

Prevalence of Missed HIV Treatment Appointments among Adolescents Living With HIV in Nyatike Sub-County, Migori County, Kenya

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ABSTRACT

Adolescents living with HIV require regular treatment appointments for antiretroviral medicine refills, clinical monitoring, adherence support, and viral-load monitoring. Missing scheduled appointments may signal emerging disengagement from HIV care and may affect continuity of treatment. However, the burden of missed appointments among adolescents in rural, high-HIV-burden settings such as Nyatike Sub-County is not adequately described. This study determined the prevalence of missed HIV treatment appointments among adolescents living with HIV in Nyatike Sub-County, Migori County, Kenya. A retrospective quantitative analysis of routine HIV treatment records was conducted among adolescents aged 10–19 years receiving HIV care in Nyatike Sub-County. A census of 976 eligible adolescent records was analyzed. Appointment attendance data were extracted from electronic medical records and relevant HIV monitoring and reporting tools. Missed appointment prevalence was estimated using frequencies, percentages and a 95% confidence interval. Key informant interviews (9) were used to provide contextual explanations for the quantitative findings. Of the 976 adolescents included, 139 (14.2%; 95% CI: 12.2–16.6%) had missed at least one scheduled HIV treatment appointment, while 837 (85.8%) had not.

All adolescents who missed appointments had missed one to two appointments, and none had missed three or more. Adolescents aged 15–19 years accounted for 100 of 652 (15.3%) missed appointments compared with 39 of 324 (12.0%) among those aged 10–14 years; this difference was not statistically significant ($p=0.200$). Key informants identified transport difficulties, school demands, caregiver-related challenges, stigma and fear of disclosure as contextual barriers. Appointment reminders, peer support, early tracing and supportive follow-up were identified as facilitators of re-engagement. Missed HIV treatment appointments affected approximately one in seven adolescents in Nyatike Sub-County. Although missed appointments were limited to one or two visits among those affected, the finding represents an important retention concern and highlights the need for prompt and supportive re-engagement of adolescents following missed appointments. HIV programs should strengthen early identification and supportive tracing of missed appointments, with particular attention to adolescent-responsive services, appointment reminders, peer and caregiver support, flexible scheduling, and barriers related to transport and school commitment. All 27 facilities offering HIV care and treatment in Nyatike Sub-County were included; therefore, no HIV-service facility was excluded from the study. Individual records were assessed against the predefined eligibility criteria. The final analytical dataset comprised 976 eligible adolescent records. The available study documentation does not provide a verified count of records screened and excluded before the final dataset, so no exclusion number has been estimated.

Keywords: adolescents living with HIV; missed appointments; HIV treatment; retention in care; appointment adherence; antiretroviral therapy

INTRODUCTION

Adolescents living with HIV remain an important population in the global HIV response. Approximately 1.7 million adolescents aged 10–19 years were living with HIV globally in 2023, accounting for approximately 4% of all people living with HIV, 11% of new HIV infections and 4% of AIDS-related deaths. Despite progress in HIV prevention and treatment, adolescents continue to experience challenges in maintaining consistent engagement with HIV care (UNICEF, 2025).

Regular attendance at HIV treatment appointments is essential for maintaining continuity of care among adolescents living with HIV. Clinic visits provide opportunities for antiretroviral therapy (ART) refills, monitoring of treatment response, adherence support and clinical assessment. Consistent engagement with HIV services is therefore important for achieving and maintaining optimal treatment outcomes. However, adolescents may experience individual, household, school-related and health-system challenges that interfere with their ability to attend scheduled appointments (Dzinamarira & Moyo, 2024; Hlophe et al., 2023). Missed HIV treatment appointments are a concern because they may represent an early disruption in engagement with HIV care. Although a single missed appointment does not necessarily indicate treatment interruption or loss to follow-up, repeated non-attendance can contribute to interruptions in treatment and monitoring. Evidence reviewed in the present study indicates that treatment interruptions remain an important challenge among adolescents living with HIV, highlighting the importance of maintaining continuous engagement with HIV services (Conan et al., 2021; Mushy et al., 2024).

The prevalence of missed HIV treatment appointments varies considerably across settings. Studies from Uganda and Tanzania have reported missed appointment or treatment interruption rates ranging from less than 7% to more than 26% among adolescents living with HIV (Mushy et al., 2024; Mwangi & Wyk, 2021; Nabukeera-Barungi et al., 2015). Such variation may reflect differences in the definition of a missed appointment, observation periods, study populations and HIV treatment and retention programs. In particular, studies measuring prolonged treatment interruption or loss to follow-up may produce different estimates from studies that classify an adolescent as having missed an appointment after failing to attend at least one scheduled visit.

In Kenya, adolescents living with HIV continue to experience challenges in maintaining long-term engagement with HIV services. Evidence from western Kenya indicates that poverty, stigma, caregiver circumstances, family conflict, isolation and negative healthcare-worker relationships can undermine adolescent retention, while supportive family, peer and healthcare relationships can facilitate continued engagement (Enane et al., 2021). School schedules, disclosure concerns and competing responsibilities may also influence adolescents' ability to remain engaged in HIV care (Wiggins et al., 2022).

Nyatike Sub-County in Migori County provides an important context for examining missed HIV treatment appointments among adolescents. The thesis identifies the area as a rural, high-HIV-burden setting in which adolescents may experience challenges related to transport, poverty, school commitments, caregiver support, stigma and disclosure. Despite the availability of adolescent HIV treatment and retention programs, context-specific evidence on the magnitude of missed HIV treatment appointments among adolescents in Nyatike remains limited.

Understanding the prevalence of missed HIV treatment appointments is important for identifying the magnitude of the retention challenge and providing a local baseline for HIV program planning and monitoring. The present study, therefore, aimed to determine the prevalence of missed HIV treatment appointments among adolescents living with HIV in Nyatike Sub-County, Migori County, Kenya. The study focused on adolescents who had missed at least one scheduled HIV treatment appointment and examined the frequency of missed appointments using routinely collected HIV treatment records.

METHODS

An analytical cross-sectional study using retrospective routine HIV treatment data was conducted among adolescents living with HIV in Nyatike Sub-County, Migori County, Kenya. A mixed-methods approach was

used. The quantitative component assessed the prevalence of missed HIV treatment appointments and factors associated with appointment adherence, while the qualitative component used key informant interviews (KIIs) to provide contextual explanations for barriers and facilitators that were not adequately captured in routine records.

The study was conducted in Nyatike Sub-County, Migori County, Kenya. The quantitative component included all 27 health facilities offering HIV care and treatment services in the sub-county during the study period. These facilities comprised sub-county hospitals, health centres, dispensaries and mission/private facilities providing HIV care. A census approach was used, whereby all eligible records of adolescents aged 10–19 years receiving HIV treatment in these facilities between January and December 2025 were included. A total of 976 eligible adolescent HIV treatment records were analysed. Because all facilities providing HIV care and treatment in Nyatike Sub-County were included, The qualitative component involved nine purposively selected key informants, comprising four Clinical Officers involved in HIV treatment and care in high-volume facilities, the Sub-County HIV Coordinator, and four adolescent and youth HIV peer champions. Participants were purposively selected because of their roles, experience and direct knowledge of adolescent HIV care, appointment adherence, service delivery, tracing and retention. This sampling strategy was intended to obtain complementary perspectives from healthcare providers, programme coordination and adolescent peer-support structures. All nine selected key informants participated in the interviews, giving a 100% response rate.

Records were eligible if they belonged to adolescents aged 10–19 years living with HIV, receiving HIV treatment in the selected Nyatike Sub-County facilities during the study period, and containing the appointment information required for the analysis. Records of adolescents receiving treatment in Nyatike but not resident in Nyatike Sub-County and records with incomplete information for the variables required for the relevant analysis were excluded. The final analytic dataset contained 976 eligible records. The routine data extraction process did not maintain a separate screening log from which a single total number of records excluded before eligibility could be calculated; therefore, an exclusion flow count was not reconstructed or estimated.

Quantitative data were extracted using a structured data abstraction tool developed from the study objectives and variables of interest. Data were extracted from Kenya-EMR/electronic medical record systems and KHIS. Trained data officers used a standardized abstraction process implemented through a MySQL script. Extracted records were de-identified before export and analysis. For the qualitative component, a semi-structured KII guide was developed from the study objectives and literature. The guide explored barriers and facilitators to appointment attendance, including transport, school commitments, caregiver support, food shortage, stigma, disclosure concerns, healthcare-worker attitudes, waiting time, reminders and tracing. Interviews were conducted in private settings and took approximately 30–45 minutes. With participant permission, interviews were audio-recorded to facilitate accurate transcription; recordings were to be destroyed after transcription.

A missed HIV treatment appointment was defined as failure to attend a scheduled HIV treatment appointment by the end of the seven-day grace period following the scheduled appointment date. Thus, an appointment scheduled for the 5th day of a month was considered missed if the adolescent had not attended by the 12th. Missed-appointment frequency was categorized as 0, 1–2, or ≥ 3 missed appointments during the observation period. The prevalence of missed appointments was calculated as the proportion of adolescents who missed at least one scheduled appointment among the 976 eligible adolescent records analyzed.

The quantitative data abstraction tool was pre-tested using approximately 10% (98) of records from Suna West Sub-County, which had comparable demographic and HIV service-delivery characteristics to Nyatike Sub-County but was excluded from the main study. The qualitative interview guide was also pre-tested with two purposively selected key informants with experience in adolescent HIV care. Feedback from the pre-tests was used to refine the instruments, coding procedures and data-collection process. Pre-test records and participants were excluded from the final study. Data officers were trained on study procedures, use of the abstraction tool and ethical requirements, and the researcher supervised data collection and reviewed extracted data and interview procedures for accuracy, consistency and completeness.

Quantitative data were managed and analyzed using R statistical software version 4.5.2. Frequencies and percentages were used to summarize participant characteristics and missed-appointment frequency. The prevalence of missed appointments was calculated as the proportion of adolescents with at least one missed appointment among all eligible records and reported with a 95% confidence interval. The difference in missed-appointment prevalence between adolescents aged 10–14 years and 15–19 years was assessed using Pearson’s chi-square test. The 95% confidence interval for the prevalence estimate was calculated using the binomial proportion method. Qualitative data from the KIIs were analyzed using thematic content analysis. Following each interview, field notes were reviewed and audio recordings were transcribed. Transcripts were read repeatedly for familiarization, systematically coded, and grouped into related categories. Recurring patterns across interviews were identified and consolidated into themes. Illustrative quotations were selected to represent the themes while protecting participants’ identities. The qualitative findings were then integrated with the quantitative findings to provide contextual explanations for observed patterns, particularly barriers and facilitators that were not consistently captured in routine records.

Ethical clearance was obtained from the University of Eastern Africa, Baraton Research Ethics Committee (UEAB/ISERC/03/11/2025). Permission to conduct the study was obtained from Maseno University, the National Commission for Science, Technology and Innovation (NACOSTI), and the Migori County Department of Health. Routinely collected HIV treatment records were de-identified before extraction and analysis; consequently, no direct participant consent was required for the secondary record review. Written informed consent was obtained from all qualitative key informants before interviews. Participants were informed about the purpose of the study, voluntary participation, confidentiality, their right to decline questions or withdraw, and the use of audio recording. Interview data were coded and reported without names or other direct identifiers.

RESULTS

A total of 976 adolescents aged 10–19 years receiving HIV treatment were included in the analysis. The conceptual framework specified scheduled HIV treatment appointments, missed appointments and the frequency of missed appointments as the key variables for this objective. Of the 976 adolescents, 324 (33.2%) were aged 10–14 years while 652 (66.8%) were aged 15–19 years. Female adolescents constituted 518 (53.1%) of the study population, while 458 (46.9%) were male.

Table 1: Prevalence and Frequency of Missed HIV Treatment Appointments Among Adolescents Living with HIV

Variable	Category	Frequency (n)	Percentage (%)
Age group	10–14 years	324	33.2
	15–19 years	652	66.8
Missed HIV treatment appointment	No missed appointment	837	85.8
	≥1 missed appointment	139	14.2
Frequency of missed appointments	0	837	85.8
	1–2	139	14.2
	≥3	0	0.0
Sex	Female	518	53.1
	Male	458	46.9

Source: Study data, 2026.

As shown in Table 1, 139 (14.2%; 95% CI: 12.2–16.6%) adolescents had missed at least one HIV treatment appointment, while 837 (85.8%) had not missed an appointment. The frequency distribution showed that

85.8% had no missed appointments, 14.2% had missed one to two appointments, and none had three or more missed appointments.

By age group, 39 (12.0%) adolescents aged 10–14 years and 100 (15.3%) adolescents aged 15–19 years had at least one missed appointment. The difference between the two age groups was not statistically significant ($p = 0.200$). Qualitative data from key informant interviews were used to provide additional insights into these factors. Key informants described the procedures used to identify and follow up adolescents who missed scheduled HIV treatment appointments.

The Clinical Officer stated

“In our facility, a patient is noted as having missed an appointment when they do not show up on their scheduled date plus the 7-day grace period. So if your appointment was on the 5th, and you haven't come by the 12th, that is a documented missed appointment. That triggers tracing.” (KII-01, Clinical Officer)

A key informant also described repeated non-attendance following an initial missed appointment:

“When you miss your appointment, there is this fear that builds inside you. You know you are supposed to go, but maybe you are scared of being scolded by the doctor. So you avoid. Then you miss again. The longer you stay away, the harder it becomes to go back because you think they will be angry. Some of my peers just stopped coming completely because they felt ashamed and afraid.” (KII-04, OTZ Champion, Male, 19 yrs.)

The key informants therefore reported the identification of missed appointments after the scheduled date and grace period and described repeated non-attendance among some adolescents.

DISCUSSION

This study found that 139 (14.2%) of the 976 adolescents living with HIV had missed at least one scheduled HIV treatment appointment during 2025. Most adolescents (85.8%) had no recorded missed appointment, and among those who missed, the recorded frequency was one to two appointments. The prevalence shows that, while the majority of adolescents remained engaged with scheduled care, missed appointments affected about one in seven adolescents and therefore represent a meaningful retention concern in this setting. A missed appointment should not automatically be interpreted as treatment interruption or loss to follow-up, but it provides an opportunity for the HIV programme to identify adolescents who may need additional support before non-attendance becomes more prolonged.

The 14.2% prevalence falls within the range reported in previous studies of adolescents living with HIV in sub-Saharan Africa, although direct comparisons should be made cautiously because studies use different definitions of missed appointments, observation periods and retention outcomes (Maskew et al., 2022). Some studies measure prolonged treatment interruption or loss to follow-up, whereas the present study classified an appointment as missed after the scheduled date and the seven-day grace period. These differences can produce substantially different estimates. The finding is also consistent with evidence from western Kenya showing that adolescent retention in HIV care is influenced by social and economic circumstances as well as experiences within health services. Enane et al. (2021), for example, identified stigma, poverty, transport costs, school commitments, caregiver circumstances and negative healthcare-worker relationships as important challenges to continued engagement in care.

The qualitative interviews provided context for the quantitative results, highlighting how adolescents in Nyatike access care. Key informants pointed out barriers such as transport costs, long distances, school commitments, caregiver challenges, food insecurity, stigma, and the fear of disclosure, all of which can hinder clinic attendance. These issues are especially significant for adolescents, who must balance attending clinics with school, family duties, and privacy concerns. One peer champion noted that adolescents who miss an appointment may hesitate to return due to fear of reprimand. This indicates that the response to missed appointments is crucial: supportive follow-up and re-engagement can facilitate adolescents' return to care,

while judgmental interactions might discourage them. Overall, these qualitative insights enrich the quantitative findings by revealing contextual factors that routine data collection may overlook.

Missed appointments were more common among adolescents aged 15–19 years than among those aged 10–14 years (15.3% versus 12.0%), but the difference was not statistically significant ($p=0.200$). This pattern aligns with evidence suggesting that older adolescents may have greater difficulty remaining engaged in HIV care (Leshargie et al., 2022). However, Nyatike's results do not provide sufficient evidence to conclude that age was associated with missed appointments. The higher proportion among older adolescents may warrant program attention, but it should be interpreted as a descriptive pattern rather than a statistically established difference. Qualitative accounts offer plausible context, as older adolescents may have greater school and social responsibilities, but these explanations were not directly measured in the routine quantitative data.

The absence of adolescents with three or more missed appointments is also notable. Key informants described a system in which a missed appointment is identified after the seven-day grace period and can trigger tracing. They also described reminders, peer support and follow-up as mechanisms that can help adolescents return to care. These programme practices may be relevant to the observed pattern, but the quantitative data cannot establish that tracing or other interventions caused the absence of repeated missed appointments. The findings point to a practical approach to adolescent HIV retention in Nyatike. The focus should not only be on whether an appointment was missed, but also on what happens after the missed visit. Early, respectful and adolescent-friendly follow-up may help prevent a single missed appointment from developing into prolonged disengagement. The qualitative findings suggest that interventions should be responsive to the realities adolescents face, including transport costs, school schedules, stigma, disclosure concerns, inadequate food and caregiver support. Strengthening peer support, appointment reminders, flexible scheduling and supportive tracing may therefore be useful components of the local HIV retention response. These approaches are consistent with the broader evidence that adolescent retention is shaped by both individual circumstances and the way HIV services are organized and experienced (Enane et al., 2021; Hlophe et al., 2023; Maskew et al., 2022).

LIMITATIONS

This study has several limitations. First, the quantitative component relied on routinely collected HIV records, which may be affected by incomplete documentation, data-entry errors or variation in how appointment information is recorded across facilities. Second, the analysis was restricted to one sub-county, which limits generalizability to other settings. Third, the qualitative component involved nine purposively selected key informants rather than adolescents who missed appointments; therefore, the qualitative findings represent the perspectives of healthcare providers, program coordinators, and peer champions and should not be interpreted as direct accounts from adolescents. Fourth, the routine dataset did not retain a separate screening log from which the total number of records excluded before eligibility could be independently reconstructed.

CONCLUSION

Missed HIV treatment appointments affected 14.2% of adolescents living with HIV in Nyatike Sub-County, with 139 of the 976 adolescents missing at least one scheduled appointment. Although the majority of adolescents maintained their scheduled appointments and those who missed appointments reported only one to two missed visits, the observed prevalence indicates that missed appointments remain an important concern for continuity and retention in HIV care. The findings highlight the need for timely identification and supportive follow-up of adolescents who miss scheduled HIV treatment appointments to promote continued engagement in care.

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Availability Of Data And Materials

The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request, subject to applicable ethical and confidentiality requirements.

Author's Contributions

JAO Judith Amisi Ochieng conceived and designed the study, participated in data collection, data analysis, interpretation of findings, and preparation of the manuscript. DM and DO provided critical review and revisions to the study protocol and data collection procedures.

Ethics Approval and Consent To Participate in The Study

Permission to conduct the study was obtained from the School of Graduate Studies, Maseno University, while ethical clearance was obtained from the University of Eastern Africa, Baraton Research Ethics Committee. (UEAB/ISERC/03/11/2025) A research permit was also obtained from the National Council for Science, Technology and Innovation (NACOSTI). The routinely collected HIV treatment records used for the quantitative analysis were de-identified before extraction and analysis to protect participants' privacy and confidentiality. As the quantitative component involved secondary analysis of routinely collected records, no direct participant consent was required for the record review.

REFERENCES

1. Conan, N., Badawi, M., Chihana, M. L., Wanjala, S., Kingwara, L., Mambula, C., Ngugi, C., Okomo, G., Opollo, V., Salumu, L., Nesbitt, R., Szumilin, E., & Huerga, H. (2021). Two-fold increase in the HIV viral load suppression rate along with decreased incidence over six years in Ndhiwa sub-county, Kenya. *Tropical Medicine & International Health: TM & IH*, 26(12), 1609–1615. <https://doi.org/10.1111/tmi.13688>
2. Dzinamarira, T., & Moyo, E. (2024). Adolescents and young people in sub-Saharan Africa: Overcoming challenges and seizing opportunities to achieve HIV epidemic control. *Frontiers in Public Health*, 12, 1321068. <https://doi.org/10.3389/fpubh.2024.1321068>
3. Enane, L. A., Apondi, E., Aluoch, J., Bakoyannis, G., Lewis Kulzer, J., Kwena, Z., Kantor, R., Chory, A., Gardner, A., Scanlon, M., Goodrich, S., Wools-Kaloustian, K., Elul, B., & Vreeman, R. C. (2021). Social, economic, and health effects of the COVID-19 pandemic on adolescents retained in or recently disengaged from HIV care in Kenya. *PloS one*, 16(9), e0257210. <https://doi.org/10.1371/journal.pone.0257210>
4. Hlophe, L. D., Tamuzi, J. L., Shumba, C. S., & Nyasulu, P. S. (2023). Barriers and facilitators to anti-retroviral therapy adherence among adolescents aged 10 to 19 years living with HIV in sub-Saharan Africa: A mixed-methods systematic review and meta-analysis. *PloS one*, 18(5), e0276411. <https://doi.org/10.1371/journal.pone.0276411>
5. Kose, J., Tiam, A., Siamba, S., Lenz, C., Okoth, E., Wolters, T., van de Vijver, D., & Rakhmanina, N. (2022). Clinical outcomes among adolescents living with HIV in Kenya following initiation on antiretroviral treatment. <https://doi.org/10.1371/journal.pgph.0000094>
6. Leshargie, C. T., Demant, D., Burrowes, S., & Frawley, J. (2022). The proportion of loss to follow-up from antiretroviral therapy (ART) and its association with age among adolescents living with HIV in sub-Saharan Africa: A systematic review and meta-analysis. *PloS one*, 17(8), e0272906. <https://doi.org/10.1371/journal.pone.0272906>
7. Maskew, M., Technau, K., Davies, M. A., Vreeman, R., & Fox, M. P. (2022). Adolescent retention in HIV care within differentiated service-delivery models in sub-Saharan Africa. *The Lancet. HIV*, 9(10), e726–e734. [https://doi.org/10.1016/S2352-3018\(22\)00137-0](https://doi.org/10.1016/S2352-3018(22)00137-0)
8. Mushy, S. E., Mtisi, E., Mkawe, S., Mboggo, E., Ndega, J., Yahya-Malima, K. I., Kamugunya, D., Kilimba, E. S., Mlay, B. S., Muya, A., & Ngalesoni, F. (2024). Barriers to viral load suppression among adolescents living with HIV on anti-retroviral therapy: A retrospective study in Tanga, Tanzania. *AIDS Research and Therapy*, 21(1). <https://doi.org/10.1186/s12981-024-00622-7>

9. Mwangi, A., & van Wyk, B. (2021). Factors associated with viral suppression among adolescents on antiretroviral therapy in Homa Bay County, Kenya: a retrospective cross-sectional study. *HIV/AIDS-Research and Palliative Care*, 1111-1118. <https://doi.org/10.2147/HIV.S345731>
10. Nabukeera-Barungi, N., Elyanu, P., Asire, B., Katureebe, C., Lukabwe, I., Namusoke, E., Musinguzi, J., Atuyambe, L., & Tumwesigye, N. (2015). Adherence to antiretroviral therapy and retention in care for adolescents living with HIV from 10 districts in Uganda. *BMC Infectious Diseases*, 15(1), 520. <https://doi.org/10.1186/s12879-015-1265-5>
11. UNICEF. (2025). Adolescent HIV prevention. UNICEF DATA. <https://data.unicef.org/topic/hivaids/adolescents-young-people/>
12. Wiggins, L., O'Malley, G., Wagner, A. D., Mutisya, I., Wilson, K. S., Lawrence, S., Moraa, H., Kinuthia, J., Itindi, J., Muhenje, O., Chen, T. H., Singa, B., Mcgrath, C. J., Ngugi, E., Katana, A., Ng Ang A, L., John-Stewart, G., Kholer, P., & Beima-Sofie, K. (2022). 'They can stigmatize you': a qualitative assessment of the influence of school factors on engagement in care and medication adherence among adolescents with HIV in Western Kenya. *Health education research*, 37(5), 355–363. <https://doi.org/10.1093/her/cyac018>