Malaria Case Presentation: The Results of a Web Based Malaria Surveillance in Plateau State, Nigeria

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Abstract

Nigeria bears the heaviest malaria burden of any single nation in the world and has relentlessly pursued the elimination of the disease. One of the key strategies for the elimination of malaria is increasing the specificity and sensitivity of surveillance. To this end, this study sought to determine malaria transmission along an altitudinal gradient of Plateau state, central Nigeria, while examining socio- demographic factors affecting the prevalence of malaria at these sites. Three communities each at high and low elevation areas of Plateau State in central Nigeria were surveyed for incidence of malaria cases. Information on age, gender, use of long-lasting insecticide treated nets, pregnancy status in women, and, malaria severity were recorded in 1700 study subjects. Using venipuncture method, 4ml blood samples were collected in EDTA vials for laboratory analyses. Microscopy (thick and thin blood smear techniques) and Rapid Diagnostic test were used to detect malaria parasites and determine the Plasmodium species involved. Using a propriety application (ELDACAP), real time geolocation data, socioeconomic, health, and preventative status information were also collected from all 1700 respondents. Our findings showed more cases of malaria prevalence in lowland areas compared to highland areas. The main predictors of malaria incidence were age, sex, use of ITN and the presentation of symptoms. Non-net users had more prevalence of malaria compared to users, males had a higher positive frequency compared to females, and malaria was more prevalent in the younger age group compared to older group. Malaria *eradication in north-central Nigeria must take into account geographic differences, cultural and social practices, previous anti-malaria preventative measures (use of ITN), as well as the presence of asymptomatic malaria carriers who serve as reservoir in the population.*

Keywords: *Malaria, Surveillance, altitude, central Nigeria*

INTRODUCTION

Nigeria is one of the countries with the highest malaria morbidity and mortality rate in the world. High risk groups include children under five years, pregnant women, and those who live at altitude below 1,200 (NMIS & NPC, 2010). It is evident that malaria transmission varies from one geographical location to the other, depicting risk differences in the distribution of malaria burden across global, national, and regional areas(Gosoniu et al., 2012) In addition, other risk factors, notably, practices that influence the transmission of malaria such a behaviour, demographic and socio-economic factors, are thought to be contributors to the malaria transmission in communities (Messina et al., 2011). The cases of malaria worldwide, has been steadily increasing by 6% since 2006 (NMIS & NPC, 2010) mainly due to vector and parasite resistance to preventative and treatment methods. These cases are disproportionately highest in the African region, and Nigeria is one of six countries contributing about half of the global burden of malaria cases (World Health Organization, 2020).

Plateau state, in north-central Nigeria, consistently records high prevalence of malaria with generalized results showing variation in terms of frequency and severity between season but not so much on the variation due to location despite remarkable ecological difference in the different regions of the state (Nanvyat et al., 2017). Efforts aimed at elimination of malaria in Nigeria are hinged on key global strategies that integrate prompt and effective case management, intermittent preventive treatment (IPT) of malaria and integrated vector management (IVM) (NMIS & NPC, 2010). However, a malaria risk mapping and estimate of malaria cases across locations is important in guiding appropriate and more focused interventions in the control and elimination of malaria using a reliable and evidence based technology (Adigun et al., 2015). This study was designed to provide evidence of the real situation of the risk distribution and estimation of malaria in selected communities in highland and lowland parts of Plateau State, Nigeria.

METHODOLOGY

The study was conducted in the three geopolitical zones in Plateau State: Jos South Local government Area (8°51'N, 9°45'E) from the northern zone, Pankshin LGA (9°29', 9°18' 42) from the central zone and Shendam LGA (9°39', 8°48') from the southern zone. These sites represent the two elevation gradients at 1200, 1170, and 200masl, respectively. Three sampling sites within each zone were selected using a simple randomized sampling technique and one primary health care (PHC) facility was selected in each of the sampling sites. Community members gathered at the PHCs and were seen by medical officers/physicians, and were afterwards sent to the laboratory for blood sample collection and investigation. Informed consent was acquired from all respondents.

Blood samples were collected into a 4ml Ethylenediamine tetraacetic acid (EDTA) coated container (Becton Dickinson, United Kingdom) using a BD Precision Glide™ for venipuncture. Diagnosis of malaria was made for each participant using Rapid Diagnostic Test kits CareStart™ Malaria HRP2 Pf (Access Bio, New Jersey USA) and microscopy using thick and thin blood film was made for each patient on a frosted end slide. Thick blood films were examined to detect the presence of malaria parasites while thin blood films were examined to determine parasite species. A slide was classed negative after 100 High Powered Films were examined and no malaria parasites observed. For positive slides, the specific species of the malaria parasite was determined from the thin slide. In all participants, malaria symptoms were classified as asymptomatic, uncomplicated, or severe (Bartoloni & Zammarchi, 2012) depending on the degree of debilitation.

Geolocation data, interview records and questionnaires administered in the communities were collected in real time using a Web-based Malaria Information System (WebMIS) developed at the University of Jos. Details collected from respondents were age, sex, whether or not they slept under insecticide treated nets (ITN), and whether or not they were taking antimalarial drugs. In women respondents, they were also asked for pregnancy status (pregnant *vs* not pregnant).

Data was analysed using the R software (R Development Core Team, 2019). Chi-square test was used to compare the number of positive and negative malaria cases across demographic and socioeconomic categories. The categories were zone, sex, use of insecticide treated nets (ITN), pregnancy status in women, and malaria severity (asymptomatic, uncomplicated and severe) while adjusting for unbalanced ratio of observations between groups. For instance, females outnumbered males by 2:1, therefore, an appropriate adjustment factor was applied when calculating the expected frequencies.

A logistic regression was then used to test the predictive relationship between malaria incidences (present *vs* absent) with the above-mentioned variables.

RESULTS

The malaria parasites detected via microscopy were *Plasmodium falciparum*, occurring in 94% of the respondents, and *P. ovale* occurring in 6% of the respondents. Our results also indicate that Rapid Diagnostic (RDT) test kit was better at detecting malaria, detecting 197 positive cases, compared to the traditional microscopy which detected 16 positive cases.

According to the chi-square test, there was significant difference in the incidence of positive and negative malaria cases between zones, sexes, use of ITN, and pregnancy status (Table 1). While, the number of respondents differed between zones, proportionately the highest number of positive malaria cases were recorded in the lowland area of Shendam compared to the two highland areas (Table 1). Males had proportionately more positive cases than females, those who slept under ITN compared to those who didn't, as well as in non-pregnant *vs* pregnant women (table 1). Based on result of the logistic regression, the factors that significantly determined malaria incidences were zone, age, sex, and type of malaria symptoms (Table 2). The effect of these factors on malaria incidences were similar to the results gotten from the chi-square tests. The probability of malaria incidence was significantly higher at the lower elevation zone compared to the highland sites, males had a higher probability of being infected compared to females, while the probability of testing positive for malaria was higher among those who did not sleep under the ITN compared to those who did (Table 2). Results also show that the risk of malaria infection decreased with age (Table 2; figure 1) but this effect differed between zones with the probability of infection highest in the lowland area of Shendam and lowest in the highland area of Jos.

Table 1: Chi-square test comparing number of respondents who tested positive or negative for malaria across zone and socio-demographic categories

		Number			
Variables		**Negative (%)**	**Positive (%)**	χ^2	**p**
Zones	Jos South	414(92%)	36(8%)	33.55	<0.0001
	Pankshin	604(89.7%)	69(10.3%)		
	Shendam	453(80.9%)	107(19.1%)		
Sex	Females	1012(89.4%)	120(10.6%)	11.94	0.005
	Males	465(83.3%)	93(16.7%)		
Slept under ITN					
	No	598(84.3%)	111(15.7%)	9.85	0.001
	Yes	879(89.6%)	102(10.4%)		
Pregnant	No	1421(87.2%)	209(12.8%)	6.66	0.009
	Yes	56(93.3%)	4(6.7%)		

Rate of malaria infection was highest in children within the ages of 5-9years (25%), followed by 10-14 years (23%) and then 15-19 years (9%) with lowest numbers above the 20-years mark (figure 1). However, in the logistic model, pregnancy status was not a strong predictor of malaria incidence (Table 2). This could be attributed to low sample size of pregnant women who tested positive for malaria (n=5), thus low predictive power with respect to the model.

Table 2: Relationship between malaria incidences with socio-demographic factors at three zones in Plateau State, Central Nigeria

	df	Deviance	P
Zone	2	32.61	<0.001
Age	1	85.41	<0.001
Sex	1	4.77	0.025
Use of ITN	1	11.07	0.030
Pregnancy status	1	0.94	0.333
Malaria symptoms	2	39.11	<0.001
Zone*age	2	10.96	0.006
Zone*Use of ITN	2	7.55	0.022
Zone*sex	2	2.04	0.359

When examining the link between malaria incidence and exhibition of symptoms, we found that the symptoms significantly differed with malaria incidence (Table 2).

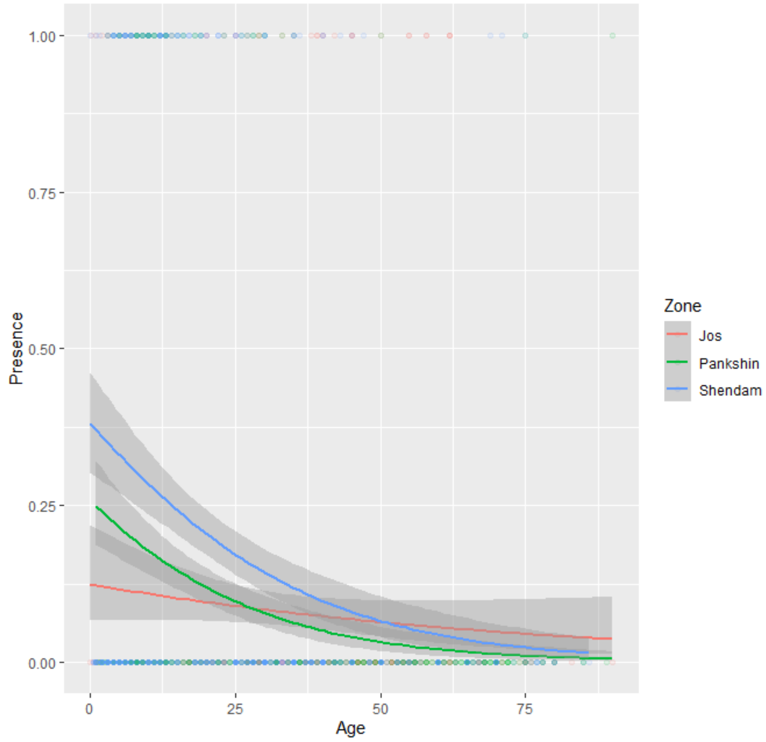

Figure 1: Malaria infection by age group at the three study sites in Jos-Plateau, north-central Nigeria

Ninety-eight percent of people who were asymptomatic tested negative for malaria, 89% of people with uncomplicated malaria symptoms tested positive for malaria, and 50% exhibiting severe malaria symptoms were negative (Figure 2).

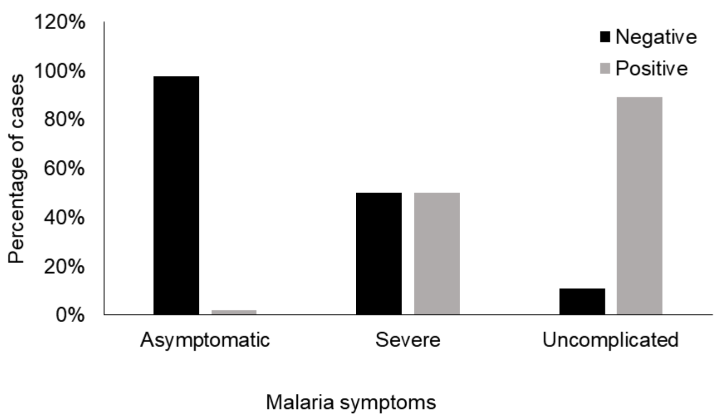

Figure 2: malaria results (positive vs negative) in relation to severity of the symptoms presented by patients

DISCUSSION

Malaria infection in this study was more prevalent in the lowland part of the State which is characterized by relatively high temperature and humidity (Nanvyat et al. 2017). The combination of high humidity and temperature, in addition to other factors, promotes the breeding of mosquitoes contributing to the higher incidence of malaria in this part of the state. *Plasmodium falciparum*, the major cause of malaria in Nigeria and currently detected in this study, is transmitted by female *Anopheles* mosquitoes. These vector mosquitoes tend to thrive and attend high densities in the hot humid tropical weather (Bassey & Izah, 2017; N. Nanvyat et al., 2018). Some studies conducted in Ethiopia and Rwanda corroborate this finding as malaria prevalence was far higher in the lowland areas compared to the highland areas (Tesfaye et al., 2011; Woyessa et al., 2012). It is an indication that prevention activities should focus more in areas with higher number of cases and prevalence such as the southern zone of Plateau State. In view of the evidence that sleeping under insecticide treated net reduced malaria infection as observed in this study, the distribution of the nets at high-risk areas to ensure coverage backed by other integrated vector control measures should be part of malaria control strategies for the state. Since the interaction between zones and use of ITN was significant, it is an indication that the use of ITN differed between the zones. This could be due to uneven distribution of ITN between areas or that the compliance in the use of ITN was lower in some areas compared to others. This highlights the need to include social and cultural studies as part of malaria eradication strategies as people's attitudes towards use of ITN could affect malaria eradication measures.

Our analysis also indicated that malaria cases were significantly higher in males than females. This contrasts findings elsewhere that malaria cases are more severe in females (Jenkins et al., 2015). Studies in Kenya reported malaria infection to be higher among females (Jenkins et al., 2015). Higher prevalence of malaria among men is not surprising, considering the cultural context in Nigeria. Men typically have separate quarters from women and the household members most likely to sleep under a net would be women and children. Also, the outdoor nature of men particularly their participation in outdoor activities such as farming, community gathering, even leisure and social activities, could be possible contributors to higher infection rate among the males.

Our results indicate that the malaria symptoms exhibited by respondents did not always reflect the status of malaria infection. Many of the sampled people who were asymptomatic tested positive for malaria. These asymptomatic populaces could serve as malaria parasite reservoirs, maintaining the infection within the population, thus making complete eradication of malaria problematic. Asymptomatic carriers of the parasite can contribute to the spread of the disease if not given attention in the current elimination strategies.

Conclusion

Malaria eradication strategies should take into account geographic differences in malaria risk as well as gender roles and cultural norms as contributing factors. In the past, emphasis was placed on the prophylactic treatment of malaria in children as the high-risk group; but increased records of parasitaemia among adult populations indicates that such strategies must be in cooperated across all age groups. The presence of asymptomatic carriers also emphasizes the need for this strategy into malaria eradication strategies.

REFERENCES

Adigun, A. B., Gajere, E. N., Oresanya, O., & Vounatsou, P. (2015). Malaria risk in Nigeria: Bayesian geostatistical modelling of 2010 malaria indicator survey data. *Malaria Journal*, *14*(1), 1–8. https://doi.org/10.1186/s12936-015-0683-6

Bartoloni, A., & Zammarchi, L. (2012). Clinical aspects of uncomplicated and severe malaria. *Mediterranean Journal of Hematology and Infectious Diseases*, *4*(1). https://doi.org/10.4084/MJHID.2012.026

Bassey, S. E., & Izah, S. C. (2017). Some Determinant Factors of Malaria Prevalence in Nigeria. *Journal of Mosquito Research*, *July*. https://doi.org/10.5376/jmr.2017.07.0007

Gosoniu, L., Msengwa, A., Lengeler, C., & Vounatsou, P. (2012). Spatially explicit Burden estimates of malaria in Tanzania: Bayesian geostatistical modeling of the malaria indicator survey data. *PLoS ONE*, *7*(5). https://doi.org/10.1371/journal.pone.0023966

Jenkins, R., Omollo, R., Ongecha, M., Sifuna, P., Othieno, C., Ongeri, L., Kingora, J., & Ogutu, B. (2015). Prevalence of malaria parasites in adults and its determinants in malaria endemic area of Kisumu County, Kenya. *Malaria Journal*, *14*(1). https://doi.org/10.1186/s12936-015-0781-5

Messina, J. P., Taylor, S. M., Meshnick, S. R., Linke, A. M., Tshefu, A. K., Atua, B., Mwandagalirwa, K., & Emch, M. (2011). Population, behavioural and environmental drivers of malaria prevalence in the Democratic Republic of Congo. *Malaria Journal*, *10*(1), 161. https://doi.org/10.1186/1475-2875-10-161

Nanvyat, N., Mulambalah, C., Barshep, Y., Ajiji, J., Dakul, D., & Tsingalia, H. (2018). Malaria transmission trends and its lagged association with climatic factors in the highlands of Plateau State, Nigeria. *Tropical Parasitology*, *8*(1). https://doi.org/10.4103/tp.TP_35_17

Nanvyat, Nannim, Siteti Mulambalah, C., Barshep, Y., Mugatsia Tsingalia, H., & Anthony Dakul, an. (2017). Retrospective analysis of malaria transmission patterns and its association with meteorological variables in lowland areas of Plateau state, Nigeria. ~ *101 ~ International Journal of Mosquito Research*, *4*(4), 101–106.

NMIS, & NPC. (2010). *National Malaria Indicator Survey (NMIS) 2010*.

R Development Core Team. (2019). R Development Core Team. In *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria. http://www.mendeley.com/research/r-language-environment-statistical-computing-96/%5Cnpapers2://publication/uuid/A1207DAB-22D3-4A04-82FB-D4DD5AD57C28

Tesfaye, S., Belyhun, Y., Teklu, T., Mengesha, T., & Petros, B. (2011). Malaria prevalence pattern observed in the highland fringe of Butajira, Southern Ethiopia: A longitudinal study from parasitological and entomological survey. *Malaria Journal*, *10*, 1–9. https://doi.org/10.1186/1475-2875-10-153

World Health Organization. (2020). World Malaria Report: 20 years of global progress and challenges. In *World Health Organization*. https://www.who.int/publications/i/item/9789240015791

Woyessa, A., Deressa, W., Ali, A., & Lindtjørn, B. (2012). Prevalence of malaria infection in Butajira area, south-central Ethiopia. *Malaria Journal*, *11*, 1–8. https://doi.org/10.1186/1475-2875-11-84