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Bridging the gap to malaria vaccination in Africa: Challenges and opportunities

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ABSTRACT

The current state of malaria is devastating owing to the continual dominance of P. falciparum in the African region. Despite progress, the burden remains high, with the African continent contributing significantly to global malaria deaths. The introduction of malaria vaccines, such as RTS,S/AS01 and R21/Matrix-M™, brings hope to the continent, but challenges persist in achieving widespread coverage. Financial constraints, fragmented supply chains, logistical challenges, and vaccine hesitancy are key obstacles. The complex interplay of social, cultural, biological, political, and educational factors further complicates the fight against malaria. To bridge the vaccination gap, a multifaceted approach involving healthcare facilities, governments, non-profit organisations, and global agencies is expedient. It emphasises the importance of community engagement, collaboration with cultural and religious leaders, and leveraging mass media for awareness campaigns tailored to diverse African cultures. Specific recommendations include improving healthcare infrastructure, enhancing access to qualified healthcare providers, creating effective transportation management systems, and implementing comprehensive inventory management policies. Governments are urged to prioritise multistakeholder collaboration, strengthen technical working groups, expedite bureaucratic processes, and invest in multidisciplinary research to identify and address obstacles to malaria vaccination. It calls for cooperative efforts, better data utilisation, improved diagnostics, and comprehensive interventions to reduce the prevalence of malaria and improve public health in Africa. By emphasising the significance of education, knowledge, targeted awareness campaigns, and strategic communication in the malaria vaccine rollout, we can bridge the gaps in malaria vaccination in Africa.

1. Introduction

Malaria continues to be a major public health concern in Africa, ranking among the top 10 causes of premature mortality and drawing attention throughout the world [1,2]. People who are exposed to the harsh realities of malaria while growing up in endemic areas of Africa experience severe illness, hospitalisations, or the loss of friends and relatives [1]. In more severe cases, the illness can cause cerebral malaria, acute renal injury, pulmonary edema, lactic acidosis, hypoglycemia, liver impairment, and severe anaemia (2). 99.7% of the malaria cases that the World Health Organisation (WHO) assessed to have occurred in the African region in 2018 were caused by *Plasmodium falciparum*. It accounted for 50% of malaria cases in the Eastern Mediterranean, 65% in the Western Pacific, and 50% in the WHO's South-East Asia region, while in 2019, 94% of malaria deaths and cases occurred in the region [3,4]. Almost 619,000 deaths globally in 2021 were attributed to malaria, with children under five accounting for about 80% of these cases, with a loss of over 750 lives daily, which is an incredibly tragic rate of death [5]. In 2022, global malaria burden remained high, with 249 million recorded cases and 608,000 casualties. A stunning 76% of these deaths were children below the age of five, demonstrating the devastation on innocent lives. The WHO African Region took on the greatest proportion of this burden, accounting for 94% of all malaria cases and 95% of deaths globally in 2022 [6,7]. It was significant given that children under the age of five accounted for 78% of all malaria-related deaths in the region. Notably, Nigeria, the Democratic Republic of the Congo, Uganda, and Mozambique made major contributions, accounting for slightly over fifty percent of the global malaria death rate [6]. Africa took the brunt of this burden, with an estimated 96% of all deaths, which could be preventable [8].

An infection with malaria carries a higher risk of consequences for children and the elderly. Among the problems that pregnant women with malaria may face are low birth weight (LBW) babies, miscarriages, premature births, and reduced foetal growth (intrauterine growth restriction, or IUGR) [9]. Vaccinations are effective in the fight against the development and spread of antibiotic resistance (AMR). They aid in the reduction of susceptible and drug-resistant infections, which in turn lessens the need for pharmacological therapies and the selective pressure that promotes resistance [10,11]. Thus, significant health and financial consequences are avoided. The complexity of the parasite's life cycle makes the development of a vaccine to fight malaria difficult. In addition, although there was support from the WHO, RTS,S/AS01 to develop the vaccines, it took almost thirty years to receive regulatory approval and initiate pilot implementation studies [8,12]. The discovery of this vaccine is expedient in providing tactical insights into strategies for combating malaria and hastening the creation of easy access to effective vaccines, both of which are essential for lowering the illness's burden and thwarting the spread of antibiotic resistance. The implementation of new vaccinations is filled with both opportunities and obstacles, and the malaria vaccine could certainly not be an exemption. In order to ramp up the malaria vaccination campaign on the African continent, there is a pressing need to recognise components that may promote or act as bottlenecks to the roll-up [13]. The aim of this study is to comprehensively assess the challenges and direct efforts to bridge the

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gap in malaria vaccination in order to lessen the terrible impacts of this disease in Africa and worldwide.

1.1. The current state of malaria vaccination in Africa

In the twenty-first century, efforts to eradicate vector-borne diseases, especially malaria, represent a critical public health problem. Despite tremendous progress in preventing malaria, there is still a gap in its eradication implementation, which is made worse by problems such as medicine and pesticide resistance and weakened public health sectors [14]. The WHO has set lofty goals, including a 90% reduction in worldwide incidence and mortality rates by 2030 and the eradication of malaria in endemic nations. African countries have put into practice a variety of techniques, including preventative chemotherapy, vector control, and case management [15]. The long-awaited malaria vaccine, which has the potential to save countless lives, particularly those of children and pregnant women, is a crucial development in this battle. Even though African communities have quickly accepted the vaccination and expressed a strong desire for the immunization, it is still imperative to provide universal access [16]. The first malaria vaccine, RTS,S/AS01, has been approved by the WHO after fruitful test programmes in Malawi, Kenya, and Ghana [17]. The RTS, S/AS01 malaria vaccine has sparked tremendous community interest and has successfully reached a large number of children in a short time. Other African countries, such as Cameroon, Liberia, Burundi, Niger, Burkina Faso, Sierra Leone, Benin, the Democratic Republic of the Congo (DRC), and Uganda, have also been allocated funds to implement the vaccine [18]. The second vaccination against malaria licensed by the WHO, the R21/Matrix-M™ vaccine, demonstrated considerable efficacy and safety in a Phase III clinical study comprising 4800 children from Tanzania, Kenya, Burkina Faso, and Mali. The vaccine demonstrated 75% efficacy in areas with strong seasonal malaria transmission and 68% efficacy in areas with greater perennial transmission. The vaccine also increased antibody titres among participants aged 5 to 17 months, with the younger age group showing the most promising outcomes. These findings point to the vaccine's potential for major impact, particularly among the younger population [17,19]. The R21/Matrix-M™ vaccine is now available in Nigeria as well. By April 2024, a statewide deployment of Nigeria's comprehensive vaccination programme is anticipated, with the goal of improving vaccine security, independence, and accessibility. These initiatives highlight the increasing fervor and dedication to eliminating malaria in Africa and other regions [16,20].

1.2. Challenges to malaria vaccination in Africa

Vaccines against malaria encounter several and persistent obstacles in Africa. Firstly, malaria has a huge financial cost for Africa, creating a vicious cycle of illness and deprivation in lower-middle-class and low-income African nations. Their ability to fund and maintain crucial intervention programmes, such as research and the acquisition of necessary supplies for the control of malaria, such as insecticide-treated nets and diagnostic tools, is hampered by a lack of finances [21]. These financial constraints are further exacerbated by fragmented supply chains, thus making vaccines unavailable among people living in precarious conditions [22,23]. This difference in socioeconomic status and geography affects access to diagnostics and medical care, coupled with uncaring hospital staff, poor patient-staff communication, and the impact of sociocultural traditions and religious affiliations that oppose vaccination [23,24]. Although lower socioeconomic groups are primarily affected by malaria, the disease persists because these vulnerable people frequently lack access to appropriate treatments and early diagnosis [25,26]. The high frequency of similar symptoms is attributed to the lack of easily accessible healthcare practitioners and medical examinations, as well as the misdiagnosis of illnesses resembling malaria [27,28]. Additionally, patients with illnesses such as sickle cell anaemia may experience life-threatening consequences from malaria. The issue of human resources in the healthcare sector is particularly significant due to the subpar compensation and benefits provided. As a result, health professionals often choose to leave the field in search of better opportunities [29,30]. Rates of illiteracy combined with the financial strains caused by malaria imprisoned communities result in cycles of poverty and illiteracy that eventually impede access to education and healthcare. Although healthcare costs, wasted income, and public sector investments are commonly used to quantify the economic costs of malaria, they do not take into consideration the longer-term, and more comprehensive effects on economic growth. The complexity and necessity of combating malaria in Africa are highlighted by these interrelated difficulties [4,29]. It is imperative to address vaccine hesitancy, which is fueled by false information and misconceptions [30]. Obstacles in African communities include mistrust of vaccines, conspiracy beliefs, and worries about side effects, while the transportation and storage of vaccines present logistics challenges [31,32]. It is crucial to keep the cold chain system operating consistently within the required temperature range; however, in some places, inadequate infrastructure and power supply interruptions could compromise the safety of vaccines [33,34]. Follow-up on administration, the lack of funds for vaccine acquisition in some African nations, and the removal of financial backing from private institutions are among the obstacles that malaria vaccinations face in Africa. Furthermore, the demand to protect millions of African children is not met by the restricted supply of GlaxoSmithKline's (GSK) four-dose Mosquirix vaccine, as GSK can only manufacture around 15 million doses per year until 2028 [35,36].

Malaria in Africa is a complex issue with interwoven social, cultural, biological, political, and educational aspects. The disease's burden disproportionately affects the poorest people, exposing glaring health disparities and emphasising the importance of tailored interventions [37]. Cultural factors, such as traditional beliefs and behaviours, have an impact on the effectiveness of malaria prevention efforts. Biological factors show that insufficient shelter and malnutrition in disadvantaged areas generate environments susceptible to malaria transmission. Political factors contribute to economic barriers and inequities in healthcare quality, prompting policy changes to provide equitable access to care. Educational disparities exacerbate the problem, with limited access impeding health information transmission [38,39]. Malaria has a strong link to poverty, as indicated by reduced incomes and delayed economic growth, which is especially prominent in Africa. The economic impact is severe, with malaria-infested regions overlapping with impoverished areas, resulting in significantly reduced purchasing-power parity GDP per capita in impacted countries. A detailed study of 150 countries from 1965 to 1990 found that countries with severe malaria experienced lower income growth than non-malarial nations [40]. The association persists even after accounting for geographical, historical, and policy-related variables, highlighting malaria's independent impact on poverty. The study emphasises the importance of focused treatments that address both the medical and financial implications of malaria in afflicted regions around the world [41]. Malaria has a major economic impact, accounting for 5% and 47% of the Mozambican average yearly income in mild and severe cases, respectively. Household costs, particularly in mild cases, are significant, accounting for 10% to 21% of monthly expenditure for Zambézian households [41–43].

1.3. Bridging the gap

To improve malaria vaccine availability in Africa, comprehensive interventions and creative solutions are needed to strengthen health systems [44]. Addressing factors like poor accessibility, provider compliance, patient adherence, cultural factors, governance, and supply chain constraints is crucial. This includes enhancing access to qualified healthcare providers and ensuring the quality and timeliness of care [44,45]. Robust infrastructure and a steady supply of safe pharmaceuticals and vaccinations should be provided, as well as addressing inequities and enhancing education, prevention, and treatment among Africa's

most marginalised groups [46]. Stakeholders in Africa must work together to create effective transportation management systems and information networks that enhance inter-tier communication for more efficient data flow. It should place a strong emphasis on the creation of comprehensive inventory management policies that clearly define roles and duties and involve active government engagement [4,46]. Proactive leadership is necessary, as it is an improved system of epidemiological surveillance throughout Africa. Improving the monitoring, case record-keeping, and preparation of the national healthcare network is expedient [47]. It is anticipated that the malaria burden will drastically decline if significant progress is made in lowering the illiteracy rates in Africa. It will need a thorough and well-coordinated effort to reduce the malaria burden in Africa, particularly using vaccinations [48]. Collaboration with different stakeholders, such as foreign donors, local and global non-governmental organisations, and health authorities, is necessary to create a shared goal and agenda that is in line with the population's welfare. This highlights the necessity of coordination and alignment of efforts in the battle against malaria [49].

Key recommendations to eradicate malaria in Africa encompass a multifaceted approach involving healthcare facilities, government, non-profit organizations, and global agencies. To increase malaria vaccination coverage in Africa, healthcare facilities should follow revised WHO guidance and deliver the appropriate dosages of malaria vaccinations [50]. To address malaria immunisation disparities, healthcare facilities should look into alternative delivery strategies for the most impacted communities by collaborating with cultural and religious leaders, community leaders, market women, student associations and schools to raise the public's understanding and embrace of revolutionary malaria vaccinations through mass and social media channels and launch awareness efforts customised to varied African cultures in order to secure widespread malaria vaccination adoption [17]. The community-based administration of malaria vaccine is a promising technique that has been shown to be beneficial in pilot projects in Senegal, Madagascar, Burkina Faso, Sierra Leone, the Democratic Republic of the Congo, Nigeria, Malawi and Mozambique [50]. Addressing financial obstacles and creating plans for fair distribution and access are essential if Africa is to close the vaccination gap. Financial obstacles have historically impeded efforts to prevent malaria, such as the introduction of the RTS,S/AS01 vaccine, which, despite its efficiency, has not been widely used because of a lack of financing for distribution and purchase [51,52]. Continued investment, innovation, and scaled-up implementation, aided by financial support from global organisations such as the President's Malaria Initiative and the Global Fund, will help to close the gap and prevent malaria in vulnerable populations. Governments, non-profit organisations, and global agencies must collaborate to address financing gaps in malaria research and development (R&D). They should work together to increase coordination across intervention areas, with an emphasis on collaboration among product developers to ensure the seamless integration of next-generation treatments. Given the lack of a high-income market in endemic locations, innovative funding strategies are required. There is also a demand for ongoing monitoring of financial flows, stronger data systems, and the closing of data gaps to ensure the proper adoption and optimisation of new approaches. These proposals emphasise the need for ongoing efforts and collaboration among stakeholders to close gaps in malaria research and development while also addressing broader concerns affecting diseases in low- and middle-income countries [53].

Governments should prioritise multistakeholder collaboration and work with expert advisory organisations such as National Immunization Technical Advisory Groups (NITAG). They should form and strengthen technical working groups to conduct rigorous vaccination assessments, focusing on evidence-based decision-making. Additionally, governments should expedite bureaucratic processes to facilitate timely policy integration and address the region's unique malaria concerns [54]. Africa should use multidisciplinary approach to identify obstacles, formulate plans, and encourage widespread adoption and the removal of bottlenecks in the roll-out of public health interventions in order to enhance malaria vaccination campaigns [55]. In low-transmission environments, better diagnostics are essential to address validity concerns and gene deletions. In addition to new diagnostic tools, health systems should invest in case management frameworks and malaria prevention resources [44,56]. Data quality and surveillance-response skills need to be enhanced for malaria vaccinations in Africa to be more effective [57]. By resolving problems with data quality, utilising DHIS2 software, and adding clinical data from commercial clinics, in-country surveillance responses can be improved [58]. At the national and district levels, data-driven decision-making based on malaria surveillance ought to be a fundamental intervention. Gaining knowledge from effective advertisements and incorporating qualitative datasets might yield insightful results. Increasing the ability to use data is essential for the successful control of malaria and bridging the vaccination gap in Africa [58,59]. Investing in trained practitioners and leaders is critical to improving malaria vaccines on the continent [60]. African nations should take charge of their malaria programmes, address capacity constraints in the fields of social sciences, genomics, and data sciences, and increase training from primary to tertiary levels, improving the development of interventions and evaluating the effects of socioeconomic variables [44,59,60].

2. Conclusion

This study emphasizes the impact of education, knowledge, targeted awareness campaigns, supportive interventions and strategic communication in translating knowledge and providing insights for targeted interventions in malaria-endemic regions and prevention practices in Africa. These findings, combined with other considerations, can help policymakers and practitioners make well-informed decisions about malaria vaccine delivery to vulnerable groups and high-endemic areas. The study emphasises the significance of implementation research and programme assessment for these strategies and supportive interventions in specific scenarios in order to ensure a long-term impact beyond trial circumstances. Building capacity, providing funding, and implementing comprehensive interventions are all necessary to address the complex issues surrounding the distribution of malaria vaccines in Africa. Reducing the prevalence of malaria and improving public health in the region require cooperative efforts, better data utilisation, and improved diagnostics.

Ethical approval

Approval from the ethical committee was not applicable.

Author contributions

All authors contributed equally to the writing of this paper and have read and approved the final draft.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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