Cardiometabolic syndrome in HIV-positive and HIV-negative patients at Zewditu Memorial Hospital, Addis Ababa, Ethiopia: a comparative cohort study

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Background **Cardiometabolic syndrome (CMetS) has recently emerged as a serious public health concern, particularly for individuals living with chronic conditions. This study aimed to determine the incidence and prevalence of CMetS, as well as the risk factors linked with it, in HIV-positive and HIV-negative adult patients.**

Methods **A comparative cohort study was designed. The National Cholesterol Education Program (NCEP) and the International Diabetes Federation (IDF) tools were used to determine the outcome variables. Association studies were done using logistic regression.**

Result **CMetS was found to have a greater point and period prevalence, and incidence estimation in HIV-negative than HIV+ patients using both the NCEP and the IDF tools. Using the NCEP tool, the risk of obesity was 44.1% [odds ratio (OR)=0.559, 95% confidence interval (CI), (0.380–0.824); *P*=0.003] lower in HIV+ than in HIV-negative participants. By contrast, no apparent difference was noted using the IDF tool. Similarly, hyperglycemia [OR=0.651, 95% CI (0.457–0.926); *P*=0.017], and hypertension [OR=0.391, 95% CI (0.271–0.563); *P*<0.001] were shown to be lower in HIV+ patients than HIV-negative patients by 34.9% and 60.9%, respectively. The study revealed significant variation in all biomarkers across the follow-up period in both HIV+ and HIV-negative participants, except for SBP.**

Conclusions **CMetS caused more overall disruption in HIV-negative people with chronic diseases than in HIV-positive people. All of the indicators used to assess the increased risk of CMetS were equally meaningful in HIV+ and HIV-negative subjects. *Cardiovasc Endocrinol Metab* 12: 1–20 Copyright © 2022 The Author(s). Published by Wolters Kluwer Health, Inc.**

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Introduction

Cardiometabolic syndrome (CMetS) is an umbrella term used to broadly describe a cluster of diseases, including diabetes, obesity, hypertension, dyslipidemia, and other heart, kidney, prothrombotic, and inflammatory abnormalities [1,2].

CMetS has recently emerged as a major health concern, particularly for patients with chronic illnesses like HIV [3–6]. CMetS is most common in those over 40 years of age, having comorbidities, a sedentary lifestyle, obesity, physical and cognitive limitations, substance use, hereditary vulnerability, low socioeconomic status, consumption of genetically modified foods, and a poor quality of life [7–12]. It is also becoming an acknowledged component in childhood and adolescent overweight and obesity [13,14].

Millions of people worldwide are affected by HIV/AIDS and other chronic diseases, and CMetS is increasingly becoming a major concern that necessitates prevention, routine monitoring, and proper treatment [15,16]. In the sub-Saharan African region (SSA), where two-thirds of the world's HIV-positive people live, HIV has established itself as a cause of chronic illness and high mortality [17]. Chronic diseases and their repercussions are therefore expected to be on the rise throughout Africa, putting a strain on the limited resources available for healthcare delivery systems [18–21].

Though much-anticipated vaccines to eradicate HIV have yet to appear [22,23], existing combination antiretroviral therapy (cART), which is designed to slow disease progression and prolong survival, is facing significant challenges from non-adherence, virus resistance, drug–drug interactions, side effects, switching medication, pregnancy-related factors, and the presence of

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overlapping chronic comorbidities in the form of CMetS [24–31].

Even though CMetS is well known to be a concern to both HIV+ and HIV-negative people [1,32–34], few studies comparing the burden in both groups are available in the literature. Moreover, the studies focused on specific disease derangements such as carotid artery intima-media thickening [35], blood pressure [36], arterial wave reflection [37], anthropometric alterations [38], and the male [39] or female gender [39]; rather than making a comprehensive comparison. Thus, one could say that the burden of CMetS has not been thoroughly examined.

Even though SSA is considered the world epicenter of HIV/AIDS, there are currently few studies concentrating on CMetS and comparisons between HIV+ and HIV-negative patients [36,40,41]. Ethiopia, as one of those countries, lacks such studies, although investigations on CMetS are thought to be both necessary and urgent to develop effective prevention and control strategies [42].

Moreover, if findings emanating from such studies are effectively translated into clinical practice, there will be an overall improvement in healthcare service delivery as well as faster patient recovery and fewer hospitalizations [43,44]. The objective of this study was therefore to see how common CMetS is and determine its prevalence, incidence, biomarkers, and related variables in HIV+ and HIV-negative patients.

Methods

Study design, period, and setting

A hospital-based comparative cohort study was conducted from 25 January 2019 to 25 February 2021 among patients visiting the HIV and adult ambulatory clinics of Zewditu Memorial Hospital (ZMH), Addis Ababa, Ethiopia. This hospital has been a pioneer in establishing and launching ART care services in Ethiopia since 2003 [45]. It also provides other clinical services and palliative care for the general population, in addition to HIV counseling and testing, sexually transmitted infection services, and post-exposure prophylaxis services. As a general hospital, there are also all-round services offered through the different clinics, departments, and wards. Currently, ZMH provides service to over 1163 HIV+ and more than 3000 HIV-negative patients every month.

Population and sample size determination

Patients visiting ZMH for HIV and other chronic conditions formed the source population. The study population consisted of eligible patients who satisfy the inclusion criteria. All patients age 18 years and above, with a minimum of three completed appointments, willing to participate in the study and provide written consent were included in the study. Severely ill patients, and pregnant and breastfeeding patients during the study period were excluded.

The following sample size estimation formula for independent cohort studies was used to calculate the sample size for the study [46].

$$n = \frac{\left[\begin{array}{c} Z_{1-\alpha/2}\sqrt{(1+1/m)p^*(1-p)} \\ +Z_{1-\beta}\sqrt{p_0{}^*(1-p_0/m)p_1(1-p_1)} \end{array}\right]^2}{(p_0-p_1)^2}. \quad (1)$$

Given a two-sided significance threshold (1-alpha) of 95 percent, a power (1-beta, percent chance of detecting) of 80 percent, a ratio of Unexposed/Exposed = 1, and a percentage of Exposed with Outcome of 11.3% [41], a sample size of 590 was calculated. Adding a 5% contingency, the sample size increased to 620, with 320 exposed and 300 unexposed participants. A systematic sampling technique was used to recruit study participants.

Data collection

Detailed information about the participants was obtained through laboratory tests, clinical examination and measurements, patient interviews, and chart review. The questionnaire for a face-to-face interview was adapted from the structured questionnaire used by the WHO stepwise approach to non-communicable disease risk factor surveillance (STEPS – 2014) [47]. The questionnaire includes information related to sociodemographic characteristics [age, gender, waist circumferences (WCs), height, weight, BMI, religion, civil status, address, educational level, occupation, and monthly income]; substance use (tobacco use, alcohol consumption, coffee use, and use of the khat plant); and clinical measurements (blood pressure, blood sugar, lipid profile, and use of any medications).

Study procedure

All participants recruited in this study were categorized as (1) HIV+: those registered at follow-up care of ART clinic, and (2) HIV-negative: those registered at follow-up care of adult ambulatory clinics. All patients who had CMetS at baseline (point prevalence) or later at any time (incidence or period prevalence) were considered study participants. There are five commonly used definitions for the determination of CMetS [5,48,49]. However, we used two of the tools considering their applicability and feasibility: The National Cholesterol Education Adult Treatment Program III (NCEP-ATP III) – 2005 or NCEP or NCEP – 2005, and The International Diabetes Federation (IDF) – 2005 or simply IDF.

The following biomarkers were considered during calculating CMetS using the NCEP tool: WC in inch (>40 inches in male and >35 inches in female); lipid-1 [triglycerides (TGs) >150 mg/dL or >1.7 mmol] or use of any lipid-lowering drug/s; lipid-2 [high-density lipoprotein (HDL-C) <40 mg/dL or <1.034 mmol in male, and <50 mg/dL or <1.293 mmol in female] or use of any lipid-lowering drug/s; fasting blood glucose (FBS) >100 mg/dL or >5.56 mmol or use of any blood glucose-lowering medications; SBP

>130 mmHg, and DBP >85 mmHg or use of any blood pressure-lowering medications (Annex 1, Supplemental Digital Content 1, *http://links.lww.com/CAEN/A36*).

The biomarkers used in the case of the IDF tool were similar to the NCEP except in two conditions (S1 Fig. 1): (1) WC was measured in cm and the cutoff values were lower than the NCEP (>94 cm in males or >80 cm in females) and (2) WC was considered as an absolute criterion for calculating CMetS by IDF, whereas there were no criteria set for the NCEP as per the guidelines.

Patients were reexamined at the 8th and 18th months after baseline data collection. The incidence and prevalence of CMetS were assessed using the five clinical definitions needed to determine CMetS according to the tools. These were hypertension, SBP > 130 mmHg and DBP > 85 mmHg or hypertension treatment; hyperglycemia, pre-prandial serum glucose >100 mg/dL, and/or diabetes treatment; dyslipidemia-1, serum TG >150 mg/dL, and/or lipid-lowering treatment; dyslipidemia-2, serum HDL-C <50 mg/dL in female or <40 mg/dL in male, and/or lipid-lowering treatment; and central obesity, using NCEP: (WC >35 inches in women or >40 inches in men) or using IDF (WC > 80 cm in women or >94 cm in men).

The NCEP-ATP III – 2005 confirms CMetS if any three of the five criteria are fulfilled. On the other hand, the IDF – 2005 confirms CMetS, if three of the five are fulfilled, one of the three scores must be the WC [5,50–52].

We used the NIH protocol for measuring WC instead of the WHO STEPS protocol due to the convenience of measuring [53]. BP was measured by Omron HEM 7203 (Omron Healthcare Co. Ltd., Kyoto, Japan). The devices were regularly calibrated for proper validation. A Mercury sphygmomanometer was also used for evaluating the accuracy of the devices. An appropriate BP arm cuff of the correct size was used before measurements were taken. Participants were allowed to sit and relax without talking for 5 min before BP measurement, and legs were uncrossed and the arm was supported at heart level during measurements. Three BP recordings were obtained from the right arm with an interval of 5 min and the mean was used for analysis [54,55]. Lipid profiles and glucose were analyzed using SIEMENS (Siemens Healthcare GmbH Henkestr, Erlangen, Germany) (Dimension EXL 200 Integrated Chemistry System), Omnia Health, North Road Chaoyang, Beijing, China (CS-T240 Auto-Chemistry Analyzer), and LipidPlus, Ellicott, Maryland, USA. Operational definitions used in the present study are included in the supporting information (Annex 2, Supplemental Digital Content 2, *http://links.lww.com/CAEN/A37*).

Data analysis

Data were coded, double-entered, and analyzed using IBM statistics software version 25 for Windows. All categorical variables were coded as 0 or 2 (for females, no responses, and HIV-negative) and 1 (for males, yes responses, and HIV-positive). The dependent variables were coded as dichotomous measurements and were coded as '0 or 2' for 'No-CMetS' and '1' for 'CMetS').

Descriptive statistics were used to present sociodemographic information, incidence, and prevalence data. Data were expressed as mean (±SD). The weighted odds ratios in a 2×2 contingency table were determined using the Mantel-Haenszel test. Logistic regression analysis was employed to determine the association of predictors with the outcome variables. Independent variables having a P value <0.20 in the bivariate logistic regression were entered into a multivariate logistic regression to control the effect of confounders.

Friedman analysis of variance (ANOVA) was used to compare the mean ranks between the related repeated measurements and results were presented in chi-square statistic (χ^2) value and the significance level ('Asymp. Sig'.) was set at $P < 0.05$. Since the Friedman test identifies only the presence of an overall difference among the repeated measurements, a post-hoc test using Wilcoxon signed-rank was conducted for all statistically significant results. The Bonferroni adjustment less than $0.05/3 = 0.017$ was then used to report significant values of the post-hoc analysis. Moreover, Cochran's Q test was used to determine the statistical difference of CMetS (burden of CMetS) at the three-time points (baseline, the 8th, and 18th month). Significant values were tested by McNemar's test, and results were reported by considering the Bonferroni adjustments. Except for the post-hoc analysis, in all parts of the analyses, a 95% CI and P value of <0.05 were considered statistically significant. For post-hoc analysis, the Bonferroni adjustment (less than P value divided by the degree of freedom) was considered significant.

Results

Enrolment

Of the 620 randomly selected participants for screening and baseline data, a total of 320 HIV+ and 300 HIV-negative patients were recruited. Thirty-two individuals from the HIV+ and 78 from the HIV-negative group refused to continue after consent was obtained. Baseline data were, therefore, complete for 288 HIV+ and 222 HIV-negative individuals. A total of 10 patients were missing from the first follow-up appointment at the 8th-month data collection period due to refusal (7 individuals) and clinical illnesses (3 individuals). Data were complete for 284 HIV+ and 216 HIV-negative patients at the 8th month of appointment. All the 'lost to follow-up' cases were from the HIV-negative group and the final 490 participants comprising 281 (55.1%) HIV+ and 209 (41%) HIV-negative participants completed the final 18th-month follow-up (Fig. 1).

Sociodemographic characteristics

Most participants in the HIV+ group were relatively younger (<45 years old, mean 43.5 ± 11.3) and high schoolers (grades 9–12); whereas those in the

HIV-negative group were relatively older (>45 years old, mean 50.7 ± 14.3) and college-educated. The majority of the participants came from Addis Ababa's Kirkos sub-city, where the study site is located. Substance use (tobacco smoking and alcohol consumption) was found to be more prevalent among HIV-negative than the HIV+ group. Chi-square analysis found significant variations in age, family history, traditional medicine (TM) use, educational status, monthly income, and coffee use between HIV+ and HIV-negative groups (Table 1).

Clinical characteristics

Prevalence and incidence of cardiometabolic syndrome

CMetS was found to have a greater point prevalence, period prevalence, and incidence estimation in HIV-negative than HIV+ patients using NCEP and IDF tools. Furthermore, the prevalence estimates obtained by IDF were typically higher than that of NCEP (Fig. 2).

HIV status and biomarkers

Table 2 presents biomarker measurements within the follow-up period. The majority of the biomarkers had mean values within the reference range. The mean values of SBP, TG, and HDL (male) were; however, above the reference range, with SBP and TG tending to be higher in HIV-negative than HIV+ patients in all the follow-up periods. HDL was higher at baseline in HIV-negative patients but became higher in HIV+ patients in the 8th and 18th follow-up periods (Table 2). Even though the mean WC remained within acceptable limits, it was slightly greater in the HIV+ group (significantly higher in males) as compared to the HIV-negative group.

In HIV-negative patients, the mean (SD) pre-prandial serum glucose level was significantly elevated at baseline, 143.66 (76.51); at the 8th month, 140.22 (73.17); and at the 18th month, 119.28 (41.40); while it remained within the normal range in HIV+ patients.

Using the NCEP tool, the Mantel–Haenszel test found that the risk of obesity was 44.1% [OR = 0.559, 95% CI (0.380–0.824); $P = 0.003$] lower in HIV+ than in HIV-negative participants. By contrast, no apparent difference was noted using the IDF tool. Similarly, hyperglycemia [OR = 0.651, 95% CI (0.457–0.926); $P = 0.017$] and hypertension [OR = 0.391, 95% CI (0.271–0.563); $P < 0.001$] were shown to be lower in HIV+ patients than HIV-negative patients by 34.9% and 60.9%, respectively. The results were likewise consistent between the 8th and 18th months of the follow-up period, as shown in Table 3.

Variations in biomarker measurements

Friedman's ANOVA was carried out to analyze the overall changes in biomarker distribution over the follow-up period, taking into account the time effect. The study revealed significant variation in all biomarkers across the follow-up period in both HIV+ and HIV-negative participants, except for SBP, which was not significantly different among the follow-up periods in HIV-negative patients (Table 4).

The mean rank demonstrated a significant increase in the prevalence of the biomarkers for WC, TG, HDL, and FBS on the 18th of the follow-up period. DBP had the highest mean rank during the 18th month of follow-up (Table 4).

According to a post hoc analysis using the Wilcoxon-Signed Ranks Test, there was no significant variation in WC measurements between the 8th and 18th months in HIV+ patients. There were no significant differences in SBP measurements between the baseline and 8th month, the 8th and 18th month, or the baseline and 18th month in HIV-negative patients. Furthermore, there were no substantial changes in DBP or HDL levels among HIV+ persons between baseline and 8th or baseline and 18th month. In the remaining cases, as well as for TG and FBS, there were significant disparities in measurements over the follow-up periods (Table 5).

HIV status vs. cardiometabolic syndrome

The Mantel-Haenszel test was also used to assess the risk of CMetS in both groups using both tools at all time points (Table 6). The analysis revealed that CMetS was significantly lower ($P < 0.05$) in the HIV+ group than in the HIV-negative group at each study point using both cardiometabolic assessment tools.

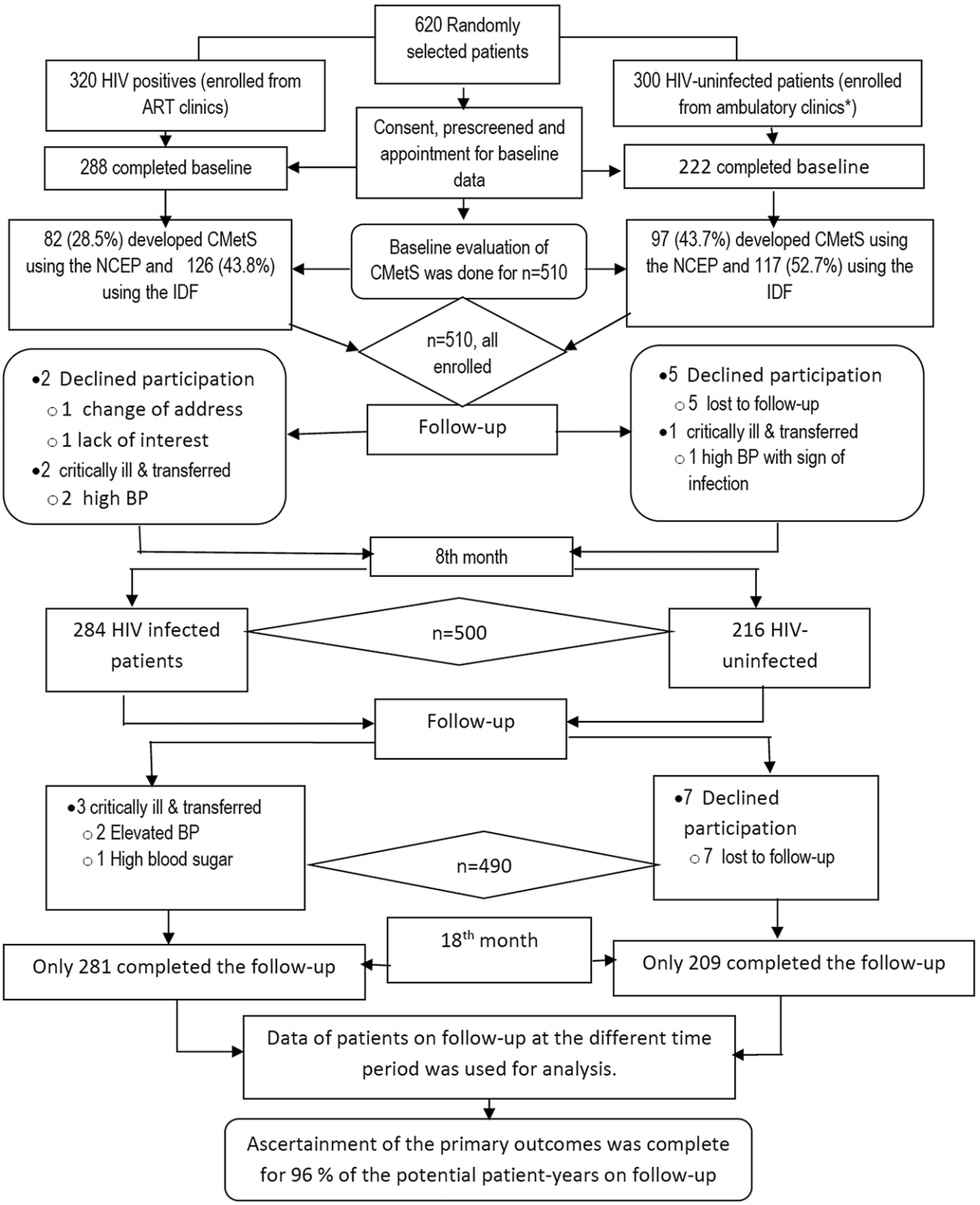
Cochran's Q test demonstrated that there was a considerable burden of CMetS in both HIV-negative and HIV+ patients using the NCEP (χ^2 (2) = 57.571, $P < 0.001$) as well as the IDF (χ^2 (2) = 6.846, $P < 0.033$) tool (Fig. 3).

McNemar's test must be performed as a post hoc analysis following Cochran's test to determine the relationships at each follow-up period. Accordingly, the test demonstrated that the burden of CMetS was considerably higher during the transition from the baseline to the 8th month as well as from the baseline to the 18th month using the NCEP tool. By contrast, no apparent changes were observed among the different transition time points using the IDF tool or during the 8th–18th months' transition using the NCEP tool (Fig. 4).

The relationship between cardiometabolic syndrome and predictors

Using bivariate and multivariate logistic regressions, the NCEP tool was used to explore the influence of cardiometabolic syndrome on predictor variables in HIV+ patients compared to HIV-negative and CMetS-free persons (Table 7).

Fig. 1



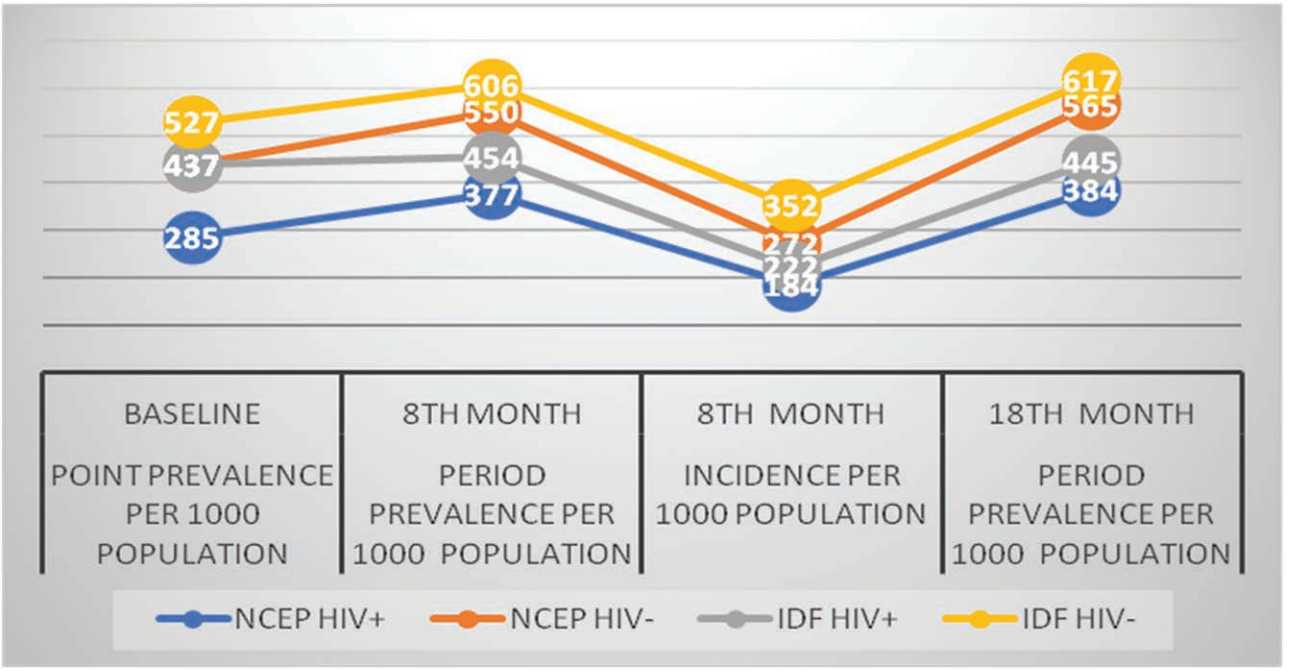
Flowchart for screening, enrolment, and follow-up of patients for cardiometabolic syndrome study at Zewditu Memorial Hospital in Addis Ababa, Ethiopia. ART, antiretroviral therapy; CMetS, cardiometabolic syndrome; IDF, International Diabetes Federation; NCEP, National Cholesterol Education Program.

Table 1 Sociodemographic characteristics of HIV-positive and HIV-negative patients on follow-up care at Zewditu Memorial Hospital, Addis Ababa, Ethiopia, 2021

Characteristics	Baseline (*n*=510)		χ^2 value	*P* value	8th month (*n*=500)		χ^2 value	*P* value	18th month (*n*=490)		χ^2 value	*P* value
	HIV+	HIV-negative			HIV+	HIV-negative			HIV+	HIV-negative		
Number, *n* (%)	288 (56.5)	222 (43.5)			284 (56.8)	216 (43.2)			281 (57.3)	209 (42.7)		
Age (mean±SD)	43.51 (11.27)	50.74 (14.31)			44.57 (11.26)	51.47 (14.30)			43.54 (11.31)	52.84 (14.03)		
Age												
>45	131 (45.5)	147 (66.2)	20.898	<0.001	129 (45.4)	141 (65.3)	18.680	<0.001	132 (47.0)	142 (67.9)	20.534	<0.001
<45	157 (54.5)	75 (33.8)			155 (54.6)	75 (34.7)			149 (53.0)	67 (32.1)		
Gender												
Male	126 (43.8)	87 (39.2)	0.893	0.343	126 (44.4)	83 (38.4)	1.544	0.214	124 (44.1)	79 (37.8)	1.726	0.189
Female	162 (56.3)	135 (60.8)			158 (55.6)	133 (61.6)			157 (55.9)	130 (62.2)		
Address												
Kirkos sub-city	113 (39.6)	77 (34.8)	1.030	0.310	111 (39.5)	75 (34.9)	0.920	0.337	110 (39.6)	71 (34.1)	1.280	0.258
Else[‡]	172 (60.4)	144(65.2)			170 (60.5)	140 (65.1)			168 (60.4)	137 (65.9)		
Civil status												
Never married	53 (18.4)	36 (16.2%)	6.577	0.087	53 (18.7)	34 (15.7)	5.732	0.125	52 (18.5)	31 (14.8)	6.745	0.080
Married	130 (45.1)	125 (56.3)			126 (44.4)	119 (55.1)			124 (44.1)	117 (56.0)		
Divorced	62 (21.5)	36 (16.2)			62 (21.8)	38 (17.6)			62 (22.1)			
Widowed/r	43 (14.9)	25 (11.3)			43 (15.1)	25 (11.6)			43 (15.3)	25 (12.0)		
Edu												
No-formal education	35 (12.2)	40 (18.0)	93.441	<0.001	34 (12.0)	38 (17.6)	89.732	<0.001	34 (12.1)	37 (17.7)	88.383	<0.001
Primary	65 (22.6)	18 (8.1)			63 (22.2)	18 (8.3)			62 (22.1)	18 (8.6)		
Secondary	27 (9.4)	17 (7.7)			27 (9.5)	17 (7.9)			26 (9.3)	17 (8.1)		
High school	96 (33.3)	36 (16.2)			94 (33.1)	34 (15.7)			93 (33.1)	31 (14.8)		
College (diploma)	47 (16.3)	111 (50.0)			48 (16.9)	109 (50.5)			48 (17.1)	106 (50.7)		
University (first degree and above)	18 (6.3)	0 (0.0)			18 (6.3)	0 (0.0)			18 (6.4)	0 (0.0)		
Family history												
Yes	47 (16.3)	63 (28.5)	10.256	0.001	47 (16.5)	61 (28.4)			47 (16.7)	59 (28.4)	8.864	0.003
No	241(83.7)	158 (71.5)			237 (83.5)	154 (71.6)	9.400	0.002	234 (83.3)	149 (71.6)		
Income												
>50 USD	133 (46.2)	139 (62.6)	12.948	<0.001	132 (46.5)	136 (27.2)	12.750	<0.001	130 (46.3)	130 (62.2)	11.592	0.001
<50 USD	155 (53.8)	83 (37.4)			152 (53.5)	80 (37.0)			151 (53.7)	79 (37.8)		
TM												
Yes	2 (0.7)	52 (23.5)	66.367	<0.001	2 (0.7)	51 (23.7)	65.883	<0.001	2 (0.7)	51 (24.5)	67.662	<0.001
No	286 (99.3)	169 (76.5)			282 (99.3)	164 (76.3)			279 (99.3)	157 (75.5)		
Tobacco-smoking												
Yes	15 (5.2)	23 (10.4)	4.169	0.041	15 (5.3)	22 (10.2)	3.678	0.055	15 (5.3)	21 (10.1)		
No	273 (94.8)	198 (89.6)			269 (94.7)	193 (89.8)			266 (94.7)	187 (89.9)	3.301	0.069
Alcohol-drinking												
Yes	25 (8.7)	55 (24.9)	23.584	<0.001	24 (8.5)	51 (23.7)	21.162	<0.001	24 (8.5)	47 (22.6)	17.909	<0.001
No	263 (91.3)	166 (75.1)			260 (91.5)	164 (76.3)			257 (91.5)	161 (77.4)		
Coffee-drinking												
Yes	135 (46.9)	190 (86.0)	81.129	<0.001	135 (47.5)	184 (85.6)	75.169	<0.001	133 (47.3)	177 (85.1)	71.841	<0.001
No	153 (53.1)	31 (14.0)			149 (52.5)	31 (14.4)			148 (52.7)	31 (14.9)		
Khat-chewinga												
Yes	14(4.9%)	14 (6.3)	0.277	0.598	14 (4.9)	14 (6.5)	0.318	0.573	14 (5.0)	14 (6.7)	0.392	0.531
No	274 (95.1)	207 (93.7)			270 (95.1)	201 (93.5)			267 (95.0)	194 (93.3)		

[a]Khat, plant/substance chewed in East-Africa and the Middle East as a stimulant or benefit for 'recreational values'; Pearson Chi-Square was used and Continuity Correction was computed for a 2×2 table; Primary, 1st–6th grades; Secondary Junior, 7th–8th grades; High school, 9th–12th grades; TM, traditional medicine.
Edu, education; TM, traditional medicine.

Fig. 2



Prevalence and incidence of CMetS as computed by NCEP and IDF tools per 1000 of the population of the respective study groups at the Zewditu Memorial Hospital in Addis Ababa, Ethiopia, 2021. CMetS, cardiometabolic syndrome; IDF, International Diabetes Federation; NCEP, The National Cholesterol Education Program.

In the bivariate analysis, educational status, coffee intake, and biomarkers such as blood glucose, TG, HDL, WC, and obesity were shown to be substantially linked with CMetS+ in HIV+ subjects and included in the multivariate analysis. All the variables obtained through the bivariate analysis after adjusting for covariates were substantially linked to CMetS in a multivariate logistic regression analysis. As a result, those with a diploma or above were less likely to develop CMetS in HIV+ people, and coffee drinking was likewise linked to a lower incidence of CMetS in HIV+ people at all study points, yielding the same results. TG had the highest odds ratio among the biomarkers, with nearly seven times the risks of developing CMetS, followed by SBP and WC with five and two times the odds, respectively (Table 7).

Similarly, bivariate and multivariate logistic regressions were used to investigate the influence of CMetS using the NCEP tool on predictor variables in HIV-negative participants. Bivariate analysis revealed that age, gender, biomarkers (blood glucose, TG, HDL, WC), obesity, coffee consumption, and comorbidity were shown to be significantly linked with CMetS+. All the variables obtained through the bivariate analysis after adjusting for covariates were substantially linked with CMetS in multivariate logistic regression (Table 8).

The risk of CMetS increased approximately by more than two times in participants aged 45 and above compared to those lower than 45. Males were less likely to have CMetS as compared to females'. Other variables such as college-level or above education and coffee consumption were observed to be associated with a reduced rate of CMetS in HIV-negative subjects. All of the biomarkers linked to an elevated risk of CMetS in HIV+ people had a comparable effect in HIV-negative people. One additional variable associated with increased odds of CMetS in HIV-negative subjects was comorbidity and the presence of one or more comorbidity was associated with a 2–2.5 increased risk of CMetS (Table 8).

Discussion

The NCEP and IDF criteria were used to determine the incidence and prevalence of CMetS in this investigation. The effect of biomarkers and other variables on CMetS as well as the outcome variable were also studied.

From the data in Figs. 2–4 and Tables 1–8, some intriguing findings were observed. When sociodemographic variables such as those listed in Table 1 were taken into account, it was observed that a considerable number of people aged 45 and above were HIV-negative. Furthermore, HIV-negative patients were more likely to have a college or higher education, and a higher rate of substance and TM use than HIV+ patients. Although no additional sources of information on substance and TM use differences were found in these groups, it is plausible to assume that the strict counseling and surveillance

Table 2 Clinical characteristics among HIV-positive and HIV-negative patients undergoing follow-up care at Zewditu Memorial Hospital in Addis Ababa, Ethiopia, in 2021

	Baseline (n=510)				In the 8th month (n=500)				In the 18th month (n=490)				
	HIV+ (n=288)	HIV-negative (n=222)	Pearson's R	*P* value	HIV+ (n=284)	HIV-negative (n=216)	Pearson's R	*P* value	HIV+ (n=281)	HIV-negative (n=209)			Reference values
Characteristics	Mean (±SD)	Mean (±SD)			Mean (±SD)	Mean (±SD)			Mean (±SD)	Mean (±SD)	Pearson's R	*P* value	Mean
WC (inch)													
Female	33.36 (4.36)	32.65 (9.18)	0.051	0.384	33.47 (4.37)	32.59 (9.23)	0.066	0.262	33.94 (4.17)	32.88 (9.21)	0.076	0.198	≤35
Male	35.56 (4.47)	32.57 (9.00)	0.215	0.002	35.56 (4.47)	32.14 (8.97)	0.250	<0.001	36.00 (4.50)	32.54(8.74)	0.253	<0.001	≤40
SBP (mmHg)	127.91 (21.17)	136.97 (21.47)	−0.206	<0.001	130.04 (15.20)	136.94 (13.85)	−0.228	<0.001	129.04 (16.65)	136.40 (15.73)	−0.219	<0.001	≤130
DBP (mmHg)	82.93 (11.81)	82.67 (12.11)	0.011	0.805	83.47 (12.16)	86.98 (13.41)	−0.136	0.002	88.82 (16.00)	96.39 (15.56)	−0.231	<0.001	≤85
TC (mg/dL)	187.34 (51.57)	193.83 (50.77)	−0.063	0.156	197.88 (44.70)	199.39 (40.87)	−0.017	0.700	187.72 (43.89)	202.73 (47.35)	−0.162	<0.001	≤200
Triglycerides (mg/dL)	156.19 (87.77)	165.06 (83.16)	−0.051	0.247	207.37 (96.45)	230.41(115.19)	−0.108	0.015	179.14 (79.55)	184.86 (81.14)	−0.035	0.436	≤150
LDL (mg/dL)	114.37 (46.60)	115.82 (47.93)	−0.015	0.732	166.78 (59.35)	159.22 (49.95)	0.068	0.132	112.30 (44.81)	125.35 (45.05)	−0.142	0.002	≤100
HDL (mg/dL)													
Female	46.49 (7.39)	49.47 (17.53)	−0.113	0.051	49.80 (11.92)	48.22 (11.73)	0.039	0.510	45.09 (8.41)	43.43 (8.83)	0.058	0.330	≥50
Male	46.19 (8.33)	47.68 (12.39)	−0.072	0.299	51.89 (10.92)	50.99 (12.52)	−0.066	0.344	46.59 (8.30)	45.59 (9.16)	−0.095	0.179	≥40
Pre-prandial serum sugar level (mg/dL)	97.32 (23.55)	143.66 (76.51)	−0.277	<0.001	113.71 (42.30)	140.22 (73.17)	0.222	<0.001	105.86 (19.90)	119.28 (41.40)	0.249	<0.001	≤100

CI, confidence interval; HDL, high-density lipoprotein; LDL, low-density lipoprotein; OR, odds ratio; TC, total cholesterol.
P value is based on normal approximation.

Table 3 Correlations of cardiometabolic biomarkers at baseline, 8th, and 18th months of the follow-up periods among HIV-positive and HIV-negative patients at Zewditu Memorial Hospital, Addis Ababa, Ethiopia, 2021, using the National Cholesterol Education Program and International Diabetes Federation tools

Biomarker characteristics	HIV-positive group, *n* (%)	HIV-negative group, *n* (%)	Mantel-Haenszel OR estimate (95% CI)	*P* value
At baseline, *n*=510				
Obesitya				
NCEP	68 (23.6)	79 (35.6)	0.559 (0.380–0.824)	0.003*
IDF	141 (49.0)	123 (55.4)	0.772 (0.543–1.097)	0.149
Hyperglycemiab	116 (40.3)	113 (50.9)	0.651 (0.457–0.926)	0.017*
Dyslipidemia-1c	148 (51.4)	103 (46.4)	0.779 (0.547–1.110)	0.167
Dyslipidemia-2d	140 (48.6)	124 (55.9)	0.835 (0.588–1.187)	0.316
Hypertensione	83 (28.8)	113 (50.9)	0.391 (0.271–0.563)	0.001*
At the 8th month, *n*=500				
Obesitya				
NCEP	70 (24.9)	74 (35.4)	0.605 (0.409–0.895)	0.012*
IDF	149 (53.0)	112 (53.6)	0.978 (0.683–1.400)	0.902
Hyperglycemiab	109 (38.8)	107 (51.2)	0.604 (0.421–0.868)	0.006*
Dyslipidemia-1c	152 (54.1)	124 (59.3)	0.808 (0.562–1.160)	0.248
Dyslipidemia-2d	105 (37.4)	87 (41.6)	0.837 (0.580–1.206)	0.340
Hypertensione	99 (35.2)	128 (61.2)	0.344 (0.238–0.499)	<0.001*
At the 18th month, *n*=490				
Obesitya				
NCEP	70 (24.9)	74 (35.4)	0.605 (0.409–0.895)	0.012*
IDF	143 (50.9)	112 (53.6)	0.897 (0.627–1.285)	0.554
Hyperglycemiab	109 (38.8)	106 (50.7)	0.616 (0.429–0.884)	0.009*
Dyslipidemia-1c	152 (54.1)	124 (59.3)	0.808 (0.562–1.160)	0.248
Dyslipidemia-2d	151 (53.7)	123 (58.9)	0.812 (0.566–1.166)	0.266
Hypertensione	99 (35.2)	129 (61.7)	0.337 (0.233–0.489)	0.001*

IDF, International Diabetes Federation; OR, odds ratio; NCEP, The National Cholesterol Education Program.
[a]Obesity = NCEP: Waist-circumference >40 inch (M); and IDF: >35 inch (F); IDF: Waist-circumference >94 cm (M), >80 cm (F).
[b]Hyperglycemia = Fasting glucose >100 mg/dL or diabetes treatment in both NCEP and IDF.
[c]Dyslipidemia 1 = TG >150 mg/dL or Lipid lowering Rx.
[d]Dyslipidemia 2 = HDL <50 mg/dL in females or <40 mg/dL in male or lipid-lowering Rx.
[e]Hypertension = SBP>130 mmHg and DBP>85 mmHg or hypertension treatment.
*Significant values.

measures provided to HIV+ patients could have helped them avoid using agents that interfere with their current treatment plan.

The HIV-negative group had a higher overall incidence and prevalence of CMetS than the HIV+ group using both the NCEP and IDF tools (Fig. 2). There was no open access source that compared the incidence of CMetS in HIV+ and HIV-negative patients in the literature, although multiple studies have addressed the prevalence of CMetS. Accordingly, the prevalence of this study was slightly higher than the previously published reviews [29,56] as well as a cross-sectional study reported from Kenya [57]. On the other hand, a much higher prevalence report was obtained from Uganda, which estimated 580 per 1000 population [58]. In the HIV-negative group, our report was comparable to a South African [59] and a Chinese study [60]. The discrepancies in prevalence reports could be due to several factors including study design, sample selection, study year, CMetS definition, and sociodemographic features.

Since the HIV-negative group had more comorbidities in our study, this might have also led to the increase in CMetS in this group. In addition, the IDF score was higher than that of the NCEPs. The modest rise in CMetS prevalence when the IDF tool was employed instead of the NCEP could be explained by the differences in obesity criteria between the two methods. The IDF utilizes a far lower obesity cutoff point than the NCEP (by 7.6 cm in males and by 8.9 cm in females), which could have made more participants fulfill the definition [5]. Furthermore, WC is an absolute condition for IDF, which makes it easier for more elderly people in the CMetS+ category to meet the IDF's definition.

Except for SBP, FBS, and TG; the mean for most cardiometabolic indicators was within the normal range (Table 2). The mean SBP, FBS, and TG were continuously higher in the HIV-negative than in the HIV+ group. The majority of the HIV-negative group participants had one or more chronic conditions, which might have contributed to the elevated CMetS in this cohort. The influence of comorbidity indicated a similar outcome in a study carried out to investigate a single group of the HIV population [61].

Table 3 shows that the IDF found no significant change in WC between HIV+ and HIV-negative participants. However, the NCEP found that HIV-negative people were more likely to be obese than HIV-positive people throughout the cohort. The findings might imply that the NCEP tool has greater power in defining central obesity than the IDF. This might also be attributable to the fact that HIV-negative individuals are older than HIV-positive participants in this cohort. Unhealthy weight gain in the form of central obesity is becoming a major issue among the elderly in all countries across the world. Similar findings have been reported elsewhere [34,37,57,62,63].

The use of WC rather than BMI to identify obesity and the risk of cardiovascular events is also a subject of controversy. BMI has been used to determine obesity in several published research. Recent studies suggest that WC, rather than BMI, should be used to diagnose obesity since central obesity is proving to be a considerably

Table 4 The impact of biomarkers on the outcome of cardiometabolic syndrome across time in a cohort of HIV-positive and HIV-negative patients on follow-up care at Zewditu Memorial Hospital in Addis Ababa, Ethiopia, in 2021

	All patients					HIV-positive group					HIV-negative group				
Description	Mean	Median	Mean rank	χ^2 value	*P* value	Mean	Median	Mean rank	χ^2 value	*P* value	Mean	Median	Mean Rank	χ^2 value	*P* value
Waist-circumference (inch)															
Baseline	33.58	34.00	1.39	374.91	<0.001	34.33	33.50	1.37	196.46	<0.001	32.62	39.40	1.41	198.48	<0.001
8th month	34.25	34.52	2.56			35.00	34.22	2.45			33.27	39.77	2.70		
18th month	33.99	34.10	2.05			34.83	34.00	2.18			32.91	39.40	1.89		
SBP (mmHg)															
Baseline	131.88	130.00	1.90	9.46	0.009	127.95	124.50	1.81	17.23	<0.001	136.97	140.00	2.02	.59	.744
8th month	133.07	134.00	2.09			130.01	130.00	2.14			137.05	137.00	2.02		
18th month	132.14	130.00	2.01			129.12	130.00	2.05			136.05	137.00	1.96		
DBP (mmHg)															
Baseline	82.82	80.50	1.69	141.63	<0.001	82.93	81.33	1.79	46.97	<0.001	82.67	80.00	1.55	107.95	<0.001
8th month	84.92	84.79	1.91			83.37	83.66	1.89			86.92	85.85	1.93		
18th month	92.02	90.00	2.41			88.92	90.00	2.32			96.04	97.00	2.52		
Serum TGs (mg/dL)															
Baseline	160.05	137.00	1.54	198.18	<0.001	156.19	133.00	1.40	182.28	<0.001	165.06	143.50	1.72	36.09	<0.001
8th month	217.27	191.37	2.42			206.84	188.08	2.52			230.79	199.19	2.29		
18th month	180.91	160.00	2.04			178.15	156.00	2.08			184.50	166.00	1.99		
High-density lipoprotein (mg/dL)															
Baseline	47.41	46.50	1.99	66.97	<0.001	46.37	46.00	1.90	39.71	<0.001	48.77	48.00	2.10	34.88	<0.001
8th month	50.53	49.14	2.26			51.03	49.43	2.30			49.87	48.68	2.21		
18th month	45.48	44.00	1.75			46.03	44.00	1.80			44.76	44.00	1.68		
Fasting blood sugar l (mg/dL)															
Baseline	106.80	97.00	1.56	157.38	<0.001	97.32	94.00	1.47	120.93	<0.001	119.10	98.00	1.67	53.25	<0.001
8th month	126.70	101.87	2.30			113.63	99.39	2.26			143.66	105.54	2.36		
18th month	111.67	98.00	2.14			105.45	98.00	2.27			119.75	100.00	1.98		

Median (IQR) = 50th percentiles; *P* value is two-sided; χ^2 = Friedman Q test.

more reliable predictor of cardiovascular risks than BMI-derived broad obesity [64–69].

In this study, HIV+ participants were less likely than HIV-negatives to have hypertension, hyperglycemia, or central obesity (Table 3). These parameters have been extensively documented as predictors in several previous studies, even though studies comparing these groups are widely lacking [56,57,70].

Table 4 shows the effect of time on repeated measurements of cardiometabolic biomarkers. For successful CMetS prevention and therapy, assessment of biomarkers on an epidemiological and clinical basis is crucial [71]. Even though sociodemographic factors, genetic composition, sample population, and other factors may all influence the outcomes, all biomarkers are thought to be equally useful in identifying CMetS [61]. The total impact of repeated measurements of these biomarkers during the cohort was determined using the Freidman ANOVA. All of the variables, except SBP in the HIV-negative group, exhibited considerable variation in measurements during the duration of the research. Because the Freidman ANOVA only shows the aggregate variabilities in the measurement of the biomarkers over the course of the cohort, a posthoc analysis was necessary for further exploration. As demonstrated in Table 5, posthoc

Table 5 Post-hoc analysis of the impact of biomarkers on the outcome of cardiometabolic syndrome among patients on follow-up care at Zewditu Memorial Hospital in Addis Ababa, Ethiopia, in 2021

	All patients (n=510)		HIV-positive group (n=288)		HIV-negative group (n=222)	
Description	z-statistics	*P* value	*z*-statistics	*P* value	z-statistics	*P* value
Waist-circumference (inch)						
Baseline * 8th month	−17.705b	<0.001	−13.508b	<0.001	−11.467b	<0.001
Baseline * 18th month	−11.312b	<0.001	−8.640b	<0.001	−6.727b	<0.001
8th month * 18th month	−7.007c	<0.001	−2.283c	0.022^{NS}	−8.408c	<0.001
SBP (mmHg)						
Baseline * 8th month	−2.625b	0.009	−3.427b	0.001	−0.160b	0.872^{NS}
Baseline * 18th month	−1.793b	0.073^{NS}	−2.933b	0.003	−0.616c	0.538^{NS}
8th month * 18th month	−2.185c	0.029^{NS}	−1.596c	0.110^{NS}	−1.450c	0.147^{NS}
DBP (mmHg)						
Baseline * 8th month	−3.262b	0.001	−0.722b	0.470^{NS}	−4.004b	<0.001
Baseline * 18th month	−13.824b	<0.001	−8.495b	<0.001	−10.668b	<0.001
8th month * 18th month	−8.359b	<0.001	−4.751b	<0.001	−7.371b	<0.001
Serum TGs (mg/dL)						
Baseline * 8th month	−12.673b	<0.001	−10.781b	<0.001	−7.144b	<0.001
Baseline * 18th month	−10.911b	<0.001	−9.639b	<0.001	−5.105b	<0.001
8th month * 18th month	−8.513c	0.001	−7.456c	<0.001	−4.745c	<0.001
High-density lipoprotein (mg/dL)						
Baseline * 8th month	−5.768b	<0.001	−6.187b	<0.001	−1.781b	0.075
Baseline * 18th month	−4.990c	<0.001	−1.397c	0.163^{NS}	−5.750c	<0.001
8th month * 18th month	−8.642c	<0.001	−6.596c	<0.001	−5.581c	<0.001
Fasting blood sugar l (mg/dL)						
Baseline * 8th month	−11.567b	<0.001	−8.985b	<0.001	−7.328b	<0.001
Baseline * 18th month	−9.988b	<0.001	−10.739b	<0.001	−3.061b	0.002
8th month * 18th month	−5.798c	<0.001	−2.417c	0.016	−5.762c	<0.001

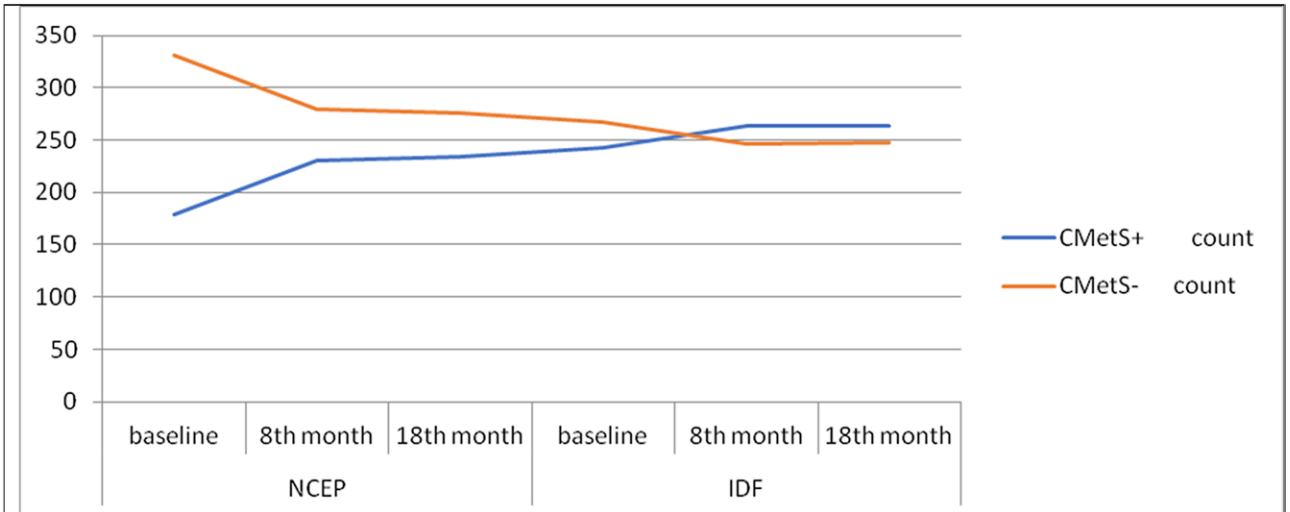
The reference *P* value for the Wilcoxon-Signed Ranks Test is 0.017; NS, not significant considering Bonferroni corrections.
[a]Wilcoxon-Signed Ranks Test;
[b]Based on negative ranks;
[c]Based on positive ranks.

Table 6 Association of HIV status with cardiometabolic syndrome status among participants on follow-up care at Zewditu Memorial Hospital, Addis Ababa, Ethiopia, 2021

CMetS tools	Follow-up	HIV status	CMetS+, *n* (%)	CMetS−, *n* (%)	Mantel-Haenszel, OR Estimate (95% CI)a	*P* value
NCEP	Baseline					0.001
		HIV+	82 (45.8)	206 (62.2)	0.513 (0.355–0.742)	
		HIV-negative	97 (54.2)	125 (37.8)		
	8th month	HIV+	107 (47.3)	177 (64.6)	0.493 (0.329–0.706)	<0.001
		HIV-negative	119 (52.7)	97 (35.4)		
	18th month	HIV+	107 (47.6)	174 (65.7)	0.474 (0.331–0.683)	<0.001
		HIV-negative	118 (52.4)	91 (34.3)		
IDF	Baseline	HIV+	126 (51.9)	162 (60.7)	0.698 (0.491–0.992)	0.045
		HIV-negative	117 (48.1)	105 (39.3)		
	8th month	HIV+	129 (49.6)	155 (64.6)	0.540 (0.377–0.773)	0.001
		HIV-negative	131 (50.4)	85 (35.4)		
	18th month	HIV+	125 (49.2)	156 (66.1)	0.497 (0.345–0.716)	<0.001
		HIV-negative	129 (50.8)	80 (33.9)		

CMetS, cardiometabolic syndrome; CMetS+, those who developed cardiometabolic syndrome; CMetS−, those who do not develop cardiometabolic syndrome; IDF, International Diabetes Federation; NCEP, The National Cholesterol Education Program.
[a]0 cells (0.0%) have an expected count of less than 5.

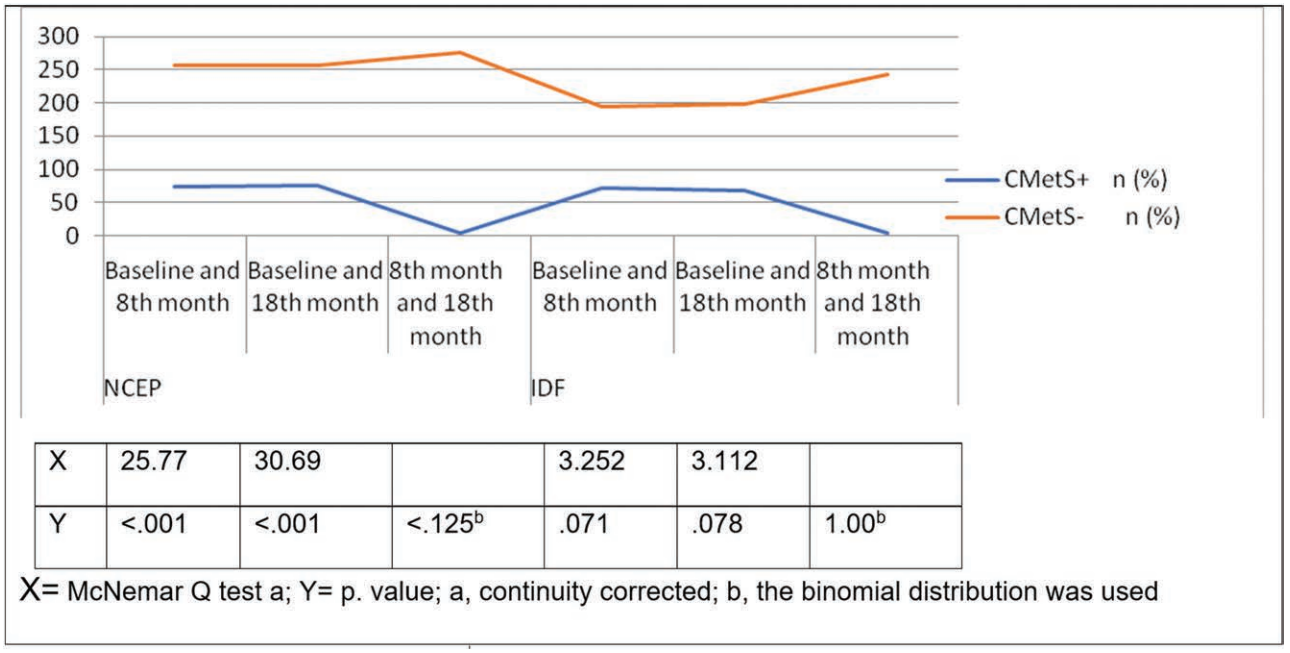
Fig. 3



X	57.571a	6.846a
Y	<.001	.033
X= Cochran's Q test; Y= p. value; a, continuity corrected;		

Cochran's Q test showing the overall impact of cardiometabolic syndrome during the cohort period among participants on follow-up cares at Zewditu Memorial Hospital, Addis Ababa, Ethiopia, 2021. CMetS, cardiometabolic syndrome; IDF, International Diabetes Federation; NCEP, The National Cholesterol Education Program.

Fig. 4



X	25.77	30.69		3.252	3.112	
Y	<.001	<.001	<.125[b]	.071	.078	1.00[b]

X= McNemar Q test a; Y= p. value; a, continuity corrected; b, the binomial distribution was used

McNemar's Q test (post hoc) showing the impact of the cardiometabolic syndrome within the transition of the cohort period among patients on follow-up care at Zewditu Memorial Hospital, Addis Ababa, Ethiopia, 2021. CMetS, cardiometabolic syndrome; IDF, International Diabetes Federation; NCEP, The National Cholesterol Education Program.

analysis revealed that WC, TGs, and FBS consistently showed significant changes across the transition points in all patients as well as in HIV+ and HIV-negative groups. This finding emphasizes the significance of biomarkers as a strategic target for CMetS management in addition to their use as a diagnostic tool [72]. Indeed, variations in biomarker readings throughout research periods might be useful in tailoring prevention strategies since they could be connected to our lifestyles [73].

Increased WC, TGs, and FBS have been demonstrated to be helpful clinical indications of metabolic syndrome in various studies [74,75]. Despite playing a crucial role in CMetS progression, one important biomarker, SBP, showed no significant alterations among HIV-positive patients during the course of the study. The antihypertensive medications the patients were taking might have had a role in the observed findings.

Table 6 shows the effect of biomarkers on the outcome variable, resulting in a high prevalence of CMetS in the HIV-negative group. However, in studies that use healthier controls from the general population, the results and interpretation could be different. Indeed, many studies comparing HIV+ and HIV-negative groups (with a healthier control group from the general population) found that the risk was higher in the HIV+ group [37,76]. In certain studies; however, both groups had similar outcomes [39]. One Chinese study found results that were comparable to ours [77]. We believe that the cohort's elder recruits might have had a stronger influence on the control group's increased CMetS frequency apart from the impact of counseling and more astringent monitoring parameters employed in the HIV+ group during follow-up of the ART clinics.

The presence of high TGs coupled with low HDL-C in both HIV+ and HIV-negative groups could indicate the presence of atherogenic dyslipidemia. In light of this, investigations have shown that atherogenic dyslipidemia is more common in type 2 diabetes and cardiometabolic individuals, and it is increasingly becoming a hallmark for myocardial infarction and coronary heart disease pathologies [78–81]. Therapeutic lifestyle changes such as increased physical activity, a low-carbohydrate, and high-polyunsaturated fatty acid diet, reduced consumption of animal-based saturated fats, and avoidance of substance use can effectively control atherogenic dyslipidemia and should be considered in both groups to resolve similar problems in the future [81,82].

Figure 3 shows that the total burden of CMetS in HIV+ and HIV-negative adults were significantly high during the cohort period utilizing both the NCEP and the IDF tools, according to Cochran's Q test. A post hoc analysis using McNemar's Q test in Fig. 4 demonstrated a significant change in CMetS prevalence from baseline to the 8th month [χ^2 (1) = 25.773, $P<0.001$] as well as to the 18th month [χ^2 (1) = 30.695, $P<0.001$]. However, there were no significant differences between the 8th and 18th months detected using NCEP. In general, the IDF observed no significant changes in McNemar's time transition. This is best demonstrated by the IDF's absolute criterion plus smaller WC range, which allowed more persons with significantly lower risk to be classified as CMetS but failed to be classified as CMetS+ when laboratory investigations for the other parameters were done.

Table 7 shows association studies of CMetS using the NCEP tool. According to the findings, HIV-negative participants aged 45 and above were more likely to have CMetS than their younger counterparts. This finding; however, was not replicated in the HIV+ group. The explanation for this might be that, as previously stated, the HIV+ group's mean age was lower than the HIV– group's, which might have influenced the outcome. Multiple studies have shown similar results to ours, demonstrating that the prevalence of CMetS rises with age [34,83].

There were no significant associations found among HIV+ individuals when gender was taken into account. However, among HIV-negative subjects, males were less likely than females to develop CMetS. Although there is no apparent cause for this, it might be related to the age distribution of the participants. Naturally, the female gender does have a lower risk for CMetS before 45 years (during the premenopausal period) because of an estrogen hormone. However, after 45 years (postmenopausal period), they are equally susceptible to the risk, and the variation during the postmenopausal period could depend on multiple factors [84–86]. In our study, there were more females aged 45 and above than males. This preponderance, with a slightly higher proportion of females, might have made this group more vulnerable in the present study. Similar study reports were found to agree with our findings [87,88].

Education is essential for acquiring, retrieving, and critically interpreting information. We examined educational status to see if it influenced CMetS occurrence, and we found that individuals with a college (diploma) level or higher educational status were less likely to have CMetS than those with a lower level of education. Incorporating an educational program into clinical visits for literate patients with chronic conditions increased disease-specific knowledge and encouraged patients to become more active and involved in their treatment, resulting in better health habits and results [89].

Many Ethiopians drink coffee daily, similar to how tea is taken in Arabian and Far Eastern nations. Although clinical trials on the relationship between coffee and CMetS have yet to be conducted, we have identified that people who drink coffee regularly were less likely to develop CMetS than those who did not drink coffee

Table 7 Cardiometabolic syndrome among HIV-positive participants and its association with independent variables using the National Cholesterol Education Program tool at baseline, 8th, and 18th months among patients on follow-up care at Zewditu Memorial Hospital, Addis Ababa, Ethiopia, 2021

	Baseline				8th Month				18th Month			
Description	CMetS+ and HIV+	Elsea	COR (95% CI)	AOR (95% CI)	CMetS+ and HIV+	Elsea	COR (95% CI)	AOR (95% CI)	CMetS+ and HIV+	Elsea	COR (95% CI)	AOR (95% CI)
Age												
≥45 years	44 (53.7)	234 (54.7)	0.980 (0.598–1.542)^{NS}		57 (53.3)	213 (54.2)	0.963 (0.628, 1.479)^{NS}		59 (55.1)	215 (56.1)	0.960 (0.624, 1.478)^{NS}	
<45 years	38 (46.3)	194 (45.3)			50 (48.7)	180 (45.8)			48 (44.9)	168 (43.9)		
Gender												
Male	33 (40.2)	180 (42.1)	0.928 (0.573–1.501)^{NS}		43 (40.2)	166 (42.2)	0.919 (0.595–1.420)^{NS}		43 (40.2)	160 (41.8)	0.936 (0.605–1.449)^{NS}	
Female	49 (59.8)	248 (57.9)			64 (59.8)	227 (57.8)			64 (59.8)	223 (58.2)		
Civil status												
Married	40 (48.8)	215 (50.2)	0.944 (0.588–1.514)^{NS}		52 (48.6)	203 (51.7)	0.885 (0.577–1.357)^{NS}		53 (49.5)	196 (51.2)	0.936 (0.610–1.438)^{NS}	
Else	42 (51.2)	213 (49.8)			55 (51.4)	190 (48.3)			54 (50.5)	187 (48.8)		
Education												
Diploma and above	18 (22.0)	158 (36.9)	0.481 (0.275–0.840)*	0.415 (0.204–0.843)*	23 (21.5)	152 (38.7)	0.434 (0.262–0.719)**	0.375 (0.211–669)**	23 (21.5)	149 (38.9)	0.430 (0.260–0.712)*	0.371 (0.207–0.664)**
Else	64 (78.0)	270 (63.1)			84 (78.5)	241 (61.3)			84 (78.5)	234 (61.1)		
Income												
≥50 USD/month	42 (51.2)	230 (53.7)	0.904 (0.563–1.450)^{NS}		53 (49.5)	215 (54.7)	0.813 (0.530–1.246)^{NS}		53 (49.5)	207 (54.0)	0.834 (0.543–1.281)^{NS}	
<50 USD/month	40 (48.8)	198 (46.3)			54 (50.5)	178 (45.3)			54 (50.5)	175 (46.0)		
Hyperglycemia												
FBS ≥ 100 mg/dL or DM Rx	57 (69.5)	172 (40.2)	3.393 (2.041–5.642)***	3.329 (1.808–6.131)***	65 (60.7)	154 (39.2)	2.402 (1.550–3.721)***	2.106 (1.261–3.517)**	65 (60.7)	150 (39.2)	2.404 (1.550–3.729)***	2.215 (1.309–3.749)**
FBS < 100 mg/dL	25 (30.5)	256 (59.8)			42 (39.3)	239 (60.8)			42 (39.3)	223 (60.8)		
Dyslipidemia-1												
TG ≥ 150 mg/dL or lipid-lowering Rx	64 (78.0)	155 (36.2)	6.262 (3.581–10.951)***	7.905 (4.078–15.321)***	94 (87.9)	191 (48.6)	7.647 (4.144–14.113)***	8.108 (4.193–15.679)***	94 (87.9)	182 (47.5)	7.986 (4.323–14.751)***	7.707 (3.984–14.910)***
TG < 150 mg/dL	18 (22.0)	273 (63.8)			13 (12.1)	202 (51.4)			13 (12.1)	201 (52.5)		
Dyslipidemia-2												
HDL < 50 mg/dL in females or <40 mg/dL in males	24 (29.3)	248 (57.9)	1.300 (0.180–1.502)***	1.399 (0.215–1.741)***	52 (48.6)	145 (36.9)	1.617 (1.051–2.488)*	1.204 (0.724–2.003)^{NS}	77 (72.0)	197 (51.4)	2.423 (1.519–3.866)***	1.823 (1.054–3.152)*
HDL ≥ 50 mg/dL in females or ≥40 mg/dL in males or lipid-lowering R_x	58 (70.7)	180 (42.1)			55 (51.4)	248 (63.1)			30 (28.0)	186 (48.6)		
HTN												
SBP > 130 mmHg and BP > 85 mmHg or HTN R_x	56 (68.3)	140 (32.7)	4.431 (2.668–7.357)***	5.292 (2.816–9.945)***	74 (69.2)	156 (39.7)	3.407 (2.156–5.382)***	4.066 (2.370–6.975)***	74 (69.2)	154 (40.2	3.335 (2.109–5.273)***	3.932 (2.273–6.804)***

(Continued)

Table 7
(Continued)

	Baseline				8th Month				18th Month			
Description	CMetS+ and HIV+	Elsea	COR (95% CI)	AOR (95% CI)	CMetS+ and HIV+	Elsea	COR (95% CI)	AOR (95% CI)	CMetS+ and HIV+	Elsea	COR (95% CI)	AOR (95% CI)
SBP ≤130 mmHg and BP ≤ 85 mmHg	26 (31.7)	288 (67.3)			33 (30.8)	237 (60.3)			33 (30.8)	229 (59.8)		
Obesity_NCEP												
WC > 35' in women and > 40' in men	42 (51.2)	105 (24.5)	3.230 (1.987–5.250)***	2.420 (1.320–4.438)**	48 (44.9)	99 (25.2)	2.416 (1.550–3.766)***	2.403 (1.418–4.069)**	48 (44.9)	96 (25.1)	2.432 (1.558–3.798)***	2.251 (1.325–3.825)**
WC ≤ 35' in women and ≤35' in men	40 (48.8)	323 (75.5)			59 (55.1)	294 (74.8)			59 (55.1)	287 (74.9)		
FH												
Yes	18 (22.0)	92 (21.5)	1.024 (0.578–1.814)		26 (24.3)	82 920.9)	1.213 (0.733–2.010)^{NS}		26 (24.3)	80 (20.9)	1.212 (0.731–2.010)^{NS}	
No	64 (78.0)	335 (78.5)			81 (75.7)	310 (79.1)			81 (75.7)	302 (79.1)		
Tobacco-current												
Yes	2 (2.4)	36 (8.4)	0.272 (0.064–1.151)^{NS}		9 (8.4)	28 (7.1)	1.194 (0.545–2.613)^{NS}		9 (8.4)	27 (7.1)	1.207 (0.550–2.652)^{NS}	
No	80 (97.6)	391 (91.6)			98 (91.6)	364 (92.9)			98 (91.6)	355 (92.9)		
Alcohol consumption												
Yes	4 (4.9)	75 (17.8)	0.237 (0.084–0.667)^{NS}		10 (9.3)	65 (16.6)	0.519 (0.257–1.048)^{NS}		10 (9.3)	61 (16.0)	0.543 (0.268–1.099)^{NS}	
No	78 (95.1)	351 (82.2)			97	327 (83.4)			97 (90.7)	321 (84.0)		
Coffee consumption												
Yes	41 (50.0)	284 (66.5)	0.504 (0.312–812)**	0.346 (0.187–0.640)*	58 (54.2)	261 (66.6)	0.694 (0.385–0.917)*	0.343 (0.198–0.592)***	58 (54.2)	252 (66.0)	0.611 (0.395–0.944)*	0.357 (0.205–0.621)***
No	41 (50.0)	143 (33.5)			49 (45.8)	131 (33.4)			49 (45.8)	130 (34.0)		
Khat chewing												
Yes	2 (2.4)	26 (6.1)	0.386 (0.090–1.657)^{NP}		7 (6.5)	21 (5.4)	1.237 (0.511–2.992)^{NS}		7 (6.5)	21 (5.5)	1.203 (0.497–2.912)^{NS}	
No	80 (97.6)	401 (93.9)			100 (93.5)	371 (94.6)			100 (93.5)	361 (94.5)		
Comorbidity												
One or more comorbidity	13 (12.1)	62 (15.8)	0.738 (0.389–1.401)^{NS}		13 (12.1)	62 (15.8)	0.738 (0.389–1.401)^{NS}		13 (12.1)	64 (16.7)	0.689 (0.364–1.306)^{NS}	
No comorbidity	94 (87.8)	331 (84.2)			94 (87.9)	331 (84.2)			94 (87.9)	319 (83.3)		

[a]Else = CMetS+ and HIV–, or all CMetS–.
[b]Else = CMetS+ and HIV+, or all CMetS–.
*$P<0.05$.
**$P<0.01$.
***$P<0.001$; *NS, >0.20.
Disease type (Else), all diseases with/without comorbidities except HIV, diabetes, and hypertension with/without comorbidities; Edu, educational status; FH, family history; FBG, fasting blood glucose; TM, traditional medicine.

at all. Such a result may necessitate additional investigation, and we anticipate that randomized clinical studies will be necessary before drawing any hasty conclusions. However, there are several studies available on the health impact of coffee and one study reported that coffee has effects on body mass, blood glucose, lipid levels, blood pressure, and prevention of cardiovascular diseases which is based on chlorogenic acid consisting of antioxidant activity [90]. According to another cohort research done in Germany, coffee consumption did not increase the risk of chronic illness, but it may be linked to a lower risk of T2D [91].

Table 8 Cardiometabolic syndrome among HIV-negative participants and its association with independent variables using the National Cholesterol Education Program tool at baseline, 8th, and 18th months among patients on follow-up care at Zewditu Memorial Hospital, Addis Ababa, Ethiopia, 2021

	Baseline				8th month				18th month			
Description	CMetS+ and HIV−	Elseb	COR (95% CI)	AOR (95% CI)	CMetS+ and HIV−	Elseb	COR (95% CI)	AOR (95% CI)	CMetS+ and HIV−	Else b	COR (95% CI)	AOR (95% CI)
Age												
≥45 years	73 (75.3)	205 (49.6)	3.086 (1.872–5.088)***	3.227 (1.587–6.563)**	84 (70.6)	186 (48.8)	2.516 (1.616–3.917)***	2.133 (1.114–4.084)*	89 (75.4)	185 (49.7)	3.102 (1.947–4.942)***	2.385 (1.192–4.770)*
<45 years	24 (24.7)	208 (50.4)			35 (29.4)	195 (51.2)			29 (24.6)	187 (50.3)		
Gender												
Male	29 (29.9)	184 (44.6)	0.531 (0.330–0.854)**	0.453 (0.196–1.044)*	34 (28.6)	175 (45.9)	0.471 (0.301–0.737)**	0.213 (0.100–0.452)***	35 (29.7)	168 (45.2)	0.512 (0.328–0.799)**	0.364 (0.161–0.819)*
Female	68 (70.1)	229 (55.4)			85 (71.4)	206 (54.1)			83 (70.3)	204 (54.8)		
Civil status												
Married	50 (51.5)	205 (49.6)	1.079 (0.693–1.680)^{NS}		60 (50.4)	195 (51.2)	0.970 (0.643–1.464)^{NS}		56 (47.5)	193 (51.9)	0.838 (0.553–1.268)^{NS}	
Else	47 (48.5)	208 (50.4)			59 (49.6)	186 (48.8)			62 (52.5)	179 (48.1)		
Education												
Diploma and above	40 (41.2)	136 (32.9)	0.429 (0.908–1.249)^{NS}	0.275 (0.136–0.856)*	52 (43.7)	123 (32.3)	0.628 (0.068–0.980)*	0.416 (0.292–0.918)**	51 (43.2)	121 (32.5)	0.579 (0.033–0.913)*	0.333 (0.205–0.919)*
Else	57 (58.8)	277 (67.1)			67 (56.3)	258 (67.7)			67 (56.8)	251 (67.5)		
Income												
≥50 USD/month	54 (55.7)	218 (52.8)	1.123 (0.720–1.752)^{NS}		68 (57.1)	200 (52.5)	1.207 (0.797–1.827)^{NS}		66 (55.9)	194 (52.2)	1.165 (0.768–1.765)^{NS}	
<50USD/month	43 (44.3)	195 (47.2)			51 (42.9)	181 (47.5)			52 (44.1)	178 (47.8)		
Hyperglycemia												
FBS ≥ 100 mg/dL or DM Rx	76 (78.4)	153 (37.0)	6.150 (3.646–10.374)***	7.137 (3.428–14.860)***	87 (73.1)	132 (34.6)	5.129 (3.248–8.099)***	6.958 (3.685–13.135)***	86 (72.9)	129 (34.7)	5.062 (3.200–8.008)***	7.160 (3.614–14.187)***
FBS < 100 mg/dL	21 (21.6)	260 (63.0)			32 (26.9)	249 (65.4)			32 (27.1)	243 (65.3)		
Dyslipidemia-1												
TG ≥ 150 mg/dL or lipid-lowering Rx	70 (72.2)	149 (36.1)	4.594 (2.822–7.478)***	4.696 (2.352–9.380)***	96 (60.7)	189 (49.6)	4.240 (2.579–6.972)***	6.899 (3.358–14.174)***	94 (79.7)	182 (48.9)	4.089 (2.499–6.689)***	5.492 (2.608–11.565)***
TG < 150 mg/dL	27 (27.8)	264 (63.9)			23 (19.3)	192 (50.4)			24 (20.3)	190 (51.1)		
Dyslipidemia-2												
HDL < 50 mg/dL in females or < 40 mg/dL in males	24 (24.7)	248 (60.0)	1.219 (1.132–1.361)***	1.190 (1.091–1.396)***	66 (55.5)	131 (34.4)	2.376 (1.563–3.613)***	2.364 (1.284–4.352)**	93 (78.8)	181 (48.7)	3.926 (2.414–6.383)***	7.166 (3.283–15.641)***
HDL ≥ 50 mg/dL in females or ≥40 mg/dL in males or lipid-lowering Rx	73 (75.3)	165 (40.0)			53 (44.5)	250 (65.6)			25 (21.2)	191 (51.3)		
HTN												
SBP > 130 mmHg and BP > 85 mmHg or HTN Rx	69 (71.1)	127 (30.8)	5.549 (3.412–9.026)***	4.306 (2.175–8.523)***	93 (78.2)	137 (36.0)	6.371 (3.932–10.321)***	8.007 (4.070–15.751)***	94 (79.7)	134 (36.0)	6.956 (4.237–11.420)***	7.749 (3.776–15.903)***
SBP ≤ 130 mmHg and BP ≤ 85 mmHg	28 (28.9)	286 (69.2)			26 (21.8)	244 (64.0)			24 (20.3)	238 (64.0)		
Obesity_NCEP												
WC > 35' in women and >40' in men	65 (67.0)	82 (19.9)	8.199 (5.038–13.350)***	6.631 (3.307–13.295)***	65 (54.6)	82 (21.5)	4.389 (2.839–6.787)***	4.003 (2.126–7.540)***	65 (55.1)	79 (21.2)	4.549 (2.930–7.060)***	4.374 (2.202–8.690)***
WC ≤ 35' in women and ≤35' in men	32 (33.0)	331 (80.1)			54 (45.4)	299 (78.5)			53 (44.9)	293 (78.8)		
FH												
Yes	30 (31.3)	80 (19.4)	1.892 (1.152–3.106)*	1.480 (0.695–3.154)^{NS}	36 (30.5)	72 (18.9)	1.884 (1.180–3.010)**	1.185 (0.610–2.304)^{NS}	37 (31.6)	69 (18.5)	2.031 (1.270–3.247)**	1.282 (0.624–2.635)^{NS}
No	66 (68.8)	333 (80.6)			82 (69.5)	309 (81.1)			80 (68.4)	303 (81.5)		
Tobacco-current												
Yes	11 (11.3)	27 (6.6)	1.824 (0.871–3.819)^{NS}		10 (8.4)	27 (7.1)	1.199 (0.563–2.556)^{NS}	.	10 (8.5)	26 (7.0)	1.229 (0.574–2.629)^{NS}	
No	86 (88.7)	385 (93.4)			109 (91.6)	353 (92.9)			108 (91.5)	345 (93.0)		
Alcohol consumption												

(Continued)

Table 8
(Continued)

Description	Baseline				8th month				18th month			
	CMetS+ and HIV−	Elseb	COR (95% CI)	AOR (95% CI)	CMetS+ and HIV−	Elseb	COR (95% CI)	AOR (95% CI)	CMetS+ and HIV−	Else b	COR (95% CI)	AOR (95% CI)
Yes	19 (19.6)	61 (14.8)	1.402 (0.792–2.479)	1.186 (0.424–3.315)^{NS}	25 (21.0)	50 (13.2)	1.755 (1.031–2.988)^{NS}	2.270 (0.997–5.168)^{NS}	24 (20.3)	47 (12.7)	1.760 (1.023–3.028)*	2.028 (0.868–4.737)^{NS}
No	78 (80.4)	351 (85.2)			94 (79.0)	330 (86.8)			94 (79.7)	324 (87.3)		
Coffee consumption												
Yes	82 (84.5)	243 (59.0)	0.802 (0.119–0.820)***	0.273 (0.190–0.993)***	103 (86.6)	216 (56.8)	0.888 (0.780–1.022)***	0.809 (0.293–1.085)***	101 (85.6)	209 (56.3)	0.605 (0.048–0.880)***	0.176 (0.037–0.465)***
No	15 (15.5)	169 (41.0)			16 (13.4)	164 (43.2)			17 (14.4)	162 (43.7)		
Khat chewing												
Yes	5 (5.2)	23 (5.6)	0.919 (0.340–2.482)^{NS}		6 (5.0)	22 (5.8)	0.864 (9.342–2.184)^{NS}		6 (5.1)	22 (5.9)	0.850 (0.336–2.148)^{NS}	
No	92 (94.8)	389 (94.4)			113 (95.0)	358 (94.2)			112 (94.9)	349 (94.1)		
Comorbidity												
One or more comorbidity	43 (336.1)	32 (8.4)	6.171 (3.667–10.385)***	2.344 (1.059–5.189)*	43 (36.1)	32 (8.4)	6.171 (3.667–10.385)***	2.258 (1.114–4.579)*	44 (37.3)	33 (8.9)	6.108 (3.643–10.240)***	2.630 (1.255–5.513)**
No comorbidity	76 (63.9)	349 (91.6)			78 (63.9)	349 (91.6)			74 (62.7)	339 (91.1)		

[a]Else = CMetS+ and HIV−, or all CMetS−.
[b]Else = CMetS+ and HIV+, or all CMetS−.
*<0.05.
**<0.01.
***<0.001; *NS, >0.20; Disease type (Else), all diseases with/without comorbidities except HIV, diabetes, and hypertension with/without comorbidities; Edu, educational status; FH, family history; TM, traditional medicine.

In both HIV+ and HIV-negative individuals, all of the cardiometabolic markers employed by the NCEP and IDF tools to diagnose CMetS were substantially associated with CMetS. TG had the greatest odds ratio of almost 7 times in HIV+ patients, followed by SBP (4 times), WC (2.5 times), HDL, and FBS (2 times each). Among HIV-negative people, SBP had the greatest odds ratio (8 times), followed by HDL and FBS (7 times each), TG (5 times), and WC (4 times). The association of the specific biomarker with either HIV+ or HIV-negative might be relevant to link it with genetic composition, disease progression, or lifestyles. TG was the leading cause of CMetS in HIV+ participants in our study. Hypertriglyceridemia appears to be more frequent in patients treated with ART especially associated with protease inhibition [92]. This has been demonstrated in several prior investigations [92–94]. Similarly, among the biomarkers linked to CMetS in the HIV-negative population, SBP accounted for the largest chunk. This was also supported by several additional investigations [95–97]. Since most patients on prior first-line ART regimens have been switched to DTG-based regimens, the risk of obesity-related to DTG treatment is anticipated to be higher, posing a greater problem in this population. Although our results showed identical finings in both groups, the odd were larger in HIV-negative persons. This scientific inconsistency may stem from the fact that the effect of DTG-based regimens may be too early to be anticipated in most patients because most were switched to the therapy during the research periods [52].

The presence of one or more comorbidities is important in the development and progression of CMetS [98]. As a result, more comorbidity increases the likelihood of CMetS. In this investigation, we discovered that CMetS was associated with comorbidity in HIV-negative subjects. This might be because comorbidity is more common in older people. The overall findings revealed that the problem of CMetS remains mostly unexplored in practice, although posing a considerable burden on most chronic disease populations, with a particular emphasis on the elderly. The findings of this study will greatly benefit all stakeholders involved in chronic disease management and prevention research, practice, and policy.

Limitations of the study

Both the studied groups are known for their susceptibility to the CMetS. An ideal comparison group should have been the one with a lesser risk for the outcomes. The study obtained results from a single healthcare system. Thus, there is a need for a further longitudinal study with a multicenter approach to boost representativeness for the whole studied group as well as to reveal undetected or hidden outcomes.

Conclusion

CMetS caused more overall disruption in HIV-negative people with chronic diseases than in HIV-positive people. All of the indicators used to assess the increased risk of CMetS were equally meaningful in HIV+ and HIV-negative subjects. In this cohort; however, we identified that the NCEP tool predicts better than the IDF tool.

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M.A.: conceptualization, methodology, software, formal analysis, investigation, data curation, writing – original draft, writing – review and editing, project administration, funding acquisition; O.M.: supervision, conceptualization, methodology, formal analysis, investigation, writing – review and editing; W.S.: supervision, funding acquisition, review, and editing; A.S.: data curation, writing – review and editing; E.E.: supervision, conceptualization, methodology, formal analysis, investigation, writing – review and editing.

The data that support the findings of this study are available from the corresponding author, (E.E.), upon reasonable request. Informed consent was obtained from all subjects involved in the study. Because no personal identifiers were utilized, there was no requirement to seek formal informed consent from the patient(s) before publishing.

The study was approved by: (1) the Muhimbili University of Health and Allied Sciences, Office of the Director of Research and Publications (Ref. No. 2018-04-23/AEC//Vol. XII/88), Dar el Salaam, Tanzania; (2) School of Pharmacy, Addis Ababa University Ethical Review Board (ERB/SOP/41/11/2018), Addis Ababa, Ethiopia; (3) College of Health Sciences, Addis Ababa University Institutional Review Board (IRB, Meeting number 08/2018), Addis Ababa, Ethiopia; and (4) City Government of Addis Ababa Health Bureau, Ethical Clearance Committee (Ref no. A/A/HB/344438/227), Addis Ababa, Ethiopia. The study was carried out under the tenets of the Declaration of Helsinki. Patients provided informed consent before they participated in the study. Confidentiality and anonymity were maintained by removing any identifiers and restricting access.

Conflicts of interest

There are no conflicts of interest.

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