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Prevalence and determinants of metabolic syndrome among adults living with HIV on antiretroviral therapy in the West Region of Cameroon: a cross-sectional study

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Abstract

The epidemiology and factors associated with the onset of metabolic syndrome (MS) in the context of HIV remain poorly understood. In this cross-sectional study (September-October 2024, West Cameroon, two hospitals), we estimated the prevalence of MS and identified risk factors among 300 antiretroviral therapy (ART)-treated people living with HIV (PLHIV). MS was defined by the National Cholesterol Education Program – Adult Treatment Panel (NCEP-ATP) III criteria. Lipid profiles were from serum; diabetic/hypertensive status from records. Regression analyses used R software (threshold 0.05). The prevalence of MS was 15.0% (95% confidence interval [CI]: 11.2-19.1). Factors associated with MS included older than 40 years old (adjusted odds ratio [aOR]=2.8; 95% CI: 1.0-7.6; $p=0.041$), female sex (aOR=1.2; 95% CI: 1.1-1.9; $p=0.044$), treatment duration ≥ 1 year (aOR=1.1; 95% CI: 1.0-2.2; $p=0.015$). The regimen based on dolutegravir (DTG), an integrase strand transfer inhibitor (INSTI), was associated with MS in the univariate analysis; however, this association was no longer statistically significant after adjustment for other factors. MS is common among PLHIV on ART in the West Region of Cameroon, influenced by patient related factors, and duration of treatment. The therapeutic follow-up protocol for PLHIV should include monitoring for MS to reduce the occurrence of opportunistic diseases.

Key words: antiretroviral therapy; metabolic syndrome; PLHIV; prevalence; risk factors.

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Introduction

HIV/AIDS remains a major global public health challenge. In 2020, the Joint United Nations Programme on HIV/AIDS estimated that nearly 37.7 million people were living with HIV, with 1.5 million new infections and 680,000 AIDS-related deaths.¹ The distribution of the HIV pandemic is highly asymmetrical: in 2022, sub-Saharan Africa was home to 65% of all people living with HIV (PLHIV) and accounted for 60% of all AIDS-related deaths.² Faced with this situation, the advent of antiretroviral therapy (ART) radically transformed the prognosis for infection, changing it from a fatal disease to a chronic condition requiring lifelong treatment. In Cameroon, national efforts to improve access to treatment have resulted in a dramatic increase in ART coverage, from 26% in 2013 to 55% in 2018.³

While ART has increased life expectancy among PLHIV, it has also led to new comorbidities, particularly metabolic syndrome (MS), dyslipidemia, high blood pressure, and hyperglycemia.^{4,5} Persistent chronic inflammation from both HIV itself and cumulative ART toxicity promotes the development of MS.⁶

ART has been implicated in the onset of MS. Nucleoside

reverse transcriptase inhibitors (NRTIs), particularly stavudine, are associated with insulin resistance and marked dyslipidemia, with particularly high triglyceride (TG) levels.⁷ Protease inhibitors (PIs) increase total cholesterol (TC), TG, and low-density lipoprotein cholesterol (LDL-C).⁶ Non-nucleoside reverse transcriptase inhibitors (NNRTIs) like efavirenz, may induce lipid abnormalities, and both PIs and NNRTIs are associated with high blood pressure.^{6,8} Integrase strand transfer inhibitors (INSTIs), such as dolutegravir (DTG), show good efficacy but cause significant weight gain, a well-established risk factor for dyslipidemia and diabetes.^{9,10} MS (abdominal obesity, dyslipidemia, hypertension, insulin resistance) is common among PLHIV on ART; however, few studies have investigated this issue in Cameroon. Diesse *et al.* (2020) reported a 37.7% prevalence¹¹ and Dimala *et al.* (2016) highlighted the impact of ART on the metabolic profile.¹²

Despite national and regional data, specific cross-sectional studies on overall MS prevalence and its multifactorial risk factors are lacking in the West Region. Treatment regimens, genetics, and comorbidities vary regionally, potentially influencing MS profile. Thus, local data are needed to guide screening, prevention, and management strategies in the West Region.

Materials and Methods

Study design

We conducted a two-month cross-sectional study (1 September to 31 October 2024) in two health facilities in West Cameroon: Bafoussam Regional Hospital and Mbouo Protestant Hospital. These facilities were selected based on their active PLHIV case-load and to compare quality of care in public and private settings.

Study population and sampling strategy

Patients receiving HIV/AIDS care at Bafoussam Regional Hospital and Mbouo Protestant Hospital were consecutively invited to participate. Eligible participants were ≥ 18 years of either sex who had provided informed consent and were living with HIV and receiving ART. Participants were excluded if they had incomplete data, hemolyzed blood samples, or pre-existing metabolic abnormalities documented before ART initiation. Sample size was calculated using Cochran's formula:

$$n = (z^2 \times p \times (1-p)) / m^2$$

where: n = required sample size; z = z-score corresponding to the confidence level (usually 1.96 for 95% confidence); p = estimated prevalence of MS in South-West region of Cameroon (0.156, *i.e.*, 15.6%);¹³ m = margin of error (0.05). This gave $n=203$.

After accounting for 50% attrition, the final sample was 305, from which 5 patients with hemolyzed blood were excluded.

Data collection

Data collection was preceded by obtaining administrative authorizations (from the heads of the health facilities targeted by the study) and ethical authorizations (from the West Region Ethics Committee). This was followed by obtaining the free and informed consent of the patients included in the study. Information on their sociodemographic and clinical profiles was then collected using a questionnaire (Supplementary Material). A pre-test was conducted with 10 PLHIV who were on antiretroviral drugs (ART) to assess the clarity and consistency of the data collection instrument, and the necessary modifications were then made. Consultation records and patient files were also used to collect data on patients' latest viral load, blood sugar levels and data on hypertension. Participants' weight and height were measured to estimate their body mass index (BMI). BMI was defined as underweight if < 18.5 kg/m², normal weight if BMI was between 18.5 and 24.9 kg/m², overweight if BMI was between 25.0 and 29.9 kg/m², and obese if BMI was > 30 kg/m².^{14,15} Finally, a blood sample was taken to assess the lipid profile.

Blood sampling and laboratory procedures

Fasting venous blood (4 mL) was collected, centrifuged at 3,000 rpm for 10 minutes to obtain serum, and 2 mL of serum was stored at -20°C until analysis. All aliquots were transported in insulated safety boxes with ice packs to the laboratory of the Evangelical University Institute of Cameroon and stored at -20°C until analysis.

Serum TC, TG, and high-density lipoprotein cholesterol (HDL-C) were measured using a commercial Dutch diagnostic kit with spectrophotometry (SmartSpec 3000). LDL-C was calculated using the Friedewald formula.¹⁶ Blood glucose and blood pressure were obtained from medical records. An abnormal lipid profile was

defined as follows: TC ≥ 200 mg/dL; TG ≥ 150 mg/dL; HDL-C < 40 mg/dL;⁸ and LDL-C ≥ 160 mg/dL.

Criteria for identifying metabolic syndrome

MS was defined according to the revised National Cholesterol Education Program – Adult Treatment Panel (NCEP-ATP) III criteria, requiring at least three of five components: abdominal obesity (waist > 102 cm in men or > 88 cm in women, or BMI ≥ 30 kg/m²); elevated TGs (≥ 150 mg/dL or treated); reduced HDL-C (< 40 mg/dL in men or < 50 mg/dL in women, or on treatment); elevated blood pressure (systolic ≥ 130 mmHg and/or diastolic ≥ 85 mmHg, or on antihypertensive medication); and elevated fasting glucose (≥ 110 mg/dL, or previously diagnosed diabetes, or on antidiabetic medication).^{11,16,17}

Statistical analysis

The analyses included descriptive statistics (absolute/relative numbers for qualitative variables, means for quantitative variables) and association studies between sociodemographic factors, lipid profile, and MS. Interpretations used a 5% threshold. Association analyses employed Chi-square tests, followed by univariate and multivariate binary logistic regressions using R software version 7.2 *via* R-cmdr. Univariate regressions provided crude odds ratios (cOR), 95% confidence interval (CI), and p-values. Variables with $p < 0.05$ were included in multivariate models yielding adjusted odds ratios (aOR). Before modelling, multicollinearity was assessed, leading to two regression models per factor category.

Results

Sociodemographic characteristics

A total of 300 PLHIV on ART were enrolled (age 18-79, mean 48.7 ± 14 years); 34% were aged 48-57 years. Most participants were female (77.7%), with one pregnancy (0.3%). Married participants accounted for 46.3%, and non-smokers 96.0%. Overweight and obesity were present in 45% and 34.7%, respectively. Secondary education was reported by 53.3%, unemployment by 66.4%, and urban residence by 69.3%. The majority (86.3%) received tenofovir disoproxil fumarate (TDF)+3TC+DTG, with 99.0% treatment adherence. Viral load < 40 copies/mm³ was found in 93.6%, and 26.0% had been on treatment for over 10 years (Table 1).

Prevalence of metabolic syndrome

The prevalence of MS was 15.0% (95% CI: 11.2-19.1; Figure 1). The most common components of MS were high blood pressure (38.3%), diabetes (37.3%), followed by obesity (34.7%). A total of 104 participants (34.7%) had at least one component of the MS. Seventy (23.3%) had two components and 27 (9.0%) had four components (Figure 2).

Risk factors for metabolic syndrome

In univariate logistic regression (Table 2), factors significantly associated with MS were: age > 40 years (cOR=2.1; 95% CI: 1.0-4.6; $p=0.037$), female sex (cOR=1.2; 95% CI: 1.1-2.8; $p=0.019$), married status (cOR=4.5; 95% CI: 2.6-7.9; $p=0.037$), single status (cOR=3.2; 95% CI: 2.6-7.5; $p=0.046$), not being overweight (cOR=0.7; $p < 0.0001$), normal weight (cOR=0.8; $p < 0.001$), treatment duration > 1 year (cOR=2.2; 95% CI: 1.1-4.3; $p=0.015$), and INSTI (DTG)-based regimen (cOR=1.5; 95% CI: 1.4-2.6; $p=0.041$). In multivariate analysis (Table 3, model 2), independent risk factors for MS were: age > 40 years (aOR=2.8; 95% CI: 1.0-

7.6; $p=0.041$), female sex (aOR=1.2; 95% CI: 1.1-1.9; $p=0.044$), married status (aOR=1.1; 95% CI: 0.9-2.1; $p<0.001$), and treatment duration >1 year (aOR=1.1; 95% CI: 1.0-2.2; $p=0.015$).

Discussion

This cross-sectional study conducted in the West Region of Cameroon aimed to determine the prevalence and risk factors for MS among PLHIV on ART. This study reported a prevalence of 15% (45/300) of MS among PLHIV on ART, similar to the South-West Region¹³ but lower than in Bafoussam (28.8%) and Yaoundé (32.8%).^{12,18} This difference could be explained by the predominantly TDF+3TC+DTG regimen used, known for its favorable lipid profile, or to a healthier initial metabolic status.^{8,19} HIV infection itself induces chronic inflammation with high levels of interleukin (IL-6), tumour necrosis factor alpha and biomarkers such as D-dimer and C-reactive protein.⁶ Combined with cumulative ART toxicity, this disrupts lipid and carbohydrate metabolism and promotes endothelial dysfunction, increasing MS risk.^{18,20} The most prevalent MS components were arterial hypertension (38.3%) and diabetes (37.8%), similar to findings in South-West (26.5% and 24.7%) and Bafoussam (33.4% and 40.6%)^{11,21} and in Bafoussam (33.4% and 40.6%, respectively).¹² This is explained by a dual mechanism: HIV-induced chronic immune activation and pro-inflammatory cytokines promote insulin resistance and endothelial dysfunction,^{5,22} while direct ART toxicity, particularly from PIs and possibly INSTIs, contributes to insulin resistance.^{5,6}

Being over 40 years and female sex were independently associated with MS, consistent with studies identifying advanced age as a major risk factor and women of African descent as more vulnerable to ART metabolic effects.^{14,22,23} Ageing involves immunological senescence and chronic inflammation exacerbated by HIV/ART.⁵ In women, hormonal influence increases sensitivity to mitochondrial dysfunction and oxidative stress.^{9,24}

Metabolic syndrome

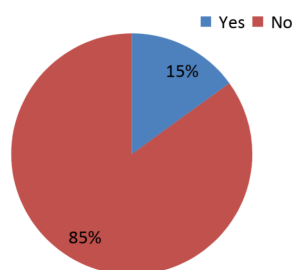


Figure 1. Prevalence of MS among study participants.

Metabolic syndrome components

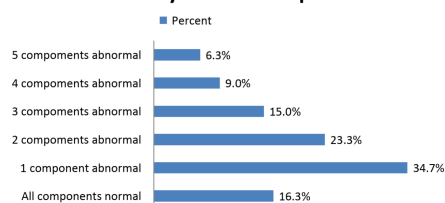


Figure 2. Distribution of number of MS components among PLHIV (N=300).

Table 1. Sociodemographic features and clinical profile of the participants.

Variables and category	Frequency (N=300)	Percentage (%)
Age		
Mean±SD	48.7±14	
18-27	15	5.0
28-37	17	5.7
38-47	84	28.0
48-57	102	34.0
58-67	60	20.0
68-77	21	7.0
>77	1	0.3
Sex		
Female	233	77.7
Male	67	22.3
Pregnant women		
Yes	1	0.3
No	299	99.7
Marital status		
Single	65	21.7
Cohabitation	15	5.0
Married	139	46.3
Widower	81	27.0
Smoking status		
Smoking	12	4.0
Non-smoker	288	96.0
Body mass index		
Mean±SD	28.7±14.7	
Normal	60	20.0
Obesity	104	34.7
Underweight	1	0.3
Overweight	135	45.0
Educational level		
Primary	110	36.7
Secondary	166	53.3
University	17	5.7
Non-formal	7	2.4
Freelance work		
Yes	101	33.6
No	199	66.4
Place of residence		
Rural	92	30.7
Urban	208	69.3
PLHIV treatment		
TDF+3TC+EFV	14	4.7
TDF+3TC+DTG	259	86.3
3TC+AZT+ATV	4	1.3
TDF+3TC+ATV	7	2.3
ABC+3TC+ATV	11	3.7
ATV/ABC	2	0.6
TDF+3TC+LPVr	3	1.0
Treatment adherence		
Yes	297	99.0
No	3	1.0
Viral load		
<40 copies/mm ³	281	93.6
>40 copies/mm ³	19	6.3
Duration of taking medication		
3 months	24	8.0
4 months	46	15.3
5 months	58	19.3
6 months	22	7.3
1 to 2 years	4	1.3
3 to 4 years	22	7.3
5 to 6 years	16	5.3
7 to 8 years	30	10.0
≥10 years	78	26.0

SD, standard deviation; PLHIV, people living with HIV; TDF, tenofovir; 3TC, lamivudine; EFV, efavirenz; DTG, dolutegravir; AZT, zidovudine; ATV, atazanavir; ABC, abacavir; LPVr, lopinavir.

Table 2. Univariate analysis of sociodemographic factors associated with MS.

Variables	MS Yes, n=45 (15%)		cOR No, n=255(85%)	95% CI	p
Age >40 years					
Yes	35 (18.2)	157 (81.1)	2.1	1.0-4.6	0.037
No	10 (9.3)	98 (90.7)	1		
Sex					
Female	41 (17.6)	192 (82.4)	1.2	1.1-2.8	0.019
Male	4 (6.0)	63 (94.0)	1		
Single					
Yes	8 (12.3)	57 (87.7)	3.2	2.6–7.5	0.046
No	37 (15.7)	198 (84.3)	1		
Married					
Yes	15 (10.9)	123 (89.1)	4.5	2.6–7.9	0.037
No	30 (18.5)	132 (89.1)	1		
Overweight					
Yes	0 (0.0)	135 (100.0)	1		<0.001
No	45 (27.3)	120 (72.7)	0.7	0.6-0.7	
Normal weight					
Yes	0 (0.0)	60 (100.0)	0.8	0.7-0.8	<0.001
No	45 (18.8)	195 (81.3)	1		
Secondary education					
Yes	30 (18.1)	136 (81.9)	1.7	0.8-3.4	0.097
No	15 (11.2)	119 (88.8)	1		
Independent activity					
Yes	16 (15.8)	85 (84.2)	1.1	0.5-2.1	0.771
No	29 (14.6)	170 (85.4)	1		
Place of residence					
Rural	11 (12.0)	81 (88.0)	1.4	0.6-2.8	0.326
Urban	34 (16.3)	174 (83.7)	1		
Tuberculosis					
Yes	4 (28.6)	10 (71.4)	2.3	0.7-7.9	0.145
No	41 (14.3)	245 (85.7)	1		
Duration of treatment					
<1 year	15 (10.0)	135 (90.0)	1		0.015
≥1 year	30 (20.0)	120 (80.0)	2.2	1.1-4.3	
ART					
TDF+3TC+EFV	1 (7.1)	13 (92.9)	5.4	0.2-126.7	0.293
TDF+3TC+DTG	39 (15.1)	220 (84.9)	1.9	0.1-22.0	0.600
3TC+AZT+ATV	0 (0.0)	4 (100.0)	1E9		
TDF+3TC+ATV	2 (28.6)	5 (71.4)	0.9	0.0-17.062	0.950
ABC+3TC+ATV	1 (9.1)	10 (90.9)	4.7	0.2-111.7	0.335
ATV/ABC	1 (50.0)	1 (50.0)	0.5	0.0-19.5	0.711
TDF+3TC+LPVr	1 (33.3)	2 (66.7)	1E9		
INSTI (DTG)					
Yes	39 (15.1)	220 (84.9)	1.5	1.4-2.6	0.041
No	6 (14.6)	35 (85.4)	1		
Treatment compliance					
Yes	45 (15.2)	252 (84.8)	1.1	1.1-1.2	0.465
No	0 (0.0)	3 (100.0)	1		
Viral load					
<40 copies/mm ³	42 (14.9)	239 (85.1)	1.0	0.2-3.8	0.921
>40 copies/mm ³	3 (15.8)	16 (84.2)	1		
Duration of taking medication					
3 months	2 (8.3)	22 (91.7)	1		0.445
4 months	3 (6.5)	43 (93.5)	1		
5 months	6 (10.3)	52 (89.7)	1.3	0.6-2.7	
6 months	4 (18.2)	18 (81.8)	1		
1 to 2 years	0 (0.0)	4 (100.0)	1		
3 to 4 years	7 (31.8)	15 (68.2)	1.4	1.1-2.1	0.130
5 to 6 years	2 (12.5)	14 (87.5)	1		
7 to 8 years	6 (20.0)	24 (80.0)	1		
≥10 years	15 (19.2)	63 (80.8)	1.8	0.9-3.3	

cOR, crude odds ratio; CI, confidence interval; ART, antiretroviral therapy; TDF, tenofovir; 3TC, lamivudine; EFV, efavirenz; DTG, dolutegravir; AZT, zidovudine; ATV, atazanavir; ABC, abacavir; LPVr, lopinavir; INSTI, integrase strand transfer inhibitors; DTG, dolutegravir.

Table 3. Multivariate analysis of sociodemographic factors and clinical profile associated with MS.

Variables	aOR	Model 1 95% CI	p	aOR	Model 2* 95% CI	p
Age >40 years						
Yes	1.8	0.9-2.8	0.169	2.8	1.0-7.6	0.041
No	1			1		
Sex						
Female	1.2	1.0-1.9	0.038	1.2	1.1-1.9	0.044
Male	1			1		
Single						
Yes	2.7	0.3-23.4	0.362	3.8	0.4-31.4	0.210
No	1			1		
Married						
Yes	1.1	0.8-2.5	<0.001	1.1	0.9-2.1	<0.001
No	1			1		
Overweight						
Yes	1					
No	1.2		1.000			
Duration of treatment						
<1 year				1		
≥1 year				1.1	1.0-2.2	0.015
INSTI (DTG)						
Yes	0.1	0.0-3.5	0.244			
No	1					

aOR, adjusted odds ratio; CI, confidence interval; INSTI, integrase strand transfer inhibitors; DTG, dolutegravir; *best model.

Treatment duration greater than or equal to 1 year was significantly associated with MS. This is consistent with several studies that have shown an increase in metabolic parameters with the duration of ART.^{25,26} Cumulative ART toxicity leads to mitochondrial toxicity, oxidative stress and persistent inflammation.^{20,27}

Although not significant in the final multivariate model, an association between DTG-based regimen and MS was noted in univariate analysis. Studies report weight gain and diabetes risk with integrase inhibitors,^{9,10} confirmed in Cameroon.²⁸ This suggests INSTI metabolic effects are mediated by weight gain and central obesity rather than direct lipid or blood pressure disruption.

Limitations of the study

This study had two main limitations. First, the cross-sectional design prevents establishing causal relationships between risk factors and MS. Second, CD4 data were frequently missing and were replaced by viral load, which was well documented and, like CD4 count, allows disease stage classification.

Conclusions

This study found a 15% prevalence of MS among PLHIV on ART in West Cameroon, highlighting an emerging public health issue. Age over 40 and female sex are strongly associated, indicating a need for targeted screening. Prolonged ART duration (≥1 year) is an independent factor, underscoring the metabolic impact of long-term antiretroviral exposure.

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Online supplementary material
Supplementary material 1. Questionnaire.

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Availability of data and materials: data supporting the findings of this study are available from the corresponding author upon reasonable request.

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