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Prevalence of Human Malaria Infection and its Transmission Pattern in the Highlands and Lowlands of Plateau State, Nigeria

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Abstract

Objectives: To quantify the prevalence of *Plasmodium* species and transmission patterns of human malaria in the highland and lowland areas of Plateau State, Nigeria. **Methods/Statistical Analysis:** Malaria prevalence studies were conducted from November, 2015 through to October, 2016. Microscopic examination using thin and thick blood smears was employed. Determination of malaria parasite presence and *Plasmodium* species identification was carried out using X100 objectives under oil immersion. Chi square (χ^2) statistics was used to test statistical significance of the relationship between sex, age and occupation. **Findings:** The results show the overall prevalence of malaria infection in the study area was 48.1%. The most prevalent malaria parasite recorded in this study was *Plasmodium falciparum* (94.1%). This was followed by *Plasmodium malariae* (5.9%). Sex related prevalence by LGA show that infection did not differ significantly in all the LGAs ($P > 0.05$) except in Barkin Ladi LGA where males had significantly higher infection than females ($P < 0.05$). Prevalence of malaria parasites was significantly associated with age in all the LGAs ($p<0.05$) except for Jos-North LGA ($p>0.05$). In these LGAs, infection was highest in age-group 5-9 and 6-14 years with the lowest infection recorded in age-group 35 years and above. Prevalence of Plasmodium infection differs significantly by occupation in all the LGAs ($p< 0.05$) except for Jos-North LGA ($p> 0.05$). Transmission occurred all year round. In the highlands, transmission peaked in June whereas in the lowlands, it peaked in July. The variation in transmission patterns observed in this study will be informative in planning programmes geared towards controlling the disease. **Application/Improvements:** This study has provided a better understanding of the epidemiology of malaria in Plateau state which will help in formulating specific and efficient intervention strategies.

Keywords: Malaria, Nigeria, Prevalence, Plateau State, Transmission Pattern

1. Introduction

Malaria is a complex disease caused by parasites of the genus *Plasmodium*. This is a serious disease and still remains a public health concern around the globe especially in Nigeria where the disease is responsible for enormous cases of morbidity and mortality in many parts of the country.

According to[1] an estimated 429,000 deaths and about 212 million reported cases of malaria were reported worldwide in 2015, with majority of these reported cases and mortality occurring in World Health Organization African region (90%).

Concerted efforts have been made over the years in the areas of drug development, diagnosis and control measures to eliminate and eradicate the disease. As a

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result, out of the ninety-one countries that still had continuing malaria transmission in 2015, about forty were reported to have witnessed a reduction of about 40% or more reported number of deaths that resulted from malaria between 2010 and 2015[1].

The highest burden of reported malaria mortality world-wide is in sub- Saharan Africa. Nigeria together with Congo DR accounted for about 36% of the global malaria mortality in 2015[1]. It was estimated in 2015 that about 97% Nigerians are exposed to the danger of contracting malaria with the disease being the primary cause for about 60% outpatient attendance at various health centres, 30% childhood death, 25% of death in children under one year and 11% maternal mortality making malaria the most important cause of mortality among children[2].

The determination of the endemic level of human malaria infection in populations exposed to the disease is very essential in order to formulate specific and appropriate intervention strategies.

Although many studies have recorded prevalence of malaria across Nigeria, such studies focused only on specific groups such as children, asymptomatic individuals and pregnant women or they were cross-sectional surveys that cover just one or two months in a year [3-8]. There remains paucity of information on studies that estimate parasite prevalence amongst all age groups and all year-round. Malaria transmission can occur all year round or in certain months of the year. Knowledge of malaria transmission pattern in every epidemiological setting is essential for appropriate selection and planning of intervention strategies and monitoring.

The current study was designed to estimate the prevalence of malaria in all individuals presenting with clinical symptoms of the disease such as fever in the general hospitals of the selected local government areas of Plateau state, North- Central Nigeria for a complete year from November 2015 to October 2016.

2. Materials and Methods

2.1 Research Design

Malaria prevalence study was conducted for a full year beginning from November, 2015 through to October, 2016. Microscopic examination using thin and thick blood smears was used for the prevalence study.

2.2 The Study Area

Plateau state is located in the North-Central geopolitical zones of Nigeria. Plateau state lies between latitudes 80°24'N and longitudes 80°32' and 100°38' east with a climate that is define by two seasons. The rainy (wet) season run from April to September whereas the dry season starts from October to March. The study was conducted in three selected Local Government Areas (LGAs) each from the highlands: Bassa, Jos-North and Barkin-Ladi (altitudes ≥ 1,200m above sea level) and lowlands: Langtang-North, Mikang and Shendam (altitudes ≤300m above sea level) areas in Figure 1.

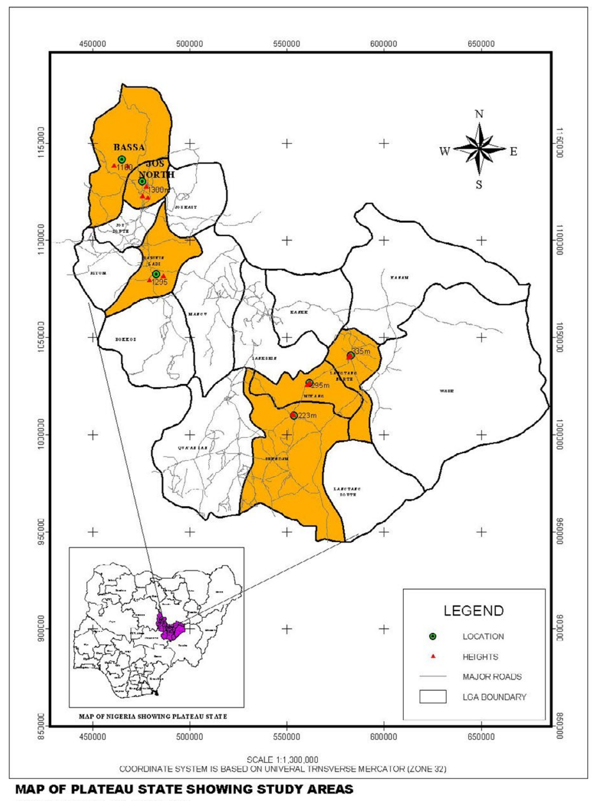

Figure 1. Map of Plateau State Showing Study Areas.

2.3 Sampling/ Sample size determination

Individuals who presented with clinical symptoms of malaria were recruited for the study. Blood sample collection was from participants of both sexes and ages. Sampling was carried out twice every month from November 2015 to October 2016.

The sample size for each study site was derived using an anticipated population proportion of 50%, confidence level of 95% and absolute precision of 5 percentage point. The sample size was calculated using the following formula adopted from[9]:

$$n = \frac{Z^2 \times P\,(1 - P)}{d^2}$$

Where n is the minimum sample size, P is the anticipated population proportion and d is the absolute precision at 5 percentage point (0.05).

This gives an approximate sample size of 384 participants for each of the study sites. This gave a sample size of at least 1,152 individuals for the entire study.

2.3 Blood collection, preparation and parasites identification

Standard methods described by[10] were used.

The dried slides were packed carefully in sturdy slide boxes in the field biweekly and transported to the medical parasitology laboratory for examination.

Table 1. Overall malaria prevalence due to *Plasmodium* species in LGAs

LGAs	No. Screened	No. Infected	P. *falciparum* (%)	P. *malariae* (%)
Bassa	364	222	204 (91.9)	18 (8.1)
Jos-North	410	200	190 (95.0)	10 (5.0)
Barkin Ladi	405	188	180 (95.8)	08 (4.2)
Langtang-North	410	211	202 (95.7)	09 (4.3)
Mikang	412	192	177 (92.2)	15 (7.8)
Shendam	400	141	133 (94.3)	08 (5.7)
Total	**2401**	**1154(48.1)**	**1086 (94.1)**	**68 (5.9)**

Table 2. Sex-related malaria prevalence in different LGAs

Sex/LGAs	No. Screened	No. infected	Percentage (%)	P value
Bassa Male	146	93	63.7	
Female	218	129	59.2	0.386
Jos-North Male	189	90	47.6	
Female	221	110	49.8	0.386
Barkin Ladi Male	147	83	56.5	
Female	258	105	40.7	**0.002**
Mikang Male	170	74	43.5	
Female	242	118	48.8	0.295
Langtang-North Male	140	69	49.3	
Female	270	142	52.6	0.525
Shendam Male	164	54	32.9	
Female	236	87	36.9	0.418
Total				
Male	956	463	48.4	0.624
Female	1445	691	47.8	
TOTAL	2401	1154	48.1	

To ensure quality assurance, a second microscopic examination was carried out with the assistance of qualified and experienced malaria microscope specialists. The second microscopist was blinded to the results of the first reading. All positive and 10% of negative slides were reread.

2.4 Eligibility criteria

Participation in this study was open to individuals of all ages and sexes who consented to participate in the study. Individual who participated in the study signed an informed consent form (Appendix I)

2.5 Ethics consideration

The study protocol received approval (PSSH/ADM/ETH.CO/2015/004 and PSSH/ADM/ETH.CO/2016/003) from the Plateau State Specialist Hospital Health Research Ethics Committee (Appendices II&III). Verbal and written informed consent to participate in the study were sought from all eligible participants older than eighteen years of age or from the parents of participants who were of ages 0-17 years(minors).

2.6 Data Analysis

Data collected were thoroughly cleaned for errors, completeness and consistency checks. Information collected were entered into excel spread sheet for storage and were later fed into in STATA statistical software for the analysis.

3. Results

3.1 *Plasmodium* species composition and prevalence in Plateau state

The distribution of *Plasmodium* species identified among study participants in the study areas are shown in Table 1. A total of 2,401 males and females aged one year and above were screened for *Plasmodium* species from November, 2015 to October, 2016. The overall prevalence of malaria infection in the study area was 48.1%.

Chi-square analysis demonstrated a significant difference $\chi^2 = 13.1$, $P = 0.004$ ($p < 0.05$) between *P. falciparum* and *P. malariae* occurrence in all the LGAs. *P. falciparum* was the most prevalent species accounting for 94.1% of

Table 3. Age group related malaria prevalence in different LGAs

LGA	Mikang			Langtang North			Shendam			Bassa			Jos-North			Barkin Ladi		
Age Group	**No. Scr.**	**No. Inf**	%	**No. Scr.**	**No. Inf**	%	**No. Scr.**	**No. Inf**	%	**No. Scr.**	**No. Inf**	%	**No. Scr.**	**No. Inf**	%	**No. Scr.**	**No. Inf**	%
≤5	59	31	52.5	31	21	67.7	34	16	47.1	62	48	77.4	69	39	56.5	37	22	59.5
5-9	34	15	44.1	33	26	78.8	24	08	33.3	25	20	80.0	32	13	40.6	46	24	52.2
10-14	15	12	80.0	36	27	75.0	38	20	52.6	23	15	65.2	59	31	52.5	35	18	51.4
15-19	31	21	67.7	46	33	71.7	47	19	40.4	17	11	64.7	21	08	38.1	39	19	48.7
20-24	40	28	70.0	40	25	62.5	53	24	45.3	19	12	63.2	26	13	50.0	51	21	41.2
25-29	43	30	69.8	59	35	59.3	41	14	34.2	41	29	70.7	45	24	53.3	57	27	47.4
30-34	37	09	24.3	32	13	40.6	28	03	10.7	40	22	55.0	35	15	42.9	36	17	47.2
35-39	41	17	41.5	30	10	33.3	38	03	7.9	27	17	63.0	33	14	42.4	35	13	37.1
40-44	23	11	47.8	20	03	15.0	50	17	34.0	19	09	47.4	20	11	55.0	19	11	57.9
≥45	89	18	20.2	83	18	21.7	47	17	36.2	91	39	42.9	70	32	45.7	50	16	32.0
TOTAL	412	192	46.6	410	211	51.5	400	141	35.3	364	222	61.0	410	200	48.8	405	188	46.4
(pValue)	**0.001**			**0.001**			**0.001**			**0.001**			0.076			**0.0306**		

No. Scr. = Number screened, No. Inf. = Number infected, % = Percentage of number infected

Table 4. Occupation-related Malaria prevalence in different LGAs

Occupation	No. Screened	No. Infected	Percentage (%)	P value
Langtang-North				
Student	128	93	72.7	0.000
Farmer	217	85	39.2	
Civil servant	10	03	30.0	
Traders	10	03	30.0	
Mikang				0.004
Student	93	57	61.3	
Farmer	237	96	40.5	
Civil servant	09	03	33.3	
Traders	06	01	16.7	
Shendam				0.027
Student	124	52	41.9	
Farmer	212	65	30.7	
Civil servant	14	13	21.4	
Traders	14	03	21.4	
Bassa				0.008
Student	62	44	71.0	
Farmer	211	120	56.9	
Civil servant	17	06	35.3	
Traders	07	03	42.9	
Jos-North				0.550
Student	109	50	45.9	
Farmer	175	84	48.0	
Civil servant	23	09	39.1	
Traders	25	14	56	
Barkin Ladi				0.129
Student	122	60	49.2	
Farmer	227	102	44.9	
Civil servant	07	01	14.3	
Traders	06	01	16.7	
Total	2401	1154	48.1	

the diagnosed cases in all the LGAs with P. *malariae* only accounted for 5.9% of the total malarial cases in the study sites.

3.2 Malaria prevalence by sex in Plateau state

The prevalence of malaria in relation to sex is shown in Table 2. The infection was slightly higher in males 691(48.4%) compared to females 463(47.8%). Chi square test show that the overall differences between sexes was not significant ($p>0.05$). Sex related prevalence by LGA shows that infection did not differ significantly in all the

3.3 Age-group related malaria prevalence in different LGAs

In Langtang-North, Mikang, Shendam, Bassa and Barkin Ladi LGAs, Chi square test show that malaria prevalence was significantly associated with age (($\chi^2_{(9)}$ 77.67, P=

0.001), ($\chi^2_{(9)}$ 63.99, P= 0.001), ($\chi^2_{(9)}$ 29.95, P= 0.001), ($\chi^2_{(9)}$ 27.30, P= 0.001) and ($\chi^2_{(9)}$ 10.56, P= 0.306)) respectively. The prevalence was however not significantly associated with age in Jos-North LGA ($\chi^2_{(9)}$ 29.95, P= 0.076) as indicated in Table 3. In Langtang-North and Bassa LGA, prevalence was highest in the age group 5-9 years. It was lowest in those aged between 40-44 years in Langtang-North and age groups ≥45 years in Bassa. In Shendam and Mikang LGAs, the highest infection was recorded in age groups 10-14 years with the lowest in age group 35-39 years and age groups ≥45 years respectively. Whereas in Barkin Ladi LGA, the highest infection was recorded in age groups 5 years old and below with the lowest in age group 45 years and above.

3.4 Occupation-related malaria prevalence in different LGAs

Prevalence of Plasmodium infection differs significantly by occupation in Langtang-North, Mikang, Shendam Bassa and Barkin Ladi LGAs, (($\chi^2_{(3)}$ 49.46, P= 0.001), ($\chi^2_{(3)}$ 15.26, P= 0.004), ($\chi^2_{(3)}$ 10.99, P= 0.027), ($\chi^2_{(3)}$ 13.93, P= 0.008) and ($\chi^2_{(3)}$ 7.14, P= 0.0129) respectively. This was however not significant in Jos-North LGA ($\chi^2_{(3)}$ 3.04, P= 0.550) as indicated in Table 4. Infection was highest in students in both LGAs. The lowest prevalence was recorded in traders (those involved in buying and selling fulltime) and Civil servants (All full time government employees) in all the LGAs.

3.5 Monthly malaria transmission pattern in the highlands and Lowlands.

The highest malaria prevalence in the highlands was observed in June with the lowest in December. Whereas in the lowlands, the highest prevalence was observed in July with the lowest in February.

Malaria cases were more prevalent during the rainy seasons (May-October) but transmission continues throughout the year in Figure 2.

4. Discussion

Plasmodium falciparum was the most prevalent malaria parasite in all the LGAs. The extrinsic incubation period of *P. falciparum* is shorter than those of other species. Its life cycle proceeds without interruption when temperatures are between 16^0C and 32^0C[11,12]. The average monthly temperature in the study areas falls within this conducive range for rapid and uninterrupted P. *falciparum* development thus enhancing transmission. These results are consistent with those of other findings around the world. In a similar study in the western highlands of Kenya,[13] found equally higher prevalence for *P. falciparum* and lower prevalence for P. *malariae*. In other related studies, [14] in Ethiopia and[15] in Yemen have also recorded higher prevalence of P. *falciparum* compared to other species. In Nigeria, related studies[4,16,17] have also shown that P. *falciparum* is the most common species.

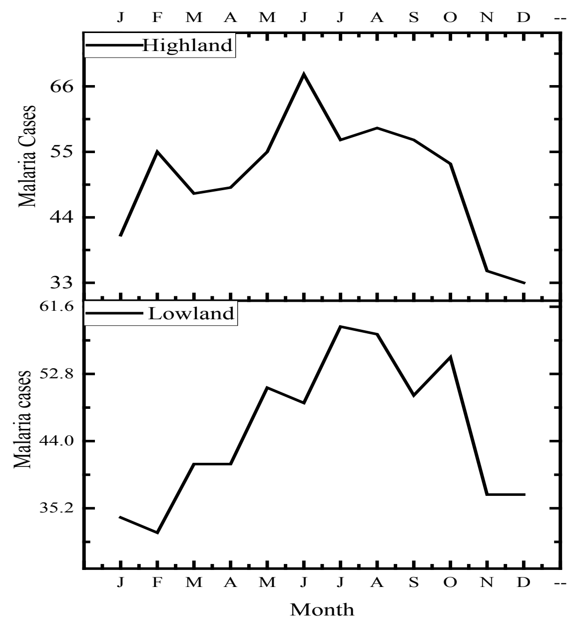

Figure 2. Malaria transmission patterns in the highlands and lowlands.

The study findings show that there was variation in malaria prevalence according to sex in all the study LGAs. But over all this do not differ significantly except in Barkin Ladi LGA (p< 0.05). The overall findings indicated that gender is not a determinant of susceptibility to malaria infection. Related Studies in Ethiopia[18] and Malaysia[19] have found no significant difference in malaria infection between sexes.

A number of studies in Nigeria have reported that malaria infection does not differ significantly between sexes [4,7,20,21]. In one of the study sites, Barkin Ladi LGA, infection was significantly higher in males. This finding is comparable to studies in India[22,23] and Nigeria[17]. Most men in Barkin Ladi LGA work outdoors especially at mining sites (kuza) and irrigation farms. Herdsmen in the LGA are also known to stay late outdoors to watch over livestock visited the general hospital regularly where this study was carried out. This means that men in this study area are at a greater occupational risk of contracting malaria because these activities occurs during peak biting times of the female anopheles mosquitoes[24].

Age was found to be a significant risk factor for malaria prevalence in the study area except for Jos-North LGA. In all the LGAs, the highest infections were recorded between age groups 5-9 years and 10-14 years with the lowest observed from ages 35 and above. This variation is an indication that age-dependent immunity to malaria parasites may exist in these LGAs. Adults have demonstrated natural acquired immunity to *plasmodium* infection, but infants and young children, at least occasionally, do not [25] Findings in the current study are consistent with previous studies that have compared data across sites with different transmission intensities in Sub-Saharan Africa[26]. From these studies, it was confirmed that the peak age of uncomplicated clinical malaria declines with increasing transmission intensity.

In Nigeria, recent studies conducted among all age individuals in Lagos and Kaduna States reported highest prevalence in age group 5–14 year [3,17]. Also consistent with the results in the current study was the results of a survey conducted in September 2010 in Plateau state[7] and a hospital based prevalence study[27]. They reported highest prevalence between age groups 5–9 and 10–14 years.

This means that infants and children represent a high risk group in these LGAs, and intervention strategies can be targeted at them.

It was also observed that the variation in age group prevalence in Jos-North was not significant. This is an indication that age dependent immunity was probably absent in the study area. The situation in Jos-North could be attributed to unstable malaria transmission leading to equal susceptibility to malaria infection. This is a common feature in highland areas prone to malaria outbreaks. This agrees with a study elsewhere in the high lands of western Kenya by[12]. They reported no significant association between malaria prevalence and age suggesting the absent of community acquired immunity in their study locations. Another study in Nigeria has also found the role of age in malaria prevalence insignificant[20].

Occupation-related prevalence differs significantly in all LGAs except for Jos-North. This demonstrates that occupation is a significant risk factor for malaria parasite prevalence in these LGAs. The highest prevalence occurred in students with the lowest occurrence in civil servants/traders. Related studies have also reported occupation to be a significant determinant in the disease distribution in communities[5,6,28]. They attributed the significant association in these populations to the increase exposition to the vector of people with certain activities. Young men who are mostly students have been reported in some communities in the study areas to have the privilege of staying as late as 19:00GMT swimming in the rivers /streams before returning home[29]. Apart from the late outdoors activities, majority of day schools' students wake up early to prepare for school which may include going to fetch water from rivers/streams. These late and early outdoors activities have been attributed to increased malaria incidence in Peru[30].

The low prevalence reported in civil servants and traders is in agreement with similar studies elsewhere[4,31]. Civil servants and traders are knowledgeable about the causes and prevention of malaria infection and most of them can afford buying insecticides, mosquito nets, insecticides treated nets (ITNs) and antimalarial drugs. This is because having good knowledge about malaria and economic status play important roles in malaria incidence. For instance household incidences of malaria in Nigeria have been reported to increase with economic status, with the highest incidence among the least poor[32].

The results in this study did not find any statistically significant association between malaria infection and occupation in Jos-North LGA. This demonstrates that occupation is not a risk factor in these populations, even though occupation has been related to malaria incidence in other populations[5,33].

The findings in the present study indicated that malaria transmissions patterns in the study areas occur all year round with seasonal variations. The higher transmission in May-October throughout the study period in all study sites corresponds to the rainy season. This is plausible because precipitation and temperature are suitable for vector breeding (reproduction), their abilities for the disease transmission and parasite development during the same period[12,34]. These findings are consistent with other related studies around the world. For instance, in Venezuela, malaria transmission has been reported to occur throughout the year with a peak in June at the beginning of the rainy season[35]. In Ghana and Botswana, the prevalence of malaria parasites was highest during the rainy seasons (May-October) although transmission remained high throughout the year[36,37].

Low cases of malaria were recorded between December and February in all the study locations. These months were usually dry with very low relative humidity (<50%). This leads to a rapid dry up of mosquitoes breeding sites and increased larval mortality bringing about decline in vector population[38,39].

Another important trend observed in this study is that malaria transmission during the rainy season peak in June in the highlands and July in the lowlands.

5. Conclusion

The most prevalent malaria parasite recorded in this study, *Plasmodium falciparum* is responsible for the most virulent and fatal form of the disease worldwide. Hence it occurrence in the present study as the most prevalent species means concerted efforts must be put in place to reduce or prevent associated mortality and morbidity. The identification of the age groups and occupations with the greatest burden of clinical malaria in Langtang-North, Mikang, Shendam, Bassa and Barkin Ladi LGAs would enable interventions to be targeted to those most vulnerable. This was however not the case in Jos-North LGA where a higher proportion of the population is at the risk of infection and clinical disease. Malaria transmission during the rainy season peaked in June in the highlands and July in the lowlands.

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