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Prevalence and Factors Responsible for Asymptomatic Malaria Reservoir of Plasmodium Falciparum Among Adults in Nasarawa State, Nigeria

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Abstract

Asymptomatic malaria is prevalent in highly endemic areas of Africa, with only a small percentage of individuals exhibiting clinical symptoms. The clinical consequence of asymptomatic malaria is not fully understood. Some researchers are of the view that asymptomatic parasitaemia is involved in the development of partial immunity and may protect against clinical disease from new infections. The purpose of this study was to assess the prevalence of malaria reservoir of plasmodium falciparum among adult people of Nasarawa state of Nigeria and to identify the factors associated with malaria in this category of people. A community-based cross-sectional study was conducted among selected local government areas of the state. The outcome variable was the presence or absence of malaria in which its asscoiation with demographic information, knowledge and awareness, measures and control, environmental factors are tested. The local government areas were observed to have reported the highest positivity rate of malaria between 2017 to 2022. The study was conducted from August 2022 to April 2023. A semi-structured questionnaire was employed to collect socio-demographic data and other associated risk factors by trained health professionals. Body temperature and other clinical manifestations were examined to identify the asymptomatic individuals. This examination was carried out after selection of individuals from households before mRDT is conducted. Data entry and analysis was carried out using SPSS (Statistical Package for the Social Sciences) version 20 software. The results obtained are very desirable.

Keywords: *Artemisinin Combined Therapy, Asymptomatic, Long Lasting Insecticide Net, Malaria Rapid Diagnostic Test, Plasmodium Falciparum, Screening.*

Introduction

Asymptomatic malaria is the presence of malaria parasite in the blood in the absence of symptoms. However, the clinical symptoms may vary across different epidemiological settings and are fully understood. It is also generally assumed that in endemic areas asymptomatic parasitaemia is involved in development of partial immunity and may protect against clinical disease from new infections [1]. While on the other hand, asymptomatic parasitaemia provides a reservoir for transmission and maybe precursor in progression to symptomatic disease [1].Although experts have emphasized the role of asymptomatic carrier in various studies, but the interesting point is the absence of a unified definition of asymptomatic malaria [2].

Asymptomatic malaria is prevalent in highly endemic areas of Africa, with only a small percentage of individuals exhibiting clinical symptoms [3]. The clinical consequence of asymptomatic malaria is not fully understood [1]. Some researchers are of the view that asymptomatic parasitaemia is involved in the development of partial

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immunity and may protect against clinical disease from new infections.

Based on the latest data from the World Malaria Report, the year 2020saw a total of 241 million reported cases of malaria, marking an increase from the 227 million cases recorded in 2019. Tragically, the estimated count of malaria-related deaths reached 627,000 in 2020, representing a rise of 69,000 fatalities compared to the previous year [4].

The burden of malaria remains significantly concentrated in the WHO African Region. In the year 2020, this region accounted for an overwhelming 95% of all reported malaria cases and a striking 96% of the total reported deaths due to malaria. Distressingly, around 80% of all malaria-related deaths in this region were among children under the age of 5 [4].Malaria is one of the greatest threats to modern society in terms of morbidity and mortality [5].

The global malaria landscape was notably influenced by four African countries, which collectively contributed to slightly over half of the total global malaria deaths. These countries are Nigeria (31.9%), the Democratic Republic of the Congo (13.2%), the United Republic of Tanzania (4.1%), and Mozambique (3.8%). According to the World Malaria Report 2021, Nigeria accounts for a major portion of the global malaria burden, in terms of both global estimated malaria cases and deaths, 27 per cent and 32 per cent, respectively [6]. In areas of endemicity such as Nigeria, it poses a major problem to both human capital, and economic development among other factors [7].

Furthermore, malaria is a major public health risk in Nigeria where children and pregnant women are most vulnerable. In Nigeria, this infectious disease continues to be the primary source of both illness and death among children. Malaria is also the reason for hospital attendance in 7 out of every 10 patients seen in Nigerian hospitals [8]. Despite considerable efforts to control malaria, it is still the most prevalent and devastating disease in tropical Africa with pregnant women and children below five years being the highest risk groups[9].

The burden of malarial infections cannot be underestimated; it is widely agreed that malaria is a disease of the poor [10]. Malaria is transmitted throughout Nigeria, with 97% of the population at risk of malaria. The duration of the transmission season ranges from year-round transmission in the south to three months or less in the north [11]. According to the 2021 World Malaria Report, Nigeria had the highest number of global malaria cases (27 % of global malaria cases) and the highest number of deaths (32 % of global malaria deaths) in 2020 [12]. The country accounted for an estimated 55.2% of malaria cases in West Africa in 2020 [13]. Case numbers increased by 5.3% between 2017 and 2020, from 298 to 314 per 1000 of the population at risk. Deaths increased by 4.7%, from 0.92 to 0.97 per 1000 of the population at risk during that same period [13].

The prevalence of malaria amongst children 6 – 59 months was 27% with a slight decline to 23% in 2018 [14, 15]. Many studies have shown that the malaria burden is generally higher in rural compared to urban areas [3]. The prevalence of malaria is higher in the Northern part of the country.

According to NDHS 2018, Nigeria's prevalence rate was 22.6% while Nasarawa state reported a 13.6% prevalence rate [13]. Nasarawa state is one of the states in the northcentral that is supported with different interventions by various developmental partners/non-governmental organizations in malaria. The donors provide support to the state malaria elimination program on case management, surveillance monitoring and evaluation, drug-based prevention and treatment approaches (intermittent preventive treatment in pregnancy and seasonal malaria chemoprevention) which are more directed to those under five years and pregnant women, health system strengthening (planning

management and program monitoring), distribution of long-lasting insecticide nets (LLIN), malaria commodities (drugs, malaria test kits). Therefore, this study's primary objectives were to determine the factors linked to the prevalence of malaria reservoir of plasmodium falciparum (PF) among adult people of Nasarawa state of Nigeria

Materials and Methods

Source of Data

A cross-sectional survey was done between August 2022 and April 2023, which is a period of high malaria transmission intensity to capture peak transmission. A community-based cross-sectional study was conducted among the selected local government areas (Keana, Nasarawa and Wamba) in Nasarawa state. They are the local government areas that have had relatively higher malaria positivity rates in the past 5 years according to the DHIS2 (District Health Information System) report from 2017 to 2022. To achieve the set goals for this study, three (3) health facilities were identified in the different senatorial zones. The study considered some selected settlements in the catchment areas that are within a 5km radius of the health facilities. The sample population was drawn from people aged 18 years and above, preferably household heads in Nasarawa state using a stratified sampling method. Within the stratum, the LGAs with the highest malaria positivity rate were selected. The sample population included willing participants based on age, gender, occupational status, marital status, educational background, and household size. Consequently, a mixed population of 1200 individuals were screened, and the survey was conducted between August 2022 to April 2023.

The study comprised individuals (aged 18 and above) within the community, particularly those with no history of fever before the survey, axillary body temperature ranging from 35.9°c to 36.7°c, and exhibited no additional indications or symptoms linked to malaria (such as headache, vomiting, abdominal pain, nausea, or diarrhoea). Participation was voluntary, contingent on the completion and signature of a consent form by everyone. Furthermore, the study exclusively enrolled individuals currently residing in Nasarawa State during the survey period. People with fever, those currently taking anti-malaria and those who took anti-malaria or have been on the therapy within the past 2 weeks were excluded. Additionally, individuals with life-threatening illnesses (other than malaria) were also excluded. However, all participants showing clinical malaria signs present at the time of the study were tested and treated if their malaria parasite presence was confirmed.

Variables

The malaria rapid diagnostic test (RDT) result is the study's response variable of interest. RDT is an immune-chromatography test that helps diagnose malaria by identifying particular antigens, or proteins, that malaria parasites create in the blood of an infected individual. While some RDTcan identify numerous species, others only identify one species (plasmodium falciparum). The patient tests positive for malaria if there are malaria antigens present. The individual tests negative for malaria if there are no malaria antigens. Therefore the

(a) dependent variable is either the presence of malaria or no malaria

(b) Independent variables include the level of knowledge, and demographic and socio-economic factors responsible for malaria asymptomatic plasmodium falciparum like temperature, age, sex, educational level, occupation status, monthly income, household size and control measures among others.

Statistical Methods and Analysis

A stratified sampling technique was used to select 400 adults across the three selected LGAs (Nasarawa, Nasarawa eggon and

Keana) respectively. The selected LGA were further stratified into wards by purposive sampling which was further deployed to randomly select households in selected communities in a given ward where one individual was tested per household. Malaria prevalence was determined among persons 18 years and above using RDT.

For participants who tested positive for malaria parasites, the majority were treated using Artemisinin Combined Therapy (ACT) in line with malaria treatment guidelines. Artemether-Lumefantrine (AL) and alternatives: Artemether-Lumefantrine is the primaryACT deployed programmatically in Nigeria, with Artesunate-Amodiaquine as an alternative. To ensure adherence to the treatment regimen and to document any adverse effects, the initial dose was administered under direct supervision. Subsequently, participants were monitored for treatment adherence on days 1, 2, and 3 [18]. Each participant's retention of the drug was observed for a duration of 5 minutes after the treatment was administered.

A semi-structured questionnaire was employed to collect socio-demographic data and other associated risk factors by trained health professionals. Body temperature and other clinical manifestations were examined to identify symptomatic and asymptomatic individuals. This examination was carried out after the selection of individuals from households before mRDT (Malaria Rapid Diagnostic Test) was conducted. Data entry and analysis will be carried out using SPSS version 20 software.

Statistical Analysis

In this study, an open data kit (ODK) was used to collect data for this research. Hence, data was exported to Excel for cleaning. While SPSS (IBM SPSS Statistics 20, United States) was employed for the analysis of the data. Meanwhile, the household was considered as the unit of enrolment. The proportion of participants confirmed with malaria parasite during screening was used to report malaria prevalence. These proportions were categorized based on demographic variables such as age, gender, educational status, occupational status, marital status, andsenatorial zones. The aim was to ascertain the extent of malaria prevalence related to asymptomatic parasitaemia among adults in Nasarawa state. Descriptive statistics, including tables and bar charts, were utilized for this purpose. To investigate the association between parasitaemia prevalence and environmental factors affecting malaria prevalence, a Chi-square statistic was applied. The significance level chosen for this analysis was 95% confidence ($\alpha = 0.05$).

Results and Interpretation

The study revealed that the female participants made up 47.1%while the male counterparts made up 52.9% of the total participants (Table 1). The age group affected the most are those from 25 – 29 years (73.4%), probably because they stay out late and mostly in skimpy dresses, and nearly one-third of the population earn a monthly income within ₦30,000 – ₦80,000 (33.8%). The average household reported in the study was 3 – 5 household size. Malaria knowledge among the participants was very good, 91.9% understand that a patient with a fever should be tested, and they will prefer to go to the hospital to see a health worker rather than do a self-medication. Regarding LLIN coverage and usage, 94.2% of the participants have LLIN, out of which 47.8% have more than two LLINs. Most of the LLIN was gotten during the mass campaign, and 87.6% slept in the LLIN last night before the data collection. The majority of those who slept inside the LLIN were children under 5 years (64.4%).

Of the 1200 participants targeted across the three senatorial zones, the prevalence rate ranged from 19.3% (77/400) to 26.8% (111/400) (Table 1). Considering the three

different locations across the study. Asymptomatic malaria parasite carriage was found to be at 19.3% in Keana, 24.3% in Nasarawa and 26.8% in Wamba LGAs respectively. These observations reflect the seasonality of malaria inthe zones across the state.

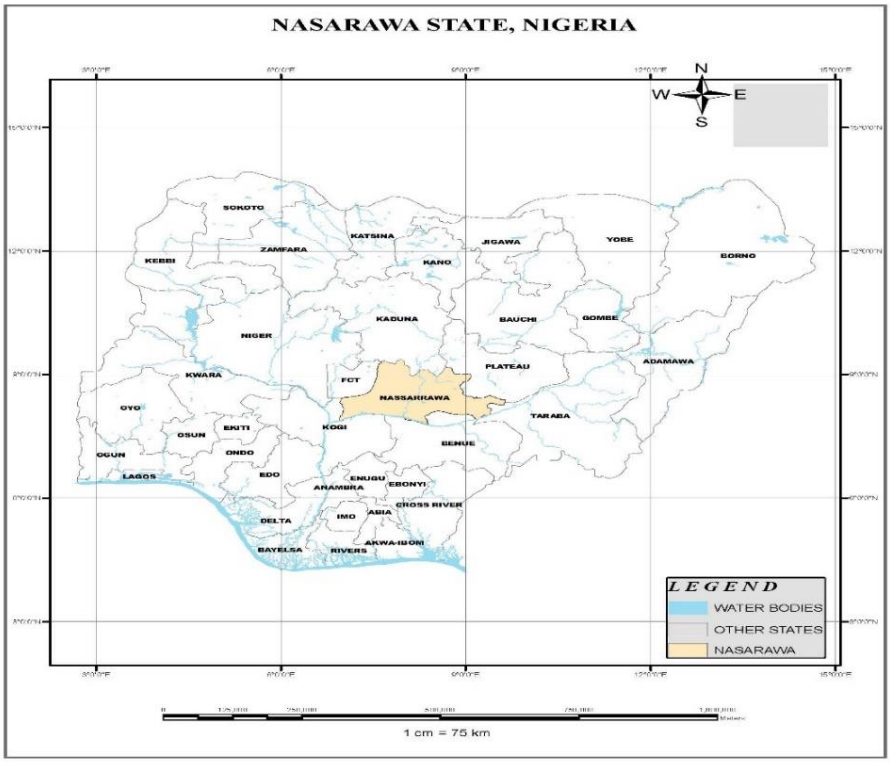

Figure 1. Map of Nigeria Showing Nasarawa State the Study Area

Table 1. Demographic Information, Knowledge and Awareness, Measures and Control, Environmental Factorsin the Three Geopolitical Zones of Nasarawa State

Characteristics/Variables	**Category**	**Frequency (N=1200)**	**Percentage (%)**
Demographic information			
Age	18 – 24 years	232	19.3
	25 – 59 years	881	73.4
	>60 years	88	7.3
Sex	Male	635	52.9
	Female	565	47.1
Educational status	Graduate	149	12.4
	Postgraduate	640	53.3
	Secondary	230	19.2
	Primary	18	1.5
	None	163	13.6
Occupational status	Business	388	32.3
	Civil service	122	10.2
	Currently unemployed	14	1.2

	Farmer	166	13.8
	Housewife	328	27.3
	Retired	60	5
	Student	122	10.2
Monthly income	<30,000	696	58
	30,000 – 80,000	406	33.8
	>80,000	98	8.2
Household size	1 – 2	166	13.8
	3 – 5	530	44.2
	6 – 9	335	27.9
	>10	169	14.1
Knowledge and awareness			
	Fever	1103	91.9
	Chills	24	2
	Vomiting	43	3.6
	Diarrhea	12	1
	I don't know	18	1.5
Who decides you have malaria	Health worker	1097	91.4
	Self	92	7.7
	Others	11	0.9
What you do when you suspect malaria	Self-medication	66	5.5
	Go to the lab	17	1.4
	Go to the hospital	1112	92.7
	Others	5	0.4
Control measures			
LLIN availability	Yes	1130	94.2
	No	70	5.8
	One	95	7.9
	Two	468	39
	Above two	573	47.8
	None	64	5.3
How LLIN was gotten	During mass campaign	892	74.3
	During antenatal	135	11.3
	During immunization	158	13.2
	Others	15	1.3
Did anyone sleep inside LLIN last night	Yes	1051	87.6
	No	149	12.4

Reason for not sleeping inside LLIN last night	Net too old/had holes	27	18
	Net not hung	24	16
	Discomfort due to heat	48	32
	Other reasons	50	34
Category of those that slept inside LLIN	Persons below 5 years	773	64.4
	Persons above 5 years	277	23.1
Environmental Factors			
Stagnant water present in compound	Yes	337	28.1
	No	863	71.9
	Yes	407	33.9
Presence of water vessels in the compound	No	793	66.1
	Yes	656	54.7
Presence of overgrown vegetation (within 5 metres) of the house	No	544	45.3
Prevalence of asymptomatic malaria			
Keana – south senatorial zone		77/400	19.3
Nasarawa – west senatorial zone		97/400	24.3
Wamba – North senatorial zone		111/400	26.8
Nasarawa state		285/1200	23.8

Table 2. Chi-square (x^2) Analysis of the Demographic Information, Knowledge And Awareness, Measures and Control, Environmental Factors Associated With Prevalence of Asymptomatic Malaria in the Three Geopolitical Zones of Nasarawa State

Characteristics/Variables	**X^2 value**	**P value**	**Decision**
Gender	1.941[a]	0.164	Not significance
Age	0.712[a]	0.7	Not significance
Marital status	2.279[a]	0.517	Not significance
Education	1.501[a]	0.826	Not significance
Occupation	5.605[a]	0.469	Not significance
Monthly income	16.212[a]	0	Significance
Children <5 years in the household	2.503[a]	0.475	Not significance

Position of the participants	12.012[a]	0.007	Significance
Household size	12.889[a]	0.005	Significance
Malaria signs	2.224[a]	0.695	Not significance
Who decides you have malaria	2.071[a]	0.355	Not significance
What is done if malaria suspected	1.361[a]	0.715	Not significance
Malaria is dangerous	0.327[a]	0.567	Not significance
Malaria is preventable	0.296[a]	0.586	Not significance
LLIN availability	0.133[a]	0.71	Not significance
Number of LLIN owned	28.824[a]	0	Significance
Where LLIN was gotten	12.030[a]	0.007	Significance
Did anyone sleep inside LLIN last night	0.009[a]	0.926	Not significance
Reason for not sleeping inside LLIN	0.490[a]	0.921	Not significance
Category of those that slept inside LLIN	4.302[a]	0.38	Not significance
Stagnant water present in compound	0.915[a]	0.339	Not significance
Presence of water vessels in the compound	2.947[a]	0.046	Not significance
Presence of overgrown vegetation in the house	15.845[a]	0	Significance

Table 1, above revealed that some variables (social, preventive, and environmental) showed an association with malaria prevalence. However, among these variables are monthly income, the position of participants, and household size all played a vital role in malaria preventive measures. Hence, the study indicated that there is a very significant association between the prevalence and social, preventive, and environmental factors.

Considering, the number of LLIN owned by each household, and where the LLIN were gotten from, the study revealed a significant association with malaria prevalence. Additionally, the presence of water vessels in the compound and overgrown vegetation in the house showed association with malaria prevalence. This can be attributed to poverty and lack of awareness of the need and use of LLIN as a major preventive measure for malaria. In 2019, the National Bureau of Statistics (NBS) announced Poverty and Inequality in Nigeria", which highlights that 40 per cent of the total population, or almost 83 million people, live below the country's poverty line of 137,430 naira ($381.75) per year. Hence, Nasarawa state had a poverty rate of 57.3 percent, making it the 12th state in Nigeria with the highest poverty rate. While in north-central region, it had the second-highest poverty rate [19].

Therefore, the prevalence of unfavorable environmental and social factors that

contribute to disease are highest among individuals living in poverty [20].

Discussion

Asymptomatic malaria is far more prevalent than previously thought, plays a significant role in onwards transmission and is probably not completely asymptomatic. However, many important questions remain unanswered, with the key issues discussed in this review article. Asymptomatic, low-density infections are a significant component of the malaria reservoir, which also appear to contribute to the infectious reservoir [21]. However, the study revealed high prevalence rates of asymptomatic malaria parasitaemia in the three geopolitical zones of Nasarawa State.

A good proportion of asymptomatic carriers of parasites with no evident symptoms of malaria might be responsible for perpetuating transmission of malaria parasites in the presence of susceptible mosquitoes in the study areas as described previously [22]. Therefore, in the course of ongoing malaria elimination efforts in the country, there is a need to take into consideration routine surveillance, awareness creation during routine immunization sessions (either fixed or outreach), antenatal care sessions and encourage treatment of asymptomatic carriers of malaria to minimize infection rates.

In the survey, the presence of stagnant water in the compound is insignificant compared to the presence of vessels that could potentially hold water (open water containers, earthen pots, discarded tyres and indiscriminate disposal of waste and containers that can hold water) for mosquito breeding and presence of overgrown vegetation within 5 meters of houses of the study participants was significantly associated with asymptomatic plasmodium infection, while educational status (being literate) seems to have played a protective role against malaria infection.

The reported high malaria prevalence in this study was therefore associated with highparasite density; higher prevalence rate among participants at Keana (19.3%), whileNasarawa (24.3%), and Wamba (24.3%) who had higher parasite densities respectively compared to Keana. The study showed that conducting malaria outreach is feasible and could lessen asymptomatic malaria, especially in highly endemic areas. During the study period, it was observed that some malaria-asymptomatic persons in endemic communities do not become febrile. However, an investigative study indicates that some parasite carriers in endemic communities do not become febrile[23]. Although, more people can be cleared of the parasite through active community screening and treatment (outreaches) in addition to the current facility-based consultations that focus on symptomatic patients in areas identified to have a high malaria positivity rate.

Conclusions

In conclusion, this study reveals the encouraging findings regarding LLIN coverage and usage among the study participants. The results indicate that a substantial portion of the population has adopted and effectively utilized LLINs, reflecting commendable efforts in malaria prevention. However, it is important to note that the presence of stagnant water within the compounds was relatively low, in contrast to the prevalence of containers capable of harboring water for mosquito breeding. Additionally, the observed overgrown vegetation within proximity to the houses raises concerns about potential mosquito habitats.

Furthermore, the study's exploration of associated factors has unveiled significant connections with asymptomatic plasmodium infection. These findings underscore the intricate interplay of various factors in shaping the malaria landscape within the studied

community. Addressing these factors, such as the presence of potential mosquito breeding sites and overgrown vegetation, is crucial for achieving comprehensive malaria control and reducing asymptomatic infections.

In essence, while the study highlights the commendable progress in LLIN coverage and usage, it also emphasizes the need for targeted interventions to address the remaining challenges. By targeting both the identified risk factors and the factors associated with asymptomatic plasmodium infection, public health efforts can be more effectively channeled towards creating a holistic approach to malaria control in the community. This research serves as a valuable resource for policymakers, health practitioners, and stakeholders, guiding them in formulating strategies that encompass both prevention and intervention measures to combat malaria more effectively.

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Conflict of Interests

Authors declared no conflict of interest.

Ethics Approval and Consent for the Study

The protocol for this study was reviewed and approved by the Nasarawa State Ministry of Health Ethics Review Committee (NHREC Protocol Number: 18/06/2017). Meanwhile, participants signed an informed consented form prior to participating in the study. An entry meeting was conducted with community chiefs and elders to seek their approval while households' consent was given by the household heads.

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