NS          | NRTIs: TDF, 3TC, AZT NNRTIs: NVP, EFV Pls: LPV/r | NS       | NS                       |
| Wondifraw et al | Cross-sectional | MDRD    | 33.13 (±12.3) | NS          | NRTIs: d4T, 3TC, TDF, AZT NNRTI: NVP, EFV | NS       | 234/275 took for >48 months |
| Owiredu et al   | Cross-sectional | MDRD    | 36.91 (±0.8) | NS          | NRTIs: CBV, d4T, 3TC NNRTIs: NVP, EFV | NS       | NS                       |
| Sarfo et al     | Cohort     | MDRD    | 38 (32-45) | 11 (9.6%)   | NRTI: d4T, 3TC, AZT NNRTI: NVP, EFV | NS       | 30 (12-54)               |
| Brennan et al   | Cohort     | MDRD    | 37.1 (32.5-43.4) | NS     | NRTIs: d4T, 3TC, TDF NNRTIs: NVP, EFV | 6 (0.7) | 35.8 (21.8–51.4)        |
| Zachor et al    | Cohort     | CKD-EPI | 37.9 (±9.4) | NS          | NRTI: TDF-based | 15 (2.3%) | 54 (46.6–98)           |
| De Waal et al   | Cohort     | MDRD    | 35.4 (29.9–42) | NS          | NRTI: TDF-based | 153/1000 | 12.9 (5.1–23.3)        |
| Mpondo et al    | Cohort     | MDRD    | 43 (38-48) | 43.9%       | NRTIs: AZT, 3TC, d4T, TDF NNRTIs: NVP, EFV | NS       | 24                       |
| Peck et al      | Cross-sectional | CKD-EPI | 40 (38-47) | 58 (38.7%) | NRTIs: 3TC, AZT, TDF NNRTIs: NVP, EFV Pls | NS       | 56 (31–68)              |
| Kalayjian et al | Cohort     | MDRD    | 38 (33–45) | NS          | NS | NS | 44 (28–57) |                       |
| Deckert et al   | Cross-sectional | CKD-EPI | 41 (35–47) | NS          | NRTIs: AZT, TDF, 3TC, ABC, d4T NNRTIs: NVP, EFV Pls: LPV, RVR | NS       | 48.7 (3.3–144.7)       |
| Mulenga et al   | Cohort     | CKD-EPI | 33 (28–39) | NS          | NRTI: TDF-based, non-TDF based NNRTIs: NVP, EFV | NS       | 12                       |
| Zannou et al    | Cross-sectional | Cockcroft-Gault | 41.4 (±9.2) | 57 (11.9%) | NRTIs: AZT, TDF, 3TC, D4T, A, ABC, DDI, FTC NNRTIs: EFV, NVP Protease inhibitors: LPV, IDV, NFV, SQV, APV | NS | 360/480 took for >29 months |
| Ambetsa et al   | Cohort     | MDRD    | 39 (35–44) | NS          | NRTIs: d4T, 3TC, TDF NNRTIs: NVP, EFV | (4.3%) | NS                       |

AB: Abacavir, AVP: Lopinavir, AZT: Zidovudine, CBV: Combivir, d4T: Stavudine, EFV: Efavirenz, 3TC: Lamivudine, NNRTI: Non-nucleoside reverse transcription inhibitor, NRTI: Nucleoside reverse transcription inhibitor, NVP: Nevirapine, PI: Protease inhibitor, rt: Ritonavir, TDF: Tenofovir Disoproxil fumarate, NS: Not stated.
### Table 1: Summary of studies included in the meta-analysis

| Author/year | ES (95% CI) | Weight |
|-------------|-------------|--------|
| Cailhol J et al/2011 | 2.00 (0.25, 3.75) | 7.53 |
| Mulenga L et al/2014 | 13.70 (12.50, 14.90) | 11.63 |
| Ambetsa MO et al/2015 | 2.00 (0.25, 3.75) | 7.53 |
| Mekuria Y et al/2016 | 7.60 (4.12, 11.08) | 5.04 |
| Sarfo FS et al/2013 | 13.70 (12.50, 14.90) | 8.27 |
| Zachor H et al/2016 | 5.20 (3.74, 6.66) | 7.94 |
| Wondifraw B et al/2017 | 11.60 (7.82, 15.38) | 4.66 |
| De Waal R et al/2017 | 13.70 (12.50, 14.90) | 8.33 |
| Peck et al/2014 | 9.53 (5.61, 13.44) | 9.70 |
| Zachor H et al/2016 | 5.20 (3.74, 6.66) | 7.94 |
| De Waal R et al/2017 | 1.90 (1.68, 2.12) | 9.03 |

**NOTE:** Weights are from random effects analysis.

### Figure 2. Subgroup analysis that shows the pooled sample size of the studies derived from categories of different authors in sub-Saharan Africa.

### Figure 3. Subgroup analysis of the pooled prevalence of CKD between countries in sub-Saharan Africa.
CKD is common in Africa, particularly in sub-Saharan Africa and cause high morbidity and mortality. The current systematic review tries to see the burden of CKD among HIV-infected individuals who are active with different anti-retroviral regimens. As indicated from 15 studies included in this review and meta-analysis the overall pooled prevalence of CKD was 6.42% with a CI of (5.25, 7.59). This finding was in line with the systematic review and meta-analysis done on HIV patients globally which had pooled prevalence of (6.4%)

### Discussion

Figure 4. The pooled prevalence of chronic kidney disease among the different stages of kidney disease. The odds of stages were calculated by dividing positives in each stage by sum of stages.

| Stage | Author/year | ES (95% CI) | % Weight |
|-------|-------------|-------------|----------|
| stage3 | Cailhol J et al/2011 | 2.00 (-10.27, 14.27) | 6.4 |
| | Mekuria Y et al/2016 | 7.20 (-5.09, 19.49) | 6.4 |
| | Wondifraw B et al/2017 | 10.80 (0.05, 21.55) | 6.2 |
| | Owiredjo WBSA et al/2013 | 12.00 (-1.90, 25.90) | 0.51 |
| | Sarfo FS et al/2013 | 10.60 (-0.78, 14.42) | 4.15 |
| | Brennan A et al/2011 | 5.20 (-1.22, 11.62) | 2.00 |
| | Zachor H et al/2016 | 2.30 (-5.29, 9.89) | 1.52 |
| | Mpondo BCT et al/2014 | 1.20 (-11.12, 13.52) | 0.64 |
| | Peck et al/2014 | 10.70 (-4.45, 25.85) | 0.43 |
| | Deckert A et al/2017 | 2.60 (-6.27, 7.87) | 2.71 |
| | Mulenga L et al/2014 | 2.70 (0.35, 3.45) | 9.59 |
| | Zannou DM et al/2015 | 18.00 (10.06, 25.94) | 1.41 |
| | Ambetsa MO et al/2015 | 10.00 (-2.54, 22.54) | 0.61 |
| Subtotal (I-squared = 66.7%, p = 0.000) | | 6.78 (3.58, 9.97) | 25.66 |
| stage4 | Mekuria Y et al/2016 | 0.40 (-2.60, 3.40) | 5.37 |
| | Wondifraw B et al/2017 | 0.40 (-1.79, 2.59) | 6.88 |
| | Owiredjo WBSA et al/2013 | 0.70 (-2.87, 4.27) | 4.50 |
| | Sarfo FS et al/2013 | 2.00 (0.26, 3.74) | 7.80 |
| | De Waal R et al/2017 | 1.90 (0.33, 3.47) | 8.16 |
| | Deckert A et al/2017 | 0.30 (-1.51, 2.11) | 7.65 |
| | Mulenga L et al/2014 | 0.20 (-0.01, 0.41) | 10.08 |
| Subtotal (I-squared = 29.1%, p = 0.206) | | 0.69 (0.02, 1.36) | 50.44 |
| stage5 | Wondifraw B et al/2017 | 0.40 (-1.79, 2.59) | 6.88 |
| | Sarfo FS et al/2013 | 1.10 (-0.20, 2.40) | 8.69 |
| | De Waal R et al/2017 | 0.20 (-1.26, 1.16) | 8.33 |
| | Deckert A et al/2017 | 0.20 (-0.01, 0.41) | 10.08 |
| Subtotal (I-squared = 0.0%, p = 0.648) | | 0.66 (-0.03, 1.55) | 23.90 |
| Overall (I-squared = 79.6%, p = 0.000) | | 2.08 (1.04, 3.07) | 100.00 |

NOTE: Weights are from random effects analysis

Table 2. Characterizing the effect of omitting each article over the pooled prevalence.
CKD in HIV infection

The prevalence in the current review was comparable with the study conducted among HIV patients on ART in France; using large scale study with sample size of 7378 showed that 349 (4.73%) had CKD. The prevalence in the current review was slightly lower than the study from America, which was a large scale cohort study involving 16,405 participants that took ART and, a systematic review performed on HIV patients involving 43,114 participants of which 8.5% and 7.3% had CKD, respectively. On the other hand, it was higher than the study from the Netherlands (2.3%) involving 16,836 participants that took ART.

The studies included in this review had prevalence ranging from 1.2% from Tanzania to 18.7% from Benin. The difference in prevalence from article to article may be challenged with limitation of CKD estimation methods as they are confronted with different variables for eGFR equation models.

Subgroup analysis was performed for this review using models of eGFR estimation (MDRD, CKD-EPI, or CG) and showed 7.92%, 3.1%, and 13.2% prevalence rates, respectively. This finding was comparable with a systematic review done globally which had a prevalence of 6.4%, 4.8%, and 13.3% for MDRD, CKD-EPI, and CG methods, respectively. Since there was high heterogeneity with in all of the above models ($I^2 = 98.4\%, 72.1\%$ and $94.9\%$) for MDRD, CKD-EPI, and CG, respectively, we attempted to analyze the data using study methods (designs) of original articles. Based on the analysis, the heterogeneity ($I^2 = 94.6\%, 98.5\%$) for cross-sectional and cohort study designs, respectively, showed high variability. The possible cause of high heterogeneity between study designs might be the variation in outcome between cross-sectional and cohort study design. In our study, further subgroup analysis was performed between countries where the studies had been conducted. We found tolerable heterogeneity which indicates that countries are not the possible source of heterogeneity. The studies from Ethiopia showed subgroup prevalence of 9.53%, 95% CI (5.61, 13.44) and tolerable heterogeneity ($I^2 = 57\%, P = 0.127$). There was no heterogeneity between studies from Ghana ($I^2 = 00\%$) with subgroup 13.65%, 95% CI (12.47, 14.82). However, studies from S.Africa and Tanzania showed high heterogeneity ($I^2 = 89.8\%, 96.1\%$), respectively.

CKD was defined by GFR <60 mL/min/1.73
m² for ≥3 months, regardless of the cause and the stages were categorized based on the classification system established by the National Kidney Foundation – Kidney Disease Outcomes Quality Initiative classification as stages of 3, 4, and 5.²¹ For the meta-analysis between stages, the study by Kalayjian et al.,²⁶ did not classify CKD into stages and it was excluded for stage analysis. As a result, the subgroup analysis for stages of CKD in the current meta-analysis was made only using 14 articles. Thus, on the bases of sub-group analysis, there was low heterogeneity among all stages. Majority (thirteen) of the articles had CKD in Stage 3, with a prevalence of 6.78%, 95% CI (3.58, 9.97), and low heterogeneity (I² = 29.1%). The other study by Choi et al.⁴¹ Three studies had CKD in stage 5 with prevalence of 0.66%, 95% CI (−0.23, 1.55) and there was no heterogeneity between them (I² = 0.0%). The sub-group prevalence in this stage was lower than the study from America, where, 4.9% had CKD stage 5.⁴¹ Therefore, the staging of CKD is not the cause of heterogeneity, and hence, it is important to see the risk of CKD by categorizing among the different stages.

In general, there was no single influential study on the overall prevalence of CKD. A study which had a slightly greater effect on the overall prevalence of CKD was performed by Mulenga et al²³ and De Waal et al.³⁴ Omitting this article from the review process resulted in 7.55% pooled prevalence, which was higher than the 6.42% prevalence if they were included in the review (6.42%). On the other hand, the study by Sarfo et al., resulted in the decrement of the total prevalence. Since this study had a higher prevalence by itself, omitting it resulted in the dropping of the overall prevalence (5.11%) as compared to its inclusion to the review.

Conclusion

The pooled prevalence of CKD among HIV positive patients on ART in Sub-Saharan Africa was relatively high (6.42%). The highest subgroup prevalence was reported from Ghana (13.65%) with no statistical heterogeneity (I² = 0%). Majority of CKD was reported in stage 3 with subgroup prevalence of 6.78% and tolerable statistical heterogeneity (I² = 66.7%). There was high kidney disease in association with ART.

Conflict of interest: None declared.

References

1. Coresh J, Astor BC, Greene T, Eknoyan G, Levey AS. Prevalence of chronic kidney disease and decreased kidney function in the adult US population: Third National Health and Nutrition Examination Survey. Am J Kidney Dis 2003;41: 1-2.
2. Obrador GT, Ruthazer R, Arora P, Kausz AT, Pereira BJ. Prevalence of and factors associated with suboptimal care before initiation of dialysis in the United States. J Am Soc Nephrol 1999;10:1793-800.
3. Nissenson AR, Collins AJ, Hurley J, Petersen H, Pereira BJ, Steinberg EP. Opportunities for improving the care of patients with chronic renal insufficiency: Current practice patterns. J Am Soc Nephrol 2001;12: 1713-20.
4. HIV and AIDS Statistics. 2017 Global HIV Statistics. Available from: http://www.avert.org.aglobal. [Last accessed on March 8, 2019].
5. World Health Organization. Antiretroviral Therapy (ART) Coverage Among all Age Groups. Global Health Observatory (WHO) Data. World Health Organization; 2017.
6. Elewa U, Sandri AM, Rizza SA, Fervenza FC. Treatment of HIV-associated nephropathies. Nephron Clin Pract 2011;118 c346-54.
7. Islam FM, Wu J, Jansson J, Wilson DP. Relative risk of renal disease among people living with HIV: A systematic review and meta-analysis. BMC Public Health 2012;12: 234.
8. Guaraldi G, Orlando G, Zona S, Menozzi M, Carli F, Garlassi E, et al. Premature age-related comorbidities among HIV-infected persons compared with the general population. Clin Infect Dis 2011;53:1120-6.

9. Pathai S, Bajillan H, Landay AL, High KP. Is HIV a model of accelerated or accentuated aging? J Gerontol A Biol Sci Med Sci 2014;69:833-42.

10. Longenecker CT, Funderburg NT, Jiang Y, et al. Markers of inflammation and CD8 T-cell activation, but not monocyte activation, are associated with subclinical carotid artery disease in HIV-infected individuals. HIV Med 2013;14:385-90.

11. Scherzer R, Estrella M, Li Y, et al. Association of tenofovir exposure with kidney disease risk in HIV infection. AIDS 2012;26:867-75.

12. Laprise C, Baril JG, Dufresne S, Trottier H. Association between tenofovir exposure and reduced kidney function in a cohort of HIV-positive patients: results from 10 years of follow-up. Clin Infect Dis 2013;56:567-75.

13. Naicker S. End-stage renal disease in sub-Saharan Africa. Ethn Dis 2009;19:S1-13-5.

14. Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat. World Population Prospects: The 2007 Revision and World Urbanization Prospects. Available from: http://www.un.org/esa/population/unpop.htm. [Last accessed on 15 December 2018].

15. Thomas BA, Wulf S, Mehrotra R, Himmelfarb J, Naghavi M, Murray CJ. The Rapidly Growing Global Burden of End-Stage Renal Disease – An Analysis of the Chance in Maintenance Dialysis Prevalence between 1990 and 2010. Atlanta: Proceedings of the American Society of Nephrology; 2013.

16. Grassmann A, GiebERGE S, Moeller S, Brown G. ESRD patients in 2004: Global overview of patient numbers, treatment modalities and associated trends. Nephrol Dial Transplant 2005;20:2587-93.

17. Han TM, Naicker S, Ramdial PK, Assounga AG. A cross-sectional study of HIV-sero-positive patients with varying degrees of proteinuria in South Africa. Kidney Int 2006;69:2243-50.

18. Szczech LA, Gupta SK, Habash R, et al. The clinical epidemiology and course of the spectrum of renal diseases associated with HIV infection. Kidney Int 2004;66:1145-52.

19. Liberati A, Altman DG, Tetzlaff J, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. PLoS Med 2009;6:e1000100.

20. The Joanna Briggs Institute. Critical Appraisal tools for use in JBI Systematic Reviews. Available from: http://joannabriggs.org/research/critical-appraisal-tools.html. [Last accessed on 11 October 2018].

21. National Kidney Foundation. K/DOQI clinical practice guidelines for chronic kidney disease: Evaluation, classification, and stratification. Am J Kidney Dis 2002;39:S1-266.

22. Higgins JP, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. BMJ 2003;327:557-60.

23. DerSimonian R, Laird N. Meta-analysis in clinical trials. Control Clin Trials 1986;7:177-88.

24. Cailhol J, Nkurunziza B, Izzedine H, et al. Prevalence of chronic kidney disease among people living with HIV/AIDS in Burundi: A cross-sectional study. BMC Nephrol 2011;12:40.

25. Mekuria Y, Yilma D, Mekonnen Z, Kassa T, Gedefaw L. Renal function impairment and associated factors among HAART naïve and experienced adult HIV positive individuals in Southwest Ethiopia: A comparative cross sectional study. PLoS One 2016;11:e0161180.

26. Wondifraw Baynes H, Tegene B, Gebremichael M, Birhane G, Kedir W, Biadgo B. Assessment of the effect of antiretroviral therapy on renal and liver functions among HIV-infected patients: A retrospective study. HIV AIDS (Auckl) 2017;9:1-7.

27. Owiredu WK, Quaye L, Amidu N, Addai-Mensah O. Renal insufficiency in Ghanaian HIV infected patients: Need for dose adjustment. Afr Health Sci 2013;13:101-11.

28. Peck RN, Shedafa R, Kalluvya S, et al. Hypertension, kidney disease, HIV and antiretroviral therapy among Tanzanian adults: A cross-sectional study. BMC Med 2014;12:125.

29. Deckert A, Neuhann F, Klose C, et al. Assessment of renal function in routine care of people living with HIV on ART in a resource-limited setting in urban Zambia. PLoS One 2017;12:e0184766.

30. Zannou DM, Vigan J, Azon-Kouanou A,
31. Sarfo FS, Keegan R, Appiah L, et al. High prevalence of renal dysfunction and association with risk of death amongst HIV-infected Ghanaians. J Infect 2013;67:43-50.

32. Brennan A, Evans D, Maskew M, et al. Relationship between renal dysfunction, nephrotoxicity and death among HIV adults on tenofovir. AIDS 2011;25:1603-9.

33. Zachor H, Machekano R, Estrella MM, et al. Incidence of stage 3 chronic kidney disease and progression on tenofovir-based antiretroviral therapy regimens: A cohort study in HIV-infected adults in Cape Town, South Africa. AIDS 2016;30:1221-8.

34. De Waal R, Cohen K, Fox MP, et al. Changes in estimated glomerular filtration rate over time in South African HIV-1-infected patients receiving tenofovir: A retrospective cohort study. J Int AIDS Soc 2017;20:21317.

35. Mpondo BC, Kalluvya SE, Peck RN, et al. Impact of antiretroviral therapy on renal function among HIV-infected Tanzanian adults: A retrospective cohort study. PLoS One 2014;9:e89573.

36. Kalayjian RC, Franceschini N, Gupta SK, et al. Suppression of HIV-1 replication by antiretroviral therapy improves renal function in persons with low CD4 cell counts and chronic kidney disease. AIDS 2008;22:481-7.

37. Mulenga L, Musonda P, Mwango A, et al. Effect of baseline renal function on tenofovir-containing antiretroviral therapy outcomes in Zambia. Clin Infect Dis 2014;58:1473-80.

38. Ambetsa MO, Makori JO, Osanjio GO, et al. Incidence and risk factors of renal dysfunction in patients on nevirapine-based regimens at a referral hospital in Kenya. Afr J Pharmacol Ther 2015;4:48-58.

39. Ekrikpo UE, Kengne AP, Bello AK, et al. Chronic kidney disease in the global adult HIV-infected population: A systematic review and meta-analysis. PLoS One 2018;13:e0195443.

40. Flandre P, Pugliese P, Cuzin L, et al. Risk factors of chronic kidney disease in HIV-infected patients. Clin J Am Soc Nephrol 2011;6:1700-7.

41. Choi AI, Rodriguez RA, Bacchetti P, et al. Low rates of antiretroviral therapy among HIV-infected patients with chronic kidney disease. Clin Infect Dis 2007;45:1633-9.

42. Park J, Zuñiga JA. Chronic kidney disease in persons living with HIV: A systematic review. J Assoc Nurses AIDS Care 2018;29:655-66.

43. Schoffelen AF, Smit C, van Lelyveld SF, et al. Diminished impact of ethnicity as a risk factor for chronic kidney disease in the current HIV treatment era. J Infect Dis 2015;212:264-74.