



# Climate and *Plasmodium falciparum* Infection on the Jos Plateau, Nigeria

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**Abstract:** The occurrence and prevalence of malaria depend on several factors, both climatic and non-climatic. Given that the Jos plateau is more temperate than other parts of Nigeria, this work set out to look at the prevalence of malaria infection on the Jos plateau. Capillary blood samples were collected from 200 febrile patients of both sexes attending the Jos University Teaching Hospital (JUTH), Nigeria from October 2012 to March 2013. Thick and thin films were prepared, stained with 10% giemsa and examined following the procedure recommended by the WHO. A mini review of how climatic factors affect malaria prevalence was also carried out. Two hundred subjects took part in the study. Their ages ranged from one day to 78 years with a mean of 39 years. There were 92 (46%) males and 108 (54%) females with a male to female ratio of approximately 1:1. A total of 30 (15%) of the 200 samples were positive for *Plasmodium falciparum* by microscopy. The climate of the Jos plateau, Nigeria, does not support a high prevalence of *P. falciparum* malaria. Therefore, healthcare providers on the Jos plateau should investigate patients for other causes of fever at the same time they are asking for malaria parasite.

**Keywords:** Climate, Malaria, Jos Plateau

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## 1. Introduction

Malaria is the most important parasitic disease of man [1]. It affects approximately 5% of the world's population and causes about 438,000 deaths each year [2]. It is endemic in sub Saharan Africa, Papua New Guinea, Haiti, central and parts of South America, the Middle East, the Indian Subcontinent, South East Asia and Oceania [1]. Where malaria is found depends mainly on climatic factors such as temperature, altitude and rainfall [3]. This is because these factors affect where the *Anopheles* mosquito survive and multiply and where malaria parasites can complete their growth cycle in the mosquito [3]. In Nigeria, malaria is considered holoendemic [4]. Studies from different parts of the country show high prevalence rates of *Plasmodium falciparum* infections: 70.6% in Sokoto (North West Nigeria) [5], 74.2% in Abia (South East Nigeria) [6], 81.5% in Ogun (South West Nigeria) [7], 71.4% in Cross River (South South

Nigeria) [8] and 88% in Nasarawa (North Central Nigeria) [9]. But malaria transmission is linked to the geography and climate of an area [10, 11], and not every part of the county share the same geographical features. The main ecological zones in Nigeria are the forest zones in the south and the savannah zones in the north [4]. Interspersed in these zones are high altitude and semi temperate areas like the Jos and Mambilla plateaus in the north and the Obudu Mountain in the south. Looking at the occurrence of malaria in different climatic areas of Nigeria will help to identify areas of high and low transmission. This is important because the clinical and epidemiological features of malaria differ in different areas of transmission [12, 13, 3, 14] and this will consequently determine approach to case management and control efforts. This study was carried out to determine the prevalence of *P. falciparum* malaria on the Jos plateau, given its peculiar climatic characteristics.

## 2. Methodology

### 2.1. Study Site

Sample collection and malaria microscopy were carried out at the Jos University Teaching Hospital from October 2012 to March 2013.

Jos is located at 9°6'N 8°53'E/ 9.933°N 8.883°E. Its altitude ranges from 1238m above sea level to 1,829 meters in the Shere hills area [4]. Its overall average relative humidity is 55% [4]. Though its average monthly temperatures range from 17°C to 29°C, from mid-November to late January night time temperatures drop as low as 11°C resulting in chilly nights [4]. The city of Jos receives about 1,400 mm (55.1 in) of rainfall annually [4] with July to September being the months with the highest rainfall. The average rainfall during the months of October to March is 13.3mm [4]. There are several surface water dams which are used to provide water for the city's industries, for irrigation and for generation of hydroelectric power. These include the surface dams in the Lamingo area and the Bukuru dam and reservoir on the Shen River. Also, mining activities have left numerous ponds where people live, farm and work where mosquitoes could breed.

### 2.2. Study Design

This study was a hospital based, cross sectional study. Demographic and clinical data were collected from the patients by means of a structured questionnaire.

### 2.3. Study Population

Inpatients and outpatients of both sexes for whom requests for malaria microscopy were received in the microbiology department.

### 2.4. Inclusion Criteria

A history of fever or body temperature of > 37.5°C in both adults and children.

### 2.5. Exclusion Criteria

Any patient on anti-malarial treatment or any who had received anti-malarial therapy in the two weeks preceding the study.

### 2.6. Subject Recruitment

2400 patients presented themselves to the department for investigations during the period of this study. Out of these, 620 came for malaria parasite test and 550 were approached to participate in the study. 215 were eligible, 200 accepted to be part of the study while 15 declined.

### 2.7. Sample Collection and Processing

Capillary blood was collected by pricking the ball of the middle finger or heel in neonates with a sterile lancet. A single drop of blood was collected on the middle of the slide for the thin film and two drops of blood were collected on another slide for the thick film.

Each thin film was fixed by flooding with absolute methanol. The thick films were not fixed. The films were stained with 10% Giemsa stain for 10 minutes. 200 fields of the thick film were viewed at a magnification of x1,000 before a thick film was declared negative. The thin films were examined until the presence and species of the malaria parasite had been identified, or up to at least 800 fields before a negative result was recorded. When a slide was positive for *P. falciparum*, the parasite count was carried out on the thick film against white blood cells. If after 200 white blood cells had been counted, 100 or more parasites were found, the counting ended there. If after 200 white blood cells had been counted, the number of parasites were 99 or fewer, counting continued up to 500 white blood cells. The parasites density was calculated and expressed as 'parasites per microlitre of blood' from formula (1).

$$\frac{NP}{NL} \times 8000 \quad (1)$$

Where NP = number of parasites counted  
NL = number of leucocytes

### 2.8. Ethical Consideration

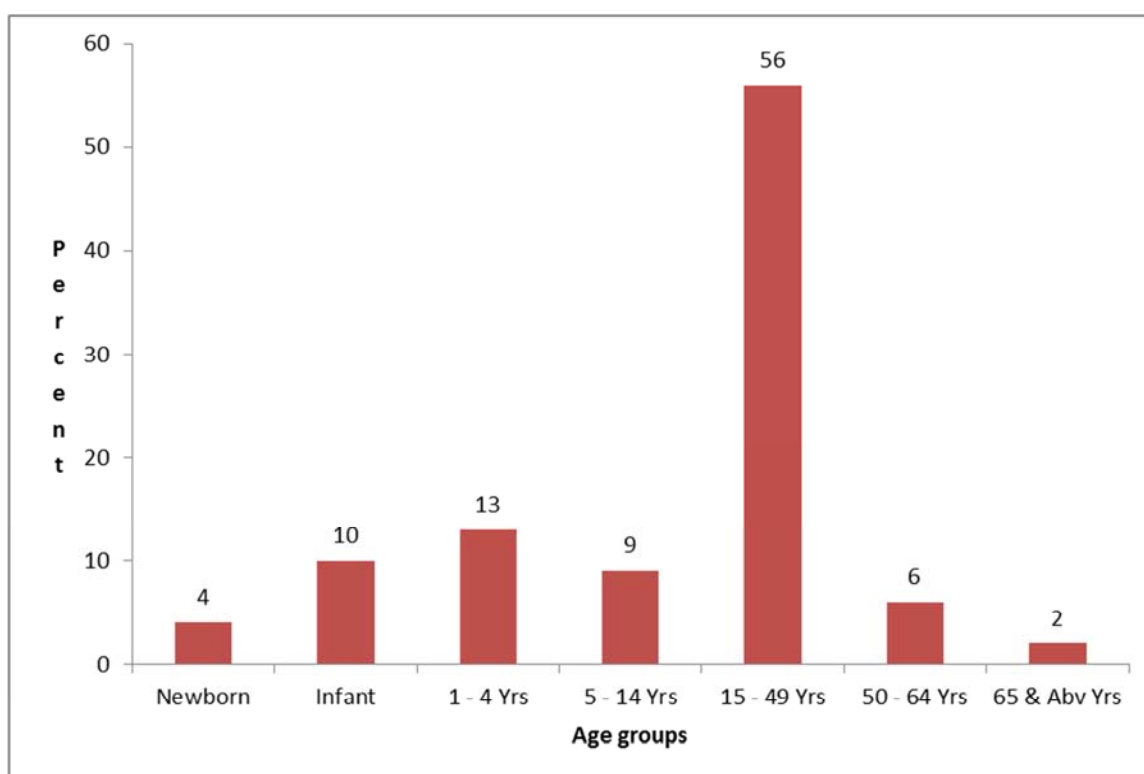
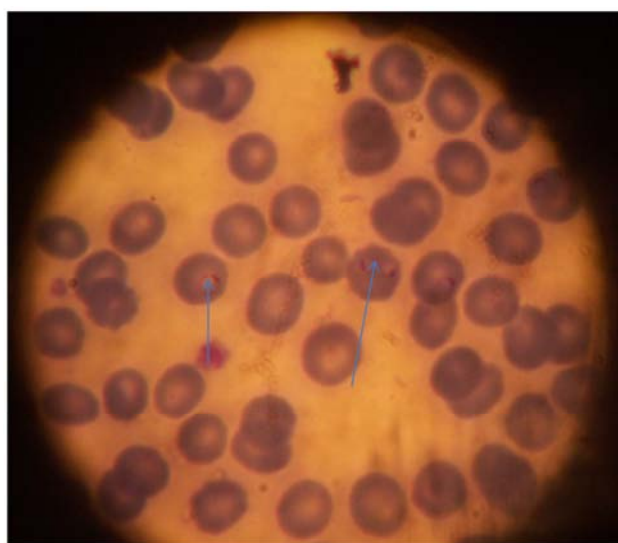
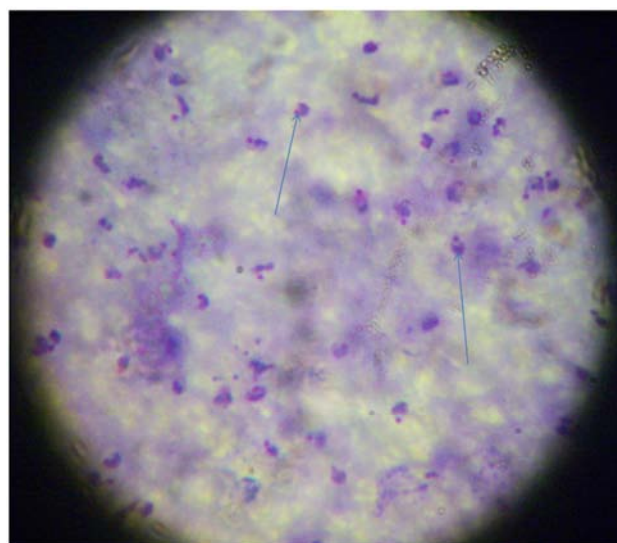
Ethical clearance was obtained from the ethical review board of Jos University Teaching Hospital. Written informed consent was obtained from patients prior to recruitment into this study. Consent for the children was obtained from the parents/guardians, while the assent of adolescents in the age of assent was sought and gotten.

## 3. Results

A total of 200 subjects were recruited into the study. The ages of the participants ranged from one day to 78 years with a mean of 39 years. The highest proportion of participants were those aged 15-49 years accounting for 56% of the study population, while those aged 65yrs and above were the lowest accounting for 2% of the study population (figure 1). There were 92 (46%) males and 108 (54%) females with a male to female ratio (M: F) of approximately 1:1. Thirty out of the 200 subjects were positive for malaria parasite (figures 2 and 3) resulting in a prevalence of *P. falciparum* malaria of 15%. The distribution of the microscopy results among the study population is shown in table 1. The highest parasite count was 48,000 parasites/μL and the lowest count was 64 parasites/μL with a geometric mean of 2705 parasites/μL.

**Table 1.** Malaria Microscopy Results Among inpatients and outpatients, JUTH, 2013.

Age Group	Freq (-ve)	Freq (+ve)	Percent % (-ve)	Percent % (+ve)
Newborn	8	0	4.0	0.0
Infant	19	2	9.5	1.0
1 - 4 Yrs	22	4	11.0	2.0
5 - 14 Yrs	16	2	8.0	1.0
15 - 49 Yrs	89	22	44.5	11.0
50 - 64 Yrs	12	0	6.0	0.0
65 & Abv Yrs	4	0	2.0	0.0
Total	170	30	85.0	15.0

**Figure 1.** Distribution of the age groups tested for malaria at JUTH, 2013.**Figure 2.** Thin blood film showing ring forms of *P. falciparum* (arrows).**Figure 3.** Thick blood film showing malaria parasites (arrows).

## 4. Discussion

The prevalence of *P. falciparum* malaria in this study by microscopy was 15%. This agrees with a study carried out in 2005 on the Jos plateau by Uneke *et al* [16] where an overall prevalence of 16.3% was found. This prevalence is however low when compared with similar studies in other parts of the country [5-9], where a prevalence rates ranging from 70.6% to 88% have been recorded. Differences in temperature, rainfall, altitude and relative humidity may account for this difference as the review below shows.

Temperature is an important variable in the prevalence of malaria. This is because temperature is particularly critical for the development of *Plasmodium falciparum* and the *Anopheles* vector. For example, at temperatures below 20°C, *P. falciparum* cannot complete its growth cycle in the *Anopheles* mosquito, and thus cannot be transmitted [3]. The development rate of mosquito larvae is also temperature dependent: below 16°C development of *Anopheles gambiae* mosquitoes stops and below 14°C they die. In cold temperatures the larvae develop very slowly and in many cases they may be eaten by predators and may never live to transmit the disease [17-19]. Omonijo *et al* [20] in Ondo, southwestern Nigeria showed that an increase of 1°C in air temperature and sea surface temperature was associated with 53.4% and 29% increase in monthly malaria occurrence (CI: 95%) in derived savanna, while an increase of 1°C in air temperature and sea surface temperature was associated with 56.4% and 15.4% increase in monthly malaria occurrence (CI: 95%). Zhang *et al* [21] also showed that in Jinan, a temperate city in northern China, a 1°C rise in maximum temperature may be related to a 7.7% to 12.7% increase in the number of malaria cases, while a 1°C rise in minimum temperature may result in approximately 11.8% to 12.7% increase in cases. On the Jos plateau, night-time temperatures during the period of this study may drop as low as 11°C [15]. Thus, during the period of this study, there could be times when the temperature required for the development and transmission of the parasite would be sub-optimal, leading to decreased transmission and consequently low prevalence of malaria.

Malaria is usually a “rainy season disease” coinciding with increased mosquito abundance. Rainfall is the real climatic variable in Nigeria with June to September the rainiest months throughout the country [4]. Weli *et al* [22] in Port Harcourt, southern Nigeria, showed that as rainfall increased, there was a corresponding increase in the cases of malaria reported in Port Harcourt. This was also reported by Efe *et al* [23] in Warri, southern Nigeria. On the Jos plateau, the months with the highest amount of rainfall are July to September [15]. This study, though, was carried out between the months of October and March, outside the months of maximum rainfall, which could partly explain the low prevalence.

The altitude also plays a part in the prevalence of malaria. Altitude influences the distribution and transmission of malaria indirectly, through its effect on temperature. As altitude increases, temperature decreases (0.5°C to 0.7°C every 100 meters) [24, 25]. Addis Ababa and most of the

Ethiopian highlands above 2,000 metres have little or no locally transmitted malaria [26]. De Beaudrap *et al* [27] showed that altitudes higher than 1,500 m in western Uganda were shown to be associated with low malaria risk. With an altitude of up to 1,829 meters [28], the Jos plateau will likely have a lower transmission rate of malaria and consequently a lower prevalence than areas that are low lying.

Relative humidity has an effect on malaria transmission and thus on prevalence [29]. Relative humidity affects malaria transmission through its effect on the activity and survival of mosquitoes. Mosquitoes survive better under conditions of high humidity. They also become more active when humidity rises. This is why they are more active and prefer feeding during the night – the relative humidity of the environment is higher at night. If the average monthly relative humidity is below 60%, it is believed that the life of the mosquito is so short that very little or no malaria transmission is possible. On the Jos plateau, there is an average morning relative humidity of 67%, an average evening relative humidity of 42% and an overall average relative humidity of 54.5% [30]. With this level of relative humidity, the level of transmission of malaria and its prevalence on the Jos plateau would be low.

A major lifestyle factor that could play a role in the low prevalence of malaria in this study is dressing for the cold weather. Due to the cold temperatures, during the period of this study, inhabitants of the Jos plateau generally wear clothes to protect them from the cold weather. Thus the populace at this time is less exposed to mosquito bites.

The limitations of this study are its cross sectional nature and the fact that this study was carried out during the dry season. Therefore, more studies on the prevalence of malaria throughout the year and the effect of climatic factors on malaria prevalence on the Jos plateau are necessary.

## 5. Conclusion

Though malaria is endemic in sub-Saharan Africa, the optimum combination of climatic and lifestyle factors are required for a high prevalence of the condition in a community. Healthcare providers on the Jos plateau should investigate patients for other causes of fever at the same time they are asking for malaria parasite testing given the relatively low prevalence of malaria among febrile patients in this study. Also, given the predicted changes in global climatic conditions, monitoring the climate can be used as an effective malaria epidemic preparedness tool on the Jos plateau.

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