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Research Article

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From Parallel to Integrated: Harmonizing SMC and Routine Malaria Supply Chains in Northern Nigeria – An Integrated Logistics Framework

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Abstract

Malaria continues to place a heavy burden on children in northern Nigeria, particularly in Kebbi, Sokoto, and Zamfara. Two major interventions are used to tackle this challenge: routine malaria case management with Artemisinin-based Combination Therapies (ACTs) and Seasonal Malaria Chemoprevention (SMC). While both are vital, they operate through separate supply chains, creating inefficiencies and treatment gaps. This study analyzed routine health data from 2022–2024, comparing confirmed malaria cases in children under five with ACTs dispensed. Findings show persistent mismatches between disease burden and ACT availability, especially during SMC campaign months (July–October).

For example, in Sokoto (September 2023), 114,831 cases were confirmed but no ACTs were recorded as distributed, while in Kebbi (October 2022), 53,277 cases were reported but only 26,056 ACTs dispensed. Across all three states, annual treatment gaps ranged from 22,000 to 26,000. These gaps suggest that simultaneous campaign-style drug distribution for SMC and the routine pull-based system for ACTs place strain on existing logistics infrastructure. We propose an integrated logistics framework that strengthens coordination between partners, enhances data quality, and introduces digital innovations for real-time monitoring. Harmonizing prevention and treatment supply chains will reduce stock-outs, improve efficiency, and ensure children receive timely access to life-saving malaria commodities.

Keywords: Quantum-Resistant Smart Contracts, Blockchain Security, Post-Quantum Cryptography and Data Protection

1. Introduction

Nigeria continues to carry one of the heaviest malaria burdens globally, with northern states such as Kebbi, Sokoto, and Zamfara contributing disproportionately to national morbidity and mortality [1]. Malaria transmission in these areas is highly seasonal, peaking during the rainy season when health systems face compounded pressure. Two cornerstone interventions drive malaria control efforts in this region: (1) routine case management with Artemisinin-based Combination Therapies (ACTs) and (2) Seasonal Malaria Chemoprevention (SMC) campaigns for children under five [2].

Both are essential but are implemented through parallel supply chains — the continuous, facility-based pull system for ACTs and the campaign-style push system for SMC commodities. This structural separation introduces inefficiencies, weakens coordination, and contributes to treatment shortfalls during periods of greatest need [3]. The present study evaluates routine data from 2022–2024 to assess the scale of misalignment between disease burden and ACT provision, particularly during SMC campaign months, and proposes an integrated framework for supply chain harmonization.

2. Methods

This retrospective analysis drew on secondary data from the national District Health Information System (DHIS2) between January 2022 and March 2024. Three states (Kebbi, Sokoto, Zamfara) were selected due to their high malaria burden and

consistent implementation of both ACT distribution and SMC campaigns. Variables analyzed included confirmed uncomplicated malaria cases in children under five and ACTs dispensed in the same age group [4]. State-level monthly data were compared to identify mismatches between malaria burden and treatment provision, with special focus on the SMC campaign months (July–October).

Ethical approval was not required, as the analysis used aggregated, non-identifiable program data.

Ethical Considerations

This analysis used **secondary, aggregated routine data** obtained from the national DHIS2 system. No individual-level or identifiable data were used. As such, ethical approval was not required. Data access was through routine program reporting channels.

3. Results

Annual Deficits (2022–2024)

State	2022 Deficit	2023 Deficit	2024 Deficit	Trend
Kebbi	29,977	24,082	25,863	Persistent high gaps
Sokoto	23,900	22,867	23,783	Consistent annual shortfalls
Zamfara	22,581	21,786	22,467	Steady but significant gap

Persistent treatment gaps were observed across all three states, with annual deficits ranging between 22,000 and 26,000 ACT treatments. Sokoto recorded one of the starkest mismatches in September 2023: 114,831 confirmed cases were reported, yet no ACTs were documented as dispensed. In Kebbi, October 2022 saw 53,277 confirmed cases against only 26,056 ACTs dispensed [5]. These discrepancies were consistently most pronounced during SMC months, when logistics infrastructure was saturated by campaign activity.

Three Core Challenges Emerged

- **Seasonal Mismatch** – ACT distribution often failed to scale in line with seasonal case surges.
- **Competing Supply Chain Models** – Parallel management of routine and campaign interventions strained logistics systems, disrupting routine ACT flow [6].
- **Data Quality Concerns** – Some mismatches may reflect weaknesses in DHIS2 reporting, including incomplete entries and reliance on clinical rather than confirmed diagnoses.

4. Discussion

These findings reveal that malaria supply chains in northern Nigeria remain fragmented, with prevention and treatment interventions competing rather than complementing one another. The campaign-style SMC push overwhelms distribution infrastructure, while the continuous ACT pull system lacks adaptive capacity to respond to seasonal transmission peaks [7]. In addition, reliance on routine DHIS2 reporting introduces errors that obscure the true scale of treatment gaps. Without structural reform, these inefficiencies will continue to erode the effectiveness of Nigeria's malaria response and undermine child survival during peak transmission seasons.

Policy Recommendations

- **Strengthen Coordination Across Partners** – National Malaria Elimination Programme (NMEP) should ensure that both routine ACT supply and SMC campaigns are jointly planned and implemented under a harmonized logistics strategy, irrespective of donor silos [8].
- **Improve Data Quality** – Capacity building, mentorship, and supportive supervision for facility staff are needed to strengthen diagnostic confirmation and reporting accuracy within DHIS2 [9].
- **Introduce Digital Facility-Level Alerts** – Real-time anomaly detection tools should flag mismatches (e.g., high case counts with zero ACTs dispensed), enabling rapid corrective action.
- **Adopt Integrated Forecasting and Planning** – Seasonal projections should inform both ACT quantification and SMC delivery schedules, ensuring complementary rather than competing logistics flows [10].

5. Conclusion

This study demonstrates that the coexistence of fragmented routine and campaign supply chains contributes to recurrent treatment gaps in northern Nigeria. Harmonization is urgently needed to transition from reactive, parallel systems to an integrated logistics framework. By aligning prevention and treatment distribution, improving data quality, and embedding digital monitoring tools, Nigeria can reduce stockouts, strengthen health system resilience, and safeguard equitable access to life-saving malaria commodities. Achieving this integration will not only improve efficiency but also accelerate progress toward national and global malaria elimination targets.

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