Submicroscopic Malaria Infections During Pregnancy: Impacts on Maternal Haematological Parameters and Adverse Foetal Outcomes in Rural Nigeria

Amuche Patience Ugwu-Chiefuna

Ambrose Alli Univeristy, Nigeria

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ABSTRACT

Malaria during pregnancy remains a significant public health challenge in Nigeria, particularly in rural areas where access to quality healthcare services, including advanced diagnostic facilities, is limited. Traditional diagnostic methods such as microscopy and rapid diagnostic tests are commonly used; however, they do not always detect submicroscopic malaria infections, leading to an underestimation of the true disease burden. This study presents a literature review of the prevalence of submicroscopic malaria infections, their impact on maternal haematological parameters, and their relationship with adverse foetal outcomes in rural areas of Nigeria and similar resource-limited settings.

A narrative review design with a systematic search strategy was employed. Relevant studies published between 2005 and 2025 were retrieved from PubMed, Scopus, Web of Science, Google Scholar, and African Journals Online. Data were extracted, synthesised, and organised under the themes of prevalence, maternal haematological outcomes, and foetal health outcomes.

The review indicated that submicroscopic malaria infections account for a significant proportion of malaria cases during pregnancy. The prevalence of these infections was found to be associated with the diagnostic method used, the intensity of malaria transmission, and the extent of coverage of malaria preventive interventions. The association between submicroscopic infections and maternal anaemia, low haemoglobin levels, and reduced packed cell volume was consistently reported. Furthermore, these infections were linked to adverse foetal outcomes, including low birth weight, preterm delivery, and intrauterine growth restriction (IUGR). These risks were further exacerbated by inadequate diagnostic facilities and limited coverage of preventive services in rural areas.

The study concludes that submicroscopic malaria infections are a clinically significant yet often overlooked contributor to maternal and neonatal morbidity in rural Nigeria. Strengthening diagnostic capacity, improving preventive interventions, and enhancing antenatal care services are essential to reducing their impact on maternal and child health outcomes.

Keywords: Submicroscopic malaria, pregnancy, maternal anaemia, foetal outcomes, rural Nigeria, placental malaria.

INTRODUCTION

Malaria during pregnancy remains one of the most significant public health challenges in sub-Saharan Africa and is a major cause of maternal and perinatal morbidity and mortality. Malaria infection during pregnancy induces various physiological changes that are primarily attributed to the presence of *Plasmodium falciparum* in the placenta. Sequestration mediated by VAR2CSA on infected erythrocytes causes inflammation, placental dysfunction, and maternal and foetal complications (Minwuyelet et al., 2025). Malaria is a major preventable

cause of adverse pregnancy outcomes, and even in areas with moderate transmission, pregnant women remain particularly vulnerable to its effects.

Nigeria bears one of the highest malaria burdens globally. The country accounts for approximately 26–27% of all malaria cases and a substantial proportion of malaria-related deaths worldwide. In recent years, malaria has remained highly prevalent among pregnant women and continues to be an important cause of maternal mortality in the country. Reported prevalence rates among pregnant women range from 7% to over 60%, depending on the diagnostic method used and the intensity of local transmission. This burden is disproportionately higher in rural areas, where access to healthcare is limited, coverage of insecticide-treated nets (ITNs) is low, and uptake of intermittent preventive treatment in pregnancy (IPTp) remains inadequate. These conditions contribute to increased transmission, maternal anaemia, and adverse birth outcomes (Severe Malaria Observatory, n.d.; World Health Organization, 2025).

In recent years, growing attention has been directed towards submicroscopic malaria infections. These infections are characterised by parasite densities that are undetectable by conventional microscopy or rapid diagnostic tests but can be identified using more sensitive molecular techniques such as polymerase chain reaction (PCR). Submicroscopic infections have been reported as a major component of pregnancy-associated malaria in many endemic regions. Van Eijk et al. (2023), in a systematic review and meta-analysis, reported a prevalence of 13.5% for submicroscopic infections, which accounted for approximately 59% of all PCR-positive infections in Africa, compared with 8.0% for microscopic infections. Similarly, Ibekpobaoku et al. (2024) identified submicroscopic *P. falciparum* infections among pregnant women in Nigeria using RT-PCR, demonstrating that standard diagnostic methods often fail to detect these infections. Although these low-density infections may be asymptomatic, they can sustain transmission and exert significant clinical effects through placental sequestration (Adebusuyi et al., 2024).

Pregnant women are particularly susceptible to malaria because of physiological and immunological changes that occur during pregnancy. The maternal immune system undergoes modulation to facilitate foetal tolerance, resulting in reduced cell-mediated immunity and a diminished ability to clear malaria parasites. Primigravidae and secundigravidae are especially vulnerable because they lack parity-specific immunity against placental-binding parasites. Additional factors such as poverty, malnutrition, and co-infections, including HIV, further increase susceptibility among women in rural Nigerian communities. These conditions contribute to persistent infections that may be less effectively controlled than in non-pregnant adults (Oranuka et al., 2024).

Both microscopic and submicroscopic malaria infections during pregnancy are associated with significant haematological complications. Maternal anaemia is a common consequence resulting from malaria-induced haemolysis, splenic sequestration, and bone marrow suppression. In sub-Saharan Africa, placental malaria has been strongly associated with an increased risk of maternal anaemia. Malaria parasitaemia has consistently been linked to lower haemoglobin levels and reduced packed cell volume during the third trimester of pregnancy in Nigeria. Beyond increasing the risk of maternal mortality, anaemia contributes to fatigue, reduced work capacity, and postpartum haemorrhage. These haematological changes are often accompanied by chronic low-grade infection, a frequently overlooked component of the inflammatory response (Cottrell et al., 2015; Gilder et al., 2025).

Evidence suggests that malaria during pregnancy is associated with adverse birth outcomes, including low birth weight (LBW), preterm delivery, small-for-gestational-age births, stillbirth, and increased neonatal mortality. Placental malaria impairs the transfer of nutrients and oxygen to the foetus, resulting in intrauterine growth restriction. Oranuka et al. (2024) reported a prevalence of 42.4% for placental malaria among primigravidae in Bauchi and found a significant association with lower mean birth weight (2.8 kg versus 3.2 kg among uninfected women; $p = 0.001$). Meta-analyses have further confirmed that malaria during pregnancy increases the risk of LBW and preterm delivery. Although submicroscopic infections have also been linked to these outcomes, the strength of the association may vary depending on study context and preventive strategies. In rural Nigeria, where diagnostic limitations remain widespread, undetected submicroscopic infections may contribute substantially to these adverse outcomes (Satapathy et al., 2024; van Eijk et al., 2023).

Although malaria control interventions have advanced considerably, including the use of insecticide-treated nets (ITNs) and IPTp with sulfadoxine-pyrimethamine, coverage remains inadequate in many rural regions of Nigeria. This highlights the need to consolidate existing knowledge on submicroscopic infections to support the development of more sensitive diagnostic approaches and targeted interventions. Such knowledge is essential for improving maternal and child health outcomes in high-burden rural settings by enhancing understanding of the interplay between submicroscopic infections, maternal haematological parameters, and adverse foetal outcomes.

Statement of the Problem

Despite significant advances in malaria control and treatment, submicroscopic malaria infections during pregnancy remain a silent threat to maternal and foetal health in rural Nigeria. These low-density infections often go undiagnosed when conventional diagnostic methods such as microscopy and rapid diagnostic tests are used, yet they can result in placental sequestration, maternal anaemia, and poor perinatal outcomes. The burden of submicroscopic malaria remains poorly understood in rural areas where access to molecular diagnostic tools such as polymerase chain reaction (PCR) is extremely limited. This diagnostic gap contributes to underestimation of infection prevalence, delayed or inadequate interventions, and the persistence of high rates of anaemia, low birth weight, and preterm delivery. Furthermore, the lack of synthesised evidence on the haematological and foetal effects of submicroscopic infections in rural Nigerian communities makes it difficult to develop targeted strategies for improving case detection and management.

Purpose of the Study

This study aimed to summarise available evidence on the prevalence of submicroscopic malaria infections during pregnancy, their effects on maternal haematological parameters, and their association with adverse foetal outcomes among rural populations in Nigeria and other resource-limited settings.

Research Questions

The following research questions guided the study:

1. How prevalent are submicroscopic malaria infections among pregnant women in rural Nigeria and similar resource-limited settings, and what are their epidemiological characteristics?

2. What impact do submicroscopic malaria infections have on the haematological parameters of pregnant women?

3. What adverse foetal outcomes are associated with submicroscopic malaria infections during pregnancy?

LITERATURE REVIEW

Submicroscopic malaria infections during pregnancy represent an under-recognised yet important aspect of malaria epidemiology in endemic regions and are particularly prevalent in rural Nigeria. These infections involve *Plasmodium* parasites that cannot be detected using conventional microscopy or rapid diagnostic tests but can be identified through molecular techniques such as PCR. Despite their low parasite density, they can have substantial effects on maternal and foetal health (van Eijk et al., 2023). In many sub-Saharan African settings, submicroscopic infections constitute a significant proportion of the total malaria burden during pregnancy. Van Eijk et al. (2023), in a systematic review and meta-analysis, reported a prevalence of 13.5% for submicroscopic infections during pregnancy compared with 8.0% for microscopic infections. Furthermore, submicroscopic infections accounted for approximately 59% of all PCR-detected malaria infections in Africa.

Adebusuyi et al. (2024) investigated malaria prevalence among asymptomatic pregnant women in southwestern Nigeria and reported positivity rates of 8.9% using rapid diagnostic tests, 21% using microscopy, and 32%

using nested PCR. These findings indicate that a substantial proportion of infections remain undetected by conventional diagnostic methods. Similarly, Ibekpobaoku et al. (2024) identified submicroscopic *Plasmodium falciparum* infections among pregnant women using RT-PCR and reported a prevalence of 3.3%, alongside the presence of multiple drug-resistant alleles that may complicate treatment. These findings support broader evidence suggesting that parasites expressing the VAR2CSA antigen may sequester within the placenta while remaining undetectable in peripheral circulation, thereby causing chronic low-grade inflammation (van Eijk et al., 2023; Ibekpobaoku et al., 2024).

The effects of submicroscopic malaria on maternal haematological parameters are of particular concern. Anaemia is already prevalent in resource-limited settings and is further exacerbated by malaria-induced haemolysis, dyserythropoiesis, and splenic sequestration of red blood cells. Studies have reported lower mean haemoglobin levels and an increased risk of anaemia among pregnant women with submicroscopic *P. falciparum* infections, particularly among primigravidae (Cottrell et al., 2015). Placental malaria has also been associated with a higher risk of maternal anaemia (Alemayehu et al., 2025). This relationship has been consistently observed in Nigeria, where malaria parasitaemia is associated with lower haemoglobin levels and reduced packed cell volume, especially during the later stages of pregnancy. Even in the absence of clinical symptoms, submicroscopic infections may worsen these haematological conditions through chronic low-grade inflammation and nutrient depletion (Adebusuyi et al., 2024).

Malaria-induced adverse foetal outcomes are closely associated with placental infection. Placental parasitisation interferes with the transfer of nutrients and oxygen to the foetus, leading to intrauterine growth restriction, low birth weight, preterm birth, and increased neonatal mortality. Oranuka et al. (2024) reported that 38.4% of primigravidae in Bauchi, northern Nigeria, had placental malaria, and this condition was strongly associated with lower mean birth weight (2.8 kg versus 3.2 kg among women without placental malaria; $p = 0.001$). Although the study focused on histopathologically confirmed cases, evidence from meta-analyses suggests that even submicroscopic infections increase the risk of low birth weight and preterm delivery (Satapathy et al., 2024; Gilder et al., 2025). In rural Nigeria, where malaria transmission remains high, these undetected infections may contribute substantially to adverse perinatal outcomes.

The burden of submicroscopic malaria during pregnancy is further intensified by healthcare challenges in rural Nigeria. Many rural communities experience low utilisation of antenatal care services, inadequate supply of intermittent preventive treatment in pregnancy (IPTp) with sulfadoxine-pyrimethamine (SP), and poor coverage of insecticide-treated nets (ITNs). Geographical barriers, transportation costs, poverty, and inadequate healthcare staffing often limit timely screening and intervention (Ogba et al., 2022; Muhammad et al., 2021). In addition, poor awareness, stock-outs of preventive medications, and cultural beliefs continue to undermine malaria prevention efforts. A major challenge is the lack of diagnostic infrastructure, as molecular techniques such as PCR are rarely available outside research settings. Consequently, submicroscopic infections frequently remain undetected and untreated, exposing pregnant women to prolonged infection and increasing the risk of haematological deterioration and adverse foetal outcomes.

Furthermore, inadequate training of healthcare providers on malaria-in-pregnancy guidelines and weak referral systems contribute to suboptimal case management. The risk is particularly high among primigravidae and women with limited formal education in rural northern and southwestern Nigeria due to lower uptake of preventive measures and delayed antenatal booking. Collectively, these factors sustain malaria transmission and hinder effective control efforts. Given the contribution of submicroscopic infections to the overall malaria burden and their frequent omission from routine diagnostics, the integration of more sensitive diagnostic tools and community-based interventions is essential (Adeojo et al., 2024).

The literature underscores the need to move beyond traditional diagnostic approaches and adopt a more comprehensive strategy for understanding and addressing submicroscopic malaria infections in rural Nigeria. Although considerable progress has been made in understanding microscopic malaria, the haematological and foetal consequences of subpatent parasitaemia, combined with persistent weaknesses in rural healthcare systems, require focused research and programmatic interventions. Addressing these gaps is crucial to reducing the hidden burden of malaria on maternal and child health outcomes.

Theoretical Framework

This study is anchored on two theoretical perspectives: the Maternal-Foetal Health Framework and the Disease Burden Theory. These frameworks provide a robust basis for understanding the complex interactions between submicroscopic malaria infections, maternal haematological changes, and adverse foetal outcomes in rural Nigerian settings.

The Maternal-Foetal Health Framework emphasises the intricate biological and physiological relationship between the mother and the foetus during pregnancy. The framework posits that maternal health status directly influences foetal growth and development through mechanisms such as placental function, nutrient transfer, and immunomodulation. It further explains how *Plasmodium falciparum* can sequester within the intervillous spaces of the placenta through VAR2CSA-mediated adhesion, resulting in placental inflammation and impaired oxygen and nutrient transfer despite the absence of detectable peripheral parasitaemia (Minwuyelet et al., 2025). This placental pathology contributes to maternal haematological disturbances, including anaemia resulting from haemolysis and bone marrow suppression, while simultaneously impairing foetal growth and development.

The framework also highlights the increased vulnerability of primigravidae, who lack parity-specific immunity against placental malaria parasites. This absence of immunity increases their susceptibility to chronic, low-density infections that often remain undetected by conventional diagnostic methods. In rural Nigeria, where access to sensitive molecular diagnostic tools is limited, submicroscopic infections may continue to cause silent maternal morbidity and adverse perinatal outcomes despite the absence of obvious clinical symptoms.

In addition, the Maternal-Foetal Health Framework incorporates socio-ecological factors that influence maternal and foetal health outcomes. It recognises that delayed antenatal care attendance, inadequate access to intermittent preventive treatment during pregnancy, and poverty increase the risk of adverse maternal and foetal outcomes. The framework advocates interventions that address the health of the mother and child as an interconnected unit rather than as separate individuals. Such an approach supports the implementation of more sensitive diagnostic and preventive measures aimed at breaking the cycle of infection and adverse pregnancy outcomes (World Health Organization, 2025).

The Disease Burden Theory complements the Maternal-Foetal Health Framework by providing a broader public health perspective on the impact of disease at the individual, community, and societal levels. Originating from the Global Burden of Disease (GBD) studies, the theory employs indicators such as disability-adjusted life years (DALYs), years lived with disability (YLDs), and years of life lost (YLLs) to quantify disease burden. Applied to malaria in pregnancy, the theory suggests that submicroscopic infections contribute substantially to the overall disease burden despite often remaining undetected. The consequences of these infections, including chronic maternal anaemia, postpartum haemorrhage, and long-term developmental challenges in children, impose significant economic and social costs on resource-limited rural communities (Murray et al., 2012; World Health Organization, 2025).

Furthermore, the Disease Burden Theory accounts for the cumulative effects of co-existing vulnerabilities in rural Nigeria, such as malnutrition, co-infections, and weak healthcare systems. These factors amplify the impact of submicroscopic malaria infections and contribute to sustained malaria transmission. Because such infections frequently go undetected by routine surveillance systems, they remain an obstacle to achieving malaria elimination targets at both national and global levels. The theory links submicroscopic infections to measurable health outcomes and population-level deficits, thereby providing a useful framework for guiding policy development, resource allocation, and public health interventions.

This narrative review is informed by the integration of the Maternal-Foetal Health Framework and the Disease Burden Theory. While the Maternal-Foetal Health Framework explains the biological pathways through which submicroscopic parasitaemia affects maternal haematological status and foetal development, the Disease Burden Theory provides insights into the broader epidemiological, socioeconomic, and public health implications of these infections in rural Nigeria. Together, these frameworks underscore the need to address diagnostic gaps and strengthen antenatal healthcare services to reduce the burden of submicroscopic malaria on maternal and child health.

METHODOLOGY

Research Design

This study adopted a narrative review design supported by a systematic search strategy to examine available evidence on the current status of submicroscopic malaria infections during pregnancy, their effects on maternal haematological parameters, and their association with adverse pregnancy outcomes in rural Nigeria. Given the limited availability of primary data and the need to synthesise findings from previously published studies conducted in similar low-resource settings, a narrative review approach was considered appropriate. This design facilitated an in-depth examination and interpretation of the existing scientific literature on the burden, clinical consequences, and public health implications of submicroscopic malaria infections during pregnancy.

Search Strategy

A comprehensive search was conducted across electronic databases, including PubMed, Google Scholar, Scopus, Web of Science, and African Journals Online (AJOL). The search incorporated combinations of keywords and Medical Subject Headings (MeSH) terms such as “submicroscopic malaria,” “pregnancy,” “maternal anaemia,” “haematological parameters,” “foetal outcomes,” “placental malaria,” “low birth weight,” “preterm birth,” “Nigeria,” and “rural areas.” Relevant studies published between 2005 and 2025 were identified. Boolean operators were used to refine and expand the search as appropriate. Additional studies were identified through manual searches of the reference lists of selected articles and relevant review papers.

Inclusion and Exclusion Criteria

The review included studies that focused on malaria during pregnancy and utilised molecular diagnostic techniques, particularly polymerase chain reaction (PCR), to identify submicroscopic malaria infections. Eligible studies also examined maternal haematological parameters and/or adverse foetal outcomes and were conducted in Nigeria, sub-Saharan Africa, or similar resource-limited settings. Only peer-reviewed journal articles, conference papers, and institutional reports published in English were considered.

Studies were excluded if they lacked sufficient methodological information, were not relevant to pregnancy-related outcomes, were duplicate publications, or focused exclusively on microscopic malaria infections without assessing submicroscopic infections.

Study Selection Process

The study selection process was conducted in several stages. Initially, titles and abstracts of retrieved articles were screened to determine their relevance to the objectives of the review. Studies considered potentially relevant were subsequently subjected to full-text assessment to determine their eligibility based on the inclusion criteria. Duplicate studies were removed during the screening process, and only studies directly relevant to the subject matter were included in the final synthesis.

Data Extraction

A structured data extraction process was employed to ensure consistency in the collection and organisation of information from the selected studies. Data extracted included authors’ names, year of publication, study setting, study design, sample characteristics, diagnostic methods used, maternal haematological parameters assessed, and reported foetal outcomes associated with submicroscopic parasitaemia. This approach facilitated systematic comparison and interpretation of findings across studies.

Data Synthesis and Analysis

A thematic narrative synthesis approach was used to analyse the data obtained from the selected studies. The major themes identified from the literature included the prevalence of submicroscopic malaria infections, maternal haematological changes, adverse pregnancy and foetal outcomes, and healthcare challenges in rural

Nigeria. Similarities, differences, and recurring patterns across studies were critically examined and interpreted in relation to the objectives of the review. The synthesis also highlighted existing knowledge gaps and identified areas requiring further research and intervention.

Ethical Considerations

Ethical approval was not required for this study because it was based exclusively on secondary data obtained from previously published scholarly literature and publicly accessible sources. Nevertheless, all sources of information used in the review were appropriately cited and acknowledged to ensure academic integrity and avoid plagiarism.

RESULTS

This narrative review synthesised peer-reviewed studies published between 2005 and 2025 on submicroscopic malaria infections during pregnancy, with a particular focus on Nigeria and other sub-Saharan African settings. Following systematic screening of relevant databases, eligible studies were included in the review. The studies comprised various research designs, including cross-sectional, cohort, and case-control studies, most of which were conducted in hospital-based or community settings. Nigerian studies covered both urban and rural populations, while evidence from other African countries provided comparative insights relevant to rural, resource-limited settings. Most studies employed polymerase chain reaction (PCR) as the gold standard for detecting submicroscopic infections, alongside conventional microscopy and rapid diagnostic tests (RDTs).

Prevalence of Submicroscopic Malaria

Submicroscopic malaria infection emerged as a significant but often overlooked component of the malaria burden during pregnancy. In their systematic review and meta-analysis, van Eijk et al. (2023) reported a prevalence of 13.5% for submicroscopic infections in endemic regions, compared with 8.0% for microscopic infections. The study further showed that submicroscopic infections accounted for approximately 59% of all PCR-positive malaria infections in Africa.

In Nigeria, Adebusuyi et al. (2024) reported substantial differences in diagnostic yield among asymptomatic pregnant women in southwestern Nigeria, with nested PCR identifying significantly more infections than microscopy or RDTs. Similarly, Ibekpobaoku et al. (2024) used RT-PCR to detect submicroscopic *Plasmodium falciparum* infections and reported a prevalence of approximately 3.3%, underscoring the importance of more sensitive diagnostic methods. Across rural and semi-urban settings, prevalence rates varied according to transmission intensity, seasonal factors, and the extent to which preventive interventions such as IPTp were consistently utilised.

Maternal Haematological Findings

The studies reviewed consistently demonstrated an association between submicroscopic malaria infections and adverse maternal haematological outcomes, particularly anaemia. Even in the absence of fever or high parasite density, Cottrell et al. (2015) reported that submicroscopic *P. falciparum* infections were associated with lower mean haemoglobin levels and an increased risk of maternal anaemia. These effects were attributed to chronic low-grade haemolysis, inflammation, and suppression of bone marrow activity.

In Nigeria, malaria parasitaemia has been consistently associated with reduced packed cell volume (PCV) and haemoglobin levels, particularly during the third trimester of pregnancy. Alemayehu et al. (2025), in a meta-analysis, reported that placental malaria was associated with an increased risk of maternal anaemia (OR = 2.18, 95% CI: 1.73–2.63). Submicroscopic infections contribute to this burden through prolonged placental sequestration and nutrient depletion, thereby exacerbating existing vulnerabilities in rural communities where malnutrition and inadequate antenatal care are common.

Reported Foetal Outcomes

Both microscopic and submicroscopic malaria infections were found to be strongly associated with adverse

foetal outcomes. A study conducted in Bauchi, northern Nigeria, reported a placental malaria prevalence of 38.4% among primigravidae and found a significant association with lower mean birth weight (2.8 ± 0.5 kg versus 3.2 ± 0.4 kg; p = 0.001) (Oranuka et al., 2024). The study also established a significant relationship between placental malaria and low birth weight, while identifying IPTp uptake as an independent protective factor.

Similarly, other meta-analyses reported increased risks of preterm birth, small-for-gestational-age births, and stillbirth among women with malaria infections during pregnancy. Gilder et al. (2025) further observed that early detection of submicroscopic malaria was associated with reduced foetal growth parameters during pregnancy. These findings suggest that undetected submicroscopic infections may contribute substantially to intrauterine growth restriction in rural Nigerian populations through chronic inflammation and impaired placental function.

Major Trends and Patterns

Several recurring trends emerged from the literature reviewed. First, the prevalence of submicroscopic malaria infections consistently exceeded that of microscopic infections when sensitive molecular diagnostic methods were employed, highlighting a significant gap in routine antenatal malaria diagnosis. Second, the absence of parity-specific immunity made primigravidae and younger women more susceptible to infection. Third, women residing in rural communities were found to be at greater risk due to inadequate coverage of intermittent preventive treatment in pregnancy (IPTp), low utilisation of insecticide-treated nets (ITNs), and delayed antenatal care attendance.

Fourth, the severity of haematological effects and adverse foetal outcomes was associated with the persistence of infection and placental involvement, even when parasite densities remained below the detection threshold of conventional diagnostic methods. Finally, *Plasmodium falciparum* remained the predominant malaria species identified, and some Nigerian studies reported the presence of drug-resistance alleles, further complicating disease management.

These trends suggest that greater attention and targeted interventions are required to address the burden of submicroscopic malaria infections in rural Nigerian communities.

Overall, the evidence indicates that submicroscopic malaria infection is a silent but clinically significant contributor to poor maternal haematological outcomes and adverse foetal health outcomes. The findings underscore the need for the adoption of more sensitive molecular diagnostic approaches and strengthened preventive measures to effectively address these challenges.

DISCUSSION

The findings of this narrative review highlight the significant yet largely under-recognised impact of submicroscopic malaria infections on maternal and foetal health in rural Nigeria. Consistent with global evidence, submicroscopic infections represent a hidden reservoir of malaria that frequently remains undiagnosed, thereby contributing to ongoing transmission and adverse pregnancy outcomes (van Eijk et al., 2023). These low-density infections exacerbate existing vulnerabilities in rural communities where healthcare infrastructure and access to diagnostic services remain limited. The findings align with the Maternal-Foetal Health Framework and the Disease Burden Theory, both of which explain how placental sequestration of *Plasmodium falciparum*, even at subpatent levels, can negatively affect maternal haematological status and foetal development.

The review consistently demonstrated a strong association between submicroscopic malaria infections and maternal anaemia. This relationship is mediated through chronic haemolysis, inflammatory cytokine activity, and impaired erythropoiesis, all of which contribute to reductions in haemoglobin concentration and packed cell volume (Cottrell et al., 2015; Alemayehu et al., 2025). These haematological effects are particularly concerning in rural Nigeria, where nutritional deficiencies and delayed antenatal care are common. Consequently, affected women face an increased risk of fatigue, postpartum haemorrhage, and maternal

mortality. These findings are consistent with evidence from other parts of sub-Saharan Africa, where placental malaria has been identified as a major risk factor for maternal anaemia. The burden of submicroscopic infections is particularly challenging because they often remain undetected during routine antenatal care and may not present with obvious clinical symptoms.

About foetal outcomes, the synthesis revealed a consistent association between submicroscopic malaria infections and adverse outcomes such as low birth weight, preterm delivery, and intrauterine growth restriction. Placental inflammation and impaired nutrient transfer caused by parasite sequestration have been shown to directly affect foetal growth and development. This relationship was evident in the Bauchi study, where significant reductions in birth weight were observed among women with placental malaria (Oranuka et al., 2024). Similar findings have been reported for submicroscopic infections, supporting previous evidence that even low-density malaria infections can contribute to adverse perinatal outcomes (Gilder et al., 2025; Satapathy et al., 2024). Diagnostic limitations in rural settings further exacerbate the problem, as many infections remain undetected and untreated, thereby contributing to neonatal morbidity, mortality, and long-term health disparities.

These challenges are further compounded by deficiencies within rural healthcare systems. Low uptake of IPTp, inadequate coverage of insecticide-treated nets, long distances to healthcare facilities, and frequent shortages of essential medicines create favourable conditions for the persistence of submicroscopic infections (Ogba et al., 2022). Such systemic barriers reduce the effectiveness of existing malaria control strategies and emphasise the need for context-specific interventions. The review also identified patterns such as increased susceptibility among primigravidae and the presence of drug-resistant parasite alleles in some Nigerian populations (Ibekpobaoku et al., 2024). Collectively, these findings suggest that reliance on microscopy and rapid diagnostic tests alone is insufficient for effective malaria case management in high-transmission rural settings.

CONCLUSION

Submicroscopic malaria infections during pregnancy represent a significant public health challenge in rural Nigeria. Although these infections often remain undetected by conventional diagnostic methods, they contribute substantially to maternal anaemia and adverse foetal outcomes, including low birth weight, preterm delivery, and intrauterine growth restriction. The Maternal-Foetal Health Framework and Disease Burden Theory provide valuable perspectives for understanding the biological and public health implications of these infections. Addressing this hidden burden is essential for reducing maternal and perinatal morbidity and mortality in resource-limited settings.

RECOMMENDATIONS

Based on the findings of this review, several recommendations are proposed. First, more sensitive diagnostic tools such as polymerase chain reaction (PCR) and loop-mediated isothermal amplification (LAMP) should be introduced into antenatal care services, particularly in selected sentinel sites within rural Nigeria. Second, community-based strategies and targeted health education campaigns should be strengthened to improve the uptake of intermittent preventive treatment in pregnancy (IPTp) among vulnerable populations.

Third, future research should employ longitudinal study designs to monitor submicroscopic malaria infections throughout pregnancy and assess their effects on maternal haematological parameters and birth outcomes across different trimesters. Fourth, policies should be strengthened to improve the training of frontline healthcare workers on malaria-in-pregnancy management guidelines and to enhance referral systems. Finally, multisectoral collaboration involving nutrition programmes, poverty alleviation initiatives, and maternal health interventions is required to address the broader determinants of vulnerability and improve maternal and child health outcomes.

LIMITATIONS

This study has several limitations. Although a systematic search strategy was employed, relevant grey literature and studies published in languages other than English may not have been captured. In addition, the diversity of

study designs, diagnostic methods, and outcome measures among the included studies limited the possibility of direct quantitative comparisons. Furthermore, the limited availability of high-quality, large-scale studies focusing specifically on rural Nigerian populations with PCR-confirmed submicroscopic infections constrained the depth of the synthesis. Despite these limitations, the review provides valuable insights into the burden and implications of submicroscopic malaria infections during pregnancy and offers a foundation for future empirical research.

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