Prevalence of Malaria Co-Infection and Antiretroviral Therapy Adherence Practices among Outpatients Living With HIV/AIDS in Ondo-State, Nigeria: A Cross-Sectional Study

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ABSTRACTS

Background: Malaria and HIV/AIDS burdens remain major public health concern in sub-Saharan Africa, often co-existing resulting in worsening health outcomes. This study investigates the frequencies of malaria episodes and Antiretroviral Therapy (ART) adherence practices among HIV patients registered for care and support programme at the HIV clinic unit of the University of Medical Sciences Teaching Hospital, Ondo. It explores the relationship between frequencies of presenting for malaria treatment among HIV patients and socio-demographic factors, ART regimen type and ART medication adherence.

Methods: The cross-sectional study involves 246 HIV patients and a well-designed questionnaire was administered to the participants in a semi-interview manner. Their responses were corroborated with their clinic medical records to ensure accuracy. Data were analysed using SPSS, and the chi-square test was used to assess the association. Multivariate logistic regression was used to evaluate the factors predisposing patients to coming down with malaria symptoms and a $p < 0.05$ was considered statistically significant.

Results: The overall prevalence of treated malaria episodes, at least once in the last 6 months was 43.5%. Frequencies of malaria episodes was significantly associated with age (X^2= 18.79; p = 0.002), ART regimen (X^2= 15.26; p = 0.002) and medication adherence (X^2= 18.79; p = 0.017). The most common reasons for missed ART doses included medication burden, religious fasting and lack of privacy. These findings highlight the complex interplay between ART adherence, socio-cultural barriers, and malaria co-infection. Addressing stigma, improving treatment accessibility, and integrating malaria prevention strategies into HIV care programs are crucial for improving health outcomes. Future interventions should focus on patient-centred adherence support and optimizing ART regimens to minimize malaria risk.

Keywords: Malaria, HIV, ART adherence, Malaria Co-infection, Ondo-State, Nigeria.

INTRODUCTION

Malaria and Human Immunodeficiency Virus (HIV) are two of the most significant public health challenges in sub-Saharan Africa, where they frequently co-exist and contribute to high morbidity and mortality rates (Gumel *et al*., 2020; Kwenti *et al*., 2018; Obebe and Falohun 2021). Nigeria, as the country with the highest malaria burden globally and one of the highest HIV prevalence rates in West Africa, faces unique challenges in managing these co-infections Isiko *et al*., 2024; Shekarau *et al*., 2024; Haider, 2021). The country accounts for approximately 27% of global malaria cases and 31% death according to the recent records (Shekarau *et al*., 2024). The high transmission intensity is driven by multiple factors, including the favorable tropical climate, widespread presence of *Plasmodium falciparum* which is the most virulent malaria parasite species and socio-economic barriers that limit access to effective malaria control interventions (Zekar and Sharman, 2023). Despite significant progress in malaria prevention through long lasting insecticide-treated nets (LLIN), indoor residual spraying (IRS), and artemisinin-based combination therapies (ACTs), the disease continues to exert a significant health and economic toll on affected populations, particularly among vulnerable groups such as

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children under five years of age, pregnant women, and individuals with compromised immune systems (Okumu and Moore, 2011; Loha *et al*., 2019; Oladipo *et al*., 2022).

Concurrently, the burden of HIV/AIDS in Nigeria remains a critical health issue, with an estimated 1.9 million people living with the virus as of 2022 (Bassey and Miteu, 2023; Onovo et al., 2023). Although antiretroviral therapy (ART) has significantly improved survival and quality of life, HIV/AIDS remains a leading cause of morbidity and mortality (Kemnic and Gulick, 2022; Woldegeorgis *et al*., 2024). The intersection of malaria and HIV poses a unique challenge, as co-infection is common in endemic regions like Nigeria, where transmission rates of both diseases often overlap (Kwenti, 2018; Obeagu *et al*., 2024). HIV infection is known to increase susceptibility to malaria due to immune suppression, prolong parasite clearance time, and exacerbate malaria severity. Furthermore, malaria infection has been shown to enhance HIV replication, thereby accelerating disease progression (Obase et al., 2023; Mirzohreh et al., 2022). These bidirectional interactions necessitate targeted interventions to effectively manage co-infected individuals. The interaction between malaria and HIV is complex, with evidence suggesting that HIV-induced immunosuppression increases susceptibility to malaria infection, severity, and treatment complications (Van Geertruyden, 2014). Similarly, recurrent malaria episodes in HIV-infected individuals can further compromise immune function and exacerbate disease progression, leading to poorer health outcomes (Hochman and Kim 2012; Ashleigh et al., 2021).

A key aspect to the successful management of HIV-infected individuals is ensuring optimal treatment adherence. Adherence to recommended malaria treatment regimens, particularly artemisinin-based combination therapies (ACTs), is critical to achieving effective parasite clearance (Banek et al., 2014). Poor adherence contributes to treatment failure, the emergence of drug-resistance cases, viral resistance, increased morbidity, and mortality (Kyeyune et al., 2013; Masikini and Mpondo, 2015). Among HIV-positive individuals, adherence to treatment regimen may be influenced by several factors, including pill burden, perceived drug side effects, socio-economic barriers, stigma and health system inefficiencies (Moomba abd Van Wyk, 2019; Legesse and Reta, 2019). Additionally, antiretroviral therapy (ART) interactions with antimalarial drugs pose a significant challenge, potentially affecting treatment efficacy and patient outcomes (Parikh et al., 2016). Understanding the frequency of malaria treatment episodes and the patterns of medication adherence in this vulnerable population is essential for improving disease management strategies.

Ondo State, located in south-western Nigeria, is highly endemic for malaria, with year-round transmission that peaks during the rainy season. The state also has a significant HIV burden, necessitating targeted interventions for co-infected individuals (Owolabi *et al*., 2024). Despite various governmental and non-governmental efforts to enhance malaria control and HIV care, there is limited empirical research examining malaria treatment frequencies and adherence behaviors of outpatients living with HIV in Ondo State. Identifying gaps in adherence and the determinants of malaria treatment patterns among this population is crucial for informing tailored public health interventions that can enhance treatment efficacy and improve health outcomes.

This study aims to assess the frequency of malaria treatment episodes and evaluate adherence to ART regimens among HIV-infected outpatients in Ondo State, Nigeria. The findings will provide insight into the challenges faced by this population and offer evidence-based recommendations for strengthening integrated HIV-malaria management programs. Specifically, the study seeks to know how frequently outpatients living with HIV seek treatment for malaria, the levels of adherence to ART medications among these patients and the key factors influencing adherence and treatment patterns in this population. By addressing these questions, this study will contribute to the broader discourse on the intersection of infectious diseases and medication adherence in resource-limited settings. The outcomes will be valuable in guiding policy formulation and programmatic interventions aimed at improving the management of HIV-infected individuals, ultimately enhancing their overall health and quality of life.

METHODS

Study design and population

An hospital based cross-sectional study was carried out among HIV out-patients registered and receiving care at the University of Medical Sciences Teaching Hospital, Ondo. The study was carried out from October 2024

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to January 2025. Ondo is an urban city with an estimated population of over 510,000 inhabitants as of 2025. The urbanisation of the city with regular ongoing construction and housing patterns provides sufficient breeding sites for malaria parasites (Adams and Fagbohunka, 2024).

Inclusion criteria

All HIV patients reporting for treatment in the clinic and whose registration is not less than six months were included in the study. Their inclusion is essentially dependent on their voluntary completion of the assent forms having been adequately informed on the purpose of the study.

Exclusion Criteria

HIV patients whose registration are less than six months and those who decline to participate in the study were excluded from the study.

Ethical Consideration

Ethical review clearance was sought from the Institutional Review Board and the approval was given an authorisation number UNIMEDTHC/024/ERC/168 before the commencement of the study. Informed consent forms were given to patients after a clear explanation on the aim and purpose of the study and consenting patients who met the inclusion criteria were enrolled

Sample size

The sample size adopted for this study was calculated using the Lorenz formula stated as follows $n=z^2 p(1-p)/d^2$, where z denotes *Z* score for 95 % confidence interval = 1.96, *p* denotes past prevalence, and *d* equals acceptable error (5 %). The past prevalence of Malaria infection among HIV patients in Ondo was used and it is 20% according to Onifade *et al*., 2007. The sample size attained from the calculation was 246 participants.

Sampling Technique

A simple random sampling technique was adopted for this study where all the HIV outpatients receiving treatment at the University of Medical Science Teaching Hospital every Fridays and fulfil the inclusion criteria has equal chances of being selected.

Data collection

Administration of Questionnaire

A well-structured questionnaire pretested to affirm its psychometric fitness (Validity and Reliability) and reviewed by experts was administered to the research participants. The administration was done in a semi-interview approach for each participants by well-trained research assistance guided by the principal researcher in order to ensure accuracy. The questionnaire covers the socio-demographic data of the participants such as their age, gender, occupation, marital status and religion as well as their knowledge and attitude to malaria prevention techniques especially the use of long lasting insecticide treated nets. The questionnaire equally sought information on their use and duration of being on ART, the type of ART and their adherence to clinical routines and medications. The number of times they have received treatment for malaria in the last 6 months which coincidentally were parts of the peak period for malaria was inquired. Their response was corroborated with their medical reports to ensure accuracy.

Measure of Medication Adherence

The ARV level in the blood is the golden standard for assessing medication adherence in HIV patients. Viral load could also be used as a measure but data emanating from self-reports are easily accessible. Self-reported data have been reported to accurately correlates with viral loads. Therefore, for this study, adherence was rated through the self-reported data obtained from the participants using a 4-day recall semi structured follow up

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questionnaire adapted from Adults AIDS Clinical Trials Group (AACTG). The percentage of adherence was calculated by dividing the total number of drugs taken in the last four days by the total number of drugs recommended to be taken for the four days multiplied by 100 as summarized below. Adherence was then categorized as greater or equal to 95% and non-adherence as less than 95%.

[(Total number of drugs taken / Total number of drugs prescribed) x (100/1)]

Data analyses. Data were recorded and entered in a Microsoft Excel database in a secure computer and analysis was done with SPSS version 20 and EPI info version 7. Data were statistically described using frequencies and percentages. The significance of the difference in prevalence with respect to socio-demographic factors were explored using Pearson's chi-square test. A *p*-value of less than 0.05 was considered statistically significant. Multivariate analysis was applied to analyze risk factors associated with malaria occurrences among the HIV patients.

RESULTS

Variables	**Frequency n=246**	**Percentage**
Age group		
0-15	16	6.5
16-24	48	19.5
25-30	73	29.7
31-40	47	19.1
41-50	23	9.3
51 and above	39	15.9
Gender		
Male	78	31.7
Female	168	68.3
Marital Status		
Married	142	57.7
Single	85	34.6
Divorced	19	7.7
Highest Educational Level		
Primary	37	15.0
Secondary	104	42.3
Tertiary	91	37.0
No formal Education	14	5.7
Employment		
Employed	152	61.8

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Not employed	94	38.2
Usage of LLIN		
Always	46	18.7
Sometimes	153	62.2
Never	47	19.1
Malaria treatment episodes in the last six months		
Twice/more	39	15.9
Once	68	27.6
None	139	56.5
Duration of ART medication		
1-2years	32	13.0
2-3years	85	34.6
3 or more years	129	52.4
ART Type		
NRTIs	102	41.5
NNRTIs	97	39.4
PIs	62	25.2
INSTIs	92	37.4
No of daily pills		
1-2pills	76	30.9
3-4pills	112	45.5
5 or more pills	58	23.6
Ever forget taking medication		
Yes	195	79.3
Never	51	20.7
Ever stopped taking medication for more than two days		
Yes	93	37.8
No	153	62.2
Ever missed taking medication in the last four days		
Yes	158	64.2
No	88	35.8

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How many times medication was missed in the last four days		
Once	42	17.1
Twice	116	47.2
None	88	35.8
Overall medication Adherence		
Adherent (>95%)	76	30.9
Non-adherent (<95%)	170	69.1

Table 2: Prevalence of malaria in the study population

Variables	**Number examined**	**Number treated for malaria at least once in the last 6 months (%)**	**Chi-square (X^2)**	**P-value**
Age group			18.79	0.002
0-15	16	9 (56.3%)		
16-24	48	22(45.8%)		
25-30	73	17(23.3%)		
31-40	47	26(55.3%)		
41-50	23	11(47.8%)		
51 and above	39	22(56.4%)		
Gender			0.01	0.906
Male	78	33(42.3%)		
Female	168	74(44.0%)		
Marital Status			4.84	0.089
Married	142	64(45.0%)		
Single	85	31(36.5%)		
Divorced	19	12(63.2%)		
Highest Educational Level			6.16	0.105
Primary	37	16(43.2%)		
Secondary	104	52(50.0%)		
Tertiary	91	31(34.1%)		
No formal Education	14	8 (57.1%)		
Employment			0.18	0.669
Employed	152	64(42.1%)		
Not employed	94	43(45.7%)		

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Usage of LLIN			5.32	0.070
Always	46	21(45.7%)		
Sometimes	153	59(38.6%)		
Never	47	27(57.4%)		
Duration of ART medication			0.58	0.748
1-2years	32	12(37.5%)		
2-3years	85	37(43.5%)		
3 or more years	129	58(45.0%)		
ART Type			15.26	0.002
NRTIs	102	46(45.0%)		
NNRTIs	97	22(22.7%)		
PIs	62	17(27.4%)		
INSTIs	92	22(23.9%)		
Overall medication Adherence			5.67	0.017
Adherent	76	24(3.6%)		
Non-adherent	170	83(48.8%)		

Table 3: Factors associated with Malaria among HIV-infected patients enrolled for the study

Variables	**COR (95% CI)**	**P-value**	**AOR (95 % CI)**	**P-value**
Age group				
0-15	1		1	
16-24	0.66(0.21-2.06)	0.476	0.63(0.25-1.59)	0.325
25-30	0.24(0.08-0.73)	0.011	0.23(0.09-0.61)	0.003
31-40	0.96(0.31-3.02)	0.944	0.96(0.36-2.56)	0.933
41-50	0.71(0.20-2.57)	0.599	0.75(0.24-2.31)	0.620
51 and above	1.01(0.31-3.25)	0.987	1.02(0.39-2.67)	0.972
Gender				
Male	1		1	
Female	1.07(0.62-.85)	0.808	0.93(0.51-1.72)	0.850
Marital Status				
Married	1		1	
Single	0.70(0.40-1.21)	0.207	0.67(0.37-1.20)	0.180

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Divorced	2.09(0.78-5.62)	0.143	1.89(0.65-5.46)	0.246
Highest Educational Level				
Primary	1		1	
Secondary	1.31(0.62-2.79)	0.482	1.32(0.65-2.69)	0.440
Tertiary	0.68(0.31-1.48)	0.333	0.65(0.30-1.42)	0.280
No formal Education	1.75(0.51-6.06)	0.375	1.88(0.50-7.01)	0.356
Employment				
Employed	1		1	
Not employed	1.16(0.69-1.95)	0.575	1.15(0.67-1.96)	0.610
Usage of LLIN				
Always	1		1	
Sometimes	0.75(0.38-1.45)	0.4000	0.74(0.38-1.44)	0.380
Never	1.61(0.71-3.65)	0.254	1.53(0.72-3.25)	0.265
Duration of ART medication				
1-2years	1		1	
2-3years	1.28(0.56-2.96)	0.561	1.28(0.55-2.98)	0.570
3 or more years	1.36(0.61-3.02)	0.451	1.37(0.62-3.000	0.440
ART Type				
NRTIs	1		1	
NNRTIs	0.36(0.19-0.66)	0.001	0.39(0.21-0.73)	0.003
PIs	0.46(0.23-0.91)	0.027	0.49(0.24-0.98)	0.045
INSTIs	0.38(0.21-0.71)	0.002	0.42(0.22-0.80)	0.008
Overall medication Adherence				
Adherent	1		1	
Non-adherent	2.07(1.17-3.65)	0.012	1.65(1.03-2.63)	0.036

Table 4: Reasons for missing medication and clinic schedules (n=246)

Items	**SA**	**A**	**SD**	**D**	Mean Rating	Rank
Away from home	87	66	43	49	2.80	9th
Simply forget	116	86	21	23	3.21	4th
Run out of medication	47	52	78	69	2.28	16th

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Religious fasting	158	79	6	3	3.58	2nd
Busy with other things	47	32	91	76	2.14	17th
Sometimes not mindful of it	56	63	83	44	2.37	13th
No food to take	27	38	95	86	1.99	18th
Trying to avoid side effects	69	47	77	53	2.44	12th
Feels alright and healthy and medication is probably not necessary	97	88	34	27	3.01	7th
Lack of money to buy medication	55	53	87	51	2.31	15th
Lack of privacy and trying to avoid people noticing daily intake of medications	147	64	21	14	3.37	3rd
Sometimes feels depressed and unhappy about the whole situation	117	84	32	13	3.16	5th
Still in doubt about the infection	19	22	161	44	1.59	19th
Daily intake of medication becoming a great burden	198	42	2	4	3.77	1st
The clinic is a great distance from home and sometimes lacks transport fare	87	77	60	22	2.78	10th
Clinic time is not convenient or clashes with other essential schedules	123	66	36	21	3.12	6th
Not comfortable attending an open clinic prefers private treatment	102	71	32	41	2.99	8th
Unpleasant treatment from health officials	68	54	66	58	2.50	11th
Strong feelings of stigmatization	47	64	79	56	2.32	14th

Characteristics of the study participants

The study participants were two hundred and forty-six HIV-infected patients.Table 1 is a breakdown of their socio-demographic characteristics. Majority of them were female (68.3%) and within age 25-30 (29.7%). 43.5% of them have been treated for malaria at least once in the last six months. The usage of long lasting insecticide treated nets has been inconsistent with only 18.7% using it always. Adherence to ART is low as 69.1% of the participants were classified as non-adherent.

Malaria occurrences among the HIV-infected patients

The age group 0-15 years had the highest malaria parasitemia (56.3%)**,** followed closely by those in age group 51 and above (56.4%) then group 31-40 years (55.3%)**.** The lowest prevalence was seen in the 25-30 years age group (23.3%)**.** The association between age and malaria co-infection is statistically significant (p = 0.002), meaning age is an important factor influencing malaria prevalence. Males (42.3%) and females (44.0%) had similar malaria prevalence. The p-value (0.906) indicates no significant difference in malaria co-infection between genders. Malaria prevalence was highest among divorced individuals (63.2%)**,** followed by married (45.0%) and single (36.5%)**.** The p-value (0.089) suggests that marital status is not significantly associated

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with malaria occurrences. Individuals with no formal education (57.1%) and secondary education (50.0%) had higher malaria episodes compared to those with tertiary education (34.1%). The p-value (0.105) indicates no significant relationship between education level and malaria occurrences. Malaria prevalence was slightly higher among the unemployed (45.7%) compared to the employed (42.1%). The p-value (0.669) shows no significant association between employment status and malaria co-infection. Individuals who never used LLINs had the highest malaria prevalence (57.4%)**,** while those who used them always had a lower prevalence (45.7%)**.** However, the p-value (0.070) is slightly above 0.05, meaning the association is not statistically significant but suggests a potential protective effect. Malaria episodes among the HIV patients was similar across all ART duration groups, ranging from 37.5% (1-2 years) to 45.0% (3 or more years)**.** The p-value (0.748) indicates no significant relationship between ART duration and malaria co-infection. Malaria occurences was highest among individuals on NRTIs (45.0%) and lowest among NNRTIs (22.7%)**.** The p-value (0.002) indicates a significant association between ART type and malaria co-infection, suggesting that different ART regimens might influence malaria susceptibility. Malaria occurences was significantly higher in non-adherent individuals (48.8%) compared to adherent individuals (3.6%). The p-value (0.017) suggests a significant association, indicating that better adherence to ART medication might reduce malaria susceptibility. Age group is significantly associated with malaria parasitemia **(**p = 0.002**),** with the 0-15 years and 51+ years groups having the highest prevalence. ART type is significantly associated with malaria prevalence **(**p = 0.002**)**, with NRTIs showing the highest prevalence. Medication adherence is significantly associated with malaria occurence (p = 0.017), with non-adherent individuals having much higher malaria prevalence.

Factors associated with malaria

The 25-30 years group had significantly lower odds of malaria compared to the 0-15 years group as shown in table 3. This suggests individuals aged 25-30 years were significantly less likely to come down with malaria compared to children aged 0-15 years. Other age groups did not show significant differences. Being in the 25-30 years group significantly reduces the odds of malaria**.** Both the crude and adjusted odds ratios for females compared to males were close to 1 (COR = 1.07, AOR = 0.93) with *p*-values > 0.05, meaning gender is not a significant factor**.**

No significant association between gender and malaria parasitemia. Divorced individuals had higher odds of malaria **(**COR = 2.09, AOR = 1.89**)**, but the association was not statistically significant (p > 0.05). Marital status is not significantly associated with malaria. Tertiary education appeared to reduce malaria risk (COR = 0.68, AOR = 0.65) but was not statistically significant (p > 0.05)**.** Education level does not have a statistically significant effect. Being unemployed was associated with slightly higher odds of malaria (COR = 1.16, AOR = 1.15)**,** but this was not significant (p > 0.05)**.** No significant association between employment and malaria. Individuals who never used LLINs had higher odds of malaria (AOR = 1.53), but the effect was not statistically significant (p > 0.05)**.** No strong evidence that LLIN use significantly affects malaria risk. Individuals on ART for longer durations had slightly higher odds of malaria, but these results were not statistically significant (p > 0.05)**.** ART duration does not significantly affect malaria prevalence. Compared to NRTIs (reference group), other ART types significantly reduced malaria odds**:** NNRTIs (AOR = 0.39, p = 0.003) PIs (AOR = 0.49, p = 0.045) INSTIs (AOR = 0.42, p = 0.008) NNRTIs, PIs, and INSTIs significantly reduce malaria risk compared to NRTIs**.** Non-adherent individuals had significantly higher odds of malaria compared to adherent individuals **(**AOR = 1.65, p = 0.036**).** Poor medication adherence increases malaria risk**.**

Reasons for missing pills

The most significant reason for missing medication is the perceived burden of daily intake. Many respondents feel overwhelmed by the long-term nature of their treatment. A major challenge, especially in regions where religious practices involve fasting. Many individuals skip medication during fasting periods due to concerns about breaking fast**.** Lack of privacy and avoiding people noticing medication intake. This suggests stigma and confidentiality concerns significantly affect adherence. Patients prefer secrecy due to fear of discrimination or social judgment**.** Forgetfulness is a common problem in medication adherence. This suggests a need for reminder systems like alarms or support groups. Psychological distress plays a key role in non-adherence. This highlights the need for mental health support alongside medical treatment. Many patients find clinic hours conflicting with work or personal commitments**.** This suggests that flexible scheduling or weekend/after-hours

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services might improve adherence. Some individuals stop taking medication because they no longer feel sick**.** This is a common issue in chronic illness management, where patients may not understand the need for continuous treatment**.** Privacy concerns influence clinic attendance. Some individuals prefer private healthcare settings to avoid exposure. Travel or movement contributes to missing medication. This suggests a need for portable medication solutions and mobile clinics**.** Distance and transportation issues create barriers to accessing healthcare. Mobile clinics or transport assistance programs could help. Some patients experience poor attitudes from healthcare workers. This could affect trust and willingness to seek care. Some patients stop taking medication due to fear of side effects. This highlights the need for proper counselling on managing side effects. Similar to forgetfulness but indicates a lack of prioritization of treatment. While stigma is a concern, it ranks lower compared to other reasons. More education and support groups could help reduce stigma-related non-adherence**.** Financial difficulties can impact adherence, though it ranks lower than expected. Subsidized programs or government support may reduce this issue. This suggests that some patients face supply issues, but most can access medication. Being busy is not a major reason for non-adherence. Some medications require food intake, and food insecurity can cause non-adherence. However, it ranks low, indicating it affects only a small proportion of patients. Very few patients doubt their diagnosis, meaning awareness levels are high**.**

DISCUSSION

The high burdens of malaria and HIV infections in Nigeria often result in their co-existence, and it has devastating effects on the already compromised state of patients living with HIV. The result of this study indicates that 43.5% of the HIV patients have received malaria treatment at least once in the last six months. This is higher than the 22.9% reported in Kaduna by Shafiu *et al*., 2021, and 18.5% reported among HIV patients in Osogbo by Ojurongbe *et al*., 2014. The wide gap in the prevalence recorded in this study may be due to differences in research methodology. While this study collates patients' history of malaria episodes for 6 months, these other studies were one-time records of malaria co-infections determined by laboratory analysis. The prevalence of malaria in this study was, however comparable to 56.8% reported in Keffi by Yohanna *et al*., 2019. Differences in malaria infection across geographical locations may be due to variances in parasites' abundance and survival rate influenced by various factors including environmental, socio-economic and human behavioural factors among others.

In this study, no significant difference exists in malaria co-infection between male and female participants. Some studies have reported higher malaria prevalence among females (Adeola *et al.*, 2022; Amadi et al., 2018; Bello and Ishaleku, 2018) and this has been associated with their daily house chores usually done outdoors while some other studies have equally reported higher malaria prevalence in males also associated with occupational risks (Akinbo et al., 2016; Dikwa et al., 2020; Okokon et al., 2017). The result of this study has shown undifferentiated pattern in the frequencies of malaria episodes between the male and female HIV patients and it is comparable to what was reported by Jegede *et al*., 2020 in Kano state, Nigeria. This may be connected with the recent economic downturn in Nigeria homes resulting from the sudden removal of fuel subsidies which has necessitated making extra effort in monetary pursuit excluding no gender thereby exposing both to equal risks.

Age is found to be significantly associated with malaria in this study with children less or equal to 15 years having the most malaria prevalence. This is in agreement with other studies that have reported higher chances of children experiencing frequent malaria episodes compared to adults (Isiko *et al*., 2024; Ranjha *et al*., 2023).

ART medication adherence was equally found to be significantly associated with malaria occurrences among the HIV patients with non-adherent individuals having more malaria episodes. Studies have shown non-adherent HIV patients to be more susceptible to malaria and other opportunistic infections (Tankoua-tchounda *et al*., 2024; Kasirye *et al*., 2017).

Studies show that medication adherence is crucial in preventing the worsening of HIV-malaria co-infections. Poor adherence is linked to increased morbidity and mortality, with financial constraints and ART side effects being major contributing factors (Isika et al., 2022; Lai et al., 2024). The findings showing that overall medication adherence significantly affects health outcomes agrees with previous studies demonstrating that

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non-adherence doubles the risk of treatment failure (Walsh et al., 2019; Stewart et al., 2022). Results from this study show that adherence to LLIN use is inconsistent, with some individuals only using them sometimes or never. This supports the WHO's malaria control findings, which indicate that net usage is often influenced by socio-economic factors, knowledge, and accessibility (Njatasoa *et al*., 2021; Wubishet *et al*., 2021, Damien *et al*., 2023). The results are comparable to studies demonstrating that sleeping under LLINs consistently reduces malaria cases by more than 50% in endemic regions (Cote et al., 2021; Wubishet *et al*., 2021). Additionally, ART duration did not significantly influence malaria risk, which aligns with studies suggesting that malaria susceptibility among HIV patients is influenced more by immune status than by ART duration (Parikh *et al*., 2016; Nnimbo *et al*., 2023; Enuma *et al*., 2022). However, NNRTI- and PI-based ARTs showed significant associations with malaria outcomes, corroborating research that suggests some ART types provide indirect protective effects against malaria (Kasirye et al., 2017; Azevedo et al., 2020).

The ranking of reasons for missing medication, particularly "daily intake becoming a burden" and "religious fasting," is consistent with prior research on medication adherence. Studies show that medication fatigue is a key factor leading to non-adherence among patients with chronic illnesses (Chia, 2008; Ingersoll and Cohen, 2008). Religious fasting as a reason for non-adherence has been reported in studies among Muslim populations, where fasting periods interfere with regular ART intake (Trepanowski *et al*., 2022; Trabelsi *et al*., 2022). "Forgetfulness" is another highly ranked factor, similar to findings from medication adherence studies that highlight the role of cognitive burden and lack of reminders in missed doses (Altmann *et al*., 2022). Moreover, "lack of privacy" and "stigma" align with research showing that HIV-related stigma significantly reduces ART adherence (Gillette *et al*., 2023; Stecher *et al*., 2023).

Key socioeconomic barriers indicated in this study include financial constraints, transportation issues, and unpleasant treatment from health officials. These findings align with WHO reports indicating that financial hardship is one of the biggest impediments to treatment adherence in low-income settings (Syed *et al.*, 2013; Biddell *et al.*, 2023). Patients facing long travel distances and inconvenient clinic schedules also struggle with adherence, which aligns with studies showing that decentralizing ART services improves medication adherence rates (Moomba *et al.*, 2019; Buh *et al.*, 2023). The effect of unpleasant healthcare interactions is also documented in literature, where negative experiences with health providers discourage patients from attending follow-up visits (Lonnie *et al.*, 2021; Eriksen *et al*., 2023).

CONCLUSION

The findings from these tables align with existing literature on medication adherence, malaria treatment, and socioeconomic barriers in healthcare. Strengthening malaria prevention strategies, addressing ART-related side effects, and improving healthcare accessibility are essential for enhancing treatment adherence and patient outcomes. The results emphasize the need for targeted interventions, such as patient education, improved healthcare provider interactions, and community-based support to address these barriers.

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