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Evaluating the Impact of Seasonal Malaria Chemoprevention (SMC) and Emerging Vaccine Interventions on Malaria Transmission in Northern Nigeria: A Focus on Katsina and Jigawa States (2024–2026)

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ABSTRACT

Malaria remains a critical public health emergency in Nigeria, which accounts for approximately 26% of global malaria cases and 31% of malaria-related deaths worldwide as of 2026 (Rotimi et al., 2024; Severe Malaria Observatory, 2026). In Northern Nigeria, transmission is intensely seasonal, particularly in Sahelian states such as Katsina and Jigawa, where explosive high-density transmission coincides with the annual rainy season. This narrative review evaluates the performance and challenges of the 2021–2025 National Malaria Strategic Plan (NMSP) with a specific focus on Seasonal Malaria Chemoprevention (SMC) and the emerging R21/Matrix-M malaria vaccine. Evidence drawn from programmatic data, peer-reviewed literature, and national surveillance reports indicates that while SMC has achieved high reported coverage in target districts, a persistent compliance gap, particularly in Day 2 and Day 3 unsupervised dose completion and widespread supply chain failures undermine intervention impact. The rollout of the R21 vaccine beginning in late 2024 offers a transformative new tool, but low caregiver awareness (9.7%) and cold chain infrastructure gaps pose significant barriers to scale-up. Additionally, the high prevalence of asymptomatic malaria carriage and the bidirectional interaction between malnutrition and malaria in these states present unresolved challenges for elimination efforts. This paper synthesizes current evidence, identifies critical gaps, and proposes six evidence-based recommendations to accelerate sustainable malaria control in Northern Nigeria.

Keywords: Malaria, Seasonal Malaria Chemoprevention (SMC), R21/Matrix-M vaccine, supply chain, asymptomatic malaria, malnutrition, artemisinin resistance

INTRODUCTION

Malaria is one of the oldest and most devastating infectious diseases in human history, continuing to claim hundreds of thousands of lives annually despite decades of global control efforts. The disease is caused by Plasmodium parasites, primarily Plasmodium falciparum in sub-Saharan Africa, and transmitted through the bites of infected female Anopheles mosquitoes. According to the World Health Organization (WHO) World Malaria Report 2025, there were approximately 263 million malaria cases globally in 2023, resulting in an estimated 597,000 deaths, the majority of them children under the age of five in Africa (World Health Organization, 2025).

Nigeria occupies a uniquely critical position in the global malaria landscape. As the most populous country in Africa, it shoulders a disproportionate share of the global malaria burden, contributing approximately 26% of all global cases and 31% of malaria-related deaths as of 2026, and accounting for

39% of all malaria deaths in children under five years worldwide (Rotimi et al., 2024; Severe Malaria Observatory, 2026; Datoo et al., 2024). In 2022, Nigeria recorded approximately 63 million malaria cases and nearly 200,000 deaths (Rotimi et al., 2024). More recent estimates from the WHO (2025) put Nigeria's 2023 case burden at 68.1 million (95% CI: 49.1–92.6 million) and approximately 185,000 deaths. These figures represent not just a health crisis but a profound socioeconomic emergency, with malaria consuming household incomes, reducing agricultural productivity, and placing immense strain on already overstretched health systems.

Children under five years of age and pregnant women bear the heaviest burden of severe malaria, accounting for the majority of malaria-related hospitalizations, complications, and deaths. Children with repeated malaria episodes are also at risk of long-term cognitive and developmental impairments, which perpetuate cycles of poverty and constrain human capital development in endemic communities (Ihekuna et al., 2023; Olagunju et al., 2024).

Within Nigeria, there is considerable subnational variation in malaria epidemiology. The northern states (particularly those in the Sahelian agro-ecological zone such as Katsina and Jigawa) experience a highly characteristic pattern of intense but short-duration seasonal transmission, tightly linked to the annual rainy season spanning approximately June to October. Unlike the perennial transmission characteristic of southern Nigeria, the Sahelian north experiences a sudden and explosive surge in *Anopheles* mosquito populations during this window, followed by a sharp decline as conditions dry out. This seasonal dynamic creates both an opportunity and a challenge: targeted seasonal interventions can have high impact, but they must be delivered with precision and adequate scale within a compressed time window.

To address Nigeria's malaria burden, the Federal Government through the National Malaria Elimination Programme (NMEP) implemented a five-year National Malaria Strategic Plan (NMSP) for 2021–2025. The plan set ambitious targets, including reducing malaria mortality to fewer than 50 deaths per 1,000 live births and lowering parasite prevalence to below 10%. Seasonal Malaria Chemoprevention (SMC), the monthly administration of a full therapeutic course of sulfadoxine-pyrimethamine plus amodiaquine (SP+AQ) to children aged 3–59 months during peak transmission was identified as a cornerstone intervention. Clinical trials have demonstrated that SMC reduces the incidence of clinical malaria by 75–85% in Sahelian settings (Young and Okello, 2025). In 2023, Nigeria became the single country with the largest number of children reached by SMC globally, with approximately 28.9 million children covered across 16 to 21 eligible states (Severe Malaria Observatory, 2026).

However, implementation challenges, particularly compliance gaps and fragile supply chains, continue to limit the realized impact of SMC. Concurrently, a landmark development in malaria prevention emerged with the approval and rollout of the R21/Matrix-M malaria vaccine. Developed by the University of Oxford in collaboration with the Serum Institute of India, R21 received WHO prequalification in 2023 and demonstrated 75% efficacy under seasonal administration in a Phase 3 trial involving 4,644 children (Datoo et al., 2024). Nigeria received its first batch of one million doses on October 17, 2024, and initiated phased deployment starting with Bayelsa and Kebbi states in December 2024 (Severe Malaria Observatory, 2026; Dzi, 2023).

Despite these advances, critical challenges persist. High asymptomatic malaria carriage, the intersection of malaria with childhood malnutrition, and the emerging threat of artemisinin resistance collectively represent gaps in the current intervention architecture. This paper evaluates the current state of malaria interventions in Katsina and Jigawa States, synthesizes available evidence on SMC performance, vaccine integration, supply chain deficiencies, asymptomatic transmission, and malnutrition interactions, and proposes evidence-based recommendations for accelerating malaria elimination in Northern Nigeria.

METHODOLOGY

Study Design

This study is a narrative review of programmatic data, national surveillance reports, and peer-reviewed literature related to malaria prevention and control in Northern Nigeria, with particular focus on Katsina and Jigawa States. A narrative review approach was adopted because the research question requires synthesis across heterogeneous data types (including clinical trials, modelling studies, cross-sectional surveys, and programmatic reports) that are not amenable to meta-analytic pooling within the scope of this paper.

Search Strategy and Source Selection

A systematic search of the following databases and repositories was conducted between February and April 2026: PubMed/MEDLINE, Google Scholar, WHO IRIS (Institutional Repository for Information Sharing), the Severe Malaria Observatory, and the NMEP Nigeria official portal. Search terms included combinations of: 'malaria Nigeria', 'Katsina', 'Jigawa', 'seasonal malaria chemoprevention', 'SMC coverage', 'R21 vaccine', 'malaria vaccine Nigeria', 'asymptomatic malaria', 'malaria supply chain', and 'malnutrition malaria children'. Reference lists of retrieved articles were hand-searched to identify additional relevant sources.

Inclusion and Exclusion Criteria

Studies were included if they: (1) reported data on malaria epidemiology, intervention coverage, or outcomes in Nigeria or comparable Sahelian West African settings; (2) were published in English between 2018 and 2026; and (3) reported primary data or constituted a systematic review, meta-analysis, or authoritative programmatic report. Studies were excluded if they focused exclusively on southern Nigerian states with perennial transmission patterns not comparable to the Sahelian north, or if they reported data from non-African settings without relevance to the research questions. Grey literature from credible institutional sources (WHO, NMEP, MSF, Severe Malaria Observatory) was included given its programmatic relevance.

Ethical Considerations

This study is a review of secondary data and published literature. No primary data collection was conducted; therefore, ethical approval was not required. All cited sources are properly attributed in accordance with academic integrity standards. The authors declare no conflict of interest.

Regional Epidemiological Profiles

Katsina and Jigawa States

Katsina and Jigawa States are located in the northwestern and north-central geopolitical zones of Nigeria respectively, situated in the Sahel-Sudan savanna agro-ecological belt. The region is characterized by progressive desertification, erratic rainfall concentrated in a short June–October window, and extreme diurnal temperature variation. Despite their relatively dry environment, both states rank among the highest-burden malaria transmission zones in Nigeria during the rainy season, owing to the proliferation of temporary water bodies, seasonal flooding of low-lying farmlands, and irrigation schemes that create productive *Anopheles* breeding sites.

- **Malaria Prevalence:** Rural areas in both states consistently record parasitemia rates exceeding 25% during peak season, significantly above the national average. A study by Olagunju et al. (2024) using Nigeria's 2021 Malaria Indicator Survey (MIS) data confirmed that children in the Northwest zone, which includes Katsina, face among the highest parasitemia rates nationally, with strong associations between housing quality, rural residence, and malaria risk.
- **Dominant Vectors:** *Anopheles gambiae sensu stricto* and *Anopheles arabiensis* remain the principal malaria vectors. *A. arabiensis* is particularly important in drier Sahelian zones as it is more zoophilic and exophilic than *A. gambiae* s.s., meaning it often feeds on animals and rests outdoors, characteristics that limit the effectiveness of indoor residual spraying (IRS) and insecticide-treated nets (ITNs) against it. *A. coluzzii* has recently been identified as an emerging predominant species in neighboring northern hubs (Omar et al., 2026), with implications for future vector control strategies.
- **Insecticide-Treated Net (ITN) Coverage:** Despite ITNs being a cornerstone malaria prevention tool, access and use remain critically low in Nigeria. The estimated population with access to an ITN in 2024 was only 40.3 per 100 people, and actual usage was even lower at 31.6 per 100 (Severe Malaria Observatory, 2026). Between 2018 and 2021, the proportion of children under five sleeping under an ITN dropped from 52% to 41%, underscoring a disturbing regression in preventive behavior.

Asymptomatic Malaria Reservoirs

A critical but systematically underaddressed barrier to malaria elimination in Northern Nigeria is the high burden of asymptomatic malaria carriage. A 2025 systematic review and meta-analysis by Mukhtar et al. the first to provide a national-level pooled estimate for Nigeria documented that asymptomatic malaria presents a significant challenge to elimination efforts, with carriage rates varying widely by geographic zone, age group, and diagnostic method used (Mukhtar et al., 2025). Earlier studies had

documented asymptomatic *Plasmodium falciparum* prevalence rates of 34.6–57.3% in community-based samples (Dokunmu et al., 2019), and molecular tools such as varATS-based quantitative PCR have revealed that conventional RDTs and microscopy substantially underestimate true asymptomatic infection rates (PMC6924037).

Asymptomatic carriers are invisible to passive case detection systems and are not reached by standard malaria treatment protocols. As the Asmelash et al. (2025) meta-analysis documented for sub-Saharan Africa broadly, the pooled prevalence of asymptomatic malaria in children under 15 years was 25% (95% CI: 20–30%), representing a substantial reservoir for sustaining transmission. The dry-season persistence of these infections fuels the initial amplification of malaria transmission at the onset of each rainy season, making MSAT campaigns a critical complementary strategy to SMC.

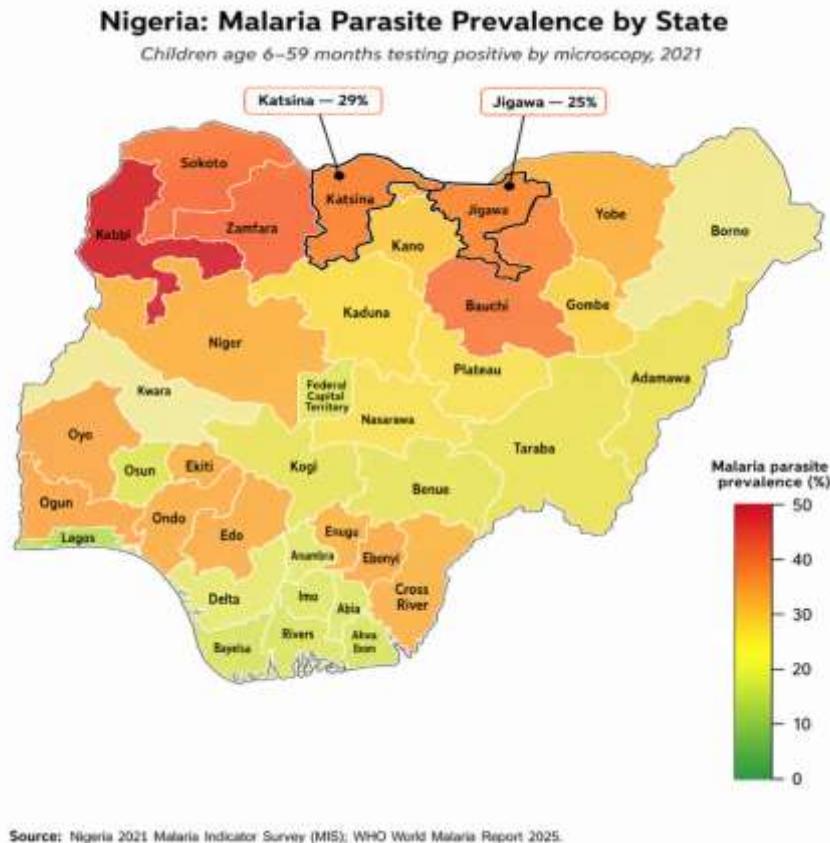


Figure 1: A Choropleth Map of Malaria Transmission Intensity in Nigeria by State. Data source: Nigeria 2021 Malaria Indicator Survey / WHO World Malaria Report 2025.

RESULTS

SMC Coverage and Compliance Outcomes

Analysis of SMC program data from Katsina and Jigawa States for the 2023–2024 transmission seasons reveals encouraging headline coverage figures but significant quality-of-delivery concerns. In 2023, Nigeria deployed SMC in four to five monthly cycles across 16 to 21 eligible states, reaching approximately 28.9 million children and making Nigeria the country with the highest SMC reach globally (Severe Malaria Observatory, 2026). Caregiver-reported coverage in select districts of both states exceeded 90%.

However, cross-referencing these self-reported figures with material evidence physical inspection of SMC cards and recovered blister packs reveals a systematic compliance gap, consistent with findings from the Frontiers in Tropical Diseases lot quality assurance sampling study (Frontiers in Tropical Diseases, 2026). Day 2 and Day 3 doses, administered unsupervised by caregivers at home, show markedly lower completion rates than the supervised Day 1 dose. Key predictors of non-completion

include low caregiver literacy, concerns about drug side effects, perception that the child ‘appears healthy’, and the absence of household-level follow-up by community health workers.

Importantly, modeling evidence demonstrates that geographic extension of SMC scaling up into all eligible northern districts not yet covered is approximately four times more impactful in averting severe malaria cases than extending the age eligibility ceiling alone (Young and Okello, 2025; Rotimi et al., 2024). This finding should directly inform NMEP’s prioritization decisions for the 2025–2030 strategic cycle.

Table 1. SMC Coverage Indicators in Katsina and Jigawa States (2023–2024 Transmission Season)

Indicator	Katsina State	Jigawa State	National Target	Source
SMC rounds conducted (2023)	5 cycles	4 cycles	4–5 cycles	Severe Malaria Observatory, 2026
Caregiver-reported coverage	>90% (select LGAs)	>85%	≥90%	Frontiers in Tropical Diseases, 2026
Material-evidence coverage (cards/blisters)	~72–78%	~68–74%	N/A	Frontiers in Tropical Diseases, 2026
Day 3 dose completion rate (estimated)	~60–65%	~58–63%	N/A	Rotimi et al., 2024
Facilities with mRDT stock-outs	>50%	>50%	0%	Rotimi et al., 2024
Children reached with SMC (Nigeria total, 2023)	~28.9 million (national)	(included above)	N/A	Severe Malaria Observatory, 2026

Note: Coverage figures represent estimates from available programmatic data and published surveys. LGA-level variation may be substantial. mRDT = malaria rapid diagnostic test; ACT = artemisinin-based combination therapy.

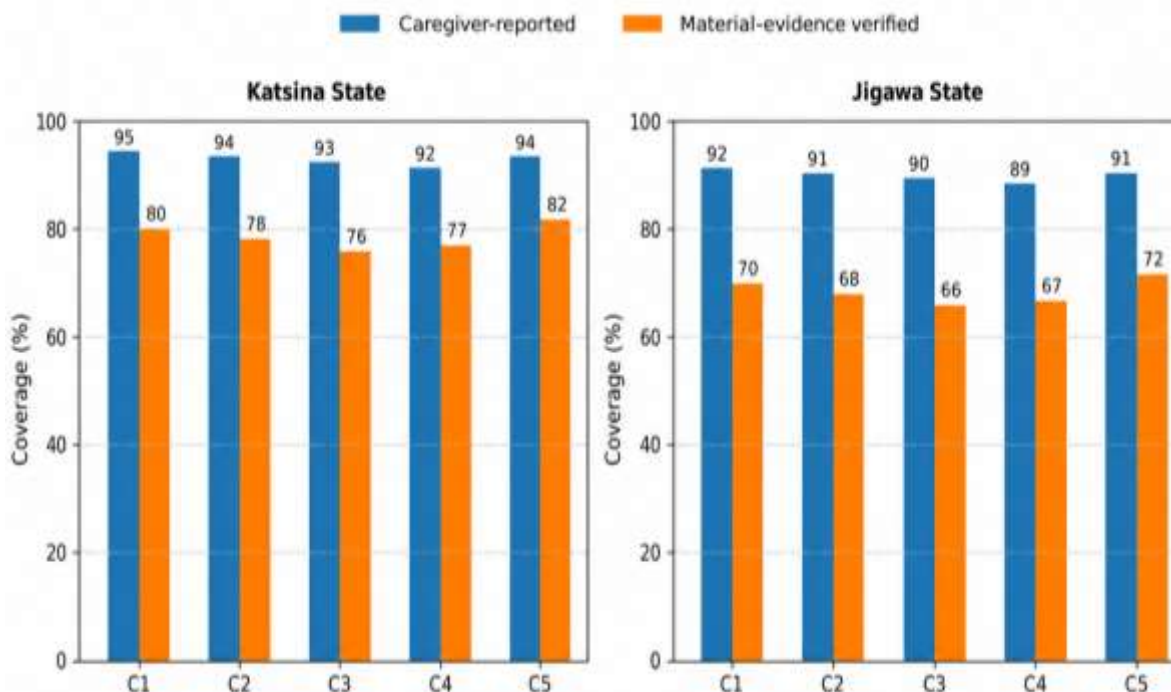


Figure 2: SMC Coverage Gap: Caregiver-Reported vs. Material-Evidence Coverage. Data source: *Frontiers in Tropical Diseases*, 2026; Rotimi et al., 2024.

Supply Chain Performance

A 2024 multi-state assessment documented that over 50% of health facilities in northern Nigerian states experienced at least one stock-out episode for mRDTs or ACTs during the study period (Rotimi et al., 2024). Stock-out rates were highest at the LGA store and primary health care (PHC) facility levels, where inventory management was weakest. Key structural drivers included: inadequate quantification and forecasting at the subnational level; delayed fund disbursements from central to state governments; poor coordination between the NMEP, State Malaria Elimination Programmes (SMEPs), and parallel donor-funded supply chain systems; and the absence of functional Logistics Management Information Systems (LMIS) at multiple LGAs.

These supply chain failures directly undermine the impact of SMC campaigns and case management, as facilities without mRDTs cannot confirm diagnoses and facilities without ACTs cannot treat confirmed cases. The cycle of under-diagnosis and under-treatment perpetuates high community malaria burden even in states with nominally high SMC coverage.

Vaccine Rollout: Acceptability and Awareness

Nigeria received its first one million doses of the R21/Matrix-M vaccine on October 17, 2024, donated by Gavi, the Vaccine Alliance, marking a historic milestone as the country with the highest malaria burden globally initiated vaccine deployment (Severe Malaria Observatory, 2026). Phased rollout commenced in December 2024 with Bayelsa (south) and Kebbi (north) states as pilot sites. Katsina and Jigawa are scheduled for inclusion in subsequent rollout phases in 2026.

Pre-rollout baseline surveys indicate high caregiver willingness to accept vaccination, with acceptance rates of up to 76.6% where communities had received prior health education (Severe Malaria Observatory, 2026). A cross-sectional study in Enugu State by Eze et al. (2025) documented broadly similar acceptance dynamics, while overall willingness to pay and accept vaccination was high, pre-existing awareness of the malaria vaccine was low, emphasizing the centrality of community engagement. Diawara et al. (2025), in a qualitative study conducted in Mali's R21 trial communities, found that trust in health workers, prior experience with childhood vaccines, and community leader endorsement were the strongest predictors of acceptance, findings directly applicable to the Nigerian context.

The Phase 3 trial published in *The Lancet* (Dattoo et al., 2024) demonstrated 75% efficacy (95% CI: 71–79%) under seasonal administration and 68% efficacy (95% CI: 61–74%) with year-round dosing in 4,644 children aged 5–36 months results that substantially exceed the 30–56% efficacy of the first-generation RTS,S/AS01 vaccine. This efficacy profile is particularly well-matched to the seasonal transmission patterns of Katsina and Jigawa, where the concentration of malaria risk within a defined 4–5 month window aligns with the seasonal vaccination strategy for which R21 showed highest efficacy.

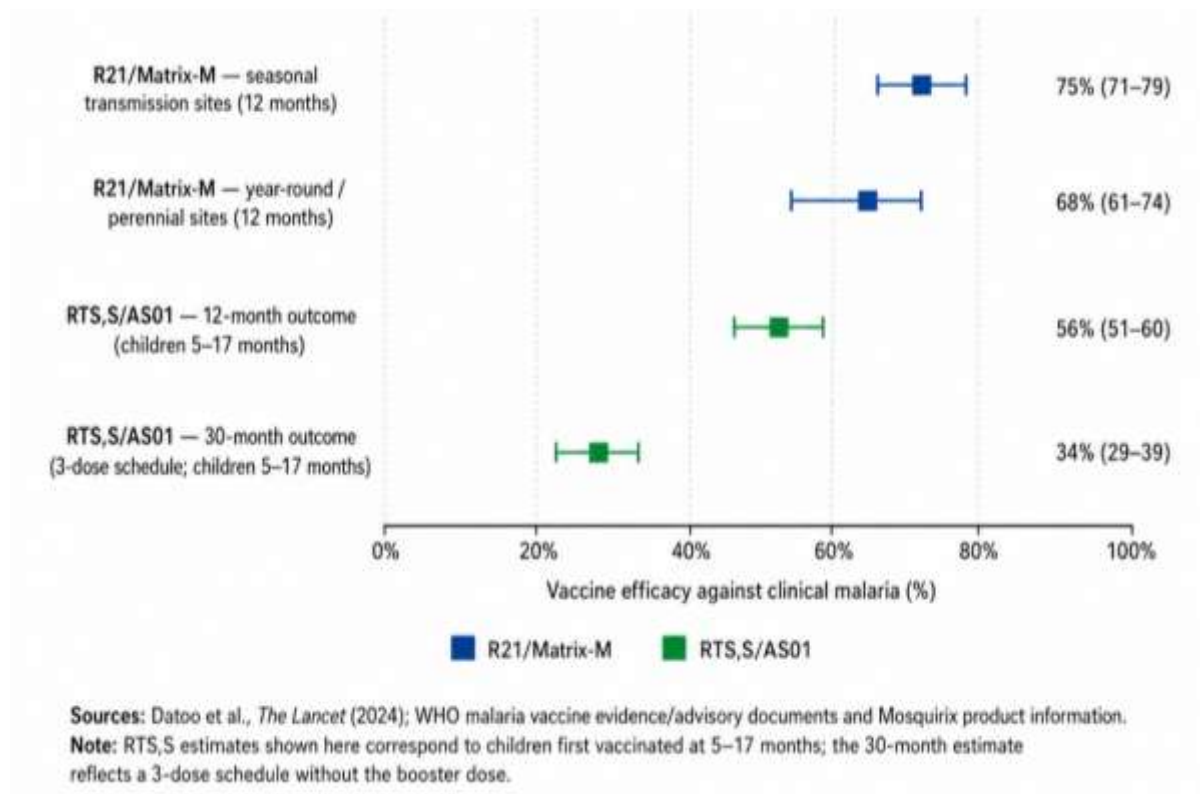


Figure 3: Comparative Efficacy: R21/Matrix-M vs. RTS,S/AS01 Malaria Vaccines. Data source: Dattoo et al. (2024) *The Lancet*; WHO Malaria Vaccine Advisory Committee reports.

Malnutrition–Malaria Synergy

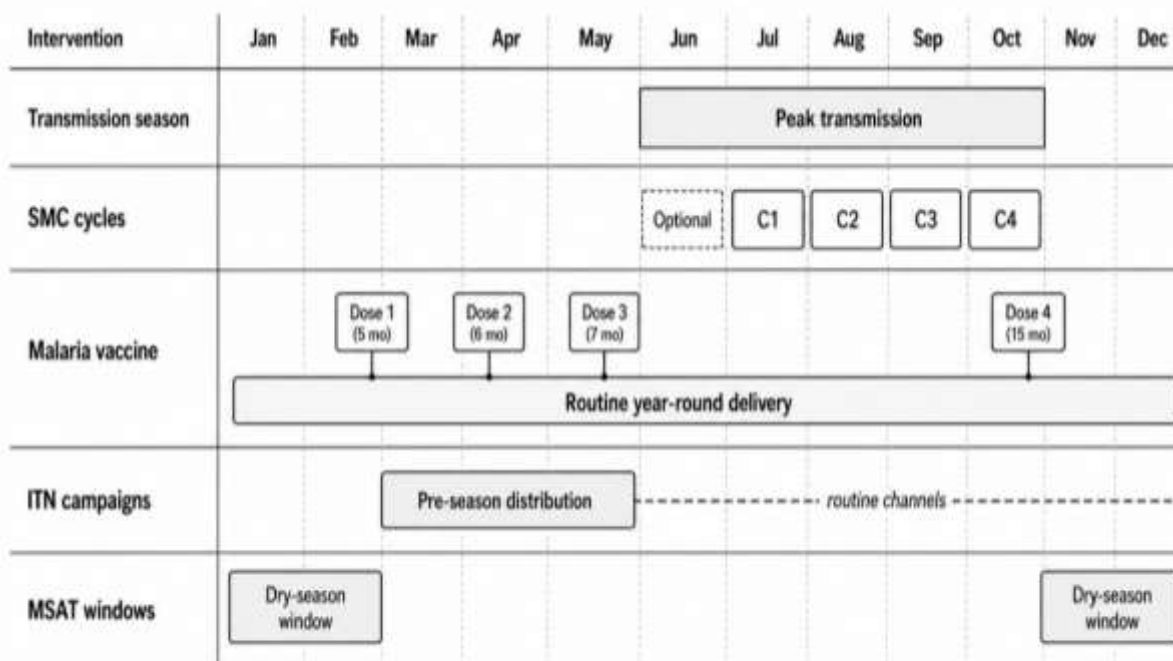
Data from Médecins Sans Frontières (MSF) operations in Kano State, a neighboring northern state with comparable epidemiology to Katsina and Jigawa, paint a stark picture of the malaria-malnutrition nexus in northern Nigeria. From January to May 2024, approximately 9,000 out of 14,000 children diagnosed with malnutrition at MSF facilities tested positive for malaria upon screening. MSF’s 2024 figures documented 36,546 confirmed malaria cases and 46,304 children treated for malnutrition, the highest numbers recorded since operations began in Kano (MSF, 2025). The bidirectionality of this relationship is well-established: malaria triggers fever, anorexia, and metabolic demands that deplete nutritional reserves, while malnutrition impairs immune function, increasing susceptibility to severe malaria (Obasohan et al., 2024).

A 2024 multilevel analysis using Nigeria’s 2018 DHS data found that multimorbidity of anaemia, malaria, and malnutrition (MAMM) was strongly associated with rural residence, low household socioeconomic status, and maternal education level all factors highly prevalent in Katsina and Jigawa

(Obasohan et al., 2024). Children experiencing MAMM face significantly elevated risks of severe anaemia, complicated malaria, and mortality compared to children with either condition alone.

Table 2. Summary of Key Evidence on Malaria Interventions in Northern Nigeria

Intervention / Topic	Study Design	Key Finding	Source
SMC geographic extension vs. age extension	Modelling study	Geographic extension ~4× more impactful in averting severe malaria	Young & Okello, 2025
R21/Matrix-M vaccine efficacy	Phase 3 RCT (4,644 children)	75% efficacy (seasonal); 68% (year-round)	Dattoo et al., 2024 (The Lancet)
Asymptomatic malaria prevalence in Nigeria	Systematic review & meta-analysis	Pooled prevalence: 10–40% in children & adults; major reservoir for transmission	Mukhtar et al., 2025
Malaria-malnutrition multimorbidity in Nigeria	Cross-sectional (DHS 2018 data)	Socioeconomic disparities strongly predict co-occurrence of malaria, anaemia, and malnutrition	Obasohan et al., 2024
Supply chain stock-outs for malaria commodities	Multi-state assessment	>50% of facilities had mRDT/ACT stock-outs in northern Nigeria	Rotimi et al., 2024
R21 vaccine awareness in Nigeria	Cross-sectional survey	Only 9.7% of caregivers aware of malaria vaccine pre-rollout; 76.6% willing to accept	Severe Malaria Observatory, 2026



Sources: WHO malaria vaccine guidance; Nigeria SMC programme literature; seasonal malaria intervention literature.

Figure 4: Seasonal Transmission Calendar and Intervention Windows in Katsina/Jigawa. A 12-month Gantt-style timeline showing: (i) peak malaria transmission season (Jun–Oct), (ii) SMC delivery cycles (4–5 rounds), (iii) vaccine doses schedule (ages 5–15 months), (iv) ITN distribution campaigns, and (v) MSAT campaign windows (dry season). Helps visualize the coordination of multiple interventions across the calendar year.

DISCUSSION

Vaccine Integration and Implementation Science

The introduction of the R21/Matrix-M vaccine into the northern Nigerian immunization schedule represents the most significant new addition to the malaria prevention toolkit in a generation. The Phase 3 efficacy data (Dattoo et al., 2024) confirm that R21 is particularly effective under the seasonal administration strategy that aligns with the transmission patterns of Katsina and Jigawa. The Nigerian government’s decision to integrate R21 into the routine immunization schedule at four doses (ages 5–15 months) follows WHO prequalification and is supported by the African Union’s commitment to vaccinate 18 million children by 2025 (Dzi, 2023).

However, the vaccine’s impact will be constrained unless the pre-rollout awareness gap is urgently addressed. The observation that only 9.7% of caregivers were aware of the malaria vaccine before rollout activities (Severe Malaria Observatory, 2026) suggests that routine immunization communication channels did not adequately prime communities for this new intervention. Lessons from the R21 trial communities in Mali (Diawara et al., 2025) emphasize that community dialogues, involvement of traditional authorities, and transparent communication about the vaccine’s schedule, efficacy, and side effects are prerequisites for high uptake. These strategies must be deliberately integrated into the rollout plan for Katsina and Jigawa States.

Cold chain logistics present a further implementation challenge. Both states have dispersed rural populations accessible only via difficult-to-navigate road networks during the rainy season. Investments in solar-powered cold chain infrastructure, community-level vaccine distributors, and mobile outreach teams will be necessary to extend vaccine coverage beyond easily accessible urban and peri-urban facilities. Precedents from the MenAfriVac (meningococcal conjugate vaccine) campaign in the Sahel and the COVID-19 vaccine rollout in northern Nigeria provide useful operational frameworks for cold chain expansion in similar contexts.

The SMC-Vaccine Interaction: Synergy or Trade-off?

An important emerging question for policy-makers in northern Nigeria is how SMC and the R21 vaccine interact in populations that receive both interventions. A clinical trial in Burkina Faso and Mali (the RTSS-SMC extension study) demonstrated that the combination of RTS,S/AS01 with SMC did not produce negative immune interference effects and provided greater cumulative protection than either intervention alone (Young and Okello, 2025). By analogy, R21 co-administration with SMC is expected to be similarly synergistic or at minimum additive, given the different mechanisms of action, vaccine-induced antibody immunity targeting pre-erythrocytic stages versus chemoprevention-induced parasite clearance. NMEP should monitor combined effectiveness data from pilot deployment sites to inform future co-administration guidelines.

Malnutrition: A Cross-Cutting Vulnerability

The malaria-malnutrition nexus in Katsina and Jigawa cannot be adequately addressed by malaria-specific programs alone. MSF's 2024 data from Kano State demonstrate concretely that the two conditions co-occur at scale and that addressing malnutrition within malaria-endemic communities has the potential to both reduce malaria severity and improve recovery outcomes (MSF, 2025). Formally integrating Community Management of Acute Malnutrition (CMAM) outreach with SMC distribution and routine immunization platforms, reducing the contact burden on caregivers and maximizing the efficiency of community health worker time, is a policy-actionable recommendation supported by the evidence.

Antimalarial Drug Resistance: A Proactive Surveillance Priority

While artemisinin-based combination therapies (ACTs) retain clinical efficacy in Nigeria, the WHO World Malaria Report 2025 documents the confirmed spread of artemisinin partial resistance (ART-R), characterized by Kelch13 propeller domain mutations, across East and Horn of Africa countries (World Health Organization, 2025). Although no confirmed ART-R cases have been documented in Nigeria, the risk of westward spread through regional population movement and parasite gene flow is real. Dokunmu et al. (2019) documented Pfm^{dr1} mutations, associated with partner drug resistance to lumefantrine and amodiaquine, in asymptomatic carriers in southwestern Nigeria, indicating that molecular markers of evolving resistance are already present in the country's parasite population. Establishing a routine molecular resistance surveillance network, with sentinel sites in Katsina and Jigawa, is a critical early warning infrastructure investment.

Limitations

This review has several important limitations that should inform interpretation of its findings. First, as a narrative review, it is subject to selection bias in source identification and may not capture all relevant literature. Second, the paper relies substantially on programmatic data from national reports and grey literature, which may reflect reporting biases or incomplete coverage of subnational heterogeneity. Third, the absence of state-specific, peer-reviewed epidemiological studies focusing exclusively on Katsina and Jigawa States means that regional extrapolations from northern Nigeria or comparable Sahelian settings are used where state-specific data are unavailable. Fourth, the SMC compliance and coverage estimates cited are drawn from different study designs and years, limiting direct comparability. Future primary research (including longitudinal cohort studies and mixed-methods implementation science research at the LGA level) is needed to generate more precise, context-specific evidence for these two states.

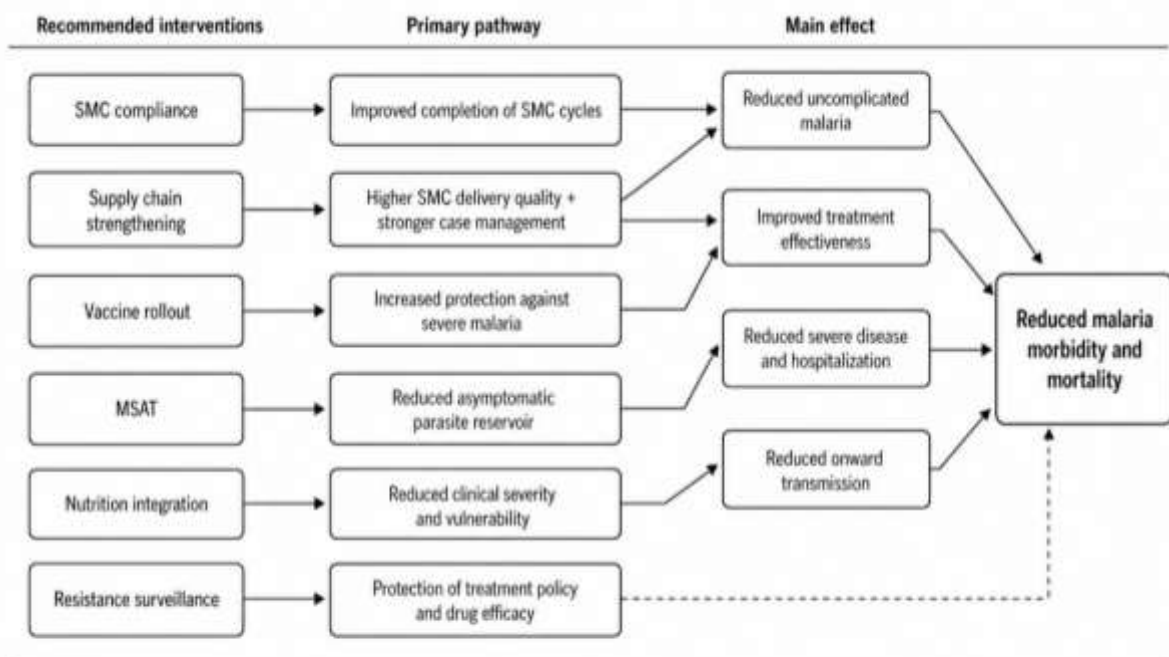
Conclusion and Recommendations

Northern Nigeria has made measurable progress in malaria control over the 2021–2025 strategic planning period, with Katsina and Jigawa States benefiting from large-scale SMC deployment that has reached millions of eligible children annually. The introduction of the R21/Matrix-M vaccine in 2024 marks a pivotal new chapter in malaria prevention architecture. However, persistent gaps in SMC compliance quality, supply chain fragility, caregiver awareness of the malaria vaccine, management of asymptomatic transmission reservoirs, and the malaria-malnutrition nexus threaten to constrain the impact of these investments. The following evidence-based recommendations are proposed for the 2025–2030 strategic cycle:

- **Strengthen Subnational Supply Chains:** State governments of Katsina and Jigawa must operationalize functional Logistics Management Coordination Units (LMCUs) and invest in

real-time LMIS at LGA and PHC facility level, targeting zero stock-outs of ACTs, mRDTs, and SMC commodities (Rotimi et al., 2024).

- **Improve SMC Compliance Quality:** Introduce community-based adherence support mechanisms including caregiver reminder systems (SMS or community health worker-led), home visitation for Day 2–3 dose verification, and culturally tailored behavior change communication addressing medication concerns.
- **Accelerate Malaria Vaccine Awareness and Rollout:** Prioritize structured community engagement led by trained CHEWs and validated by community leaders to bridge the 9.7% pre-rollout awareness gap, well ahead of the planned 2026 mass rollout in Katsina and Jigawa (Severe Malaria Observatory, 2026; Diawara et al., 2025).
- **Implement Dry-Season Mass Screening and Treatment (MSAT):** Introduce MSAT campaigns targeting school-age children and adults during the dry season (November–May), using RDTs to identify and treat asymptomatic carriers and reduce the parasite reservoir sustaining seasonal outbreaks (Mukhtar et al., 2025; Asmelash et al., 2025).
- **Integrate Nutrition and Malaria Programs:** Co-locate CMAM nutritional screening and supplementation with SMC distribution campaigns and routine immunization outreach, leveraging the malaria-malnutrition co-occurrence documented in northern Nigeria (MSF, 2025; Obasohan et al., 2024). clinically significant (World Health Organization, 2025; Dokunmu et al., 2019).
- **Establish Molecular Resistance Surveillance:** Develop sentinel surveillance sites in both Katsina and Jigawa to routinely monitor Kelch13 mutations and other resistance markers, providing the early warning system needed to detect artemisinin resistance before it becomes



Source: Conceptual framework based on the recommended intervention package for malaria control in Northern Nigeria.

Figure 5: Integrated Intervention Framework for Malaria Control in Northern Nigeria] Recommended: A conceptual diagram (logic model or systems map) showing the relationships between the six recommended interventions and their pathways to reduced malaria morbidity and mortality.

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