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Correlates of viral load suppression among people living with HIV on antiretroviral treatment in Mbujimayi, Democratic Republic of Congo: a cross-sectional study

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Research Article

Keywords: Suppression, Viral load, PLWH, ART, Mbujimayi

Posted Date: April 7th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-9330574/v1

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Additional Declarations: No competing interests reported.

Abstract

Context

Acquired immunodeficiency syndrome (AIDS) remains a major global public health concern and one of the leading causes of mortality worldwide. Lifelong antiretroviral therapy (ART) enables viral load suppression or undetectability, reducing the risk of opportunistic infections and improving survival. However, some individuals fail to achieve viral suppression, and understanding the associated factors is critical. This study aimed to identify key determinants of successful viral suppression among people living with HIV (PLWH) on ART.

Methods

A cross-sectional study was conducted in Mbujimayi, Democratic Republic of Congo, involving 561 PLWH from ten healthcare facilities with available viral load results. Data on ART adherence, sexual behavior, and sociodemographic characteristics were collected. Viral load served as the primary outcome. Variables with $p < 0.20$ in bivariate analysis were included in a multivariable modified binomial logistic regression model to adjust for confounders. Statistical significance was set at $p < 0.05$.

Results

Participants had a median age of 49 years (IQR: 18) and a median ART duration of 9 years (IQR: 7); 66.31% were female, and 67.56% were in WHO clinical stage 3. Condom use was reported by 67.91%, while 84.3% had no casual sexual partners; 91.78% abstained from alcohol, and 86.45% adhered to ART. Multivariable analysis identified ART adherence (AOR 11.743 [95% CI: 4.153–33.204], $p < 0.001$), absence of casual sexual partners (AOR: 2.179 [95% CI: 1.221–3.888], p = 0,008), and condom use AOR: 1.764 [95% CI: 1.144–2.721], $p = 0.010$), and ART duration (AOR: 1.590 [1.086–2.328], $p = 0.045$) as significant predictors of viral suppression. However, no alcohol consumption was a protective factor (AOR: 0.486 [95% CI: 0.240–0.985]).

Conclusion

Strict ART adherence and stable sexual behaviors (absence of casual sexual partners, condom use) were associated with viral suppression. Strengthening health education and psychosocial support programs to promote adherence and safe sexual practices could improve treatment outcomes. These findings provide evidence to guide public health strategies for HIV management in resource-limited settings.

BACKGROUND

Acquired immunodeficiency syndrome (AIDS) remains a major global public health challenge and has been one of the leading causes of mortality worldwide since the onset of the epidemic. Between its emergence and 2021, approximately 40.1 million people died from AIDS-related illnesses [1]. With improved access to prevention, diagnosis, treatment, and care, infection with the human immunodeficiency virus (HIV) has increasingly been managed as a chronic condition, allowing many individuals to live longer and healthier lives.

The advent of antiretroviral therapy (ART) has transformed the trajectory of the epidemic, offering hope for better control. However, access to ART remains problematic in many low- and middle-income countries [2]. In these settings, ART is predominantly delivered through primary care facilities, where laboratory capacity for viral load monitoring is limited, health systems often lack the ability to act on viral load results, and evidence-based interventions to strengthen adherence are scarce [2, 3].

According to the WHO and CDC, sustained adherence to ART is the key determinant of viral load suppression and reduced transmission risk. Yet, long-term adherence in resource-limited settings is hindered by multiple patient- and program-related barriers, including poverty, food insecurity, alcohol and tobacco use, poor quality of life, sexual behaviors, forgetfulness, limited knowledge, treatment interruptions, distance to health facilities, and the cost of care [4].

Suboptimal adherence or treatment interruptions can lead to viral rebound, undermining the benefits of long-term ART [4–6]. Conversely, individuals who achieve viral suppression experience stronger immune recovery, improved clinical outcomes, and reduced mortality [7]. Moreover, maintaining an undetectable viral load eliminates the risk of sexual transmission to HIV-negative partners, a principle captured in the Undetectable or Untransmittable campaign [7, 8].

Despite these advances, a proportion of patients continue to struggle with achieving or maintaining viral suppression [9]. In the Democratic Republic of Congo (DRC), studies conducted in Kinshasa and Haut Katanga reported viral suppression rates ranging from 62% to 92.5%, with undetectable viral load levels between 53% and 56.4% [4, 10, 11].

According to national estimates from the HIV/AIDS Control Program (PNLS/PNMLS), only 19% of PLWH had a suppressed viral load, far below the UNAIDS 95-95-95 targets [12]. Social determinants of health—including depression, adverse events, self-efficacy, and social support—also play critical roles in adherence and viral suppression [9]. Poor engagement in care, particularly during the early stages of treatment, is strongly associated with inadequate adherence [9].

In East Kasai Province, where Mbujimayi is located, monitoring ART effectiveness remains particularly challenging. Provincial laboratories lack the capacity to perform viral load testing, limiting systematic surveillance and hindering timely clinical interventions such as adherence counseling [13].

In accordance with the national policy for integrated HIV/AIDS care in DRC and WHO recommendations for viral load monitoring among PLWH on ART specifically, an initial test six months after treatment

initiation, followed by a second test at 12 months (six months after the first). After two consecutive undetectable results, RNA testing is performed annually [14–16]. However, significant gaps persist in resource-limited contexts, particularly in the East Kasai province.

This study aimed to identify the factors associated with viral load suppression among people living with HIV receiving highly active antiretroviral therapy (HAART) in Mbujimayi, Democratic Republic of Congo. By clarifying these determinants, the study seeks to contribute to improved patient follow-up and to reducing HIV-related morbidity and mortality.

MATERIALS AND METHODS

Study Design and Setting

We conducted a cross-sectional study to document the factors that can influence viral load suppression of PLWH to ART in the Mbujimayi city, the capital of East Kasai Province in the Democratic Republic of the Congo. Mbujimayi town comprises 10 of East Kasai Province's 19 health zones. We conducted our study at 10 healthcare facilities in Mbujimayi (Hospital Bonzola Hospital, Dipumba Hospital currently Clinique Universitaire de Mbujimayi, Presbyterian Hospital, Kansele Hospital, Kayembe Hospital, Saint Franciscans Hospital, Bena Cibuabua Center, Camp Nsele Center and Centre Nyongolo Center), which care for PLWH and have viral load results.

Study population

The target population of the study was HIV-positive people on ART attending HIV/AIDS treatment and diagnosis centers in the city of Mbujimayi. Given the constraints related to the achievement of the viral load (VL), the accessible population on which we worked was composed of PLWH attending the targeted hospitals and organizing the VL between the study period.

Study eligibility criteria

Inclusion criteria

The inclusion criteria for the study participants were individuals who met the following conditions: all HIV patients on antiretroviral treatment who received a viral load in the selected facilities during the study period.

Non-inclusion criteria

All PLWH were not receiving antiretroviral therapy (ART) at the study period; patients who did not undergo a viral load test during the study period, patients followed up in health facilities not selected for

the study and individuals with incomplete or missing data regarding HIV status, ART regimen, or viral load results.

Sample size

We estimated the sample size using the Fleiss formula for two proportions [17]:

$$N = \frac{[Z_{\alpha}\sqrt{p(1\text{-}p)(\frac{1}{q_1}+\frac{1}{q_2})}\:+\:Z_{\beta}\sqrt{p_1(1\text{-}P1)\frac{1}{q_1}+p_2(1\text{-}P2)\frac{1}{q_2}}]^2}{(P2\text{-}P1)^2}$$

where p1 is the proportion of patients with a suppressed viral load, 0.19 [12], and p2 is the expected proportion of no suppressed patients in the study (35%). We set the power at 80% (Zβ = 0.84) and the confidence interval at 95% (Zα = 1.96) with a no suppressed/suppressed ratio of 2:1. Consequently, the initial estimated sample size was approximately 561 PLWH on ART, including 187 suppressed PLWH and 374 no suppressed PLWH.

Data collection

Investigators were recruited in Mbujimayi based on their availability, educational background, and adherence to the principal investigator's guidelines. Prior to data collection, they underwent comprehensive training on the use of the data collection tool. The training covered the study context, specific objectives, case definitions, and operational acronyms. Additionally, ethical and cultural considerations, appropriate dress code, and professional conduct during fieldwork were emphasized. Potential factors that could influence data quality were also discussed to ensure methodological rigor.

We used a data collection grid in PLWH files. Data collection took place from November 7, 2022, to January 9, 2023. Pretesting of the data collection tool (questionnaire) was carried out in two healthcare facilities (Muya Hospital and Christ-Roi Hospital) before the actual data collection was launched in the selected care facilities. Final modifications were made to the data collection tool immediately after the pretest, and enumerators were reassessed for suitability; unsuitable enumerators were automatically excluded from the study. Given that our main source of data was the records of PLWH on targeted ART in health facilities, and supplemented by interviewing patients about missing elements in the record, we were able to select PLWH who had achieved a viral load and whose result was available, respecting the ratio of 1 suppressed for 2 not suppressed. Once selected, cases were approached by investigators or research assistants at the earliest opportunity.

Study variables and measurements

The primary objective of this study was to identify predictors of viral load suppression, defined as a viral load of ≤ 1000 RNA copies per milliliter of blood. This criterion aligns with the World Health Organization (WHO) guidelines and the standard measurement used in the Democratic Republic of Congo (DRC) [14–16]. To ensure consistency and accuracy, the most recent viral load result was used for analysis; thus, a single RNA measurement served to define viral load suppression.

In addition to viral load suppression, the analysis considered several explanatory variables, including sociodemographic, economic, and HIV-related clinical factors. Sociodemographic variables included sex, age, geographic origin, main activities (occupation), socioeconomic status, education, marital status, household size, presence of a stable and/or occasional partner, and alcohol and tobacco use. Clinical variables included duration on ART, WHO clinical stage, ART regimen, tuberculosis co-infection, condom use, and ART adherence.

ART adherence was defined as correct and consistent intake of prescribed antiretroviral drugs. Adherence was assessed using patient medical records and confirmed through self-report during interviews. Participants were classified as adherent (≥ 95% of doses taken) or non-adherent [14, 16].

The ART regimen used by all patients included in this study consists of a combination of two nucleoside reverse transcriptase inhibitors (tenofovir and lamivudine) and one integrase inhibitor (dolutegravir), in accordance with the integrated HIV management guidelines in the DRC.

These variables were selected based on their epidemiological relevance and documented association with viral load suppression in the scientific literature. They were categorized according to international standards to ensure comparability and analytical robustness.

Data management

The data were initially received in a Microsoft Excel format and subsequently imported into Stata 17 for further processing and analysis. In Stata, variables were meticulously constructed and defined in accordance with the specified measurements and parameters of the study.

To ensure the integrity and reliability of the dataset, a rigorous data cleaning process was undertaken. This process commenced with the execution of descriptive statistical analyses to identify any anomalies, errors, inconsistencies, or missing values within the dataset. Observations with missing data points pertaining to the outcome variable were systematically excluded from subsequent analyses. This step was undertaken to maintain the robustness and validity of the analytical procedures employed.

Statistical analysis

Data were analyzed using Stata statistical software, version 17. Descriptive analysis was conducted; wherein continuous variables such as age, ART duration and household size were presented as medians with interquartile range (IQR). Categorical variables were summarized as frequencies and percentages with their 95% IC. Bivariable analysis was conducted using the chi-square test for all dichotomized variables. Factors that were significant at $p \leq 0.2$, such as profession, provenance, casual sexual partner, condom use, smoking, alcoholism, pulmonary tuberculosis, clinical stage, ART duration and adherence, were further evaluated in the multivariable binomial logistic regression model to adjust for measured confounding factors and predict the variability of the response as a function of the explanatory variable. Adjusted odds ratios (AOR) was estimated with their 95% CI to measure the strength of the associations

between the independent variables considered and the suppression of the viral load. All variables with a $p \leq 0.05$ were considered statistically significant and retained in the final model.

RESULTS

Characteristics of study participants.

This table shows that the median age of PLWH on ART is 49 years (IQR: 19). The median household size is 5 persons (IQR: 4), and the median duration on ART is 9 years (IQR: 7). Participants were 66.31% female, 48.48% married, and 81.11% had a secondary education level. Employment was reported by 52.58%, 89.48% resided in the urban area of Mbujimayi, and 93.94% had low socioeconomic status. A stable sexual partner was reported by 48.66% and a casual sexual partner by 15.69%. Smoking was observed in 14.08% and alcohol consumption in 8.02%. Pulmonary tuberculosis was present in 57.40%, and 67.56% were classified as WHO stage III. Condom use was reported by 67.91%. All participants were on the TDF/3TC/DTG (TLD) regimen, with good adherence achieved in 86.45% (Table 1).

Table 1
Sociodemographic and economic characteristics and clinical and therapeutic variables

Variables	N = 561	% [95%CI]	Median (Q1 – Q3)
Age (year)			49 (39–57) years
[15–49]	296	52.76 [48.63–56.86]	
Beyond 49	265	47.24 [43.14–51.37]	
Household size (person)			5 (3–7)
[0–5]	339	60.43 [56.32–64.39]	
Beyond 5	222	39.57 [35.61–43.68]	
Duration ART (year)			9 (6–13) years
[0–9]	297	52.94 ǀ48.80–54.04]	
[Beyond 9]	264	47.06 [42.96–51.20]	
Viral load (copy/ml)			
[≤ 40]	164	29.23 [25.62–33.13]	
[41–1000]	23	4.10 [2.75–6.08]	
[Beyond 1000]	374	66.67 [62.66–70.44]	
Sex			
Female	372	66.31 [62.30–70.10]	
Male	189	33.69 [29.90–37.70]	
Marital status			
Single	86	15.33 [12.59–18.55]	
Married	272	48.48 [44.37–52.62]	
Widower	155	27.63 [24.09–31.47]	
Divorced	48	8.56 [6.51–11.16]	
Education			
Uneducated	13	2.32 [1.36–3.92]	
Primary	59	10.52 [8.24–13.33]	
Secondary	455	81.11 [77.66–84.13]	
Higher and University	34	6.06 [4.37–8.35]	
Main activities (occupation)			

Variables	N = 561	% [95%CI]	Median (Q1 – Q3)
Employees	295	52.58 [48.45–56.69]	
Nonemployees & others	266	47.42 [43.31–51.55]	
Place of residence			
Urban	502	89.48 [86.67–91.76]	
Rural	59	10.52 [8.24–13.33]	
Socioeconomic status			
Low	527	93.94 [91.65–95.63]	
Average	34	6.06 [4.37–8.35]	
Stable sexual partner			
Yes	273	48.66 [44.55–52.79]	
No	288	51.34 [47.21–55.45]	
Casual sexual partner			
Yes	88	15.69 [12.91–18.93]	
No	473	84.31 [81.07–87.09]	
Smoking			
Yes	79	14.08 [11.45–17.21]	
No	482	85.92 [82.79–88.55]	
Alcohol use			
Yes	45	8.02 [6.05–10.57]	
No	516	91.98 [89.43–93.95]	
Pulmonary tuberculosis			
Yes	322	57.40 [53.27–61.43]	
No	239	42.60 [38.57–46.73]	
WHO disease stage			
Stage I	11	1.96 [1.10–3.48]	
Stage II	105	18.72 [15.71–22.15]	
Stage III	379	67.56 [63.58–71.30]	
Stage IV	66	11.76 [9.35–14.69]	

Variables	N = 561	% [95%CI]	Median (Q1 – Q3)
Condoms use			
Yes	381	67.91 [63.94–71.64]	
No	180	32.09 [28.36–36.06]	
ART adherence			
Yes	485	86.45 [83.37–89.04]	
No	76	13.55 [10.96–16.63]	
Viral load suppression			
Yes	187	33.33 [29.56–37.34]	
No	374	66.67 [62.66–70.44]	

Prediction factors with viral load suppression among people living with HIV.

The bivariate analysis revealed a statistically significant relationship between nonexistence of casual sexual partners (p = 0.005), condom use (p = 0.0011), pulmonary tuberculosis (p = 0.013), clinical stage (p = 0.32), duration of ART (p = 0.004) and adherence (p < 0.001) with viral load suppression (Table 2). In the Multivariate analysis with binomial logistic regression model, the absence of a casual sexual partner (AOR: 2.179 [95% CI: 1.211–3.888], p = 0.008), condom use (AOR: 1.764 [95% CI: 1.144–2.721], p = 0.010), duration of ART beyond 9 years (AOR: 1.590 [1.086–2.328], p = 0.017), and adherence (AOR: 11.743 [4.153–33.204], p < 0.001) were significant factors associated with viral load suppression in PLWH on ART. Alcohol abstinence was also a protective factor (AOR: 0.486 [0.240–0.985], p = 0.045). (Table 2).

Table 2
Prediction factors (bivariate analysis and multivariate analysis with binomial logistic regression)

Variables	Viral load suppression					
	Yes (n = 187)	No (n = 374)	COR [95%CI]	p	AOR [95%CI]	p
Age						
[15–49]	94 (31.76)	202 (68.24)	0.861 [0.606–1.223]	0.403		
Beyond 49	93 (35.09)	172 (64.91)	1			
Sexe						
Female	118 (31.72)	254 (68.28)	0.869 [0.559–1.167]	0.260		
Male	69 (36.51)	120 (63.49)	1			
Marital Status						
Living alone (single, widowed, divorced)	97 (33.56)	192 (66.44)	1.022 [0.719–1.452]	0.905		
Married	90 (33.09)	182 (66.91)	1			
Instruction						
Uneducated & Primary	21 (29.17)	51 (70.83)	0.801 [0.466–1.377]	0.422		
Secondary & High/University	166 (33.95)	323 (66.05)	1			
Household size (person)						
[0–5]	110 (32.45)	229 (67.55)	0.905 [0.632–1.294]	0.583		
Beyond 5	77 (34.68)	145 (65.32)	1			
Profession						

Variables	Viral load suppression					
	Yes (n = 187)	No (n = 374)	COR [95%CI]	p	AOR [95%CI]	p
Age						
Employees	109 (36.95)	186 (63.05)	1.412 [0.991–2.013]	0.056	1.280 [0.808–1.915]	0.208
Nonemployees & others	78 (29.32)	188 (70.68)	1		1	
Place of residence						
Urban	174 (34.66)	328 (65.34)	1.877 [0.987–3.569]	0.052	1.412 [0.712–2.801]	0.323
Rural	13 (22.03)	46 (77.97)	1		1	
Socioeconomic status						
Law	177 (33.59)	350 (66.41)	1.214 [0.568–2.594]	0.617		
Average	10 (29.41)	24 (70.59)	1			
Stable sexual partner						
Yes	91 (33.33)	182 (66.67)	1.00 [0.704–1.421]	1.000		
No	96 (33.33)	192 (66.67)	1			
Casual sexual partner						
Yes	18 (20.45)	70 (79.55)	1		1	
No	169 (35.73)	304 (64.27)	2.162 [1.246–3.751]	0.005	2.179 [1.221–3.888]	0.008
Condoms use						
Yes	144 (37.80)	237 (62.20)	1.936 [1.297–2.889]	0.0011	1.764 [1.144–2.721]	0.010
No	43	137	1		1	

Variables	Viral load suppression					
	Yes (n = 187)	No (n = 374)	COR [95%CI]	p	AOR [95%CI]	p
Age						
	(23.89)	(76.11)				
Smoking						
Yes	32 (40.51)	47 (59.49)	1		1	
No	155 (32.16)	327 (67.84)	0.696 [0.427–1.134]	0.145	0.895 [0.514–1.556]	0.694
Alcohol						
Yes	21 (46.67)	24 (53.33)	1		1	
No	166 (32.17)	350 (67.83)	0.542 [0.293–1.002]	0.068	0.486 [0.240–0.985]	0.045
Pulmonary tuberculosis						
Yes	121 (37.58)	201 (62.42)	1.578 [1.098–2.267]	0.013	1.413 [0.947–2.107]	0.090
No	66 (27.62)	173 (72.38)	1		1	
WHO disease stage						
Stage 1 & 2	29 (25.00)	87 (75.00)	1		1	
Stage 3 & 4	158 (35.51)	287 (64.49)	1.652 [1.040–2.624]	0.032	1.578 [0.956–2.605]	0.075
ART duration (years)						
[0–9]	83 (27.95)	214 (72.05)	1		1	
Beyond 9	104 (39.39)	160 (60.61)	1.676 [1.177–2.387]	0.004	1.590 [1.086–2.328]	0.017
ART adherence						

Variables	Viral load suppression					
	Yes (n = 187)	No (n = 374)	COR [95%CI]	p	AOR [95%CI]	p
Age						
Yes	183 (37.73)	302 (62.27)	10.907 [3.920–30.352]	< 0.001	11.743 [4.153–33.204]	< 0.001
No	4 (5.26)	72 (94.74)			1	

ROC Curve

The area under the curve (AUC) values indicated that the ability to predict viral load suppression among PLWH was approximately 72.5% (AUC: 0.725 [95% CI: 0.682–0.769], p < 0.001) (Fig. 1).

DISCUSSION

This study highlights the following: the factors associated with viral load suppression in our study were adherence, the absence of an occasional sexual partner and condoms use.

In our work, we found that therapeutic adherence was 86.45%, whereas nonadherence was 14.55%. Abdullahi *et al.* (2020), in their 2020 work in Ethiopia, reported that 36.1% of participants had low adherence and that poor adherence was associated with a 10-fold increased risk of an unsuppressed viral load [18]. The difference between the two studies may be explained by variations in treatment regimens and patient follow-up. In our setting, simplified therapeutic strategies and consistent monitoring likely contributed to better adherence. These findings reinforce the importance of optimized treatment and strengthened follow-up to improve compliance and reduce treatment failure. Several studies have highlighted considerable variability in ART adherence, for instance, Ladak *et al.* (2019) reported adherence rates exceeding 95% [19]. In contrast, Touzard Romo *et al.* (2014) documented fluctuations between 2003 and 2010, with adherence ranging from 67% to 86% [20]. Moreover, Kalichman *et al.* (2014), found that 47% of patients did not adhere properly to ART, and identified alcohol consumption, lack of medication and certain social situations as contributing factors [21].

In previous studies on the determinants of suppression or no suppression of the viral load, the authors consistently reported increased risks of no suppression in people with poor adherence to therapy [18, 21–23]. A high viral load is observed in people with poor adherence because an optimal drug concentration is needed to control viral replication. It has been reported that 95% or more adhesion is required for sustained viral suppression [18, 24].

Viral load suppression among PLWH on ART is influenced by several factors, including coinfections, specific ART regimen, suboptimal adherence, drug resistance, and the stage of infection [25]. Consistent adherence is critical to achieving and sustaining suppression. Although, alcohol consumption has often been studied in relation to adherence, its direct effect on viral suppression has received less attention. Evidence from India showed that improved adherence was the main determinant of suppression, with 88% of PLWH achieving viral load suppression despite 48% initially experiencing clinical or immunological failure [26]. Nevertheless, the emergence of ART-resistant strains demonstrates that even patients with good adherence may fail to achieve suppression, as resistance frequently results from a history of poor adherence [21].

In our series, we found that adherence was significantly associated with viral load suppression ($p < 0.001$). Good adherence was associated with approximately a seven-fold greater likelihood of achieving viral load suppression (IRR 6.956 [95% CI: 2.579–18.763). This result highlights interest and reinforces the need to improve adherence and therapeutic compliance at a high level, more than 90%, to ensure the sustained and lasting effectiveness of the ART for the suppression of the viral load.

Previous studies have shown that good adherence, duration of ART, and disclosure of status are factors in viral load suppression [10, 21, 26–28]. A study conducted in 2022 in Kinshasa and Upper Katanga in the DRC before and after COVID-19 by Shah *et al*. revealed that viral load suppression was associated with the timing of ART initiation (AOR: 2.50), female sex (AOR: 1.23), rural residence (AOR: 1.83), and the timing of the last visit (AOR: 1.50) [11]. However, homelessness and lack of moral support [29], male sex, initiation of ART < 15 years, treatment for tuberculosis, duration of one year and more than 10 years under ART [30], drug and alcohol use [19], poor adherence to therapy [9, 31], and nevirapine-based treatment [32] are associated with no suppression of the viral load and/or rebound.

In East Kasai Province in the DRC, 19% of HIV patients on ART had access to a viral load test [13]. This low rate of access is explained by the difficulty in supplying inputs to the provincial laboratory, thus having a negative impact on the follow-up of patients. Currently, many more than 1000 unanalyzed samples are at the National Institute for Biomedical Research, possibly because either the influx of samples or the samples are not taken in the standards and are unanalyzable. We believe that if the provincial laboratory was supplied with inputs to achieve a viral load, PLWH would be monitored without any problems, which would lead to better monitoring of patients [13].

The absence and/or absence of an occasional sexual partner was significantly associated with viral load suppression (AOR: 2,179 [95% CI: 1,221–3,888], $p = 0.008$. Although the mechanisms underlying this situation were not explored in our study, it is possible that individuals with greater adherence to ART may also be more selective in their sexual partnerships, thereby contributing to improved adherence and more consistent follow-up. However, this hypothesis cannot be confirmed with the current analysis. This statistical association highlights the need for further research to clarify the influence of relational contexts on adherence and viral suppression among PLWH.

We also found that condom use (AOR: 1,764 [95% CI: 1,144–2,721]) and the duration of treatment beyond 9 years (AOR: 1,590 [95% CI: 1,086 – 2,328]) were also factors in viral load suppression in PLWH. In contrast, alcohol was a protective factor (AOR: 0.486 [95% CI: 0.240–0.985]). Some authors found factors in their study that predicted viral load suppression. These factors include a longer duration of antiretroviral treatment (> 3 years) [33], WHO stage I diagnosis, good adherence to antiretroviral therapy, nevirapine-based treatment and increasing duration of treatment [34]; women and people with higher levels of education [35]; and reduced alcohol consumption [36]. In contrast, our study identified therapeutic adherence, condom use, and the absence of casual sexual partners as the only factors associated with viral suppression. This variation may reflect the particular characteristics of the study population and the limitations inherent in a cross-sectional design, which restricts the ability to capture additional clinical or socio-demographic predictors.

On the other hand, the probability of viral load suppression was lower in people who had been on antiretroviral therapy for 36 to 59 months [35]. Occasional and frequent heavy drinking is associated with viral no suppression [37–39]. The authors also showed that the association was not statistically significant when restricted to people on antiretroviral treatment, suggesting that the relationship between alcohol consumption and viral suppression is explained by the use of antiretroviral treatment [38]; young people aged 15–29 years, among men, people reporting irregular condom use with nonmarital/casual partners versus people with marital/permanent partners only [39]. Other authors have reported a no association between abusive, hazardous, harmful and dependent alcohol consumption and HIV viral suppression [40, 41].

A meta-analysis revealed that on the basis of scientific evidence and high-quality data, the risk of sexual transmission of HIV is negligible when an HIV-positive sexual partner is on antiretroviral therapy and maintains a suppressed viral load of less than 200 copies/ml, measured every 4–6 months. Sexual transmission of HIV occurs when the viral load is above 200 copies/ml with antiretroviral therapy or when condoms alone are used, although the risk remains low [42]. One study reported irregular condom use in the first year after HIV diagnosis of 47.0% to 17.5% ($p < 0.05$) and 49.6% to 17.8% ($p < 0.01$) for anal sex primary and casual partners, respectively. The rate of irregular condom use remained at approximately 20% after treatment initiation and viral load suppression [43].

Antiretroviral therapy has been demonstrated to lower the risk of sexual transmission of HIV. Moreover, sexual behavior patterns, particularly the avoidance of practices classified as high-risk, are frequently reported as factors that may influence adherence, treatment outcomes, and viral suppression among people living with HIV [44].

Study limitations

The population of our study is PLWH, a category of patients who has been subject to discrimination and stigma, which contributed to participant attrition and may have affected the representativeness of the sample. Some variables, such as weight, height or even the calculation of body mass index, were not

considered. We had to collect data from several health care facilities because of the nonavailability of viral load results despite sampling due to the nonfunctioning of the provincial laboratory and the fact that all samples were sent to Kinshasa or Lubumbashi for analysis.

The cohort had an average of nine years on antiretroviral therapy, indicating a population with relatively greater stability and adherence; however, this may restrict the generalizability of findings to newly diagnosed individuals or those with shorter treatment histories. Overall, these limitations highlight the need for future research aimed at reducing attrition, incorporating a broader range of clinical variables, and ensuring more timely access to virological data.

CONCLUSION

This study of viral load suppression in PLWH on ART highlighted the effectiveness of current treatments in managing HIV and reducing the viral load to undetectable levels. The results indicated that, in many situations, PLWH on ART who reported correct adherence to treatment, consistent condom use, and the absence of casual sexual partners were more likely to achieve viral suppression. While these associations suggest potential benefits for both quality of life and reduced risk of HIV transmission, the cross-sectional and observational design of the study does not allow for causal inferences. In addition, although antiretrovirals have significantly improved HIV management, strengthening patient support strategies, particularly with respect to treatment adherence and compliance education, comorbidity prevention and stigma reduction, remains crucial. A holistic approach that combines medical care, psychosocial support and treatment accessibility is essential to optimize ART outcomes and ensure a healthy, fulfilling life for PLWH.

These results highlight the crucial impact of treatment adherence and sexual health practices on viral control. They support the implementation of targeted strategies to strengthen patients' commitment to treatment and reduce risk behaviors.

Abbreviations

and acronyms
AIDS
Acquired Immunodeficiency Syndrome
ART
Anti-Retroviral Therapy
HIV
Human Immunodeficiency Virus
IQR
Interquartile range
IRR
Incidence rate ratio

PLWH
Person leaving with HIV
VL
Viral load

Declarations

Ethics approval and consent to participate

N/A

Consent for publication

All participants provided consent for the publication of the study results, with full respect for confidentiality and anonymity.

Competing interests

The authors declare that they have no competing interests.

Ethical consideration

Ethical authorization was granted by the ethics committee of the Official University of Mbujimayi, registered in number 001/2024/CERUOM/NKL. Free and informed consent was used in both French and Tshiluba (the local national language). The ethical regulations outlined in the Declaration of Helsinki were followed throughout the study. The data were stored on a laptop computer with a password-protected and locked cabinet, and only the lead investigator and study supervisor had access to the data.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Author Contribution

Conceptualization: DB and GN, Methodology: AM, KNM, PMC and PL, Data curation: DB, BMN and CT, Formal analysis: DB, GN, AM and BMN, Writing – original draft: DB, CT, CKM, Writing – review & editing: DB, AMK, KNM, CKM, PMC, and PL and, Supervision: AMK, PMC, CKM and PL, Validation: All authors, Final approval of the manuscript: All authors

Acknowledgement

We would like to thank Official University of Mbujimayi, Provincial coordination of the national HIV/AIDS program in East Kasai, and administrators of the hospitals as well as staffs of the hospitals for their genuine cooperation during the data collection processes. Our gratitude also goes to data collectors and supervisors for their hardworking and patience in obtaining the necessary information. Our special thanks also go to participants who generously shared their thoughts and feelings and other commitments

Data Availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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patients infected with human immunodeficiency virus in Taiwan. Clin Microbiol Infect. 2006;12(7):660–5.

Figures

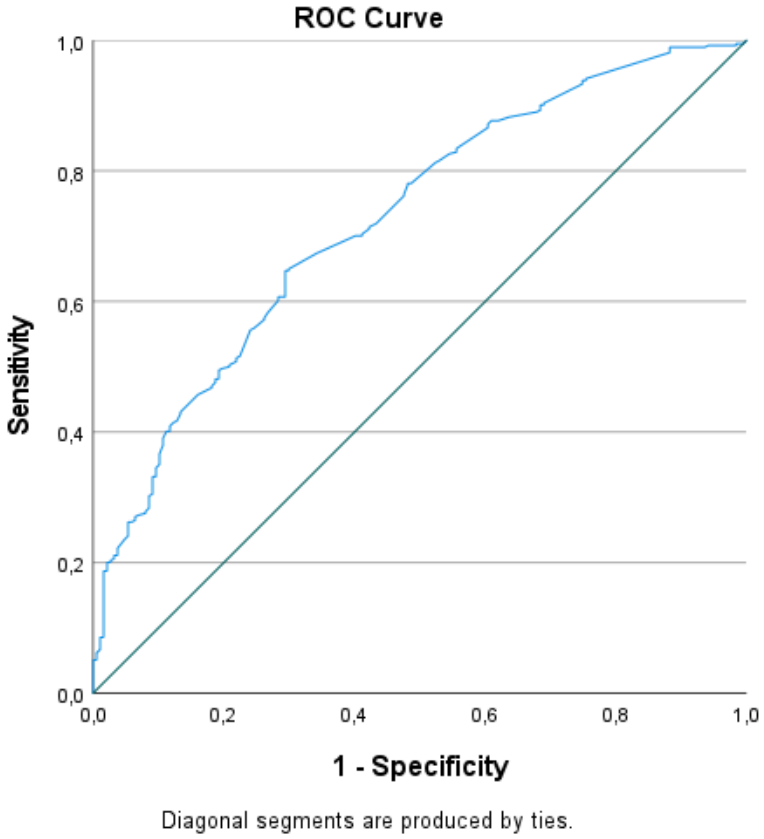


Figure 1

ROC curve