

RESEARCH ARTICLE

Prevalence and predictors of viral load non-suppression among adolescents on dolutegravir-based antiretroviral therapy: A cross-sectional study from three urban clinics, Soroti City

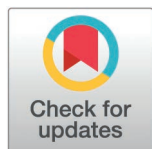
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Abstract

Background

Despite advances in HIV care, viral load suppression (VLS) among adolescents living with HIV (ALHIV) in Uganda continue to lag behind that of adults, even with the introduction of dolutegravir (DTG)-based regimens, the Youth and Adolescent Peer Supporter (YAPS) model, and community-based approaches. Understanding factors associated with HIV viral load non-suppression in this population is critical to inform HIV treatment policy. This study assessed the prevalence and predictors of viral load non-suppression among ALHIV aged 10–19 years on DTG-based ART in Soroti City, Uganda.

Methods

We conducted a cross-sectional study among 447 ALHIV attending three urban HIV clinics in Soroti City. Data were abstracted using a structured questionnaire and analyzed in STATA 15.0. Modified Poisson regression with robust error variance was used to identify predictors of viral load non-suppression. Adjusted relative risks (aRR) and 95% confidence intervals (CIs) were reported, with statistical significance set at $p \leq 0.05$.

Results

Of the 447 participants, 53.5% were female, with a median age of 16 years (IQR: 14.0–17.6). The majority (72.9%) were from Soroti district and had been on DTG-based ART for a median of 42.5 months (IQR: 37.0–48.0). Most were receiving multi-month dispensing (MMD) (75.2%) and were active in care (98%). The prevalence

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Citation: Nait C, Ouma S, Ssentongo SM, Oryokot B, Oluka AI, Kusiima R, et al. (2025) Prevalence and predictors of viral load non-suppression among adolescents on dolutegravir-based antiretroviral therapy: A cross-sectional study from three urban clinics, Soroti City. PLoS One 20(9): e0331835. <https://doi.org/10.1371/journal.pone.0331835>

Editor: YAGAI BOUBA, UniCamillus: Saint Camillus International University of Health and Medical Sciences, CAMEROON

Received: March 27, 2025

Accepted: August 21, 2025

Published: September 9, 2025

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Data availability statement: All relevant data are within the paper and its [Supporting Information](#) files.

Funding: The author(s) received no specific funding for this work.

Competing interests: The authors have declared that no competing interests exist.

of viral load non-suppression was 19.2% (86/447). Independent predictors of non-suppression included older age (15–19 vs. 10–14 years) (aRR: 1.69; 95% CI: 1.08–2.67), male sex (aRR: 1.48; 95% CI: 1.05–2.11), prior non-suppression before switching to DTG (aRR: 1.76; 95% CI: 1.19–2.59), use of non-fixed dose DTG regimens (aRR: 2.03; 95% CI: 1.23–3.33), history of poor adherence (aRR: 4.36; 95% CI: 2.05–9.26), and not receiving MMD (aRR: 2.83; 95% CI: 1.93–4.15).

Conclusion

Nearly one in five adolescents on DTG-based ART in Soroti City had viral non-suppression, despite optimized treatment regimens. Targeted interventions—particularly enhanced adherence counseling for older and male adolescents, expanding MMD coverage, and provision of fixed-dose regimens—are urgently needed to improve VLS among ALHIV. These findings underscore the need for adolescent-centered HIV care strategies to close the viral suppression gap and advance progress towards epidemic control.

Introduction

HIV/AIDS remains one of the greatest public health challenges in the world, with sub-Saharan Africa (SSA) having the biggest burden. An estimated 1.65 million adolescents aged 10–19 years were living with HIV at the end of 2022, of the 39.0 million people living with HIV worldwide [1]. Approximately 140,000 adolescents were newly infected and an estimated 27,000 died of AIDS-related illnesses in the same year [1]. In Uganda, it is estimated that nearly 80,000 adolescents and 1,400,000 adults were living with HIV/AIDS in 2022 [2].

To end HIV as a public health threat by 2030, the Joint United Nations Programme on HIV/AIDS (UNAIDS) set the 95-95-95 targets (diagnosis of 95% of HIV-infected people, provision of treatment for 95% of people diagnosed with HIV, and viral suppression in 95% of treated people). As such, there has been a rapid scale up of ART, use of more effective DTG based regimens and client centered service delivery models among adolescents living with HIV (ALHIV) in many countries in SSA in recent years. Uganda adopted the “test-and-treat” policy among adolescents in 2013 to accelerate epidemic control [3]. However, for epidemic control to be achieved, the ALHIV initiated on ART need to be retained in care and they should attain and sustain HIV viral load suppression.

However, there are several barriers such as the development of side effects, long duration on ART and transition challenges among ALHIV, these remain a big challenge for HIV programs in SSA and form an obstacle to the attainment of the second and third UNAIDS 95-95-95 targets [4]. Additional barriers to retention in care and VL suppression targets include lifestyle challenges such as the absence of medications when away from home, schedule changes and the stigma associated with HIV diagnosis [4]. Strategies to enhance the attainment of retention in care and VL

suppression targets include; strengthening of adolescent friendly services, use of simple regimens, and tailoring regimens with the patient's daily and family activities.

The World Health Organization (WHO) recently approved the integrase strand transfer inhibitors (INSTIs) that include DTG as preferred regimens for treating ALHIV [5]. DTG has interesting pharmacokinetic and pharmacodynamic features such as prolonged intracellular half-life, absence of negative interactions with other anti-retroviral drugs, and potent activity against HIV-1 strains that are resistant to other INSTIs [6]. Its use is currently approved for treatment of CALHIV aged ≥ 4 weeks and weighing ≥ 3 kg [7]. The safety and efficacy of DTG among adolescents was supported by the results from the IMPAACT P1093 study [8] and the ODYSSEY clinical trial [9]. However, several questions remain about the rollout of DTG in LMICs, especially in ALHIV where the variations in pharmacogenetics, nutritional status, and other socio-demographic characteristics may significantly affect the effectiveness and safety of the regimen [10]. It has been reported that virological failure was high among patients on DTG born in SSA compared to patients born in other countries. In fact, ALHIV in SSA continue to have lower rates of viral suppression, and higher rates of mortality in comparison to adults [11].

Currently, in Uganda, DTG is being used for the treatment of most ALHIV and has been used since 2018 [12]. Despite its reported potent antiviral activity from clinical trials, program reports at The AIDS Support Organization Center Of Excellence (TASO COE) and Soroti Regional Referral Hospital (SRRH) indicate high levels of viral load non-suppression among ALHIV [13]. Research data on the effectiveness of DTG in program and clinical settings is scant. Similarly, little is known about the predictors of HIV viral load non-suppression among ALHIV on DTG-based ART aged 10–19 years in the Teso region, northeastern, Uganda.

The use of dolutegravir in the treatment of HIV among ALHIV is based on solid clinical trials and experiences of high-income countries (HIC); however, real-world data specifically for Soroti City remains limited. Townsend et al in their study recommended long-term monitoring of the use of integrase inhibitors in adolescent populations to fill evidence gaps [14]. Furthermore, a study conducted in Eastern Ethiopia recommended more comprehensive and broader research to explore reasons for virological non-suppression among HIV-positive individuals on dolutegravir-based Antiretroviral treatment [15]. Another study conducted in Southern Tanzania recommended further exploration of characteristics of ALHIV failing on INSTI regimens [16]. This study aimed to understand the predictors of HIV viral load non-suppression among ALHIV on DTG-based ART, as well as the characteristics of ALHIV failing on INSTI regimens. This will enable health providers to effectively select and implement programs and interventions that aim at achieving HIV viral load suppression among ALHIV which will improve their quality of life and also curb onward transmission of HIV.

Materials and methods

Study design

This was a cross-sectional study. The data was collected from 1st to 15th July 2024.

Study setting

The study was conducted at three high-volume ART clinics in Soroti City offering comprehensive HIV/AIDS prevention, care, and treatment services; TASO Soroti Centre of Excellence, Soroti Regional Referral Hospital (SRRH) and Uganda Cares. The 3 clinics are located in Soroti City, Eastern Uganda, approximately 330 km east of Uganda's capital city, Kampala. By the end of December 2023, 6090, 3200 and 2740 PLHIV including 269, 144 and 105 ALHIV aged 10–19 years were active in care at TASO Soroti, SRRH and Uganda Cares respectively [17]. PLHIV attending these three clinics come from various districts throughout the Teso region and beyond, as far away as Kapelebyong and Kaberamaido districts that are about 80kms from Soroti City.

All the 3 clinics are located in the Soroti Hospital complex with a team of clinicians, adolescent counselors, and social workers who provide HIV care according to MOH guidelines including routine clinical assessment at every visit, viral load testing,

and CD4 testing [18]. Viral load testing is done six months after the start of ART and thereafter every six months for children and adolescents to identify those who have unsuppressed VL and are in need of interventions. The caretakers of the unsuppressed children and adolescents are then taken through intensive adherence counselling (IAC) for three months, at least one month apart before a repeat VL is done to determine those failing who are switched to the next line or referred for resistance testing. Children due for VL testing are identified using the electronic system or clinician file recordings. Blood samples (either DBS or plasma) are collected and shipped weekly to central public health laboratories (CPHL) through the SRRH hub.

Study population

The study population comprised of ALHIV aged 10–19 years on DTG-based ART at the 3 clinics. We included ALHIV aged 10–19 years who had been on DTG-based ART regimens for more than 6 months and were active in care. We excluded ALHIV aged 10–19 years on DTG-based ART for more than 6 months with missing or inconclusive VL results.

Sample size estimation

Given that the study utilized secondary data that was already collected, we did not estimate the sample size using a formula but instead reviewed the records of all adolescents who had been on DTG-based ART for more than 6 months. We collected data from 458 adolescents who were active in care during the time of our study and met the eligibility criteria.

Study variables

The **dependent variable** was HIV viral load non-suppression among ALHIV on DTG-based ART aged 10–19 years. HIV viral load non-suppression was defined as; viral load copies that were equal to or greater than 201 copies per milliliter of blood according to Uganda MOH 2022 consolidated guidelines for HIV prevention and treatment.

The most recent viral load was considered.

The **independent variables** were grouped into; Socio-demographic factors that included sex of the adolescent, age, address of the adolescent, and type of residence

Clinical factors that included duration on ART, baseline ARV regimen, current ARV regimen, duration on DTG-based ART, WHO clinical stage, nutrition status, adherence, and co-morbidities, Psychosocial factors that included mental health disorders, Health facility factors that included clinic support groups, facility-based DSD models and Community factors that included community support groups, community-based DSD models. Measurement of all the independent variables and their definitions have been done in a table that has been uploaded in the supplement ([S1 Table](#)).

Data collection tools and procedures

We used a designed data abstraction tool to abstract secondary data from the Uganda Electronic Medical Records (EMR) and patient-level files.

The research assistants (RA) who collected the data were first trained on the study objectives, matters related to adolescents, ART, VL, and the confidentiality required during research, secondary data abstraction, and data triangulation. The RAs sought permission from the facility I/Cs, working with the adolescent focal persons and data clerks of the two facilities, they proceeded to abstract data from the EMR first and then the client files for those variables that were missing in the EMR.

The data collected was de-anonymised whereby unique identifiers (serial numbers) were allocated to the study participants instead of using the facility identifiers.

Data management

All data extracted into Excel 2019 were reviewed for completeness and those with missing data or incomplete data were completed by triangulation of data sources (EMR and client files). Data was then password-protected to ensure no

unauthorized access. Missing data was handled by complete case analysis whereby any observation that had a missing value for the outcome variable was automatically discarded and only complete observations were analyzed.

Data analysis

Data were then imported into STATA version 15.0 and were checked for uniqueness to get rid of duplicates. Variables were renamed and recoded where necessary for easy handling during analysis, continuous numerical responses were entered as absolute values while categorical responses were coded.

Descriptive statistics were conducted and reported as; mean and standard deviation for continuous variables or else median and interquartile range (IQRs) for the continuous variables with skewed distributions. Categorical variables were reported as frequencies and proportions.

The association between HIV Viral load non-suppression and the categorical variables was determined using the Chi-square or Fisher's exact test, and associations between treatment success and numerical variables were assessed using the student t-test. The variables significant ($p < 0.05$) at bivariate analysis were included in the multivariable analysis where modified Poisson regression with robust error variance was conducted to assess association between each independent variable with HIV viral load non-suppression using a stepwise model building.

The results were presented as unadjusted and adjusted relative risk with confidence intervals. The final model was checked for goodness-of-fit using the Hosmer- Lemeshow test, and model diagnostics were conducted using the Area under the ROC curve (AUC).

Ethical considerations

Ethical clearance for this study was sought from the Makerere School of Public Health Research and Ethics Committee (MakSPH-REC), approval number, 437. Administrative clearances were sought from TASO, SRRH and Uganda Cares management. Since we were collecting secondary data, informed consent/assent was waived off. The data obtained from the records was discreetly handled and anonymity was ensured by keeping data safely under lock and key by the Principal Investigator.

Results

Recruitment of study participants. Of the 458 ALHIV aged 10–19 years, 11 had missing variables of interest, including the most recent viral load, and were dropped. A total of 447 ALHIV were included in the final analysis, as shown [S1 Fig](#)

Socio-demographic characteristics

The median age (IQR) of the study participants was 16 (14–17.6) years with more than half of them in the 15–19 years age category (68%, $n = 304$), and a slightly higher proportion of females (53.7%). Most participants were from the Soroti district (72.9%, $n = 341$), and had been on DTG based ART for median (IQR) 42.5 (37–48) months. Nutritional status was generally good, with most participants in the green (normal) category (87%, $n = 389$) as per the last appointment visit. The most common current regimen was TDF/3TC/DTG (79%, $n = 353$). The majority were receiving multi-month dispensing (75.2%, $n = 336$) and were active in care (98%, $n = 438$), more than half (93.3%, $n = 417$) were classified as having WHO clinical stage one. The majority (65.3%, $n = 292$) had a Nevirapine-based regimen as the baseline. They were utilizing various differentiated service delivery models, with the Facility-Based Group model being the most common (66.4%, $n = 299$) as presented in [Table 1](#) below.

Prevalence of HIV viral load non-suppression

The prevalence of HIV virologic non-suppression was 19.2% (95% CI: 15.8–23.2). By study site, TASO Soroti had the highest proportion of virologic non-suppression at 25.89% (51/197) followed by Uganda Cares at 22.83% (21/92). In comparison, Soroti Regional Referral Hospital had the lowest rate of virologic non-suppression at 8.86% (14/158).

Table 1. Socio-demographic characteristics of study participants.

Characteristics	Frequency (N)	Percentage (%)
Study site		
Soroti Regional Referral Hospital	158	(35.4)
TASO Soroti	197	(44.1)
Uganda Cares	92	(20.6)
District of residence		
Amuria	32	(7.2)
Kumi	3	(0.7)
Ngora	15	(3.4)
Soroti	341	(72.9)
Kaberaido	11	(2.5)
Katakwi	11	(2.5)
Serere	34	(7.6)
Age in completed years: Median (IQR)	16 (14-17.6)	
Age groups		
10-14	143	(32)
15-19	304	(68)
DTG duration (months): median (IQR)	42.5 (37-48)	
Sex		
Male	208	(46.5)
Female	239	(53.5)
Nutrition status*		
Normal	389	(87)
MAM	46	(10.3)
SAM	12	(2.7)
WHO staging		
WHO staging 1	408	(91.3)
WHO staging 2	29	(6.5)
WHO staging 3	7	(1.6)
WHO staging 4	3	(0.7)
Baseline ART Regimen		
DTG based	32	(7.2)
Efavirenz based	106	(23.7)
Nevirapine based	292	(65.3)
Protease Inhibitor based	17	(3.8)
Type of Dispensing		
Multi-month dispensing (MMD)	336	(75.2)
No MMD	111	(24.8)
Current ART regimen		
TDF/3TC/DTG	353	(79)
ABC/3TC/DTG	68	(15.2)
Non fixed dose DTG regimens	26	(5.8)
Current ART status		
Active in care	438	(98)
Lost to follow-up	9	(2)
Current DSDM model*		
FBG	299	(66.4)

(Continued)

Table 1. (Continued)

Characteristics	Frequency (N)	Percentage (%)
FTDR	57	(12.8)
FBIM	56	(12.5)
CCLAD	20	(4.5)
CDDP	15	(3.4)
TB suspect		
No signs of TB	275	(61.5)
TB suspect	172	(38.5)
CD4 done		
No	248	(55.5)
Yes	199	(44.5)
CD4 done (n = 199)		
< 200	145	(72.9)
≥ 200	54	(27.1)
Adherence		
Good	387	(86.6)
Fair	44	(9.8)
Poor	16	(3.6)
Viral before DTG		
Non-suppressed	91	(20.4)
Suppressed	284	(63.6)
Unknown	72	(16.1)

*MAM=Moderate acute malnutrition, SAM=Severe acute malnutrition

*DSMD=Differentiated Service Delivery Model, FBG=Facility Based Group, FTDR=Fast track drug refill, FBIM=Facility Based Individual Management, CCLAD=Community Client Led ART Delivery, CDDP=Community Drug Distribution Point.

Nonfixed dose DTG regimens: AZT/3TC/DTG, TDF/3TC/DTG/DRVr, ABC/3TC/DTG/DRV

<https://doi.org/10.1371/journal.pone.0331835.t001>

Predictors of HIV viral load non-suppression

From [Table 2](#) below, several factors were found to be associated with HIV virologic non-suppression; study sites, Age group, sex, multi-month dispensing, current ART regimen, being on fixed-dose combination, Current DSD model, being a presumptive TB, adherence to ART, and viral load suppression status before DTG. Virologic non-suppression varied by study site ($P<0.001$). Adolescents aged 15–19 had significantly higher non-suppression than those aged 10–14 (22% vs 13.3%: $P=0.029$). Males were more likely to be non-suppressed as compared to females (24.6% vs 14.5%: $P<0.004$). The non-suppression was higher among clients not on multi-month dispensing (MDD) (39.6%) as compared to those on MDD (39.6% vs 12.5%: $P<0.001$). The non-suppression was varied by regimen ($P<0.001$) and not being on fixed dose combination as compared to being on fixed dose (46.7% vs 17.3%: $P<0.001$). Individuals without TB signs and symptoms had higher non-suppression than the presumptive TB (25.1% vs 9.9%: $P<0.001$), having a poor adherence was associated with non-suppression compared to good adherence (62.5% vs 16.3%: $P<0.001$), virologic non suppression varied by viral load suppression status before DTG initiation ($P<0.001$) as shown in [Table 2](#).

Multivariable analysis investigating the factors associated with HIV virologic non-suppression among study participants

The multivariable analysis identified several key associated factors with HIV virologic non-suppression. Independent predictors of non-suppression included older age (15–19 vs. 10–14 years) (aRR: 1.69; 95% CI: 1.08–2.67), male sex

Table 2. Bivariable analysis of the factors associated with virologic non-suppression in Soroti City.

Variables		Non suppressed		p-value
		No (n = 361,80.8%)		Yes (n= 86, 19.2%)
Study site				
Soroti Regional Referral Hospital	158 (35.4)	144 (91.1)	14 (8.9)	0.001*
TASO Soroti	197 (44.1)	146 (74.1)	51 (25.9)	
Uganda Cares	92 (20.6)	71 (77.2)	21 (22.8)	
District of residence				
Amuria	32 (7.2)	25 (6.9)	7 (8.1)	0.878
Kumi	3 (0.7)	2 (0.6)	1 (1.2)	
Ngora	15 (3.4)	11 (3.1)	4 (4.7)	
Soroti	341 (72.9)	278 (77)	63 (73.3)	
Kaberamaido	11 (2.5)	8 (2.2)	3 (3.5)	
Katakwi	11 (2.5)	10 (2.5)	3 (3.5)	
Serere	34 (7.6)	27 (7.5)	7 (8.1)	
Age groups				
10-14	143 (32)	124 (86.7)	19 (13.3)	0.029*
15-19	304 (68)	237 (78)	67 (22)	
Sex				
Female	239 (53.5)	205 (85.8)	34 (14.2)	0.004*
Male	208 (46.5)	156 (75)	52 (25)	
Nutrition status				
Normal	389 (87)	317 (81.5)	72 (18.5)	0.396
MAM	46 (10.3)	36 (78.3)	10 (21.7)	
SAM	12 (2.7)	8 (66.7)	4 (33.3)	
WHO staging				
WHO staging 1	408 (91.3)	330 (80.9)	78 (19.1)	0.911
WHO staging 2	29 (6.5)	23 (79.3)	6 (20.1)	
WHO staging 3	7 (1.6)	6 (85.7)	1 (14.3)	
WHO staging 4	3 (0.7)	2 (66.7)	1 (33.3)	
Baseline ART Regimen				
DTG based	32 (7.2)	29 (90.6)	3 (9.4)	0.194
Efavirenz based	106 (23.7)	86 (81.1)	20 (18.9)	
Nevirapine based	292 (65.3)	230 (78.8)	62 (21.2)	
Protease Inhibitor based	17 (3.8)	16 (94.1)	1 (5.9)	
Multi-month dispensing (MMD)				
Yes	336 (75.2)	294 (87.5)	42 (12.5)	0.001*
No	111 (24.8)	67 (60.4)	44 (39.6)	
Current ART regimen				
TDF/3TC/DTG	353 (79)	294 (83.3)	59 (16.7)	0.001*
ABC/3TC/DTG	68 (15.2)	54 (79.4)	14 (20.6)	
Non fixed dose DTG regimens	26 (5.8)	13 (50)	13 (50)	
Current ART status				
Active in care	438 (98)	206 (81)	83 (19)	0.279
Lost to follow-up	9 (2)	6 (66.7)	3 (33.3)	
Current DSDM model*				
FBG	299 (66.4)	243 (81.3)	56 (18.7)	0.001*

(Continued)

Table 2. (Continued)

Variables		Non suppressed		p-value
		No (n = 361, 80.8%)	Yes (n = 86, 19.2%)	
FTDR	57 (12.8)	55 (96.5)	2 (3.5)	
FBIM	56 (12.5)	37 (66.1)	19 (33.9)	
CCLAD	20 (4.5)	15 (75)	5 (25)	
CDDP	15 (3.4)	11 (73.3)	4 (26.7)	
TB status				
No signs of TB	275 (61.5)	206 (74.9)	69 (25.1)	0.001*
Presumptive TB	172 (38.5)	155 (90.1)	90 (9.9)	
CD4 done				
No	248 (55.5)	220 (80.7)	48 (19.4)	0.945
Yes	199 (44.6)	161 (80.8)	38 (19.2)	
Adherence				
Fair	387 (86.6)	31 (70.5)	13 (29.6)	0.001*
Poor	44 (9.8)	6 (37.5)	10 (62.5)	
Good	16 (3.6)	324 (83.7)	63 (16.3)	
Viral suppression before DTG				
Non-suppressed	91 (20.4)	60 (65.9)	31 (34.1)	0.001*
Suppressed	284 (64.6)	245 (86.3)	39 (13.7)	
Unknown	72 (16.1)	56 (77.8)	16 (22.2)	

*FDC = Fixed dose combination, Non-FDC DTG regimens include: AZT/3TC/DTG, DRVr/DTG, TDF/3TC/DTG/DRVr

<https://doi.org/10.1371/journal.pone.0331835.t002>

(aRR: 1.48; 95% CI: 1.05–2.11), prior non-suppression before initiating DTG (aRR: 1.76; 95% CI: 1.19–2.59), use of non-fixed dose DTG regimens (aRR: 2.03; 95% CI: 1.23–3.33), history of poor adherence (aRR: 4.36; 95% CI: 2.05–9.26), and not receiving MMD (aRR: 2.83; 95% CI: 1.93–4.15) as shown in [Table 3](#) below

Discussion

The study found that the proportion of adolescents on **Dolutegravir-Based Antiretroviral Therapy** with a recently non-suppressed viral load was high at 19.2%. Adolescents in the age group of 15–19 years, being a male, having a history of VL non suppression before initiating DTG, poor adherence, being on non-fixed dose combination DTG regimens and not receiving MMD significantly increased the chance of being non-suppressed.

In this study we found that the proportion of adolescents with a recently non-suppressed viral load was 19.2%. This was higher than the UNAIDS target of 5% non-suppressed [19]. A previous study on HIV viral load suppression rate among adolescents in Kenya reported similar findings (Viral non-suppression = 20%) [20]. However, this viral load non-suppression rate is lower than that reported in two previous Zimbabwe studies which were at 35.1% and 46.8% [21,22]. In this study, we found that about 96% of adolescents at our study sites are receiving DTG-based ART now, this is a possible reason for lower non-suppression as compared to the two previous studies. A comparable study conducted among children and adolescents living with HIV in Tanzania found high viral suppression rates of 91.64% [23]. The figure of our viral load non-suppression rate is slightly lower than that of a similar study conducted among adults in the DRC that found that 27.2% of the participants had a VL of >50 copies per ml [24]. High viral load non-suppression could have been due to; poor medication adherence, and missed clinic appointments which resulted in intermittent access to ART, drug-resistant mutations, and adverse drug effects. Similarly, these adolescents are at substantial risk of stigma and its harmful effects on adherence and viral load outcomes. Comparable studies across African countries have also found that being

Table 3. Multivariable analysis of the factors associated with virologic non-suppression in Soroti City.

Variable	Crude Relative Risk (CI 95%)	p-value	Adjusted Relative Risk (CI 95%)	p-value
Age categories				
10–14	Reference			
15–19	1.65 (1.04–2.65)	0.035	1.69 (1.08–2.67)	0.022*
Sex at birth				
Female	Reference			
Male	1.68 (1.14–2.49)	0.008	1.48 (1.05–2.11)	0.027*
Study site				
SRRH	Reference			
TASO Soroti	2.92 (1.67–5.08)	0.001	2.14 (0.67–6.89)	0.202
Uganda Cares	2.57 (1.37–4.81)	0.003	2.74 (0.81–9.27)	0.104
Viral before DTG				
Suppressed	Reference			
Non-suppressed	2.48 (1.64–3.73)	0.001	1.76 (1.19–2.59)	0.004*
Unknown	1.61 (0.96–2.72)	0.071	1.28 (0.72–2.28)	0.39
Current ART regimen*				
TDF/3TC/DTG	Reference			
ABC/3TC/DTG	1.23 (0.73–2.07)	0.434	1.28 (0.75–2.19)	0.361
Non fixed dose DTG regimens	2.99 (1.91–4.69)	0.001	2.03 (1.23–3.33)	0.005*
Adherence to ART				
Fair	Reference			
Poor	2.11 (1.16–3.82)	0.013	4.36 (2.05–9.26)	0.001*
Good	0.55 (0.33–0.92)	0.022	0.76 (0.45–1.27)	0.307
Multi-month dispensing				
Yes	Reference			
No	3.17 (2.20–4.56)	0.001	2.83 (1.92–4.13)	0.001*
TB status				
No signs of TB	Reference			
Presumptive TB	0.39 (0.23–0.64)	0.001	1.25 (0.44–3.54)	0.665
Current DSDM model*				
CCLAD	Reference			
CDDP	1.06 (0.34–3.31)	0.911	0.96 (0.35–2.61)	0.937
FBG	0.74 (0.33–1.66)	0.477	0.95 (0.49–1.85)	0.891
FTDR	0.14 (0.03–0.66)	0.014	0.23 (0.04–1.13)	0.071
FBIM	1.35 (0.58–3.15)	0.478	1.16 (0.55–2.44)	0.695

<https://doi.org/10.1371/journal.pone.0331835.t003>

an adolescent is a key predictor of failure to achieve VL suppression [25]. A previous retrospective study found that the availability of youth-friendly services plus trained providers was associated with increased rates of virological suppression [26]. Similarly, peer-based strategies are now recommended at HIV clinics by WHO and are showing promising virological results.

This study found that male adolescents had a high likelihood of virologic non-suppression compared to females. This could be because most males report to health facilities at advanced stages of the disease which contributes to interruption of treatment. Boys and men also have lower engagement in psychosocial support services. This is consistent with previous findings where being a male was associated with HIV viral load non-suppression and virologic failure in South Africa [27], Zimbabwe [21], and Kenya [28]. Among adults in SSA, there is good evidence of poorer viral suppression among

male individuals [29–31]. This was initially thought to be a result of late presentation, poor adherence, and higher substance abuse. However, there is emerging evidence of possible biological differences in drug metabolism [32]. However, two studies conducted in Ghana [33] and Tanzania [34] showed contrary findings that females were 2.5 times more likely to have virological non-suppression as compared to males. While other studies have found no association between sex and virological non-suppression [35], Njom et al. think that the role of gender in virological suppression could be biological [36]. Therefore, the relationship between virological suppression and gender is inconclusive and requires further studies.

Our study found that adolescents on non-fixed dose combination DTG regimens had higher odds of virologic non-suppression as compared to adolescents on TDF/3TC/DTG. Our findings are consistent with a previous study done in Uganda and Tanzania where high VL suppression rates were found among those on TDF/3TC/DTG and ABC/3TC/DTG, this could have been due to once-a-day dosing compared to AZT/3TC/DTG and third-line regimens that are usually taken twice daily and have higher pill burdens [37–39]. Previous studies have reported that a high pill burden is associated with poor adherence, which in turn is linked to lower rates of viral load suppression [40,41]. A majority of these regimens are third-line ART implying that the adolescent has failed both first-line and second-line regimens, there's therefore a possibility that the adolescent has developed drug resistance and mutations across most of the drug classes rendering the drugs ineffective to suppress the viral load.

In this study we found adherence as a strong predictor of virologic non-suppression. Those with poor adherence had significantly higher odds of non-suppression versus those with good adherence. This is in agreement with the previous findings where poor adherence was reported to be associated with virologic failure [21,42]. This is because adherence maintains an optimal drug level and allows the drug to achieve the desired effects of suppressing viral replication thus promoting immune recovery. In a recent study however, intensive adherence interventions resulted in suppression among 23% of children and adolescents [43], compared with 70% suppression in adults, which may indicate a higher likelihood of resistant viruses in children and adolescents emphasizing the need to achieve and sustain good adherence in the population [44].

Adolescents who were not receiving MMD were more likely to be non-suppressed as compared to those who were enrolled in MMD. Our findings are consistent with earlier findings in Nigeria, and Uganda that MMD increased the VLS rate [45–47]. However this was contrary to the findings in South Africa where VLS was similar among ART adherence club members who received ART for six months with annual clinical consultations compared with those receiving ART for two months [48]. This is because an adolescent who is not receiving MMD is expected to have a clinical encounter every month, which could possibly lead to missed clinic appointments and then frequent drug interruptions and consequently non-viral suppression.

This study also found that adolescents in the age group of 15–19 years were more likely to be non-suppressed as compared to their counterparts in the age group of 10–14 years. This is contrary to two previous studies conducted in Uganda and Tanzania that found that HIV viral load non-suppression was more common among children and lower adolescents compared to the older ones [16,49]. Related findings in Swaziland also revealed that pre-adolescents (10–14) were more likely to remain non-suppressed at retesting following completion of IAC [35]. HIV viral load non-suppression among the older adolescents (15–19) years could have been because of negative peer pressure, stigma, and the discovery of sexuality, these affect their ability to access quality HIV care and make proper health decisions.

This study further found that adolescents who had a history of VL non-suppression before initiation on DTG based ART were more likely to be non-suppressed as compared to those who had a suppressed VL. This is consistent with findings of a previous study that found that having an initial VL between 1000 and 50,000 copies/ml was a key predictor of VL non-suppression [25]. Having a history of VL non-suppression could imply the development of drug resistance and mutations across the different ART drug classes rendering the drugs ineffective to suppress the viral load.

Limitations of the study

The study used secondary data, conclusions could have been limited by issues of data quality and incomplete values which were mitigated with triangulation of data from EMR and patient records. General HIV drug resistance testing was

unavailable for this study, preventing any conclusions about VL suppression due to drug failure. Additionally, this study's method for measuring adherence by utilizing clinic records that were captured by self-reports likely underestimates the true rate of non-adherence.

However, this study had notable strengths of being done in ART clinics with the greatest number of ALHIV active in care in the region and including all ALHIV in care making the findings generalizable. This study adds to the limited literature on viral load suppression among the ALHIV on a DTG-based regimen and complements Uganda and PEPFAR efforts to optimize the ALHIV on the efficacious DTG-based regimen to achieve the UNAIDS target by 2030.

Conclusion

Our study demonstrates high rates of viral non-suppression among the adolescent population living with HIV, which was associated with the adolescents in the age group of 15–19 years, male sex, having a history of VL non-suppression before initiating DTG, being on non-fixed dose combination DTG regimens, having poor adherence, and not receiving MMD. Therefore, there is a need to optimize adherence strategies among ALHIV especially the male and older adolescents, implement routine HIV resistance testing and scale up fixed-dose DTG regimens to improve VL suppression which will improve treatment outcomes for adolescents. HIV programs then need to design targeted age and gender specific care and treatment policies, programs, and interventions, or to modify the existing ones, to improve VL suppression among adolescents living with HIV on DTG-based ART, to achieve the 95-95-95 targets by 2030.

Supporting information

S1 Data. Dataset on the prevalence and predictors of HIV viral load non-suppression (excel).
(CSV)

S2 Questionnaire. Questionnaire on the prevalence and predictors of HIV viral load non-suppression.
(PDF)

S3 Strobe Checklist. Checklist of items that should be included in reports of observational studies.
(DOCX)

S1 Table. Definitions and measurement of independent variables.
(PDF)

S1 Fig. Study flow.
(TIF)

Acknowledgments

The authors acknowledge the support of the data clerks, adolescent focal persons and YAPs of SRRH, TASO Soroti CoE and Uganda cares who were very instrumental in the data abstraction.

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References

1. Unicef. Global and regional trends. Jul. 2023. Accessed September 08, 2023. [Online]. Available: <https://data.unicef.org/topic/hiv/aids/global-regional-trends/>
2. UNAIDS. Country factsheets Uganda 2022. UNAIDS, 2022. Accessed September 16, 2023. [Online]. Available: <https://www.unaids.org/en/regionscountries/countries/uganda>
3. Opito R, Mpagi J, Bwayo D, Okello F, Mugisha K, Napyo A. Treatment outcome of the implementation of HIV test and treat policy at The AIDs Support Organization (TASO) Tororo clinic, Eastern Uganda: A retrospective cohort study. *PLoS One*. 2020;15(9):e0239087. <https://doi.org/10.1371/journal.pone.0239087> PMID: 32960927
4. Bruzzese E, Lo Vecchio A, Smarrazzo A, Tambaro O, Palmiero G, Bonadies G, et al. Dolutegravir-based anti-retroviral therapy is effective and safe in HIV-infected paediatric patients. *Ital J Pediatr*. 2018;44(1):37. <https://doi.org/10.1186/s13052-018-0469-x> PMID: 29558972
5. Gibert CL. Treatment guidelines for the use of antiretroviral agents in HIV-infected adults and adolescents: an update. *Fed Pract Health Care Prof VA DoD PHS*. 2016;33(Suppl 3):31S-36S.
6. Rathbun RC, Lockhart SM, Miller MM, Liedtke MD. Dolutegravir, a second-generation integrase inhibitor for the treatment of HIV-1 infection. *Ann Pharmacother*. 2014;48(3):395–403. <https://doi.org/10.1177/1060028013513558> PMID: 24259658
7. WHO. Consolidated guidelines on HIV prevention, testing, treatment, service delivery and monitoring: recommendations for a public health approach. Geneva, Switzerland: World Health Organization, 2021.
8. Viani RM, Alvero C, Fenton T, Acosta EP, Hazra R, Townley E, et al. Safety, pharmacokinetics and efficacy of Dolutegravir in treatment-experienced HIV-1 infected adolescents: forty-eight-week results from IMPAACT P1093. *Pediatr Infect Dis J*. 2015;34(11):1207–13. <https://doi.org/10.1097/INF.0000000000000848> PMID: 26244832
9. Moore CL, Turkova A, Mujuru H, Kekitiinwa A, Lugemwa A, Kityo CM, et al. ODYSSEY clinical trial design: a randomised global study to evaluate the efficacy and safety of dolutegravir-based antiretroviral therapy in HIV-positive children, with nested pharmacokinetic sub-studies to evaluate pragmatic WHO-weight-band based dolutegravir dosing. *BMC Infect Dis*. 2021;21(1):5. <https://doi.org/10.1186/s12879-020-05672-6> PMID: 33446115
10. Tsuchiya K, Hayashida T, Hamada A, Oki S, Oka S, Gatanaga H. High plasma concentrations of dolutegravir in patients with ABCG2 genetic variants. *Pharmacogenet Genomics*. 2017;27(11):416–9. <https://doi.org/10.1097/FPC.0000000000000308> PMID: 28858994
11. Dehority W, Abadi J, Wiznia A, Viani RM. Use of integrase inhibitors in HIV-infected children and adolescents. *Drugs*. 2015;75(13):1483–97. <https://doi.org/10.1007/s40265-015-0446-2> PMID: 26242765
12. Twimukye A, Laker M, Odongpiny EAL, Ajok F, Onen H, Kalule I, et al. Patient experiences of switching from Efavirenz- to Dolutegravir-based antiretroviral therapy: a qualitative study in Uganda. *BMC Infect Dis*. 2021;21(1):1154. <https://doi.org/10.1186/s12879-021-06851-9> PMID: 34774018
13. PHL Uganda. Uganda Viral Load Dashboard. Accessed: January 26, 2024. [Online]. Available: <https://vldash.cphluganda.org/>
14. Townsend CL, O'Rourke J, Milanzi E, Collins IJ, Judd A, Castro H, et al. Effectiveness and safety of dolutegravir and raltegravir for treating children and adolescents living with HIV: a systematic review. *J Int AIDS Soc*. 2022;25(11):e25970. <https://doi.org/10.1002/jia2.25970> PMID: 36377082
15. Gemechu A, Mihret A, Atire FA, Aseffa A, Howe R, Seyoum B, et al. Virological non-suppression among newly diagnosed HIV-positive individuals on Dolutegravir-based antiretroviral treatment in Eastern Ethiopia: follow-up study. *Trop Med Infect Dis*. 2023;8(8):391. <https://doi.org/10.3390/trop-icalmed8080391> PMID: 37624329
16. Khamadi SA, Bahemana E, Dear N, Mavere C, George F, Kapene R, et al. Factors associated with viral suppression and drug resistance in children and adolescents living with HIV in care and treatment programs in Southern Tanzania. *J Pediatric Infect Dis Soc*. 2023;12(6):353–63. <https://doi.org/10.1093/jpids/piad040> PMID: 37279560
17. National-Population-and-Housing-Census-2024-Final-Report-Volume-1-Main.pdf." Accessed Mar. 15, 2025. [Online]. Available: <https://www.ubos.org/wp-content/uploads/2024/12/National-Population-and-Housing-Census-2024-Final-Report-Volume-1-Main.pdf>

18. Consolidated-HIV-and-AIDS-Guidelines-20230516.pdf." Accessed Mar. 15, 2025. [Online]. Available: <https://dsduganda.com/wp-content/uploads/2023/05/Consolidated-HIV-and-AIDS-Guidelines-20230516.pdf>
19. Winnie Byanyima. "UNAIDS welcomes new research on 'opt-out' HIV testing in England," presented at the HIV opt-out testing will consolidate the gains towards HIV epidemic control in the UK, London, Nov. 29, 2023. Accessed Aug. 08, 2021. [Online]. Available: https://www.unaids.org/en/resources/presscentre/pressreleaseandstatementarchive/2023/november/20231129_new-research-on-opt-out-hiv-testing-england#:~:text=In%20the%20UNAIDS%20Global%20AIDS,treatment%20to%20be%20virally%20suppressed
20. Mwangi A, van Wyk B. Factors associated with viral suppression among adolescents on antiretroviral therapy in Homa Bay County, Kenya: a retrospective cross-sectional study. *HIV AIDS (Auckl)*. 2021;13:1111–8. <https://doi.org/10.2147/HIV.S345731> PMID: 34992469
21. Simms V, Bernays S, Chibanda D, Chinoda S, Mutsinze A, Beji-Chauke R, et al. Risk factors for HIV virological non-suppression among adolescents with common mental disorder symptoms in Zimbabwe: a cross-sectional study. *J Int AIDS Soc*. 2021;24(8):e25773. <https://doi.org/10.1002/jia2.25773> PMID: 34402199
22. Mavhu W, Willis N, Mufuka J, Bernays S, Tshuma M, Mangenah C, et al. Effect of a differentiated service delivery model on virological failure in adolescents with HIV in Zimbabwe (Zvandiri): a cluster-randomised controlled trial. *Lancet Glob Health*. 2020;8(2):e264–75. [https://doi.org/10.1016/S2214-109X\(19\)30526-1](https://doi.org/10.1016/S2214-109X(19)30526-1) PMID: 31924539
23. Maghembe AA, Boer MS, Marikias G, Amour C, Mahande MJ. HIV viral suppression and associated factors among children and adolescents on a Dolutegravir (DTG) based antiretroviral regimen in Tanzania Mainland. Cold Spring Harbor Laboratory. 2023. <https://doi.org/10.1101/2023.05.17.23290106>
24. Buju RT, Akilimali PZ, Kamangu EN, Mesia GK, Kayembe JMN, Situakibanza HN. Predictors of viral non-suppression among patients living with HIV under Dolutegravir in Bunia, Democratic Republic of Congo: a prospective cohort study. *Int J Environ Res Public Health*. 2022;19(3):1085. <https://doi.org/10.3390/ijerph19031085> PMID: 35162109
25. Kadima J, Patterson E, Mburu M, Blat C, Nyanduko M, Bukusi EA, et al. Adoption of routine virologic testing and predictors of virologic failure among HIV-infected children on antiretroviral treatment in western Kenya. *PLoS One*. 2018;13(11):e0200242. <https://doi.org/10.1371/journal.pone.0200242> PMID: 30412576
26. Wilson K, Onyango A, Mugo C, Guthrie B, Slyker J, Richardson B, et al. Kenyan HIV clinics with youth-friendly services and trained providers have a higher prevalence of viral suppression among adolescents and young adults: results from an observational study. *J Assoc Nurses AIDS Care*. 2022;33(1):45–53. <https://doi.org/10.1097/JNC.000000000000302> PMID: 34939987
27. Joseph Davey D, Abrahams Z, Feinberg M, Prins M, Serrao C, Medeossi B, et al. Factors associated with recent unsuppressed viral load in HIV-1-infected patients in care on first-line antiretroviral therapy in South Africa. *Int J STD AIDS*. 2018;29(6):603–10. <https://doi.org/10.1177/0956462417748859> PMID: 29334886
28. Njuguna I, Neary J, Mburu C, Black D, Beima-Sofie K, Wagner AD, et al. Clinic-level and individual-level factors that influence HIV viral suppression in adolescents and young adults: a national survey in Kenya. *AIDS*. 2020;34(7):1065–74. <https://doi.org/10.1097/QAD.0000000000002538> PMID: 32287060
29. Bulage L, Ssewanyana I, Nankabirwa V, Nsubuga F, Kihembo C, Pande G, et al. Factors associated with virological non-suppression among HIV-positive patients on antiretroviral therapy in Uganda, August 2014–July 2015. *BMC Infect Dis*. 2017;17(1):326. <https://doi.org/10.1186/s12879-017-2428-3> PMID: 28468608
30. Boullé C, Kouanfack C, Laborde-Balen G, Boyer S, Aghokeng AF, Carrieri MP, et al. Gender differences in adherence and response to antiretroviral treatment in the stratal trial in rural district hospitals in Cameroon. *J Acquir Immune Defic Syndr*. 2015;69(3):355–64. <https://doi.org/10.1097/QAI.0000000000000604> PMID: 26181708
31. Kipp W, Alibhai A, Saunders LD, Senthilselvan A, Kaler A, Konde-Lule J, et al. Gender differences in antiretroviral treatment outcomes of HIV patients in rural Uganda. *AIDS Care*. 2010;22(3):271–8. <https://doi.org/10.1080/09540120903193625> PMID: 20390506
32. Ofotokun I, Chuck SK, Hitti JE. Antiretroviral pharmacokinetic profile: a review of sex differences. *Gend Med*. 2007;4(2):106–19. [https://doi.org/10.1016/s1550-8579\(07\)80025-8](https://doi.org/10.1016/s1550-8579(07)80025-8) PMID: 17707845
33. Afrane AKA, Goka BQ, Renner L, Yawson AE, Alhassan Y, Owiafe SN, et al. HIV virological non-suppression and its associated factors in children on antiretroviral therapy at a major treatment centre in Southern Ghana: a cross-sectional study. *BMC Infect Dis*. 2021;21(1):731. <https://doi.org/10.1186/s12879-021-06459-z> PMID: 34340689
34. Muri L, Gamell A, Ntamatungiro AJ, Glass TR, Luwanda LB, Battegay M, et al. Development of HIV drug resistance and therapeutic failure in children and adolescents in rural Tanzania: an emerging public health concern. *AIDS*. 2017;31(1):61–70. <https://doi.org/10.1097/QAD.0000000000001273> PMID: 27677163
35. Jobanputra K, Parker LA, Azih C, Okello V, Maphalala G, Kershberger B, et al. Factors associated with virological failure and suppression after enhanced adherence counselling, in children, adolescents and adults on antiretroviral therapy for HIV in Swaziland. *PLoS One*. 2015;10(2):e0116144. <https://doi.org/10.1371/journal.pone.0116144> PMID: 25695494
36. Njom Nlend AE, Motaze AN, Ndiang ST, Fokam J. Predictors of virologic failure on first-line antiretroviral therapy among children in a referral pediatric center in Cameroon. *Pediatr Infect Dis J*. 2017;36(11):1067–72. <https://doi.org/10.1097/INF.0000000000001672> PMID: 28661967
37. Quaker AS, Shirima LJ, Msuya SE. Trend and factors associated with non-suppression of viral load among adolescents on ART in Tanzania: 2018–2021. *Front Reprod Health*. 2024;6:1309740. <https://doi.org/10.3389/frph.2024.1309740> PMID: 38292142

38. Namayanja GA, Da Silva J de F, Elur B, Nasirumbi PM, Raizes E, Ssempiira J, et al. High viral suppression rates among PLHIV on dolutegravir who had an initial episode of viral non-suppression in Uganda September 2020–July 2021. *PLoS One*. 2024;19(6):e0305129. <https://doi.org/10.1371/journal.pone.0305129> PMID: [38923981](https://pubmed.ncbi.nlm.nih.gov/38923981/)
39. Ramadhani HO, Bartlett JA, Thielman NM, Pence BW, Kimani SM, Maro VP, et al. Association of first-line and second-line antiretroviral therapy adherence. *Open Forum Infect Dis*. 2014;1(2):ofu079. <https://doi.org/10.1093/ofid/ofu079> PMID: [25734147](https://pubmed.ncbi.nlm.nih.gov/25734147/)
40. Kini V, Ho PM. Interventions to improve medication adherence: a review. *JAMA*. 2018;320(23):2461–73. <https://doi.org/10.1001/jama.2018.19271> PMID: [30561486](https://pubmed.ncbi.nlm.nih.gov/30561486/)
41. Attaianese F, Dalpiaz I, Failla M, Pasquali E, Galli L, Chiappini E. Fixed-dose antiretroviral combinations in children living with human immunodeficiency virus type 1 (HIV-1): a systematic review. *J Chemother*. 2024;36(5):355–69. <https://doi.org/10.1080/1120009X.2023.2297095> PMID: [38153234](https://pubmed.ncbi.nlm.nih.gov/38153234/)
42. Li JZ, Gallien S, Ribaud H, Heisey A, Bangsberg DR, Kuritzkes DR. Incomplete adherence to antiretroviral therapy is associated with higher levels of residual HIV-1 viremia. *AIDS*. 2014;28(2):181–6. <https://doi.org/10.1097/QAD.000000000000123> PMID: [24361679](https://pubmed.ncbi.nlm.nih.gov/24361679/)
43. Nasuuna E, Kigozi J, Babirye L, Muganzi A, Sewankambo NK, Nakanjako D. Low HIV viral suppression rates following the intensive adherence counseling (IAC) program for children and adolescents with viral failure in public health facilities in Uganda. *BMC Public Health*. 2018;18(1):1048. <https://doi.org/10.1186/s12889-018-5964-x> PMID: [30134880](https://pubmed.ncbi.nlm.nih.gov/30134880/)
44. Bonner K, Siemieniuk RA, Boozary A, Roberts T, Fajardo E, Cohn J. Expanding access to HIV viral load testing: a systematic review of RNA stability in EDTA tubes and PPT beyond current time and temperature thresholds. *PLoS One*. 2014;9(12):e113813. <https://doi.org/10.1371/journal.pone.0113813> PMID: [25437009](https://pubmed.ncbi.nlm.nih.gov/25437009/)
45. Casalini C, Bateganya M, Akolo C, Sanwo O, Idemudia A, Nwaokoro P, et al. Increasing multimonth dispensing of antiretrovirals and assessing the effect on viral load suppression among children and adolescents receiving HIV services in Nigeria. *PLoS One*. 2023;18(6):e0286303. <https://doi.org/10.1371/journal.pone.0286303> PMID: [37315075](https://pubmed.ncbi.nlm.nih.gov/37315075/)
46. Ainembabazi B, Ssebunya RN, Akobye W, Mugume A, Nahirya-Ntege P, Birungi DJ, et al. Viral load suppression and retention in care among children and adolescents receiving multi-month anti-retroviral therapy refills: a program data review in Uganda. *BMC Pediatr*. 2024;24(1):804. <https://doi.org/10.1186/s12887-024-05295-9> PMID: [39645566](https://pubmed.ncbi.nlm.nih.gov/39645566/)
47. Long L, Kuchukhidze S, Pascoe S, Nichols BE, Fox MP, Cele R, et al. Retention in care and viral suppression in differentiated service delivery models for HIV treatment delivery in sub-Saharan Africa: a rapid systematic review. *J Int AIDS Soc*. 2020;23(11):e25640. <https://doi.org/10.1002/jia2.25640> PMID: [33247517](https://pubmed.ncbi.nlm.nih.gov/33247517/)
48. Cassidy T, Grimsrud A, Keene C, Lebelo K, Hayes H, Orrell C, et al. Twenty-four-month outcomes from a cluster-randomized controlled trial of extending antiretroviral therapy refills in ART adherence clubs. *J Int AIDS Soc*. 2020;23(12):e25649. <https://doi.org/10.1002/jia2.25649> PMID: [33340284](https://pubmed.ncbi.nlm.nih.gov/33340284/)
49. Sempa JB, Kiragga AN, Castelnovo B, Kamya MR, Manabe YC. Among patients with sustained viral suppression in a resource-limited setting, CD4 gains are continuous although gender-based differences occur. *PLoS One*. 2013;8(8):e73190. <https://doi.org/10.1371/journal.pone.0073190> PMID: [24013838](https://pubmed.ncbi.nlm.nih.gov/24013838/)