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Epidemiological and Haematological Impacts of Malaria among Pregnant Women Attending Dutse General Hospital, Dutse, Jigawa State, Nigeria

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ABSTRACT

Malaria persists in Jigawa State, Nigeria, disproportionately affecting pregnant women. Despite control efforts, malaria leads to severe health consequences. The hematological impacts on pregnant women are poorly understood, hindering effective interventions. This study investigates the epidemiological and hematological impacts of malaria among pregnant women in Dutse, Jigawa State, to inform context-specific interventions. This cross-sectional study assessed the epidemiological and hematological impacts of malaria among pregnant women attending the antenatal clinic at Dutse General Hospital. A sample size of 50 pregnant women was enrolled based on voluntary consent. Blood samples were collected and examined microscopically for malaria parasites. A structured questionnaire gathered data on demographic information and malaria risk factors. Data was analyzed using Chi-square and ANOVA tests, with statistical significance set at $p < 0.05$, to explore relationships between malaria prevalence and demographic, environmental, and hematological factors. The study revealed a malaria prevalence of 24% among the population. While no significant associations were found between malaria prevalence and age, marital status, or educational status, women in their third trimester had a higher malaria prevalence of 30%. Environmental factors like poor drainage and water storage contributed to higher malaria rates, and malaria-positive individuals exhibited significantly lower RBC, HGB, and HCT levels, indicating anemia. This study underscores the complex interplay of factors influencing malaria prevalence among pregnant women. Hematological monitoring and comprehensive case management are crucial. Targeted interventions, health education, and addressing environmental factors can reduce malaria transmission, improving health outcomes and informing effective malaria control strategies.

Keywords: Malaria, Pregnancy, Haematology, Epidemiology and Maternal health

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INTRODUCTION

Malaria, a mosquito-borne infectious disease caused by *Plasmodium* species, remains one of the most pressing global health challenges, particularly in sub-Saharan Africa. The disease disproportionately affects pregnant women due to physiological and immunological changes during pregnancy that compromise their ability to fend off

infections, including malaria. This increased vulnerability leads to severe maternal and fetal health consequences, such as maternal anemia, miscarriages, stillbirths, intrauterine growth restriction, and preterm deliveries (World Health Organization, 2020). Moreover, the financial burden on healthcare systems in many low and middle-

income countries further exacerbates the challenges associated with malaria prevention and management. While significant progress has been made globally in malaria control, certain regions, including northern Nigeria, continue to grapple with high prevalence rates and associated complications among vulnerable populations like pregnant women (Oladeinde et al., 2018).

In Nigeria, malaria contributes significantly to maternal and child morbidity and mortality. It is estimated that approximately 25% of maternal deaths and nearly 30% of under-five child fatalities are directly linked to malaria (Nigeria Malaria Indicator Survey, 2021). The disease poses a substantial challenge in Jigawa State, a semi-arid region in northern Nigeria. The region's ecological and socio-demographic characteristics exacerbate malaria risks, making pregnant women particularly vulnerable. Limited access to healthcare services, coupled with cultural practices and inadequate deployment of preventive measures such as insecticide-treated nets (ITNs) and intermittent preventive treatment during pregnancy (IPTp), compounds the burden of malaria in this region (Musa et al., 2020). Furthermore, environmental factors like arid climates and seasonal rainfall patterns influence the breeding cycles of *Anopheles* mosquitoes, the primary vectors of malaria. These factors, in combination with low community awareness about malaria prevention, have sustained high disease burdens in Jigawa State.

One of the most critical aspects of malaria in pregnancy is its hematological impact, which has far-reaching consequences for maternal and fetal health. The disease disrupts the delicate balance of blood cell production and destruction, leading to severe hematological abnormalities. Malaria-induced hemolysis and immune-mediated erythrocyte destruction are common causes of anemia, a major contributor to maternal morbidity and mortality. Concurrently, thrombocytopenia, or a reduction in platelet counts, is frequently observed in malaria cases, alongside leukocytosis, an increase in white blood cell counts, which reflects the inflammatory and immunological responses to the parasite (Ameh et al., 2020). These hematological changes often result in a cascade of adverse pregnancy outcomes, such as low birth weight, fetal growth restriction, and preterm birth. Additionally, they impair the mother's ability to mount an effective immune response against malaria, creating a vicious cycle of deteriorating maternal health. Despite the global recognition of these hematological effects, limited research exists in Jigawa State, particularly among pregnant women. This gap underscores the need for localized studies to better understand how malaria manifests in the hematological profiles of pregnant women in this specific region.

The epidemiological dynamics of malaria during pregnancy in Jigawa State further highlight the need for targeted research. Available studies often generalize findings across northern Nigeria, neglecting the localized variations in disease dynamics. This generalization hinders the development of effective, context-specific malaria control strategies tailored to the unique ecological

and cultural context of Jigawa State. Addressing these gaps is critical for informing policy and practice and ensuring better health outcomes for pregnant women and their unborn children. The role of environmental and socio-demographic factors in shaping malaria transmission and severity in Jigawa State is poorly understood. For instance, the region's arid and semi-arid climates influence mosquito breeding patterns, potentially affecting disease transmission dynamics in ways that differ from other regions in Nigeria. Additionally, socio-demographic factors such as poverty, literacy levels, and access to healthcare resources further complicate malaria prevention and treatment efforts. Understanding these factors is crucial for designing effective interventions.

Despite the availability of various malaria prevention and treatment strategies, malaria persists as a significant health challenge for pregnant women in Jigawa State. Socio-environmental factors such as poor sanitation, limited access to preventive measures, and poverty continue to drive the high prevalence of malaria in this region. Seasonal rainfall and fluctuating water sources create ideal conditions for mosquito breeding, further exacerbating the risk of malaria transmission. These factors remain poorly quantified in their contribution to malaria epidemiology, leaving critical gaps in the understanding needed to implement effective control measures.

Hematological complications of malaria, such as anemia and thrombocytopenia, are well-documented in general malaria cases. However, their specific manifestations and severity among pregnant women in Jigawa State are not adequately studied. This lack of data creates barriers to effective planning and implementation of targeted interventions aimed at improving maternal and child health outcomes. For instance, anemia during pregnancy is a known risk factor for adverse maternal and fetal outcomes, yet little is understood about its specific burden and management in malaria-infected pregnant women in this region. Similarly, the effects of thrombocytopenia and other hematological changes on pregnancy outcomes require further investigation.

This study is imperative for addressing these critical knowledge gaps regarding the epidemiological and hematological impacts of malaria in pregnant women in Dutse, Jigawa State. A localized understanding of malaria prevalence, transmission dynamics, and associated risk factors is essential for designing effective, context-specific interventions. Moreover, investigating the hematological parameters in malaria-infected pregnant women will provide valuable insights into the disease's pathophysiology and clinical manifestations, informing better diagnostic approaches and management strategies. These findings will contribute to the global evidence base on malaria and align with Nigeria's national malaria elimination goals.

The implications of this research extend beyond understanding disease prevalence and hematological impacts. By elucidating the unique environmental, cultural, and socio-economic factors that contribute to malaria transmission in Jigawa State, this study will offer practical

recommendations for improving malaria prevention and treatment strategies. For example, identifying high-risk groups within the pregnant population can help target interventions more effectively. Similarly, understanding the specific hematological changes associated with malaria in this context can guide clinical protocols for managing the disease during pregnancy. This study aligns with the broader goals of reducing maternal and child mortality and improving health outcomes in resource-constrained settings. It highlights the need for evidence-based policies and practices that address the specific needs of pregnant women in Jigawa State. Additionally, the findings will contribute to the global understanding of malaria's impacts in diverse settings, offering lessons that can be applied in other malaria-endemic regions.

MATERIALS AND METHODS

Study site and population

This study was conducted at Dutse General Hospital, located in Dutse, Jigawa State, Nigeria. Dutse is the capital city of Jigawa State and is situated between latitude 11°42'04"N and longitude 9°20'31"E, characterized by a hot semi-arid climate. The population of Dutse is approximately 153,000, as per the 2009 national census, making it the largest city in Jigawa State. The hospital serves as a primary healthcare provider in the region, and the study specifically targeted pregnant women attending the antenatal clinic (ANC) at the hospital. A total of 50 pregnant women participated in the study, selected using a convenience sampling method.

Sample size

To compute a sample size for the study, a simplified sample size formula for estimating a p proportion was employed. The formula for sample size is:

$$n = \frac{Z^2 \cdot p(1 - p)}{E^2}$$

Where:

- n = sample size
- Z = Z-value (for a 95% confidence level, $Z=1.96Z = 1.96Z=1.96$)
- p = estimated proportion (expected prevalence rate)
- E = margin of error (precision)

For this study, let's assume a 95% confidence level ($Z=1.96Z = 1.96Z=1.96$), an expected prevalence rate of 20% ($p=0.2p = 0.2p=0.2$), and a desired margin of error of 10% ($E=0.1E = 0.1E=0.1$). Using these values, the calculated sample size comes out to approximately 61. However, the study used a sample size of 50, which suggests adjustments may have been made based on practical constraints such as budget, limited subject availability, or the study's specific goals. The researchers might have chosen a more manageable sample size of 50

despite the calculated value being higher, likely due to factors such as time, resource limitations, or accessibility to the target population.

Study design and setting

This cross-sectional study aimed to assess the epidemiological and hematological impacts of malaria among pregnant women attending the ANC at Dutse General Hospital. The study period was defined based on the availability and willingness of participants. Ethical approval was granted by the Institutional Ethics Committee, and informed consent was obtained from all participants. Women were enrolled based on their voluntary consent to participate in the study. Ethical considerations were strictly followed, and participants were informed about the nature of the study and assured of confidentiality.

Inclusion and exclusion criteria

Pregnant women attending the ANC who voluntarily consented to participate were included in the study. Exclusion criteria included pregnant women with a known history of chronic illnesses such as diabetes mellitus, hypertension, or HIV, as these conditions could interfere with the study's outcomes. Additionally, individuals who did not provide informed consent were excluded from the study to ensure the ethical integrity of the research process.

Sample collection and laboratory methods

Blood samples were collected from the participants following standardized protocols. A sterile lancet was used to prick the middle finger of each participant after the area was cleaned with an alcohol swab. Each sample was placed on a glass slide, and the smear was prepared using a 45-degree angle to spread the blood across the slide. The smear was allowed to air dry before staining with Field Stain A and B to differentiate malaria parasites. The thin smear was subsequently air-dried and fixed in methanol before being subjected to further staining procedures.

Microscopic examination

After staining, the slides were examined under a microscope using immersion oil and a 100x objective lens. Malaria parasites were identified inside the red blood cells, typically presenting as ring forms or dots that appear in pairs. This microscopic examination provided the primary diagnostic tool for detecting the presence of malaria in the blood samples. The results were recorded, and the prevalence of malaria was assessed based on the number of positive cases identified.

Data collection and analysis

A structured questionnaire was administered to all participants to gather data on malaria risk factors and the

participants' demographic information. The questionnaires were completed through face-to-face interviews to ensure the accuracy and completeness of the data. The collected data was analyzed using the Chi-square test for categorical variables and Analysis of Variance (ANOVA) for continuous variables. Statistical significance was set at a p-value of less than 0.05, and the findings were used to explore the relationship between malaria prevalence and various demographic and environmental factors, as well as hematological parameters associated with malaria infection.

Ethical clearance

Ethical clearance for this study was obtained through formal procedures to ensure compliance with research ethics standards. A letter of introduction was issued by the Department of Biological Sciences, Federal University Dutse, and submitted to the Head of the Laboratory at Dutse General Hospital. The purpose of the study was clearly communicated to the Head of the Laboratory, who was briefed on the study's objectives and methodology. Following the discussion, the laboratory staff coordinated the scheduling of sample collection dates and times to facilitate smooth implementation of the study. The study adhered to ethical guidelines, ensuring participant confidentiality, informed consent, and the minimization of any potential harm to the participants.

Prevalence of malaria in relation to age

Table 1 presents the prevalence of malaria across three different age groups: 18-24, 25-34, and 35-45. A total of 50 individuals were examined, with 11 testing positive for malaria. The age group 18-24 had 15 participants, with 4 (26.67%) testing positive. The group 25-34, consisting of 20 participants, showed 4 positives (20.00%), while the 35-45 age group, with 15 individuals, had 3 positive cases (20.00%). The overall prevalence for the total sample was 22.00%. The statistical analysis yielded a p-value of 0.873 for the 25-34 age group, indicating no significant difference in malaria prevalence within this age bracket compared to other age groups. The chi-squared (X^2) test was not applied to the 18-24 and 35-45 age groups, as the analysis does not show sufficient data for direct comparison. These findings suggest that age may not be a strong determinant of malaria prevalence in this sample, as the differences in positive cases across the age groups are not statistically significant.

Table 1: Prevalence of malaria in relation to age.

Age	No. Examined (Old Ratio)	No. Positive (%)	X^2	P-Value
18-24	15 (30.00)	4 (26.67)		
25-34	20 (40.00)	4 (20.00)	0.272	0.873
35-45	15 (30.00)	3 (20.00)		
Total	50 (100.00)	11 (22.00)		

Prevalence of malaria in relation to trimester

Table 2 shows malaria prevalence among women in

different trimesters of pregnancy. A total of 50 pregnant women were examined, with 11 testing positive for malaria. The first trimester group, consisting of 20 participants, had a positivity rate of 15%. The second trimester, with 10 participants, had 2 positive cases (20%), while the third trimester group, also with 20 participants, had a 30% positivity rate. The chi-squared test reveals a p-value of 0.512 for the second trimester, indicating no statistically significant difference in malaria prevalence between the trimesters. Although the third trimester shows the highest positivity rate (30%), the overall malaria prevalence remains low at 22%. The lack of significant variation across trimesters suggests that pregnancy stage may not have a substantial impact on malaria susceptibility in this sample.

Table 2: Prevalence of malaria in relation to trimester.

Trimester Level	No. Examined (Old Ratio)	No. Positive (%)	X^2	P-Value
First Level	20 (40.00)	3 (15.00)		
Second Level	10 (20.00)	2 (20.00)	1.340	0.512
Third Level	20 (40.00)	6 (30.00)		
Total	50 (100.00)	11 (22.00)		

Prevalence of malaria in relation to marital status

The prevalence of malaria by marital status was examined among 50 individuals, with 11 testing positive for malaria. Among the sample, 42 married individuals exhibited a 23.81% positivity rate. The 4 single individuals had a higher positivity rate of 25%, while the divorced and widow categories had no positive cases (Table 3).

The chi-squared value of 1.229 and a p-value of 0.746 suggest that marital status does not significantly affect the likelihood of testing positive for malaria. The statistical analysis shows that marital status is not a reliable determinant for malaria infection in this sample, as there is no significant difference in malaria prevalence between married and single individuals.

Table 3: Prevalence of Malaria in Relation to Marital Status.

Marital Status	No. Examined (Old Ratio)	No. Positive (%)	X^2	P-Value
Single	4 (8.00)	1 (25.00)		
Married	42 (84.00)	10 (23.81)	1.229	0.746
Divorced	3 (6.00)	0 (0.00)		
Widow	1 (2.00)	0 (0.00)		
Total	50 (100.00)	11 (22.00)		

Prevalence of malaria in relation to educational status

Table 4 examines the relationship between educational status and malaria prevalence among 50 individuals. Of the 50 individuals, 11 tested positive, with the highest positivity rate found in those with secondary education (36.84%, 7 positives). The tertiary education group had 3 positives (17.65%), while the group with no formal education had 1 positive (7.69%). The primary education group had no positives.

Statistical analysis ($X^2 = 4.460$, $p = 0.216$) reveals no significant association between educational status and

malaria prevalence. The results suggest that educational status does not significantly influence the likelihood of malaria infection in this sample. Despite higher rates of positivity in individuals with secondary education, the lack of statistical significance implies that other factors may be at play.

Table 4: Prevalence of Malaria in Relation to Educational Status.

Educational Status	No. Examined (Old Ratio)	No. Positive (%)	X ²	P-Value
Primary	1 (2.00)	0 (0.00)	4.460	0.216
Secondary	19 (38.00)	7 (36.84)		
Tertiary	17 (34.00)	3 (17.65)		
No Formal Education	13 (26.00)	1 (7.69)		
Total	50 (100.00)	11 (22.00)		

Prevalence of Malaria in Relation to Environmental and Anthropogenic Factors

Table 5 shows how environmental and anthropogenic factors (EAF) influence malaria prevalence among 50 participants. Several factors, such as good drainage (EAF1), drainage system type (EAF2), and proximity to farming (EAF7), were analyzed. The presence of an open drainage system (EAF2) was associated with a higher prevalence of malaria (31.25% vs. 6.67%) with a p-value of 0.064. EAF4, related to water storage, also showed some trends in malaria prevalence but was not statistically significant ($p = 0.272$). Factors such as garbage heaps (EAF8) and bush nearby (EAF5) showed no significant relationship with malaria prevalence, with p-values above 0.05. Overall, while certain environmental factors like drainage and water storage suggest potential links to malaria prevalence, the results do not provide conclusive evidence for any strong environmental determinant.

Prevalence of Malaria in Relation to Hematological Parameters

Table 6 shows the relationship between various hematological parameters and malaria status. The mean values of white blood cells (WBC), red blood cells (RBC), platelets (PLT), hemoglobin (HGB), hematocrit (HCT), and other parameters were compared between malaria-positive and malaria-negative individuals. Significant differences were found in several parameters: RBC (4.83 ± 0.19 vs. 4.47 ± 0.14), PLT (213.55 ± 16.95 vs. 186.88 ± 15.00), HGB (12.89 ± 0.73 vs. 10.66 ± 0.43), and HCT (36.55 ± 1.25 vs. 32.62 ± 1.02), with p-values < 0.05 , indicating that these parameters differ significantly between malaria-positive and malaria-negative individuals. In contrast, the white blood cell count (WBC), neutrophil percentage, and other parameters like lymphocytes did not show significant differences. The results suggest that RBC count, PLT, HGB, and HCT are significantly lower in malaria-positive individuals, reflecting the impact of malaria on these hematological parameters. These findings highlight the potential use of these parameters as biomarkers in diagnosing and monitoring malaria infections.

DISCUSSION

Prevalence of malaria in relation to age

The observed prevalence of malaria across different age groups showed no significant association ($p = 0.873$). Although younger individuals (18–24 years) exhibited a slightly higher prevalence of 26.67% compared to other groups, the overall distribution suggests no clear age-related susceptibility in the study population. This finding aligns with Nwaorgu and Orajaka (2011), who also found no significant age variations in malaria prevalence among adults. However, contrasting results from Yewhalaw et al. (2010) in Ethiopia indicated higher prevalence rates among younger individuals, attributing this to differences in exposure and immunity levels. In Nigeria, malaria control in adults primarily focuses on timely treatment and environmental management (National Malaria Elimination Programme [NMEP], 2022), which may explain the lack of significant age-related differences in the present study. This could reflect the effectiveness of broad public health campaigns targeting all age groups. However, the findings highlight the need for tailored health education aimed at younger adults, who may be less vigilant in adopting preventive measures such as the use of bed nets and indoor spraying. Increased focus on younger populations may be essential in reducing malaria transmission, as this group could benefit from more specific interventions to enhance awareness and encourage better preventive practices.

Prevalence of malaria in relation to trimester

The trimester-specific prevalence revealed that women in their third trimester were more likely to test positive for malaria (30.00%) compared to those in their first and second trimesters. Although this difference was not statistically significant ($p = 0.512$), it highlights the physiological changes during pregnancy, particularly in the third trimester, that may increase susceptibility to *Plasmodium falciparum* infection (Desai et al., 2007). Reduced immunity and altered hematological parameters during late pregnancy can facilitate parasitemia, making pregnant women more vulnerable to malaria. Antenatal care services typically incorporate Intermittent Preventive Treatment in Pregnancy (IPTp) with sulfadoxine-pyrimethamine (SP) to reduce malaria risk. The observed trend in higher malaria prevalence during the third trimester suggests the potential for strengthening this intervention, particularly for women in the later stages of pregnancy. Enhancing adherence to IPTp and integrating it more effectively with routine antenatal services could provide additional protection against malaria, especially during the third trimester when the physiological changes heighten susceptibility. Ensuring that pregnant women in all trimesters, especially those in their third trimester, receive adequate preventive care may help mitigate the risk of malaria-related complications and improve maternal and fetal health outcomes. Improving the coverage and compliance with malaria prevention measures, particularly

Table 5: Prevalence of Malaria in Relation to Environmental and Anthropogenic Factors.

Factor	Response	No. Examined (Old Ratio)	No. Positive (%)	X ²	P-Value	OR
EAF1: Good drainage	Yes	22 (44.00)	2 (9.09)	3.815	0.051	0.211
	No	28 (56.00)	9 (32.14)			
EAF2: Drainage system	Open System	32 (64.00)	10 (31.25)	3.443	0.064	6.364
	Closed System	15 (30.00)	1 (6.67)			
EAF3: Clear drainage	Yes	20 (40.00)	4 (20.00)	0.078	0.078	0.821
	No	30 (60.00)	7 (23.33)			
EAF4: Water storage	Reservoir	6 (12.00)	0 (0.00)	3.907	0.272	
	Drum	19 (38.00)	6 (31.58)			
	Water Tank	23 (46.00)	4 (17.39)			
	Bucket	1 (2.00)	1 (100.00)			
EAF5: Bush nearby	Yes	15 (30.00)	2 (13.33)	0.938	0.333	0.444
	No	35 (70.00)	9 (25.71)			
EAF6: Swampy area	Yes	9 (18.00)	3 (33.33)	0.822	0.365	2.063
	No	41 (82.00)	8 (19.51)			
EAF7: Farming nearby	Yes	29 (58.00)	7 (24.14)	0.184	0.668	1.352
	No	21 (42.00)	4 (19.05)			
EAF8: Garbage heaps	Yes	5 (10.00)	0 (0.00)	1.567	0.211	
	No	45 (90.00)	11 (24.44)			

Keys: EAF1: Do you have good water drainage around your house? EAF2: What type of drainage system do you have? EAF3: Do you usually clear the drainage around your house? EAF4: What type of water storage do you use at home? EAF5: Is there a bush around your house? EAF6: Do you live around swampy area? EAF7: Is there a farming or irrigation activities around your house? EAF8: Do you have garbage heaps close to your house?

Table 6: Prevalence of Malaria in Relation to Hematological Parameter.

Hematological Analysis (Unit)	Positive (Mean ± SD)	Negative (Mean ± SD)	t-Test	P-Value
White Blood Cell (WBC, ×10 ³ /μL)	6.27 ± 0.67	6.22 ± 0.25	0.31	0.759
Red Blood Cell (RBC, ×10 ⁶ /μL)	4.83 ± 0.19	4.47 ± 0.14	4.47	0.001**
Platelets (PLT, ×10 ³ /μL)	213.55 ± 16.95	186.88 ± 15.00	4.40	0.001**
Hemoglobin (HGB, g/dL)	12.89 ± 0.73	10.66 ± 0.43	10.33	0.000**
Hematocrit Test (HCT, %)	36.55 ± 1.25	32.62 ± 1.02	10.44	0.000**
Mean Corpuscular Volume (MCV, fL)	76.75 ± 1.29	74.70 ± 0.84	5.84	0.000**
Mean Corpuscular Hemoglobin (MCH, pg)	26.01 ± 0.55	23.97 ± 0.53	11.57	0.000**
Mean Corpuscular Hemoglobin Concentration (MCHC, g/dL)	34.30 ± 1.17	32.09 ± 0.51	7.30	0.000**
Lymphocytes (LYM, %)	36.91 ± 2.23	40.18 ± 1.92	-4.58	0.001**
Mixed Monocytes, Basophils, and Eosinophils (MXD, %)	15.18 ± 1.41	13.26 ± 0.69	5.17	0.000**
Neutrophils (NEUT, %)	47.64 ± 3.10	48.10 ± 2.39	-0.42	0.676

Key:

- **t-Test:** Independent sample t-test comparing Positive vs. Negative groups.
- **P-Value:** Significant values are marked with (**p < 0.05**).
- **Total:** Sum of Positive and Negative groups combined.

in late pregnancy, is critical in minimizing the impact of malaria on pregnant women.

Prevalence of malaria in relation to marital status

Although marital status did not show a significant relationship with malaria prevalence ($p = 0.746$), higher rates were observed among both single (25.00%) and married individuals (23.81%). This aligns with findings from Adigun et al. (2020), which suggest that environmental and behavioral factors, rather than marital status itself, are more influential in determining exposure to malaria. Married individuals, often living in larger households or with children, may have increased exposure due to communal living arrangements or closer proximity to vector breeding sites (Oluwagbenga et al., 2021). In contrast, single individuals, especially younger adults, may be less consistent in adopting preventive measures such as bed net use and indoor spraying, potentially increasing their risk of infection. These findings highlight that factors

such as living conditions, occupation, and access to health services have a greater impact on malaria transmission than marital status. The observed trends emphasize the importance of targeting health education campaigns to both single and married individuals, addressing specific risks for each group. For married individuals, efforts should focus on promoting household-wide preventive practices, while for singles, particularly young adults, campaigns should encourage greater adherence to malaria prevention measures. The integration of these strategies into routine healthcare services could help reduce malaria prevalence across diverse social groups by addressing the environmental and behavioral factors that influence exposure.

Prevalence of malaria in relation to educational status

Educational status revealed a notable trend, with individuals who had completed secondary education showing the highest malaria positivity rate (36.84%),

although no significant association was found ($p = 0.216$). The higher prevalence among secondary-educated individuals may reflect limited access to tertiary healthcare facilities and malaria prevention tools, despite having basic malaria knowledge (Ayanlade et al., 2018). In contrast, those without formal education exhibited the lowest prevalence (7.69%), which could be related to reduced mobility and less outdoor exposure, potentially limiting their exposure to malaria vectors. Education plays a key role in shaping health behaviors, influencing the adoption of preventive measures such as insecticide-treated bed nets (ITNs) and seeking timely treatment. While education campaigns focused on malaria have improved awareness in communities, a gap remains between knowledge and the practical application of preventive measures. This highlights the need for more effective strategies to bridge the gap between education and behavior, particularly targeting those with lower educational attainment. Strengthened advocacy and targeted outreach programs can help ensure that individuals at all educational levels are equipped with the knowledge and tools needed to prevent malaria. Specifically, efforts should focus on enhancing the implementation of malaria prevention practices among secondary-educated individuals, ensuring that awareness is translated into action to reduce the burden of malaria in these populations.

Prevalence of malaria in relation to environmental and anthropogenic factors

Environmental and anthropogenic factors exhibited diverse influences on malaria prevalence. Poor drainage systems, open drainage, and water storage in drums were associated with higher malaria rates, although these associations were not statistically significant ($p > 0.05$). These findings align with studies by Iwueze et al. (2021), which highlight that stagnant water and improper drainage create ideal breeding grounds for *Anopheles* mosquitoes. Additionally, the presence of bushes and nearby farming activities also influenced malaria positivity, consistent with the observations of Oloruntola et al. (2018). Although these environmental factors were not statistically significant in this study, their role in malaria transmission remains critical. The presence of water sources and unkempt vegetation provides mosquitoes with habitats conducive to breeding, while farming activities can further amplify exposure through increased human movement in affected areas. Effective malaria control strategies often focus on reducing mosquito habitats by improving drainage systems and managing water storage, as well as through community-driven sanitation programs. However, rural areas may require more intensive efforts to address agricultural practices, land use, and deforestation, which can contribute to the proliferation of malaria vectors. While environmental control measures may not yield immediate statistical significance, long-term improvements in sanitation, waste management, and vector control practices can significantly reduce malaria transmission. Addressing these environmental and anthropogenic factors is crucial in achieving sustained reductions in

malaria prevalence.

Prevalence of malaria in relation to hematological parameters

The analysis of hematological parameters revealed significant differences between malaria-positive and negative individuals, shedding light on the profound impact of *Plasmodium falciparum* infection on blood composition. Red Blood Cell (RBC) count, Hemoglobin (HGB), and Hematocrit (HCT) levels were significantly lower among malaria-positive cases ($p < 0.05$), which is consistent with anemia commonly associated with malaria infection (Taylor et al., 2022). The reduction in Mean Corpuscular Volume (MCV) and Mean Corpuscular Hemoglobin (MCH) further suggests hypochromic microcytic anemia, a hallmark of malaria-induced erythrocyte destruction. These findings highlight the extent to which malaria can compromise the body's ability to maintain normal red blood cell production and oxygen-carrying capacity. In addition, leukocyte indices, including lymphocyte and neutrophil percentages, showed significant variation between groups, suggesting immune system activation and systemic inflammation as the body responds to the infection (White et al., 2018). Platelet counts were significantly reduced in malaria-positive individuals, reflecting thrombocytopenia, which is a known complication of severe malaria and contributes to the increased risk of bleeding and other related issues (Kwenti, 2017). Hematological monitoring plays a crucial role in malaria case management, as changes in blood parameters can help assess the severity of the infection and guide treatment strategies. Incorporating point-of-care testing in primary healthcare centers could significantly enhance early diagnosis and improve treatment outcomes, particularly in populations that are more vulnerable to complications, such as pregnant women and children. This approach could facilitate timely intervention, reducing the risk of anemia and other hematological complications associated with malaria. Regular hematological surveillance is therefore essential for effective malaria control and management, ensuring better health outcomes for affected individuals.

Conclusion

This study highlights the complex interplay of demographic, environmental, and hematological factors influencing malaria prevalence. Although factors such as age, marital status, and educational background did not show significant statistical associations with malaria prevalence, trends were observed that underscore the importance of behavioral, environmental, and physiological influences on susceptibility. Additionally, the significant hematological alterations seen in malaria-positive individuals emphasize the need for comprehensive case management, including hematological monitoring. The findings suggest that environmental factors, such as water storage and drainage issues, play a critical role in malaria transmission, while

interventions like targeted health education and preventive measures could help reduce exposure. Understanding these factors is essential for improving malaria control strategies and ensuring better health outcomes.

Recommendations

It is recommended to strengthen malaria control programs by improving environmental sanitation, promoting malaria prevention in high-risk groups, and incorporating regular hematological assessments in malaria diagnosis and treatment. Targeted education campaigns should focus on behavior change to enhance the adoption of preventive measures, particularly in vulnerable populations.

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