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Antiretroviral Therapy Adherence and Associated Factors Among Children and Adolescents with HIV in Bamenda, Cameroon: A Multicenter Retrospective Observational Study.

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ABSTRACT

Background: Antiretroviral therapy (ART) adherence among children and adolescents living with human immunodeficiency virus (HIV) remains low and is associated with age, disclosure status, drug formulation, and palatability. Adherence in this population in the Bamenda municipality was hypothesized to be low.

Methods: This multicenter retrospective observational study analyzed longitudinal medical, pharmacy, and adherence-monitoring data from three HIV treatment centers in Bamenda (January 1, 2024–March 30, 2025). Consecutive records of patients aged ≤19 years with confirmed HIV, active ART follow-up, and ≥12 months of pill-count monitoring were eligible; 403 of 436 screened records were included. Poor adherence was defined as mean pill-count adherence <95%. Bivariable and multivariable logistic regression yielded adjusted odds ratios (aORs) with 95% confidence intervals (CIs).

Results: Poor adherence occurred in 237 participants (58.8%; 95% CI 53.9%–63.5%). It was independently associated with a non-parent caregiver (aOR 2.05, 95% CI 1.24–3.38; p = 0.005), non-urban residence (aOR 4.47, 2.70–7.40; p < 0.001), more-than-once-daily dosing (aOR 9.18, 4.83–17.44; p < 0.001), ART duration ≤10 years (aOR 1.67, 1.01–2.77; p = 0.045), and attendance at Nkwen District Hospital (aOR 4.41, 1.44–13.56; p = 0.010) or Saint Mary Soledad Hospital (aOR 3.42, 1.14–10.32; p = 0.029). Compared with monthly appointments, 2–3-month intervals were associated with lower odds of poor adherence (aOR 0.42, 0.20–0.90; p = 0.025), though this should be interpreted cautiously, as scheduling may have reflected pre-existing adherence difficulties.

Conclusion: Pediatric and adolescent ART adherence in Bamenda remains suboptimal, with caregiver-, residence-, treatment-, and facility-related barriers. Strengthening caregiver support and health service delivery may improve adherence in similar resource-limited settings.

Keywords: antiretroviral therapy; pediatric HIV; adolescent HIV; antiretroviral adherence; pill count method; logistic regression

INTRODUCTION

Human immunodeficiency virus remains a significant global public health challenge, with an estimated 39.9 million people with HIV in 2023, including approximately 1.4 million children aged 0–14 years [1]. The African region bears the greatest burden, with 25.6 million people with HIV, of whom 4.8 million are in West and Central Africa [2]. Cameroon continues to face a significant challenge of pediatric HIV, with approximately 27,960 children living with HIV as of 2023 [3]. The success of ART greatly relies on continuous and high levels of adherence [2] among children and adolescents. Attaining and maintaining optimal adherence to ART is particularly challenging due to dependence on caregivers, stigma and various socioeconomic influences [3].

Although antiretroviral therapy is available, HIV related morbidity and mortality among children remains high. In 2024, about 34.2% of children under 10 years diagnosed with HIV and 32.4% of adolescents aged 10-19 years in Cameroon were receiving ART [4]. Poor adherence leads to virologic failure, the development of drug resistance, and disease progression [5] and is affected by factors such as age, disclosure status, caregiver involvement, socioeconomic status, pill burden, adverse effects, and stigma [6-8]. Maintaining consistent adherence among children and adolescents remains a significant challenge, despite national campaigns to increase access to ART. Poor adherence has may reflect on more general public health issues, such as ongoing HIV transmission and the emergence of drug-resistant strains, in addition to individual health outcomes like virologic failure, worsening disease, and increased morbidity and mortality.

Reports from different settings show considerable variability in ART adherence rates, ranging from 29-55% in the United States of America (USA) [9] and 38% in Rwanda [10] to 87.2% in Ethiopia, where urban residence and biological caregiver were factors associated with optimal adherence [11]. Adolescent adherence in Cameroon has been reported to be 83%, with treatment-related side effects and stigma having a major result on adherence outcomes [12]. Previous Cameroonian studies have primarily examined ART adherence among adolescents. Bongfen et al [12] assessed adherence amongst adolescents aged 10-19 years across treatment facilities in the North & South West Cameroon, while Lantche et al [7] focused on adherence amongst adolescents aged 15-19 years in Yaounde. These studies provide important evidence concerning adolescent adherence but did not comprehensively include younger children, whose medication-taking behaviour is more dependent on parents or other caregivers. Evidence concerning adherence across the full pediatric and adolescent age range therefore remains limited.

The present study addressed this gap by including children and adolescents aged 2-19 years and examining repeated pill count adherence measurements documented over at least 12 months. It simultaneously evaluated child, caregiver, treatment and health service-related characteristics across three major HIV treatment facilities in Bamenda. This broader age range and longitudinal use of routinely collected adherence records provide information that complements earlier adolescent-focused Cameroon investigations.

The objective of this study was to determine the prevalence of poor pill-count adherence and examine participant, caregiver, treatment, and health services-related factors associated with poor adherence among children and adolescents aged 2-19 years receiving ART at three treatment facilities in Bamenda, Cameroon.

MATERIALS AND METHODS

This investigation was a multicenter retrospective observational study using longitudinal medical, pharmacy, and adherence monitoring records from three HIV treatment centres in Bamenda, with an observation period from 1 January 2024 to 30 March 2025, , and retrospective extraction of information from the existing medical, pharmacy and adherence-monitoring records was conducted from 10 January 2025 to 30 March 2025 using a structured data-extraction form. Administrative authorisations for access to records were obtained from the Faculty of Health Sciences, the North West Regional Delegation of the Ministry of Public Health and the participating health facilities. Repeated pill count measurements recorded over at least 12 months of follow-up were used to calculate participant-level mean adherence.

Because several caregivers, residence and treatment-related characteristics were measured during the same observation period as adherence, associations were interpreted as observational rather than causal. We selected three treatment facilities: The Regional Hospital Bamenda, Saint Mary Soledad Hospital, and Nkwen District Hospital. These facilities were purposively selected because they provide substantial pediatric and adolescent HIV services within Bamenda. Consecutive records meeting the eligibility criteria were reviewed. Because facility selection was purposive and non-random, the study population should not be considered statistically representative of all children and adolescents receiving ART in the North West Region of Cameroon. The findings are primarily generalizable to patients receiving care in the participating facilities and should be extrapolated to other settings with caution.

Study Population and Sampling

The Participants were eligible when: were aged 19 years or younger, had confirmed HIV infection, were actively receiving ART at one of the participating facilities, had been receiving ART for at least 12 months, and had at least 12 months of documented pill count monitoring. Records were excluded when: participants had received ART for less than 12 months; had insufficient longitudinal pill-count information to determine the primary adherence outcome; participants transferred out to another treatment centre; had substantial or internally inconsistent information that prevented reliable determination of the study outcome or required explanatory variables.

The minimum sample size was estimated using Cochran's formula for a single population proportion:

$$n_0 = \frac{Z^2 pq}{e^2}$$

where $\boldsymbol{Z}$ = 1.96 for a 95% confidence level, $\boldsymbol{p}$ = 0.83, based on the 83% ART adherence prevalence reported by Bongfen et al [12]. Among adolescents in Cameroon, $\boldsymbol{q}$ = 1- p, which is 0.17 and $\boldsymbol{e}$ = 0.05, representing a 5% margin of error. The calculated minimum sample size is 216.8, which was rounded up to 217 participants' records. As consecutive eligible records were reviewed during the study period, all records meeting the eligibility criteria were included, resulting in a final analytical sample of 403 participant records, which exceeded the calculated minimum sample size.

Patients older than 19 years do not appear as exclusions because they were outside the defined target population and were not considered among the 436 screened records. (Figure 1).

A total of 436 potentially eligible records were screened. 15 records were excluded because the participants had transferred out to another treatment centre, and 18 were excluded because of substantial missing or inconsistent information required for reliable adherence and covariate assessment. The remaining 403 records were included in the final analysis.

The primary study outcome was participant-level pill count adherence status. For each participant, the arithmetic mean of all valid visit-level pill count adherence measurements during follow-up was calculated. Mean adherence <95% was classified as poor adherence, whereas mean adherence ≥ 95% was classified as good adherence.

The reporting of this multicenter retrospective observational study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement. Because longitudinal medical, pharmacy and adherence-monitoring records were analysed over a defined observation period, the STROBE checklist for cohort studies was used to guide reporting. The completed checklist is provided as supplementary material.

During eligibility screening, records were assessed for completeness of the information required to determine adherence status and evaluate the predefined participant, caregiver, clinical and treatment-related variables. Eighteen records were excluded because they contained substantial missing or internally inconsistent information. Missing data varied across records and included absent adherence monitoring data, incomplete caregiver information, incomplete child-related information and inconsistent or insufficient treatment information. These records were excluded before analysis because the missing information prevented reliable determination of the study outcome or relevant explanatory variables. The final analytical sample comprised 403 records with sufficient information for the study analyses.

Data Collection and Adherence Measurement

Data were extracted retrospectively from existing medical, pharmacy and adherence-monitoring records using a structured data extraction form developed for the study. The instrument was divided into five sections: the first section recorded the social, demographic and economic details of the children and adolescents and their caregivers; the second section recorded clinical data of the children and adolescents; the third section evaluated adherence behaviours; the fourth section looked at factors related to healthcare; and the fifth section concentrated on drug refill monitoring.

The pill count method, a commonly used and useful indicator of medication adherence in settings with limited resources, was primarily used to assess adherence to ART [13]. Pill count adherence was selected as the primary adherence measure because it was routinely and repeatedly documented at successive clinical or pharmacy visits in all three facilities. For each eligible inter-visit interval, the quantity of ART dispensed at the preceding visit was linked to the quantity of the corresponding medication returned at the subsequent visit. Returned tablets were physically counted. The expected number of tablets to be taken during the interval was calculated from the prescribed daily dose and the actual number of days elapsed between the two visits. Participant-level adherence was calculated as the mean of the available visit-level pill count measurements recorded during follow-up.

Adherence (%) = [(tablets dispensed at the preceding visit – tablets returned at the current visit) / Tablets expected to have been taken during the actual inter-visit interval] x 100 [14].

The expected number of tablets was calculated as the prescribed number of tablets per day multiplied by the actual number of days elapsed between consecutive visits. Consequently, early or delayed attendance was accounted for using the actual inter-visit interval rather than the scheduled appointment date. For each participant, the arithmetic mean of all valid visit-level adherence percentages recorded during at least 12 months of follow-up was calculated.

Pill count cannot distinguish between tablets actually ingested and tablets that are discarded, shared, damaged, lost without being reported or otherwise removed before the follow-up visit. Consequently, pill dumping or other unreported handling of tablets may lead to misclassification and particularly overestimation of adherence.

Participants' records showed varying numbers of adherence monitoring visits during the observation period. Among the 403 participants' records, the median number of valid recorded follow-up visits was 6 (interquartile range:5-8; range: 3-14), with a mean of 7.02 ± 2.30 visits per participant. Participant-level adherence was calculated as the arithmetic mean of all valid visit-level adherence percentages available during follow-up. The number and timing of adherence measurements varied between participants. Although each participant contributed a single mean adherence estimate to the final analysis, estimates based on fewer measurements may have been less precise than those based on more repeated observations. This variation in measurement density may therefore have reduced comparability between participants.

For each eligible inter-visit interval, the quantity of ART dispensed at the preceding visit was linked to the quantity of the corresponding medication returned at the subsequent visit. Returned tablets were physically counted. The expected number of tablets to be taken during the interval was calculated as the prescribed number of tablets per day multiplied by the actual number of days elapsed between visits. When an ART regimen or dosing schedule changed, the previous monitoring interval was closed and new pill-count monitoring interval was initiated based on the newly prescribed regimen and quantity dispensed. Adherence for the subsequent interval was therefore calculated using the new regimen-specific expected tablet consumption. Tablets reported as lost were considered unavailable for confirmed consumption and contributed to poor adherence for that interval. No valid visit-level pill-count adherence value exceeded 100%; therefore, no capping or truncation was required.

For the purpose of this study, good adherence was defined as a mean adherence rate of ≥ 95% in accordance with established benchmarks associated with optimal ART outcomes [14].

No valid visit-level pill-count adherence value exceeded 100%; consequently, no capping or truncation was required before calculation of participant-level mean adherence.

Pharmacy refill and viral load information were abstracted where available but were not used to define the primary adherence outcome. Pharmacy refill records indicate medication acquisition but do not confirm ingestion. Viral load testing was not conducted at uniform time points and was not consistently aligned with the pill count observation period. Viral load results may also reflect resistance or regimen-related factors in addition to adherence.

Statistical Analysis

Study results were evaluated using R version 4.4.1.

Bivariable analysis: All predictor variables assessed in Tables 2-4 are categorical, and their association with the binary adherence outcome was tested using the chi-squared test. Age was recorded in completed years and categorized as 2-13 years and 14-19 years for the categorical analysis. This grouping was used to distinguish younger pediatric/early-adolescent participants from older adolescents within the study population. The categorization was informed by the developmental ranges described by the American Academy of Pediatrics, which recognizes childhood and adolescence as overlapping developmental phases and identifies early adolescence as approximately 11-14 years. Accordingly, the 2-13year category should not be interpreted as a strict definition of childhood; it

includes children and younger early adolescents, whereas the 14-19year category comprises older adolescents in the study population Adherence counselling status was excluded from formal significance testing, as all participants in both adherence groups had received counselling (100%), leaving no variability to test.

Multivariable model construction: Variables for the primary multivariable logistic- regression model were selected a priori on the basis of clinical releveance, previous literature, and potential confounding rather than bavariable statistical alone. The model included treatment facility, age, sex, residence, caregiver relationship, caregiver employment, duration on ART, daily ART dosing frequency, and appointment interval. All selected factors were entered simultaneously into the multivariable logistic regression model using the Enter method. An analysis incorporating additional measured candidate variables was used to assess robustness to alternative model specification. This analysis does not address residual or unmeasured confounding. With 237 poor adherence events and eight factors retained in the final model, the events per variable ratio was approximately 29.6:1, comfortably exceeding the commonly recommended minimum of 10 events per variable and supporting the model's stability against overfitting. Multicollinearity was assessed using variance inflation factors (VIFs); values substantially below 5 were considered inconsistent with problematic collinearity. Overall model improvement relative to the intercept-only model was assessed using the likelihood ratio test. McFadden's pseudo-R^2 was used as a descriptive measure of model explanatory performance. Discrimination was assessed using the area under the receiver operating characteristic curve (AUC), and overall probabilistic prediction error using the Brier score. Calibration was assessed using the Hosmer-Lemeshow goodness-of-fit test. Treatment facility was evaluated overall using a joint Wald test of the two facility indicator coefficients. Statistical significance was assessed using two-sided $p < 0.05$. Final model diagnostics: from the verified model

- Maximum VIF = **1.44**
- Overall facility joint Wald X^2 test **p = 0.014**
- Model likelihood ratio test **p = 0.0003**
- McFadden pseudo-R^2 = **0.060**
- AUC = **0.652**
- Brier score = **0.224**
- **Hosmer-Lemeshow p = 0.924**

From the above we can relate the facility variable was significant overall even though the Saint Mary Soledad Hospital comparison was not.

RESULTS

The overall prevalence of poor adherence to antiretroviral therapy among the study participants was found to be 58.8% (Figure 2). The prevalence of poor adherence varied across the different health facilities, as detailed in Table 1, with prevalence as follows: Regional Hospital Bamenda (55.0%) followed by Saint Mary Soledad Hospital (81.5%) and Nkwen District Hospital (85.2%) (Table 1).

A total of 403 children and adolescents aged 19 years and below were included in this study. The children's ages ranged from 2 to 19 years, with a mean age of 15 ± 4.2 years. Among participants with poor adherence, 161 out of 237(67.9%) were aged 14-19 years and 76 out of 237(32.1%) were aged 2-13 years, compared to 119 out of 166 with good adherence. We had more females with poor adherence, 134(56.5%), giving a female-to-male sex ratio of female to male with poor adherence of 1.30:1. Also, a greater proportion of participants with poor adherence were educated 178(75.1%) and lived in non-urban areas 167(70.5%), with most of them being orphans 128(54%) (Table 2).

Most children and adolescents with poor adherence had non-parent caregivers, 137(57.8%). A great proportion caregivers were unemployed 130(55.0%), were not educated 205(86.5%) and approximately half of caregivers in the poor adherence group were HIV positive 120(50.6%) (Table 3).

Most participants with poor adherence had been on First-line ART 207(87.3%). We had 152(64.1%) of the participants with poor adherence on treatment for ≤10 years; most participants with poor adherence were on medication once daily 121(51%), and had appointment interval every 2-3 months 193(81.4%). All participants had been counselled on adherence 403 (100%). We noticed most participants with poor adherence were not transferred in from another treatment centre 219(92.4%), and among participants classified as having poor pill count adherence 183(77.2%) had no recorded missed appointment (Table 4). Absence of missed clinic appointments should not be interpreted as evidence of good medication adherence because appointment attendance and medication-taking behavior measure different aspects of engagement in care.

Bivariable analysis was performed on all recorded factors, and this identified several factors associated with poor pill count adherence, such as children and adolescents, Residence, Primary caregiver, Caregiver employment, Daily ART dosing, appointment interval, and Duration on ART (Table 5). The multivariable analysis, which controlled for potential confounding variables, revealed the following factors associated with poor adherence:

Caregiver Relationship**:** Children and adolescents under the care of a non-parent caregiver reflected higher odds of poor adherence (adjusted Odds Ratio (aOR = 2.05, 95% CI: 1.24 – 3.38, p = 0.005). This finding demonstrates that non-biological caregivers may face obstacles, such as a lack of support, reduced capacity to supervise or support strict routines. In some cases, such caregivers may lack the necessary understanding of the importance of daily adherence when it comes to effectively managing ART for children living with HIV.

Children and adolescents in non-urban areas presented higher odds of poor adherence when compared to those in urban areas (aOR = 4.47, 95% CI: 2.70-7.40, p < 0.001). This could be supported by some limitations such as difficult access to healthcare services, longer travel times to treatment facilities, and possibly lower levels of support and literacy; this observed disparity is probably multifactorial.

Participants on ART regimens requiring more than once daily dosing display higher odds of poor adherence (aOR = 9.18, 95% CI: 4.83 – 17.44, p = <0.001). This finding highlights the fact that a single daily dose is easier to remember; multiple doses increase the likelihood of forgetting one or more doses; once-daily dosing reduces the caregiver's workload and scheduling burden.

Participants scheduled for visits every 2-3 months had lower odds of poor adherence (aOR = 0.42, 95% CI: 0.20-0.90, p = 0.025) than those scheduled monthly. This finding should be interpreted cautiously and may reflect that patients already experiencing adherence challenges had been assigned monthly visits for more intensive monitoring. More constant interactions with healthcare professionals may improve adherence through ongoing counselling, monitoring, and timely problem-solving, benefits that may diminish when appointments are spaced further apart.

It was noticed that most participants with ≤ 10 years on antiretroviral therapy had increased odds of poor adherence (aOR = 1.67, 95% CI: 1.01 – 2.77, p = 0.045). This observation could suggest that patients and caregivers in the earlier phase of ART, or those with comparatively shorter treatment histories, may still be encountering challenges in sustaining long-term adherence, potentially due to initial challenges in regimen adaptation or insufficient sustained support mechanisms.

We also identified that, relative to Regional Hospital Bamenda, we had increased odds from the other health facilities (aOR = 4.41, 95% CI: 1.44 – 13.56, p = 0.010) for the Nkwen District Hospital and (aOR = 3.42, 95% CI: 1.14-10.32, p = 0.029) for the Saint Mary Soledad Hospital. These estimates may reflect differences in case mix, service organisation, referral patterns, or the small facility sample sizes. Treatment facility should therefore be retained in the primary adjusted model regardless of its relationship with other factors.

An overview of the associations identified in both bivariable and multivariable analyses is presented in (Table 6).

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Figures, tables and schemes

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Recruitment Flow Diagram

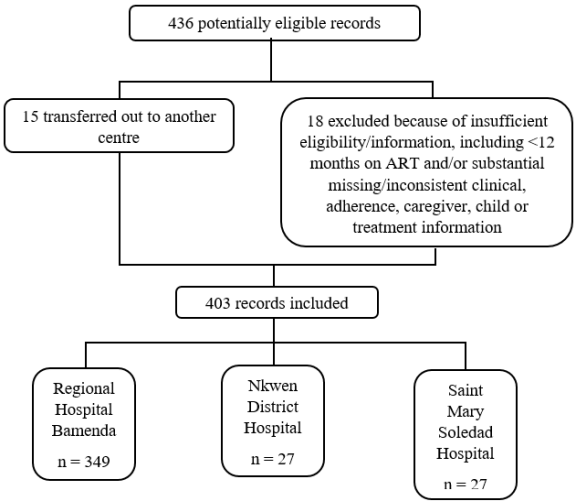


Figure 1: Participants selection and exclusion

Prevalence of poor pill count adherence

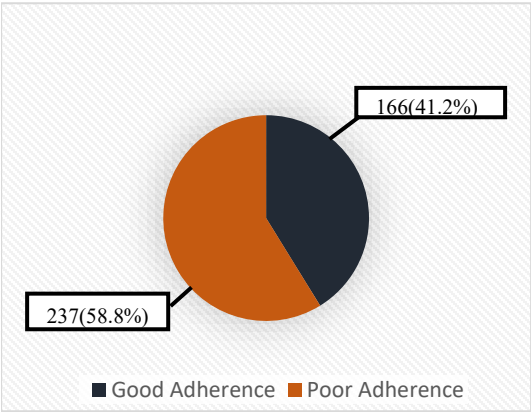


Figure 2: Prevalence of poor pill count adherence among children and adolescents on antiretroviral therapy in the three hospitals.

Throughout our study, a total of 403 participant's files met our inclusion criteria, out of which 237 having poor pill count adherence, giving a prevalence of poor adherence in children and adolescents being as high as 58.8%.

Table 1: Prevalence of Poor adherence according to treatment facilities

The Regional Hospital Bamenda had the lowest prevalence (55.0%) followed by St Mary Soledad Catholic Hospital (81.5%) and then Nkwen District Hospital (85.2%).

Treatment Facility	Poor adherence/total	Prevalence %	95% CI
Regional Hospital Bamenda	192/349	55.0	49.8-60.2
Nkwen District Hospital	23/27	85.2	67.5-94.1
Saint Mary Soledad Hospital	22/27	81.5	63.3-91.8
Overall	**237/403**	**58.8**	**53.9-63.5**

Table 2: Sociodemographic characteristics of children and adolescents by adherence status (N=403)

The children's ages ranged from 2 to 19 years, with a mean age of 15 ± 4.2 years. Among participants with poor adherence, majority aged 14 to 19 years 161(67.9%). We had more females 134(56.5%), ratio of 1.30:1. The majority were educated 178(75.1%), lived in non-urban areas 167(70.5%) and were orphan 128(54.0%).

Variables	ADHERENCE	
	Poor Adherence n%	Good Adherence n%
Age group (years)		
2-13	76(32.1%)	47(28.3%)
14-19	161(67.9%)	119(71.7%)
Total	**237(100%)**	**166(100%)**
Sex		
Male	103(43.5%)	81(48.8%)
Female	134(56.5%)	85(51.2%)
Total	**237(100%)**	**166(100%)**
Level Of Education		
Educated	178(75.1%)	131(78.9%)
Not Educated	59(24.9%)	35(21.1%)
Total	**237(100%)**	**166(100%)**
Residence		
Urban	70(29.5%)	110(66.3%)
Non-Urban	167(70.5%)	56(33.7%)
Total	**237(100%)**	**166(100%)**
Orphan Status		
Not Orphan	109(46.0%)	77(46.4%)
Orphan	128(54.0%)	89(53.6%)
Total	**237(100%)**	**166(100%)**

Table 3: Caregiver characteristics by adherence status (N=403)

Among the poor adherence group, non-parents were the greater proportion of caregivers 137(57.8%). More caregivers were unemployed 130(55.0%), were uneducated 205(86.5%), and were living as a couple 127 (53.6%).

Variables	ADHERENCE	
	Poor Adherence n%	Good Adherenc n%
Primary Caregiver		
Parent	100(42.2%)	100(60.2%)
Non Parent	137(57.8%)	66(39.8%)
Total	**237(100%)**	**166(100%)**
Profession		
Employed	107(45.0%)	101(61.0%)
Unemployed	130(55.0%)	65(39.0%)
Total	**237(100%)**	**166(100%)**
Level of Education (Caregiver)		
Educated	32(13.5%)	31(18.7%)
Not Educated	205(86.5%)	135(81.3%)
Total	**237(100%)**	**166(100%)**
Marital Status		
Living as a couple[a]	127(53.6%)	89(53.6%)
Living single[b]	110(46.4%)	77(46.4%)
Total	**237(100%)**	**166(100%)**
HIV Status of Caregiver		
Positive	120(50.6%)	93(56.0%)
Negative	117(49.4%)	73(44.0%)
Total	**237(100%)**	**166(100%)**

*Values are presented as n (%). Percentages are calculated within adherence category: n=237 for poor adherence and n=166 for good adherence.

Table 4: Treatment characteristics of the children and adolescents by adherence status (N=403)

Among participants with poor adherence, the treatment-related characteristics showed that most participants were on First-line ART 207(87.3%). 152(64.1%) of the participants had been on treatment for ≤10 years; most participants were on a once daily medication 121(51.0%) and had follow up schedule of every 2 to 3 months 193(81.4%). All participants had been counselled on adherence (100%). Most of the participants were not transferred from a different treatment centre 219 (92.4%), and had no recorded missed appointments 183(77.2%).

Variables	ADHERENCE	
	Poor Adherence n%	**Good Adherence n%**
ART Regimen		
First Line	207(87.3%)	149(89.8%)
2nd&3rd line	30(12.7%)	17(10.2%)
Total	**237(100%)**	**166(100%)**
Duration on ART(years)		
> 10 years	85(35.9%)	80(48.2%)
≤ 10 years	152(64.1%)	86(51.8%)
Total	**237(100%)**	**166(100%)**
Daily ART dosing		
Once daily	121(51.0%)	151(91.0%)
>Once daily	116(49.0%)	15(9.0%)
Total	**237(100%)**	**166(100%)**
Appointment interval		
Every Month	44(18.6%)	14(8.4%)
Every Two-Three months	193(81.4%)	152(91.6%)
Total	**237(100%)**	**166(100%)**
Adherence Counselling		
Yes	237(100%)	166(100%)
Transfer in from another treatment center		
Yes	18(7.6%)	15(9.0%)
No	219(92.4%)	151(91.0%)
Total	**237(100%)**	**166(100%)**
Missed Appointment		
None Missed	183(77.2%)	137(82.5%)
≥ 1 Missed	54(22.8%)	29(17.5%)
Total	**237(100%)**	**166(100%)**

Table 5: Bivariable analysis of factors associated with pill count adherence.

On bivariable analysis, we could identify some factors that were associated with poor pill count adherence, as shown below.

Variable	Adherence		cOR (95% CI)	P-Value
	Poor Adherence n = 237	Good Adherence n = 166		
Treatment Facility				
Regional Hospital Bamenda	----------	---------- -	-------- --	----- ----- ----
Nkwen District Hospital	23(9.7)	4(2.4)	4.70(1.59-13.88)	**0.005**
Saint Mary Soledad Hospital	22(9.2)	5(3.0)	3.60(1.33-9.72)	**0.012**
Age group (years)				
2-13	76(32.1%)	47(28.3%)	-------- ---	----- ----- -
14-19	161(67.9%)	119(71.7%)	0.84(0.54-1.29)	0.421
Sex				
Male	103(43.5%)	81(48.8%)	-------- --	----- -----
Female	134(56.5%)	85(51.2%)	1.24(0.83-1.85)	0.290
Level Of Education				
Educated	178(75.1%)	131(78.9%)	-------- -	----- -----
Not Educated	59(24.9%)	35(21.1%)	0.81(0.50-1.30)	0.374
Residence				
Urban	70(29.5%)	110(66.3%)	-------- ---	----- ----- --
Non-Urban	167(70.5%)	56(33.7%)	4.69(3.06-7.17)	**<0.01**
Orphan Status				
Not Orphan	109(46.0%)	77(46.4%)	-------- ---	----- ----
Orphan	128(54.0%)	89(53.6%)	1.02(0.68-1.51)	0.938
Primary Caregiver				
Parent	100(42.2%)	100(60.2%)	--------	----- ----
Non Parent	137(57.8%)	66(39.8%)	2.07(1.38-3.10)	**0.004**
Caregiver Employment				
Employed	107(45.0%)	101(61.0%)	-------	----- -
Unemployed	130(55.0%)	65(39.0%)	1.88(1.25-2.85)	**0.002**
Level of Education (Caregiver)				
Educated	32(13.5%)	31(18.7%)	-------	----- ---
Not Educated	205(86.5%)	135(81.3%)	1.47(0.86-2.52)	0.161
Caregiver Marital Status				
Living as a couple[a]	127(53.6%)	89(53.6%)	-------- --	----- -----
Living single[b]	110(46.4%)	77(46.4%)	1.00(0.67-1.49)	0.996

HIV Status of Caregiver				
Positive	120(50.6%)	93(56.0%)	----------	------
Negative	117(49.4%)	73(44.0%)	1.24(0.83-1.85)	0.286
ART Regimen				
1st Line	207(87.3%)	149(89.8%)	----------	------
2nd & 3rd Line	30(12.7%)	17(10.2%)	1.27(0.68-2.39)	0.458
Duration on ART(years)				
> 10 years	85(35.9%)	80(48.2%)	----------	------
≤ 10 years	152(64.1%)	86(51.8%)	1.66(1.11-2.50)	**0.014**
Daily ART Dosing				
Once daily	121(51.0%)	151(91.0%)	----------	------
> Once daily	116(49.0%)	15(9.0%)	9.65(5.38-17.38)	**<0.001**
Appointment interval				
Every Month	44(18.6%)	14(8.4%)	----------	------
Every 2 to 3 Months	193(81.4%)	152(91.6%)	0.40(0.21-0.76)	**0.005**
Transfer in from another treatment center				
No	219(92.4%)	151(91.0%)	----------	------
Yes	18(7.6%)	15(9.0%)	0.83(0.40-1.69)	0.604
Missed Appointment				
None Missed	183(77.2%)	137(82.5%)	----------	------
≥ 1 Missed	54(22.8%)	29(17.5%)	1.39(0.84-2.30)	0.195

Table 6: Multivariable analysis of factors associated with poor pill count adherence

In the multivariable analysis, Residence, Caregiver, Daily ART dosing, Appointment interval and Duration on ART were associated with poor adherence.

Variables	**cOR (95% CI)**	**p-value**	**aOR (95% CI)**	**p-value**
Residence				
Urban	—	—	—	—
Non-urban	4.69 (3.06 – 7.17)	***0.0006***	4.47 (2.70 – 7.40)	***<0.001***
Caregiver				
Parent	—	—	—	—
Non-parent	2.07 (1.38 – 3.10)	***0.0004***	2.05 (1.24 – 3.38)	***0.005***
Caregiver employment				

Employed	—	—	—	—
Unemployed	1.88 (1.25 – 2.85)	***0.002***	1.35 (0.45 – 2.38)	0.324
Daily ART Dosing				
Once daily	-----	**----**	-----	**----**
> Once daily	9.65 (5.38-17.38)	***<0.001***	9.18 (4.83-17.44)	***<0.001***
Appointment interval				
Every month	----	**----**	-----	-----
Every 2-3 months	0.40 (0.21-0.76)	***0.005***	0.42 (0.20-0.90)	***0.025***
Duration on ART(years)				
> 10 years	----	----	------	------
≤ 10 years	1.66 (1.11-2.50)	***0.014***	1.67 (1.01-2.77)	***0.045***
Hospital Facility				
Regional Hospital Bamenda	-----	------	------	-------
Nkwen District Hospital	4.70 (1.59-13.88)	***0.005***	4.41 (1.44-13.56)	***0.010***
Saint Mary Soledad Hospital	3.60 (1.33-9.72)	***0.012***	3.42 (1.14-10.32)	***0.029***

DISCUSSION

The findings of the present research provide significant information about the use of antiretroviral therapy in children and adolescent patients with HIV in the Bamenda municipality. The prevalence of poor pill count adherence was 58.8%, which is a significant concern. This finding is consistent with reports from other settings with limited resources, where maintaining ART adherence remains a persistent challenge despite global efforts to increase treatment access [11–15]. The influence of poor adherence is quite significant, which raises the likelihood of virologic failure, the emergence of drug resistance, disease progression and eventual morbidity and mortality in HIV infected children and adolescents [5,6].

Caregiver relationship has relevant odds of poor adherence, with children receiving care from non-parent caregivers showing noticeably higher odds of poor adherence. According to earlier research by Gemechu et al. in Ethiopia and Zhou et al. in South Africa, caregivers play a crucial role in ensuring pediatric ART adherence [11,16]. Non-parent caregivers may face particular difficulties such as changes in guardianship due to parental illness, death, migration; limited legal authority, financial limitations, and inadequate support or knowledge in managing antiretroviral therapy. However, this observation contrasts with the findings of Ketchaji et al in Cameroon [17], Eboua et al in Ivory Coast [14]. In these studies, a majority of poorly adherent adolescents were under parental care. These results reflect the need for focused interventions that address the unique difficulties faced by non-parent caregivers. Examples of these interventions include improved caregiver education, psychosocial support, and deeper connections to local resources.

Another important finding was that non-urban residence was associated with higher odds of poor adherence. These findings are in line with those of Wondifraw et al in Ethiopia and Lopez De La Espriella et al in Colombia [15,18]. Children and adolescents living in rural settings may have a longer distance to travel, more transportation expenses, and a low contact rate with healthcare providers, which will negatively influence adherence. This differs from the findings of Ketchaji et al in Cameroon [17], Gemechu et al in Ethiopia [11], Tiruneh et al in Northwest Ethiopia [19], and Alemayehu et al in East Ethiopia [20] were poor adherence occurred more in children and adolescents living in urban areas. The possible options to solve this inequity are the decentralisation of ART services, the introduction of mobile clinics, the creation of community-based adherence support programs, and the exploitation of digital health interventions to overcome geographical constraints.

Additionally, our study showed that dosing frequency was associated with higher odds of poor adherence linked to regimens requiring more than once-daily dosing. It is well known that children and adolescents find it challenging to regularly integrate complicated regimens into their daily routines, especially when they have little control over their medication schedules. Previous research by Habumugisha et al. in Rwanda and Dame et al. in Ghana [10,21] supports these findings. Therefore, when clinically appropriate, reducing drug regimens to once-daily dosing may simplify dosing schedules and this has been associated with better adherence in previous studies.

Participants scheduled for appointments every 2-3 months had lower adjusted odds of poor adherence than participants scheduled monthly. This finding should be interpreted with particular caution. Appointment frequency was not randomly assigned, and patients already experiencing adherence difficulties may have been scheduled for more frequent monitoring. The observed association may therefore reflect reverse causation or confounding by indication rather than an effect of less frequent follow-up. The present study therefore cannot determine whether appointment interval influences subsequent adherence.

Lastly, higher odds of poor adherence were linked to treatment duration of ≤ 10 years on ART. In contrast to findings reported by Eboua et al. in Ivory Coast [14]. This could be due to the initial adaptation to regimen, treatment fatigue or lack of a proper sustained support program at the start of treatment, as well as during early and mid-stages of ART, with the focus on long term retention in care and the support of consistent adherence.

Treatment facility was independently associated with adherence status. Participants receiving care at Nkwen District Hospital had higher adjusted odds of poor adherence than those receiving care at Regional Hospital Bamenda. However, this finding should be interpreted cautiously because the two smaller facilities contributed relatively few participants, resulting in wide confidence intervals. The association

may reflect differences in patient case mix, service organisation, access, adherence support practices or other unmeasured facility-level characteristics and should not be interpreted as evidence that the facility itself caused poor adherence.

STUDY LIMITATIONS

We have to mention that this study has some limitations, which are explained below:

First, the three participating facilities were purposively selected rather than randomly sampled, and most participants were recruited from Regional Hospital Bamenda. Consequently, the findings may not be generalizable to all children and adolescents receiving HIV care elsewhere in the North West Region of Cameroon or in other settings.

Second, excluding records with substantial missing information improved the reliability of the variables included in the analysis and avoided unsupported imputation. However, complete record exclusion may have introduced selection bias if participants with incomplete documentation systematically differed from those retained in the study. Because the excluded records did not contain information for reliable classification across key study domains, these potential differences could not be fully evaluated.

Third, adherence was assessed primarily using pill count. Although repeated pill counts provide a practical quantitative measure of medication use in routine clinical settings, they do not directly confirm medication ingestion and may overestimate adherence if unused tablets are discarded, shared, lost, or not returned. Pill count derived adherence should therefore be interpreted as an indirect measure of medication-taking behaviour.

Fourth, viral-load and pharmacy refill information could not be used as uniform alternative adherence endpoints. Viral load measurements were not performed at consistent time points across all participants and were not systematically aligned with the pill count observation periods. Viral suppression may also be influenced by factors other than adherence, including drug resistance and regimen-related factors. Similarly, pharmacy refill records document medication acquisition but do not confirm ingestion. The inability to consistently triangulate pill count adherence with these additional measures represents an important limitation.

Fifth, the final model had modest discriminatory ability (AUC=0.652), indicating that additional unmeasured factors are likely to contribute to adherence status.

Finally, as an observational study based on routinely collected clinical records, residual confounding from unmeasured factors such as household income, travel distance, caregiver burden, mental health, food insecurity, medication availability, and other behavioral or health system characteristics remains possible. The findings consequently demonstrate associations rather than causal relationships.

CONCLUSION

This study showed poor pill count adherence was common among children and adolescents living with HIV in the Bamenda municipality, indicating that adherence is still below optimal levels. We found a number of important factors pertaining to both the pediatric patients and their caregivers such as residence, caregiver, caregiver employment, daily ART dosing, Hospital appointment, duration on ART(years) and Hospital facility although It should be noted having appointment interval every 2-3 months (aOR = 0.42, p = 0.025) had lower adjusted odds of poor adherence than those schedule monthly; however, this association should be interpreted cautiously because appointment schedules may have been influenced by existing adherence difficulties. These results highlight the intricate, multifaceted character of adherence issues in the population, which include systemic, and caregiver-related factors. Targeted interventions that address these factors can contribute to improving ART adherence and health outcomes for children and adolescents in similar resource-constrained settings. By providing solutions to overcome these factors, healthcare systems can better support sustained adherence, which will ultimately improve the long-term health of this vulnerable population.

LIST OF ABBREVIATIONS

ART	Antiretroviral Therapy
HIV	Human Immunodeficiency Virus
USA	United States of America
aOR	Adjusted odds ratio
cOR	Crude odds ratio
95% CI	95% Confidence Interval
IRB	Institutional Review Board
SD	Standard deviation

Author Contributions:

A.C. Conceptualisation, project administration, visualisation, writing – review & editing and Supervision. R.T.K data curation, formal analysis, writing – original draft. K.K, S.A, L.T.M, M.M.G, C.S and A.C.Z.K.B methodology, supervision and visualisation. All authors reviewed the manuscript, provided scientific input to the manuscript, and agreed with the decision to submit the manuscript.

Availability of Data and Materials

The de-identified dataset is not publicly available because it contains sensitive clinical information concerning children and adolescents living with HIV. An anonymised dataset may be made available by the corresponding author upon a scientifically justified request, subject to approval by the relevant ethics committee and participating health facilities.

Conflicts of Interest

The authors have no conflict of interest to declare.

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Ethical Commetti Approval and Consent to Participate

The Ethical Review Committee of the University of Bamenda on 06 May 2025 granted ethical clearance for this study (Project Identification number: 2025/0048H/UBa/IRB). Administrative authorisation was also obtained from the North West Regional Delegation of Public Health, the Faculty of Health Sciences of the University of Bamenda, and the administrations of the participating health facilities. The requirement of individual informed consent, parental or legal-guardian permission, and participant assent was waived by the Ethics Committee because the study involved retrospective review of routinely collected medical records, posed minimal risk and used anonymised data.

Human Rights Statement

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki.

Standards of Reporting

This multicenter retrospective observational study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE).

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AI-declaration

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