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Determinants of geospatial distribution of parasitaemia among patients infected with *Plasmodium falciparum* malaria in Ondo State, Southwest, Nigeria

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ABSTRACT: Malaria is a disease caused by *Plasmodium* parasites which is transmitted by female *Anopheles* mosquitoes. It remains one of the most deadly diseases globally and especially in the tropical nations of the world. In the clinical setting, the level of parasitaemia is useful as one of the criteria in defining "severe *Plasmodium falciparum* malaria" and to monitor the effect of anti-malarial therapy. Mapping is a known vital tool in the control and elimination of malaria globally. In this study, blood samples were collected from 415 malaria infected patients in the outpatient department of 10 randomly selected government hospitals. Coordinates of the patients' address were taken, geocoding, mapping and cartographic display were carried out. Thin and thick blood smear preparations and microscopy were conducted on the blood samples collected from outpatients attending some selected government hospitals and percentage parasitaemia were determined. Ondo North Senatorial District had the highest mean parasitaemia of 1.06% while Ondo South had the least mean parasitaemia (0.89%). The risk map revealed that majority of patients in Ondo North 26.05% (31/119) and few in Ondo Central 12.73% (21/165) senatorial district had high malaria burden with high parasitaemia (2.62 to 5.1% parasitaemia). Based on the malaria map developed, this study could be used as guide in monitoring the efficacy of antimalarial therapy and provide information for malaria control intervention in Ondo State.

Keywords: Coordinates, malaria, parasitaemia, risk map.

INTRODUCTION

Malaria is a disease caused by *Plasmodium* parasites which is transmitted by female *Anopheles* mosquitoes. It remains one of the most deadly diseases globally and especially in the tropical nations of the world (Omoya and Oyebola, 2018). There are six species able to infect humans, namely, *Plasmodium falciparum*, *P. vivax*, *P. ovale*, *P. malariae*, and the zoonotic monkey malaria species *P. knowlesi* and *P. cynomolgi* (Millar and Cox-Singh, 2015; Ta et al., 2014). About 300 million cases of clinical malaria are recorded every year. Approximately, half a million deaths occur in Africa and are mainly due to *P. falciparum* infections (WHO, 2015). *Plasmodium* parasites have a complex life cycle which starts with the inoculation of sporozoites into the dermis of the mammalian host by infected mosquitoes. Sporozoites are highly motile and a majority of them migrate from the skin to the capillaries for dissemination by the bloodstream (Amino et al. 2008; Amino et al., 2006).

Infection with *P. falciparum* (PF) is more severe than other malarial species, because of fatal complications associated with it. This lethal parasite can be the basis of cerebral malaria, acute renal failure, acute malarial hepatitis, hypoglycaemia, hyperpyrexia, non-cardiogenic pulmonary oedema, adult respiratory distress syndrome, adrenal insufficiency-like syndrome, hyperparasitaemia, cardiac arrhythmias and gastrointestinal syndromes like secretory diarrhea (Bhalli and Samiullah, 2001; Kochar et al., 2006; Mohapatra, 2006; Dawaki et al., 2016). *P. falciparum* infects erythrocytes with the potential of development of high-grade parasitaemia (Ali et al., 2008).

Due to the rapid multiplication of this *P. falciparum* parasite, the parasite count can increase up to 20-fold within 48 hours in the absence of malaria treatment (Rowe et al., 2002). In the clinical setting, the level of parasitaemia is useful as one of the criteria in defining “severe *P. falciparum* malaria” and to monitor the effect of anti-malarial therapy (Ali et al. 2008). Studies have shown that in *P. falciparum* malaria, a direct correlation exists between an individual’s asexual erythrocytic-stage parasite density during active infection and the severity of clinical disease (Ali et al. 2008; Kepha et al., 2016). Patients with high parasite count have more severe and complicated course, mortality is also correlated with parasitaemia as patients with the higher parasite densities have the higher fatality possibility (Murthy et al., 2000).

The relationship between the parasite density and severity of illness in *P. falciparum* malaria is not direct as it varies with populations. This relationship differs with populations and age groups. In non-immune children and adults, in areas of unstable endemicity, peripheral parasitaemia of 4% or more carries an increased risk of death and is considered a sign of severe malaria whereas, in areas of stable endemicity higher parasite density is considered severe malaria (Ali et al. 2008; Kochar et al., 2006). According to world malaria report 2017, Nigeria accounted for the highest proportion of global malaria cases (WHO, 2017). Ondo state, Nigeria with 21% has the highest malaria prevalence in the South Western part of the country, closely followed by Osun state.

Geographical information system (GIS) can be described as general purpose computer based technology for handling geographical data in digital form in order to capture, store, manipulate, analyse and display diverse sets of spatial or geo-reference data. It aid in visualization of differences, clustering, heterogeneity or homogeneity within data. The link between climate and medical data has not been well defined, and health information systems have been weak due to the lack of case detection, irregularity in reporting, under reporting and poor coordination. There is need for risk map to draw attention to hot spots and areas where intervention measures can be tailored to improve the monitoring of the occurrence, distribution and control of malaria in the study area (Machault et al., 2011; Hassan et al*.,* 2013). GIS are currently underutilized for studying malaria in Nigeria and have not been used previously for the purpose considered in this study. This study therefore demonstrates the geospatial mapping of parasitaemia in *falciparum* malaria infected patients in Ondo State, Nigeria.

MATERIALS AND METHODS

Study area, selection and enrollment of participants for the study

This study focused mainly on the malaria infected patients in Ondo State. In this study, 415 blood samples of falciparum malaria positive patients were collected between February, 2018 and May, 2018 in 10 randomly selected government hospitals in Ondo State, Nigeria covering all senatorial districts of the state. Participants were out patient attending government hospital and are presenting with complicated or uncomplicated *P. falciparum* malaria. Inclusion criteria for participants were: residency within 60 km of the study clinics, residency in the state during the onset of the infection and informed consent. Children between the ages of 6 months and 8 years who weighs above 6 kg, male, female and pregnant women were also recruited for the study.

Location of the sites of sample collection represented on Ondo State map using the coordinates

The result of the location of the sites of sample collection represented on Ondo State map using the coordinates is revealed in Figure 1. The geographical coordinates of 7°10ˈN latitude, 5°05ˈE longitude and the total area covered is approximately 15,500 km^2 (6000sq ml), covering malaria infected patients in the 10 government hospitals which are State Specialist Hospital, Ikare Akoko; University of Medical Sciences Teaching Hospital Complex Akure Annex; University of Medical Sciences Teaching Hospital Complex Ondo Annex; State Specialist Hospital, Okitipupa; General Hospital, Oka Akoko; General Hospital, Ido-ani; General Hospital, Owo; General Hospital, Igbokoda; General Hospital, Ore and Mother and Child Hospital, Akure.

Ethical consideration and informed consent

The ethical approval was issued by Ondo State Health Research Ethics Committee (OSHREC) with ID NO OSHREC/30/11/2017/031, and permission was also sought from the Permanent Secretary, Hospital Management Board, Ondo State for the usage of the facilities in the selected general Hospitals within Ondo State. A written informed consent was obtained from the participants, parents/guardians of the children. Individuals were assured of voluntary participation, confidentiality of their test results and opportunity to withdraw at any time without prejudice, in line with the Helsinki Declaration (WMA, 2001). All the information obtained was treated with utmost confidentiality and used for the research purposes only.

Collection of blood samples from patients infected with malaria

Venipuncture technique was used to collect 1 ml of whole blood from the consented patients into sample bottle

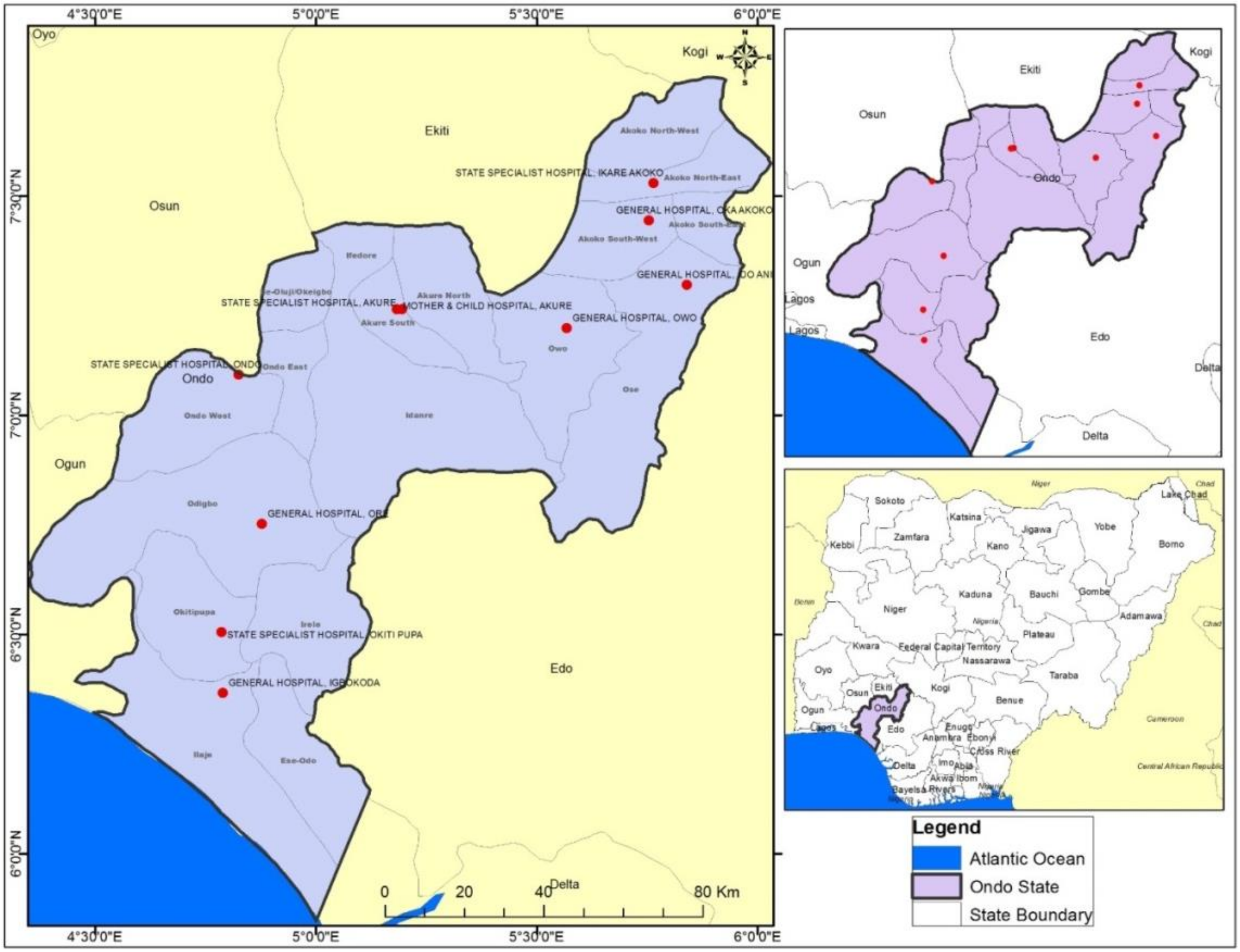

Figure 1. Map Showing the locations where study was carried out in Ondo State, Nigeria.

containing EDTA (Ethylene Diamine tetraacetic acid) as anticoagulant while 15 µl of capillary blood was collected from some of the children into capillary tube containing anticoagulant as described by Cheesbrough (2006). For proper blood sample collection, a medical laboratory scientist and a physician working in each of the hospitals visited were involved. All the blood samples were labeled correctly and processed for parasitological investigation within 30 minutes of collection.

Smear preparation and microscopy

Blood smear microscopy method was used for malaria parasite, about 6 µl of anticoagulated whole blood in EDTA was used for thick smear and 3 µl for thin smear preparation. The thick smear was used for parasite estimation and thin film was used to determine the species of parasite. Thick film smears were made on three spots from fresh blood samples. The films were properly dried (without pre-staining fixing). Thin blood films were fixed with absolute methanol and later stained along with thick blood films using 10% Giemsa solution for 20 minutes and subsequently washed (after 10 minutes) using buffered distilled water (pH 7.2) (Cheesbrough, 2006).

A drop of immersion oil was applied on the dried stained slide and examined microscopically for malaria parasites using 100x oil immersion objective lens. The films were examined following standard procedure for the detection and identification of malaria parasites (Cheesbrough, 2006). As a quality control measure, slides were read by two independent microscopists in microbiology laboratory, and in the case of any disparity, the third microscopist was employed. Slides were considered positive when the ring/trophozoite form of *Plasmodium* species was observed in the blood film.

Determination of the Parasitaemia

Using the 100x objective lens, an area of the thin film where the total number of red cells was approximately 250 per field was selected, number of parasitized red cells in 8 fields i.e. approximately 2 000 cells were counted to calculate the percentage (%) of parasitized cells. Films were examined at least twice (Cheesbrough, 2006; Zakeri et al., 2002).

$$\text{Percentage parasitaemia} = \frac{\text{PRBC}}{\text{TRBCC (2000)}}\ x\ 100$$

Where: PRBC = Parasitized red blood cell and TRBCC = Total red blood cell counted

Geocoding, mapping and cartographic displays

Coordinates of the sampled area were collected with Etrex hand held GPS, Geographical Information Systems (GIS) database for the area was created, and ArcMap GIS 10.31 software was used to determine the areas of high risk. Each of the practices was manually geolocated on a base map in ArcGIS.

Statistical analysis

Descriptive statistic was used in the presentation of data, differences in the mean percentage parasitaemia was compared with new Duncan's Multiple range test and significant were valued at $p<0.05$ using SPSS version 21.

RESULTS

Socio-demographic characteristics of the participants

Socio-demographic characteristics of the participants are revealed in Table 1. The profile of the total number of blood samples (415) collected for the investigation based on the study location revealed that Ondo Central had the highest percentage of participants with 39.8%, followed by Ondo South of 31.6% and Ondo North having the least participants of 28.7%. Based on gender of the participants, the females had the higher participants of 315(75.9%), males with 100(24.1%). The age range of 0 to 10 had the highest percentage of participants of 115(27.7%), followed by age range of 21 to 40 with 108(26.0%) while the least is age range 11 to 20 with 22(5.3%). The Yoruba tribe had the highest percentage of participants of 341(82.17%), followed by Igbos with 32(7.71%) while the least participants are the Hausa tribe with 8(1.9%). The distribution of participants according to the marital status revealed that the married had the highest percentage of participants of 266(88.67%), followed by singles of 21(7.0%) and the divorced having the least participants of 4(1.33%).

Table 1. Socio-demographic characteristics of the participants.

Socio-demographic characteristics	Number of participants	Percentage (%)
Study Location (N=415)		
Ondo Central	165	39.8
Ondo North	119	28.7
Ondo South	131	31.6
Sex (N= 415)		
Female	315	75.9
Male	100	24.1
Age range (years)		
0-10	115	27.7
11-20	22	5.3
21-30	99	23.9
31-40	108	26.0
40 and above	71	17.1
Tribe (N= 415)		
Yoruba	341	82.17
Igbo	32	7.71
Hausa	8	1.9
Others	30	7.2
Marital status (N= 300)		
Single	21	7.0
Married	266	88.67
Divorced	4	1.33
Widowed	9	3.00
Occupation (N= 415)		
Pupils	81	19.5
Students	20	4.8
Traders	164	39.5
Farmers	24	5.8
Civil servants	74	17.8
Unskilled labourers	7	1.7
Pensioners	11	2.7
Under age	32	7.7
Unemployed	2	0.5
Level of education (N= 415)		
Nursery	53	12.8
Informal	19	4.6
Primary	51	12.3
Secondary	118	28.4
Tertiary	142	34.2
Under age	32	7.7
Religion (N= 415)		
Christian	341	82.2
Muslim	74	17.8
Others	0	0

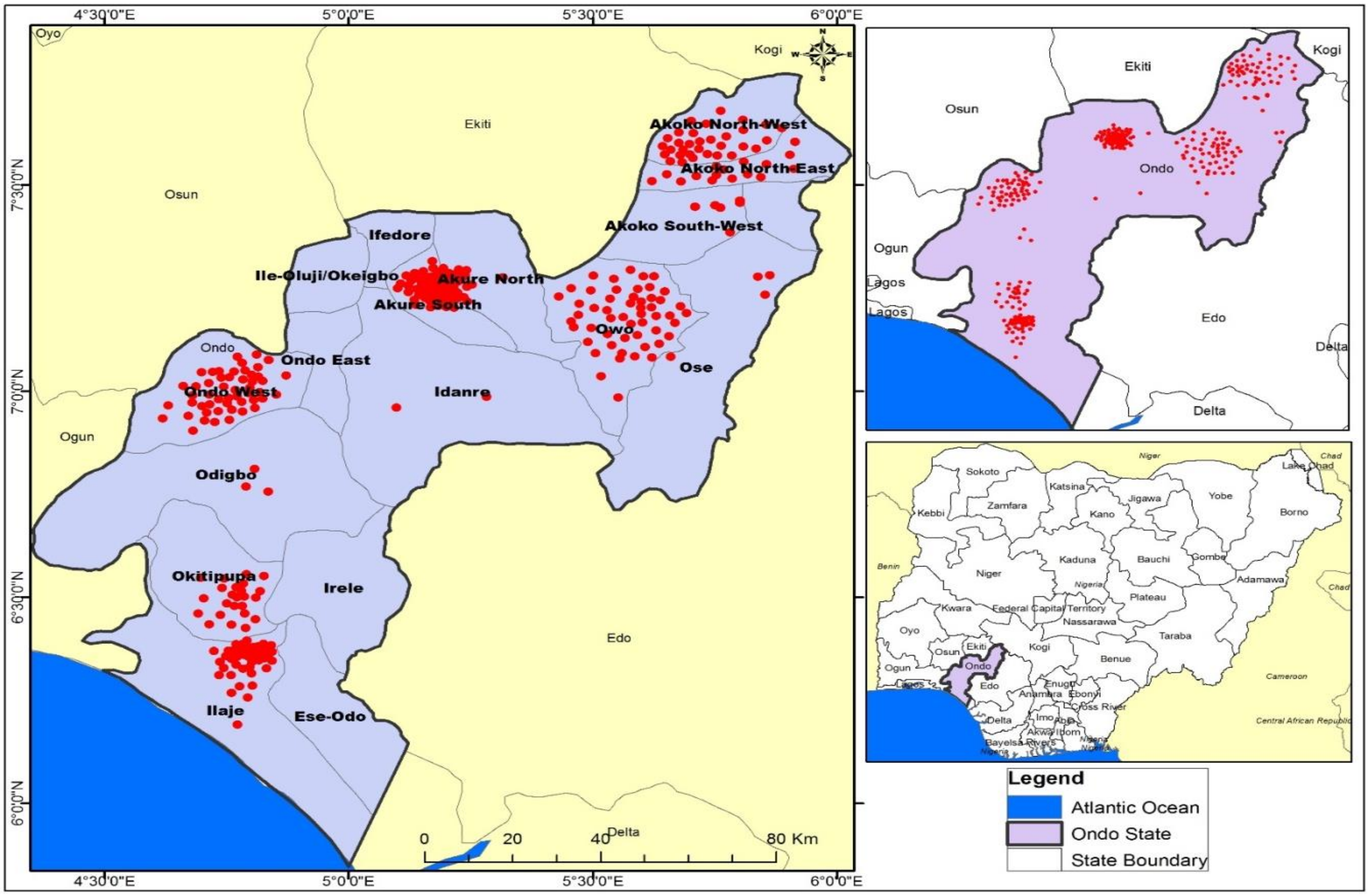

Figure 2. Geospatial coordinates of the participant's residence on Ondo State map. Red dots on the map indicates the Geolocation of the paricipants.

The result of the distribution of participants according to occupation revealed that traders had the highest percentage of participants of 164(39.5%), followed by the school pupils with 81(19.5%) while the least is the unemployed with 2(0.5%). According to level of education, tertiary institution students had the highest percentage of participants of 142(34.2%), followed by secondary school students with 118(28.4%) while the least are participants with informal education of 19(4.6%). The distribution of participants according to religion revealed that the Christians had the highest percentage of participants of 341(82.2%), followed by the Muslim with 74(17.8%).

Geospatial coordinates of the participant's residence on Ondo State map

The result of the geospatial coordinates of the participant's residence on Ondo State map was revealed in Figure 2. The geo-position of all the malaria infected patients was spotted on Ondo State map. The deep cluster in Akure South and North showed that the area is densely populated while the scattered position in Akoko North-west and North-East showed that the area is sparsely populated.

Distribution of the percentage parasite load on Ondo State map using the geospatial coordinates of participant's location

The result of the distribution of the percentage parasite load on Ondo State map using the geospatial coordinates of participant's location is revealed in Figure 3. Participants from Idanre, Odigbo, Okitipupa and Irele Local Government (ranged from 0.13 to 1.37%) had very low parasitaemia, however a little higher parasitaemia was observed in participants from Ondo west and east, Akure south and north, Owo and Akoko north-east (ranged from 1.38 to 2.62%), participants from Akoko south-east and south-west (ranged from 2.63 to 3.86%) had very high parasitaemia while participants from Akoko south-east (ranged from 3.87 to 5.1%) had hyper parasitaemia. The profile of the percentage parasitaemia according to study location (senatorial districts) of participants showed that Ondo North had the highest significant ($p<0.05$) mean

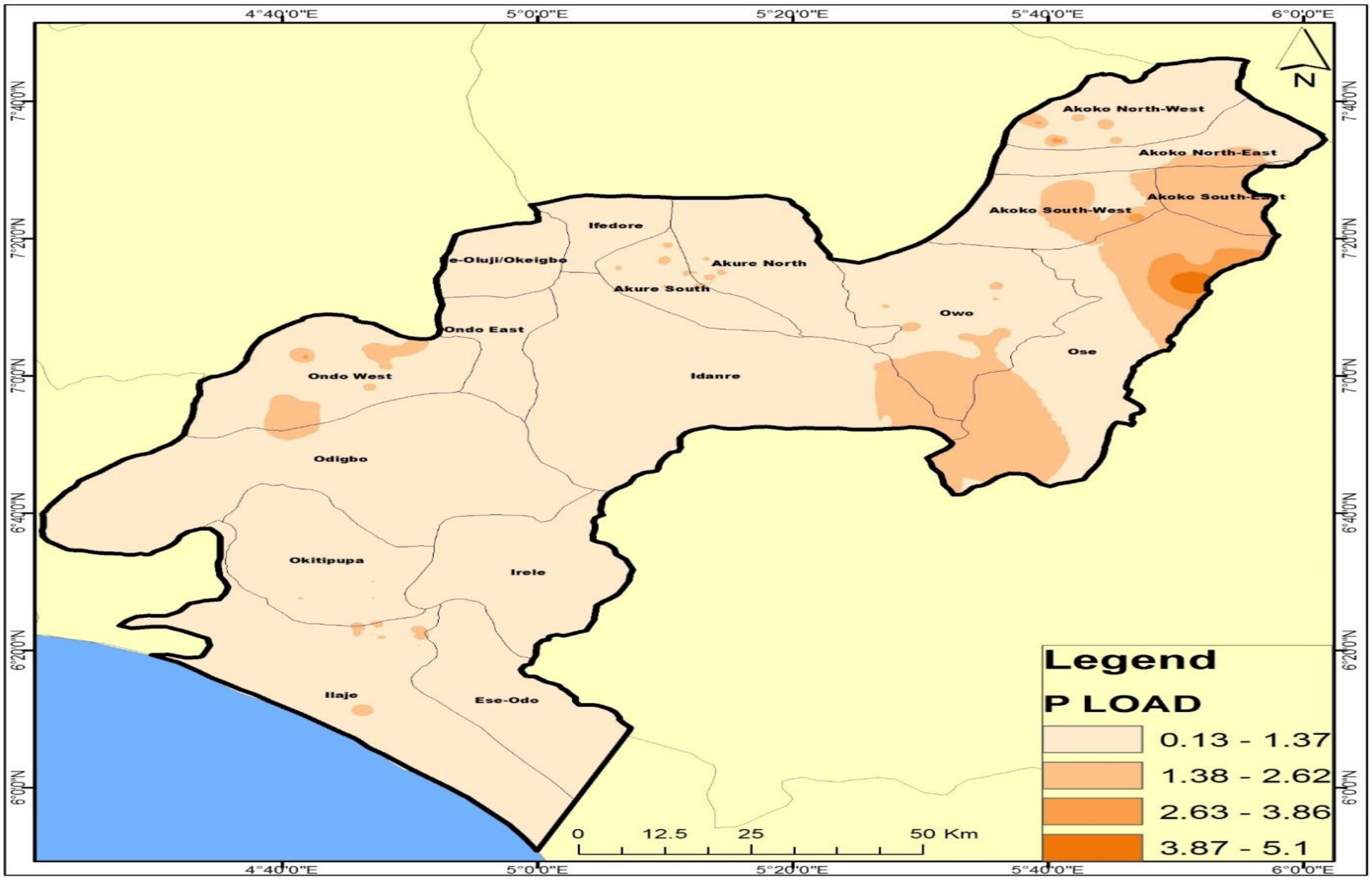

Figure 3. Distribution of the percentage Parasitaemia on Ondo State map using the geospatial coordinates of participant's location. PLoad = Plasmodial load (%).

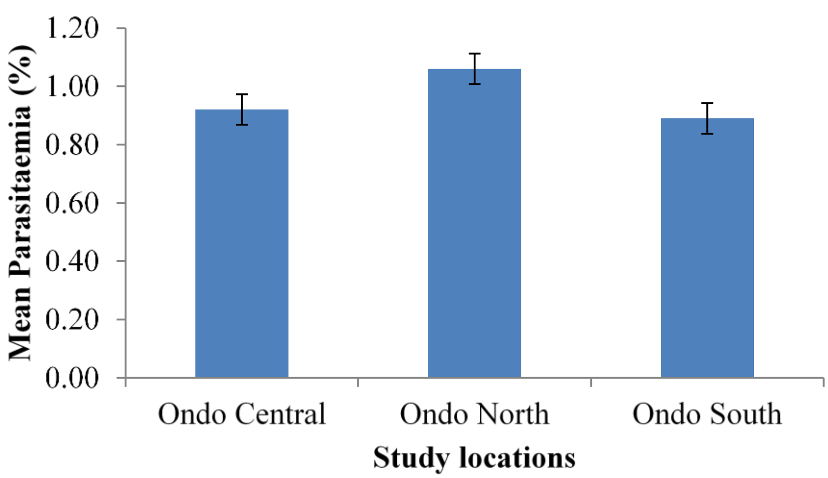

Figure 4. Percentage parasitaemia according to study location (senatorial districts) of participants.

parasitaemia of 1.06%, followed by Ondo Central of 0.92% and Ondo South having the least mean parasitaemia of 0.89% (Figure 4).

DISCUSSION

The distribution and efficiency of the insect vectors, climatic and environmental factors, acquired immunity and the behavior of the human population are some of the variables in malaria infection (Akinbo et al., 2013; Adepeju, 2017). In this study, the high percentage distribution of infected participants at the Ondo Central Senatorial District can be attributed to the fact that, it consists of the major urbanized towns of the State, which includes the State Capital with larger population whereas Ondo North Senatorial district which has the least percentage of participants have more rural settlements with lower population. People in urban area could have knowledge about treatment of malaria due to level of education and media exposure. Also, proximity to health care facilities could be responsible for the high number of malaria infected participants in this study because proximity to health care facilities encourage more people to visit the hospital (Omoya, 2017b). Higher malaria prevalence in urban area has been reported to be due to population influx from rural and peri-urban areas where the disease is of high (El Sayed et al., 2000; Castellanos et al., 2016).

Female gender having the highest percentage (75.9%) among the infected participants may be attributed to the fact that most females respond promptly to any changes in their health status when compared to their male counterpart (Abdulazeez et al., 2017). Also, some of the female participants were pregnant women which could have had immune depression as a result of pregnancy. Studies have shown that malaria is not gender blind simply because the mosquito does not discriminate in biting men or women (RBMP, 2007; WHO, 2007; Akanbi et al., 2010). However, gender can influence who gets malaria and how it is treated, children and pregnant women being biologically more susceptible to malaria, social, economic and cultural factors play a crucial role in determining differences in women's and men's vulnerability to malaria and access to malaria prevention and treatment services (Reuben, 1993; UNDP, 2015). The result of this study is in line with the findings of Ferrari et al. (2016) and Omoya (2017b).

Age is an important determinant of malaria infection (Abdulazeez et al., 2017). In this study, the age group 0 to 10 years had 27.7% which is the highest compared to other age groups. This simply indicates that children are predisposed to malaria infection than other age brackets, this is because children majorly have been known to have weak immune systems which increases their chances of easily getting infected (Ogah et al., 2013). This corroborates the findings of Obimakinde and Simon-Oke, (2017) who reported 27% prevalence among rural school children in Western Nigeria. Although, the percentage prevalence observed in this study is lower than those reported in other studies by Okafor and Oko-Ose (2012), Nwaorgu and Orajaka (2011), Ogah et al. (2013) and Kunihya et al. (2016). This variation could be due to inadequate protection against mosquito bites or insufficient knowledge about malaria transmission, climatic differences and socio-cultural factors.

Higher numbers of participants based on tribe were 'Yoruba' tribe, this may have been influenced by the study area, Ondo state (South western part of Nigeria) which is inhabited mainly by Yoruba tribe.

The highest percentage distribution (88.67%) of malaria infection observed among the married respondents may be attributed to the focus of the study. This study was primarily focused on the vulnerable in which pregnant women played a vital role, and pregnancy is a factor for decline in immune system (Omoya, 2017a). Pregnancy which leads to decline in immune system resulting in susceptibility to malaria infection may also be attributed to the reproductive age (21 to 30; 31 to 40) whose percentage distribution of participants were high though not as high as that of the children in this study.

Majority of the study population were traders; this kind of occupation predisposed this set of people to malaria infection since they are mostly outdoor and also travels/ migrates from one city to another as required by their job. Consequently, occupation may reflect both socio-economic status and differential risk of exposure through occupational attributes. The finding of Worrall et al. (2003) and Kepha et al. (2016) corroborates the findings in this study.

There was high percentage distribution of participants among Christians (82.2%) when compared with the other religion (Muslim), this was so because, the study areas were dominated by Christians. While mosquito makes no distinction between Muslims and Christians (Michael, 2009), religious belief, practice and other socio-economic factors could influence malaria infection.

The risk map generated showed that inhabitants of rural locations appear to experience higher parasitemia in this study, rural locations can be associated with increased malaria risk for both epidemiological and socioeconomic reasons. Similarly, urbanization may be accompanied by potentially protective socio-economic factors against malaria risk such as education and income (Worrall et al., 2003; Dawaki et al., 2016). Certain types of housing may influence malaria transmission, greater exposure to the outdoors (lack of windows or screens, for example) may increase contact between an individual and the mosquito vector. Similarly, the presences of particular structural features that limit contact with the mosquito vector are likely to reduce infection. Housing that places individuals at increased risk of malaria infection is used more frequently by those in lower socio-economic strata (SES) than those in higher socioeconomic strata. Some have attempted to distinguish the independent effect of housing itself from SES. It has been argued that the housing type is a more important determinant of variability in malaria risk than the socio-economic differences that accompany it (Dawaki et al., 2016).

Conclusion

This study had revealed that there was high parasitemia in some areas in Ondo North Senatorial District compared to other Senatorial Districts as revealed by the risk map. The findings of this study could be used as guide for malaria control intervention in Ondo State.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

REFERENCES

Abdulazeez, A. M., Ya'u, M., & Kurfi, B. (2017). Association of hypertension and activity of angiotensin converting enzyme in malaria patients attending Sheik Muhammad Jidda General Hospital, Kano State, Nigeria. *Nigerian Journal of Basic and Clinical Sciences*, 14(2), 121-126.

Adepeju, I. S. (2017). Prevalence of malaria parasite among asymptomatic and symptomatic Students of Federal University of Technology, Akure, Ondo State. *British Journal Research*, 4(5), 5p.

Akanbi, O. M., Badaki, J. A., Adeniran, O. Y., & Olotu, O. O. (2010). Effect of blood group and demographic characteristics on malaria infection, oxidative stress and haemoglobin levels in South Western Nigeria. *African Journal of Microbiology Research*, 4(9), 877-880.

Akinbo, F. O., Adetitun, A. J., Aruomaren, A. I., & Okaka, C. E. (2013). Asymptomatic Malaria Infection and Anaemia among Secondary School Children in Ipogun, Ondo State, Nigeria. *Nigerian Journal of Life Science,* 3, 24-29.

Ali, H., Ahsan, T., Mahmood, T., Bakht, S. F., Farooq, M. U., & Ahmed, N. (2008). Parasite density and the spectrum of clinical illness in falciparum malaria. *Journal of the College of Physicians and Surgeons Pakistan,* 18(6), 362-368.

Amino, R., Giovannini, D., Thiberge, S., Gueirard, P., Boisson, B., Dubremetz, J. F., Prévost, M. C., Ishino, T., Yuda, M., & Ménard, R. (2008). Host cell traversal is important for progression of the malaria parasite through the dermis to the liver. *Cell host & microbe*, *3*(2), 88-96.

Amino, R., Thiberge, S., Martin, B., Celli, S., Shorte, S., Frischknecht, F., & Ménard, R. (2006). Quantitative imaging of Plasmodium transmission from mosquito to mammal. *Nature Medicine*, 12(2), 220-224.

Bhalli, M. A., & Samiullah (2001). Samiullah. Falciparum Malaria-A review of 120 cases. *Journal of the College of Physicians and Surgeons Pakistan*, 11(5), 300-3.

Castellanos, A., Chaparro-Narváez, P., Morales-Plaza, C. D., Alzate, A., Padilla, J., Arévalo, M., & Herrera, S. (2016). Malaria in gold-mining areas in Colombia. *Memorias do Instituto Oswaldo Cruz*, 111(1), 59-66.

Cheesbrough, M. (2006). *District laboratory practice in tropical countries (*2nd Edition). Cambridge university press, Cambridge, UK. Pp. 165-176.

Dawaki, S., Al-Mekhlafi, H. M., Ithoi, I., Ibrahim, J., Atroosh, W. M., Abdulsalam, A. M., Sady, H., Elyana, F. N., Adamu, A. U., Yelwa, S. I., & Ahmed, A. (2016). Is Nigeria winning the battle against malaria? Prevalence, risk factors and KAP assessment among Hausa communities in Kano State. *Malaria Journal*, 15, Article Number 351.

El Sayed, B. B., Arnot, D. E., Mukhtar, M. M., Baraka, O. Z., Dafalla, A. A., Elnaiem, D. E. A., & Nugud, A. H. D. (2000). A study of the urban malaria transmission problem in Khartoum. *Acta tropica*, 75(2), 163-171.

Ferrari, G., Ntuku, H. M., Schmidlin, S., Diboulo, E., Tshefu, A. K., & Lengeler, C. (2016). A malaria risk map of Kinshasa, Democratic Republic of Congo. *Malaria Journal*, 15, Article number 27.

Hassan, A. N., El Nogoumy, N., & Kassem, H. A. (2013). Characterization of landscape features associated with mosquito breeding in urban Cairo using remote sensing. *The Egyptian Journal of Remote Sensing and Space Science*, 16(1), 63-69.

Kepha, S., Nikolay, B., Nuwaha, F., Mwandawiro, C. S., Nankabirwa, J., Ndibazza, J., Cano, J., Matoke-Muhia, D., Pullan, R. L., Allen, E., & Halliday, K. E. (2016). Plasmodium falciparum parasitaemia and clinical malaria among school children living in a high transmission setting in western Kenya. *Malaria Journal*, 15, Article Number 157.

Kochar, D. K., Kochar, S. K., Agrawal, R. P., Sabir, M., Nayak, K. C., Agrawal, T. D., Purohit, V. P., & Gupta, R. P. (2006). The changing spectrum of severe falciparum malaria: a clinical study from Bikaner (northwest India). *Journal of Vector Borne Diseases*, *43*(3), 104-108.

Kunihya, I. Z., Samaila, A. B., Nassai, I., Sarki, A., Haruna, M. Y. (2016). Prevalence of malaria infection among children attending Specialist Hospital Yola, Adamawa State, Nigeria. *Journal of Medical and Biological Science Research,* 2 (8), 136-142.

Machault, V., Vignolles, C., Borchi, F., Vounatsou, P., Pages, F., Briolant, S., & Rogier, C. (2011). The use of remotely sensed environmental data in the study of malaria. *Geospatial Health,* 5(2), 151-168.

Michael, G. (2009). Nigerian Religious Leaders join forces to fight malaria. *Washinghton post company,* 1: 2.

Millar, S. B., & Cox-Singh, J. (2015). Human infections with Plasmodium knowlesi—zoonotic malaria. *Clinical Microbiology and Infection*, 21(7), 640-648.

Mohapatra, M. K. (2006). The natural history of complicated *P. falciparum* malaria: A prospective study. *The Journal of the Association of Physicians of India,* 54, 848-53.

Murthy, G. L., Sahay, R. K., Srinivasan, V. R., Upadhaya, A. C., Shantaram, V., & Gayatri, K. (2000). Clinical profile of falciparum malaria in a tertiary care hospital. *Journal of the Indian Medical Association*, *98*(4), 160-162.

Nwaorgu, O. C., & Orajaka, B. N. (2011). Prevalence of malaria among children 1–10 years old in communities in awka north local government area, Anambra State South East Nigeria. *African Research Review*, 5(5), 264-281.

Obimakinde, E. T., & Simon-Oke, I. A. (2017). The prevalence of malaria infection among patients attending the health centre of the Federal University of Technology, Akure, Nigeria. *Interantional Journal of Tropical Disease and Health*, 27(4), 1-7.

Ogah, A. O., Ezeonwumelu, J. O. C., Okoruwa, A. G., Adiukwu, C. P., Ajayi, A. M., & Akib, S. (2013). Manifestations of severe malaria among the under-five children attending Kampala international university teaching hospital, Bushenyi, western Uganda: pilot study. *British Journal of Pharmacology and Toxicology*, 4(4), 128-135.

Okafor, F. U., & Oko-Ose, J. N. (2012). Prevalence of malaria infections among children aged six months to eleven years (6 months-11years) in a tertiary institution in Benin City, Nigeria. *Global Advanced Research Journal of Medicine and Medical Sciences,* 1(10), 273-279.

Omoya F. O., & Oyabola, T. F. (2018). Effects of some micronutrients on mice infected with *Plasmodium berghei. Journal of Public Health and Epidemiology,* 10(1), 21-27.

Omoya, F. O. (2017a). The relationship between malnutrition, immunity and malaria transmission in children. *International Journal of Medical Laboratory Research*, 2(2), 53-59.

Omoya, F. O. (2017b). Co-infection of malaria and typhoid fever among pregnant women attending primary health care centre, Ojo Local Government, Lagos, Nigeria. *Health Science Journal*, 11(2), Article Number 495.

Reuben, R., (1993). Women and malaria-special risks and appropriate control strategy. *Social Science and Medicine*, 37(4), 473-480.

Roll Back Malaria Partnership (RBMP) (2007). *A guide to gender and malaria resources*. Roll Back Malaria Partnership, Geneva.

Rowe, J. A., Obiero, J., Marsh, K., & Raza, A. (2002). Positive correlation between rosetting and parasitemia in Plasmodium falciparum clinical isolates. *The American Journal of Tropical Medicine and Hygiene*, *66*(5), 458-460.

Ta, T. H., Hisam, S., Lanza, M., Jiram, A. I., Ismail, N., & Rubio, J. M. (2014). First case of a naturally acquired human infection with Plasmodium cynomolgi. *Malaria Journal*, 13, Article Number 68.

UNDP Discussion Paper (2015 December). Gender and Malaria.

World Health Organisation (WHO) (2015). *World Malaria Report*. Geneva: World Health Organisation.

World Health Organization (WHO) (2007). Gender, Health and Malaria, WHO, Geneva, 2007,

World Health Organization (WHO) (2017). Malaria Report Sheet for 2017. WHO's World Malaria factsheet, 2017 Geneva, Switzerland. Pp. 7-9.

World Medical Association (WMA) (2001). World Medical Association Declaration of Helsinki. Ethical principles for medical research involving human subjects. *Bulletin World Health Organ*, 79, 373-374.

Worrall, E., Basu, S., & Hanson, K. (2002). The relationship between socio-economic status and malaria: a review of the literature. *Background paper for Ensuring that malaria control interventions reach the poor, London*. 46p. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.524.9870&rep=rep1&type=pdf

Zakeri, S., Najafabadi, S. T., Zare, A., & Djadid, N. D. (2002). Detection of malaria parasites by nested PCR in south-eastern, Iran: evidence of highly mixed infections in Chahbahar district. *Malaria Journal*, 1, Article number 2.