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IMPACT OF PACK CELL VOLUME (PCV) WITH MALARIA INFECTION AMONG HIV POSITIVE INDIVIDUALS AT GENERAL HOSPITAL NASARAWA TOWN, NASARAWA STATE NIGERIA

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Abstract

In Nigeria and Sub- Sahara Africa *Plasmodium* species causing malaria among Human Immunodeficiency Virus (HIV) is of public health concern where both diseases are prevalent. *Plasmodium* as a genus of protozoan parasite transmits malaria through the bite of infected female *Anopheles* mosquitoes. This study examined the prevalence and species distribution of *Plasmodium* causing malaria infection and its effect on packed cell volume (PCV) among HIV-positive patients attending General Hospital Nasarawa town, Nasarawa State, Nigeria, and associated socio-demographic factors. A hospital-based cross-sectional design was adopted, and 400 HIV-positive patients were recruited for twelve-month using a systematic random sampling technique. Thick and thin blood films were stained with Giemsa and examined microscopically for parasite detection, species identification, and density estimation, while PCV was determined using the microhaematocrit method. Data were analysed in SPSS version 27.0 using Anova tests, with statistical significance set at p <0.05. Out of the 400 patients examined, 176 (44.0%) tested positive for malaria parasites. *Plasmodium falciparum* was the predominant species (36.3%), followed by *P. malariae* (4.5%), *P. ovale* (1.8%), and

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mixed infections (1.5%) ($p < 0.001$). Mean PCV declined with infection, falling to 29.5% among patients infected with *P. falciparum* and to 27.9% among those with mixed infections, while 38.6% of malaria-positive patients had PCV values between 25% and 30% ($p = 0.001$). Malaria infection was significantly associated with gender ($p = 0.005$), age ($p = .001$), educational level ($p = .001$), and occupation ($p = .004$), with the highest prevalence recorded among male patients, aged 18-29 years, individuals with no formal education, and farmers. These findings indicate that malaria remains a considerable opportunistic burden with measurable pack cell volume consequences among HIV-positive patients in Nasarawa town. Strengthened integrated malaria-HIV control programmes, routine PCV monitoring, and targeted health education for the most vulnerable socio-demographic groups are recommended to reduce this burden.

Introduction

In Nigeria and Sub- Sahara Africa *Plasmodium* species as a major cause of malaria infection among HIV is of public health concern where both are prevalent. *Plasmodium* as a genus of protozoan parasite transmits malaria through the bite of infected female *Anopheles* mosquitoes. Human malaria is primarily caused by five recognised species, namely *Plasmodium falciparum*, *Plasmodium vivax*, *Plasmodium* malariae, *Plasmodium ovale*, and *Plasmodium knowlesi*. Among these species, *P. falciparum* remains the most virulent and epidemiologically significant in sub-Saharan Africa, accounting for the majority of malaria-related morbidity and mortality (WHO, 2024). The parasite is transmitted through the bite of infected female *Anopheles* mosquitoes and undergoes a complex life cycle involving hepatic and erythrocytic stages in humans. During the blood stage of infection, parasites invade red blood cells, leading to their destruction and contributing to anaemia, reduced packed cell volume, and other haematological complications commonly associated with malaria.

The interaction between *Plasmodium* species and HIV infection is of particular concern in areas where perennial malaria transmission sustains continuous exposure. HIV-induced immunosuppression may enhance malaria susceptibility and severity, while recurrent malaria episodes can exacerbate HIV progression through increased immune activation (Flateau *et al*., 2021). Malaria-associated haemolysis and bone marrow suppression further compound the haematological deficits already present in HIV patients, often manifesting as severe malaria reflected in significantly reduced PCV values (Ojurongbe *et al*., 2022). Packed Cell Volume, also referred to as haematocrit, is a reliable and practical indicator of anaemia and overall haematologic health in both malaria- and HIV-infected individuals

(Kavishe *et al*., 2021), and its monitoring is essential for evaluating disease severity and treatment response in co-infected populations.

Statement of the Problem

Plasmodium species, the causative agents of malaria, and HIV are leading causes of morbidity and mortality in Nigeria, with significant overlap in endemic regions such as Nasarawa State. Despite concerted public health interventions, both infections continue to persist and interact synergistically (Ojurongbe *et al*., 2022). HIV patients are particularly vulnerable to the adverse packed cell volume effects of malaria, which may exacerbate immune deficiency and reduce quality of life. However, there remains limited empirical data at General Hospital Nasarawa town on the distribution of *Plasmodium* species and their pack cell volume impact among HIV-positive patients, a gap that constrains evidence-based clinical decision-making and policy formulation. This study was therefore designed to address this gap by determining the prevalence and distribution of *Plasmodium* species causing malaria infection and assessing their effect on pack cell volume and demographic factors among HIV-positive patients attending the facility.

Study Area

The study was conducted at General Hospital Nasarawa Town, located in Nasarawa Local Government Area of Nasarawa State, North Central Nigeria. Nasarawa town lies approximately between latitude 8°32′ North and longitude 7°42′ East and serves as one of the historic administrative and commercial centres within the state. The area experiences a tropical wet and dry climate, with rainfall occurring mainly between April and October and a prolonged dry season from November to March. Temperatures are generally high throughout the year, ranging between 24°C and 36°C. These climatic conditions support continuous mosquito breeding and favour perennial malaria transmission, and the hospital, as a referral health facility, provides care to a substantial number of HIV-positive patients drawn from the town and its surrounding rural communities.

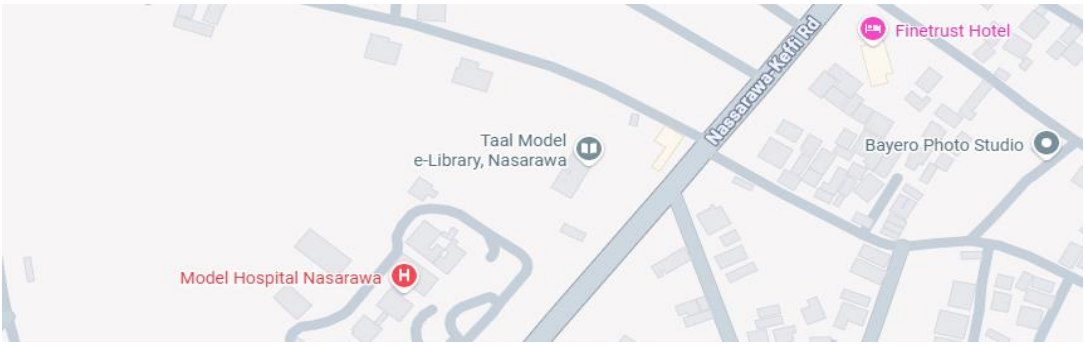


Fig. 1: Map of Nasarawa Local Government Area showing Nasarawa Town indicating General Hospital as Study Area

Research Design

A hospital-based cross-sectional design, complemented with laboratory analyses, was adopted to capture epidemiological and clinical data concurrently. This design was suitable for establishing the prevalence and distribution of *Plasmodium* species causing malaria infection among HIV patients at a specific point in time and for assessing associations with packed cell volume and demographic factors.

Duration of Study

The study was conducted for a period of one year, (August, 2025 – July, 2026) covering both the dry and rainy seasons.

Study Population

The target population consisted of adult HIV-positive patients (≥ 18 years) attending the antiretroviral therapy (ART) clinic of General Hospital, Nasarawa, during the study period. Both newly diagnosed patients and those on antiretroviral therapy for varying durations were eligible for inclusion, provided they gave informed consent. Patients with severe infection such as tuberculosis, sickle cell disease, or chronic renal failure, as well as those below 18 years of age, were excluded.

Sample Size Determination

The minimum sample size for the study was determined using Cochran's (2020) formula for sample size estimation in a population with unknown proportion:

$$n = Z^2 p(1 - p) / d^2$$

Where n is the required sample size, Z is the standard normal deviate at the 95% confidence level (1.96), p is the estimated prevalence (0.5), and d is the margin of error (0.05). Substituting these values gave a minimum sample size of 384, which was adjusted upward to 400 to accommodate an anticipated non-response rate and to align with the proportional clinic-attendance quota allocated to General Hospital Nasarawa. A total of four hundred (400) HIV-positive patients were therefore recruited into the study.

Sampling Technique

A systematic random sampling technique was employed. The clinic attendance register was used as the sampling frame, and every third HIV-positive patient meeting the inclusion criteria was selected until the hospital quota of 400 was filled. This approach reduces selection bias compared with convenience sampling and ensures that all eligible patients have a known chance of inclusion.

Ethical Approval and Clearance

Ethical clearance for the study was obtained from the Department of Zoology, Nasarawa State University, Keffi, and authorisation was sought from the management of General Hospital, Nasarawa town, prior to data collection. Written informed consent was obtained from all patients and consent forms were stored separately from the data collection instruments to preserve confidentiality.

Data Collection Procedures

A structured interviewer-administered questionnaire was used to capture patients socio-demographic factors (age, gender, education, occupation), with laboratory confirmations obtained where available within the preceding eight months.

Blood Sample Collection and Laboratory Procedures

Finger prick was used after cleaning the finger with 70% alcohol and allowing it to air dry, a sterile lancet was used to obtain blood for the preparation of thick and thin blood films on clean, grease-free slides. The films were air-dried and stained with 3% Giemsa stain (pH 7.0-7.2) for 30 minutes, following the standard procedure of Cheesbrough (2017). Stained slides were examined microscopically under oil-immersion (x100) objectives; thick films were used for parasite detection and density estimation, while thin films were used for species identification. A slide was declared negative after examination of 200 high-power fields without detecting parasites. Packed cell volume (PCV) was determined by centrifuging blood collected into microhaematocrit capillary tubes at 12,000 rpm for five minutes and reading the packed red cell column using a haematocrit reader; values below 30% were classified as parasites in accordance with WHO (2011) criteria.

Data Analysis

Data generated from the study were coded and entered into SPSS version 27.0 for analysis. Descriptive statistics (frequencies, percentages and means) were used to summarise clinical variables and demographic, while ANOVA test was used to test for associations between categorical variables. A p-value of less than 0.05 was considered statistically significant at a 95% confidence interval.

Results

A total of 400 HIV-positive patients examined at General Hospital Nasarawa. *P. falciparum* was the predominant malaria parasite identified, with 145 patients (36.3%) testing positive followed by *P. malariae*, which was detected in 18 patients (4.5%), while *P. ovale* was identified in 7 patients (1.8%). Mixed *Plasmodium* infections were observed in 6 patients (1.5%). Overall, 176 patients (44.0%) were infected with malaria parasites. The statistical

analysis showed a statistically significant difference in the distribution of malaria infection categories ($p < 0.001$) Table 1. Mixed infections recorded the lowest mean PCV (27.9%), followed by *P. falciparum* (29.5%), while *P. malariae* (32.2%) and *P. ovale* (33.1%) had comparatively higher mean values. Most *P. falciparum* and mixed infection cases had PCV values between 25 and 30%, whereas *P. malariae* infections were more frequently associated with PCV values of 31–35%. The mean PCV showed significant difference across the *Plasmodium* infection groups ($p = 0.001$) Table 2. Male patients constituted a slightly higher proportion of malaria-positive cases (51.7%) than females (48.3%), with gender showing a statistically significant association with *Plasmodium* species distribution ($p = 0.005$). Malaria infection was most prevalent among patients aged 18–29 years (31.8%), followed by those aged 30–39 years (28.4%), and the age distribution was statistically significant ($p = 0.001$). Patients with no formal education had the highest proportion of malaria-positive cases (32.4%), followed by those with secondary (26.1%), primary (22.2%), and tertiary education (19.3%), indicating a significant association between educational level and *Plasmodium* species distribution ($p = 0.001$). Farmers accounted for the highest proportion of malaria-positive HIV patients (40.3%), followed by traders (33.5%) and civil servants (26.1%), with occupation also showing a statistically significant association with *Plasmodium* species distribution ($p = 0.004$).

Table 1: Distribution of *Plasmodium* Species Among HIV-Positive Patients in General Hospital Nasarawa Town

Site for Total Samples Collected	Number Examined	*Plasmodium* Species			Mixed Infection No. Infected (%)	Total No. Infected (%)	p-value
		P. falciparum No. Infected (%)	*P. malariae* No. Infected (%)	*P. ovale* No. Infected (%)			
GHN	400 HIV+	145 (36.3)	18 (4.5)	7 (1.8)	6 (1.5)	**176 (44.0)**	<0.001

Key: GHK = General Hospital Keffi; % = Percentage; No. = Number
P. value <0.001 statistically significant at 95% confidence interval

Table 2: Mean Packed Cell Volume (PCV) and Distribution of PCV Categories Among *Plasmodium* Species in HIV-Positive Patients Attending General Hospital Nasarawa Town

PCV Category (%)	*P. falciparum* n (%)	*P. malariae* n (%)	*P. ovale* n (%)	Mixed Infection n (%)	Total n (%)	p-value
Mean PCV (%)	**29.5**	**32.2**	**33.1**	**27.9**	**30.7**	**0.001**
< 25	23 (15.9)	2 (11.1)	1 (14.3)	1 (16.7)	**27 (15.3)**	
25-30	58 (40.0)	5 (27.8)	2 (28.6)	3 (50.0)	**68 (38.6)**	
31-35	48 (33.1)	7 (38.9)	2 (28.6)	1 (16.7)	**58 (33.0)**	
> 35	16 (11.0)	4 (22.2)	2 (28.6)	1 (16.7)	**23 (13.1)**	
Total	**145 (100.0)**	**18 (100.0)**	**7 (100.0)**	**6 (100.0)**	**176 (100.0)**	

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Key: % = Percentage; HIV = Human Immunodeficiency Virus

P. value 0.001 statistically significant at 95% confidence interval

Table 3: Distribution of Demographic Factors Among HIV-Positive Patients According to *Plasmodium* Species in General Hospital Nasarawa Town

Demographic Variable	*P. falciparum* No. Positive (%)	*P. malariae* No. Positive (%)	*P. ovale* No. Positive (%)	Mixed Infection No. Positive (%)	Total No. Positive (%)	p-value
Gender						
Male	75 (51.7)	9 (50.0)	4 (57.1)	3 (50.0)	**91 (51.7)**	**0.005**
Female	70 (48.3)	9 (50.0)	3 (42.9)	3 (50.0)	**85 (48.3)**	
Age Group (Years)						
18-29	46 (31.7)	6 (33.3)	2 (28.6)	2 (33.3)	**56 (31.8)**	**0.001**
30-39	41 (28.3)	5 (27.8)	2 (28.6)	2 (33.3)	**50 (28.4)**	
40-49	33 (22.8)	4 (22.2)	2 (28.6)	1 (16.7)	**40 (22.7)**	
≥ 50	25 (17.2)	3 (16.7)	1 (14.2)	1 (16.7)	**30 (17.1)**	
Educational Level						
No. Formal Education	47 (32.4)	6 (33.3)	2 (28.6)	2 (33.3)	**57 (32.4)**	**0.001**
Primary Education	32 (22.1)	4 (22.2)	2 (28.6)	1 (16.7)	**39 (22.2)**	
Secondary Education	38 (26.2)	5 (27.8)	2 (28.6)	1 (16.7)	**46 (26.1)**	
Tertiary Education	28 (19.3)	3 (16.7)	1 (14.2)	2 (33.3)	**34 (19.3)**	
Occupation						
Farmers	59 (40.7)	7 (38.9)	3 (42.9)	2 (33.3)	**71 (40.3)**	**0.004**
Traders	49 (33.8)	6 (33.3)	2 (28.6)	2 (33.3)	**59 (33.5)**	
Civil Servants	37 (25.5)	5 (27.8)	2 (28.6)	2 (33.3)	**46 (26.1)**	
Total	**145 (100)**	**18 (100)**	**7 (100)**	**6 (100)**	**176 (100)**	

Key: % = Percentage; ≥ = Greater than or equal to

P. value 0.005 statistically significant at 95% confidence interval

Discussion

The findings revealed that malaria remained a significant burden among HIV-positive patients attending General Hospital Nasarawa town, with an overall prevalence of 44.0% (176/400) ($p < 0.001$). This is comparable to the 41.5% co-infection prevalence reported by the National Agency for the Control of AIDS (NACA, 2022) in its national HIV/AIDS indicator and impact survey, and is higher than the 26.8% general-population malaria prevalence reported for North-Central Nigeria by the Nigeria Centre for Disease Control (NCDC, 2022), reinforcing that HIV-positive individuals carry a disproportionately higher malaria burden than the general population which is lower than the 48.6% prevalence reported by

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Ojurongbe *et al.* (2022) among malaria-HIV co-infected patients in southwestern Nigeria, suggesting that facility-level and geographic differences continue to shape the extent of co-infection burden across Nigerian health institutions. *Plasmodium falciparum* was the predominant species identified, accounting for 145 (36.3%) of the participants examined, followed by *P. malariae* (4.5%), *P. ovale* (1.8%) and mixed infections (1.5%) ($p < 0.001$). This predominance is consistent with the findings of Oboh *et al.* (2023), who reported a closely comparable *P. falciparum* prevalence of 34.6% among HIV-positive individuals in North-Central Nigeria, affirming *P. falciparum* as the principal malaria parasite circulating within this population. The proportion of non-falciparum infections recorded in this study is broadly consistent with Abdulraheem *et al.* (2022), who reported *P. malariae* and *P. ovale* detection rates of 5.4% and 2.7% respectively using molecular methods in West Africa, figures only marginally higher than those obtained by conventional microscopy in the present study, an expected difference given the greater sensitivity of molecular diagnostic techniques for low-density non-falciparum infections. The mixed-infection rate of 1.5% recorded here is also comparable to the 2.1% mixed-infection frequency reported by Ndamukong-Nyanga *et al.* (2022) among immunocompromised patients in Central Africa, who attributed such co-infections to sustained mosquito exposure combined with HIV-related suppression of protective immune clearance mechanisms.

The mean PCV declined progressively across malaria infection categories, from 33.1% among patients infected with *P. ovale* and 32.2% among those with *P. malariae*, to 29.5% among patients infected with *P. falciparum*, and to the lowest value of 27.9% among patients with mixed infections ($p = 0.001$). This pattern is consistent with White *et al.* (2022), who reported mean PCV reductions of between 8 and 11 percentage points below baseline among patients with severe malaria, and is closely comparable to the mean PCV of 28.6% documented among malaria-HIV co-infected patients by (Ojurongbe *et al.*, 2022). The finding that 38.6% of malaria-positive patients in this study recorded PCV values between 25% and 30%, with only 13.1% maintaining PCV values above 35% (Table 2, $p = 0.001$), aligns with (Kavishe *et al.*, 2021), who linked oxidative stress arising from parasite-induced haemolysis to sustained reductions in packed cell volume of a similar magnitude among malaria patients on artemisinin-based therapy. The comparatively lower PCV recorded among patients with mixed infections further mirrors the observation of (Alemu *et al.,* 2021), who reported that approximately 30.0% of high parasite-density cases in their Ethiopian cohort were classified as moderately to severely anaemic, a proportion consistent with the compounded PCV burden of concurrent-species infection observed in this study.

Analysis of socio-demographic factors showed that malaria infection was slightly more prevalent among male patients (51.7%) than female patients (48.3%) ($p = 0.005$), a distribution broadly comparable to national trends reported by UNAIDS (2023), which

similarly documented a modestly higher HIV-malaria co-infection burden among males across sub-Saharan Africa, attributed largely to greater occupational and outdoor exposure rather than differences in biological susceptibility. The ages of 18-29 years had the highest prevalence (31.8%), followed by 30-39 years (28.4%), while the lowest prevalence occurred among patients aged 50 years and above (17.1%) ($p = 0.001$). This trend is consistent with (Tadesse *et al.*, 2023), who reported peak malaria prevalence of 33.0% among HIV-positive aged 20-29 years, with prevalence declining to approximately 18.0% among those aged 50 years and above, attributing the decline in older adults to gradually acquired residual immunity from repeated malaria exposure over the life course. Educational level was also significantly associated with malaria infection ($p = 0.001$), patients with no formal education had the highest prevalence (32.4%) and those with tertiary education showed the lowest (19.3%). This inverse relationship is consistent with (Okonkwo *et al.*, 2020), who reported a comparable prevalence of 34.0% among HIV-infected individuals with no formal education compared with 17.5% among those with tertiary education in their Nigerian cohort, reinforcing that educational attainment strongly shapes malaria prevention knowledge and treatment-seeking behaviour among HIV-positive populations. Similarly, occupation was significantly associated with malaria infection ($p = 0.004$), farmers had the highest prevalence (40.3%), followed by traders (33.5%), while civil servants showed the lowest prevalence (26.1%). This pattern is consistent with Nwosu *et al.* (2021), who reported a comparable farmer prevalence of 43.0% in rural Nigerian communities, more than 20 percentage points above the 21.5% prevalence indicated among civil servants in this study, due to prolonged farmland exposure during peak mosquito biting hours.

Conclusion

Conclusively, this study assessed the prevalence and species distribution of *Plasmodium* (Malaria) infection and its impact on packed cell volume among HIV-positive patients attending General Hospital Nasarawa town, alongside associated socio-demographic factors. 400 HIV-positive patients examined, 176 (44.0%) tested positive for malaria parasites, with *Plasmodium falciparum* identified as the predominant species, followed by *P. malariae*, *P. ovale*, and mixed infections at considerably lower frequencies. Malaria infection was associated with a measurable decline in packed cell volume. Socio-demographic analysis revealed that male patients aged 18-29 years, no formal education and farmers showed the highest prevalence of infection.

Recommendations

Continuous health education programmes should be organised to improve awareness of malaria prevention, use of Insecticide treated Nets, early diagnosis, and prompt

treatment among HIV-positive patients, especially those with limited formal education. Future investigations should incorporate advanced molecular diagnostic techniques, including polymerase chain reaction (PCR) to improve detection of mixed-species infections, low-density parasitaemia, and emerging *Plasmodium* species.

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Conflict of Interest

Authors declare no competing interest.

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