Malaria Vaccine Implementation in Nigeria: Feasibility and Awareness

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Abstract
Malaria remains a major public health challenge in Nigeria, particularly among children under five and pregnant women. Despite existing control measures, malaria transmission persists due to drug and insecticide resistance, weak healthcare systems, and socioeconomic challenges. The introduction of malaria vaccines, particularly RTS, S/AS01 and R21/Matrix-M, offers a significant opportunity to strengthen malaria prevention and control. This paper examines the development of malaria vaccines, their effectiveness, and their integration with existing interventions such as insecticide-treated nets, indoor residual spraying, and antimalarial drugs. It also highlights challenges to vaccine implementation in Nigeria, including inadequate funding, poor infrastructure, cold-chain limitations, vaccine hesitancy, and public awareness. The paper emphasizes the need for government support, sustainable financing, community engagement, and effective immunisation programmes. It concludes that malaria vaccines, when combined with existing control strategies, can significantly reduce malaria infections, illness, and deaths in Nigeria.

1.0 Introduction

Malaria is caused by protozoan parasites of the genus *Plasmodium* and is primarily transmitted through the bite of infected female *Anopheles* mosquitoes. Transmission can also occur through contaminated blood products (transfusion malaria) or congenitally. Symptoms typically develop 7–10 days after infection and vary in severity depending on the *Plasmodium* species and host immunity. The disease may present as asymptomatic, uncomplicated, or severe. Early manifestations include low-grade fever, chills, muscle aches, and gastrointestinal discomfort in children. These symptoms may escalate into high fever, profuse sweating, fatigue, and in severe cases, life-threatening complications such as severe anaemia, multi-organ dysfunction, and cerebral malaria. Globally, malaria remained a major public health concern in 2024. An estimated 282 million malaria cases were recorded across 80 malaria-endemic countries, including French Guiana. This represented an increase of approximately 9 million cases (3%) compared with 2023. Ethiopia, Madagascar and Yemen accounted for about 58% of the global increase in malaria cases during this period (World Health Organization [WHO], 2025).

The global malaria situation has changed considerably over the years. Between 2000 and 2015, the number of malaria cases across countries that were endemic in 2000 declined slightly from about 239 million to 230 million. However, since 2015, malaria cases have increased by approximately 22.6%. The largest proportion of this increase occurred in the WHO African Region (88%), while the WHO Eastern Mediterranean Region accounted for 12%. Population growth partly contributed to the increase, while other factors, including armed conflicts, extreme climate events and disruptions to health services, also affected malaria control efforts. Improved surveillance and increased detection of cases may have further contributed to the rise in reported cases (WHO, 2025). In 2024, five countries accounted for almost half of all malaria cases worldwide. Nigeria contributed 24.3%, followed by the Democratic Republic of the Congo (12.5%), Uganda (4.7%), Ethiopia (4.4%) and Mozambique (3.6%). This demonstrates the particularly high burden of malaria in sub-Saharan Africa, with Nigeria accounting for the largest proportion of global cases (WHO, 2025). Malaria incidence also changed over this period. Between 2000 and 2015, the global incidence rate declined by 25.6%, from 79.4 to 59.0 cases per 1,000 population at risk. However, between 2015 and 2024, incidence increased by 8.5%, reaching 64.0 cases per 1,000 population at risk in 2024, compared with 62.7 in 2023. The largest increases in incidence between 2023 and 2024 were recorded in Rwanda, Yemen, Madagascar and Ethiopia (WHO, 2025). The impact of malaria was also evident in mortality. In 2024, an estimated 610,000 malaria-related deaths occurred globally, representing an increase of approximately 12,000 deaths compared with 2023. Madagascar, Ethiopia and Yemen accounted for about 85% of this increase (WHO, 2025). These figures show that, despite significant progress in malaria prevention and control, malaria continues to be an important global health challenge, particularly in the WHO African Region.

2.0 Literature Review

History of malaria vaccine development

There has been tremendous advancement in malaria control since the formulation of artemisinin-based combination therapy (ACT). However, the primary obstacle to the global eradication of malaria is the widespread clinical resistance to artemisinin and its derivatives. Vaccination remains one of the most effective strategies for eliminating infectious diseases. Nevertheless, constant polymorphisms in the biology of *Plasmodium* species have made it challenging to identify the most suitable vaccine candidate among the thousands of *Plasmodium* antigens. Therefore, the development of a malaria vaccine remains crucial, as there is currently no fully licensed malaria vaccine available. Etefia E *et al*., (2023) Malaria remains one of the most persistent and deadly mosquito-borne diseases affecting humans, caused by parasites of the *Plasmodium* genus. Nearly half of the global populationparticularly those living in tropical and subtropical regions remains at risk of infection. According to the latest WHO estimates, malaria cases climbed to 247 million in 2021, with approximately 619,000 deaths reported. This resurgence has been largely attributed to disruptions in control, diagnosis, and prevention efforts during the COVID-19 pandemic.

Five *Plasmodium* species are known to infect humans: *P. falciparum*, *P. vivax*, *P. ovale*, *P. malariae*, and *P. knowlesi*—the latter being a zoonotic strain primarily found in Southeast Asia that can jump from non-human primates to humans. Among these, *P. falciparum* is responsible for the most severe and fatal cases. In 2021 alone, it accounted for 95% of recorded infections and 96% of malaria-related deaths, with 80% of fatalities occurring in African children under the age of five. Tsoumani, M *et al.,* (2023)

Despite its devastating impact, considerable progress has been made through strategies combining vector control, improved diagnostics, and widespread access to effective treatments. However, malaria transmission remains challenging to eliminate due to the parasite's complex life cycle, which alternates between human hosts and *Anopheles* mosquitoes. Following a mosquito bite, injected sporozoites travel to the liver and develop into merozoites, which later invade red blood cells and progress through ring, trophozoite, and schizont stages. The cycle continues as newly released merozoites infect additional erythrocytes. Tsoumani, M. E., *et al.*, (2023)

The WHO Global Technical Strategy for Malaria (2016–2030) targets a 90% reduction in both malaria incidence and mortality. Achieving this goal requires innovative and sustainable preventive measures. Vaccination is considered a cornerstone of long-term control efforts, yet the development of an effective malaria vaccine has been hindered by the parasite's biological complexity and the sophisticated immune response required for protection. Tsoumani, M. E., *et al*., (2023) Nonetheless, recent scientific advances and the emergence of novel vaccine platforms especially mRNA-based technologies—have renewed optimism. This review provides an updated overview of current progress in malaria vaccine development, highlighting historical approaches, present challenges, and future opportunities in the transition from traditional vaccine strategies to next-generation molecular technologies.

Prevalence of Malaria in Nigeria

According to *Awosolu et al*., (2021), malaria is transmitted throughout the year in Nigeria, with over 194 million individuals at risk of infection. This persistent burden has contributed significantly to poverty due to recurring expenses on treatment, control, and prevention. Additionally, valuable time that should be spent at work or school is frequently lost to illness, further worsening socioeconomic conditions in both rural and urban communities.

Multiple determinants contribute to malaria transmission in Nigeria and can be classified into demographic, environmental, climatic, and socioeconomic factors. Demographic influences include age and gender, while environmental factors involve the presence of bushes, forests, or stagnant water that create breeding grounds for mosquitoes. Climatic elements such as temperature, humidity, and rainfall further support the rapid development of malaria vectors. Socioeconomic variables—including education level, occupation, and income also play a critical role by shaping patterns of exposure and treatment-seeking behaviour. These risk factors have been extensively documented, particularly in rural and peri-urban areas.

Comparative studies have revealed higher malaria prevalence in rural areas compared to urban locations. However, despite improved infrastructure and healthcare access, malaria remains prevalent in many urban settings. The specific drivers of transmission in these environments, however, are not yet fully understood. Govoetchan *et al*., (2022)

To align with the World Health Organisation's Global Technical Strategy for Malaria, which aims to reduce malaria incidence by 90% between 2016 and 2030, there is a growing need for detailed epidemiological data to inform effective control strategies, particularly in urban areas.

Chemoprevention of Malaria

Seasonal Malaria Chemoprevention (SMC) was adopted as a national malaria control strategy in Nigeria by the Federal Ministry of Health in early 2014 Ogbulafor *et al*., (2023). Prior to nationwide rollout, pilot programmes were implemented in Katsina State in 2013 and 2014 and in Kano State in 2014. These pilots demonstrated that SMC could achieve high coverage, operate safely, and remain affordable. Following these successes, the intervention was expanded to Sokoto

and Zamfara States between 2015 and 2016 and subsequently scaled up across the country. By 2021, SMC was being implemented in 18 states, with plans to extend coverage to all 21 eligible states in 2022, targeting approximately 27.1 million children.

SMC involves the monthly administration of sulfadoxine pyrimethamine and amodiaquine to children aged three to fifty-nine months during peak malaria transmission periods, usually between June and October. Community drug distributors administer the first dose, while caregivers provide the remaining doses at home over two days. Each treatment cycle offers about one month of protection. During the 2021 campaign, approximately 143,000 community drug distributors delivered SMC to an estimated 23.1 million eligible children across four or five monthly cycles, depending on state-specific transmission patterns Ogbulafor *et al*., (2023).

Evidence from pilot and scale-up phases confirms that SMC is both effective and cost efficient. In Katsina State, more than 80 percent of eligible children received at least one dose, no serious adverse drug reactions were reported, and the cost per child remained below four United States dollars. A multi-country evaluation conducted in 2015 and 2016 reported substantial reductions in malaria cases presenting at health facilities and in malaria related hospital deaths, while drug resistant parasite genotypes remained uncommon despite some selection pressure for resistance to sulfadoxine pyrimethamine. In Nigeria, a case control study in Zamfara State reported a protective efficacy of 83 percent within 28 days of treatment, and routine health facility data showed reductions in malaria incidence of approximately 25 percent during transmission seasons Ogbulafor *et al*., (2023). Despite high initial uptake, completion of all treatment cycles has remained inconsistent in some settings. Surveys conducted between 2015 and 2017 revealed gaps in full dose completion and socio-economic inequalities in coverage, particularly in Sokoto State. However, improved delivery strategies and revised sampling approaches resulted in consistently high coverage levels in surveys conducted between 2019 and 2021 Ogbulafor *et al*., (2023). Community engagement has been identified as a key determinant of programme success. Although community attitudes toward SMC have generally been positive, qualitative research conducted after the 2021 campaign highlighted the need for structured mechanisms to capture community perspectives and address barriers to uptake. At the global level, the World Health Organization formally recommended SMC in 2012 for areas with highly seasonal malaria transmission in the Sahel region. Meta-analyses of randomised and quasi-experimental studies have shown a protective efficacy of approximately 74 percent against clinical malaria in children under five. However, evaluating effectiveness under routine programme conditions remains essential. Analyses using national household survey data demonstrated significantly lower odds of malaria infection among children living in SMC areas in both Burkina Faso and Nigeria, reinforcing the population-level impact of the intervention, da Cola *et al*., (2022). These findings emphasise the importance of accounting for SMC in national malaria burden estimates to avoid underestimating its contribution to malaria control and elimination efforts.

Case Management

Despite significant progress in global malaria control over the last two decades, malaria remains one of the leading causes of illness and death among children under the age of five, who account for nearly two-thirds of the global malaria burden. Recent data further indicate that progress in malaria control is slowing in the countries with the highest burden. Nigeria, which contributes approximately 25% of global malaria morbidity, records an estimated 50 million cases and 100,000 deaths annually, with malaria responsible for around 60% of outpatient hospital visits. The most vulnerable population group is under-five children, who experience an average of two to four

episodes per year and account for as much as 90% of national malaria mortality. Consequently, up to 36% of all under-five deaths in Nigeria are attributable to malaria. (*Dasgupta et al., 2022)*
While prompt and effective treatment yields good clinical outcomes in young children, untreated, delayed, or ineffective care often leads to severe disease and life-threatening complications. Nigeria's high under-five malaria mortality is largely linked to a health financing system that leaves many individuals uninsured, resulting in high out-of-pocket (OOP) medical expenditure that discourages timely care-seeking, particularly among poor households. Nigeria has one of the lowest rates of care-seeking for suspected childhood malaria globally, with fewer than one in five febrile under-fives being brought to health facilities for diagnosis and parasitological testing.
Even when treatment is sought, the most effective antimalarial regimens remain financially inaccessible to most Nigerians. Artemisinin-based combination therapy (ACT), the World Health Organization's first-line recommendation for uncomplicated malaria, achieves approximately 98% adequate parasitological and clinical response but is up to twenty times more expensive than less effective monotherapies such as chloroquine or sulfadoxine-pyrimethamine. Due to the high financial burden, ACT is used in only about 40% of malaria cases among under-five children, with utilisation rates particularly low among the poorest households, who use ACT at roughly half the rate of their wealthier counterparts. Evidence from several sub-Saharan African countries has demonstrated that appropriate malaria diagnosis and treatment are cost-effective interventions for case management in under-fives. However, as highlighted by (*Dasgupta et al*., 2022), there remain substantial gaps in understanding not only the cost-effectiveness of these interventions within Nigeria but also how equitably their benefits would be distributed across socioeconomic groups. Addressing this evidence gap is essential, particularly in a country where under-five mortality among the poorest households is nearly three times higher than among the richest, making child health inequity one of Nigeria's most pressing public health priorities.

Aims and Objectives for Vaccine introduction in Nigeria

Malaria remains one of the most significant global public health challenges, disproportionately affecting sub-Saharan Africa, where children under five and pregnant women are particularly vulnerable. Nigeria bears approximately 26.8% of the global malaria burden, with 76% of its population at risk of infection annually (Okereke et al., 2025). Despite sustained efforts through control initiatives such as insecticide-treated nets (ITNs), indoor residual spraying (IRS), and intermittent preventive treatment in pregnancy (IPTp), malaria remains endemic in Nigeria (Okereke et al., 2025). The disease not only contributes to high mortality and morbidity rates but also imposes a considerable economic burden on the country's already strained healthcare system Okereke *et al*., (2025). To address this persistent challenge, Nigeria approved the R21/Matrix-M malaria vaccine on 17 April 2023, becoming the second country in the world to do so after Ghana Okereke *et al.,* (2025). Developed by the University of Oxford and manufactured by the Serum Institute of India (SII), the R21 vaccine has demonstrated over 75% efficacy in children aged 5 to 36 months, marking a major breakthrough in malaria prevention Okereke *et al*., (2025) Unlike its predecessor, the RTS, S vaccine, which faces production and funding limitations, the R21 formulation is deemed more scalable for nationwide rollout Okereke *et al*., (2025). However, despite this promising advancement, several challenges may hinder successful implementation in Nigeria, including logistical barriers, vaccine hesitancy, financial constraints, and infrastructural limitations. This narrative review aims to explore the anticipated challenges in implementing the R21 malaria vaccine in Nigeria while proposing evidence-based strategies to address them. By identifying critical obstacles such as weak vaccine logistics, cold chain limitations, healthcare

workforce shortages, and widespread misinformation, the review seeks to inform policymakers, healthcare professionals, and non-governmental organizations (NGOs) on practical measures to enhance vaccine uptake Ultimately, addressing these constraints will be crucial to ensuring that malaria vaccination is effectively integrated into Nigeria's immunization program and contributes to the nation's long-term malaria elimination goals.

According to Okereke *et al.*, (2025), the development of an effective malaria vaccine has remained a major global health priority for several decades. This effort has resulted in the approval of two important malaria vaccines, RTS, S/AS01 and the more recently developed R21/Matrix-M. The R21/Matrix-M vaccine, developed by the University of Oxford in collaboration with the Serum Institute of India, has shown promising efficacy in clinical trials, with protection exceeding 75% under seasonal transmission conditions. This performance is above the World Health Organization's recommended efficacy benchmark for malaria vaccines.

Nigeria became the second country, after Ghana, to approve the R21/Matrix-M vaccine in April 2023, representing an important development in the country's efforts to strengthen malaria prevention and control. The vaccine is designed to stimulate the immune system by promoting the recruitment of antigen-presenting cells and enhancing antigen presentation in the lymph nodes. It contains a parasite-derived circumsporozoite protein linked to a hepatitis B virus surface antigen carrier protein, together with the Matrix-M adjuvant, which enhances the immune response.

The vaccine is primarily intended for children aged 5–36 months, who are among the groups most vulnerable to severe malaria. The recommended vaccination schedule consists of three primary doses, followed by a booster dose approximately 12 months later. By combining high efficacy with a dosing schedule that can be incorporated into existing childhood immunization programmes, R21/Matrix-M has considerable potential to strengthen malaria prevention efforts in Nigeria and other malaria-endemic countries.

Despite its potential to strengthen malaria prevention, the widespread adoption of the R21/Matrix-M vaccine in Nigeria may be affected by several challenges. One major concern is vaccine hesitancy, which can be influenced by previous experiences with vaccination programmes, including those for COVID-19 and polio. Concerns about possible adverse effects, mistrust of health interventions, and doubts about vaccine safety may discourage some individuals from accepting the malaria vaccine. In addition, misinformation, misconceptions, religious beliefs, and conspiracy theories may further affect public perception and willingness to vaccinate. Addressing these concerns will require sustained public education and sensitization through culturally appropriate communication channels and trusted community, religious, and healthcare leaders. Financial and logistical constraints may also pose challenges to the effective implementation and long-term sustainability of the R21 vaccination programme in Nigeria.

Public awareness and Perception of Malaria Vaccines

According to Aremu T, O *et al*., (2023) Malaria remains one of the most significant infectious diseases affecting public health, particularly across sub-Saharan Africa. It is caused by *Plasmodium* parasites transmitted to humans through the bites of infected female *Anopheles* mosquitoes. Reports from the World Health Organization (WHO) indicate that in 2020, malaria was responsible for approximately 627,000 deaths globally, with the sub-Saharan African region accounting for about 96 percent of these fatalities.

In an effort to enhance malaria control, the RTS, S/AS01 malaria vaccine was approved by the WHO in October 2021 following successful phase III efficacy trials conducted in seven sub-Saharan African countries. The four-dose vaccine regimen demonstrated an efficacy rate of 25.9

percent among children aged six to twelve weeks, and 36.3 percent among those aged five to seventeen months. The first three doses are administered intramuscularly between five and nine months of age, while the fourth dose is recommended at fifteen to eighteen months. During the pilot program in Ghana, the vaccine was found to prevent about four out of every ten malaria cases and three out of every ten severe malaria cases. In anticipation of wider distribution and administration of the malaria vaccine across sub-Saharan Africa, a cross-sectional study was conducted to assess public awareness of the vaccine in selected countries, including Uganda, Ghana, and Nigeria. Malaria remains a major public health challenge in Uganda, Ghana, and Nigeria, with each country experiencing high endemicity and implementing multiple control strategies to reduce transmission, morbidity, and mortality. In Uganda, malaria affects approximately ninety five percent of the country and exposes nearly thirty-three million people, with the World Health Organization estimating that the country accounted for about three-point five percent of global malaria deaths in twenty twenty-one. Since twenty fourteen, Uganda has relied on long lasting insecticide treated bed nets, indoor residual spraying combined with larval source management, and improved access to effective antimalarial drug therapy, following an earlier policy shift in two thousand four from chloroquine and sulfadoxine pyrimethamine to artemisinin based combination therapy due to rising treatment failures, although emerging evidence of Plasmodium falciparum resistance to artemisinin in Africa has underscored the need for additional strategies such as vaccination. In Ghana, malaria occurs year-round with seasonal peaks varying by region, and in twenty the country accounted for approximately two-point one percent of global malaria cases and one-point nine percent of malaria related deaths. National control efforts began with the Roll Back Malaria initiative in nineteen ninety nine, which informed the first National Malaria Strategic Plan aimed at reducing morbidity and mortality, followed by the introduction of artemisinin based combination therapy for uncomplicated malaria, sulfadoxine pyrimethamine for prevention in pregnancy, and indoor residual spraying, leading to substantial progress toward the goal of reducing malaria burden by seventy five percent by twenty through strengthened prevention, diagnosis, treatment, and monitoring systems. Ghana also became one of the first African countries to pilot the RTS, S AS01 malaria vaccine in twenty nineteen, targeting children under two years of age in selected high transmission regions with strong immunization coverage. Nigeria bears the highest global malaria burden, accounting for about twenty six point eight percent of cases in Africa and nearly thirty two percent of malaria deaths in twenty twenty, with children under five years representing approximately eighty percent of these deaths, and the disease continues to impose significant economic strain on households and the national health system. In response to rising drug resistance and treatment costs, Nigeria adopted the World Health Organization recommendation of parasitological confirmation before treatment through a test before treat policy, although uptake has remained low, with diagnostic testing among febrile children under five reaching only fourteen percent by twenty seventeen, alongside continued use of long lasting insecticide treated nets, intermittent preventive treatment in pregnancy, indoor residual spraying, environmental hygiene, and increasing public awareness of malaria vaccination, supported by recent progress toward local vaccine manufacturing capacity through World Health Organization backed technological support.

3.0 Conclusion

Malaria remains one of the most persistent public health challenges in Nigeria, accounting for a disproportionate share of global malaria cases and deaths, particularly among children under five and pregnant women. Despite decades of investment in vector control, chemoprevention, and

antimalarial drug therapy, the disease continues to exert a heavy health and economic burden on the country. The limitations of existing control measures, including insecticide resistance in mosquito vectors, emerging resistance to antimalarial drugs, weak healthcare infrastructure, and inequitable access to effective treatment, underscore the urgent need for complementary and sustainable interventions. In this context, malaria vaccination represents a significant and timely advancement in Nigeria's malaria control strategy.

4.0 Recommendation

To maximize the impact of malaria vaccines in Nigeria, a coordinated and evidence-based approach is required that strengthens existing malaria control efforts while addressing systemic barriers to vaccine implementation. First, malaria vaccines should be fully integrated into Nigeria's routine immunisation programme rather than implemented as stand-alone interventions. This integration will improve coverage, reduce operational costs, and ensure sustainability. Vaccination schedules should be aligned with existing child health services and, where appropriate, adapted to seasonal transmission patterns to enhance effectiveness, particularly in high-burden regions.

Second, government commitment to sustainable financing must be strengthened. While donor support from global partners remains essential, Nigeria should increase domestic funding for malaria vaccination to reduce dependency and ensure long-term programme stability. Budgetary allocations should prioritize vaccine procurement, cold-chain infrastructure, logistics, and healthcare worker training. Innovative financing mechanisms and public private partnerships may also help bridge funding gaps and support large-scale vaccine deployment.

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