



# Comorbidity of HIV, hypertension, and diabetes and associated factors among people receiving antiretroviral therapy in Bahir Dar city, Ethiopia

Journal of Comorbidity  
Volume 10: 1–12  
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DOI: 10.1177/2235042X19899319  
journals.sagepub.com/home/cob



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## Abstract

**Background:** People living with human immunodeficiency virus (HIV) are facing an increased burden of noncommunicable diseases (NCDs) comorbidity. There is, however, paucity of information on the magnitude of HIV-NCDs comorbidity, its associated factors, and how the health system is responding to the double burden in Ethiopia.

**Objective:** To determine the magnitude of comorbidity between HIV and hypertension or diabetes and associated factors among HIV-positive adults receiving antiretroviral therapy (ART) in Bahir Dar city, Ethiopia.

**Methods:** A facility-based cross-sectional study was conducted among 560 randomly selected HIV-positive adults taking ART. Data were collected using a structured questionnaire and analyzed using SPSS version 23. Descriptive statistics were used to describe the data. A logistic regression model was fit to identify associated factors with comorbidity of HIV and NCDs.

**Results:** The magnitude of comorbidity was 19.6% (95% confidence interval (CI): 16.0–23.0). Being older (55 and above years) adjusted odds ratio (AOR: 8.5; 95% CI: 3.2–15.1), taking second-line ART regimen containing tenofovir (AOR: 2.7; 95% CI: 1.3–5.6), and increased body mass index (BMI)  $\geq 25$  (AOR: 2.7; 95% CI: 1.2–6.5) were the factors associated with comorbidity. Participants reported that they were not managed in an integrated and coordinated manner.

**Conclusions:** The magnitude of comorbidity among adults was high in the study area. Being older, second-line ART regimen and high BMI  $\geq 25$  increased the odds of having NCDs among HIV-positive adults. Targeted screening for the incidences of NCDs, addressing modifiable risk factors, and providing integrated care would help to improve the quality of life comorbid patients.

## Keywords

Noncommunicable diseases, HIV, hypertension, diabetes mellitus, comorbidity, ethiopia

Received 25 May 2019; accepted: 10 December 2019

## Background

Noncommunicable diseases (NCDs) refer to a complex and heterogeneous group of diseases mainly cardiovascular disease (hypertension and stroke), diabetes mellitus (DM), renal diseases, mental illness, chronic respiratory diseases, and cancer.<sup>1</sup> These diseases are rapidly emerging and increasing in developing countries, where communicable diseases also remain the major public health challenges.<sup>2</sup>

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World Health Organization's (WHO's) projections show that NCDs will be responsible for a significantly increased total number of deaths in the next decade. Deaths due to NCDs are projected to increase by 15% globally. The greatest increases will be in the Africa region, as the rapidly urbanizing poorer population became more susceptible to comorbidity and its adverse outcomes. NCDs are predicted to overtake the burden of mortality and morbidity from communicable diseases by the year 2030.<sup>3</sup>

Access to antiretroviral therapy (ART) has resulted in increasing survival for people living with human immunodeficiency virus (HIV).<sup>4,5</sup> With the longer life spans that ART has made possible, a larger number of people living with HIV are facing the increased burden of NCDs.<sup>6</sup>

The epidemiologic overlap between NCDs and HIV and the impact of NCDs-HIV comorbidity in sub-Saharan Africa, including Ethiopia, are likely to be very large.<sup>4,7</sup>

Patients living with HIV share many common risk factors of NCDs. These mainly include unhealthy diets (high intake of fat, salt, and refined sugars), physical inactivity, tobacco use, and harmful use of alcohol.<sup>8</sup> Moreover, evidence on the causal underlying mechanisms revealed that there is a complex interaction among HIV infection, ART, and NCDs risk factors. NCDs in HIV-positive people are occurring due to a mix of chronic immune activation, medication side effects, coinfections, and the aging process itself and they may get worsened by HIV and some antiretroviral drugs.<sup>9</sup>

Comorbidity results in a very complex disease pattern that could have additive or multiplicative consequences on health outcomes.<sup>10</sup> NCDs are the major cause of death in people living with HIV/acquired immunodeficiency syndrome and cardiovascular diseases account for 46% of the total deaths.<sup>5</sup> There is a huge concern that the survival and aging possibility of patient on ART could have severely hampered by the rapidly evolving and emerging NCDs among this group of population. Both HIV and NCDs need chronic care for long follow-up, revisits, referrals, counseling, social support systems, and collaborative actions.<sup>11</sup>

Studies on the prevalence of isolated cases of chronic NCDs are flourishing in Ethiopia. However, there is sparse evidence on the magnitude of HIV-NCD comorbidity, associated factors, and how the health system is responding to this high need patient group.

This emerging double burden of disease challenges sub-Saharan's African health infrastructure and demands an effective response while recognizing the context of scarce resources within the region.<sup>12</sup> The attention given to this wave of fatal epidemic looks suboptimal, perhaps not available in poor resource countries like Ethiopia.<sup>13,14</sup>

The impact of HIV-NCDs comorbidity at the health system level is recognized globally.<sup>13,14</sup> The management of HIV-NCDs comorbidity is much more complicated and demanding for the health system, patients, and their families compared to those without.<sup>15</sup> However, the current model of care and guidelines, developed at a time when single disease frameworks were predominant, tend to focus

on diseases in isolation rather than the needs and circumstances of the person with complexity care needs.<sup>16</sup>

The absence of a strong generalist and integrated care may lead to poor quality of care and patient outcome.<sup>17</sup> Understanding the burden of HIV and the commonest NCDs comorbidity, identifying modifiable factors, and exploring how well the health system is responding to this colliding epidemic have a paramount importance<sup>9</sup> to design and strengthen the existing prevention and management strategies. Therefore, the objective of the study was to determine the magnitude of HIV-hypertension and diabetes comorbidity and identify associated factors and figure out how the current health-care system is responding to the problem among HIV-positive adults attending ART follow-up at public health facilities of Bahir Dar city, Amhara region, Ethiopia.

## Methods

### *Study design, area, and period*

A facility-based cross-sectional study was employed to determine the magnitude of HIV-hypertension and diabetes comorbidity and identify associated factors among adults attending follow-up in ART clinic at public health facilities of Bahir Dar city. The data were collected from March 1 to 31, 2018, during clinic visits.

The study was conducted in Bahir Dar city, the capital of the Amhara region. The city has a total population of 314,007.<sup>18</sup> It has 2 public hospitals, 10 health centers, 10 health posts, 1 private hospital, and 45 private clinics. These facilities are serving about five million populations living in the city and surrounding districts. Among all the health facilities in the city, 2 public hospitals and 5 health centers had ART clinic and about 11,259 patients were on ART at the time of the study.

### *Source population and inclusion criteria*

All HIV-positive adults attending follow-up in the ART clinic at public health facilities of Bahir Dar city administration were the source population. Adults with HIV positive whose age is 18 years and above and on ART for at least 6 months were included in the study.

### *Study variables*

Presence or absence of comorbidity of hypertension and diabetes in HIV patients was the outcome variable. Socio-demographic variables (age, sex, residency, education level, occupation, marital status, monthly income (Birr), and family history of NCDs), lifestyle variables (tobacco use, alcohol consumption, and physical exercise), clinical feature variables (parameters WHO HIV disease clinical stage, ART drug class exposure, and duration of exposure), and biomedical measurements (cluster differentiation 4+ (CD4+) cell count, viral load, body mass index (BMI),

blood pressure (BP), and blood glucose level) were the independent variables.

### Operational definitions

HIV-NCD comorbidity refers to the occurrence of at least one chronic NCD (hypertension and/or DM) in HIV-positive patients. As ascertaining the accuracy of the diagnosis of other chronic diseases was difficult during the study period, we limited the number and kinds of NCDs to be considered for the definition of comorbidity in this study. Hence, we decided to only include hypertension and diabetes.

### Hypertension

For the purpose of this study, hypertension was defined as systolic BP  $\geq 140$  mmHg and/or diastolic BP  $\geq 90$  mmHg or currently taking medication for hypertension.<sup>19</sup>

DM was defined as random blood sugar  $> 11.1$  mmol/L (200 mg/dL) or fasting blood sugar  $\geq 7$  mmol/L (126 mg/dL) or being on diabetes medication.<sup>20</sup>

### Physical exercise

It was defined as having high = vigorous activity for at least 3 days per week each lasting 30 min or more. Moderate = vigorous activity for 3 days per week each lasting 20 min or 5 days of walking for at least 30 min per day. Low = any activity less than those categories mentioned above.<sup>21</sup>

### Anthropometric measurements

Weighing carried out without shoes and light indoor clothing using the calibrated digital weighing scale recorded to the nearest 0.1 kg (100 g). A body meter (measured up to 2 m) used to measure the height of respondents. The respondents were barefooted and stood on a flat surface with their back on the tape attached to the wall recorded to the nearest 0.1 cm. All anthropometric measurements of weight and height performed twice separately and then the average of the two readings recorded.<sup>19</sup>

BMI was obtained by dividing weight in kilograms by height in meters squared (weight (kg)/height (m<sup>2</sup>)). Cutoff levels by WHO as underweight  $< 18.5$  kg/m<sup>2</sup>, normal 18.5–24.9 kg/m<sup>2</sup>, overweight 25–29.9 kg/m<sup>2</sup>, and obese  $\geq 30$  kg/m<sup>2</sup>.<sup>20</sup>

Employed: a person who had a permanent job with a monthly salary whereas daily laborer: a person who does not have a permanent job, but earns money by doing labor works daily.

### Sample size and sampling method

The sample size was determined using single population proportion formula by considering the following assumptions: prevalence of hypertension in the previous study ( $p = 33\%$ ),<sup>22</sup> marginal error ( $w = 5\%$ ), and 95%

confidence interval (CI) ( $Z_{\alpha/2} = 1.96$ ), design effect of 1.5, and 10% nonrespondent rate. The final sample size required was 560. Since using the hypertension prevalence yielded the maximum sample size, we decided to use that.

There were two hospitals and five health centers that provide ART services in the study area at the time of the study. First, stratification was done by type of health facilities (hospitals and health centers). One hospital and two health centers were selected using simple random sampling. Proportion to size allocation was made to determine the required sample size from the hospital and health centers. Finally, a simple random sampling technique was used to select study participants using registration records of patients as a sampling frame.

### Data collection tools

A structured questionnaire was developed and used to conduct face to face interviews and capture relevant data from the patients and their records. The questionnaire was initially prepared in English and translated to Amharic for collecting the required information, such as sociodemographic characteristics, associated factors, and clinical parameters (Online Supplement 1).

Pretest of the instrument was conducted to check its appropriateness and ensure consistency of understanding for administration. Data were collected by five trained ART nurses and two public health supervisors. Data quality was assured by providing a 1-day training on the objectives of study, how to obtain consent, and on the data collection process and confidentiality. Completed questionnaires were cross-checked daily for consistencies and completeness.

### Data management and analysis

Data were entered using Epi Info version 7 software and exported to SPSS version 23 for analysis. Descriptive statistics were run to describe data. Binary logistic regression models were fit to identify predictors of comorbidity of NCD and HIV. The variables whose  $p$  value  $< 0.05$  in the binary analysis were considered for multivariable logistic regression. Adjusted odds ratio (AOR) with 95% CI was calculated to show the strength of association and to control for the effects of confounding. A  $p$  value  $< 0.05$  was considered statistically significant to identify predictors of comorbidity.

### Ethical considerations

Ethical clearance was obtained from the College of Medicine and Health Sciences, Bahir Dar University. Formal letter was given to Amhara Regional Health Bureau and health facilities. Informed verbal consent was obtained from each study participant after briefing the objective of the study. Data were recorded anonymously to assure the

**Table 1.** Sociodemographic characteristics of study participants among adults attending ART follow-up in public health facilities of Bahir Dar city, 2018.

Variables		Sample n = 547 Number (%)	Male n = 206 Number (%)	Female n = 341 Number (%)
Sex		—	206 (37.7)	341 (62.3)
Age (years), mean (SD)		39.3 (9.6)	41.8 (8.9)	37.8 (9.6)
Age category	18–34	160 (29.3)	31 (15.0)	129 (37.8)
	35–54	346 (63.3)	159 (77.2)	187 (54.8)
	55+	41 (7.5)	16 (7.8)	25 (7.3)
Residency	Urban	523 (95.6)	192 (36.7)	331 (63.3)
	Rural	24 (4.4)	14 (58.3)	10 (41.7)
Religion	Orthodox	509 (93.1)	191 (37.5)	318 (62.5)
	Muslim	33 (6.0)	13 (39.4)	20 (60.0)
	Protestant	5 (0.9)	2 (40.0)	3 (60.0)
Ethnicity	Amhara	526 (96.2)	194 (36.9)	332 (63.1)
	Tigre	11 (2.0)	7 (63.6)	4 (36.4)
	Oromo	6 (1.1)	3 (50.0)	3 (50.0)
	Others	4 (0.7)	2 (50.0)	2 (50.0)
Education	Unable to read and write	153 (28.0)	27 (13.1)	126 (37.0)
	Grades 1–8 (primary)	192 (35.1)	78 (37.9)	114 (33.4)
	Grades 9–10 (secondary)	86 (15.7)	45 (21.8)	41 (12.0)
	TVT and above	116 (21.2)	56 (27.2)	60 (17.6)
Occupation	Employed	148 (27.1)	73 (35.4)	75 (22.0)
	Merchant	94 (17.2)	40 (19.4)	54 (15.8)
	Housewife	129 (23.6)	0 (0)	129 (37.8)
	Daily laborer	155 (28.3)	76 (36.9)	79 (23.2)
	Others	21 (3.8)	17 (8.3)	4 (1.2)
Marital status	Single	51 (9.3)	24 (9.3)	27 (7.9)
	Married	310 (56.7)	152 (73.8)	158 (46.3)
	Divorced	97 (17.7)	20 (20.6)	77 (17.7)
	Widowed	89 (16.3)	10 (4.9)	79 (23.2)
Monthly income/house hold (Birr)	<1000	223 (40.8)	70 (34.0)	153 (44.9)
	1000–3000	206 (37.7)	76 (36.9)	130 (38.1)
	>3000	118 (21.6)	60 (29.1)	58 (17.0)

ART: antiretroviral therapy; SD: standard deviation.

confidentiality of the data. Individuals diagnosed to have a new incidence of hypertension or diabetes or both were referred to seek further care.

## Results

### Sociodemographic characteristics of study participants

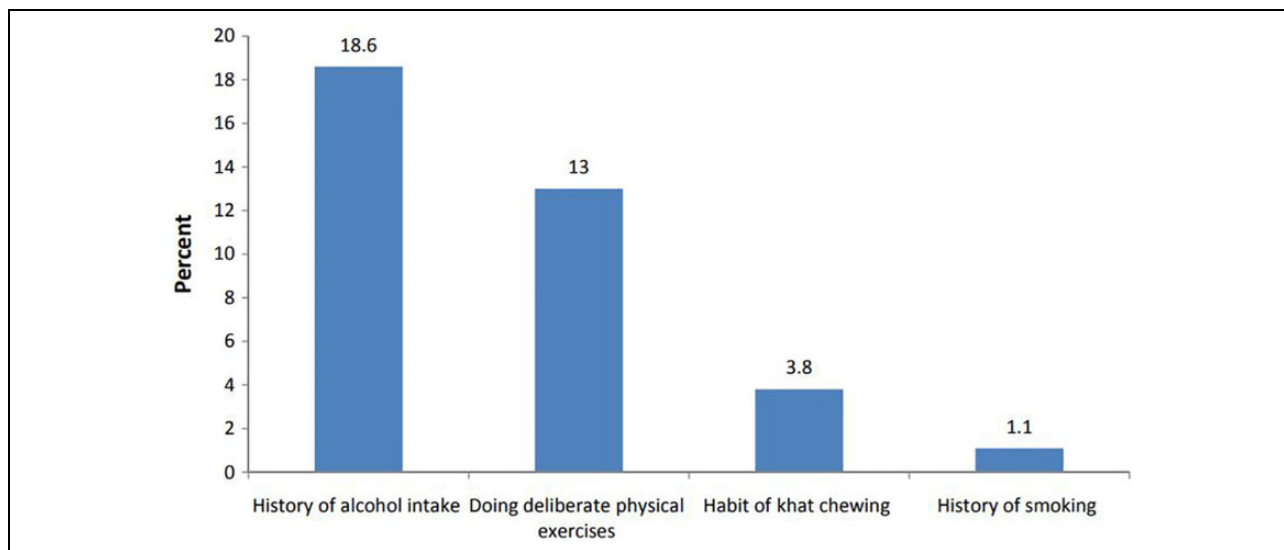
In this study, 547 participants were enrolled with a response rate of 97.7%. Due to a shortage of time, 13 (2.3%) patients refused to participate in the study. Study participants were predominantly females 341 (62.3%). The mean ( $\pm$  standard deviation) age of the study participants was 39.3 ( $\pm$ 9.6) years; 41.8 ( $\pm$ 8.9) years for males and 37.8 ( $\pm$ 9.6) years for females. Over one-third of the study participants (35%) had completed primary education. More than one-fourth of the study participants (28.3%) were daily laborers. More than half of the study participants (56.7%) were married and 40.8% of them had a monthly income per household less than 1000 Ethiopian Birr (Table 1).

### Lifestyle and behavioral characteristics of study participants

About 112 (20.5%) patients had a BMI less than 18.5 (underweight), 338 (61.8%) were in the normal range, and 97 (17.7%) were having BMI 25 and more (overweight or obese). With regard to lifestyle and behavioral characteristics, a relatively higher proportion of the participants had history of alcohol intake and the proportion of people who smoke cigarette was the lowest among the list (Figure 1).

### Clinical parameters of the participants

Among study participants, 64% (350) had CD4+ cell count greater than 350 cells/mL and 95.4% (522) of participants were put on treatment stage I. Viral load was undetectable in 510 (93.2%) participants and only 2.9% of patients had a detectable viral load greater than 10,000 copies/mL. In terms of duration on ART, approximately 71.3% (400) of the study participants took ART for over 5 years and 19.4% had been on treatment for the last



**Figure 1.** Behavioral characteristics of study participants among adults attending ART follow-up in public health facilities of Bahir Dar city, 2018. ART: antiretroviral therapy.

**Table 2.** Prevalence of NCDs (hypertension and DM) among adults attending ART follow-up in public health facilities of Bahir Dar city, 2018.

Selected NCDs	Number	Prevalence (%)	95% CI
NCDs (hypertension and/or DM comorbid with HIV)	106	19.6	16–23
Hypertension comorbid with HIV	77	14.1	11–17
DM comorbid with HIV	47	8.6	6–11
Hypertension + DM (multi-morbidity)	18	3.3	2–5
No NCDs detected	441	80.6	77–84

NCD: noncommunicable disease; DM: diabetes mellitus; ART: antiretroviral therapy; CI: confidence interval; HIV: human immunodeficiency virus.

10 years or more at the time of data collection. Tenofovir (TDF)-containing regimens were mostly prescribed (45.5%) followed by zidovudine (AZT)-based regimen (43.1%) and second-line drug regimen were the least (11.3%) prescribed.

### Magnitude of HIV-NCDs comorbidity

The prevalence of NCDs (hypertension and/or DM) among adults attending ART follow-up was 19.6% (95% CI: 16–23). Of these, 14.1% (95% CI: 11–17) of them had hypertension and 8.6% (95% CI: 6–11) had DM (Table 2).

### NCDs and HIV service delivery

When asked about the time of NCDs diagnosis, 74 (96.1%) of hypertensive and 43 (91.5%) of diabetic patients reported that the diagnosis of their chronic conditions was made after

the initiation of ART either in other units or other health facilities, but not within the ART unit. The study found that patients do not receive health care for NCDs in the ART clinic. In terms of the place of follow-up for NCDs, 86 (81.1%) had follow-up in the same health facility but at a different unit and 20 (18.9%) had follow-up from other health facilities including private clinics.

### Factors associated with HIV-NCD comorbidity

Being older, taking second-line ART regimens containing TDF, and a BMI value of 18.5 and above were the factors significantly associated with HIV-NCDs comorbidity (Table 3).

Compared to the age group between 18 years and 34 years, the odds of having HIV-NCDs comorbidity was two times and eight times higher in the age group between 35 years and 54 years (AOR 2.37; 95% CI: 1.19–4.79) and 55+ years (AOR 8.45; 95% CI: 3.16–15.07), respectively. The odds of having HIV-NCDs comorbidity was 2.7 times higher among participants who took second-line ART drug regimens containing TDF (AOR 2.73; 95% CI: 1.33–5.63) compared with that of AZT-containing regimens. Compared to those having BMI less than 18.5, the odds of having NCDs comorbidity was 2.3 (AOR 2.32; 95% CI: 1.09–4.93) times and 2.7 (AOR 2.74; 95% CI: 1.16–6.49) times higher among those having BMI 18.5–24.9 and BMI greater than or equals 25, respectively (Table 3).

### HIV-hypertension comorbidity

Old age and BMI of 25 or more were the factors significantly associated with HIV-hypertension comorbidity. However, unlike HIV-diabetes comorbidity, taking ART

**Table 3.** Factors associated with HIV-NCDs comorbidity among adults living with HIV in Bahir Dar city, 2018.

Variables	HTN and/or DM comorbid with HIV		COR	95% CI	AOR	95% CI
	Yes (%)	No (%)				
Sex	Male	49 (23.8)	157 (76.2)	1.56	1.01–2.38	<sup>c</sup>
	Female	57 (16.7)	284 (83.3)	1		
Age Category	18–34	12 (7.5)	148 (92.5)	1		
	35–54	69 (19.9)	277 (80.1)	3.07	1.61–5.85	2.37 1.19–4.71 <sup>a</sup>
	55+	25 (61.0)	16 (39.0)	9.27	3.15–15.55	8.45 3.16–15.07 <sup>b</sup>
Occupation	Employed	26 (17.4)	123 (82.6)	1		
	Merchant	16 (16.8)	79 (83.2)	0.89	0.44–1.87	
	Housewife	34 (26.8)	93 (73.2)	1.82	1.03–3.22	
	Daily laborer	18 (11.8)	135 (88.2)	0.63	0.35–1.24	
	Others	12 (52.2)	11 (47.8)	2.16	0.98–8.42	
Marital status	Single	6 (11.8)	45 (88.2)	1		
	Married	58 (18.7)	252 (81.3)	1.73	0.73–4.24	
	Divorced	20 (20.6)	77 (79.4)	1.95	0.73–5.21	
	Widowed	23 (25.8)	66 (79.4)	2.61	0.99–6.93	
Monthly income/household	<1000	43 (19.3)	180 (80.7)	1		
	1000–3000	31 (15.0)	175 (85.0)	0.74	0.45–1.23	
	>3000	32 (27.1)	86 (72.9)	1.63	0.96–2.74	
Alcohol use	Yes	28 (27.5)	74 (72.5)	1.87	1.08–2.93	<sup>c</sup>
	No	78 (17.5)	367 (82.5)	1		
Physical exercise	Yes	6 (8.5)	65 (91.5)	1		
	No	100 (21.0)	376 (79.0)	2.88	1.21–6.84	<sup>c</sup>
ART drug regimen	AZT + 3TC + Nev/Efv	54 (22.9)	182 (77.1)	1		
	TDF + 3TC + Nev/Efv	38 (15.3)	211 (84.7)	0.61	0.38–0.96	1.29 0.68–2.46
	Second-line regimens	14 (22.6)	48 (77.4)	0.98	0.50–1.91	2.73 1.33–5.63 <sup>b</sup>
Duration on ART (in years)	<5 year	18 (12.2)	129 (87.8)	1		
	5–10 years	51 (17.3)	243 (82.7)	1.50	0.84–2.68	
	>10 years	37 (34.9)	69 (65.1)	3.84	2.03–7.24	<sup>c</sup>
CD4+ count (cell/mL)	<350	32 (16.2)	165 (83.8)	1		
	350–500	33 (21.6)	120 (78.4)	1.37	0.79–2.34	
	>500	41 (20.8)	156 (79.2)	1.31	0.79–2.17	
BMI	<18.5	12 (10.7)	100 (89.3)	1		
	18.5–24.9	65 (19.2)	273 (80.8)	1.98	1.09–3.83	2.32 1.09–4.93 <sup>a</sup>
	25+	39 (29.9)	68 (70.1)	3.55	1.69–7.44	2.74 1.16–6.49 <sup>a</sup>

HIV: human immunodeficiency virus; NCD: noncommunicable disease; HTN: hypertension; DM: diabetes mellitus; COR: crude odds ratio; CI: confidence interval; AOR: adjusted odds ratio; ART: antiretroviral therapy; 3TC: lamivudine; Efv: Efavirenz; CD4+: cluster differentiation 4+; BMI: body mass index; TDF: tenofovir; AZT: zidovudine.

<sup>a</sup> $p < 0.05$ .

<sup>b</sup> $p < 0.01$ .

<sup>c</sup>Dropped in the final model.

regimens containing TDF was negatively associated with HIV-hypertension comorbidity (Table 4).

The odds of having hypertension was 4.2 times and 6.8 times higher among in the age group between 35 years and 54 years (AOR 4.24; 95% CI: 1.72–10.45) and 55+ years (AOR 6.79; 95% CI: 1.94–15.12), respectively, compared to the age between 18 years and 34 years. The odds of having hypertension among patients having BMI 18.5–24.9 (AOR 2.49; 95% CI: 1.01–6.15) and greater than or equals 25 (AOR 4.27; 95% CI: 1.55–8.75) were 2.5 and 4.2 times higher, respectively, compared to those participants having a BMI less than 18.5. The odds of having hypertension was significantly lower among participants who took ART-drug-regimen-containing TDF (AOR

0.53; 95% CI: 0.29–0.95) and second-line ART drug regimens containing TDF (AOR 0.20; 95% CI: 0.06–0.65) compared to that of AZT-containing regimens (Table 4).

### HIV-DM comorbidity

Similarly, old age, higher BMI index, and long duration on ART were the factors significantly associated with HIV-DM comorbidity. However, unlike HIV-hypertension comorbidity ART regimens containing TDF increased the risk of HIV-diabetes comorbidity (Table 5).

The odds of having DM among older patients aged 55+ (AOR 5.28; 95% CI: 1.47–10.99) was 5.3 times higher compared to the age between 18 years and 34 years.

**Table 4.** Factors associated with HIV-hypertension comorbidity among adults living with HIV in Bahir Dar city, 2018.

Variables	Hypertension comorbid with HIV		COR	95 % CI	AOR	95 % CI
	Yes (%)	No (%)				
Sex	Male	36 (17.5)	170 (82.5)	1.55	0.95–2.52	
	Female	41 (12.0)	300 (88.0)	1		
Age category	18–34	6 (3.8)	154 (96.0)	1		
	35–54	51 (14.7)	295 (85.3)	4.44	1.86–10.57	4.24 1.72–10.45 <sup>b</sup>
	55+	20 (48.8)	21 (51.2)	10.4	6.82–18.78	6.79 1.94–15.12 <sup>b</sup>
Occupation	Employed	17 (11.5)	131 (88.5)	1		
	Merchant	7 (7.4)	87 (92.6)	0.62	0.25–1.56	
	Housewife	28 (21.7)	101 (78.3)	2.14	1.11–4.12	
	Daily laborer	14 (9.0)	141 (91.0)	0.76	0.36–1.61	
	Others	11 (52.4)	10 (47.6)	3.48	0.97–12.91	
Marital status	Single	2 (3.9)	49 (96.1)	1		
	Married	41 (13.2)	269 (86.8)	3.73	0.88–15.95	
	Divorced	15 (15.5)	82 (84.5)	4.48	0.93–20.44	
	Widowed	19 (21.3)	70 (78.7)	6.65	1.48–9.86	
Monthly income (Birr)	< 1000	30 (13.5)	193 (86.5)	1		
	1000–3000	25 (12.1)	181 (87.9)	0.89	0.50–1.57	
	>3000	22 (18.6)	96 (81.4)	1.474	0.81–2.69	
Alcohol use	Yes	22 (21.6)	80 (78.4)	1.95	1.13–3.38	
	No	55 (12.4)	390 (87.6)	1		
Physical exercise	Yes	4 (5.6)	67 (94.4)	1		
	No	73 (15.3)	403 (84.7)	3.03	1.07–8.58	
ART drug regimen	AZT + 3TC + Nev/Efv	44 (18.6)	192 (81.4)	1		
	TDF + 3TC + Nev/Efv	29 (11.6)	220 (88.4)	0.57	0.35–0.95	0.53 0.29–0.95 <sup>a</sup>
	Second-line regimens	4 (6.5)	58 (93.5)	0.30	0.10–0.87	0.20 0.06–0.65 <sup>b</sup>
Duration on ART (years)	<5 year	16 (10.9)	131 (89.1)	1		
	5–10 years	39 (13.3)	255 (86.7)	1.25	0.67–2.33	
	>10 years	22 (20.8)	84 (79.2)	2.14	1.06–4.32	
CD4+ count (cell/mL)	<350	22 (11.2)	175 (88.8)	1		
	350–500	25 (16.3)	128 (83.7)	1.55	0.84–2.87	
	>500	30 (15.2)	167 (84.8)	1.43	0.79–2.58	
BMI	<18.5	8 (7.1)	104 (92.9)	1		
	18.5–24.9	46 (13.6)	292 (86.4)	2.05	0.94–4.48	2.49 1.01–6.15 <sup>a</sup>
	25+	23 (23.7)	74 (76.3)	4.04	1.71–9.53	4.27 1.55–8.75 <sup>b</sup>

HIV: human immunodeficiency virus; COR: crude odds ratio; CI: confidence interval; AOR: adjusted odds ratio; ART: antiretroviral therapy; CD4+: cluster differentiation 4+; BMI: body mass index; TDF: tenofovir; AZT: zidovudine.

<sup>a</sup>*p* < 0.05.

<sup>b</sup>*p* < 0.01.

Moreover, the odds of having DM among those having BMI greater than or equals 25 (AOR 3.61; 95% CI: 1.07–8.11) were 3.6 times higher compared to those having BMI less than 18.5. The odds of having DM was significantly lower among participants who took TDF-containing first-line ART (AOR 0.35; 95% CI: 0.15–0.84), but it was higher among those who took second-line ART (AOR 2.42; 95% CI: 1.00–5.85). The odds of having DM among those who have taken ART for more than 10 years was 7 times (AOR 7.36; 95% CI: 2.79–8.46) higher compared to those who have been on ART for less than 5 years (Table 5).

## Discussion

The magnitude of HIV-hypertension and HIV-diabetes comorbidity was high. Advanced age, type of ART

regimen, and high BMI increased the odds of having NCDs among HIV-positive adults. The study also revealed that HIV patients with coexisting chronic NCDs were being managed in isolated and fragmented fashion.

NCDs comorbidity is emerging problems in developing populations, including those living with HIV due to improving life expectancy and other factors.<sup>23</sup> Management of HIV-NCDs comorbidity is much more complicated and demanding for the already resource-constrained health systems.<sup>24</sup> Not only living with HIV, but also taking ART drugs is related to the incidences of HIV-NCDs comorbidity.<sup>25</sup>

In this study, the magnitude of NCDs (hypertension and/or DM, 19.6% (95% CI: 16–23)) among adult patients on ART follow-up was high. The magnitude of this study is consistent with other studies done in Zimbabwe (19.6% with 95% CI: 17.3–22.2)<sup>26</sup> and South Africa (22.6% with

**Table 5.** Factors associated with HIV-DM comorbidity among adults living with HIV in Bahir Dar city, 2018.

Variables	DM comorbid with HIV		COR	95% CI	AOR	95 % CI
	Yes (%)	No (%)				
Sex	Male	23 (11.2)	183 (88.8%)	1.66	0.91–3.03	
	Female	24 (7%)	317 (93%)	1		
Age Category	18–34	5 (3.1%)	155 (96.9%)	1		
	35–54	31 (9%)	315 (91%)	3.05	1.16–7.99	1.35 0.46–3.93
	55+	11 (26.8%)	30 (73.2%)	8.37	3.68–12.08	5.28 1.47–10.99 <sup>a</sup>
Occupation	Employed	10 (6.8%)	138 (93.2%)	1		
	Merchant	10 (10.6%)	84 (89.4%)	1.64	0.66–4.11	
	Housewife	16 (12.4%)	113 (87.6%)	1.95	0.85–4.47	
	Daily laborer	6 (3.9%)	149 (96.1%)	0.56	0.19–1.57	
	Others	5 (23.8%)	16 (76.2%)	1.31	0.83–10.20	
Marital status	Single	4 (7.8%)	47 (92.2%)	1		
	Married	24 (7.7%)	286 (92.3%)	0.98	0.33–2.97	
	Divorced	9 (9.3%)	88 (90.7%)	1.20	0.35–4.11	
	Widowed	10 (11.2%)	79 (88.8%)	1.48	0.44–5.01	
Monthly income (Birr)	<1000	19 (8.5%)	204 (91.5%)	1		
	1000–3000	12 (5.8%)	194 (94.2%)	0.66	0.31–1.40	
	>3000	16 (13.6%)	102 (86.4%)	1.68	0.83–3.41	
Alcohol use	Yes	15 (14.7%)	87 (85.3%)	2.23	1.15–4.28	
	No	32 (7.2%)	413 (92.8%)	1		
Physical exercise	Yes	1 (1.4%)	70 (98.6%)	1		
	No	46 (9.7%)	430 (90.3%)	7.49	1.02–15.18	
ART drug regimen	AZT + 3TC + Nev/Efv	23 (9.7%)	213 (90.3%)	1		
	TDF + 3TC + Nev/Efv	10 (4.0%)	239 (96.0%)	0.38	0.18–0.83	0.35 0.15–0.84 <sup>a</sup>
	Second-line regimens	14 (22.6%)	48 (77.4%)	2.70	1.29–5.63	2.42 1.00–5.85 <sup>a</sup>
Duration on ART (in years)	<5 year	3 (2.0%)	144 (98.0%)	1		
	5–10 years	19 (6.5%)	275 (93.5%)	3.32	0.67–2.33	2.42 0.66–8.87
	>10 years	25 (23.6%)	81 (76.4%)	8.81	4.38–15.59	7.36 2.79–18.46 <sup>b</sup>
CD4+ count (cell/mL)	<350	13 (6.6%)	184 (93.4%)	1		
	350–500	13 (8.5%)	140 (91.5%)	1.31	0.59–2.94	
	>500	21 (10.7%)	176 (89.3%)	1.69	0.82–3.48	
BMI	<18.5	5 (4.5%)	107 (95.5%)	1		
	18.5–24.9	27 (8.0%)	311 (92.0%)	1.86	0.69–4.95	1.87 0.61–5.66
	25+	15 (15.5%)	82 (84.5%)	3.92	1.37–6.21	3.61 1.07–8.11 <sup>a</sup>

HIV: human immunodeficiency virus; DM: diabetes mellitus; COR: crude odds ratio; CI: confidence interval; AOR: adjusted odds ratio; ART: antiretroviral therapy; CD4+: cluster differentiation 4+; BMI: body mass index; TDF: tenofovir; AZT: zidovudine.

<sup>a</sup> $p < 0.05$ .

<sup>b</sup> $p < 0.001$ .

95% CI: 22.1–23.1).<sup>8</sup> Hypertension and DM are a growing problem in HIV-infected adults and are the leading risk factors for mortality.<sup>25</sup> There is evidence that the prevalence of hypertension and elevated blood glucose levels in the African population was high,<sup>27,28</sup> showing an increasing trend. The increasing trend of these diseases and other NCDs is due to adverse environmental conditions, increasing urbanization, and lifestyle changes in the urban setting of developing countries.<sup>24</sup> The prevalence of hypertension in our study was 14.1%. Prevalence rates in the general population in Ethiopia have been reported as between 16%<sup>29</sup> and 19.6%.<sup>30</sup> The prevalence of hypertension in patients on ART has been reported as 17.1%<sup>13</sup> in other studies. In light of this, our findings show a lower prevalence of hypertension as compared to the rate in the general population and among patients taking ART in the region. It was, however, consistent with other similar studies

conducted in Ethiopia,<sup>31</sup> Kenya,<sup>32</sup> and other African countries.<sup>7,22</sup> The result is also consistent with global studies in general.<sup>33</sup> The possible explanation of having an increased prevalence of hypertension in HIV-infected adults could be due to chronic inflammatory and immune reconstitution syndromes caused by ART drugs<sup>34,35</sup> and the relation between HIV-specific factors and ART<sup>25</sup> rather than a direct effect of HIV drugs on BP.

This study revealed that the magnitude of DM was 8.6% (95% CI: 6–11) which is consistent with the study done conducted in HIV-infected adults in eastern Ethiopia,<sup>31</sup> Cambodia,<sup>36</sup> and Canada.<sup>37</sup> However, this result is higher than the national prevalence of DM (3.8%) in the general population reported by WHO in 2016<sup>28</sup> and the total prevalence of DM in Ethiopian adult population (20–79 years; 5–6%) as reported by International Diabetes Federation in 2017.<sup>38</sup> Therefore, the study has a high prevalence of DM



in HIV-positive patients compared to the general population of Ethiopia. This could be due to HIV- and ART-related factors. It is known that people with HIV have an increased risk of developing a number of serious health problems due to a compromised immune system and the changes in metabolic derangements. Moreover, some ART drugs such as protease inhibitors have diabetogenic effects. Evidences documented that being HIV positive and exposure to ART were found to be the factors associated with diabetes.<sup>31,39–41</sup>

Studies revealed that the risk of NCD has considerably increased as age increases.<sup>42,43</sup> Being older, obesity, long duration of ART, and type of ART regimen were found to be predictors of HIV-NCD comorbidity in the present study. Different studies reported that the prevalence of NCD increased when age increases. For instance, studies reported that alterations in glucose tolerance were more prevalent among patients who were older age.<sup>44,45</sup> Obesity was also one of the modifiable predictors of HIV-NCD comorbidity in this study which is supported by other studies.<sup>46,47</sup> The fact that obese individuals have altered metabolic processes, follow sedentary lifestyle, or affected by some ART drugs, there is a tendency that they would develop hypertension or diabetes or both.

ART drug exposure and duration of exposure were associated with comorbidity in the present study. Duration of exposure to ART drug for more than 10 years was associated with increased DM comorbidity which is consistent with other studies.<sup>48,49</sup> Overall, the study participants had considerable ART experience with more than two-third of the participants having been on treatment for at least 5 years and near one-fourth for 10 years or more. As patients stay longer, the probability of having NCD increases as their age increases. In this study, even though second-line ART drug regimens were least the prescribed drug, it was one of the associated factors with all NCDs and DM comorbidity. However, it was 80% less likely to develop hypertension comorbidity. The relationship between ART and the development of hypertension remains controversial. Studies conducted in Norway and Spain showed that the longer patients took highly active antiretroviral therapy, the more likely that they will develop hypertension.<sup>32,50</sup> This may be due to numerous underlying physiological changes that occur due to aging or the effect of antiretroviral drugs on the development of risk of chronic diseases, including hypertension and diabetes.<sup>13</sup>

The United Nations' Sustainable Development Goal 3 requires countries to move toward ensuring that all people and communities have access to health services that are of high quality, integrated, and people-centered.<sup>51,52</sup> Both HIV and noncommunicable require regular appointments, medication adherence support, side-effect management, laboratory monitoring, defaulter tracing as well as screening and education. In Ethiopia, health services are organized around single conditions and hospital doctors who specialize in one condition or area of the body often manage patients with one condition in mind, although many

people, especially as they get older, will end up with more than one diagnosed condition. Patients with several conditions will have to visit different specialists at different times and may be in different settings. General practitioners and other clinicians are oriented with a system of employing the conventional one-size-for-all chronic care guidelines in fragmented and siloed fashion.<sup>53,54</sup> Also this study revealed that the health system is poorly configured to diagnose NCDs among HIV-positive people and service delivery was not integrated to respond to the needs of HIV-positive individuals comorbid with NCDs. This may result in the provision of fragmented care that does not take account of the impact of comorbidity on a person's quality of life and their priorities, ultimately leading to negative health outcomes, including mortality.<sup>55</sup>

The study measured the prevalence of common NCDs (hypertension and DM) and associated factors in HIV patients. This study advances the state of knowledge of comorbidity prevalence and strength of the health system in responding to the evolving needs of comorbid individuals. To the best of our knowledge, this study is the first ever attempt pursued to explore the existing health service landscape for HIV-NCDs comorbid population groups.

The findings provide valuable information that can be used to improve HIV care through medical evaluation to detect and manage these diseases. This study has some limitations. Due to the lack of feasible methods of assessing other NCDs, we only ascertained the two most commonly reported NCDs (hypertension and diabetes) in the country and this might have underestimated the burden of HIV-NCDs comorbidity in the study area. A cross-sectional design does not establish temporal relationships between explanatory variables and outcome variable, so the observed associations might not necessarily be causal and the results may not represent the statuses in the general population in Ethiopia

## Conclusions

The magnitude of HIV-hypertension and/or HIV-diabetes comorbidity was high in the study area. Being older (age 55+), taking second-line ART drug regimens, taking ART for a long duration (10 years or more), and obesity (BMI  $\geq$  25) increased the odds of having NCDs in HIV-positive adults. This study also revealed that people living with HIV-NCDs comorbidity did not get integrated health care and treatment service of NCDs in ART clinics.

We, therefore, recommended that HIV patients should be screened for coexisting NCDs. Addressing modifiable factors such as obesity through counseling on dietary intake and weight management and providing an integrated person-centered care would help to improve the quality of life and longevity of patients on ART. Further studies are needed on the effect of TDF containing ART regimen, including second-line ART regimens on HIV-NCDs comorbidity.

## Acknowledgments

The authors want to thank Bahir Dar University for funding to cover the cost of data collection. We also extend our acknowledgment to Amhara Regional Health Bureau, Felege Hiwot referral hospital, Bahir Dar health center, Han health center, and staff working in ART clinic for their cooperation and support for data collection. We would like to thank supervisors and data collectors for their commitment and management of data collection and participants for their consent to participate and provision of information for the study.

## Author contributions

ZG designed the study and oversaw its implementation, performed the analysis, was the primary author, and approved the final version of the manuscript. TA and MA contributed to the concept of the study, oversaw its implementation, helped guide the analysis, participated in the writing, and approved the final version of the manuscript. FA involved in designing the concept of the study and data analysis, participated in the development of the manuscript, and approved the final version of the manuscript. All authors read and approved the final manuscript.


## Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

## Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: There was no fund secured for the study, but Bahir Dar University covered the expense related to data collection.

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## Supplemental material

Supplemental material for this article is available online.

## References

- Oni T and Unwin N. Why the communicable/non-communicable disease dichotomy is problematic for public health control strategies: implications of multi morbidity for health systems in an era of health transition. *Int Health* 2015; 7: 390–399.
- Petersen M, Yiannoutsos CT, Justice A, et al. Observational research on NCDs in HIV-positive populations: conceptual and methodological considerations. *J Acq Imm Def Syndr* 2014; 67: S8.
- World Health Organization. *Report on the status of major health risk factors for non communicable diseases*. Geneva: WHO African Region, 2016.
- Ananworanich J and Avihingsanon A. HIV and non-communicable diseases: the Asian perspective. *J Acq Imm Def Syndr* 2014; 67: S99–S103.
- Bloomfield GS, Khazanie P, Morris A, et al. HIV and non-communicable cardiovascular and pulmonary diseases in low-and middle-income countries in the ART era: what we know and best directions for future research. *J Acq Imm Def Syndr* 2014; 67: S40.
- Narayan KV, Miotti PG, Anand NP, et al. HIV and non-communicable disease comorbidities in the era of antiretroviral therapy: a vital agenda for research in low-and middle-income country settings. *J Acq Imm Def Syndr* 2014; 67: S2–S7
- Bigna JJR, Sime PSD and Koulla-Shiro S. HIV related pulmonary arterial hypertension: epidemiology in Africa, physiopathology, and role of antiretroviral treatment. *AIDS Res Ther* 2015; 12: 36.
- Oni T, Youngblood E, Boule A, et al. Patterns of HIV, TB, and non-communicable disease multi-morbidity in peri-urban South Africa – a cross sectional study. *BMC Infect Dis* 2015; 15: 20.
- Hemkens LG and Bucher HC. HIV infection and cardiovascular disease. *Eur Heart J* 2014; 35(21): 1373–1381.
- Kalyesubula R, Wearne N, Semitala FC, et al. HIV-associated renal and genitourinary comorbidities in Africa. *J Acq Imm Def Syndr* 2014; 67: S68–S78.
- Young F, Critchley JA, Johnstone LK, et al. A review of comorbidity between infectious and chronic disease in Sub Saharan Africa: TB and diabetes mellitus, HIV and metabolic syndrome, and the impact of globalization. *Glob Health* 2009; 5: 9.
- Maes KC, Shifferaw S, Hadley C, et al. Volunteer home-based HIV/AIDS care and food crisis in Addis Ababa, Ethiopia: sustainability in the face of chronic food insecurity. *Health Policy Plan* 2010; 26: 43–52.
- Abebe SM, Getachew A, Fasika S, et al. Diabetes mellitus among HIV-infected individuals in follow-up care at university of Gondar hospital, northwest Ethiopia. *BMJ Open* 2016; 6: e011175.
- Chang AY, Gomez-Olive FX, Manne-Goehler J, et al. Multi morbidity and care for hypertension, diabetes and HIV among older adults in rural South Africa. *Bull World Health Organ* 2019; 97: 10–23.
- George S, McGrath N and Oni T. The association between a detectable HIV viral load and non-communicable diseases comorbidity in HIV positive adults on antiretroviral therapy in Western Cape, South Africa. *BMC Infect Dis* 2019; 19: 348.
- Xu X, Mishra GD and Jones M. Mapping the global research landscape and knowledge gaps on multi morbidity: a bibliometric study. *J Glob Health* 2017; 7: 010414.
- Patel P, Speight C, Maida A, et al. Integrating HIV and hypertension management in low-resource settings: lessons from Malawi. *PLoS Med* 2018; 15: e1002523.
- Tassie Wegedie K. Households solid waste generation and management behavior in case of Bahir Dar city, Amhara national regional state, Ethiopia. *Cogent Environ Sci* 2018; 4: 1471025.
- World Health Organization. *The WHO STEPwise approach to non communicable disease risk factor surveillance (STEPS)*. Geneva: WHO, 2009.

20. World Health Organization. *Definition, diagnosis and classification of diabetes mellitus and its complications. Report of a WHO Consultation. Part 1: diagnosis and classification of diabetes mellitus (WHO/NCD/NCS/99.2)*. Geneva: World Health Organization, 1999.
21. World Health Organization. *Global recommendations on physical activity for health*. Geneva: World Health Organization, 2010.
22. Patel P, Rose CE, Collins PY, et al. Non communicable diseases among HIV-infected persons in low-income and middle-income countries: a systematic review and meta-analysis. *Aids* 2018; 32: S5–S20.
23. WHO. *World report on ageing and health*. Geneva: World Health Organization, 2015.
24. Koopman JJE, van Bodegom D, Ziem JB, et al. An emerging epidemic of non communicable diseases in developing populations due to a triple evolutionary mismatch. *Am J Trop Med Hyg* 2016; 94: 1189–1192.
25. Fahme SA, Bloomfield GS and Peck R. Hypertension in HIV-infected adults: novel pathophysiologic mechanisms. *Hypertension (Dallas, Tex: 1979)* 2018; 72: 44–55.
26. Magodoro IM, Esterhuizen TM and Chivese T. A cross-sectional, facility based study of comorbid non-communicable diseases among adults living with HIV infection in Zimbabwe. *BMC Res Note* 2016; 9: 379.
27. Atun R. Decisive action to end apathy and achieve 25 × 25 NCD targets. *Lancet* 2014; 384: 384–385.
28. World Health Organization. *Global report on diabetes*. Geneva: World Health Organization, 2016.
29. EPHI. *Ethiopia steps report on risk factors for non-communicable diseases and prevalence of selected NCDs*. Ethiopian Public Health Institute, Addis Ababa, Ethiopia, 2016.
30. Kibret KT and Mesfin YM. Prevalence of hypertension in Ethiopia: a systematic meta-analysis. *Publ Health Rev* 2015; 36: 14.
31. Ataro Z, Ashenafi W, Fayera J, et al. Magnitude and associated factors of diabetes mellitus and hypertension among adult HIV-positive individuals receiving highly active antiretroviral therapy at Jugal Hospital, Harar, Ethiopia. *HIV/AIDS (Auckland, NZ)* 2018; 10: 181–192.
32. Benzekri NA, Seydi M, Doye IN, et al. Increasing prevalence of hypertension among HIV-positive and negative adults in Senegal, West Africa, 1994–2015. *PLoS One* 2018; 13: e0208635.
33. Xu Y, Chen X and Wang K. Global prevalence of hypertension among people living with HIV: a systematic review and meta-analysis. *J Am Soc Hypertens* 2017; 11: 530–540.
34. 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.
35. Blodget E, Shen C, Aldrovandi G, et al. Relationship between microbial translocation and endothelial function in HIV infected patients. *PLoS One* 2012; 7: e42624.
36. Chhoun P, Tuot S, Harries AD, et al. High prevalence of non-communicable diseases and associated risk factors amongst adults living with HIV in Cambodia. *PLoS One* 2017; 12: e0187591.
37. Kendall CE, Wong J, Taljaard M, et al. A cross-sectional, population-based study measuring comorbidity among people living with HIV in Ontario. *BMC Publ Health* 2014; 14: 161.
38. IDF. *IDF diabetes atlas*. Brussels: International Diabetes Federation, 2017.
39. Brown TT, Cole SR, Li X, et al. Antiretroviral therapy and the prevalence and incidence of diabetes mellitus in the multi-center AIDS cohort study. *Arch Intern Med* 2005; 165: 1179–1184.
40. Tien PC, Schneider MF, Cole SR, et al. Antiretroviral therapy exposure and incidence of diabetes mellitus in the women's interagency HIV study. *Aids* 2007; 21: 1739–1745.
41. Han WM, Jiamsakul A, Kiertiburanakul S, et al. Diabetes mellitus burden among people living with HIV from the Asia-Pacific region. *J Int AIDS Soc* 2019; 22: e25236.
42. Cardoso SW, Torres TS, Santini-Oliveira M, et al. Aging with HIV: a practical review. *Braz Infect Dis* 2013; 17: 464–479.
43. Negin J, Mills EJ and Bärnighausen T. Aging with HIV in Africa: the challenges of living longer. *AIDS (London, England)* 2012; 26: S1.
44. Nsakashalo-Senkwe M, Siziya S, Goma FM, et al. Combined prevalence of impaired glucose level or diabetes and its correlates in Lusaka urban district, Zambia: a population based survey. *Int Arch Med* 2011; 4: 2.
45. Rasmussen LD, Mathiesen ER, Kronborg G, et al. Risk of diabetes mellitus in persons with and without HIV: a Danish nationwide population-based cohort study. *PLoS One* 2012; 7: e44575.
46. Denué A, Muazu J, Gashau W, et al. Effects of highly active antiretroviral therapy (HAART) on blood pressure changes and its associated factors in HAART naive HIV-infected patients in north eastern Nigeria. *Arch Appl Sci Res* 2012; 4: 1447–1452.
47. Dusara P, Bussmann H, Lima C, et al. *Predictors of hypertension among HIV infected adults in Botswana, Africa*. Bethesda: Federation of American Societies for Experimental Biology, 2009.
48. Dillon DG, Gurdasani D, Riha J, et al. Association of HIV and ART with cardio metabolic traits in sub-Saharan Africa: a systematic review and meta-analysis. *Int J Epidemiol* 2013; 42: 1754–1771.
49. Nduka C, Stranges S, Sarki A, et al. Evidence of increased blood pressure and hypertension risk among people living with HIV on antiretroviral therapy: a systematic review with meta-analysis. *J Hum Hypertens* 2016; 30: 355.
50. Palacios R, Santos J, Garcia A, et al. Impact of highly active antiretroviral therapy on blood pressure in HIV-infected patients. A prospective study in a cohort of naive patients. *HIV Med* 2006; 7: 10–15.

51. WHO. *Framework on integrated, people-centred health services*. Geneva: World Health Organization, 2016.
52. WHO. *Integrated care models: an overview*. Geneva: World Health Organization, 2016.
53. Abraham O, Linnander E, Mohammed H, et al. A patient-centered understanding of the referral system in Ethiopian primary health care units. *PLoS One* 2015; 10: e0139024.
54. G/Michael M, Dagnaw W, Yadeta D, et al. *Ethiopian national guideline on major NCDs 2016*. Ethiopian Federal Ministry of Health, Addis Ababa, Ethiopia, 2016.
55. Broughton EI, Muhire M, Karamagi E, et al. Cost-effectiveness of implementing the chronic care model for HIV care in Uganda. *Int J Qual Health Care* 2016; 28: 802–807.