Predictors of Non-Adherence to Antiretroviral Therapy among Adolescents Living with HIV in the Centre Region of Cameroon

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Abstract Introduction: In spite of progress in antiretroviral therapy (ART) programs, adolescents remain largely vulnerable to poor ART outcomes, due to non-adherence. In the frame of limited evidence on ART adherence during adolescence in resource-constrained settings, we aimed at evaluating the rate of adherence to ART among adolescents and associated factors in Cameroon. **Methods**: A cross-sectional study was conducted among 401 adolescents receiving ART in 13 health facilities of the Centre Region of Cameroon, from April through August 2018. Adherence was evaluated using a composite of both self-reported and pill count assessments. Risk factors of non-adherence were assessed using the socio-ecological model and p<0.05 were considered statistically significant. **Results:** Mean age was 14.63 (±2.89) and 55.9 % (224) were female. Rate of adherence was 25.2% (composite-assessment), 38.2% (pill-count) and 60.6% (self-reported). Following the composite-assessment, non-adherence was significantly higher in: vertically vs. horizontally infected adolescents (OR 4.24; 95% CI: 2.16-8.33, p<0.001); facilities with combined adult/adolescent vs. specialized adolescent care (0.32; 95% CI: 0.20-0.52, p<0.001); living beyond 5 km from the heath facility (OR 1.99; 95% CI: 1.26-3.15, p=0.003; inconvenient clinic appointments (OR 3.03; 95% CI: 1.78-5.16, p<0.001); Following multivariate analysis, non-adherence was associated with "living beyond 5 km from the heath facility" (OR 1.84, 95% CI: 1.01-3.33, p=0.045); "adolescents taking medication in the same service with adult" (OR 0.11, 95% CI: 0.03-0.35, p<0.001), managed at a rural health facility (OR 4.29, 95% CI: 1.84-9.96, p=0.001) and not counseled regularly (OR 0.02, 95% CI: 0.01-0.36, p=0.007). **Conclusion:** In the Centre region of Cameroon, about three-quarters of adolescents might be non-adherent to ART. Interventions towards improved adherence should focus on adolescents managed at the rural health facility and with vertical HIV-infection. Furthermore, convenient clinic appointments, creation of friendly adolescent healthcare centres and decentralising HIV-adolescent care in rural settings would improve adherence to ART program.

Keywords: adolescents, HIV/AIDS, ART, predictors, non-adherence and centre region of yaounde

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1. Introduction

Of the estimated 36.3 million people living with HIV (PLHIV) worldwide, about 2.1 million adolescents are adolescents [1-5], of whom the majority (1.7 million) are living in sub-Saharan Africa (SSA) [6,7]. Globally, HIV/AIDS is the second leading cause of adolescent mortality and the very first cause of mortality in Africa [7,8]. Of note, while AIDS-related deaths has decreased by 30%, mortality among adolescents has increased up to 50%, making HIV/AIDS a major health concern during adolescence, especially in low and middle income countries (LMICs) that are disproportionately burdened by the pandemic[8,9].

Adolescence (10-19 years) is known as the phase of physical growth and development, accompanied by sexual

maturation, intimate relationships, changes in sexuality [6,10,11,12], mental capacity [13], self-efficacy and independence. In this transition phase of life, adolescents are highly vulnerable to HIV/AIDS and other sexually transmitted infections (STIs), and those infected from birth encountered challenging in the continuum of care [14]. Of note, adherence to ART, known as the footprint for therapeutic success, remains a major setback for adolescents receiving ART [14]. Therefore, in order to meet the third pillar of the UNAIDS 90-90-90 targets (90% of PLHIV know their status, 90% of those who know their status are on treatment, and 90% of those on treatment are virally suppressed) among adolescents living with HIV (ALHIV) [15], it is essential to implement efficient measures for adherence assessment and to identify areas of specific interventions for the improved management and monitoring of adolescents receiving ART [14].

As a key component of adherence to ART program, retention in care has been extensively evaluated in several African countries, including Cameroon [16,17,18,19]. Nonetheless, there are fewer evidence on adherence levels among ALHIV, as well as methods and tools to ensure a thorough monitoring in routine clinical practice [14].

At country level, there is an urgent need of generating information on the number of ALHIV (10-19 years) in care and factors affecting their response to treatment, considering early and advanced age adolescence, as well as other socio-demographic, environmental and clinical factors [20,21]. Cameroon has endorsed in current UNAIDS 90-90-90 goals [19,20,21], with a preliminary report of 36% adherence rate among adolescents in an urban site of Yaoundé, which therefore call for informed policy-implementation that would contribute to the success of the ART program [22,23,24,25,26]. We therefore sought to ascertain rate of adherence to ART of adolescents and factors associated with poor adherence in a typical Cameroonian context.

2. Materials and Methods

2.1. Study Design and Population

Using a quantitative approach and a socio-ecological model, a cross-sectional study was conducted in the period ranging from April through August 2018 among ALHIV receiving ART in 13 health facilities (Mother-Child Centre of the Chantal BIYA Foundation, Yaounde Health Centre, Yaoundé Jamot Hospital, National Welfare Social Insurance Hospital, Ayos Regional Hospital, Cite Verte District Hospital, Efoulan District Hospital, Obala District Hospital, Olembe District Hospital, Mbalmayo District Hospital, Bikop Health Centre, Health and Social Animation Centre of Nkoldongo, Nkomo Medical Centre), coming from 8 health districts of the Centre Region of Cameroon.

2.2. Description of the Study Settings

The Centre region of Cameroon has the national capital city, has 30 health districts for a total of 3,724,000 inhabitants. This region also has reference paediatric

health facilities and the highest number of PLHIV on ART, including those at adolescence (25% national coverage) [22]. In the entire region, a total of 105 health facilities provide ART of which 99 had adolescent healthcare services.

2.3. Sampling Method and Procedure

Based on a stratified random sampling from the total 99 adolescent healthcare facilities in the Centre region, 26 health facilities meet the eligibility criteria of having a minimum of 30 ALHIV receiving ART. From these 26 eligible sites, 50% (13) were randomly selected as study sites to ensure the regional representativeness.

In every study site, adolescents were enrolled based on the following criteria: aged 10-19 years, on ART for at least 6 months, registered for ART monitoring in the study site, and whose consent/assent was provided.

For the entire study, the minimum sample size was calculated based on the following statistical formula (Eq1):

$$N = \frac{Z^2 x P\ (1-P)}{D^2}$$

With P=0.36 (rate of 36% adherence in the aforementioned study conducted among adolescents in the city of Yaoundé in Cameroon) [26], Z=1.96 at 95% confidence interval (CI), with D=0.05 error rate. This resulted to a minimum sample size "n" of 354 participants to be enrolled in the study.

2.4. Data Collection and Measurements

Prior to implementation, data collection tool was pretested and validated in one health facility. After pretesting, data collection was done by trained study investigators during routine clinic attendance of adolescents in each of the study site. Briefly, a structured questionnaire was administered eligible to each eligible ALHIV. This form entailed socio-demographic data as well as individual factors, health system factors, family and psychosocial factors, treatment history, biological parameters, and clinical factors that could influence adherence. Additionally, medical data were retrieved from existing medical records.

Adherence measurement was based on three different approaches: (1) self-report by the patient, (2) pharmacy pill count, and (3) composite of both self-reported and pill count. For the self-reported adherence, the Center for Adherence Support Evaluation (CASE) adherence index tool was used, consisting of three questions that summed to a total score of 19 points. Participants with a CASE Index score ≥10 were classified as good adherence compared to those with a CASE Index score <10 with poor adherence [23]. Pharmacy pill count was calculated by subtracting the number of pills returned by a patient from the expected number of pills to be available. Good adherence based on pill count was defined as a score ≥95% of drug intake (i.e. corresponding to 29 out of 30 days intake for a single pill daily prescription). Finally, the composite adherence assessment was based on the combination of both methods (CASE index score and pill count), and good adherence by the composite method was

defined as both a CASE Index score ≥10 and pill count ≥95%.

2.5. Data Analysis

Statistical analyses were done using STATA version 10.1. Chi-square test was used to evaluate differences in frequency distribution. Analysis of variance (ANOVA) was used to assess differences between group means. All p-values <0.2 from bivariate analyses were included in the multivariate logistic regression to determine the association of independent factors associated with adherence to ART. P-value less than 0.05 were considered as statistically significant at 95 % confidence level.

2.6. Ethical and Administrative Considerations

Ethical Clearance for the study was obtained both from the Regional Delegation of Public Health of the Centre region - CE02243N°/CRERSHC/2017 and the Institutional Review Board of the Faculty of Health Sciences of the University of Buea - 2018/024/UB/SG/IRB/FHS. An administrative authorization was obtained from the Regional Delegation of Public Health, Centre

region - 1902/L/MINSANTE/SG/DRSPC. A written informed consent was obtained each guardian as well as informed assent from each participant. For purpose of confidentiality and privacy, data were managed using specific identifiers and stored in a password-protected computer.

3. Results

3.1. Socio-demographic Characteristics of the Study Population

A total of 401 adolescents were enrolled from the 13 study health facilities in the Centre region of Cameroon. The mean age was 14.63 (±2.89) and 55.9% (224) were female; the majority [243(60.6%)] of the adolescents were at the secondary level of education. Almost all the adolescents [394(98.3%)] were single and more than half of them (56.6%) living with their parents at the time of study. A non-negligible number [49 (12.2%)] of these adolescents reported to be alcohol consumers and 13 (3.2%) were cigarette smokers. About half them lived around their respective health facilities (Table 1).

Table 1. Socio-demographic characteristics of study population

| Characteristics		10-14 year old N (%)	15-19 year old N (%)	Total N (%)
Gender	**Male**	97(50.8)	80(38.1)	177(44.1)
	Female	94(49.2)	130(61.9)	224(55.9)
Education	**Primary**	128(67.0)	24(11.4)	152(37.9)
	Secondary	63(33.)	180(85.7)	243(60.6)
	Tertiary	0(0.0)	6(2.9)	6(1.5)
Occupation	**Pupil**	187(97.9)	181(86.2)	368(91.8)
	Student	0(0.0)	7(3.3)	7(1.7)
	Self-employed	3(1.6)	19(9.0)	22(5.5)
	Employed	1(0.5)	3(1.4)	4(1.0)
Marital status	**Married**	1(0.5)	6(2.9)	7(1.7)
	Single	190(99.5)	204(97.1)	394(98.3)
Living with	**Parents**	112(58.6)	115(54.8)	227(56.6)
	Care-giver	79(41.4)	87(41.4)	166(41.4)
	Alone/Partner	0(0.0)	8(3.8)	8(2.0)
Use of alcohol	**Yes**	12(6.3)	37(17.6)	49(12.2)
	No	179(93.7)	173(82.4)	352(87.8)
Sexual activity	**Yes**	19 (9.9)	79(37.8)	98(24.5)
	No	172(90.1)	131(62.2)	303(75.5)
Smoking	**Yes**	6(3.1)	7(3.3)	13(3.2)
	No	185(96.9)	203(96.3)	388(96.8)
Duration of time to centre	**< 1 Hour**	96(50.3)	108(51.4)	204(50.9)
	1 -2 Hours	71(37.2)	81(38.6)	152(37.9)
	>2 Hours	24(12.6)	21(10.0)	45(11.2)
Distance to centre	**<5 Km**	90(47.1)	97(46.2)	187(46.6)
	>5 Km	101(52.9)	113(53.8)	214(53.4)

Legend. Km: kilometre.
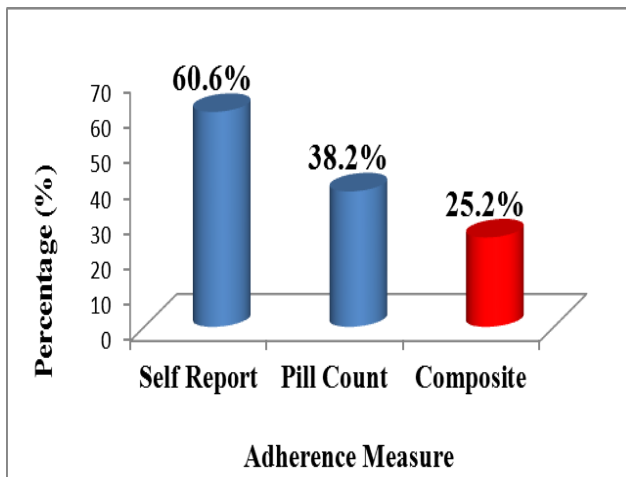
Figure 1. Adherence status of Adolescence initiated on ART

3.2. Rate of Adherence to ART in the Study Participants

According to each adherence assessment method, the rate of adolescents reported with good adherence was 60.6%, 38.2% and 25.2% by the self-reported, the pill count and the composite methods, respectively (Figure 1).

3.3. Factors Associated of Non-adherence to ART among Study Participants

3.3.1. Socio-demographic Factors

According to marital status, single adolescents were 19 times more at risk of non-adherence compared their married peers (OR 18.88; 95% CI: 2.25-158-84; p=0.007). Living more than 5 kilometers away from the health facility had 2 times more at risk of poor adherence as compared to those who lived less than 5 kilometers away (OR 1.99; 95% CI: 1.26-3.15; p=0.003), and those involved in sexual activities had two times less risk of non-adherence (OR 0.50; 95% CI: 0.31-0.83; p=0.007), as shown in Table 2.

3.3.2. Health Facilities Factors

Compared to faith-based centres, adolescents receiving ART in private health facilities were about 21 times more at risk of non-adherence (OR 20.87; 95% CI: 2.57- 169.40; p=0.004), those in parastatal health facilities had 3 times more risk of non-adherence (OR 33.06; 95% CI: 1.446- 6.44; p=0.003). Adolescents taking their treatment at the same centres with adults were at higher risk of non-adherence score as compared to those in the centres without adult care (OR 0.32; 95% CI: 0.20-0.52; p<0.001), as shown in Table 3.

Table 2. Socio-demographic factors associated to non-adherence to ART

Factors		Adherence Status		Odds Ratio	95% CI	p-value
		Adherence N (%)	Non-adherence N (%)			
Gender	Male	45(25.4)	132(74.6)	0.98	0.62-1.54	0.923
	Female	56(25.0)	168(75.0)	1.00	-	-
Age group	10-14	46(24.1)	145(75.9)	1.00	-	-
	15-19	55(26.2)	155(73.8)	0.89	0.57-1.41	0.627
Education	Primary	41(27.0)	111(73.0)	2.71	0.53-13.96	0.234
	Secondary	57(23.5)	186(76.5)	3.26	0.64-16.62	0.154
	Tertiary	3(50.0)	3(50.0)	1.00	-	-
Occupation	Pupil	91(24.7)	277(75.3)	1.00	-	-
	Student	3(42.9)	4(57.1)	0.44	0.10-1.99	0.286
	Self-employed	7(31.8)	15(68.2)	0.70	0.28-1.78	0.458
	Employed	0(0.0)	4(100.0)	-	-	-
Marital status	Married	6(85.7)	1(14.3)	1.00	-	-
	Single	95(24.1)	299(75.9)	18.88	2.25-158.84	**0.007**
Living with	Parents	63(27.8)	164(72.2)	1.00	-	-
	Care-giver	35(21.1)	131(78.9)	1.44	0.90-2.1	0.132
	Alone/Partner	3(37.5)	5(62.5)	0.64	0.15-2.76	0.550
Use of alcohol	Yes	13(26.5)	36(73.5)	0.92	0.47-1.82	0.817
	No	88(25.0)	264(75.0)	1.00	-	-
Smoking	Yes	2(15.4)	11(84.6)	1.88	0.41-8.65	0.415
	No	99(25.5)	289(74.5)	1.00	-	-
Means of transportation	By car	76(23.1)	253(76.9)	1.00	-	-
	By motor bike	11(33.3)	22(66.7)	0.60	0.28-1.30	0.193
	By foot	14(35.9)	25(64.1)	0.54	0.27-1.08	0.082
Duration to centre	< 1 Hour	59(28.9)	145(71.1)	1.00	-	-
	1 -2 Hours	32(21.1)	120(78.9)	1.53	0.93-2.50	0.093
	>2 Hours	10(22.2)	35(77.8)	1.42	0.66-3.06	0.365
Sexual activity	Yes	35(35.7)	63(64.3)	0.50	0.31-0.83	-
	No	66(21.9)	236(78.1)	1.00	-	**0.007**
Distance to centre	<5 Km	60(32.1)	127(67.9)	1.00	-	-
	>5 Km	41(19.2)	173(80.8)	1.99	1.26-3.15	**0.003**

Legend 1. Km: kilometre.

Table 3. Health facilities factors associated to non-adherence to ART

Factors		Adherence Status		Odds Ratio	95% CI	p-value
		Adherence N (%)	Non-adherence N(%)			
Types of health facilities	Public	49(39.2)	76(60.8)	1.01	0.48-2.13	0.976
	Private	1(3.0)	32(97.0)	20.87	2.57-169.40	**0.004**
	Parastatal	36(17.6)	169(82.4)	3.06	1.46-6.44	**0.003**
	Faith-based	15(39.5)	23(60.5)	1.00	-	-
Types of services	With adult care	73(34.9)	136(65.1)	0.32	0.20-0.52	**<0.001**
	Without adult care	164(85.4)	28(14.6)	1.00	-	-
Category of health facility	First and Second	52(20.2)	206(79.8)	1.00	-	-
	Third	6(35.3)	11(64.7)	0.46	0.16-1.31	0.147
	Fourth, fifth and sixth	43(34.1)	83(65.9)	0.49	0.30-0.79	**0.003**
Location of health facility	Urban	84(25.8)	242(74.2)	1.00	-	-
	Rural	17(22.7)	58(77.3)	1.18	0.65-2.15	0.577

Table 4. Clinical factors associated to non-adherence to ART

Factors		Adherence Status		Odds Ratio	95% CI	p-value
		Adherence N (%)	Non-adherence N (%)			
Type of transmission	Vertical	67(20.7)	257(79.3)	4.24	2.16-8.33	**<0.001**
	Horizontal	21(52.5)	19(47.5)	1.00	-	-
Age at initiation	6months- 1 year	2(22.2)	7(77.8)	1.00	-	-
	1-5 years	28(22.6)	96(77.4)	0.98	0.19-4.98	0.980
	6-10 years	24(20.2)	95(79.8)	1.13	0.22-5.80	0.883
	11-15 years	26(25.0)	78(75.0)	0.86	0.17-4.39	0.853
	16-19 years	20(51.3)	19(48.7)	0.27	0.05-1.47	0.131
Duration on treatment	6-12 months	30(47.6)	33(52.4)	1.00	-	-
	13-24 months	12(25.0)	36(75.0)	2.73	1.20-6.19	**0.016**
	25-36 months	9(23.7)	29(76.3)	2.93	1.20-7.18	**0.019**
	37-48 months	3(8.3)	33(91.7)	10.0	2.78-36.0	**<0.001**
	49-60 months	4(20.0)	16(80.0)	3.64	1.09-12.10	**0.035**
	>60 months	42(22.1)	148(77.9)	3.20	1.76-5.85	**<0.001**
ART regimen	First line	88(24.2)	275(75.8)	1.00	-	-
	Second line	13(37.1)	22(62.9)	0.54	0.26-1.20	0.098
Disclosure status	Yes	68(23.6)	220(76.4)	1.00	-	-
	No	33(29.7)	78(70.3)	0.73	0.45-1.19	0.209
Age at disclosure	<10 years	12(19.0)	51(81.0)	2.55	1.18-5.53	**0.018**
	10-14 years	26(17.9)	119(82.1)	2.75	1.48-5.11	**0.001**
	15-19 years	30(37.5)	50(62.5)	1.00	-	-
Viral load	Suppressed	70(37.2)	118(62.8)	1.00	-	-
	Unsuppressed	12(10.6)	101(89.4)	4.99	2.56-9.73	**<0.001**

Legend 2: ART: Antiretroviral therapy.

3.3.3. Clinical Factors

According to transmission mode, vertically infected adolescents had 4 times more risk of non-adherence compared to those infected horizontally (OR 4.24; 95% CI: 2.16-8.33; p<0.001); those on ART beyond 12 months had 3-10 times more risk of non-adherence (see Table 4). Disclosure of HIV status before 10 years of age had 3 times more risk of non-adherence compared to disclosure between at 15-19 years old. Unsuppressed viral load had 5 times more risk of non-adherence compared to those with suppressed viral load result (OR 4.99; 95% CI: 2.56-9.73; p<0.001) in Table 4.

3.3.4. Patient and Drug Factors

Failure to take treatment on time had 3 times more risk of being non-adherence to ART (OR 3.71, 95% CI: 1.64-8.40 p=0.002), and not taking medication as prescribed due to side effects also had a slight higher risk of being non-adherent (1.17; 95% CI: 1.08-2.74, p=0.023), as shown in Table 5.

3.3.5. Environmental Factors

No environmental factor was found to be associated with non-adherence, as shown in Table 6.

3.3.6. Healthcare Factors

Regarding healthcare delivery services, having an inconvenient clinic appointment date (OR 3.03, 95% CI: 1.78-5.16, p<0.000) and not attending hospital adherence awareness workshops (OR 2.38, 95% CI: 1.28-4.41, p=0.006) were significantly associated with non-adherence to ART, as detailed in Table 7.

Table 5. Patient and drug factors associated to non-adherence

Factors	Adherence N (%)	Non-adherence N (%)	Total N (%)	OR	95% CI	p-value
I remember to take my medications on time						
No	7(9.7)	65(90.3)	72(100.0)	3.71	1.64-8.40	**0.002**
Yes	94(28.6)	235(71.4)	329(100.0)	1.00	-	-
My treatment programme is easy to follow						
No	6(21.4)	22(78.6)	28(100.0)	1.25	0.49-3.18	0.635
Yes	95(25.5)	278(74.5)	373(100.0)	1.00	-	-
I am able to take all or most of the medications as directed						
No	4(18.2)	18(81.8)	22(100.0)	1.55	0.51-4.69	0.440
Yes	97(25.6)	282(74.4)	379(100.0)	1.00	-	-
I feel sick when I take my medications						
No	56(28.6)	140(71.4)	196(100.0)	1.00	-	-
Yes	45(22.0)	160(78.0)	205(100.0)	1.42	0.90-2.24	0.128
I feel depressed when I take the drugs						
No	65(25.6)	189(74.4)	254(100.0)	1.00	-	-
Yes	36(24.5)	111(75.5)	147(100.0)	1.06	0.66-1.70	0.807
The medications will have a positive effect on my health						
No	12(31.6)	26(68.4)	38(100.0)	0.70	0.34-1.45	0.342
Yes	89(24.5)	274(75.5)	363(100.0)	1.00	-	-
I don't take medications as prescribed because I want to avoid the side effects						
No	42(32.3)	88(67.7)	130(100.0)	1.17	1.08-2.74	**0.023**
Yes	59(21.8)	212(78.2)	271(100.0)	1.00	-	
I have to take many pills						
No	63(25.2)	187(74.8)	250(100.0)	1.00	0.63-1.59	0.994
Yes	38(25.2)	113(74.8)	151(100.0)	1.00	-	-
I lost confidence in the drugs because they do not curative						
No	57(23.9)	181(76.1)	238(100.0)	1.00	-	-
Yes	44(27.0)	119(73.0)	163(100.0)	0.85	0.54-1.34	0.491

Table 6. Environmental factors associated with non-adherence

Factors	Adherence N (%)	Non-adherence No (%)	Total N (%)	Crude OR	95% CI	p-value
I have told my friends about my illness						
No	72(24.6)	221(75.4)	293(100.0)	1.13	0.68-1.86	0.641
Yes	29(26.9)	79(73.1)	108(100.0)	1.00	-	-
I receive enough support from friends and/or family						
No	18(30.8)	33(69.2)	51(100.0)	0.54	0.24-1.18	0.123
Yes	17(24.6)	58(75.4)	75(100.0)	1.00	-	-
Friends are willing to remind me to take the medications						
No	18(34.6)	34(65.4)	52(100.0)	0.56	0.26-1.24	0.153
Yes	17(23.0)	57(77.0)	74(100.0)	1.00	-	-
I am avoided by friends/peers in intimate relationships						
No	19(24.1)	60(75.9)	79(100.0)	1.00	-	-
Yes	16(34.0)	31(66.0)	47(100.0)	0.61	0.28-1.36	0.228
I have enough money to go to the hospital monthly to collect my medications						
No	20(26.9)	53(73.1)	73(100.0)	0.87	0.49-1.54	0.631
Yes	81(25.1)	247(74.9)	328(100.0)	1.00	-	-
I have a continuous access to basic services (light, water, sanitation, home…						
No	8(23.5)	26(76.5)	34(100.0)	1.10	0.48-2.52	0.816
Yes	93(25.3)	274(74.7)	193(100.0)	1.00	-	-
I hide myself from others when taking my medications						
No	30(24.4)	93(75.6)	123(100.0)	1.00	-	-
Yes	71(25.5)	207(74.5)	278(100.0)	0.94	0.58-1.54	0.807
I take my medicine in public places						
No	62(25.1)	185(74.9)	247(100.0)	1.01	0.64-1.61	0.960
Yes	39(25.3)	115(74.7)	154(100.0)	1.00	-	-
I am afraid of stigma and discrimination from friends and peers						
No	31(21.2)	115(78.8)	146(100.0)	1.00	-	-
Yes	70(27.5)	185(72.5)	255(100.0)	0.71	0.44-1.15	0.169

Table 7. Healthcare factors associated with non-adherence

Factors		Adherence N (%)	Non-adherence N (%)	Total N (%)	Crude OR	95% CI	p-value
I receive enough support from health care providers							
	No	7(63.6)	4(36.4)	11(100.0)	0.18	0.05-0.63	**0.007**
	Yes	94(24.1)	296(75.9)	390(100.0)	1.00	-	-
I am constantly reminded not to miss pick up by the health care workers							
	No	5(27.8)	13(72.2)	18(100.0)	0.87	0.30-2.50	0.796
	Yes	96(25.1)	287(74.9)	383(100.0)	1.00	-	-
I find the process of medication collection easy - from file pick up to dispensation							
	No	7(28.0)	18(72.0)	25(100.0)	0.86	0.35-2.12	0.738
	Yes	94(25.0)	282(75.0)	376(100.0)	1.00	-	-
I receive counselling when placed on treatment							
	No	18(20.0)	72(80.0)	90(100.0)	1.46	0.82-2.59	0.200
	Yes	83(26.7)	228(73.3)	311(100.0)	1.00	-	-
I attend counselling sessions regularly							
	No	19(19.0)	81(81.0)	100(100.0)	1.60	0.91-2.80	0.102
	Yes	82(27.2)	219(72.8)	301(100.0)	1.00	-	-
I take care of myself when I go to the health facility							
	No	20(27.8)	52(72.2)	72(100.0)	1.00	-	-
	Yes	81(24.6)	248(75.4)	329(100.0)	1.18	0.66-2.09	0.576
I receive my drugs during all appointments in the health facility							
	No	10(34.5)	19(65.5)	29(100.0)	0.62	0.28-1.37	0.235
	Yes	91(24.5)	281(75.5)	372(100.0)	1.00	-	-
I wait for a long time to collect my medication when I go to the health facility							
	No	40(26.3)	112(73.7)	152(100.0)	1.00	-	-
	Yes	61(24.5)	188(75.5)	249(100.0)	0.91	0.57-1.44	0.684
My appointment dates are fixed at my convenience							
	No	21(13.6)	133(86.4)	154(100.0)	3.03	1.78-5.16	**<0.001**
	Yes	80(32.4)	167(67.6)	247(100.0)	1.00	-	-
The health care workers show empathy when counselling							
	No	8(19.5)	33(80.5)	41(100.0)	1.44	0.64-3.22	0.379
	Yes	93(25.8)	267(74.2)	360(100.0)	1.00	-	-
I attend hospital adherence awareness workshops							
	No	14(14.4)	83(85.6)	97(100.0)	2.38	1.28-4.41	**0.006**
	Yes	87(28.6)	217(71.4)	304(100.0)	1.00	-	-
I can speak to a counselor when I need one without feeling judged							
	No	11(26.2)	31(73.8)	42(100.0)	0.87	0.46-1.95	0.874
	Yes	90(25.1)	269(74.9)	359(100.0)	1.00	-	-

3.4. Multivariate Logistic Regression Model

3.4.1. Multivariate Logistic Regression Model for Socio-demographic Factors Predicting Non-adherence to Treatment

In multivariate analysis, factors significantly associated with non-adherence were (a) "being single" (OR17.59, 95% CI: 1.89-163-67, p=0.012) and (b) "living far from the health facility" (OR1.84, 95% CI: 1.01-3.33, p=0.045), as shown in Table 8.

3.4.2. Multivariate Logistic Regression Model for Health Facility Factors Predicting Non-adherence to Treatment

In multivariate analysis, factors significantly associated with non-adherence were: (a) "being managed in a private health facility" (OR17.59, 95% CI: 181.17-1984.99,

p<0.001); (b) "being managed in the same health facility with adults (OR0.11, 95% CI: 0.03-0.35, p<0.001); and (c) being managed at a rural health facility (OR4.29, 95% CI: 1.84-9.96, p=0.001); as detailed in Table 9.

3.4.3. Regression Model for Clinical Factors Predicting Non-adherence to Treatment

In multivariate analysis, factor significantly associated with non-adherence was have a viral load unsuppressed (OR 4.71, 95% CI: 1.88-11.79, p=0.001); as detailed in Table 10.

3.4.4. Regression Model for Medication, Social, Health Care Providers and Environmental Factors Predicting Non-Adherence to Treatment

In multivariate analysis, factor significantly associated with non-adherence was being Not counseled regularly (OR0.02, 95% CI: 0.01-0.36, p=0.007); as detailed in Table 11.

Table 8. Regression model for socio-demographic factors predicting non-adherence to treatment

Factors		Odds Ratio	95% CI	p-value
Gender	Male	0.93	0.57-1.51	0.758
	Female	1.00	-	-
Age group	10-14 years	1.00	-	-
	15-19 years	0.79	0.42-1.49	0.469
Education	Primary	3.59	0.22-58.14	0.369
	Secondary	5.09	0.32-80.33	0.248
	Tertiary	1.00	-	-
Occupation	Pupil	1.00	-	-
	Student	1.24	0.10-15.91	0.872
	Self-employed	1.03	0.34-3.16	0.955
	Employed	-	-	-
Marital status	Married	1.00	-	-
	Single	17.59	1.89-164.67	**0.012**
Living with	Parents	1.00	-	-
	Care-giver	1.61	0.97-2.67	0.063
	Alone/Partner	0.97	0.16-6.09	0.987
Use of alcohol	Yes	0.74	0.34-1.63	0.455
	No	1.00	-	-
Smoking	Yes	3.00	0.45-20.00	0.255
	No	1.00	-	-
Means of transportation	By car	1.00	-	-
	By motor bike	0.66	0.29-1.51	0.324
	By foot	0.66	0.30-1.42	0.283
Duration to centre	< 1 Hour	1.00	-	-
	1 -2 Hours	1.10	0.60-2.03	0.749
	>2 Hours	0.97	0.37-2.56	0.947
Distance to centre	<5 Km	1.00	-	-
	>5 Km	1.84	1.01-3.33	**0.045**

Table 9. Regression model for health facility factors predicting non-adherence to treatment

Factors	Odds Ratio	95% CI	p-value
Type of health facilities			
Public	1.89	0.80-447	0.149
Private	181.17	16.54-1984.99	**<0.001**
Parastatal	3.54	0.62-20.10	0.154
Faith-based	1.00	-	-
Category of Health Facilities			
First and Second	1.00	-	-
Third	1.28	0.25-6.69	0.767
Fourth, fifth and sixth	3.92	1.26-12.23	0.019
Type of care			
Health facilities with adult care	0.11	0.03-0.35	**<0.001**
Health facilities without adult care	1.00	-	-
Location of health facility			
Urban	1.00	-	-
Rural	4.29	1.84-9.96	**0.001**

Table 10. Regression model for clinical factors predicting non-adherence to treatment

Characteristic		Odds Ratio	95% CI	p-value
Type of transmission	Vertical	3.44	0.99-11.99	0.052
	Horizontal	1.00	-	-
Duration on treatment	6-12 months	1.00	-	-
	13-24 months	1.83	0.40-8.28	0.434
	25-36 months	2.00	0.38-10.71	0.417
	37-48 months	4.03	0.70-22.46	0.112
	49-60 months	3.07	0.37-25.26	0.298
	>60 months	2.82	0.76-10.52	0.122
ART regimen	First line	1.00	-	-
	Second line	0.46	0.12-1.77	0.259
Age at disclosure	<10 years	1.09	0.30-3.89	0.897
	10-14 years	0.66	0.23-1.92	0.447
	15-19 years	1.00	-	-
Viral load	Suppressed	1.00	-	-
	Unsuppressed	**4.71**	**1.88-11.79**	**0.001**

Table 11. Regression model for medication, social, health care providers and environmental factors predicting non-adherence to treatment

Variables	OR	95% CI		p-value
Capable of making decision about things	1.05	0.06	20.30	0.973
Capable to decide to take drugs	2.20	0.16	30.15	0.555
Perception the of general health condition	1.26	0.29	5.40	0.760
Don't receive enough support from friends	0.51	0.09	2.79	0.435
My friend is not willing to help me not forget to take medication	0.73	0.14	3.96	0.717
avoided by friends/colleagues in intimate relationships	0.63	0.19	2.12	0.459
Fear of stigma and discrimination from friends and colleagues	0.73	0.16	3.22	0.675
Not remembering to take treatment on time	7.52	0.67	84.52	0.102
Feel sick when medication is taken	1.50	0.42	5.37	0.533
Not taking pills at specified time	3.38	0.63	18.31	0.157
Not taking medication as prescribed because of avoidance of side effects	0.52	0.15	1.87	0.317
Feel problems were piling up so high that they could not be overcome	2.46	0.66	9.17	0.179
Don't receive enough support from health care provider	0.00	0.00	.	0.999
Not receiving counseling when placed on treatment	2.12	0.29	15.48	0.458
Not counseled regularly	0.02	0.01	0.36	**0.007**
Not receiving drugs at all the appointment in the health facility	0.17	0.01	2.51	0.195
Appointment dates are inconvenience	4.86	0.97	24.32	0.054
Not attending hospital for workshop adherence awareness	8.73	0.68	111.65	0.096

4. Discussion

With the goal to contribute in achieving the third pillar of the 90-90-90 targets through improved adherence among the most disproportionally affected population by HIV/AIDS, our present study focused on evaluating adherence to ART and associated factors among adolescents living with HIV/AIDS in the Centre Region of Cameroon.

In this study with a slightly higher proportion of female adolescents (similar to previous reports) [24,25,26,27], in a population of adolescents mainly infected vertically [28], the rate of adherence appeared very low (i.e. one quarter). This finding underscores the fact that adolescents constitute a vulnerable population in the field of HIV/AIDS, and therefore deserve specialised care to ensure their successful transition from pediatric to adult care. Moreover, adherence level varies decreasingly from the self-reported method, pill count, to the combined method. This observation is similar to a systematic review conducted in 2014 reporting a varying range of 16% to 99% adherence rates amongst ALHIV from LMICs [9]. In a study conducted in a single health facility in Yaoundé, 36% of ALHIV were reported adherent to ART following self-reporting [26], as compared to 60% from our present investigation. The discrepancy observed highlights the lack of reliability of self-reported adherence in assessing compliance to ART. Furthermore, the former study was conducted only in an urban health facility while our study was conducted in several health facilities of both rural and urban areas, thereby giving a better appraisal of the local context [9,26].

Adolescents thus face several challenges in accepting their status and in gaining autonomy towards treating their

infection, as most of them are in denial, afraid, misinformed or lack familial or social [9]. Thus, to ensure a successful transition to adult care, identifying risk factors of non-adherence are essential for ALHIV receiving ART.

Regarding socio-demographic features, neither sex nor age ranges of adolescents were not found to be associated with adherence. However, single adolescents were about 18 times at risk of non-adherence when compared to those who were married. This is similar to the study [7], likely due to the fact that married adolescents have support towards adherence from their partners, coupled to adherence motivated by the needs to avoid infecting their partner and to achieving suppressed viremia as a prerequisite for procreation [7].

Beyond 12 months after ART initiation, adherence becomes very concerning, and is known as the driven factor of the high mortality amongst ALHIV, with varying adherence in Africa as compared to the western world [25,29,30,31]. This suggests the need for active patient involvement mediated by healthcare provider's support [32].

Adolescents receiving ART in faith-based health facilities were more adherent compared to their peers in parastatal and private facilities. This should be due to the fact that in religious health facilities, prayer, as a form of psychosocial support through spiritual belief, is an important and integral part of patient care. Adolescents taking their treatment at the same centers with adults were more likely to be non-adherent rather than those in centers without adult care. This should be due to the fact that adolescents still feel belonging to the pediatric population and, coupled to their aforementioned peculiarity, need of a separate service for clinical monitoring. Nonetheless, familiarising adolescents gradually with adult care service, could help in facilitating transition to adult care, pending findings on effective implementation strategies.

It has been found that adolescents taking their medication in the facilities located in the rural zone were 5 times likely to be non-adherent rather than those in the urban zone. This should be due to the fact that most of the activities relating to the care of adolescents living with HIV are centred at the level of health facilities.

On a separate note, adolescents with unsuppressed viral load were 5 times at risk of being non-adherent compared to those with suppressed viral load. This supports the use of viremia as an indicator of adherence in the absence of HIV drug resistance [7,16].

Among the health care delivery factors, not counselled regularly by health care providers, was predictors of non-adherence to ART, suggesting the need for caregivers to pay attention to patient's need/preference [3].

Although our investigation contributes to knowledge on ART adherence and associated factors during adolescence in the Centre region of Cameroon, the current design was limited to quantitative data analysis. Qualitative assessments are henceforth needed for in-depth understanding of barriers to adherence and mitigating factors.

5. Conclusions

This study identified 7 predictors of non-adherence to ART among adolescents across 13 health facilities.

Following the composite approach, the adherence rate appears very low, and varies between self-reported and pill-count measurements. Thus, in the Centre region of Cameroon, about three quarter of adolescents might be non-adherent to ART. Interventions towards improved adherence should focus on adolescents living more than 5 km from the health facility, in rural areas, and within the private and public health facilities. Furthermore, creation of adolescent healthcare centres and enhance counselling would improve adherence to ART program in resource-constrained countries facing similar challenges like Cameroon.

Authors' Contributions

AK, FA, FM and MNN: designed and implemented the study; AK collected the data; AK, EA and JF: analysed and interpreted the data; AK: initiated the manuscript; FA and JF: revised the initial version of the manuscript; All authors: revised and approved the final version of the manuscript.

Conflict of Interest

The authors have no potential conflict of interest to declare.

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