

# A cross-sectional study of the prevalence, density and risk factors associated with malaria transmission in urban communities of Ibadan, Southwestern Nigeria

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## Research Article

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## Abstract

# Background

Malaria is a serious global public health challenge which causes great morbidity and mortality worldwide particularly in sub-Saharan Africa. This study was designed to determine the prevalence, parasite density and risk factors associated with malaria infection transmission among residents of two urban communities of Ibadan, southwestern Nigeria.

## Methods

A cross-sectional hospital-based study was carried out on 300 participants. Blood samples were obtained. Thick and thin blood films were prepared and viewed using the standard parasitological technique of microscopy. Moreover, data on sociodemographic and environmental variables were obtained using standard questionnaire.

## Results

Of the 300 participants examined, a total of 165 (55.0%) were found positive for *Plasmodium falciparum* with a mean (S.D) parasite density of 1814.70 (1829.117) parasite/ $\mu$ L of blood. The prevalence and parasite density of malaria infection was statistically significant ( $P < 0.05$ ) in relation to age group. Obviously, malaria infection decreases as age increasing with  $\leq 5$  years having the highest prevalence and mean parasite density. Similarly, in relation to gender, males significantly ( $P < 0.05$ ) had higher prevalence (60.2%) and mean (S.D) parasite density of malaria infection [2157.73 (1659.570) parasite/ $\mu$ L of blood] compared to females. Additionally, those without formal education had the highest prevalence (73.0%) and mean (S.D) parasite density of infection [2626.96 (2442.195) parasite/ $\mu$ L of blood]. The binary logistic regression analysis showed that age group 6–10 (COR 0.066, 95% CI: 0.007–0.635), presence of streams (COR 0.225, 95% CI: 0.103–0.492), distance from streams within  $\leq 1$  Km (COR 0.283, 95% CI: 0.122–0.654) and travel to rural area (COR 4.689, 95% CI: 2.430–9.049) were the major risk factors.

## Conclusions

Malaria infection is apparently endemic in the study area and greatly influenced by rural-urban movement. Multifaceted and integrated control strategy should be adopted. Health education on mosquito prevention and use of chemoprophylaxis before and during travel to rural areas are important.

## Background

Malaria is an important public health disease caused by *Plasmodium* parasite belonging to the Apicomplexans [1]. It is spread when an infected female Anopheles mosquito feeds on blood meal from man [2]. It is majorly infecting people in the tropical and subtropical countries of the world particularly in sub-Saharan Africa [3]. The four major malaria parasite causing disease in humans include *P. falciparum*, *P. vivax*, *P. malariae* and *P. ovale* while *P. knowlesi* is a zoonotic species found in Southeast Asia [4]. *P. falciparum* is considered the most pathogenic of all and it is the most prevalent in Africa [5, 6]. Though, malaria is a curable and preventable disease, it is saddening that malaria persists to have an overwhelming impact on people's health across the world particularly among pregnant women and children in rural and urban areas [3]. Globally, it is estimated that 3.2 billion people are predisposed to contracting malaria disease annually [1]. Furthermore, about 219 million cases leading to approximately 435,000 deaths were reported in 2017 [3]. In Nigeria, malaria is transmitted throughout the year with more than 97% of Nigerians predisposed to contracting malaria infection. Thus, Nigeria reported the highest malaria prevalence among all countries of the world [7]. This have led to increased level of poverty as a result of unexpected expenses on treatment, control and prevention. Moreover, time expected to be at work and school are wasted on ill-health due to malaria infection thereby further aggravating the poor condition both in rural and urban areas [8].

Major risk factors enhancing the transmission of malaria infection include demographic factors such as age and gender, environmental factors such as presence or absence of bushes and forests which enhance mosquito breeding, climatic factors including temperature, humidity and rainfall that may support rapid growth and development of mosquito vectors, and socioeconomic factors such as education, occupation and income which directly affect human exposure and treatment pattern. All these factors have been well reported particularly in rural and peri-urban communities in previous studies [9]. Other studies have compared malaria parasite prevalence in rural and urban areas [10]. Despite better conditions in urban areas, studies have shown malaria parasites to be prevalence in urban areas [11, 12]. Meanwhile, major factors enhancing malaria infections in these urban areas are yet to be fully unraveled. Thus, in order to align with the target to reduce malaria parasite by 90% between 2016 and 2030 by World Health Organization's Global Technical Strategy for malaria, there is need to understand and document adequate epidemiological data upon which malaria management and control could be based particularly in urban settings. Thus, this study sought to investigate the prevalence and risk factors enhancing the transmission of malaria parasites in two urban areas in Ibadan, Oyo State, Nigeria.

## Methods

### Study area

The study was carried out in Adeoyo State Hospital, Adegbite and Oni Memorial Children's Hospital, Ring-Road. Both hospitals are in Ibadan South West Local Government Area of Oyo State, Nigeria. Ibadan South West Local Government Area is situated between Latitude 7°21'2.48"N and Longitude 3°51'55.84"E (Fig. 1) and has a population of 282,585 as at 2006 census. Generally, Ibadan city is the third most populous city in Nigeria with over six million people. The climatic condition is typical of tropical regions which consists of both raining and dry seasons that spans through April to October and November to March respectively. The average annual rainfall is about 2100mm while the temperature is about 27°C. There are rivers running through the city of Ibadan which include Ogunpa, Kudeti and Ona river among others. The population consist of civil servants, traders, students, artisans and even farmers. While some of the residents live and settle in urban City of Ibadan, they still visit rural areas or their home village for some activities. Also, many people come from rural areas to Ibadan thereby hosting different people from various parts of the country. Nonetheless, Ibadan residents are predominantly of Yoruba ethnic group.

### Study design

This is a hospital-based and randomized cross-sectional survey. Study was conducted from May to August 2019 in two different hospitals which are Adeoyo State Hospital, Adegbite and Oni Memorial Children's Hospital, Ring-Road, Ibadan. Samples were collected from individuals attending these hospitals and met the inclusion criteria. Criteria for inclusion include feelings of headache, fever with temperature greater than 38°C, completion of questionnaires, blood samples submission and willingness to provide written or oral informed consent. Those who decline to participate were excluded. Questionnaire was given to each subject to collect their data such as age, sex, occupation, education, use of mosquito nets, presence or absence of river within  $\leq 1$  Km participant's home. Other data such as blood group and genotype were gotten from their medical records.

### Sample size

The sample size was computed using a previous malaria parasite prevalence of 78% [13] at a confidence interval (CI) of 95% and 5% margin of error following the formula of Araoye, 2014 for calculating sample size. This give rise to a total of 300 subjects that were recruited for this study.

### Blood Collection and laboratory procedures

Samples of blood were obtained intravenously with the assistance of a trained Laboratory Technologist. A 3mL blood was obtained from each participant. After collection, blood samples were transferred into an ethylenediaminetetraacetic acid (EDTA) tube to prevent the coagulation of blood. Next, thick and thin smears were made on a well cleaned and sterilized slides. The thin smear was fixed in absolute ethanol. Subsequently, 3% stain made of Giemsa was added to the thick and thin smears for 30 minutes. The slides were later viewed under x100 objective lens of the light microscope to confirm the presence or absence of

*Plasmodium* parasites and the species present. When about 200 microscopic fields have been observed and no parasite discovered, it is considered negative. The mean parasite density was classified according to the recommendations of Atroosh *et al.* [14]. Parasite density was recorded as number of Parasite/ $\mu\text{L}$  of blood, assuming an average leucocyte count of 8,000/ $\mu\text{L}$  of blood for an average individual [1]. The formula used is stated below

$$\text{Parasite}/\mu\text{L blood} = \frac{\text{Number of parasites counted} \times 8000 \text{ white cells}/\mu\text{L}}{\text{No. of white cells counted}}$$

## Statistical analysis

Data collected were analyzed using SPSS version 20.0. The presence or absence of malaria parasite was computed and the differences in prevalence between age groups and sex were calculated using chi square test at 95% level of confidence. The malaria parasite density was computed using the student's t-test for dichotomous variable while ANOVA was used to determine categorical variables. Malaria-associated risk factor were determined by Bivariate logistic model. *P-values* of  $\leq 0.05$  were recognized as significant.

## Ethical approval

The protocol for this study was approved by Ondo State Ministry of Health (protocol number OSHREC/09/04/2018/046) the Ethical Review Committee, Federal University of Technology, Akure, Nigeria. Informed consent that were written were obtained from each adult subject. However, for children, their caregiver or guardians provided the informed consent.

## Results

Of the total of 300 individuals that were selected for this study, males were 44.3% while females were 55.7%. The age range was 1-65 years while the median age was 26 years. The mean (S.D) age was 28.03 (17.52). Furthermore, the individuals examined in Adeoyo State hospital and Oni Memorial hospital were 196 (65.3%) and 104 (34.7%) respectively (Table 1). All malaria infections in this study area was observed to be caused by *P. falciparum* and most (56.4%) of the malaria infections were classified as low ( $< 1000$  parasites/ $\mu\text{L}$  of blood) while 43.6% were classified as moderate infections which ranges between 1000 to  $\leq 9999$  parasites/ $\mu\text{L}$  of blood.

In all, a total of 165 (55.0%) had malaria infection with mean (S.D) parasite density of 1814.70 (1829.117) parasite/ $\mu\text{L}$  of blood. The association between prevalence and density of *P. falciparum* and sociodemographic factors were presented in Table 1. Age group  $\leq 5$  years had the highest malaria prevalence of 76.7% while the lowest malaria prevalence of 43.2% was noted among the 31-40 years. Generally, malaria infection in this study decreases with increasing age and cumulate at age 40years (Table 1). There was significant difference ( $P < 0.05$ ). Also, the highest mean (S.D) parasite density of infection was recorded among  $\leq 5$  years [2433.43 (2547.742) parasite/ $\mu\text{L}$  of blood] while the least was recorded among  $> 50$  [956.42 (1262.708) parasite/ $\mu\text{L}$  of blood]. There was no significant difference ( $P > 0.05$ ).

In relation to gender, males had higher prevalence (60.2%) and mean (S.D) parasite density of infection [2157.73 (1659.570) parasite/ $\mu\text{L}$  of blood] compared to their female counterparts with malaria prevalence of 50.9% and mean (S.D) parasite density of 1491.85 (209.320) parasite/ $\mu\text{L}$  of blood. Infection was significant at  $P < 0.05$ .

Furthermore, those without formal education had infection that almost doubled those who attained tertiary education ( $P < 0.05$ ). Similarly travelling to rural area or village highly contributed to malaria prevalence and parasite density. Those who travel to rural area or village significantly ( $P < 0.05$ ) had higher malaria prevalence of 74.4% and mean (S.D) parasite density of 2367.51 (2098.600) parasite/ $\mu\text{L}$  of blood compared to those who did not travel to rural area or village in the previous month (Table 1).

**Table 1:** Prevalence and density of *Plasmodium falciparum* infection stratified by sociodemographic variables

| Variables        | Number of subjects | Number positive (%) | Mean ( $\pm$ S.D) Parasite Density (parasite/ $\mu$ L of blood) |
|------------------|--------------------|---------------------|---|
| <b>Age group</b> |                    |                     |   |
| $\leq 5$         | 30                 | 23 (76.7)           | 2433.43 (2547.742)  |
| 6-10             | 31                 | 22 (71.0)           | 2211.45 (1623.279)  |
| <b>11-20</b>     | <b>49</b>          | <b>26 (53.1)</b>    | <b>1478.00 (1498.845)1</b>                                      |

|  |            |                   |                           |
|--|------------|-------------------|---------------------------|
| 21-30  | 62         | 32 (51.6)         | 2327.03 (2156.780)        |
| 31-40  | 44         | 19 (43.2)         | 1527.11 (1330.635)        |
| 41-50  | 42         | 19 (45.2)         | 1575.89 (1447.093)        |
| >50  | 42         | 24 (57.1)         | 956.42 (1262.708)         |
| <i>P value</i>                                 |            | 0.03              | 0.38                      |
| <b>Gender</b>                                  |            |                   |                           |
| Male   | 133        | 80 (60.2)         | 2157.73 (1659.570)        |
| Female   | 167        | 85 (50.9)         | 1491.85 (209.320)         |
| <i>P value</i>                                 |            | 0.110             | 0.19                      |
| <b>Occupation</b>                              |            |                   |                           |
| Trading  | 74         | 37 (50.0)         | 1407.78 (1349.310)        |
| Civil servants                                 | 63         | 29 (46.0)         | 1592.24 (1622.752)        |
| Farming  | 20         | 10 (50.0)         | 2280.80 (1675.544)        |
| Students                                       | 57         | 33 (57.9)         | 2064.94 (1739.525)        |
| Artisans                                       | 42         | 24 (57.1)         | 1748.17 (2126.970)        |
| Others   | 44         | 32 (24.2)         | 2132.97 (2328.753)        |
| <i>P value</i>                                 |            | 0.115             | 0.481                     |
| <b>Education</b>                               |            |                   |                           |
| No Formal Education                            | 37         | 27 (73.0)         | 2626.96 (2442.195)        |
| Primary  | 110        | 60 (54.5)         | 1894.52 (1775.649)        |
| Secondary                                      | 109        | 58 (53.2)         | 1419.16 (1414.614)        |
| Tertiary                                       | 44         | 20 (45.5)         | 1625.75 (1857.351)        |
| <i>P value</i>                                 |            | 0.086             | 0.38                      |
| <b>Hospital visited</b>                        |            |                   |                           |
| Adeoyo State Hospital                          | 196        | 106 (54.1)        | 2207.38 (2045.230)        |
| Oni Memorial Hospital                          | 104        | 59 (56.7)         | 1109.20 (1048.542)        |
| <i>P value</i>                                 |            | 0.661             | <0.0001                   |
| <b>Travel to rural area/village last month</b> |            |                   |                           |
| Yes  | 125        | 93 (74.4)         | 2367.51 (2098.600)        |
| No   | 175        | 72 (41.1)         | 1100.65 (1050.686)        |
| <i>P value</i>                                 |            | <0.0001           | <0.0001                   |
| <b>Total</b>                                   | <b>300</b> | <b>165 (55.0)</b> | <b>1814.70 (1829.117)</b> |

Table 2 details the prevalence and parasite density of *P. falciparum* infection stratified by genotype and blood group. Genotype HbAA had the highest malaria prevalence of 62.6% and mean (S.D) parasite density of 1937.33 (1627.828) parasite/ $\mu$ L of blood while genotype HbSS had the least malaria prevalence of 12.5%. The result was statistically significant ( $P < 0.05$ ). Also, while blood group O significantly ( $P < 0.05$ ) had the highest prevalence of 68.8% and blood group AB had the least malaria prevalence (Table 2).

**Table 2:** Prevalence and density of *Plasmodium falciparum* infection stratified by genotype and blood group

| Variables          | Number of subjects | Number positive (%) | Mean ( $\pm$ S.D) Parasite Density (parasite/ $\mu$ L of blood) |
|--------------------|--------------------|---------------------|---|
| <b>Genotype</b>    |                    |                     |   |
| AA                 | 147                | 92 (62.6)           | 1937.33 (1627.828)  |
| AS                 | 133                | 67 (50.4)           | 1713.76 (2113.703)  |
| AC                 | 9                  | 4 (44.4)            | 1256.75 (1488.377)  |
| SS                 | 8                  | 1 (12.5)            | -   |
| SC                 | 3                  | 1 (33.3)            | -   |
| <i>P value</i>     |                    | 0.023               | 0.776   |
| <b>Blood group</b> |                    |                     |   |
| A                  | 97                 | 54 (55.7)           | 2118.30 (1862.318)  |
| B                  | 11                 | 5 (45.5)            | 1240.20 (1244.996)  |
| AB                 | 48                 | 7 (14.6)            | 1768.14 (3087.814)  |
| O                  | 144                | 99 (68.8)           | 1681.40 (1729.292)  |
| <i>P value</i>     |                    | <0.0001             | 0.477   |
| <b>Total</b>       | <b>300</b>         | <b>165 (55.0)</b>   | <b>1814.70 (1829.117)</b>                                       |

Table 3 presents environmental variables and their association with malaria infection prevalence and density. Presence of stream and distance from stream are significantly ( $P < 0.05$ ) related to malaria infection prevalence. Those who had open water or stream and are within the distance of  $\leq 1$ Km are more likely to have malaria infection. Similarly, sleeping under the mosquito net the previous night significantly ( $P < 0.05$ ) reduced malaria infection (Table 4).

**Table 3:** Prevalence and density of *Plasmodium falciparum* infection stratified by environmental variables

| Variables                              | Number of subjects | Number positive (%) | Mean ( $\pm$ S.D) Parasite Density (parasite/ $\mu$ L of blood) |
|--|--------------------|---------------------|---|
| <b>Presence of Vegetation</b>          |                    |                     |   |
| Yes                                    | 128                | 75 (58.6)           | 1909.12 (1884.169)  |
| No                                     | 172                | 90 (52.3)           | 1736.01 (1788.719)  |
| <i>P value</i>                         |                    | 0.280               | 0.547   |
| <b>Distance from vegetation</b>        |                    |                     |   |
| $\leq$ 1Km                             | 61                 | 39 (63.9)           | 1793.31 (1750.687)  |
| >1Km                                   | 67                 | 36 (53.7)           | 2034.58 (2036.458)  |
| No Vegetation                          | 172                | 90 (52.3)           | 1736.01 (1788.719)  |
| <i>P value</i>                         |                    | 0.285               | 0.710   |
| <b>Presence of open water/stream</b>   |                    |                     |   |
| Yes                                    | 187                | 91 (48.7)           | 1784.27 (1955.472)  |
| No                                     | 113                | 74 (65.5)           | 1852.11 (1673.128)  |
| <i>P value</i>                         |                    | 0.005               | 0.814   |
| <b>Distance from open water/Stream</b> |                    |                     |   |
| $\leq$ 1Km                             | 75                 | 48 (64.0)           | 1576.69 (1938.798)  |
| >1Km                                   | 112                | 43 (38.4)           | 2016.00 (1970.623)  |
| No open water/Stream                   | 113                | 74 (65.5)           | 1852.11 (1673.128)  |
| <i>P value</i>                         |                    | <0.0001             | 0.508   |
| <b>Environmental Sanitation</b>        |                    |                     |   |
| Yes                                    | 188                | 97 (51.6)           | 1783.96 (1760.957)  |
| No                                     | 112                | 68 (60.7)           | 1858.54 (1934.656)  |
| <i>P value</i>                         |                    | 0.125               | 0.797   |
| <b>Total</b>                           | <b>300</b>         | <b>165 (55.0)</b>   | <b>1814.70 (1829.117)</b>                                       |

**Table 4:** Prevalence and density of *Plasmodium falciparum* infection stratified by ownership and use of mosquito nets

| Variables                                    | Number of subjects | Number positive (%) | Mean ( $\pm$ S.D) parasite density (parasite/ $\mu$ L of blood) |
|--|--------------------|---------------------|---|
| <b>Own mosquito net</b>                      |                    |                     |   |
| Yes  | 215                | 129 (60.0)          | 1904.27 (1954.169)  |
| No   | 85                 | 36 (42.4)           | 1493.72 (1255.188)  |
| <i>P value</i>                               |                    | 0.006               | 0.235   |
| <b>Slept under mosquito net last night</b>   |                    |                     |   |
| Yes  | 41                 | 19 (46.3)           | 1623.58 (1547.594)  |
| No   | 175                | 111 (63.4)          | 1942.21 (2011.998)  |
| No mosquito net                              | 84                 | 35 (41.7)           | 1514.06 (1267.482)  |
| <i>P value</i>                               |                    | 0.002               | 0.432   |
| <b>Reason for not sleeping under bed net</b> |                    |                     |   |
|  | 88                 | 54 (61.4)           | 2448.94 (2189.184)  |
| Causes heat                                  | 41                 | 21 (51.2)           | 1129.05 (1256.053)  |
| Disfigure room                               | 40                 | 30 (75.0)           | 1340.40 (1689.851)  |
| Not effective                                | 6                  | 2 (33.3)            | 2015.50 (1738.776)  |
| Use alternative                              | 125                | 58 (68.8)           | 1710.84 (1557.363)  |
| No mosquito net                              |                    | 0.001               | 0.018   |
| <i>P value</i>                               |                    |                     |   |
| <b>Total</b>                                 | <b>300</b>         | <b>165 (55.0)</b>   | <b>1814.70 (1829.117)</b>                                       |

Additionally, the results of the binary logistic regression model analysis showed the risk factors associated with malaria infection (Table 5). Being age group 6-10, having blood group O, presence of open water or stream, distance from open water or stream and travel to rural area or village the previous month were observed to be associated with malaria infection prevalence.

**Table 5:** Binary logistic regression model for crude odd ratio (ORs) of factors associated with prevalence of malaria infection

| <b>Variables</b>              | <b>Crude Odd Ratio, OR (95% CI)</b> | <b>P.value</b> |
|-------------------------------|-------------------------------------|----------------|
| <b>Age group</b>              |                                     |                |
| ≤5                            | 0.133 (0.008-2.370)                 | 0.170          |
| 6-10                          | 0.066 (0.007-0.635)                 | <b>0.019</b>   |
| 11-20                         | 0.494 (0.093-2.620)                 | 0.407          |
| 21-30                         | 0.872 (0.273-2.789)                 | 0.818          |
| 31-40                         | 1.118 (0.302-4.129)                 | 0.868          |
| 41-50                         | 1.111 (0.326-3.783)                 | 0.866          |
| >50                           | 1                                   | 0.143          |
| <b>Gender</b>                 |                                     |                |
| Male                          | 1.806 (0.919-3.548)                 | 0.086          |
| Female                        | 1                                   |                |
| <b>Occupation</b>             |                                     |                |
| Trading                       | 0.907 (0.175-4.711)                 | 0.908          |
| Civil servants                | 1.491 (0.291-7.650)                 | 0.632          |
| Farming                       | 1.470 (0.197-10.952)                | 0.707          |
| Students                      | 7.105 (0.740-68.173)                | 0.089          |
| Artisans                      | 1.187 (0.192-7.320)                 | 0.853          |
| Others                        | 1                                   | 0.268          |
| <b>Education</b>              |                                     |                |
| No Formal Education           | 2.156 (0.178-26.060)                | 0.546          |
| Primary                       | 1.166 (0.331-4.103)                 | 0.811          |
| Secondary                     | 1.123 (0.379-3.333)                 | 0.834          |
| Tertiary                      | 1                                   | 0.947          |
| <b>Genotype</b>               |                                     |                |
| AA                            | 0.747 (0.037-14.898)                | 0.849          |
| AS                            | 0.864 (0.045-16.457)                | 0.923          |
| AC                            | 0.391 (0.013-11.351)                | 0.585          |
| SS                            | 7.369 (0.152-382.626)               | 0.322          |
| SC                            | 1                                   | 0.456          |
| <b>Blood group</b>            |                                     |                |
| A                             | 1.884 (0.960-3.699)                 | 0.066          |
| B                             | 3.094 (0.640-14.966)                | 0.160          |
| AB                            | 15.404 (5.248-45.214)               | <b>0.000</b>   |
| O                             | 1                                   | <b>0.000</b>   |
| <b>Presence of Vegetation</b> |                                     |                |

|                          |                     |       |
|--------------------------|---------------------|-------|
| Yes                      | 1.264 (0.474-3.376) | 0.640 |
| No                       | 1                   |       |
| Distance from vegetation |                     |       |
| ≤1Km                     | 0.436 (0.152-1.250) | 0.122 |
| >1Km                     | 1                   |       |

**Table 5 (Continue):** Binary logistic regression model for crude odd ratio of factors associated with prevalence of malaria infection

| Variables                           | Crude Odd Ratio, OR (95% CI) | Pvalue |
|-------------------------------------|------------------------------|--------|
| Presence of stream                  |                              |        |
| Yes                                 | 0.225 (0.103-0.492)          | 0.001  |
| No                                  | 1                            |        |
| Distance from Stream                |                              |        |
| ≤1Km                                | 0.283 (0.122-0.654)          | 0.003  |
| >1Km                                | 1                            |        |
| Environmental Sanitation            |                              |        |
| Yes                                 | 0.612 (0.320-1.169)          | 0.137  |
| No                                  | 1                            |        |
| Have mosquito net                   |                              |        |
| Yes                                 | 14.742 (3.121-69.630)        | 0.001  |
| No                                  | 1                            |        |
| Slept under mosquito net last night |                              |        |
| Yes                                 | 0.349 (0.115-1.062)          | 0.064  |
| No                                  | 1                            |        |
| Travel to rural area last month     |                              |        |
| Yes                                 | 4.689 (2.430-9.049)          | 0.000  |
| No                                  | 1                            |        |

## Discussion

The result of this study is a strong evidence that malaria is still highly prevalent in many urban communities including Ibadan South West Local Government Area of Oyo State, Nigeria. The high prevalence of 55% with mean (S.D) parasite density of 1814.70 (1829.117) parasite/ $\mu$ L of blood is an indication that Ibadan is a high-risk area for malaria transmission since it falls within Nigeria malaria risk map estimates of less than 20% in certain zone to more than 70% in other zones [15]. This is supported by other studies reported from Ibadan [8,16,17]. Similarly, the current prevalence of 55% from urban area of Ibadan is lower than those reported from many rural areas. This agrees with the reports of Wang *et al.* [18] and Baragatti *et al.* [19] who reported lower malaria prevalence of 24.1% and 26.1% respectively in urban areas. In some rural settings, prevalence as high as 74% and 71.4% have been reported [9,20]. Thus, while evidence abound on malaria prevalence in urban areas, prevalence is

generally lower than rural areas [11,21]. This lower malaria prevalence in urban areas could be as a result of better access to health facilities, well-designed houses that can protect against mosquito vectors, improved basic amenities and reduced mosquito breeding sites [22].

Our findings on age specific pattern of malaria prevalence and mean parasite density showed that age group  $\leq 5$  years had highest malaria infection. Similar findings have been reported in previous studies [23,24]. In fact, World Health Organization have emphasized this fact that children age five years and below are the most vulnerable group of people particularly in Africa [3]. This can be attributed to the gradual loss of maternal immunity coupled with low level of acquired immunity among children compared to adults. Thus, as age and exposure increases, malaria infection decreases except among elderly ones and the immunocompromised. Additionally, the sex pattern of infection in this study showed that males had higher malaria prevalence and mean parasite density compared to their female colleagues. This is related and comparable to previous reports from other studies in malaria endemic areas [25,26]. This could be due to the fact that males usually get involve in outdoor activities, staying late until night outside, have lackadaisical attitude towards malaria prevention and farming which inadvertently expose them to high mosquito bites than females. Furthermore, those without formal education had infection that almost doubled those who attained tertiary education though there was no association. This is in line with previous studies which showed that people can be acquainted with the knowledge of malaria transmission, prevention and control irrespective of their educational status [27,28]. This is however in contrast to the report of Adedotun *et al.*, [29], Eteng *et al.*, [30] and Dawaki *et al.*, [31] who noted that the level of education significantly influence the knowledge, attitude and practices of people which in turn can lead to reduced malaria infection. Similarly, those who travelled to rural area or village in this study area had higher malaria prevalence and density. This is corroborated by studies conducted in malaria endemic zones [19,32]. Generally, people are at greater risk when they travel from urban areas to rural areas due to the high number of mosquito vector present in rural areas. This is further aggravated by the low immunity of urban dwellers [33]. Chemoprophylactic drugs are recommended for use before and during such visit to rural areas in order to prevent development of malaria infection.

Furthermore, our findings showed that genetic factors such as genotype and blood group also influenced malaria parasite distribution in this study areas. Having blood group O is significantly associated with higher malaria infection. This is corroborated by Akhigbe *et al.*, [34] and Afoakwah *et al.*, [35] who recorded higher malaria prevalence for blood group O. Another study suggested that ABO blood group does not hinder the development of uncomplicated falciparum malaria but severe malaria [36]. This variation could be due to the different geographical regions [37]. In the same vein, haemoglobin AA is significantly associated with malaria infection in this study. This is consistent with previous findings [38,39] but inconsistent with the report of Suchdev *et al.*, [40] who finds no significant association between genotype AA, AS and SS in Kenya.

Finally, the binary logistic regression analysis showed that age group 6-10, presence of streams, distance from streams within  $\leq 1$ Km and travel to rural area were the major risk factors which often increase the odds of malaria infection in this study area. These findings is in agreement with previous studies in Nigeria and other malaria endemic regions [19,32,41,24].

## Conclusion

Apparently, malaria is endemic in Ibadan city and this is a glaring evidence indicating malaria as a public health challenge even in urban areas. Major risk factor influencing transmission include age, presence of stream within  $\leq 1$ Km from home and most importantly travel to rural areas. Health education on mosquito prevention and use of chemoprophylaxis before and during travel to rural areas is important and recommended.

## Limitations

Although this study provided relevant epidemiological findings on the prevalence, density and major risk factors affecting transmission in the urban city of Ibadan, the sample size was not large enough to accommodate likely errors due to sampling.

## Abbreviations

C.I: Confidence Interval; Km: Kilometer; OR: Odd Ratio; S.D: Standard Deviation; WHO: World Health Organization.

# Declarations

## Competing interests

The authors declare no competing interests.

## Authors' contributions

O.B.A. conceived, designed, performed the statistical analysis and drafted the original manuscript, Z.S.Y proofread and approved the final manuscript, F.H.M.T proofread and corrected manuscript, Iyabo Adepeju Simon-Oke proofread and corrected manuscript, C.F. carried out the field work and performed the laboratory experiments.

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## Availability of data and materials

The data of this current study is available from the corresponding author upon reasonable request.

## Ethical approval and consent to participate

The protocol for this study was approved by Ondo State Ministry of Health (protocol number OSHREC/09/04/2018/046) the Ethical Review Committee, Federal University of Technology, Akure, Nigeria. Informed consent that were written were obtained from each adult subject. However, for children, their caregiver or guardians provided the informed consent.

## Consent for publication

Not applicable

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## Figures

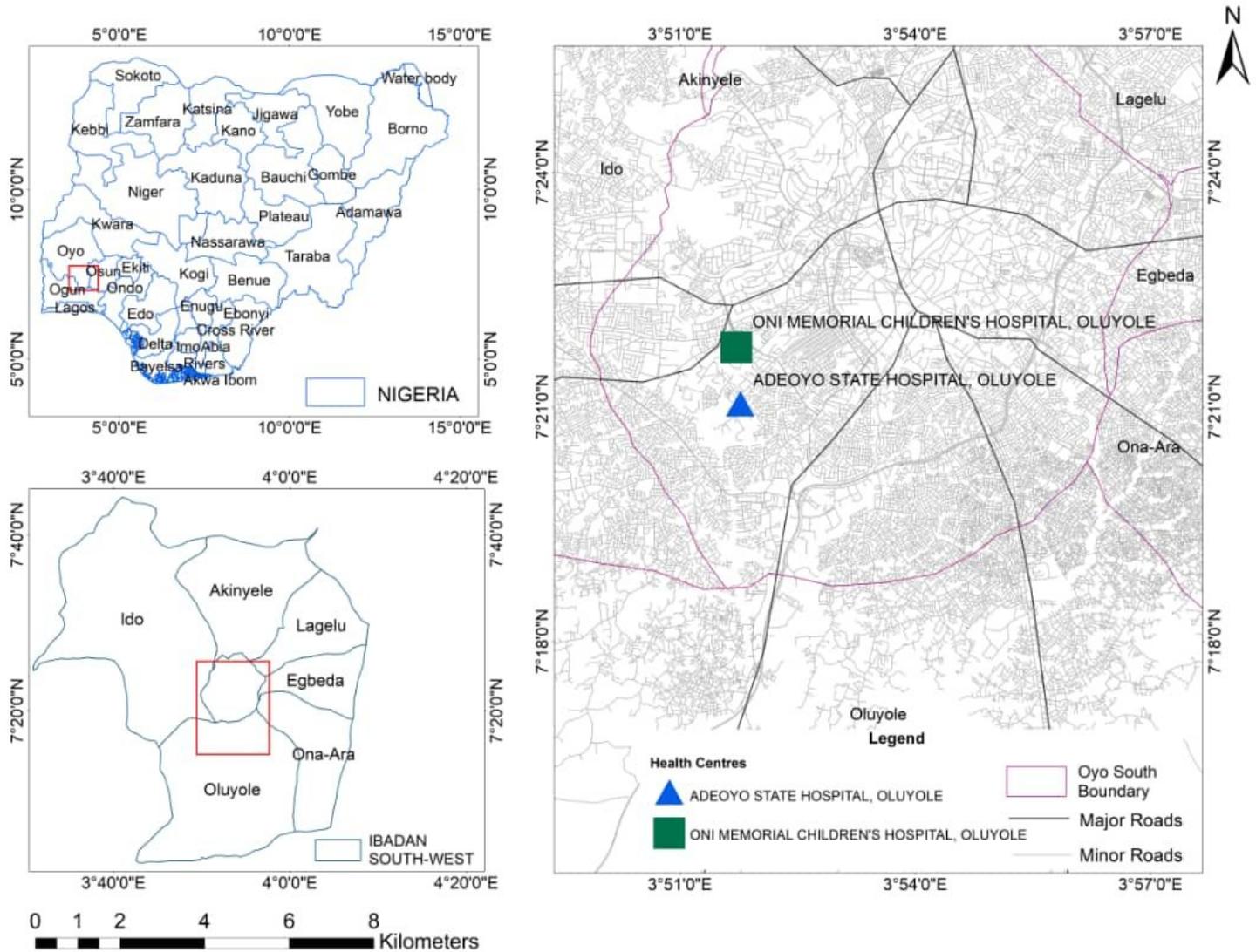


Figure 1

Map of Adeoyo State Hospital and Oni Memorial Children's Hospital in Ibadan, Nigeria