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Asymptomatic Plasmodium Infection and Its Associated Factors among Pregnant Women Attending Antenatal Consultation in Enugu North Local Government Area of Enugu State

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Authors' contributions

This work was carried out in collaboration between both authors. The Authors conceptualized, designed the study, performed the statistical analysis, wrote the protocol, and the manuscript. Both authors read and approved the final manuscript.

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ABSTRACT

Malaria infection during pregnancy is a major public health problem in tropical and subtropical regions. It affects an estimated 30 million pregnant women in sub-Saharan Africa annually with 25% of maternal deaths each year. This study investigated Plasmodium parasitemia and its associated factors among malaria-asymptomatic pregnant women attending antenatal consultation in some selected hospitals in Enugu North, through blood smear microscopy and structured questionnaire interview of 440 randomly selected women. The result indicated a 27.9% prevalence of asymptomatic Plasmodium infection among studied subjects in Enugu North Local Government Area. The number of antenatal visits varied according to the age of women, previous pregnancy

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and occupation, education, gravidity, and age of pregnancy. Plasmodium parasitemia was more in young pregnant women, pregnant women who experienced pregnancy for the first time and those in their first trimester. Knowledge about a causative organism, and malaria symptom methods of transmission prevention and treatment, varied among the social status of the studied subjects. There was a statistical association between asymptomatic Plasmodium infection with anaemia ($p<0.05$). Therefore, it is recommended that more awareness on the use of insecticide-treated nets and regular malaria tests should be done to ascertain malaria Plasmodium status, especially during pregnancy.

Keywords: Asymptomatic; plasmodium; pregnancy; anemia; knowledge.

1. INTRODUCTION

Malaria is a vector-borne parasitic disease, which in humans, is primarily caused by one of the five species of *Plasmodium*: *Plasmodium falciparum*, *Plasmodium vivax*, *P. ovale* (*P. ovale curtisi, P. ovale wallikeri*), *P. malariae* and *P. knowlesi* [1]. They are an estimated 241 million malaria cases globally and 627,000 deaths due to malaria yearly with the highest mortality reported in Africa [2].

Malaria infection during pregnancy is a major public health problem in tropical and sub-tropical regions [3,4–7]. It affects an estimated 30 million pregnant women in sub-Saharan Africa annually [8]. In malaria endemic areas, malaria is the cause of almost 25% maternal death each year, with the greatest risk of infection and morbidity occurring in pregnant women, adolescents, and those co-infected with Human Immunodeficiency Virus (HIV) [9–11] Malaria during pregnancy may cause a variety of adverse consequences including maternal anemia [12], placental accumulation of parasites, [4,13] low birth weight, prematurity and intrauterine growth retardation (IUGR), congenital infection and infant mortality [4,5,14,15]. Asymptomatic infection with Plasmodium species is common in malaria endemic areas [16]. Asymptomatic individuals, whether with detectable parasitemia by microscopy or below the microscopic detection level, can be a reservoir [17] for transmission by Anopheles mosquitoes and may progress to symptomatic disease [18].

The transmission of mosquito-borne diseases requires direct contact between the vector and host when a blood meal is taken [19]. The contact rate between humans and mosquitoes varies with the local abundance of vectors, vector host preferences and host attractiveness, which drive the likelihood of mosquito bite [20]. Many studies have demonstrated that some people attract more mosquitoes than others in laboratory studies and strong heterogeneities in exposure to mosquito bites have been observed at a local scale in the field, whereby a small fraction of people tend to receive most of the bites within a household [20]. Attractiveness has been shown to be mediated by differences in body odor, but the under-lying biological factors are less well understood, the factor behind the high burden of malaria during pregnancy could be the increased in body surface and specific odor secretion which may expose them to increased mosquito bite [20–24].

Malaria control remains a challenge in Africa where 45 countries including Nigeria, are endemic for malaria and about 600 million people are at risk [6,8,25–28]. Individuals who are constantly exposed to malaria parasites through bites of mosquito often develop semi-immunity, which prevents life threatening parasite burdens and prevent responses that cause illness [21]. During pregnancy, the acquired semi-immunity can keep the infection at an asymptomatic level in most cases [4,5,14,15]. Depending on the endemicity of malaria in an area, it can be expected that 1-50% of pregnant women may carry malaria parasitemia, especially in the placenta, Impact of malaria infection in pregnancy is due to the presence of parasites in the placenta causing maternal anemia [29–31].

The focus of malaria prevention during pregnancy has been the use of antimalaria chemoprophylaxis and the use of insecticide treated nets (ITNs) [28]. Pregnant women on anti-malaria chemoprophylaxis are at a reduced risk of the harmful effects of malaria [11,32,33], while ITNs reduces human contact with mosquitoes leading to a significant reduction in the incidence of malaria, severe morbidity and mortality due to malaria, as well as helping reduce the adverse effects of malaria transmission [28].

Asymptomatic malaria remains one of the leading causes of neonatal death, maternal anemia and low birth weight from prematurity and intrauterine growth retardation (IUGR). Some people can develop immunity to the malaria parasites Plasmodium falciparum after many years of repeated infections [9,16,16,34–36]. In these patients, a small number of parasites continue to live silently in the blood stream but do not cause any symptoms. This, however, encourages parasite transmission to non-infected individuals. New studies report asymptomatic infections are responsible for up to half of new transmission but often slid under the radar thereby sabotaging efforts of malaria elimination programs [16,34,37].

Though malaria prevention measures have received great attention in the last few years not much attention has been given to asymptomatic malaria especially in pregnant women [38]. The few research done have been at the institutional level not at a community level in general and particularly not in Enugu North Local Government. National Malaria Control and Elimination Programs (NMCEP) are doing great towards the protection of pregnant women living in malaria endemic zones because of their reduced immunity [14,33,39]. Considering, the wide variation in the reportage of the prevalence of malaria in pregnancy in Nigeria. It is therefore imperative to closely assess the prevalence and distribution of asymptomatic Plasmodium parasitemia among pregnant women in Enugu, such data is needed to complement the effort of Nigeria government other agencies like the Roll Back Malaria programme, WHO, UNICEF, and many other non-governmental agencies in the fight against malaria. In addition to determining the prevalence of asymptomatic Plasmodium infection, this study may have implications for social change by supplying the necessary research that could assist policy makers, community leaders, healthcare organizations, pregnant women, and other stakeholders in designing knowledgeable interventions and preventive approaches, including enhanced social support at various levels to lessen the impact of asymptomatic Plasmodium infection among pregnant women attending antenatal care. This present study presents investigation of asymptomatic Plasmodium infection and its associated factors among pregnant women attending antenatal consultation in some selected hospitals in Enugu North. This research may also provide more evidence in favor of various therapies and parasite control measures.

2. MATERIALS AND METHODS

2.1 Study Area

Enugu North is one of the seventeen Local Government Areas in Enugu State, Nigeria. Its headquarters are in the city of Enugu at Okpara Avenue. The entire council area constitutes the Enugu State capital city. It is located in Nigeria at 6°28′N 7°31′E coordinate. It has a land area of 106 square kilometers, a population of 244,852 according to the 2006 census. The LGA has an average temperature of 27 degrees Celsius and an average humidity of 69 percent, while the two distinct seasons are dry and rainy, with a brief harmattan in the dry season. The area mainly populated by members of the Igbo ethnic group. The Igbo and English languages are extensively spoken in the area while Christianity is the most practiced religion in the LGA. The public and commercial institutions like hospitals, hotels, banks, leisure centers, and restaurants all contribute to the vibrant economy of Enugu North LGA. There are also numerous shops, shopping centers (such as the well-known Polo Park Mall, which currently houses ShopRite), and markets (such as the Artisan Market). Most of the inhabitants of the LGA are either civil servants, traders, or artisan. Some are farmers who engage in subsistent agriculture.

2.2 Study Design

A cross-sectional survey was carried out in Paully general hospital, Asata health center, and New-haven health center, located at different political wards within Enugu North Local Government Area of Enugu State. These health centers have antenatal care units which serves an average of 35 women each working day. Questionnaires were administered to consented individuals and blood samples were also collected; the collected samples were taken to General Hospital laboratory for examination. Sampling was carried out thrice a week. A total of 440 women were randomly selected from the three different health centers. Sample size was determined using Slovin sample size formular. A structured questionnaire consisting of themes about demographic data, knowledge about malaria in pregnancy, attitude towards treatment of malaria, clinical symptoms of malaria infection and methods of prevention and control of malaria infection were administered to consented individuals. Each participant was properly educated on the purpose of the research and individuals who could not answer the interview questions were assisted by health workers.

2.3 Microscopy for Asymptomatic Malaria Parasitemia

Blood samples were collected from consented asymptomatic pregnant women attending antenatal consultation in Paully, Asata, and New-haven Health Centres, using blood smear/film method. Two ml of blood was collected and transferred into an EDTA (ethylenediaminetetraacetic acid) and after a small drop of the collected blood was smeared on a clean glass slide, creating a thin smear. The blood smear was allowed to air dry to fix the cells, the smear was heat- fixed over a flame, and later treated with Giemsa stain for about 15-30 minutes. Thereafter stain was rinsed with distilled water and slide allowed to dry. Each slide was examined microscopically, and malaria parasites positive cases were recorded. Individuals who tested positive to malaria parasites were later advised to seek medical treatment.

2.4 Determination of Hemoglobin/Anemia Status by Packed Cell Volume (PCV)

Due to the association of malaria and anemia, the study investigated Packed Cell volume (PCV) of subjects to determine their anemia status. Briefly, a micro-hematocrit tube was filled with blood and centrifuged in a micro-hematocrit rotor at 10,000 rpm for 5 minutes. PCV was read using the micro-hematocrit reader and the values recorded and classified as no anemia (for PCV value of 30%), mild anemia (25-29%), moderate anemia (20-24%), and severe anemia.

2.5 Inclusion Criteria

Pregnant women who are attendees of the selected health centers without symptom of malaria but tested positive to malaria parasite and gave their consent were included in the study.

2.6 Data Analysis

Data was analyzed using SPSS for windows version 25 for 2022, Chi square and student T text was be used to test level of significance. P value was set at < 0.05.

3. RESULTS

Asymptomatic malaria infection and its associated risk factors among pregnant women were studied in Enugu North Local government area of Enugu State. The results obtained are presented in Tables 1-7.

Table 1: Asymptomatic plasmodium infection among pregnant women attending antenatal in enugu north local government area: The prevalence of *Plasmodium* parasitemia among pregnant women attending antenatal in the three studied health centres – Pauly health centre, Asata health center, and New-haven health Centre is presented in Table 1. The overall prevalence of asymptomatic malaria parasitemia was 27.9 % (119). Paully general hospital, had the highest prevalence of 23.9% (47 asymptomatic pregnant mothers who were Plasmodium parasitemia positive) followed by New-haven health Centre, where 38 (31.4%) were positive. Asata health Centre had thirty-four (34) subjects representing 31.2% who were parasitemia positive. Comparatively, asymptomatic malaria infection was significantly more ($p<0.05$) in Pauly health centre with least infection in Asata health center.

Hemoglobin/anemia status of malaria parasitemia positive Pregnant Women Attending Antenatal consultation at various health centers in Enugu North: The packed cell volume values for malaria parasitemia positive pregnant women studied indicated that eight seven (87) subjects representing 73.1% of pregnant women examined for anemia came out normal with hemoglobin (Hb) level of ≥ 11.0g/dl, while twenty three (23) persons representing 19.3% had mild anemia with hemoglobin level of (10.0-10.9g/dl), nine (9) subjects representing 7.7% had a moderate anemia with Hb level of 7.0-9.9 (Table 2). However, there was no record of any severe anemia though there was a significant association ($p=0.001$) between asymptomatic *Plasmodium* infection and anemia in pregnant women attending antenatal consultation.

Sociodemographic details of respondents: The study had 440 research participants with 427 (97.1%) response rate while 13(2.9%) did not consent to participate in the study. The study participants' ages ranged from 20 to 40, with the former being the minimum and later the maximum respectively. Thirty-two participants (7.5%) were between the ages of 20 years while 29 % of them were between the ages of 21–25 years. Majority, 42.6% were between the ages of 26–30 years, while 16.6% were between the ages of 31-35 years and least number of participants (4.2%) were between the ages of

Table 1. Asymptomatic plasmodium infection among pregnant women according to health centres in Enugu North Local Government

		Plasmodium parasitemia	
Health centres	**Number examined**	**Positive (%)**	**Negative (%)**
Paully	197	47 (23.9)	150 (76.1)
Asata	109	34 (31.2)	75 (68.8)
New Haven	121	38 (31.4)	83 (68.6)
Total	427	119 (27.87)	308(72.13)

Table 2. Different degrees of anemia among asymptomatic pregnant women attending antenatal in Enugu North Local Government

Anaemia status Hb (g/dl)	**Frequency (N=119)**	**Prevalence (%)**
Non-anemic (≥11.0g/dl)	87	73.1
Mild (10.0-10.9g/dl)	23	19.3
Moderate (7.0-9.9)	9	7.7
Severe (<7g/dl)	0	0

Table 3. Sociodemographic characteristics of respondents who consented to the study in Enugu North Local Government Area

Variables (N=427)	**Frequency (N)**	**Percentage (%)**
Age in years		
20	32	7.5
21-25	124	29
26-30	182	42.6
31-35	71	16.6
36-40	18	4.2
Marital Status		
Single	16	3.7
Married	367	85.9
Divorce	41	9.6
widowed	3	0.7
Occupation		
Housewife	75	17.6
Civil servant	86	20.1
Trader	101	23.7
Entrepreneur	137	32.3
Others	27	27
No of Children		
1-3	320	74.9
4-7	83	19.4
8-11	24	5.6
Level of Education		
Primary	22	5.2
Secondary	207	48.5
Tertiary	192	45
None	6	1.4

36–40 years (Table 3). Three hundred and sixty-seven (85.9%) women were married, sixteen (3.7%) were single, forty-one (9.6%) were divorced while three (0.7%) were widowed. Less than two percent (1.4%) had no form of formal education, 5.2% had primary education while many women 207(48.5%) and 192(46.9%) attended Secondary and Tertiary institutions respectively. One hundred and thirty-two participants (32.3%) were Entrepreneurs, 101

(23.7%) were traders, 20.1% were civil servants, while about 6.3% of the participants were working in other areas. Concerning number of children about 75% of the women have had 1-3 children, while 19.4% and 5.6% of the women had 4-7 and 8-11 children respectively (Table 3).

Knowledge of malaria among pregnant women attending antenatal in Enugu North Local Government: The responses concerning the knowledge of malaria among pregnant women attending antenatal in Pauly general hospital, Asata health center and New-haven health Centre in Enugu North Local Government Area of Enugu State is presented in Table 4. Four hundred and twenty (98.4%) of the respondents have heard about malaria, while only 7 (1.6%) of them have not. Heard about Malaria, while about 98% of the respondents are aware that malaria is caused by mosquitoe bites while less than (3%) are not aware that malaria is caused by mosquitoes. Concerning prevention and cure of malaria, 408 (95.6%) and 412 (96.5%) of the respondents are aware that malaria can be prevented and cured while 19 (4.4%) and 15 (3.5%) of the respondents are not aware that malaria can be prevented and cured, Moreover, eighty-nine (89) participants representing 20.8% are not aware of how to prevent malaria while three hundred and thirty eight (338) representing (79.2%) respondents are aware of how to prevent malaria. Two hundred and thirty-one (231) respondents representing 54.1% have heard about ITN while one hundred and ninety-six (196) never heard about ITN. Two hundred and twenty (220) respondents representing 51.1% use ITN while two hundred and seven respondents representing 48.5% do not use insecticide treated net. Among the 400 participants that participated in the study, two hundred and seventy-seven (207) participants representing 64.7% use indoor residual spray (IRS) while one hundred and fifty (150) participants representing 35.1% do not use IRS.

Knowledge about Symptoms of Malaria Infection among asymptomatic Pregnant women attending antenatal consultation in Enugu North Local Government Area: The study assessed the subject's Knowledge about the symptoms of malaria infections. Three hundred and sixty-three (363) respondents representing 85% were aware that fever with shivering is a symptom of malaria infection while sixty-four (64) respondents representing 15% of the participants do not know (Table 5). Eight five per cent of the participants associated body pains as a symptom of malaria infection while 14.5% (62) were not agree. Ninety-eight persons (25%) agreed that fever with sweating were not symptoms of malaria while 80% (329) respondents agreed that fever with sweating are symptoms of malaria infection. Moreover, 80% (352) respondents affirmed that loss of appetite is a symptom of malaria infection while about 18% (75) of the respondents did not agree that loss of appetite is not a symptom of malaria infection.

The history of pregnancy among asymptomatic pregnant women attending antenatal consultation in Enugu North Local Government Area: One hundred and eight seven respondents representing about 44% were in their first pregnancy while 138 (32.3%) were in their second pregnancy. A total of 102 respondents (24%) have had more than two pregnancies. The participants gestational age varied among the study population. Those within first trimester were 190 representing 44.5% of the respondent while 162 (37.9%) were in their second trimester and 75 (17.5%) of respondents were in their third trimester. Concerning miscarriage, only thirty-one (31) respondents representing 7.4% said that they have had miscarriage during their pregnancy (Table 6).

Multivariate prevalence of asymptomatic Plasmodium infection in pregnant women in Enugu North Local Government Area: The multivariate prevalence that are associated with asymptomatic malaria are presented in Table 7. The study participants' ages ranged from 20 to 40, with the former being the minimum and later the maximum respectively. Out of the 32 participants between the ages of 20 years, 11 (34.4%) tested positive with Plasmodium while 21(64.5%) were negative, participants between the ages of 20-25 were about one hundred and twenty four(124), 32 (25.8%) were positive while 92(74.2%) tested negative, out of the 182 participants between the ages of 26-30 , about forty four (44) respondents representing (24.2%) tested positive while 138 respondents representing (75.8%) tested negative. Seventy-one (71) Respondents between the ages of 31-35 were examined showed that five (5) representing 7% were tested positive while sixty-six representing (92.9%) tested negative also out of the 18 respondents between the ages of 36-40 who were examined showed that

Table 4. Knowledge of malaria among pregnant women attending antenatal consultation in Enugu North Local Government

Variables (N=427)	Frequency (N)	Percentage (%)
Have you heard of malaria?		
No	7	1.6
Yes	420	98.4
Is malaria caused by mosquitoes?		
No	9	2.1
Yes	418	97.9
Can Malaria be Prevented?		
No	19	4.4
Yes	408	95.6
Can malaria be cured?		
No	15	3.5
Yes	412	96.5
Are you aware of how to prevent malaria?		
No	89	20.8
Yes	338	79.2
Do you have insecticide treated net?		
No	196	45.9
Yes	231	54.1
Do you use insecticide treated net?		
No	207	48.5
Yes	220	51.1
Do you use indoor residual spray?		
No	150	35.1
Yes	277	64.9

Table 5. Knowledge about symptoms of malaria infection among asymptomatic pregnant women attending antenatal consultation in Enugu North Local Government Area

Variables (N=427)	Frequency (N)	Percentage(%)
Fever with shivering		
No	64	15
Yes	363	85
Body pains		
No	62	14.5
Yes	365	85.5
Fever with sweating		
No	98	23
Yes	329	77
Loss of Appetite		
No	75	17.5
Yes	352	82.4

Table 6. History of Pregnancy among asymptomatic pregnant women attending antenatal consultation in Enugu North Local Government Area

Variables (N=427)	Frequency (N)	Percentage (%)
Gravidity		
First pregnancy	187	43.8
Second pregnancy	138	32.3
More	102	23.9

Variables (N=427)	Frequency (N)	Percentage (%)
Gestational age of the current pregnancy		
first trimester	190	44.5
Second trimester	162	37.9
Third trimester	75	17.6
Have you ever had miscarriage?		
No	395	92.5
Yes	31	7.4

4 respondents representing (24.2%) tested positive while fourteen (14) respondents representing (77.8%) tested negative. Concerning occupation of respondents, out of the seventy-five (75) housewives who participated thirty (30) representing (40%) tested positive while forty-five (45) representing 60% of the respondents tested negative, out of the 86 civil servants who participated, 21 representing (24.4%) tested positive while sixty-five (65) representing (76.5%) tested negative. Out of the one hundred and one (101) and one hundred and thirty-seven (137) Traders and Entrepreneurs who participated, twenty-seven (27) representing (26.7%) and 35 representing (25.5%) tested positive respectively while seventy four (74) representing (73.3%) and one hundred and two 102) representing (74.5%) tested positive respectively and other respondents who are not categorized were twenty eight (28), six (6) representing (22.2%) tested positive while twenty two (22) representing (78.5%) tested negative. Concerning Level of education, twenty-two (22) and two hundred and seven (207) respondents attended primary and secondary school out of which sixteen (16) and thirty-seven (37) representing (72.7%) and (17.9%) tested positive respectively while six (6) and one hundred and seventy (170) representing (27.3%) and (82.1%) respectively tested negative. Out of the one hundred and ninety-two (192) respondents who attended tertiary institution, twenty-three (23) representing (12%) tested positive while one hundred and sixty-nine (169) representing (88%) tested negative. Those that didn't attended any school were six (6), five (5) of the respondents representing (85.3%) tested positive while one (1) respondent representing (16.7%) tested negative. Concerning gravidity out of 187 respondents whom is their first pregnancy, thirty-seven (37) representing (17.1%) tested positive while one hundred and fifty five (155) representing 82.9% tested negative while out of one hundred and thirty eight (138) and one hundred and two (102) participants who were in their second and third pregnancy respectively, nineteen (19) and eight (8) respondents tested positive while one hundred and nineteen (119) representing (86.2%) and ninety four (94) representing (92.1%) respondents tested negative respectively. However, out of the 190 respondents attending antenatal in the various hospitals thirty-eight (38) representing (20%) tested positive while one hundred and fifty-two (152) representing (80%) tested negative. While those in their second trimester and third trimester who were 162 and 75 respondents respectively, twenty-three (23) and eight (8) tested positive while one hundred and thirty-nine (139) and sixty-seven (67) respondents tested negative respectively.

Table 7. Multivariate prevalence of asymptomatic Plasmodium infection in pregnant women in Enugu North Local Government Area

Variables		Plasmodium	infection (%)
	No Examined	**Positive**	**Negative**
Age			
20	32	11 (34.4)	21 (64.6)
21-25	124	32 (25.8)	92 (74.2)
26-30	182	44 (24.2)	138 (75.8)
31-35	71	5 (7.0)	66 (92.9)
36-40	18	4 (22.2)	14 (77.8)
Total	**427**	**96(26.5)**	**331(77.5)**
Occupation			
Housewives	75	30 (40)	45 (60)
Civil Ser.	86	21 (24.4)	65 (75.6)

Variables		Plasmodium	infection (%)
	No Examined	**Positive**	**Negative**
Traders	101	27 (26.7)	74 (73.3)
Entrepreneurs	137	35 (25.5)	102 (74.5)
Others	28	6 (22.2)	22 (78.5)
Total	**427**	**119 (27.9)**	**308 (72.1)**
Level of Edu.			
Primary	22	16 (72.7)	6 (27.3)
Secondary	207	37(17.9)	170 (82.1)
Tertiary	192	23 (12)	169(88)
None	6	5 (83.3)	1(16.7)
Total	**427**	**81(19)**	**346(81.1)**
Gravidity			
First pregnancy	187	32 (17.1)	155 (82.9)
Second pregnancy	138	19 (13.8)	119 (86.2)
Third pregnancy	102	8 (7.8)	94 (92.1)
Gestational age			
First trimester	190	38 (20)	152 (80)
Second trimester	162	23 (14.2)	139 (85.8)
Third trimester	75	8 (11)	67 (89.

4. DISCUSSION

Malaria has long been a global public health issue, and numerous efforts have been made to eradicate the disease [12]. Most malaria-endemic regions of the world, particularly Sub-Saharan Africa, are low-income countries with extreme poverty which have exacerbated the failure of malaria control initiatives and intervention implementation rates are persistently poor in these countries [60,58,7]. It is crucial to routinely test all pregnant women for asymptomatic P. falciparum infection since it is a significant cause of maternal and fetal morbidity and mortality, particularly in sub-Saharan Africa [66,12].

This study examined asymptomatic *Plasmodium* infection and its associated factors among pregnant women attending antenatal consultation in some selected health centers in Enugu North Local Government of Enugu State. The present study revealed an overall prevalence of 27.9% for asymptomatic *Plasmodium* parasitemia among pregnant women attending antenatal in selected hospitals in the studied area. This finding is in line with other studies conducted elsewhere [2,41,30]. However, the present finding is in contrast with some previous reports [26,8,25]. Increased prevalence observed in the current study could be attributed to certain factors evidence in the responses of studied subjects: There may be reduction in state malaria control efforts at the time of study which may have led to low (48.5%) use of insecticide treated nets (ITN) by the pregnant mothers. Effective use of ITNs prevents mosquito bite and possible transmission of *Plasmodium* parasites to new host. Also, only few (35.1%) of the pregnant mothers use indoor residual spray. ITN reduce human-mosquito contact, and aids in the prevention of malaria infections [27,28,33]. Absence of ITN and indoor residual spray allow endophagic mosquitoe population to build up inside rooms and increase bites and parasite transmission. The present study was conducted during a major Plasmodium transmission season (rainy) which could also contribute to high prevalence of API among pregnant women as was reported in this study. The study also showed that the prevalence of asymptomatic malaria among pregnant women was more among the younger women compared to their older counterparts. This is in line with previous finding that younger women are more vulnerable to malaria than older ones because they are still developing their natural immunity to malaria especially during pregnancy [10,62,22]. Young children with low immune systems and pregnant women with potentially compromised immune systems are particularly vulnerable to this disease and so are the highest risk populations for malaria-related deaths. Our result also showed that higher percentage of asymptomatic plasmodium was observed in single women compared to married women, collaborating other reports [34,36,50–52] who reported that single women were more likely to have an asymptomatic *P. falciparum* infection due to hormonal changes, emission of more carbon dioxide and body heat making them more attractive to mosquitoes that transmit *Plasmodium*.

According to the findings of the current study, knowledge about causative agent of malaria, it's transmission and preventive methods were associated ($p<0.05$) with *Plasmodium* parasitemia indicating the relevance of public health education in prevention and control of malaria. Previous research in Nigeria and other African nations has found that knowledge levels about malaria range from 36 to 91% [53–57]. Thus, the current study demonstrates an increase in awareness above earlier reports. In the Southwest zone of Nigeria, the awareness level was reported at between 92.3% in Ibadan, Oyo State [56,58].

Moreso, our study showed that *Plasmodium* infection was recorded more in the respondents that experienced pregnancy for the first time compared to those who have experienced pregnancy second or third time, there was a clear correlation between increasing gravidity and lower parasitemia rates. This agrees with reports of [59–63]. These might be linked to infection-specific immunological factors. Some Plasmodium-infected erythrocytes sequester in the placenta of the mother by secreting surface antigens [64], primarily variant surface antigen, which bind to chondroitin sulphate-A (CSA) receptors expressed by syncytiotrophoblasts, because they lack the anti-adhesion antibodies that emerge only after subsequent pregnancies [29,65,66]. primigravidae and secundigravidae are more vulnerable to infection Therefore, Primigravidae and secundigravidae are more vulnerable to infection because they lack the CSA-binding parasite anti-adhesion antibodies that emerge only after additional pregnancies [60,67,68]. Our study also showed that asymptomatic *Plasmodium* infection was more prevalent in pregnant women who are in their first trimester than those in second and third trimesters, collaborating the findings of [69], but in contrast with [70] that reported high prevalence of asymptomatic Plasmodium infection in women in their second and third trimester.

In addition, evidence from this study indicated statistical association between asymptomatic Plasmodium infection with anemia. Plasmodium infection has been reported to result in the destruction of both young and new red blood cells which can lead to anemia [18,29,29,64,65]. Higher parasite density had more effect on the packed cell volume with more severe degree of anemia. It is important to note that asymptomatic malaria parasitemia is one of the major causes of anemia in malaria hyper endemic environment. Apart from the reduced immunity, which is marked in the first pregnancy, the most important influence of the infestation on maternal health is caused by anemia [69,71]. A higher proportion of those with malarial parasitemia were anemic compared with those without malarial parasitemia. Denser malaria parasitemia lead to increased red blood cell haemolysis ultimately leading to anemia, which is usually normochromic and normocytic and accompany by reticulocytosis [29,30,64,65,40,42-49].

5. CONCLUSION

The study was conducted to investigate asymptomatic Plasmodium infection and its associated factors among pregnant women attending antenatal consultation in some selected hospitals in Enugu North. The study revealed 27.9% prevalence of Asymptomatic Plasmodium infection among pregnant women attending antenatal in selected hospitals in Enugu local government area. Plasmodium parasitemia was more in young pregnant women, pregnant women who experienced pregnancy for the first time and those in their first trimester. Knowledge about causative organism, method of transmission prevention and treatment, varied among the social status of the studied subjects. Education also influenced knowledge about malaria and its transmission/infection pattern. Additionally, our research revealed evidence that maternal anemia in expectant mothers may be worsened by asymptomatic Plasmodium infections. Therefore, it is recommended that; more awareness on the use of Insecticide treated net and regular visit for consultation. Molecular studies should be conducted to identify the Plasmodium species, State government through their health commissions should conduct adequate screening and treatment plan developed for pregnant women.

CONSENT

Personalized information regarding the study was provided to each subject. Before the questionnaire was administered, official consent was obtained in writing or by thumbprint. The subjects were anticipated to either grant or not grant consent after given a standardized introduction to the study as it was described in the questionnaire. The subjects were given information, including the purpose of the study and the projected time needed to complete the questionnaire (15 minutes), in a low-level English language to help them understand it.

ETHICAL APPROVAL

Ethical approval for this study was obtained from the Research Department, Enugu State Ministry of Health.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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