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PREVALENCE AND DETERMINANTS OF *PLASMODIUM FALCIPARUM* REOCCURRENCE AMONG MALARIA PATIENTS IN SELECTED HOSPITALS IN KADUNA

[1]Khadija Musa Bala, [2]Abdurrahman Adam, [3]Mani Malam Ahmad and [4]Yusuf Dahiru Sani

Kaduna State University, Kaduna[1,2,4], Aliko Dangote University, Kano[3],
Kaduna State University
Corresponding Author: binadambg@gmail.com,08169019179

ABSTRACT

Malaria continues to pose a significant public health challenge in sub-Saharan Africa, with Plasmodium falciparum *being the most prevalent and virulent species. This study examines the recurrence of* P. falciparum *infections and identifies resistance genes in malaria patients attending selected hospitals in Kaduna, Nigeria. The research aimed to determine the incidence of* Plasmodium *species among febrile patients, assess factors contributing to malaria recurrence, and detect drug resistance genes using molecular techniques. A cross-sectional survey was conducted with 150 febrile patients diagnosed with malaria across three hospitals in Kaduna. Data on clinical symptoms, demographics, and treatment history were collected through structured questionnaires. Microscopic analysis confirmed* P. falciparum *as the predominant species (99.3%), with no detection of* P. vivax *or* P. ovale*. Malaria recurrence was reported in 44% of patients, most commonly occurring within 1–3 months after treatment. The primary factors contributing to recurrence included incomplete treatment (33.3%), drug resistance (33.3%), and re-exposure to mosquito bites (20%). Socio-economic factors such as low income and education were significantly associated with poor treatment adherence ($X^2 = 14.32$, $p < 0.0001$). Molecular analysis using Polymerase Chain Reaction (PCR) and gel electrophoresis was performed on four selected* P. falciparum *isolates to detect resistance-associated mutations. The findings revealed the persistence of chloroquine resistance and emerging resistance to artemisinin-based combination therapies. These results highlight the need for continuous monitoring of drug resistance and the development of targeted malaria control strategies that address treatment adherence, socio-economic disparities, and environmental factors. This study provides valuable insights into the genetic and epidemiological factors influencing* P. falciparum *recurrence in Kaduna and emphasizes the importance of improving diagnostic accuracy, treatment protocols, and public health interventions to reduce the burden of malaria and enhance patient outcomes.*

Keywords: Prevalence; Plasmodium Falciparum; Reoccurrence; Malaria Patients; Hospitals.

Introduction

Malaria is a serious public health issue that continues to cause illness and death. According to data from 85 malaria endemic countries, the worldwide malaria burden increased from 227 million cases in 2019 to

241 million cases in 2020, with the majority of the rise coming from countries in the African Region, (WHO, 2020).

Malaria is one of the commonest diseases afflicting the impoverished in developing nations. Sub-Saharan Africa bears the brunt of the global malaria load, with the number of illnesses and deaths in the world being at an all-time high. It hurts people's health as well as economic development in many developing nations, especially in Sub-Saharan Africa, (WHO, 2020), *Plasmodium* are Intracellular parasites and are members of the phylum *Apicomplexa.* The members of this *protists* are characterized by the presence of a unique plastid-like organelle called the *apicoplast* (Sawyerr, 1982). *Plasmodium vivax*, *Plasmodium falciparum*, *Plasmodium malariae*, and *Plasmodium ovale* are the four most frequent species that cause human malaria, as well as a fifth parasitic species, *Plasmodium Knowles*, a monkey parasite. *Plasmodium vivax* is responsible for the great majority of malaria infections, owing to its widespread distribution (Kotepui, 2020). The only one of the four species that can be found in tropical, subtropical, and temperate climates is *P. vivax*. *Plasmodium falciparum* continues to infect people in tropical and subtropical areas, and it is the most common cause of a fatal type of malaria (Deress, 2019).

The parasite generally gains access to humans through the bite of an infected *Anopheles* mosquito. Inside the human, the parasite spends part of its life cycle replicating inside red blood cells causing the disease symptoms. The disease can vary from asymptomatic to severe with life threatening symptom (Plewes, 2019). For instance, the parasite can cause severe *anemia,* i.e., a significant reduction of red blood cells, or cerebral malaria, which can lead to abnormal behaviour, impairment of consciousness, and coma (Plewes, 2019). In addition, malaria infection may lead to miscarriages in pregnant women through parasite binding and inducing inflammation, which leads to parasite crossing of the placenta and ultimately *haemorrhage.* Those life-threatening symptoms are largely caused by *P. falciparum* (Mubasher, 2021).

P. falciparum is the deadliest of the five malaria species that infect humans. The parasite has a complex life cycle that includes repeated switching between its human (intermediate) host and mosquito (definitive) host. The mosquito is considered the definitive host since this is where the parasite undergoes sexual replication (Ishino *et al.*, 2019).

Statement of the Problem

Malaria, primarily driven by the *Plasmodium falciparum* parasite, remains a critical public health challenge in Nigeria, and particularly the northern region, where the temperate region falls, with Kaduna State experiencing particularly high rates of infection (Okafor *et al.,* 2020). There has been a troubling increase in reported cases of recurrent malaria infections among patients. Malaria, a

life-threatening disease caused by protozoan parasites of the genus *Plasmodium*, continues to pose a significant public health burden in Nigeria. Among the five species known to infect humans, *Plasmodium falciparum* is the most virulent and prevalent, accounting for the majority of malaria-related morbidity and mortality in the country (Akinwunmi *et al.*, 2022). The northern region of Nigeria, which includes the temperate zones, is particularly affected due to a combination of climatic conditions favorable to mosquito breeding, limited access to healthcare, and challenges in sustained vector control efforts. Kaduna State, located in this region, has consistently reported alarmingly high rates of malaria transmission, making it one of the most affected areas in the country (Okafor *et al.*, 2020). In recent years, healthcare facilities in Kaduna have documented an unsettling rise in cases of malaria reoccurrence instances where patients, after initial treatment and apparent recovery, return with new episodes of infection. This trend raises serious concerns regarding treatment efficacy, patient adherence to prescribed medication, potential resistance to antimalarial drugs, and the presence of persistent parasitemia. The increasing frequency of recurrent infections underscores the urgent need for comprehensive studies to identify underlying factors, including the possible emergence and spread of drug-resistant *P. falciparum* strains within the region (Alifrangis., 2021).

Justification

The resurgence of malaria, particularly caused by *P. falciparum*, remains a critical public health challenge in sub-Saharan Africa, including Nigeria. Despite significant efforts in malaria control and prevention, the World Health Organization (2021) reported an estimated 241 million cases of malaria globally in 2020, with the African region accounting for approximately 95% of cases. Kaduna State, characterized by fluctuating malaria transmission patterns, provides a relevant context for examining the reoccurrence of *P. falciparum* infections among patients. Studies have highlighted concerning trends in drug resistance among malaria parasites, particularly *P. falciparum*, which complicates treatment protocols. For instance, a study by (Tchouakui, 2021) emphasized the alarming emergence of mutations in the *P. falciparum* dihydrofolate reductase (Pfdhfr) and dihydropteroate synthase (Pfdhps) genes, leading to increased resistance to sulfadoxine-pyrimethamine. Moreover, the development of artemisinin resistance in certain regions has been documented, raising significant concerns about the effectiveness of current treatment regimens (Pechal, 2020). In Nigeria, there is a paucity of data on the molecular mechanisms underlying *P. falciparum* resistance. The need for targeted studies to elucidate these mechanisms is critical for informing treatment strategies and public health policies. Furthermore, exploring the factors contributing to the reoccurrence of malaria in patients, including potential environmental and sociocultural influences, is essential for a comprehensive understanding of malaria dynamics in the region (Yahaya *et al*., 2022). This study aims to investigate the reoccurrence of *P. falciparum* infections among malaria patients in selected hospitals in Kaduna, with a

specific focus on the molecular identification of resistance genes. By engaging advanced molecular techniques, this research seeks to provide insights into the genetic factors contributing to treatment failures

Aims of the Study

Prevalence and Determinants of *Plasmodium Falciparum* Reoccurrence among Malaria Patients in Selected Hospitals in Kaduna

Objective of the Study

- To investigate the cases of Malaria parasite (*P. falciparum* reoccurrence among patients at selected hospital in Kaduna)

Material And Methods

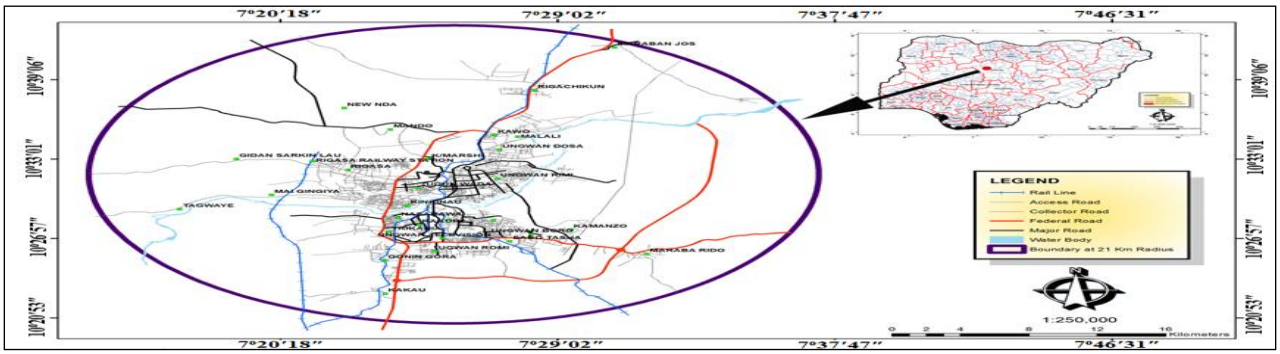


Figure 1: Map of Kaduna

Study Area: This research work will be carried out in Kaduna, Kaduna State. Kaduna is located between latitudes 10.20º North and Longitudes 10.37ºN of the Equator and Longitude 7º22 E and 7º31E of the Greenwich meridian. The city cuts across Kaduna North, Kaduna South as well as part of Igabi and Chikun Local Government areas of the State. It has an estimated area of 72km2 and density of 588.31 inh/km2. The geology of Kaduna is predominantly metamorphic rocks of the Nigerian basement complex consisting of biotite gneisses and older granites. The topographical relieve is relatively flat, having an elevation of between 600 and 650 meters in large areas of the Metropolis. It is over 650 meters above mean sea level in some places, and below 500 meters in places that slope downward towards the river (Zahraddeen, 2016).

Sampling and Sampling Size: The sample size to be controlled into the study would be calculated using Fischer's equation (Dawet *et al.*, 2022)

$$n = \frac{z^2 p(1-p)}{e^2}$$

where

n = sample size

p = prevalence obtained from the previous similar research 1.6%
Z = level of confidence = 1.645 at 90%
e = margin of error = 10%
n = $\frac{1.645^2 \; x \; 0.16 \; (1-0.16)}{0.5^2}$ = 150%ss

Sample Collection: A total of 150 fresh blood samples will be collected from patients who shows great relapse or reoccurrence after a successful treatment with acceptable antimalarial treatment at acceptable dose amongst patient attending licensed Hospitals within Kaduna(Yusuf Dan Tsoho Memorial Hospital, General Hospital Kawo, DR, Awon General Hospital Kakuri), and to establish the presence of the reoccurrence of malaria and then secondly, possible patient factors that might be responsible for the treatment failure.
The samples will be divided into two major groups. The male and female then further divided into two sub groups. That's the adult and the children group and then possibly to blood group basis, to know if gender and age bracket and blood group have an effect on the *p. falciparum* resistance.
Microscopic Method: Malaria is conventionally diagnosed by microscopic examination of stained blood films using Giemsa, Wright's, or Field's stains (Schwartz *et al.*, 2015). This method has changed very little since Laverran's original discovery of the malaria parasite, and improvements in staining techniques by Romanowsky in the late 1,800s. More than a century later, microscopic detection and identification of *Plasmodium* species in Giemsa-stained thick blood films (for screening the presenting malaria parasite), and thin blood films (for species 'confirmation) remains the gold standard for laboratory diagnosis (Arya *et al.*, 2021).

Malaria is diagnosed microscopically by staining thick and thin blood films on a glass slide, to visualize malaria parasites. Briefly, the patient's finger will be clean with 70% ethyl alcohol, allow to dry and then the side of fingertip will be prick with a sharp sterile lancet and two drops of blood will be placed on a glass slide. To prepare a thick blood film, a blood spot will be stirred in a circular motion with the corner of the slide, taking care not make the preparation too thick, and allow to dry without fixative.

After drying, the spot will be stained with diluted Giemsa (1: 20, vol/vol) for 20 min, and wash by placing the film in buffered water for 3 min. The slide will then be allowed to air dry in a vertical position and examination using a light microscope. As they are unfixed, the red cells lyse when a water-based stain is applied. A thin blood film will be prepared by immediately placing the smooth edge of a spreader slide in a drop of blood, adjusting the angle between slide and spreader to 45 and then smearing the blood with a swift and steady sweep along the surface.

The film will then be allowed to air-dry and will be fix with absolute methanol. After drying, the sample will be stained with diluted Giemsa (1: 20, vol/vol) for 20 min and washed by briefly dipping the slide in and out of a jar of buffered water (excessive

washing will decolorize the film). The slide will then be allowed to air-dry in a vertical position and examined under a light microscope (Ippopolito *et al.*, 2021).

The wide acceptance of this technique by laboratories all around the world can be attributed to its simplicity, low cost, its ability to identify the presence of parasites, the infecting species, and assess parasite density-all parameters useful for the management of malaria.

Data Presentation, Analysis, and Discussion

Data Presentation and Analysis

Table 1 Socio economic characteristics of responder in the study area

Age Range	Frequency	Percentage (%)
Less than 5 years	20	13.3
5–14 years	55	36.7
15–30 years	40	26.7
31–51 years	35	23.3
Total	150	100
GENDER		
Female	95	63.3
Male	55	36.7
Total	150	100
OCCUPATION		
Student	50	33.3
Farmer	5	3.3
Healthcare Worker	20	13.3
Other	75	50
Total	150	99.9
RESIDENTIAL AREA		
Urban	90	60
Rural	60	40
Total	150	100

Table 1highlights that a significant majority (63.4%) of respondents fall within the younger age categories (5–30 years), indicating a predominantly youthful population. Among these, the 5–14 years' group represents the largest segment, emphasizing the importance of this demographic in the overall population. In contrast, only 13.3% of respondents are

under 5 years of age, suggesting a relatively smaller proportion of very young children within the sample, youthful population distribution has critical implications for health and social interventions, particularly in contexts like malaria control. Studies indicate that children under 5 are at the highest risk of severe malaria due to their immature immune systems, and thus require targeted preventive measures such as insecticide-treated bed nets (ITNs) and access to prompt medical care (WHO, 2023).

In addition, the gender distribution among respondents, with **95 females (63.3%)** and **55 males (36.7%),** in gender representation. This aligns with findings from studies in many low-resource settings where women are primary caregivers and often access health services on behalf of their families (WHO, 2023). The presents the occupational distribution of respondents, with "Other" being the largest category (50.0%), followed by students (33.3%), healthcare workers (13.3%), and farmers (3.3%). This distribution provides insights into the demographic composition and its potential implications for the subject of study (malaria reoccurrences. Furthermore, the result indicates the residential distribution of respondents, with **90 individuals (60%)** residing in urban areas and **60 individuals (40%)** in rural areas. This provides valuable insights into the population's living environment, which has significant implications for issues like malaria prevalence and recurrence.

Table 2: perception on malaria symptom in the study area

Symptom	Frequency	Percentage
Fever	60	40
Chills	0	0
Sweating	10	6.7
Headache	30	20
Vomiting	20	13.3
Diarrhea	0	0
Fatigue	0	0
Muscle pains	30	20
Jaundice	0	0
Other	0	0
Duration		
Less than 3 days	70	46.7
3 –7 days	50	33.3
More than 7 days	30	20

Table 2; the symptom data provides valuable insights into the clinical presentation of malaria among respondents. The distribution reveals significant variations, with **fever (40.0%)** being the most commonly reported symptom, followed by **headache (20.0%), muscle pains (20.0%), vomiting (13.3%),** and **sweating (6.7%).** Interestingly, symptoms like chills, diarrhea, fatigue, jaundice, and other unspecified conditions

are not reported. Furthermore, the result outlines the duration of symptoms among respondents, with **46.7% experiencing symptoms for less than 3 days, 33.3% for 3–7 days,** and **20.0% for more than 7 days.** These result offer insights into the progression and potential severity of the disease.

Table 3: perception on the malaria diagnosis in the study area

Response	Frequency	Percentage
Yes	110	73.3
No	40	26.7

Table 3: the data shows that a substantial majority of respondents (73.3%) have had a prior malaria diagnosis, while 26.7% reported no previous diagnosis. This distribution emphasizes the high prevalence of malaria and the potential for recurrent infections within the surveyed population.

Table 4: perception on the time intervals of last malaria diagnosis in the study area

Time frame	Frequency	Percentage
Within the last month	40	26.7
1–3 months ago	80	53.3
More than 3 months ago	30	20.0

Table 4 revealed the time intervals since respondents' last malaria diagnosis. The result revealed that 26.7% were diagnosed within the past month, 53.3% reported being diagnosed 1–3 months ago, 20.0% had their diagnosis more than 3 months ago. This results sheds light on the current prevalence of malaria and underscores the recurrence patterns of the disease within the population.

Table 5: perception on diagnostic methods used for malaria detection

Method of Diagnosis	Frequency	Percentage
Blood test (microscopy)	20	13.3
Rapid Diagnostic Test (RDT)	95	63.3
Clinical diagnosis by a healthcare provider	35	23.3
Other	0	0

Table 5 provides insights into the diagnostic methods used for malaria detection. The result revealing a preference for Rapid Diagnostic Tests (RDTs) (63.3%) used method, followed by clinical diagnoses (23.3%) and traditional blood smear microscopy (13.3%).

Table 6: perception on the malaria species in the study area

Species	Frequency	Percentage
Plasmodium falciparum	149	99.3
Plasmodium vivax	0	0
Plasmodium malariae	1	0.7
Plasmodium ovale	0	0
Unknown / Not specified	0	0

Table 6 result on *Plasmodium* species reveals that **99.3%** of respondents were diagnosed with *Plasmodium falciparum*, the most common and deadly species responsible for malaria in many parts of the world. In contrast, **0.7%** of respondents were diagnosed with *Plasmodium malariae*, while there were no cases of *Plasmodium vivax*, *Plasmodium ovale*, or unspecified species. This result can be supported by result obtained in laboratory test (see figure 2)

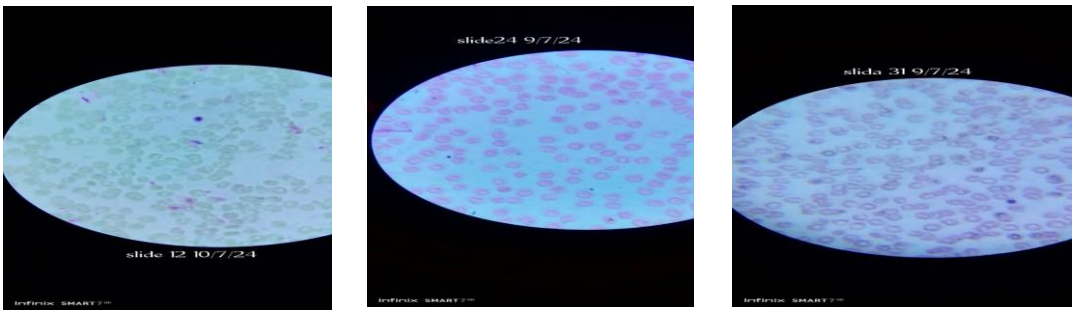


Figure 2 malaria diagnosis

Figure 1 indicates the presence of *Plasmodium falciparum*, the parasite responsible for the most severe form of malaria. These could be *Plasmodium* merozoites, trophozoites, or schizonts, which are identified using microscopy techniques. This suggests that the result highlights the presence of the parasite inside red blood cells.

Table 7: perception on the method on malaria treatment

Treatment	Frequency	Percentage
Artemisinin-based combination therapy (ACT)	82	54.7
Chloroquine	35	23.3
Quinine	13	8.7
Sulfadoxine-pyrimethamine (SP)	5	3.3
Other	5	3.3
Not treated	0	0

Table 7 the data on malaria treatment shows that **54.7%** of respondents were treated with Artemisinin-based Combination Therapy (ACT), which is the most commonly used method. This aligns with global recommendations for ACT as the first-line treatment for *Plasmodium falciparum* malaria, especially in regions where resistance to other drugs is prevalent (World Health Organization, 2021). Other treatments like **Chloroquine** (23.3%) and **Quinine** (8.7%) were less commonly used, reflecting ongoing concerns about the growing resistance to older drugs, particularly chloroquine (Jambulingam *et al.*, 2019). **Sulfadoxine-pyrimethamine (SP)** and other treatments were reported by just **3.3%** of respondents, indicating their limited application due to issues with resistance and availability (WHO, 2021). Importantly, there were no reports of individuals being untreated, which suggests that malaria diagnosis and treatment access are generally well-established within this population (Carter *et al.*, 2020).

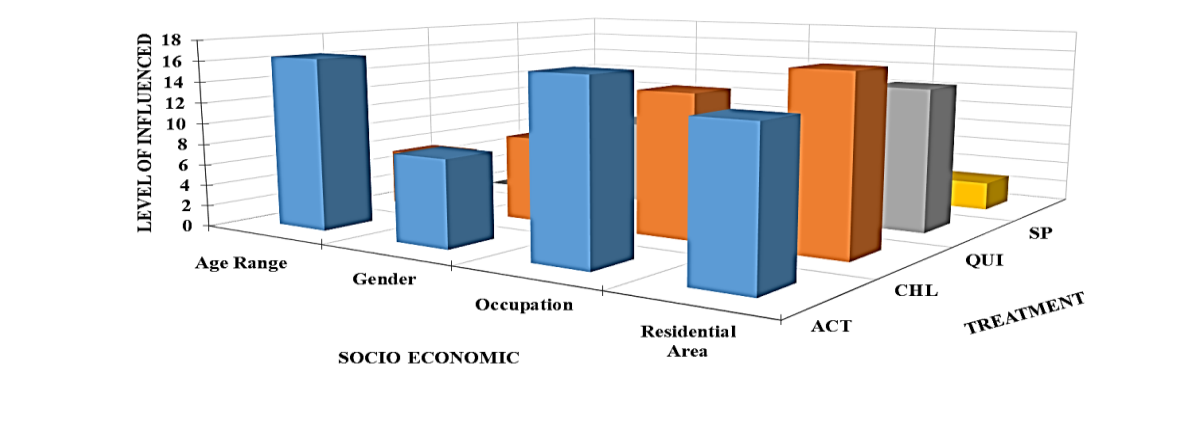


Figure 3: Socio economic influenced on the malaria treatment administered

Figure 3 illustrates the influence of socio-economic factors on malaria treatment choices. The results reveal that Artemisinin-based Combination Therapy (ACT) is strongly associated with occupation, residential area, and age category, highlighting its widespread acceptance across various demographic groups. This indicates that ACT is the preferred treatment option, potentially due to its efficacy and endorsement by health authorities. Chloroquine, on the other hand, shows a moderate association with occupation and residential area, suggesting that it may still be used in certain contexts, possibly due to affordability or accessibility despite its reduced efficacy in some regions. Quinine exhibits a more localized influence, being predominantly associated with residential area. This could reflect its use in areas with limited access to alternative treatments or specific cases where it remains effective.

These findings underscore the importance of socio-economic factors in determining

treatment choices for malaria. They suggest that tailored health interventions and awareness programs targeting specific occupations, age groups, and residential areas could improve treatment outcomes and ensure broader adoption of more effective therapies like ACT. Additionally, the associations highlight potential disparities in access to treatment options, emphasizing the need for equitable distribution and education on the most effective malaria therapies.

Table 8: significant test on socio-economic influenced on malaria treatment

	ACT	CHL	QUI	SP	Total
Age Range	4.190	0.775	5.455	0.558	10.977
Gender	0.682	0.034	0.793	0.273	1.782
Occupation	0.015	0.002	0.128	0.307	0.451
Residential Area	0.616	0.613	2.053	2.392	5.675
X^2	5.503	1.424	8.430	3.529	18.886
P-value	< 0.005	> 0.005	< 0.001	< 0.001	< 0.001

Table 8 show a level of significant influenced of socio economic influenced on malaria treatment. The result revealed the Age Range shows a strong association with ACT (X^2 = 4.190), supported by a significant p-value (< 0.005). This indicates that age plays a key role in the preference for ACT. Also, Residential Area also has a significant influence (X^2 = 0.616, $p < 0.005$), which may suggest that ACT is more readily available or preferred in certain localities. Considering the association with gender and occupation is minimal, as indicated by lower X^2 values (0.682 and 0.015, respectively).

Furthermore, considering the level of association Chloroquine use with the age range and residential area it shows moderate associations (X^2 = 0.775 and 0.613, respectively). However, the p-value (> 0.005) suggests that these associations are not statistically significant. This could imply that while Chloroquine may still be used in specific contexts, its overall influence is diminishing, possibly due to resistance concerns or recommendations against its use. The relationship of Quinine with the Age Range was a strong association (X^2 = 5.455), supported by a highly significant p-value (< 0.001). This suggests that certain age groups, possibly younger individuals or those with severe cases, are more likely to use Quinine, while Residential Area also plays a significant role (X^2 = 2.053, $p < 0.001$), likely due to its use in remote or less developed areas with limited access to modern treatments. In addition, the influence of gender and occupation is negligible.

Furthermore, the result revealed that the residential area exhibits the strongest association with SP (X^2 = 2.392), followed by age range (X^2 = 0.558). Both have significant p-values (< 0.001), suggesting that SP usage is highly influenced by location and age. This

implies that there is minimal influence from gender and occupation is observed.

Table 9: perception on experiencing malaria recurrence

Response	Frequency	Percentage
Yes	75	44
No	85	56
Time frame		
Within 1 month	30	20
1–3 months	85	56.7
More than 3 months	25	16.7
Not sure	10	6.7

Table 9 shows that **44.0%** of respondents reported experiencing malaria recurrence after treatment, while **56.0%** did not. This distribution provides insights into the persistence and challenges of managing malaria, even after treatment. Furthermore, the result reveals the following distribution of time until symptoms of malaria returned after treatment. 20.0% of respondents reported that symptoms returned within 1 month followed by 56.7% experienced a return of symptoms between 1–3 months. 16.7% had symptoms return after more than 3 months and 6.7% were unsure about the timing of symptom recurrence.

Table 10: Factors contributing to malaria reoccurrence

Factor	Frequency	Percentage
Incomplete treatment / non-compliance	50	33.3
Resistance to malaria drugs	50	33.3
Re-exposure to mosquito bites	30	20.0
Poor environmental sanitation	20	13.3
Other	0	0

Table 10 reveal that the two primary factors contributing to malaria recurrence are incomplete treatment or non-compliance and drug resistance, each cited by 33.3% of respondents. Incomplete treatment, often due to factors like misunderstanding medication instructions, side effects, or limited healthcare **access**, leads to insufficient parasite elimination, causing relapse (Baird, 2019; WHO, 2020). Drug resistance, particularly to artemisinin, has become a significant concern, especially in regions like Southeast Asia, where resistant parasites survive despite treatment, necessitating the development of alternative therapies and combination treatments (Hemingway *et al.*, 2019).

Table 11 socio-economic influences on the factors contributing to malaria reoccurrences

Factor	X^2	P-value
Incomplete treatment / non-compliance	14.32	< 0.0001
Resistance to malaria drugs	1.23	> 0.005
Re-exposure to mosquito bites	8.32	< 0.001
Poor environmental sanitation	12.23	< 0.001
total	36.1	< 0.0001

Table 11 reveal a high association (X^2 = 14.32, $p < 0.0001$) of incomplete treatment or non-compliance, which suggests that socio-economic factors such as education level, income, and access to healthcare are likely significant contributors. In lower socio-economic groups, factors like poverty, lack of education about malaria, and limited access to healthcare can lead to poor adherence to treatment. This in turn results in incomplete eradication of the disease and potential recurrence. Poor socio-economic conditions can also limit the ability of individuals to afford or access the full course of Artemisinin-based Combination Therapy (ACT) or other recommended malaria treatments.

Although the association between drug resistance and malaria outcomes is weaker (X^2 = 1.23, $p > 0.005$), socio-economic factors can still play a role in this issue. In socio-economically disadvantaged areas, there may be limited access to newer, more effective medications or the capacity to monitor drug resistance. In addition, there is a significant association (X^2 = 8.32, $p < 0.001$) between re-exposure to mosquito bites and malaria recurrence can be influenced by socio-economic factors such as residential area, and occupation. People living in rural or impoverished areas with poor housing conditions may have limited access to malaria prevention tools. Occupations that require outdoor work, such as farming or construction, can also increase the likelihood of exposure to mosquitoes, particularly in areas with inadequate sanitation or infrastructure.

Table 12: perception on follow-up treatment for malaria recurrence

Response	Frequency	Percentage
Yes	95	63.3
No	55	36.7
Not applicable	0	0
Treatment type		
Artemisinin-based combination therapy (ACT)	40	26.7
Chloroquine	80	53.3
Quinine	30	20
Other	0	0

Response		
Yes	60	40
No	70	46.7
Not sure	20	13.3

Table 12 shows result on follow-up treatment for malaria recurrence which reveals that **63.3%** of respondents received follow-up treatment after experiencing malaria recurrence, while **36.7%** did not. This indicates that a significant portion of the population affected by malaria recurrence is accessing necessary post-treatment care. Follow-up treatment is essential in ensuring that the infection is fully addressed and that any emerging complications, such as drug resistance or relapses, are managed appropriately. The need for consistent and effective follow-up care aligns with the recommendations of the World Health Organization (WHO) and other public health bodies, which emphasize the importance of **monitoring** patients after treatment to prevent the development of complications and to ensure complete recovery (WHO, 2020).

However, ongoing monitoring and resistance surveillance are necessary to ensure the continued effectiveness of these treatments. In addition, the result revealed that 40.0% of respondents believe in the effectiveness of such measures, while a larger proportion, 46.7%, insecticide-treated nets (ITNs), indoor spraying, and environmental management is essential for reducing malaria transmission. However,

Discussion

The surveyed population is predominantly young, with 63.4% of participants aged between 5 and 30 years, and the 5–14 age group constituting the largest segment (36.7%). This suggests that malaria prevention and treatment efforts should prioritize children and adolescents, who are at higher risk due to increased outdoor exposure and lower immunity compared to adults.

A higher proportion of female respondents (63.3%) reflects global trends in healthcare access, where women, often in caregiving roles, are more likely to seek medical attention. The lower male participation (36.7%) highlights the need for targeted interventions to encourage health-seeking behavior among men
Half of the respondents (50%) fall under the "Other" occupational category, likely encompassing informal or low-income jobs. The population is predominantly urban (60%), compared to 40% from rural areas. Despite the higher urban representation, malaria transmission is typically more prevalent in rural regions where access to healthcare and preventive tools like insecticide-treated nets (ITNs) is limited.
Table 2 Fever was the most frequently reported symptom (40%), followed by

headache (20%), muscle pain (20%), and vomiting (13.3%). Notably, classic symptoms like chills and fatigue were not mentioned, indicating possible underreporting or misconceptions about malaria symptom 46.7% of respondents experienced symptoms for less than 3 days, suggesting early treatment or mild cases. 33.3% reported symptoms lasting 3–7 days. 20% experienced symptoms for more than 7 days, potentially indicating severe cases or delayed treatment.

Tables 3–6 73.3% of respondents had a previous malaria diagnosis, indicating high community exposure. Rapid Diagnostic Tests (RDTs) were the most commonly used method (63.3%), followed by clinical diagnosis (23.3%) and microscopy (13.3%). The reliance on RDTs underscores the importance of maintaining quality assurance for accurate diagnosis. Plasmodium falciparum was the predominant species (99.3%), consistent with the region's epidemiology. No cases of P. vivax, P. ovale, or other species were reported.

Malaria Treatment Practices (Tables 7–.8) Artemisinin-based Combination Therapy (ACT) was the most commonly used treatment (54.7%), aligning with WHO recommendations for first-line treatment of P. falciparum. Chloroquine (23.3%) and Quinine (8.7%) were also used, despite concerns about drug resistance.

Socio-Economic Influence: Younger individuals and urban residents were more likely to use ACT, while Chloroquine and Quinine were more prevalent in rural areas, possibly due to accessibility or cost.

Tables 9–11 Malaria Recurrence and Contributing Factors, 44% of respondents reported experiencing malaria recurrence, with 56.7% of cases occurring within 1–3 months of initial treatment. Incomplete treatment or non-compliance (33.3%) and drug resistance (33.3%) were the leading causes of recurrence. Re-exposure to mosquito bites (20%) and poor environmental sanitation (13.3%) also contributed significantly. Incomplete treatment and non-compliance were strongly linked to socio-economic factors ($X^2 = 14.32$, $p < 0.0001$), while poor sanitation ($X^2 = 12.23$, $p < 0.001$) and mosquito exposure ($X^2 = 8.32$, $p < 0.001$) were more prevalent in disadvantaged communities. Comprehensive malaria control strategies must address treatment adherence, drug resistance, and environmental sanitation, with a focus on socio-economically vulnerable groups.

Table 12 63.3% of respondents sought follow-up treatment for malaria recurrence. Chloroquine was the most commonly used follow-up medication (53.3%), followed by ACT (26.7%) and Quinine (20%). While 40% of respondents believed in the effectiveness of follow-up treatments, 46.7% expressed doubts, indicating potential gaps in awareness and trust in treatment efficacy. Improving community awareness and trust in malaria treatments, alongside efforts to ensure effective follow-up care, can enhance treatment outcomes and reduce recurrence rates.

Recommendation

Based on the findings of this study, the following recommendations for further research are;

- Conduct longitudinal studies to explore factors driving *Plasmodium falciparum* recurrence, such as immunity, reinfection rates, and treatment adherence, to enhance case management strategies.

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