Research Paper

Effects of Malaria Parasites and Its Prevalence in Pregnant Women Attending the Antenatal Clinic: A Study in Gumel General Hospital, Jigawa State, Nigeria

Biliyaminu Ado[1*], Ibrahim Abdullahi Gumel[2], Bashari Babandi[3], Zaharaddeen Umar[1], Umar Usman[1], Also Sani Hotoro[4]

1. Department of Biology, Jigawa State College of Education, Gumel, Nigeria.
2. Department of Animal Science, Federal University, Dutse, Nigeria.
3. Department of Animal Health and Production, Binyaminu Usman Polytechnic, Hadejia, Nigeria.
4. College of Health Science and Technology, Kano, School of Health Technology, Bebeji, Kano State, Nigeria.

Use your device to scan and read the article online

Citation Ado B, Abdullahi Gumel I, Babandi B, Umar Z, Usman U, Sani Hotoro A. Effects of Malaria Parasites and Its Prevalence in Pregnant Women Attending the Antenatal Clinic: A Study in Gumel General Hospital, Jigawa State, Nigeria. Iranian Journal of Health Sciences. 2023; 11(4):229-238. http://dx.doi.org/10.32598/ijhs.11.4.958.1

http://dx.doi.org/10.32598/ijhs.11.4.958.1

ABSTRACT

Background and Purpose: Malaria is one of the most deadly and life-threatening parasitic infections in the world. Pregnant women and their unborn children are among the most vulnerable people to malaria, which causes maternal anemia and parental mortality. This research was carried out to investigate the prevalence of malaria parasites in pregnant women attending the Antenatal Clinic, Gumel General Hospital, Jigawa State, Nigeria.

Materials and Methods: A total of 100 pregnant women were selected using simple random sampling and examined for malaria infection from July to September 2021. The study questionnaires were administered to the respondents whose blood samples were collected. The outcome variables for this research were malaria infection (assessed using rapid diagnostic tests) and pregnant women with any Plasmodium species. The independent variables include age, social status, number of deliveries, pregnancy trimester, malaria transmission modes, and control measures of the mosquitoes/malaria. The collected data were analyzed using descriptive statistics and the chi-square test. The differences and similarities between study parameters were presented in relevant tables.

Results: A total of 64 samples (64%) were infected with *Plasmodium falciparum*. The samples aged 15-20 years demonstrated the highest prevalence of the infection (71.4%). Social status indicated that homemakers were more infected, with 66.3%. On the number of deliveries, those that delivered three times and above showed the highest prevalence of infection with 72.5%. Finally, those in the third trimester were the most infected, with 62.2%.

Conclusion: The current study showed that malaria is prevalent in pregnant women in Gumel. The associated factor with malaria infection comprised forgoing insecticide-treated bed nets, inadequate environmental sanitation, and living near stagnant water. Therefore, the future mothers should be motivated to participate early in focused antenatal care services to protect themselves from the possible harm of malaria. However, enlightenment on the devastating effects of malaria and preventive and control measures should target all women, especially at social and religious congregations, even before marriage.

Keywords: Malaria, Nigeria, *Plasmodium falciparum*, Pregnant women, Prevalence

Article info:
Received: 23 Jun 2023
Accepted: 19 Sep 2023
Available Online: 01 Oct 2023

*** Corresponding Author:**
Biliyaminu Ado
Address: *Department of Biology, Jigawa State College of Education, Gumel, Nigeria.*
E-mail: *biliyaminuado112@gmail.com*

1. Introduction

In 1880, French physician Alphonse Laveran discovered malaria parasites in the blood of malaria patients. Then, the Italian malariologists (Giovanni Battista Grassi and his co-researchers) proved in 1898 that malaria in humans was spread by an insect mosquito of the order Diptera and family Culicidae, in this case Anophelines [1].

Malaria is one of the lethal parasitic diseases affecting people all over the world, particularly in tropical and subtropical regions [2]. The disease is caused by the injection of parasitic protozoan of the genus Plasmodium by mosquitoes bites [3, 4]. *Plasmodium falciparum*, *P. malariae*, *P. ovale*, and *P. vivax* are the four major species of Plasmodium genus found in the African continent, particularly in the sub-Saharan area [5-8], *P. knowlesi* is also known to inflict humans [9]. The highest percentage of malaria infections in sub-Saharan Africa are caused by *P. falciparum* [10]. According to some studies, malaria deaths declined steadily from 897000 in 2000 to 577000 in 2015 and to 568000 in 2019 [11-13]. The malaria mortality rate halved from 2000 to 2015, from 30.1 per 100000 population at risk to 15.0 per 100000. The statistics continued to decline, reaching 14.0 per 100000 in 2019. In 2020, the mortality rate increased to about 15.1 per 100000 population at risk before decreasing slightly to 14.8 in 2021.

Nigeria is among the four countries that accounted for over half of all malaria deaths worldwide, with 31.3%. In addition, the rate of exposure to malaria infection in pregnant women was found to be highest in Africa, particularly Central Africa and the West African sub-region, with 35% each, followed by East and Southern Africa with 20%. Nearly 39% of these estimates were in the Democratic Republic of the Congo and Nigeria [14].

In pregnant women, placental malaria is a common complication of malaria in pregnancy, especially in endemic areas. The condition refers to the placental sequestration of *P. falciparum*-infected erythrocytes that accumulate in the intervillous space, resulting in pathological alteration. Accordingly, serious health problems arise for the mother and especially her baby, which include low birth weight, preterm delivery, intrauterine growth retardation, fetal anemia, congenital malaria, and fetal mortality [15-17]. In many parts of Nigeria, malaria patients look normal without showing any signs or symptoms and remain reservoir hosts of infections. The parasitic protozoa, Plasmodium species, enter the bloodstream in the human host through the bite of an infected female Anopheles mosquito. The Plasmodium passes through two separate lifecycles, one in the human or vertebrate hosts and the other in the insect ectoparasite, the female Anopheles mosquito [14]. In Northern Nigeria, pregnant women and their unborn children are also vulnerable to malaria, which serves as the primary cause of mortality, where children are dying every 30 seconds from malaria [18]. Many malaria preventive and control measures have been developed to protect pregnant women and their unborn children in malaria-endemic countries due to their reduced immunity and higher susceptibility [19].

The World Health Organization (WHO) has recommended that the appropriate use of insecticide-treated nets (ITNs) is one of the key components of malaria prevention and controls [9]. This net reduces direct human contact with mosquitoes, especially at night and during sleeping, significantly reducing the incidence and prevalence of malaria and its adverse effects during pregnancy, particularly in areas where malaria transmission is high [20].

Furthermore, preventive treatment of malaria during pregnancy is another critical intervention for preventing and controlling malaria. This therapy consists of an complete therapeutic course of antimalarial medicine given to pregnant women at routine antenatal visits, whether or not they are infected with malaria [21, 22]. Indoor residual spraying that involves well-coordinated, timely spraying of the interior walls of homes with appropriate insecticides can suppress and kill mosquitoes. Artemisinin-based combination therapy has become the standard treatment of uncomplicated malaria [23, 24]. Prior to prescription and treatment, quick and appropriate confirmation of malaria parasites through microscopic exam or rapid diagnostic test (RDT) is recommended for all suspected malaria patients. Microscopic examination has been long recommended for malaria diagnosis, but the lack of well-trained personnel, adequate reagents, and standard equipment limits its application to many people in malaria-endemic areas [25].

Jigawa State is one of the 36 states in Nigeria with established malaria transmission. Fortunately, the government has begun to minimize and wipe out malaria to an insignificant level through different malaria control projects and interventions [26]. Gumel is among the five emirates in the state and is a fast-growing city with its fair share of the burden of malaria. Therefore, it is necessary to determine the incidence of malaria among the population, especially children and pregnant women, to

ascertain the success or failure of the ongoing control programs. The present research was designed to determine the prevalence and effects of malaria infections among pregnant women attending the Antenatal Clinic, General Gumel Hospital. This study aims to provide information on the prevalence of malaria and associated risk factors in Gumel City and the greater Jigawa State.

2. Materials and Methods

Description of the study area

We conducted a cross-sectional study from July to September 2021 in the Antenatal Clinic, Gumel, General Hospital, Jigawa State. This state is in the northwest part of Nigeria, with 27 local governments. The state shares borders with Katsina and Kano from the West, Yobe State from the northeast, and Bauchi State from the east. It also shares an international border with the Niger Republic from the north. The state has two seasons: Dry season from October to May and a rainy season from June to September with a high temperature of about 420˚C. However, it experiences low temperature of about 100˚C during the rainy season [27]. Gumel local government is one of the 27 local governments in Jigawa State. Gumel is between latitude 120 37’ 51” north and longitude 90 23’ 36” east. Gumel City is about 148 km away from the state capital, Dutse. The Maigatari local government boards the city to the north and southeast with the Gagarawa local government and southwest with the Sule Tankarkar local government. According to the 2006 population census, Gumel has a total population of 106371, which increased to 182900 in 2022 [28, 29].

Study questionnaires

The interviewer administered a semi-structured questionnaire. A medical entomologist and health educator validated all questionnaire items by collecting data from 100 respondents (pregnant women) along with their blood samples. Those who cannot read and write, answered the questions verbally. Before sample collection, consent was obtained from the respondents and their husbands. The questionnaire contains data about the age, social status, number of deliveries, modes of malaria transmission, and control measures of the mosquitoes/malaria. The prepared slides were then labeled in accordance with the number of the questionnaire.

Sampling method and sample size determination

The sample size was determined using a single proportion formula considering a 50% prevalence of malaria among pregnant women, a 95% CI, a 5% margin of error, and a design effect 2. To compensate for the dropout, 10% was added to the determined sample size. Finally, finite population correction was done to adjust the final sample size, which gave a sample size of 100. A multistage sampling technique was used to select the determined sample size using a simple random sampling technique.

Inclusion and exclusion criteria

Inclusion criteria comprised all pregnant women referring to the Antenatal Clinic on the scheduled day and agreed to participate. Exclusion criteria comprised all pregnant women who had taken antimalarial drugs in the last four weeks before the study period.

Laboratory method

One milliliter of peripheral blood sample was collected through vein puncture from each pregnant woman at the hematology laboratory, General Hospital Gumel, by three medical laboratory experts for parasitological detection of Plasmodium. Two drops of blood sample were spread over a diameter of 15 mm on the grease-free, clean glass slides, to prepare a thick blood film. The prepared slides were made in duplicates for each blood sample, labeled accordingly, and allowed to dry for about 48 hours. Then, it was stained with Giemsa at pH 7.2 for about an hour. Two medical laboratory experts carried out the microscopic evaluation of the stained slides, and discrepancies between them were resolved by re-examining them before the final results were determined. A slide was considered negative when 100 high-power fields were examined under the oil immersion objective. Taking the number of leucocytes per microliter of blood as 6000, parasite density was expressed as parasite count×6000 divided by the number of leucocytes counted [9].

Data analysis

Data were analyzed using descriptive statistics and the chi-square (χ^2) test. The differences and similarities between parameters are presented in relevant tables.

3. Results

A total of 100 blood samples were examined in pregnant women in Gumel from July to September 2021. Of the samples analyzed, 64 were positive, and only one type of species, *P. falciparu*m, was identified. The obtained results were tabulated as follows.

Table 1 indicates that the age range of 15-20 has the highest percentage: Out of 56 samples examined, 40 (71.4%) were positive. Whereas the age group 31-35 has the lowest rate: Out of 7 samples examined, only 3 (42.8%) were positive.

The distribution of malaria infection by social status, as shown in Table 2, indicated that homemakers have the highest infection rate; out of 95 samples examined, 63 were positive, representing 66.3%. In contrast, traders and students have the lowest percentage (0%) out of 1 examined sample.

Table 3 reveals that those who delivered three times and above have the highest prevalence of infection with 72.5%. However, low infection rate (43.8%) was observed among those delivered once.

Table 4 indicates that the infection was higher among pregnant women in the third trimester (67.2%), with those in the first trimester having shown the lowest percentage (50%).

4. Discussion

Malaria has remained one of the most devastating public illnesses among pregnant women in Gumel. About 64% of the samples examined were positive for malaria, a high figure, which could have been due to the breeding period, suitable climate, and a high transmission season of the vectors (mosquitoes) at the time in which the research was conducted [18].

As revealed in Table 1, the highest prevalence (71.4%) of infection was found in the age range 15-20, and this could be because the immunity of these individuals is not fully developed. This finding agrees with the results of some studies [30] that reported that individuals aged 10-19 have the highest percentage (45.7%). Moreover,

Table 1. Age distribution percentage (n=100)

Age (y)	Number Examined	No. (%)	
		+Ve	-Ve
15-20	56	40(71.4)	16(28.6)
21-25	17	11(64.7)	06(35.3)
26-30	20	10(50.0)	10(50.0)
31-35	7	3(42.8)	4(57.1)
Total	100	64	36

+Ve: Number of positive malaria parasites.

Table 2. The distribution of infection by social status (n=100)

Occupation	Number Examined	No. (%)	
		+Ve	-Ve
Civil servants	3	01(33.3)	2(66.7)
Traders	1	0	1(100)
Housewives	95	63(66.3)	32(33.7)
Students	1	0	1(100)
Total	100	64	36

+Ve: Number of positive malaria parasites.

Table 3. Percentage of malaria based on number of deliveries (n=100)

Number of Deliveries	Number Examined	No. (%)	
		+Ve	-Ve
Never	27	17(63.0)	10(37.0)
One	16	7(43.8)	9(56.2)
Two	6	3(50.0)	3(50.0)
Three and above	51	37(72.5)	14(27.5)
Total	100	64	36

+Ve: Number of positive malaria parasites.

Table 4. Trimes for distribution of the infection (n=100)

Trimester (Months)	Number Examined	No. (%)	
		+Ve	-Ve
1st (0-3)	8	4(50.0)	4(50.0)
2nd (3-6)	31	19(61.3)	12(38.7)
3rd (6-9)	61	41(67.2)	20(32.8)
Total	100	64	36

+Ve: Number of positive malaria parasites.

the age group of 31-35 has the lowest rate, indicating that, out of 7 samples examined, only 3 (42.8%) were positive. This finding is also in line with the finding of some studies [30] that the individuals of the age group of 30-39 have the lowest percentage of (34.1%). Probably, they are the most active and their behavior pattern may expose them to frequent mosquito bites.

Table 2 indicates that homemakers are the most infected. This result may be because homemakers are not mobile (they are mostly at home), and most of them (the respondents in this research) were from villages; they do not know how to control and eliminate the breeding sites of the mosquitoes that, their houses have not been sanitized with poor or no drainage system. While traders and students have the lowest percentage. These low figures obtained above could be due to the low exposure of the vector among these individuals due to clean surroundings at their workplaces, offices, and classes with good drainage systems. Their houses may also be well cleaned, and they are literate, which reduces the infection rate among them. According to some studies [30], health workers have the highest percentage (100%), while craft women have the lowest percentage (34%) out of the samples examined.

As revealed in Table 3, those who delivered three times and more have the highest prevalence rate of infection (72.5%). This outcome could be a result of their body's immune system being less active to prevent them from malaria, and they belonged to the age group of 20-30; lack or little knowledge of malaria control and preventive measures is another factor that made the transmission of malaria among these individuals. This result is in accordance with the findings of some studies [31]. However, a low infection rate was observed among those delivered one time; this low infection could be because these individuals may not have exposed themselves to the mosquitoes.

The result based on trimesters, as shown in Table 4, indicates that the infection rate was higher among pregnant women in the third trimester, with 67.2%. This finding contradicts some studies [30] showing that pregnant women in the first trimester have the highest percentage (43.5%). This research also showed that those in the first trimester have shown the lowest rate (50%); this is also contrary to the findings of some studies [30], which showed that those in the second trimester have the lowest percentage (32.5%).

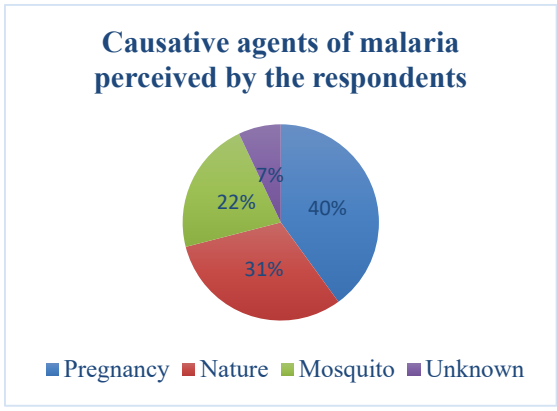

Figure 1. Causative agents of malaria

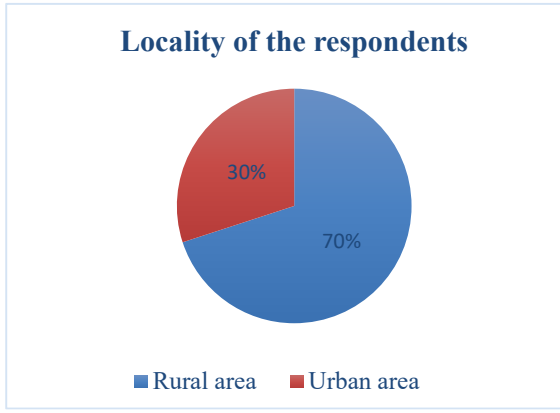

Figure 2. Locality of the respondents

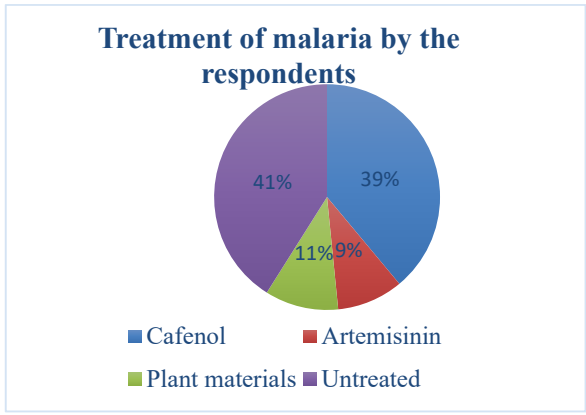

Figure 3. Treatment of malaria

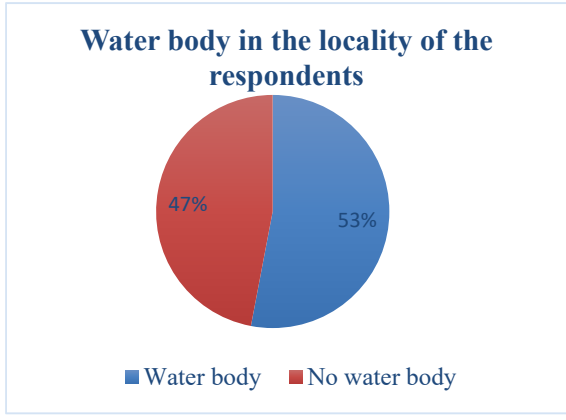

Figure 4. Water body in the locality

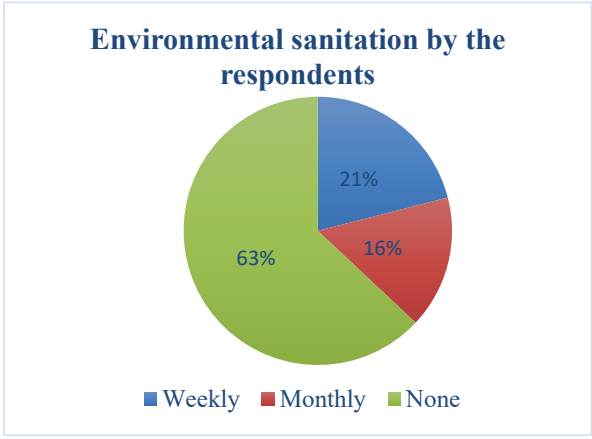

Figure 5. Environmental sanitation

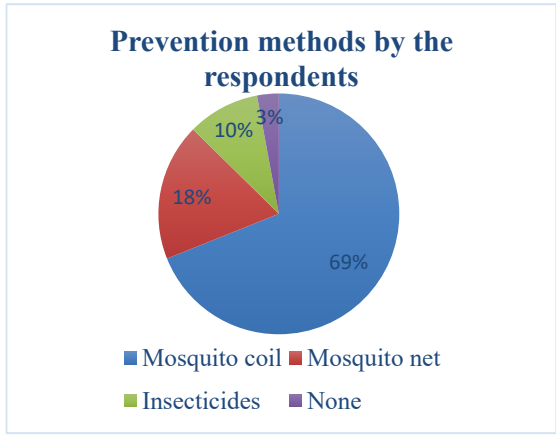

Figure 6. Prevention methods

Various findings by different research institutes, such as WHO, United Nations International Children Emergency Fund (UNICEF), Roll Back Malaria (RBM) pointed out that malaria is generally caused by the protozoan parasite (Plasmodium species). However, the result of this research shows that the causative agent of malaria perceived by some respondents was mosquitoes, with 22% by nature, with 31%. Some also believed that malaria is caused by pregnancy (40%), whereas some respondents (7%) did not know how they were affected by malaria (Figure 1). As observed above, most patients sampled in this study did not know what causes malaria; this could be attributed to the fact that most patients sampled had not even attended primary schools and were mostly from rural areas [3, 32]. Those who perceived malaria as caused by mosquitoes had little awareness of malaria and were mainly from the Gumel metropolis.

The clinical features of acute malaria are highly variable depending upon the host's immunity level. Several types of drugs, such as quinine, mefloquine, halofantrine, ferroquine, primaquine, and pyrimethamine treat malaria [33]. Of the samples examined, 70% were from rural areas (Figure 2), and the remaining were from urban areas (Gumel metropolis). Most patients interviewed usually treat malaria through self-treatment. About 37% used Cafenol, 41% did not take any drug due to poverty and illiteracy, and 11% used plant materials to treat malaria. Only 9% of those interviewed go to the hospital for treatment with Artemisinin whenever they fall sick (Figure 3).

Water bodies negatively affect our localities, especially during the rainy season, stimulating mosquito breeding. It also increases mosquitoes' survival and reproduction as they always need water bodies and moist environments [10]. Of the samples examined, 53% have water bodies in their areas; this made the malaria prevalence rate high among them. Also, 47% have no water bodies (Figure 4); this made malaria's prevalence very low among them. The study also shows that 21% of the respondents carried out environmental sanitation weekly and 16% monthly to reduce the mosquito population and to prevent themselves from being infected. In addition, 63% do not carry out environmental sanitation (Figure 5), which causes a high infection rate due to interaction with mosquitoes, the vector that can cause malaria. Out of 100 respondents, 69% use mosquito coils because they do not cost much [34]. This finding aligns with the results of some studies [35]. About 18% use mosquito nets to prevent mosquito bites, and 10% use insecticides (Figure 6). The use of insecticides and impregnated bed nets prevents malaria, which the WHO special program for training and research (TDR) has supported since most anopheles feed at night. Another way of preventing malaria is by spraying a residual insecticide at a recommended dosage and frequency to kill the (female) Anopheles mosquito [36]. Only 3% (Figure 6) did not protect themselves from being bitten by mosquitoes; this could be due to poverty, illiteracy, or a well-developed body immune system.

The global technical strategy for malaria 2016–2030 is grounded on five principles. The first is universal access to malaria prevention, diagnosis, and treatment. The program's administrative transition from the National Service of Vector-borne Diseases to the Ministry of Public Health is perceived to have weakened the diagnosis network. Likewise, there is a shortage of antimalarial medication at the primary level of care, low adherence, poor-quality drugs, drug resistance, and a shortfall of general knowledge on the disease among the healthcare staff, as many physicians are not aware of the correct first-line treatment for malaria by *P. falciparum* and *P. vivax*. However, it is evidently confirmed that reaching the area with health care services is difficult due to its geographical layout, which is one of the critical challenges faced in improving malaria diagnosis and treatment in endemic areas. Similarly, the main barrier was a lack of qualified and adequate personnel and microscopy posts [35, 37-39].

5. Conclusion

The area's available preventive and control measures should be identified, reassessed, and evaluated. Also, emphasis should be paid on frequent and adequate environmental sanitization to eliminate the breeding sites, and sensitization on the proper use of impregnated treated nets should be maintained. Pregnant women should be motivated to attend and participate early in focused antenatal care services to mitigate or eradicate the possible liable harm of malaria infections during pregnancy. However, enlightenment on the devastating effects of malaria and preventive and control measures during pregnancy should target young women before marriage, especially at schools, markets, mosques, churches, and other religious and social congregations.

Study limitations

The limitation of this research was a small sample size, suggesting that more studies with larger sample sizes be conducted in the future.

Ethical Considerations

Compliance with ethical guidelines

Ethical approval was obtained from the Jigawa State Ministry of Health and Management of Gumel General Hospital. Before sample collection, consent was obtained from the respondents and some from their husbands. The purpose and importance of the study were explained to the participants since some of our study participants cannot read and write. Confidentiality of the information was maintained by omitting their names and personal identification.

Funding

This research did not receive any grant from funding agencies in the public, commercial, or non-profit sectors.

Authors contributions

Study design, analyzed and interpreted the data collected: Biliyaminu Ado; Data collection, revised, edited and approved the final version of the manuscript: All authors.

Conflict of interest

The authors declared no conflict of interest.

Acknowledgements

The authors acknowledged the support of Gumel General Hospital, especially the medical laboratory experts in the Hematology Department, for providing the essential materials used in the experiments and all the respondents who willingly participated in the research.

References

[1] Cox FE. History of the discovery of the malaria parasites and their vectors. Parasites & Vectors. 2010; 3(1):5. [DOI:10.1186/1756-3305-3-5] [PMID]

[2] Bassey SE, Izah SC. Some determinant factors of malaria prevalence in Nigeria. Journal of Mosquito Research. 2017; 7(7):48-58. [DOI:10.5376/jmr.2017.07.0007]

[3] Pijl EK, Vanneste YTM, de Rijk AE, Feron FJM, Mathijssen J. The prevalence of sickness absence among primary school pupils - reason to be worried? BMC Public Health. 2021; 21(1):170. [DOI:10.1186/s12889-021-10193-1] [PMID]

[4] Ukaegbu CO, Nnachi AU, Mawak JD, Igwe CC. Incidence of concurrent malaria and typhoid fever infections in febrile patients in Jos, Plateau State Nigeria. International Journal of Scientific and Technology Research. 2014; 3(4):157-61. [Link]

[5] Alaba OA, Alaba OB. Malaria in rural Nigeria: Implications for the millennium development goals. African Development Review. 2009; 21(1):73-85. [DOI:10.1111/j.1467-8268.2009.00204.x]

[6] Babalola ET, Ojezele MO, Adeyi AO. Malaria parasitaemia among patients in Ibadan, Southwestern Nigeria. Journal of Applied Biosciences. 2010; 29:1774-80. [Link]

[7] Tela IA, Modibbo MH, Adamu LH, Taura MG. Prevalence of malaria infection among ABO blood groups in Jama'are, Nigeria. RA Journal of Applied Research. 2015; 1(7):255-62. [Link]

[8] Unata IM, Bunza NM, Ashcroft OF, Abubakar A, Faruk N. Prevalence of malaria parasites among HIV/AIDS patients attending HIV clinic in Usmanu Danfodiyo university teaching hospital and Sokoto State specialist hospital Sokoto, Nigeria. International Journal of Novel Research in Life Sciences. 2015; 2(2):39-43. [Link]

[9] Fana SA, Bunza MD, Anka SA, Imam AU, Nataala SU. Prevalence and risk factors associated with malaria infection among pregnant women in a semi-urban community of north-western Nigeria. Infectious Diseases of Poverty. 2015; 4:24. [DOI:10.1186/s40249-015-0054-0] [PMID]

[10] Huzortey AA, Kudom AA, Mensah BA, Sefa-Ntiri B, Anderson B, Akyea A. Water quality assessment in mosquito breeding habitats based on dissolved organic matter and chlorophyll measurements by laser-induced fluorescence spectroscopy. Plos One. 2022; 17(7):e0252248. [DOI:10.1371/journal.pone.0252248] [PMID]

[11] World Health Organization (WHO). World malaria report 2019 [Internet]. 2019 [Updated 2019 December 4]. Available from: [Link]

[12] World Health Organization (WHO). World malaria report 2020: 20 years of global progress and challenges. Geneva: World Health Organization; 2020. [Link]

[13] World Health Organization (WHO). World malaria report 2022 [Internet]. 2022 [Updated 2022 December 8]. Available from: [Link]

[14] Ukwubile CA, Krustu T, Samagoro CT, Jude O. Prevalence of malaria parasite in takum local government area, Taraba State, Nigeria. Journal of Bacteriology & Mycology. 2018; 6(1):00177. [DOI:10.15406/jbmoa.2018.06.00177]

[15] Erhabor O, Adias TC, Hart ML. Effects of falciparum malaria on the indices of anaemia among pregnant women in the Niger Delta of Nigeria. Journal of Clinical Medicine and Research. 2010; 2(3):35-41. [Link]

[16] Mbah JO, Njoku OO, Nnachi AU, Nnachi IA, Nwinyimagu AJ. Incidence of antenatal malaria parasitaemia and the effect on the haemoglobin profile of pregnant women in Enugu East Local Government Area, Enugu, Nigeria. American Journal of Epidemiology and Infectious Disease. 2015; 3(5):88-94. [DOI:10.12691/ajeid-3-5-1]

[17] Cisse M, Diallo AH, Somé DA, Poda A, Awandare AG, Guiguemdé TR. Association of placental plasmodium falciparum parasitaemia with maternal and newborn outcomes in the periurban area of Bobo-Dioulasso, Burkina Faso. Parasitology Open. 2016; 2:e15. [DOI:10.1017/pao.2016.12]

[18] Caldwell JM, LaBeaud AD, Lambin EF, Stewart-Ibarra AM, Ndenga BA, Mutuku FM, et al. Climate predicts geographic and temporal variation in mosquito-borne disease dynamics on two continents. Nature Communications. 2021; 12(1):1233. [DOI:10.1038/s41467-021-21496-7] [PMID]

[19] World Health Organization (WHO). World malaria report 2012 [Internet]. 2012 [Updated 2012 November 19]. Available from: [Link]

[20] ter Kuile FO, Terlouw DJ, Phillips-Howard PA, Hawley WA, Friedman JF, Kariuki SK, et al. Reduction of malaria during pregnancy by permethrin-treated bed nets in an area of intense perennial malaria transmission in western Kenya. The American Journal of Tropical Medicine and Hygiene. 2003; 68(4 Suppl):50-60. [DOI:10.4269/ajtmh.2003.68.50] [PMID]

[21] Oluwagbemiga A, Bamidele A, Babatunde A, Chimere A, Medinat S, Olalekan R. Prevalence of malaria in pregnant women attending antenatal clinic in primary health centres in Lagos. South West, Nigeria. Journal of Advances in Medicine and Medical Research. 2018; 25(12):1-9. [DOI:10.9734/JAMMR/2018/39620]

[22] Sabina, K. Prevalence and Epidemiology of Malaria in Nigeria: A Review. International Journal of Research in Pharmacy and Biosciences. 2017; 4(8):10-12. [Link]

[23] U.S. Embassy and Consulate in Nigeria. Nigeria malaria fact sheet. Abuja: U.S. Embassy and Consulate in Nigeria; 2011. [Link]

[24] Shaalan EA, Canyon DV. Aquatic insect predators and mosquito control. Tropical Biomedicine. 2009; 26(3):223-61. [PMID]

[25] Houmsou RS, Amuta EU, Sar TT, Adagba AH. Malarial infection among patients attending a Nigerian semi-urban based hospital and performance of HRP-2pf rapid diagnostic test (RDT) in screening clinical cases of plasmodium falciparum malaria. Translational Biomedicine. 2011; 2(1):1-5. [DOI:10. 3823/422]

[26] Ocheje AJ, Dogara MM. Prevalence of Malaria and Risk Factors among Patients Attending Dutse General Hospital, Jigawa State, Nigeria. International Research Journal of Public and Environmental Health. 2016; 3(11):270-7. [DOI:10.15739/irjpeh.16.033]

[27] Muhammad A, Ruslan BR, Murtala UM. Free maternal healthcare program under the successful delivery program in Jigawa State, Nigeria. International Journal of Psychosocial Rehabilitation. 2019; 23(4):707-18. [DOI:10.37200/IJPR/V23I4/PR190404]

[28] Adams A. Analysis of Water Pollution in Gumel Local Government Area, Jigawa State, Nigeria. Journal of Environment and Earth Science. 2014; 4(12):7-11. [Link]

[29] National Bureau of Statistics. National Census. Jigawa: National Bureau of Statistics; 2022. [Link]

[30] Bawa JA, Auta T, Liadi S. Prevalence of malaria: Knowledge, attitude and cultural practices of pregnant women in Katsina metropolis, Nigeria. European Scientific Journal. 2014; 10(21):148-67. [DOI:10.19044/esj]

[31] Duguma T, Nuri A, Melaku Y. Prevalence of malaria and associated risk factors among the community of Mizan-Aman Town and Its Catchment Area in Southwest Ethiopia. Journal of Parasitology Research. 2022; 2022:3503317. [DOI:10.1155/2022/3503317] [PMID]

[32] Idowu AP, Okoronkwo N, Adagunodo RE. Spatial predictive model for malaria in Nigeria. Journal of Health Informatics in Developing Countries. 2009; 3(2):30-6. [Link]

[33] Shahbodaghi SD, Rathjen NA. Malaria: Prevention, diagnosis, and treatment. American Family Physician. 2022; 106(3):270-8. [PMID]

[34] Hogarh JN, Agyekum TP, Bempah CK, Owusu-Ansah EDJ, Avicor SW, Awandare GA, et al. Environmental health risks and benefits of the use of mosquito coils as malaria prevention and control strategy. Malaria Journal. 2018; 17(1):265. [DOI:10.1186/s12936-018-2412-4] [PMID]

[35] Ferreira MU, Castro MC. Challenges for malaria elimination in Brazil. Malaria Journal. 2016; 15(1):284. [DOI:10.1186/s12936-016-1335-1] [PMID]

[36] Pryce J, Medley N, Choi L. Indoor residual spraying for preventing malaria in communities using insecticide-treated nets. The Cochrane Database of Systematic Reviews. 2022; 1(1):CD012688. [DOI:10.1002/14651858.CD012688.pub3] [PMID] [PMCID]

[37] Kounnavong S, Gopinath D, Hongvanthong B, Khamkong C, Sichanthongthip O. Malaria elimination in Lao PDR: The challenges associated with population mobility. Infectious Diseases of Poverty. 2017; 6(1):81. [DOI:10.1186/s40249-017-0283-5] [PMID]

[38] Mosquera-Romero M, Zuluaga-Idárraga L, Tobón-Castaño A. Challenges for the diagnosis and treatment of malaria in low transmission settings in San Lorenzo, Esmeraldas, Ecuador. Malaria Journal. 2018; 17(1):440. [DOI:10.1186/s12936-018-2591-z] [PMID]

[39] Simmalavong N, Phommixay S, Kongmanivong P, Sichanthongthip O, Hongvangthong B, Gopinath D, et al. Expanding malaria diagnosis and treatment in Lao PDR: Lessons learned from a public-private mix initiative. Malaria Journal. 2017; 16(1):460. [DOI:10.1186/s12936-017-2104-5] [PMID]

This Page Intentionally Left Blank