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Factors associated with viral load non-suppression in people living with HIV on ART in Nigeria: cross-sectional analysis from 2017 to 2021

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ABSTRACT

Objectives Identify factors (demographic and clinical) associated with a non-suppressed viral load (VL) of people living with HIV (PLHIV) on antiretroviral therapy (ART) in Nigeria.

Design Cross-sectional study.

Setting Sixteen US Agency for International Development supported states in Nigeria.

Participants 585 632 PLHIV on ART.

Primary outcome measures VL non-suppression (defined as having a VL of at least 1000 HIV RNA copies per mL of plasma). χ^2 testing and multivariable modified Poisson regression with robust variance estimates were conducted on routinely collected ART programme data.

Results Sixty-six per cent of the study population were females. The largest age groups were 25–34 and 35–44, accounting for 32.1% and 31.1%, respectively. Males had a 9% greater likelihood (adjusted prevalence ratio, APR=1.09) of being non-suppressed. The age groups below 60+ (APR=0.67) had a higher likelihood of a non-suppressed VL, with the highest in the 0–14 age group (APR=2.38). Clients enrolled at tertiary and secondary level facilities had the greatest likelihood of a non-suppressed VL. Clients who started ART between 2010 and 2015 had the greatest likelihood of viral non-suppression (APR=6.19). A shorter time on ART (<1 year (APR=3.92)) was associated with a higher likelihood of a non-suppressed VL. Clients receiving care at private facilities had a lower likelihood of viral non-suppression in the adjusted model. Clients in the Edo (APR=2.66) and Niger (APR=2.54) states had the greatest likelihood of viral non-suppression.

Conclusions Targeting males, clients of younger age, those on treatment for less than 3 years, clients at tertiary and secondary health facilities, small and medium facilities, and clients in the Edo, Niger and Borno states for interventions could lead to improvements in VL suppression in Nigeria. The independent factors associated with a non-suppressed VL can guide improvements in ART programme development and VL suppression of PLHIV on ART in Nigeria.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The study used data from over 500 000 people living with HIV enrolled on ART in 16 Nigeria states over 4 years between 2017 and 2021, which can allow the results to cover a broad portion of HIV healthcare in Nigeria in recent times.
⇒ The data used were routinely collected by clinics, reflecting the actual state of HIV healthcare in Nigeria during the period of the study.
⇒ The study included distal factors such as state, facility level, size and ownership, which can guide intervention at an infrastructural level.
⇒ Variables such as education level and marital status/cohabiting, treatment adherence, opportunistic infections and side effects were not available, and some of these factors could have been confounders of the predictors used in this study.

INTRODUCTION

In 2020, there were 37.7 million people living with HIV (PLHIV) globally; in 2021, 27.5 million (73%) had access to antiretroviral therapy (ART).[1] In 2020, 66% of PLHIV were virally suppressed.[1] Nigeria is a country with 1 of the highest numbers of PLHIV in the world (1.9 million), with a prevalence rate of 1.4% and an incidence rate of 0.34 per 1000 capita with approximately 74 000 individuals newly infected as estimated in 2021. It was also estimated that 86% of the PLHIV on ART in Nigeria were virally suppressed in 2021.[2] The Nigeria National Guidelines for HIV Prevention, Treatment and Care define virological suppression as having a viral load (VL) below 1000 HIV RNA copies per mL of plasma[3] (VL non-suppression is defined as having a VL of at least 1000 HIV RNA copies per mL of plasma). Given that an undetectable VL significantly reduces the transmission risk of HIV, suppressing the VL of 95% of PLHIV on ART is key to achieving epidemic control.[4 5]

Globally, including in some Nigerian states, factors that were found to be predictors of viral suppression were age, sex, duration on ART,[6–9] current ART regimen[10] and adherence to medications.[11] This study explored whether similar associations alongside other factors such as state

and facility level existed in Nigeria using data over a period of 4years from 16 states that were not necessarily under investigation before, contributing to the body of knowledge and allowing better targeted interventions to improve HIV programmes, the VL of clients and epidemic control in the country.

The objective of this study was to determine which factors were associated with a non-suppressed VL in Nigeria using a large cross-sectional database of clients who received ART. We explored several variables—sex, age group, ART start year, time on ART, facility size, facility level, facility ownership and state—to identify which factors were associated with viral non-suppression. The findings from the analysis can be used to guide HIV programmes to conduct targeted intervention for the PLHIV on ART with the highest likelihood of having a non-suppressed VL.

METHODS

Study design, setting and population

The study was a cross-sectional analysis of clients who were enrolled on ART at 580 facilities across 16 states (Adamawa, Akwa Ibom, Bauchi, Bayelsa, Borno, Cross River, Edo, Jigawa, Kano, Kebbi, Kwara, Lagos, Niger, Sokoto, Yobe, Zamfara) in Nigeria that were supported by the US Agency for International Development (USAID). The data set covered a period of 4 years, with the last drug pickup dates ranging from 1 January 2017 to 31 December 2021. The study was carried out to investigate the clinical and demographic factors associated with a non-suppressed VL among more than 500 000 HIV clients who had a VL test on record. The age of clients ranged between 0 and 101 with a median of 37 and a mean of 37.2.

Data source and management

The data were routinely collected by the USAID-supported implementing partners (IPs) through their quarterly data submissions using the retention and audit determination tool (RADET). Each IP submission was then combined into a single data set that was used for this study. The RADET dataset provides cross-sectional information for every client ever enrolled on ART at their last point of visit to the clinics supported by USAID and associated IPs. That is, longitudinal records for variables were not available nor ethically approved for studying, for example, only the last recorded VL test for each client was available. Depending on the purpose of the clinical visit of the clients, the data were collected to reflect the most recent clinical details of a particular client.

The data set received contained 775 013 non-longitudinal, cross-sectional client records with a last drug pickup date between 1 January 2017 and 31 December 2021. Due to missing unique client identifiers for 153 433 clients, a unique identifier was created for data deduplication using the date of birth, sex, database-provided unique identifier and client hospital number. For clarification, unique identifiers were not provided for all clients, in such cases a client hospital number was captured instead. Data cleaning involved removing duplicate unique identifiers (n=5973). Data which may have contained a typo, like records with a date of birth occurring after the ART start date (n=48) or after the date of last drug pickup (n=240) were removed. Clients with an ART start date earlier than 2002 (n=74) when the ART programme started in Nigeria[12] were also excluded from the analysis. An additional 166 037 client records without a date of VL sample collection were removed alongside a further 17 009 who did not receive their VL test results at the time of the data collection. After data cleaning, 585 632 client records were retained for downstream analyses (figure 1) to isolate a cohort that was active during the latest VL suppression policy rolled out in Nigeria, which indicates that every client on treatment for 6 months is due for a VL test, and VL tests should be repeated every 12 months.[13]

Variables engineered as predictors of a non-suppressed VL

The age variable was calculated as the time difference (in years) between the date of VL sample collection and the date of birth of the client. Then, age group was reclassified into six groups: 0–14, 15–24, 25–34, 35–44, 45–59 and

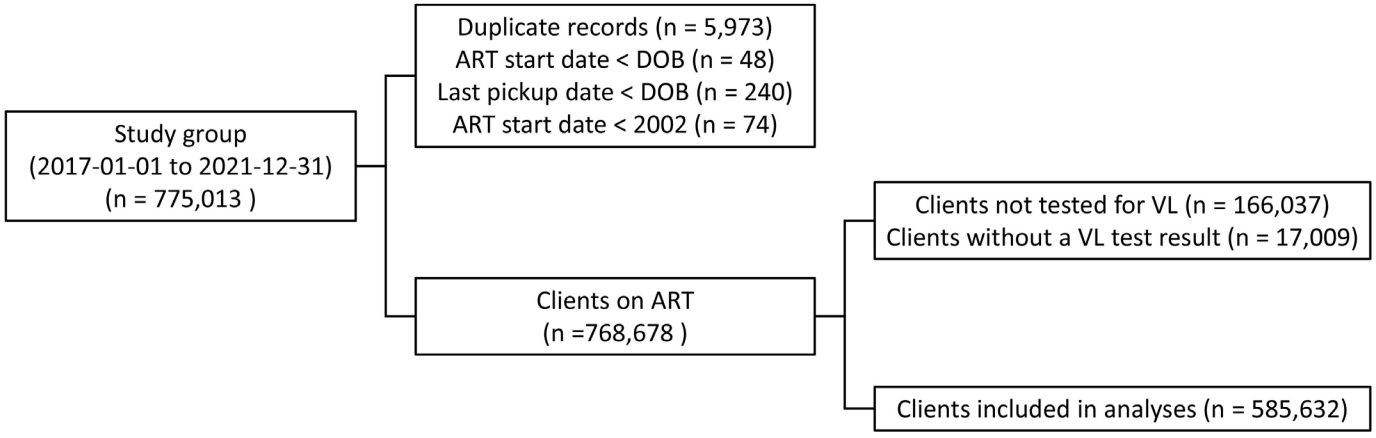

Figure 1 Data cleaning process, excluded data and study population subset analysed. ART, antiretroviral therapy; DOB, date of birth; VL, viral load.

Table 1 Summary of the distribution of facility size by the number of clients in care

Facility size	No of facilities	No of clients				
		Total	Min.	Max.	Mean	Median
Small	143	5360	4	62	37	39
Medium	295	92 348	63	1078	313	199
Large	146	487 924	1088	13 585	3342	2879

60+ years. Similarly, the 'duration on ART to last VL test' variable was created by calculating the time difference (in months) between the date of received current VL and the ART start date. The duration on ART was reclassified as <1 year, 1–3 years and 3+ years, and labelled as 'time on ART'. The 'facility size' variable was calculated by determining the number of clients receiving care at the facility, then grouped as small ((0, 25) percentiles), medium ((25, 75) percentiles) or large ((75, 100) percentiles). The number and distribution of clients into the small, medium and large facilities is presented in table 1.

The 'facility level' variable was obtained from the Nigeria Health Facility Registry (HFR).[14] The classification resulted in three levels of facilities: primary (operate at local government level), secondary (operate at state level) and tertiary (operate at federal government level).[15] Similarly, the 'facility ownership' variable was created by grouping the facilities in their respective ownership type (public or private) according to their classification in the Nigeria HFR system.[14]

The 'geopolitical zone' variable was created by grouping the 16 USAID-supported states into their nationally recognised geopolitical zones. This resulted in five geopolitical zone groupings: North-Central (Kwara and Niger states), North-East (Adamawa, Bauchi, Borno and Yobe states), North-West (Jigawa, Kano, Kebbi, Sokoto and Zamfara states), South-South (Akwa Ibom, Bayelsa, Cross River and Edo states) and South-West (Lagos).

Patient and public involvement

Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research.

Statistical analysis

For the 585 632 clients with a last VL test on record, the Pearson's χ^2 test was used to examine the association of each variable with a non-suppressed VL at a client's last VL test date. Unadjusted and adjusted modified Poisson regression with robust variance estimates models were conducted to explore the association of variables with a non-suppressed VL (a VL above 1000 RNA copies per mL of plasma). Current ART status was excluded as a factor from the regression modelling because at the time of the VL test, all clients were active, even though they may now have a different status (interruption in treatment (IIT) defined as missing a drug-pickup appointment for longer than 28 days, deceased, transferred out or stopped treatment). Similarly, the regimen line was excluded from the regression analysis because other regimen lines, aside from the first-line regimen, are prescribed in the case of a non-suppressed VL or reaction or a reported side effect from the current aniteretrovirals (ARVs). The regimen line was, therefore, dependent on the VL outcome investigated and it could not be used as an independent variable associated with VL non-suppression. The multi-month dispensing variable (MMD) was excluded from the regression models because the variable is not independent of the VL outcome. That is, eligibility criteria for MMD require that clients are virally suppressed. Model selection was done using forward addition and backward elimination of variables where the Akaike's information criterion (AIC) was used to evaluate variable inclusion in the final model. The retained model with the lowest AIC (249 787.3) resulted in the exclusion of the geopolitical zone variable. The variables included in the models were sex, age group, ART start year, time on ART to last VL test, facility level, facility size, facility ownership and state. The group accounting for the most clients in each of the independent variables analysed was set as the reference group for the respective variable. A two-tailed $p<0.05$ was used to define statistical significance. Multicollinearity was tested using the generalised variance inflation factor (GVIF) for the set of variables used in the modified Poisson regression model, and none of the variables exhibited multicollinearity (having a GVIF below 1.4). All data processing and analysis were conducted using the R software for Statistical Computing V.4.0.[16]

RESULTS

Of the 585 632 clients included in the analysis, 35 549 (6.1%) were virologically non-suppressed while the remaining 93.9% were virologically suppressed (table 2). Sixty-five per cent of the clients were female, with 6.1% of both sexes virologically non-suppressed. Clients ages 25–34 and 35–44 were the largest age groups, accounting for 32.1% and 31.1% of the total number of clients in the analysis, respectively. Clients in the 0–14 age group was the smallest group (3.4%) and had the largest proportion of virally non-suppressed individuals (17.8%).

The current ART status was recorded as active for 88.9% of the clients, with the remaining 11.1% being dead (1.7%), had stopped treatment (0.5%) had transferred out to another facility (3.1%) or had interrupted treatment (5.8%) (table 2). Most clients (95.8%) were on the adult first-line ART regimen, with 94.5% of them

Table 2 Characteristics of the 517 012 clients with a viral load test on record at Nigerian facilities between 2017 and 2021

Factors	Viral load		Total	P value (<0.05)
	Suppressed	Non-suppressed		
Sex				
Female	357 783 (93.9)	23 058 (6.1)	380 841 (65.0)	0.5
Male	192 300 (93.9)	12 491 (6.1)	204 791 (35.0)	0.5
Age group				
0–14	16 450 (82.2)	3561 (17.8)	20 011 (3.4)	
15–24	57 434 (92.9)	4416 (7.1)	61 850 (10.6)	
25–34	177 648 (94.4)	10 580 (5.6)	188 228 (32.1)	
35–44	172 070 (94.5)	10 097 (5.5)	182 167 (31.1)	
45–59	106 743 (94.8)	5813 (5.2)	112 556 (19.2)	
60+	19 738 (94.8)	1082 (5.2)	20 820 (3.6)	
Art start year				
<2005	542 (94.4)	32 (5.6)	574 (0.1)	
(2005–2010)	40 276 (92.8)	3113 (7.2)	43 389 (7.4)	
(2010–2015)	82 198 (91.1)	8012 (8.9)	90 210 (15.4)	
(2015–2020)	220 451 (92.5)	17 808 (7.5)	238 259 (40.7)	
>2020	206 616 (96.9)	6584 (3.1)	213 200 (36.4)	
Time on art				
<1 year	156 702 (94.5)	9085 (5.5)	165 787 (28.3)	
1–3 years	161 118 (94.6)	9183 (5.4)	170 301 (29.1)	
3+ years	232 263 (93.1)	17 281 (6.9)	249 544 (42.6)	
Regimen switch				
After VL test	269 102 (94.2)	16 696 (5.8)	285 798 (48.8)	
Before VL test	22 189 (78.5)	6084 (21.5)	28 273 (4.8)	
Not switched	258 792 (95.3)	12 769 (4.7)	271 561 (46.4)	
Current ART regimen				
3TC-TDF-DTG	517 510 (95.6)	24 011 (4.4)	541 521 (92.5)	
3TC-TDF-EFV	8893 (65.1)	4759 (34.9)	13 652 (2.3)	
ABC-3TC-DTG	9356 (87.0)	1403 (13.0)	10 759 (1.8)	
Other	14 324 (72.7)	5376 (27.3)	19 700 (3.4)	
ART dispensed (months)				
1–2	26 476 (67.9)	12 515 (32.1)	38 991 (6.7)	
3	99 879 (89.3)	11 911 (10.7)	111 790 (19.1)	
3+	423 728 (97.4)	11 123 (2.6)	434 851 (74.3)	
Current ART status				
Active	501 083 (96.2)	19 544 (3.8)	520 627 (88.9)	
Dead	6568 (67.1)	3217 (32.9)	9785 (1.7)	
IIT	25 849 (75.7)	8313 (24.3)	34 162 (5.8)	
Stopped	1911 (71.9)	747 (28.1)	2658 (0.5)	
Transferred out	14 672 (79.7)	3728 (20.3)	18 400 (3.1)	
Current regimen line				
Adult 1st line	529 898 (94.5)	31 006 (5.5)	560 904 (95.8)	
Adult 2nd line	9203 (81.7)	2066 (18.3)	11 269 (1.9)	
Adult 3rd line	21 (58.3)	15 (41.7)	36 (0.006)	
Peds 1st line	10 850 (82.0)	2382 (18.0)	13 232 (2.3)	

Continued

Table 2 Continued

Factors	Viral load		Total	P value (<0.05)
	Suppressed	Non-suppressed		
Peds 2nd line	97 (57.7)	71 (42.3)	168 (0.03)	
Salvage	14 (60.9)	9 (39.1)	23 (0.004)	
Facility size				
Small	4920 (91.8)	440 (8.2)	5360 (0.9)	
Medium	84 429 (91.4)	7919 (8.6)	92 348 (15.8)	
Large	460 734 (94.4)	27 190 (5.6)	487 924 (83.3)	
Facility level				
Primary	201 847 (96.5)	7428 (3.5)	209 275 (35.7)	
Secondary	284 415 (93.0)	21 275 (7.0)	305 690 (52.2)	
Tertiary	63 821 (90.3)	6846 (9.7)	70 667 (12.1)	
Facility ownership				
Private	31 279 (92.6)	2486 (7.4)	33 765 (5.8)	
Public	518 804 (94.0)	33 063 (6.0)	551 867 (94.2)	
State				
Adamawa	38 183 (92.7)	3020 (7.3)	41 203 (7.0)	
Akwa Ibom	208 852 (96.9)	6604 (3.1)	215 456 (36.8)	
Bauchi	24 565 (93.8)	1631 (6.2)	26 196 (4.5)	
Bayelsa	11 046 (91.5)	1025 (8.5)	12 071 (2.1)	
Borno	14 595 (87.3)	2122 (12.7)	16 717 (2.9)	
Cross river	59 487 (95.4)	2893 (4.6)	62 380 (10.7)	
Edo	23 832 (87.3)	3465 (12.7)	27 297 (4.7)	
Jigawa	8580 (88.8)	1083 (11.2)	9663 (1.7)	
Kano	37 577 (92.8)	2897 (7.2)	40 474 (6.9)	
Kebbi	9191 (98.4)	147 (1.6)	9338 (1.6)	
Kwara	8308 (92.2)	705 (7.8)	9013 (1.5)	
Lagos	54 689 (92.2)	4620 (7.8)	59 309 (10.1)	
Niger	30 717 (90.2)	3333 (9.8)	34 050 (5.8)	
Sokoto	8765 (92.3)	731 (7.7)	9496 (1.6)	
Yobe	7032 (90.6)	730 (9.4)	7762 (1.3)	
Zamfara	4664 (89.6)	543 (10.4)	5 207 (0.9)	
Zone				
North-Central	39 025 (90.6)	4038 (9.4)	43 063 (7.4)	
North-East	84 375 (91.8)	7503 (8.2)	91 878 (15.7)	
North-West	68 777 (92.7)	5401 (7.3)	74 178 (12.7)	
South-South	303 217 (95.6)	13 987 (4.4)	317 204 (54.2)	
South-West	54 689 (92.2)	4620 (7.8)	59 309 (10.1)	

ABC-3TC-DTG, Antiretroviral regimen: Abacavir - Tenofovir Disoproxil Fumarate - Dolutegravir; ART, antiretroviral therapy; IIT, interruption in treatment; 3TC-TDF-DTG, Antiretroviral regimen: Lamivudine -Tenofovir Disoproxil Fumarate - Dolutegravir; 3TC-TDF-EFV, Antiretroviral regimen: Lamivudine - Tenofovir Disoproxil Fumarate - Efavirenz; VL, viral load.

being virally suppressed. Clients on the adult second-line and paediatric first-line regimens each accounted for 2% of the clients in the study, with 81.7% and 82% of clients on the two regimen lines being virally suppressed, respectively.

Approximately 43% of the clients were on ART for more than 3 years and 28.3% were on treatment for less than 1 year (table 2). Clients who were on ART for less than 3 years had a higher proportion of viral suppression

(94.5%) than those who were on ART for more than 3 years (both 93.1%).

A greater proportion of ART clients received treatment from a large volume facility (83.3%), with 94.4% of these clients being virally suppressed (table 2). ART clients at the medium volume facilities comprised 15.8% of the total clients, with 91.4% of them being virally suppressed. Most clients were receiving ART at a secondary health facility (52.2%), followed by primary health facilities (35.7%) (table 2). Clients receiving treatment at a tertiary (9.7%) or secondary health facility (7.0%) were non-suppressed in higher proportions compared with clients receiving ART at a primary health facility. Ninety-four per cent of the clients received ARVs from a publicly owned facility, with 94% of them being virally suppressed (table 2). Only 6% of the clients were receiving treatment from a privately owned facility, with 7.4% of these clients virally non-suppressed.

Akwa Ibom state had the highest proportion of client records (36.8%) with viral suppression rate of 96.9%. While Zamfara had the smallest proportion of clients (0.9%) with a viral suppression rate of 89.6%, Kebbi state had the highest proportion of virally suppressed client with 98.4% although, a smaller proportion of the clients (1.6%) in the study. The South-South zone served the highest proportion of clients in the cohort and highest suppression rate (54.2% and 95.6%, respectively). Similarly, North-Central Zone had the smallest proportion and lowest suppression rate (7.4% and 90.6%, respectively) (table 2).

All factors used in the adjusted multivariable modified Poisson regression model were statistically significant, with a p-value <0.05. Males (adjusted prevalence ratio (APR) 1.09, 95% CI 1.06 to 1.11) were found to have 9% higher odds of being virally non-suppressed than females, however, the unadjusted modified Poisson regression did not identify a significant difference between the odds of viral non-suppression of females and males (table 3). The adjusted model indicated that young people ages 0–24 were associated with higher likelihood of viral non-suppression compared with the 25–34 age group. Younger clients ages 0–14 years had the highest APR of viral non-suppression (APR 2.38, 95% CI 2.29 to 2.47).

Clients who started ART between 2010 and 2015 (APR 6.19, 95% CI 5.9 to 6.51) had greater likelihood of viral non-suppression compared with clients that started before 2010 or after 2015. Compared with clients who were on ART for more than 3 years, those who were on treatment between 1 and 3 years had greater likelihood to be virally non-suppressed (APR 1.63, 95% CI 1.58 to 1.69), whereas clients on ART for less than 1 year were found to have the greatest likelihood of viral non-suppression (APR 3.92, 95% CI 3.77 to 4.08).

Clients receiving ARVs at tertiary health facilities were 68% more likely to be virally non-suppressed (APR 1.68, 95% CI 1.61 to 1.76) than primary health facilities (table 3). Moreover, clients receiving care at small (APR 1.63, 95% CI 1.48 to 1.8) and medium (APR 1.47, 95% CI: 1.43 to 1.51) facilities were found to have the higher likelihood of viral non-suppression compared with large facilities. Clients receiving treatment at privately owned facilities (APR 0.87, 95% CI 0.84 to 0.91) had a lower likelihood of viral non-suppression than clients at publicly owned facilities.

Compared with the Akwa Ibom state, clients in the Edo (APR 2.66, 95% CI 2.54 to 2.79) and Niger (APR 2.54, 95% CI 2.44 to 2.66) states had greater likelihood of VL non-suppression (table 3). Clients in the Kebbi state had the lowest likelihood for VL non-suppression (APR 0.34, 95% CI 0.29 to 0.4).

Some of the states such as Edo (766, 25.2%) and Borno (697, 26.3%), had the highest prevalence of VL non-suppression for clients on treatment less than 1 year (table 4). However, those same states also had high prevalence of VL non-suppression of clients on ART for longer than 3 years. By contrast, Bayelsa had high prevalence of VL non-suppression for clients on ART for longer than 1 year.

DISCUSSION

Our study found that males, clients in younger age groups (0–24), those who started treatment before 2020, clients on treatment for less than 1 year, those receiving care at small and medium facilities, receiving care at secondary and tertiary level facilities, publicly owned facilities and clients receiving care in the Edo, Niger and Borno states had the highest association with VL non-suppression. Other studies have found similar results for the likelihood of viral non-suppression in younger age groups in Cambodia, Uganda and South Carolina (USA),[6 8 17] and among males.[18–20] Our findings suggest that the health-seeking behaviour of certain demographics can be improved or given more attention to by HIV care programmes. In that same regard, considerations should be given to the facility types, size and public ownership.

The increased likelihood of viral non-suppression among ART clients who received treatment at tertiary health facilities have not been observed in Ethiopia where higher likelihood of viral non-suppression was associated with primary health facilities in Ethiopia.[21] Here, we found that small and medium facilities were associated with viral non-suppression of HIV clients on treatment and this was consistent with findings that clients were more likely to miss consecutive visits at lower volume facilities.[22] This could be due to smaller clinics being located within smaller communities, as a result, patients may avoid stigmatisation within their community by not pick-up treatment as routinely as patients that attend clinics that are outside of their communities.[22] Such clients who would miss their drug pickup appointments more frequently to avoid stigma are reasonably expected to have non-suppressed VLs. A possible circumvention of the stigmatisation within communities would be to offer clients a referral to HIV care facilities that are located outside of

Table 3 Factors associated with a non-suppressed viral load presented as unadjusted (UPR) and adjusted prevalence ratios (APR) derived using modified Poisson regression

	Univariable		Multivariable	
Factors	**UPR**	**P value (<0.05)**	**APR**	**P value (<0.05)**
Sex				
Female	1 (ref)		1 (ref)	
Male	1.01 (0.99–1.03)	0.51	1.09 (1.06–1.11)	
Age group				
0–14	3.17 (3.05–3.29)		2.38 (2.29–2.47)	
15–24	1.27 (1.23–1.32)		1.29 (1.24–1.34)	
25–34	1 (ref)		1 (ref)	
35–44	0.99 (0.96–1.01)	0.31	0.86 (0.84–0.89)	
45–59	0.92 (0.89–0.95)		0.72 (0.7–0.75)	
60+	0.92 (0.87–0.98)		0.67 (0.63–0.72)	
Art start year				
<2005	1.81 (1.28–2.55)		4.64 (3.27–6.59)	
(2005–2010)	2.32 (2.23–2.42)		5.34 (5.04–5.66)	
(2010–2015)	2.88 (2.78–2.97)		6.19 (5.9–6.51)	
(2015–2020)	2.42 (2.35–2.49)		4.08 (3.93–4.23)	
>2020	1 (ref)		1 (ref)	
Time on ART				
<1 year	0.79 (0.77–0.81)		3.92 (3.77–4.08)	
1–3 years	0.78 (0.76–0.8)		1.63 (1.58–1.69)	
3+ years	1 (ref)		1 (ref)	
Facility size				
Small	1.47 (1.34–1.62)		1.63 (1.48–1.8)	
Medium	1.54 (1.5–1.58)		1.47 (1.43–1.51)	
Large	1 (ref)		1 (ref)	
Facility level				
Primary	1 (ref)		1 (ref)	
Secondary	1.96 (1.91–2.01)		1.45 (1.4–1.49)	
Tertiary	2.73 (2.64–2.82)		1.68 (1.61–1.76)	
Facility ownership				
Public	1 (ref)		1 (ref)	
Private	1.23 (1.18–1.28)		0.87 (0.84–0.91)	
State				
Adamawa	2.39 (2.29–2.5)		1.86 (1.78–1.94)	
Akwa Ibom	1 (ref)		1 (ref)	
Bauchi	2.03 (1.92–2.14)		1.56 (1.48–1.65)	
Bayelsa	2.77 (2.59–2.96)		2.02 (1.89–2.16)	
Borno	4.14 (3.94–4.35)		2.46 (2.33–2.6)	
Cross river	1.51 (1.45–1.58)		1.3 (1.24–1.36)	
Edo	4.14 (3.97–4.32)		2.66 (2.54–2.79)	
Jigawa	3.66 (3.43–3.9)		2.19 (2.05–2.35)	
Kano	2.34 (2.24–2.44)		1.55 (1.48–1.62)	
Kebbi	0.51 (0.44–0.6)		0.34 (0.29–0.4)	
Kwara	2.55 (2.36–2.76)		1.64 (1.51–1.77)	

Continued

Table 3 Continued

Factors	Univariable UPR	Univariable P value (<0.05)	Multivariable APR	Multivariable P value (<0.05)
Lagos	2.54 (2.45–2.64)		1.98 (1.91–2.06)	
Niger	3.19 (3.06–3.33)		2.54 (2.44–2.66)	
Sokoto	2.51 (2.33–2.71)		1.69 (1.56–1.83)	
Yobe	3.07 (2.84–3.31)		2.08 (1.92–2.25)	
Zamfara	3.4 (3.12–3.71)		1.92 (1.76–2.11)	

P values were indicated when above 0.05.
ART, antiretroviral therapy.

their communities. However, consideration should be given to the distance needed for travel as well because although a distance less than 1 km to the clinic was associated with higher IIT in Rwanda,[22] while mean distances above 4.7 km to clinics were associate with higher IIT in Malawi.[23]

Clients who received care at privately owned facilities had lower likelihood of a non-suppressed VL when adjusting for the other variables included in the model. Nevertheless, another study had found that HIV care was of greater quality at public facilities than private in Anambra state in Nigeria.[24] This was also reflected in our unadjusted, univariable results.

ART clients who had their last VL test conducted within less than 1 year on treatment were less likely to be virally non-suppressed compared with clients who had their VL tested after 1 year on ART in the unadjusted model. Our finding was consistent with the Centers for Disease Control and Prevention's finding that PLHIV on ART could be virally suppressed within 6 months of initiation, provided that they adhered to their medication.[25] Moreover, a greater likelihood of viral suppression was found among PLHIV who were on treatment for less than 1 year compared with those on ART for more than 1 year according to a study in Ethiopia.[26] This elucidates that clients more engaged in care can have more opportunities for non-suppressed VL test results, though, this does not necessarily mean that this population is more likely to be non-suppressed. However, our adjusted model reflected the reverse, more specifically, a higher likelihood for clients on ART for less than 1 year to be virally non-suppressed. We attribute this to the high prevalence of virally non-suppressed clients in some of the states, such as Edo and Borno (table 4). Similarly, a shorter

Table 4 Cross-table of the state variable by the number of years on ART

State	Years on ART(non-suppressed/total (%)) <1 year	1–3 years	3+ years
Akwa Ibom	2566/86 893 (3)	2180/87 555 (2.5)	1 858/41 008 (4.5)
Adamawa	762/8207 (9.3)	713/8490 (8.4)	1 545/24 506 (6.3)
Bauchi	451/6935 (6.5)	321/4001 (8)	859/15 260 (5.6)
Bayelsa	189/4467 (4.2)	313/3100 (10.1)	523/4504 (11.6)
Borno	697/2648 (26.3)	461/3 255 (14.2)	964/10 814 (8.9)
Cross river	627/14 601 (4.3)	866/22 022 (3.9)	1400/25 757 (5.4)
Edo	766/3045 (25.2)	727/5145 (14.1)	1972/19 107 (10.3)
Jigawa	173/1075 (16.1)	241/1965 (12.3)	669/6623 (10.1)
Kano	372/5171 (7.2)	662/6956 (9.5)	1863/28 347 (6.6)
Kebbi	29/1842 (1.6)	34/2279 (1.5)	84/5217 (1.6)
Kwara	125/1247 (10)	191/2039 (9.4)	389/5727 (6.8)
Lagos	1038/15 290 (6.8)	1193/11 901 (10)	2389/32 118 (7.4)
Niger	955/10 923 (8.7)	792/6695 (11.8)	1586/16 432 (9.7)
Sokoto	130/1674 (7.8)	193/2198 (8.8)	408/5624 (7.3)
Yobe	96/800 (12)	145/1432 (10.1)	489/5530 (8.8)
Zamfara	109/969 (11.2)	151/1268 (11.9)	283/2970 (9.5)

ART, antiretroviral therapy.

time on ART was identified as a factor associated with a non-suppressed VL in South Africa.[27] This could suggest that although in general, clients on ART for longer than 1 year may need more attention, greater attention should be given to patients enrolled on ART for less than 1 year in states such as Edo and Borno, where non-suppression is more common in early initiates. Examples of interventions that could be implemented include enhanced/intensive adherence counselling, improved follow-up programmes or more frequent follow-ups to perhaps cultivate a habit of adherence and retention in treatment, which could result in better VL outcomes. The contradictory findings in the literature as well as those identified between the unadjusted and adjusted models could speak to the specific adherence patterns of the population investigated and models that may be specific to the study setting. Nevertheless, these findings motivate for support of newly enrolled clients, at least in some states, to develop treatment-adherence habits.

A possible explanation for the clients receiving care in the Kwara and Niger states in the North-Central zone having higher likelihood of viral non-suppression could be linked to health-seeking behaviour such as non-use of the service, poor adherence to treatment, and possibly religious affiliation (eg, Islamic religion predominant in northern Nigeria) where in certain circumstances women require permission to leave the premises of a household which can reduce access to healthcare.[28 29] Community refills, regular visits from case managers, and enhanced adherence counselling could be implemented in such communities in a door-to-door manner, perhaps staffed by female health workers, to improve VL outcomes. On the other hand, in Borno and Yobe states in the North-East zone of Nigeria, the incessant insecurity in the region has largely led to people often been displaced and this has largely impacted on the health-seeking behaviour.

One of the limitations of our study was the inaccessibility of the longitudinal data set. We were, therefore, restricted to conducting a cross-sectional study. The study cohort was composed of clients that received care at USAID-supported facilities, therefore, it may not be a true representation of the likelihood of VL non-suppression throughout the country. In facilities that support is better, the results here could overestimate the contribution of some of the factors to VL non-suppression. Vice-versa, where support is lacking, the contribution of some of the factors presented here on VL non-suppression could be underestimated.

It is possible that some of the 21.6% of client records (eliminated from analysis) without a VL test on record are a consequence of poor adherence to treatment which could lead to VL non-suppression that is not tested/recorded. This assumption is based on the concept that patients need to attend clinic visits to either receive treatment or have their VL samples collected and tested. Investigating the factors that are associated with an untested VL could provide useful insight. At the same time, longitudinal studies into both VL non-testing and VL non-suppression may ultimately be of greatest use. Additional variables relating to the capacity of clinical facilities to conduct testing would reveal whether the lack of VL testing is also affected by a low capacity.

Other unavailable variables that could be explored in future studies to identify their association with viral suppression are tuberculosis status, adherence level, ART drug regimen, side effects, IIT, marital status and education level, however, these variables would need to be provided and analysed longitudinally. Ultimately, the factors reflected in this study may not be exhaustive. The absence of VL suppression data for recently initiated clients may have also had an impact on the study seeing that they had to be excluded, therefore, only the results of tested patients could be analysed, leaving out the VL outcomes of those without a test.

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