CME LIVE OPEN ACCESS

CME Journal of Medical Microbiology

Research Article ISSN: 3070-3638

Hospital-Based Survey of Malaria and Anemia Among Children 6–10 Years and Pregnant Women in Nkanu West Local Government Area, Enugu State, Nigeria

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Received: 2026 Jan 16 **Accepted:** 2026 Feb 04 **Published:** 2026 Feb 16

Abstract

Background: *Malaria remains a significant public health concern, disproportionately impacting vulnerable populations in resource-limited settings.*

Methods: *A study conducted in Nkanu West Local Government Area examined malaria prevalence and related anemia among children aged 6-10 years and pregnant women attending a hospital. The research employed a cross-sectional, hospital-based design, using both microscopy and rapid diagnostic tests (RDTs) to evaluate malaria cases. Microscopy enabled detailed detection of parasites, while RDTs provided quick and supplementary diagnostics.*

Result: *This study revealed an alarming malaria prevalence of 70.3% in children and 65.5% in pregnant women. Microscopy prevalence slightly increased with age ($r=0.118$, $p<0.05$), while RDT decreased ($r=-0.157$, $p<0.01$). Among 10-year-olds and above, females had a significantly higher prevalence (78.5%) than males (55.2%) ($\chi^2=7.576$, $p<0.05$). There were significant differences in prevalence by sex ($p=0.005$), but not by age ($p=0.400$) and location ($p=0.228$) among children. Among pregnant women, no significant differences were found concerning age, trimester, or location. Malaria was linked to increased packed cell volume, especially in women in their third trimester, indicating hematological impact. Mean PCV of children with malaria varies significantly by age, with 5-9 year-olds having a higher mean PCV (37.65±0.90%) than other age groups ($t=2.434$, $p=0.059$).*

Conclusion: *Malaria remains a threat to children and pregnant women, requiring ongoing monitoring, community awareness, routine testing, and sanitation, especially during antenatal care. Based on our findings, priority interventions should include universal ITN distribution with sustained use, intensified vector control and larval source management in high-burden areas, strengthened IPTp delivery and ANC-based screening, environmental sanitation and waste management to curb breeding sites, and enhanced community surveillance to guide adaptive program planning.*

Keywords: Anemia, Children, Malaria, Pregnant Women, Local Government Area

1. Introduction

Malaria remains a significant public health challenge in Nigeria, primarily transmitted by female *Anopheles* mosquitoes infected with Plasmodium species. Among these, *P. falciparum* accounts for approximately 98-99% of cases [1]. Other species, such as *P. malariae* and *P. ovale*, also contribute to the disease burden. The principal mosquito vector species present in Nigeria, *Anopheles gambiae, Anopheles funestus, Anopheles arabiensis,* and *Anopheles melas,* are distributed throughout the country's primary ecological zones, which encompass Mangrove, Freshwater Swamp, Rain Forest, Derived Savannah, Guinea Savannah, Sudan Savannah, Sahel Savannah, and Mid-Altitude regions. *An. gambiae* and *An. funestus* exhibit widespread distribution, whereas *An. arabiensis* is typically found in drier environments, and *An. melas* is predominantly associated with coastal

mangrove ecosystems. The impact of malaria is extensive, responsible for 30-40% of outpatient visits, around 20% of childhood deaths, and significant maternal mortality, which exerts immense pressure on Nigeria's healthcare system. Socioeconomic effects include school absenteeism, reduced productivity, and an estimated annual cost of 132 billion naira. Despite global progress, persistent malaria transmission in Nigeria underscores the urgent need for intensified control strategies aligned with the Sustainable Development Goals, targeting malaria elimination by 2030. The pathophysiology of malaria is complex, especially regarding its most severe complication, malaria anemia. Parasites induce hemolysis by replicating inside and rupturing infected red blood cells (RBCs). Additional mechanisms include dysregulation of erythropoiesis, destruction of non-parasitized RBCs (nRBCs), increased apoptosis, and senescence of RBCs [2,3,4].

The immune response further accelerates RBC destruction through processes such as opsonization and complement activation. Nutritional deficiencies, particularly of iron, folate, and vitamin B12, exacerbate anemia, impairing recovery and elevating morbidity [5]. High parasite loads often impair erythropoiesis in the bone marrow, contributing to severe anemia, which is particularly prevalent in areas with high transmission rates. Vulnerable groups include young children and pregnant women, with severe cases often requiring blood transfusions during the rainy season when transmission peaks [6]. Clinical manifestation of malaria varies across Nigeria. For example, cerebral malaria sequelae are more common in the north, whereas severe anemia due to malaria predominates in the south [7,8]. Malaria transmission remains intense and stable nationwide, with classification based on spleen rates in children: hypoendemic (<10%), mesoendemic (11-50%), hyperendemic (>75% in children and >25% in adults), and holoendemic (>75% in children with low adult rates). Rural areas often experience holoendemic transmission with persistent high rates, while urban centers tend to be mesoendemic. Seasonality of malaria influences transmission intensity, incidence during the rainy season in the north and year-round in the south [9]. Control measures aimed to reduce morbidity and mortality but face challenges in measuring their true impact across sub-Saharan Africa [10]. Parasite density correlates with transmission intensity, with higher densities found in areas of high endemicity [11].

2. Methods

2.1. Study Area

The study was conducted in Nkanu West LGA, Enugu State, Nigeria, with headquarters in Agbani. Covering 225 km² in the tropical savanna zone, it has a population of about 211,500 [12]. Temperatures range from (23.1--31)°C, with annual rainfall of 1520-2030 mm. The region has a rainy season (March–October) and a dry season (November–February). Most residents are farmers cultivating yams, cassava, maize, rice, and vegetables, living in dispersed compounds surrounded by farmland and trees, e.gs, palm, mango, and banana, which increases exposure to mosquito bites and malaria risk.

2.2. Study Design

This descriptive observational study was carried out at the Hematology Clinic of the University of Nigeria Teaching Hospital, Ituku/Ozalla. Ethical clearance was obtained from the institutional-based review committee. The research team, including researchers, phlebotomists, and lab scientists, collected blood samples after obtaining consent from pregnant women and caregivers of children.

2.3. Study Population And Sample Size

The minimum sample size was calculated to be 487 participants, comprising 374 children and 113 pregnant women, based on standard prevalence and statistical formulas with a 95% confidence level and 5% margin of error. Therefore, $N = \frac{Z^2PQ}{D^2}$ where Z=95% (1.96), P=58% (0.58), q=1- 0.58 (0.42), d=5% (0.05); N=374

$N = \frac{Z^2PQ}{D^2}$, where, Z=95% (1.96), P= 92% (0.92), q=1- 0.92 (0.08), d=5% (0.05); N=113

2.4. Procedure for Sample Collection

A total volume of 2ml of venous blood was drawn from each participant using standard techniques. A tourniquet was tied around the upper arm after cleaning the site with an antiseptic wipe. A sterile needle was inserted into the vein, and blood was collected into EDTA anticoagulant bottles. After collection, the tourniquet was released, and pressure was applied with cotton wool to stop bleeding, followed by a plaster to secure the site. EDTA prevents blood clotting by chelating calcium, ensuring suitability for hematological analysis.

2.5. Preparation of Blood Films

Both thick and thin blood films were prepared for analysis.

2.6. Procedure for thin Film Preparation for Malaria Parasite Examination

A small volume of anti-coagulated blood was placed about 2cm from the slide edge. A spreader, held at a 45° angle, was gently applied to the blood droplet, spreading it evenly. The film was then fixed with methanol after air-drying. The slide was stained with alpha-phenolphthalein stain to preserve parasite morphology, aiding identification [13]. After staining, the slide was rinsed with clean water to remove excess stain for microscopic examination.

2.7. Microscopy Examination for Malaria Parasites

A high-power microscope, typically magnified between 400 and 1,000 times using an oil immersion objective, is employed to analyze both thick and thin blood films [14,15,16]. This technique remains the gold standard for detecting and identifying malaria parasites in laboratory settings.

2.8. Rapid Diagnostic Test

A Malaria Plasmodium antigen detection kit (manufactured by SD Bioline, India) was utilized for diagnostic purposes. The kit includes a test cassette, buffer, and pipette. Using the pipette, two drops of blood from the EDTA tube were placed

on the cassette, followed by three drops of buffer. After 15 minutes of incubation, the results were read: two lines (control and test) indicated a positive malaria antigen, while a single control line indicated a negative result.

2.9. Parasite Density Assessment

This was determined from Giemsa-stained thick blood smears by enumerating asexual parasites against 200 leukocytes and expressing the result as parasites per microliter of blood (p/µL) [14]. An assumed leukocyte concentration of 8,000/µL was applied to convert counts to density, using the formula: Parasite density (p/µL) = (parasites counted / 200) × 8,000. An independent second reader re-evaluated 10% of the slides to assess reliability, with any discrepancies resolved by a third reader. Slides exhibiting poor staining or unreadable fields were excluded from density analyses, and reported densities pertain only to slides of adequate quality.

• **Packed Cell Volume** Hematocrit was used to screen for anemia, suitable for large clinic populations [13]. The measurement involves centrifuging well-mixed, anti-coagulated blood in a capillary tube to separate RBCs. The tube is filled about threequarters, sealed with plasticine, and placed in a centrifuge with the sealed end away from the center. The centrifuge is spun for 5 minutes, then stopped, and the PCV is read using a hematocrit tube reader. The percentage of blood volume occupied by RBCs is calculated, providing the PCV value for each child and pregnant woman.

$$PCV\% = \frac{\text{Length of red cell column (mm)} \times 100}{\text{Length of total column (mm)}}$$

2.10. Statistical Analysis

Data were analyzed with SPSS version 23.0. Malaria prevalence was assessed using Chi-Square (IBM Corporation, Armonk, USA). Hematological differences were evaluated with ANOVA and Duncan's New Multiple Range Test. The Student's t-test compared PCV between sexes, while Pearson correlation examined associations between age, parasite infection, and demographic variables.

3. Results

3.1. Prevalence of Malaria Parasite Infection Among Children and Pregnant Women

Overall, malaria prevalence was 70.3% in children and 65.5% in pregnant women. Significant differences in prevalence were observed by sex (p=0.005), but not by age (p=0.400) and location (p=0.228) among children (Table 1). Among pregnant women, no significant differences were found concerning age, trimester, or location. However, higher infection rates were noted in women aged 26–30 years (75.0%), in the first trimester (71.8%), and residing in the Obe community (71.4%) (Table 2).

Indices	Variable	Total Examined	Prevalence (%)
Age (years)	5-9	251	180(71.7)
	≥10	123	83(67.5)
	Total	374	263(70.3)
			χ^2=0.709, p=0.400
Sex	Male	171	108(63.2)
	Female	203	155(76.4)
	Total	374	263(70.3)
			χ^2=7.745, p=0.005*
Location	Ituku/Ozalla	133	99(74.4)
	Obe	69	48(69.6)
	Umueze	80	58(72.5)
	Agbani	92	58(63.0)
	Total	374	263(70.3)
			χ^2=4.329, p=0.228

*Significant at p<0.05

Table 1: Overall Prevalence of Malaria Infection Among Children in the Study Area

Citation: Okwuonu, E. S., Nwankwocha, C. P., Ukwueze, C. B., Opah, A. O., Ogbonna, I. D., et al. (2026). Hospital-Based Survey of Malaria and Anemia Among Children 6–10 Years and Pregnant Women in Nkanu West Local Government Area, Enugu State, Nigeria. *CME J Med Microbiol, 3*(1), 1-14.

Indices	Category	Total Examined	Prevalence (%)
Age	21–25	19	12(63.2)
	26–30	36	27(75.0)
	31–35	28	19(67.9)
	36–40	20	9(45.0)
	41–45	10	7(70.0)
	Total	113	74(65.5)
			χ^2=5.361, p=0.252
Trimester	1–3	39	28(71.8)
	4–6	44	31(70.5)
	7–9	30	15(50.0)
	Total	113	74(65.5)
			χ^2=4.351, p=0.114
Location	Ituku/Ozalla	38	26(68.4)
	Obe	28	20(71.4)
	Umueze	18	10(55.6)
	Agbani	29	18(62.1)
	Total	113	74(65.5)
			χ^2=1.518, p=0.678

*Significant at p<0.05

Table 2: Overall Prevalence of Malaria Infection Among Pregnant Women in the Study Area

There is no significant difference in malaria prevalence across locations. Among 10-year-olds and above, females had a significantly higher prevalence (78.5%) than males (55.2%) (χ^2=7.576, p<0.05) (Table 3). There is no significant sex-related difference in prevalence among children aged 5–9 years. Parasitemia levels did not differ significantly between sexes. Low parasitemia levels were most common in children aged 5–9, with not less than 50% prevalence for both male and female (Table 4).

Age	Variable	Category	Total Examined	Prevalence (%)	χ^2	p-value
5-9	Location	Ituku/Ozalla	79	60(75.9)	2.162	**0.539**
		Obe	53	39(73.6)		
		Umueze	59	43(72.9)		
		Agbani	60	38(65.0)		
	Sex	Male	113	76(67.3)	2.012	**0.156**
		Female	138	104(75.4)		
≥10	Location	Ituku/Ozalla	54	38(70.4)	0.897	**0.826**
		Obe	16	10(62.5)		
		Umueze	21	15(71.4)		
		Agbani	32	20(62.5)		
	Sex	Male	58	32(55.2)	7.576	**0.005***
		Female	65	51(78.5)		

*Significant at p<0.05

Table 3: Prevalence of Malaria Infection Among Children in the Study Area According to Location and Sex

Age	Sex	Parasitaemia levels				Total (%)
		Low (+)	Medium (++)	High (+++)	Very High (++++)	
5-9	Male	40(52.6)	21(27.6)	15(19.7)	0(0.0)	76(42.2)
	Female	52(50.0)	32(30.8)	19(18.3)	1(1.0)	104(57.8)
	Total	92(51.1)	53(29.4)	34(18.9)	1(0.6)	180(100.0)
					χ^2=0.987, p=0.804	
≥10	Male	12(37.5)	15(46.9)	5(15.6)	0(0.0)	32(38.6)
	Female	27(52.9)	18(35.3)	6(11.8)	0(0.0)	51(61.4)
	Total	39(47.0)	33(39.8)	11(13.3)	0(0.0)	83(100.0)
					χ^2=1.882, p=0.390	

*Significant at p<0.05; [+=10-90 parasites/µl; ++=100-1,000 parasites/µl; +++=1,000-10,000 parasites/µl; ++++=>10,000 parasites/µl]

Table 4: Prevalence of Malaria Parasitemia Among Children in the Study Area According to Sex and Age.

There are no significant differences (p>0.05) in malaria prevalence among pregnant women across locations or trimesters (Table 5). Notably, higher prevalence was observed among first-trimester women in Ituku/Ozalla (85.7%) and Umueze (80.0%), while Agbani had a higher prevalence in the second trimester (70%). Malaria parasitemia levels did not significantly vary by age or pregnancy stage. Low parasitemia was more common in Ituku/Ozalla (42.3%), Obe (40.0%), and Umueze (50.0%) (Table 6).

Location	Variable	Category	Total Examined	Prevalence (%)	χ^2	p-value
Ituku/Ozalla	Age	21-25	5	3(60.0)	1.885	**0.757**
		26-30	15	10(66.7)		
		31-35	9	7(77.8)		
		36-40	7	4(57.1)		
		41-45	2	2(100.0)		
	Trimester	First	14	10(71.4)	0.754	**0.686**
		Second	21	14(66.7)		
		Third	3	2(66.7)		
Obe	Age	21-25	4	4(100.0)	7.014	**0.135**
		26-30	9	8(88.9)		
		31-35	11	6(54.5)		
		36-40	3	1(33.3)		
		41-45	1	1(100.0)		
	Trimester	First	12	9(75.0)	0.316	**0.854**
		Second	7	5(71.4)		
		Third	9	6(66.7)		
Umueze	Age	21-25	1	0(0.0)	7.166	**0.127**
		26-30	5	4(80.0)		
		31-35	3	3(100.0)		
		36-40	8	3(37.5)		
		41-45	1	0(0.0)		
	Trimester	First	5	3(60.0)	1.810	**0.405**
		Second	6	4(66.7)		
		Third	7	3(42.9)		

Agbani	Age	21-25	9	5(55.6)	0.609	**0.962**
		26-30	7	5(71.4)		
		31-35	5	3(60.0)		
		36-40	2	1(50.0)		
		41-45	6	4(66.7)		
	Trimester	First	8	5(62.5)	1.395	**0.498**
		Second	10	7(70.0)		
		Third	11	6(54.5)		

*Significant at $p<0.05$

Table 5: PPrevalence of Malaria Infection Among Pregnant Women in the Study Area According to Age and Location

Location	Variable	Category	Parasitemia levels				Total (%)
			Low (+)	Medium (++)	High (+++)	Very High (++++)	
Ituku/Ozalla	Age	21-25	2(66.7)	1(33.3)	0(0.0)	0(0.0)	3(11.5)
		26-30	3(30.0)	4(40.0)	3(30.0)	0(0.0)	10(38.5)
		31-35	4(57.1)	1(14.3)	1(14.3)	1(14.3)	7(26.9)
		36-40	2(50.0)	2(50.0)	0(0.0)	0(0.0)	4(15.4)
		41-45	0(0.0)	0(0.0)	2(100.0)	0(0.0)	2(7.7)
						χ^2=13.943, p=0.304	
	Trimester	First	4(33.3)	3(27.3)	3(25.0)	1(8.3)	11(42.3)
		Second	5(38.5)	5(38.5)	3(23.1)	0(0.0)	13(50.0)
		Third	2(100.0)	0(0.0)	0(0.0)	0(0.0)	2(6.7)
						χ^2=4.708, p=0.582	
Obe	Age	21-25	1(25.0)	2(50.0)	1(25.0)	0(0.0)	4(20.0)
		26-30	3(37.5)	3(37.5)	2(25.0)	0(0.0)	8(40.0)
		31-35	4(66.7)	1(16.7)	1(16.7)	0(0.0)	6(30.0)
		36-40	0(0.0)	0(0.0)	1(100.0)	0(0.0)	1(5.0)
		41-45	0(0.0)	0(0.0)	1(100.0)	0(0.0)	1(5.0)
						χ^2=7.465, p=0.487	
	Trimester	First	4(50.0)	2(25.0)	3(33.3)	0(0.0)	9(45.0)
		Second	1(25.0)	2(50.0)	2(40.0)	0(0.0)	5(25.0)
		Third	3(50.0)	2(33.3)	1(16.7)	0(0.0)	6(30.0)
						χ^2=3.324, p=0.505	
Umueze	Age	26-30	1(25.0)	2(50.0)	1(25.0)	0(0.0)	4(40.0)
		31-35	1(33.3)	1(33.3)	1(33.3)	0(0.0)	3(30.0)
		36-40	3(100.0)	0(0.0)	0(0.0)	0(0.0)	3(30.0)
						χ^2=4.528, p=0.339	
	Trimester	First	1(25.0)	1(25.0)	2(50.0)	0(0.0)	4(40.0)
		Second	2(50.0)	2(50.0)	0(0.0)	0(0.0)	4(40.0)
		Third	2(100.0)	0(0.0)	0(0.0)	0(0.0)	2(20.0)
						χ^2=6.875, p=0.143	
Agbani	Age	21-25	2(40.0)	2(40.0)	1(20.0)	0(0.0)	5(27.8)
		26-30	0(0.0)	2(40.0)	3(60.0)	0(0.0)	5(27.8)
		31-35	1(33.3)	1(33.3)	1(33.3)	0(0.0)	3(16.7)

		36-40	0(0.0)	0(0.0)	1(100.0)	0(0.0)	1(5.6)
		41-45	2(50.0)	1(25.0)	1(25.0)	0(0.0)	4(22.2)
						χ^2=5.444, p=0.709	
	Trimester	First	2(33.3)	1(16.7)	3(50.0)	0(0.0)	6(33.3)
		Second	2(28.6)	3(42.9)	2(28.6)	0(0.0)	7(38.9)
		Third	1(20.0)	2(40.0)	2(40.0)	0(0.0)	5(31.2)
						χ^2=0.444, p=0.979	

*Significant at p<0.05; [+=10-90 parasites/µl; ++=100-1,000 parasites/µl; +++=1,000-10,000 parasites/µl; ++++=>10,000 parasites/µl].

Table 6: Prevalence of Malaria Parasitemia Among Pregnant Women in the Study Area According to Age and Trimester

3.2. Mean Values of Pcv of Children and Pregnant Women Infected with the Malaria Parasite

Figure 1 shows that the mean PCV of children with malaria varies significantly by age, with 5-9 year-olds having a higher mean PCV (37.65±0.90%) than other age groups (t=2.434, p=0.059). No significant difference in PCV was observed between boys and girls (t=0.267, p=0.790). Figure 2 shows that among children with malaria within ages of 5-9 years, there was no significant difference in PCV levels between males and females (t=0.913, p=0.397). Conversely, male children who were 10 years old and above had higher PCV (35.84±0.90%) than females (33.22±0.52%) (t=2.720, p=0.008).

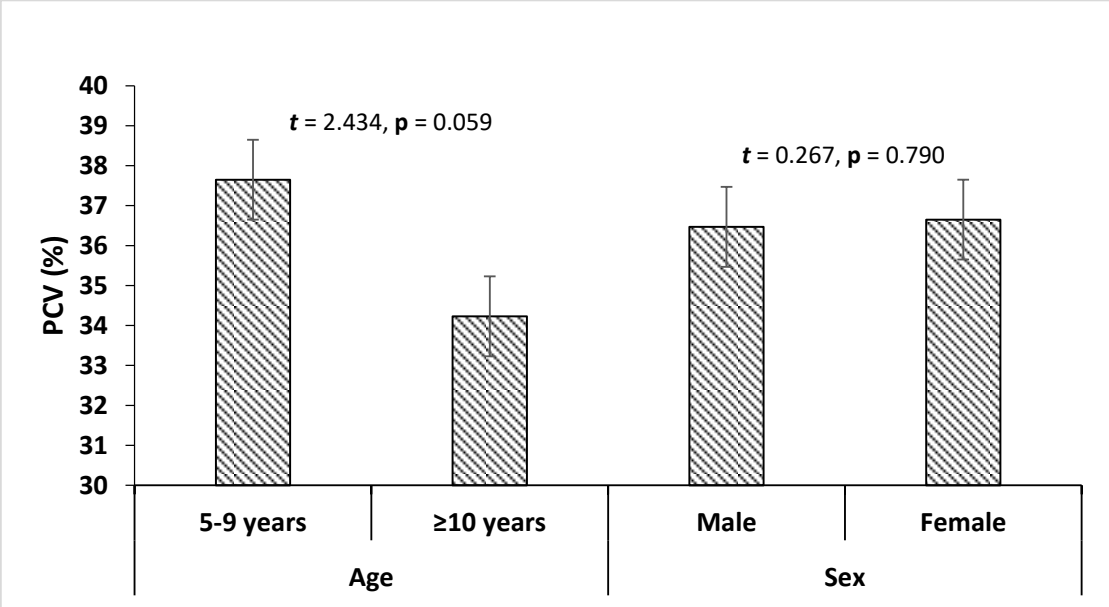


Figure 1: Overall Mean Differences of Packed Cell Volume (Pcv) Among Children with Malaria Infection in the Study Area According to Age and Sex

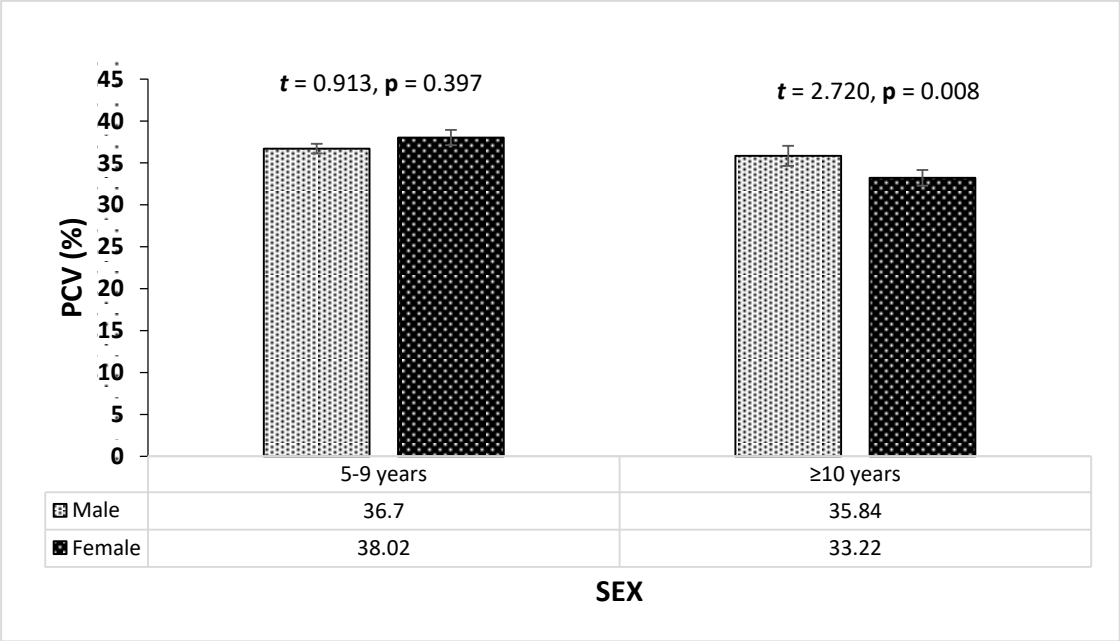


Figure 2: Mean Differences of Pcv Among Children with Malaria Infection in the Study Area According to Sex

Figure 3 shows no significant differences in mean PCV among pregnant women with malaria based on age or trimester. However, PCV was higher among women in the third trimester. Figure 4 shows no significant differences in mean PCV among pregnant women with malaria across different age groups in the study area.

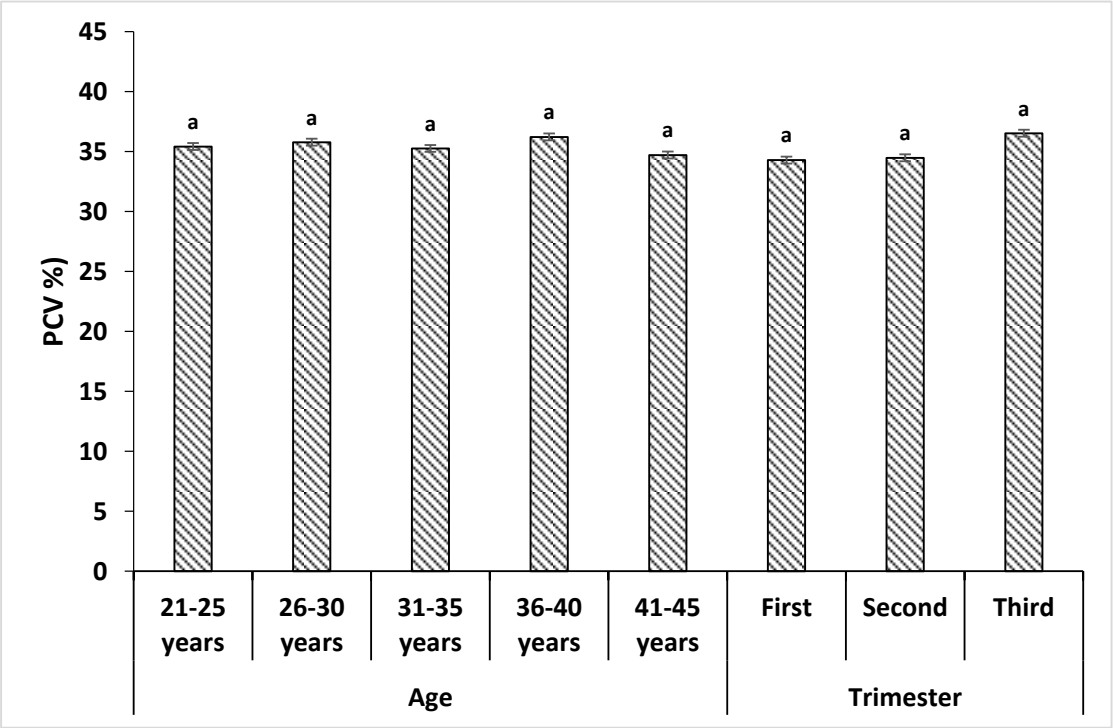
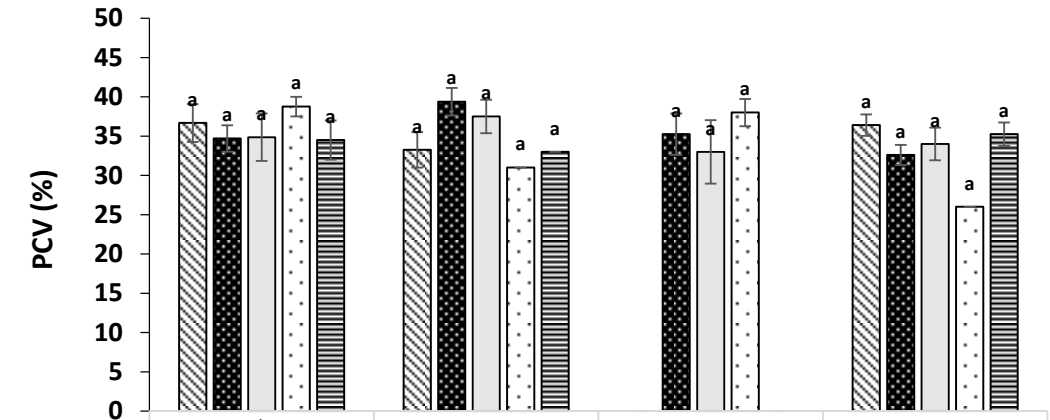


Figure 3: Overall Mean Differences of Pcv Among Pregnant Women with Malaria Infection in the Study Area According to Age and Trimester



	Ituku/Ozalla	Obe	Umueze	Agbani
21-25 years	36.67	33.25	0	36.4
26-30 years	34.7	39.38	35.25	32.6
31-35 years	34.86	37.5	33	34
36-40 years	38.75	31	38	26
41-45 years	34.5	33	0	35.25

AGE

Figure 4: Mean Differences of Pcv Among Pregnant Women with Malaria Infection in the Study Area According to Age

3.3. Correlation of Malaria Parasitemia and Pcv Among Children and Pregnant Women in the Study Area

Table 7 shows that malaria parasitemia weakly and inversely correlates with children's PCV (r–0.391, p<0.01), and age also weakly negatively correlates with PCV (r=–0.203, p<0.01). Table 8 indicates that among pregnant women, malaria parasitemia strongly and negatively correlates with PCV (r =–0.767, p<0.01).

Correlation (r)	Sex	Parasitemia	PCV	Age
Sex	1	- 0.025	0.017	0.092
Parasitemia		1	- 0.391**	0.032
PCV			1	- 0.203**
Age				1

**Significant at p<0.01

Table 7: Correlation of Demographic, Parasitemia, and Packed Cell Volume of Children in the Study Area

Correlation (r)	Age	Parasitemia	PCV	Trimester
Age	1	0.037	- 0.021	0.499**
Parasitemia		1	- 0.767**	0.042
PCV			1	- 0.147
Trimester				1

**Significant at p<0.01

Table 8: Correlation of Obstetric, Parasitemia, and Packed Cell Volume of Pregnant Women in the Study Area

3.4. Correlation of Demographic Characteristics and Malaria Prevalence by Microscopy and Rdts Among Children and Pregnant Women

Table 9 shows that age moderately correlates with malaria prevalence (p<0.01). Malaria prevalence by microscopy positively correlates with age (r= 0.118, p<0.05), while RDT prevalence inversely correlates (r=-0.157, p<0.01). Microscopy sensitivity increased with age, whereas RDT was more sensitive among younger children. There is a strong positive correlation between microscopy and RDT (r=0.659, p<0.01). Table 10 indicates that pregnancy trimester moderately correlates with malaria prevalence (p<0.01). Detection by microscopy (r=0.386) and RDT (r=0.242) both significantly correlate with trimester (p<0.01). The correlation between microscopy and RDT is also strong (r=0.626, p<0.01).

Correlation (*r*)	Age	Sex	Location	Prevalence by Microscopy	Prevalence by RDT
Age	1	0.012	0.036	0.118*	-0.157**
Sex		1	0.830**	-0.144**	-0.025
Location			1	0.152**	0.259**
Prevalence by Microscopy				1	0.659**
Prevalence by RDT					1

*,**Significant at p<0.05, p<0.01

Table 9: Correlation of Demographic Characteristics and Malaria Prevalence by Microscopy and Rapid Diagnostic Tests Among Children in the Study Area

Correlation (*r*)	Age	Parity	Location	Prevalence by Microscopy	Prevalence by RDT
Age	1	0.821*	0.040	0.089	0.038
Parity		1	0.211*	0.386**	0.242**
Location			1	0.077	0.051
Prevalence by Microscopy				1	0.626**
Prevalence by RDT					1

*,**Significant at p<0.05, p<0.01

Table 10: Correlation of Obstetric Characteristics and Malaria Prevalence by Microscopy and Rapid Diagnostic Tests Among Pregnant Women in the Study Area

4. Discussion

This hospital-based survey examined malaria-related anemia among children aged 6-10 years and pregnant women in Nkanu West LGA, Nigeria. The overall malaria prevalence was 70.3% among children, closely aligning with 71.1% reported by in semi-urban communities in Southwestern Nigeria [17]. However, the prevalence was higher than reported in some other Nigerian studies in the hospital environment [18]. These findings reinforce the World Health Organization and Nigeria Malaria Indicator Survey's assertion that malaria remains a significant public health issue globally, especially among children and pregnant women, necessitating integrated control strategies and broader efforts toward universal health coverage [19,20]. Studies from Ogun, southwestern Nigeria, and South Sudan reported higher prevalence rates of 80.5% and 78%, respectively [21,22]. Variations in malaria prevalence within Nigeria, from less than 20% in some regions to over 70% in other are influenced by geographical differences, socio-economic challenges, and disparities in malaria control interventions [23].

The elevated prevalence among children in this study may reflect environmental factors, like proximity to water bodies, drainage issues, refuse sites, and water-retaining containers, which favor mosquito breeding, especially during the rainy season. Among pregnant women, the overall malaria prevalence was 65%. Higher rates have been reported in other Nigerian studies; for example, in Port Harcourt, recorded 72%, Benin City 78.9%, while Kano State and Ile-Ife had lower figures of 39.2% and 13.1% [24,25,26,27]. Most research focused on women attending antenatal clinics, where routine screening and prophylaxis are common, highlighting the importance of healthcare access in malaria control among pregnant women. This finding is consistent with previous research indicating that anemia prevalence tends to peak during early pregnancy due to increased parasite density and immune suppression [28]. Location-specific analysis showed that Ituku/Ozalla had the highest malaria prevalence (74.4%), followed by Obe (71.4%). These high rates likely result from environmental conditions conducive to mosquito breeding, such as water-retaining containers, bushes, drainage areas, and waste sites in these communities, especially during the rainy season. Proximity to breeding habitats influences transmission rates, with environmental factors e.g. temperature and humidity also playing roles. Moreover, the highest prevalence among pregnant women was observed in the 26–30-year age group (75.0%), consistent with finding, who reported similar trends in rural Nigeria. Although no significant differences in malaria prevalence among pregnant women were observed concerning age and trimester, these factors influence anemia and hemorrhagic risks. Notably, the study found that PCV, an indicator of anemia, was higher among women in their third trimester (38.00±0.58%) [28,29]. This aligns with. work, indicating that anemia prevalence peaks during early pregnancy stages, especially in holoendemic regions, due to increased parasite density and immune suppression.

Behavioral and socioeconomic factors significantly impact malaria risk. The ownership and proper use of insecticide-treated nets can reduce malaria cases by 50-60% among children and pregnant women [30]. Socioeconomic status influences access to prevention tools, healthcare

services, and information; higher socioeconomic groups typically have better access to protection and housing, thus reducing vulnerability. Poorer communities often lack proper infrastructure, waste management, and preventive resources, leading to higher mosquito densities and increased transmission risks [31]. The study's findings on age-related differences in PCV values among children with malaria are noteworthy. Children aged 5-9 years had higher PCV values compared to older children, likely due to the development of partial immunity and reduced anemia severity. This observation highlights the importance of tailored diagnosis, treatment, and management approaches for different age groups [32,33]. The analysis of PCV levels among children showed no significant difference based on sex, consistent with previous studies [22]. Malaria causes anemia through various mechanisms, including hemolysis of infected and uninfected RBCs, shortened RBC lifespan, and impaired RBCs in the bone marrow (CDC, 2020). Chronic malaria infections often lead to dyserythropoiesis, further contributing to anemia prevalence. The findings of this study have implications for malaria control and prevention strategies in the region. The use of insecticide-treated nets, proper waste management, and access to healthcare services are critical in reducing malaria transmission and its complications [34-50]. The findings also underscore the need for location-specific analysis and targeted approaches to address the unique challenges and risk factors in different communities [51-69].

5. Conclusion

This study highlights the significance of malaria as a public health issue in Nkanu West LGA, particularly among children and pregnant women. The findings emphasize the need for integrated control strategies, broader efforts toward universal health coverage, and tailored approaches to address the unique challenges and risk factors in different communities. Future research should be expanded to encompass the entire Enugu State and Nigeria as a whole using molecular techniques to provide a more comprehensive understanding of malaria transmission dynamics in the region.

Acknowledgements

We want to appreciate the Chief Medical Director of the University of Nigeria Teaching Hospital for allowing us to perform the lab work in his hospital. Additionally, we appreciate the participants who volunteered to participate.

Funding

Not applicable.

Data Availability Statement

All data generated or analyzed during this study are included in this published article [and its supplementary information files].

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