Epidemiologic Approach to Systems Strengthening in Routine Immunization in Kogi State (A Scoping Review)

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ABSTRACT

Global guidance from the World Health Organization (WHO, 2023; 2024), UNICEF (2023; 2024), and Gavi (2023; 2024) underscores the integration of supplementation into antenatal care (ANC) as a high-impact intervention for improving maternal nutrition outcomes. Within Nigeria's National Routine Immunization Supportive Supervision (RISS) Framework (NPHCDA, 2023) and aligned with the Socio-Ecological Model (McLeroy et al., 1988), ANC–supplementation linkages are shaped by multi-level determinants from individual health worker practices to policy-driven service delivery structures. Evidence from WHO's Global Routine Immunization Strategies and Practices (GRISP, 2024 update) and UNICEF's Guidance on Reaching Zero-Dose Children highlights the value of integrated service delivery in improving coverage equity.

A descriptive exploratory study was conducted using RISS data from health facilities in Kogi State, Nigeria, collected between January and July 2025. Data were contributed by multi-stakeholder health workforce teams: National Primary Health Care Development Agency (16%), Kogi State Primary Health Care Development Agency (12%), Local Government Health Authority (7%), WHO (64%), and UNICEF (1%). In line with the PRISMA guidelines to ensure transparency and replicability, supplementation uptake was modelled as the dependent variable and ANC coverage as the independent variable. Linear regression and binary logistic regression were applied, with results interpreted through an epidemiologic framework and contextualized using SEM.

Linear regression derived through the use of SPSS 20 and Microsoft Copilot showed that ANC coverage explained 63.1% of the variation in supplementation uptake ($R^2 = 0.631$, $p < 0.001$), with each unit increase in ANC coverage associated with a 0.751-unit rise in supplementation coverage. Logistic regression yielded a pseudo-R^2 of 0.398, indicating that higher ANC coverage significantly increased the odds of supplementation uptake ($\beta_1 = 0.939$, OR ≈ 2.56, $p = 0.002$). These models demonstrated a strong, statistically significant, and consistent association, with a clear dose–response pattern.

ANC coverage is a major determinant of supplementation uptake, explaining 40–63% of observed variation. From an SEM perspective, this reflects influences at the individual (health worker counselling and service delivery), organizational (facility readiness, supply chain), community (engagement and demand generation), and policy (integration mandates) levels. Programmatic priorities include embedding supplementation into every ANC contact, targeting ANC outreach in low-coverage wards, and incorporating ANC–supplementation linkage indicators into RISS monitoring. Addressing residual variance will require strengthening supply chains, improving the counselling quality, and enhancing community mobilization are strategies that are consistent with WHO, UNICEF, and Gavi recommendations for integrated maternal and child health services.

Keywords: Antenatal care, supplementation, Routine Immunization Supportive Supervision, Socio-Ecological Model, epidemiology, integration, Nigeria.

INTRODUCTION

Background of Study

Routine Immunization Supportive Supervision (RISS) is a strategic intervention for strengthening health systems, improving service quality, and ensuring equitable vaccine coverage. Epidemiologic approaches to RISS typically focus on quantitative performance indicators linked to coverage rates, cold chain functionality, vaccine stockouts, and data quality. However, these outcomes are shaped by multi-level determinants that the Socio-Ecological Model (SEM) helps to conceptualize. The integration of SEM into epidemiologic monitoring, program evaluations is to examine the mediators and moderators or moving beyond "what" is happening to also explain "why" performance gaps persist.

The Objective of the Study

The general objective of the study is to investigate, using PRISMA-guided methodology and epidemiologic analyses of January–July 2025 Routine Immunization Supportive Supervision (RISS) data from 21 Local Government Areas in Kogi State, Nigeria, the relationship between antenatal care (ANC) coverage and iron–folic acid supplementation uptake, and how this interaction influences Routine Immunization (RI) service performance, in order to inform integrated, equity-focused strategies that strengthen maternal–child health outcomes across all socio-ecological levels.

The specific objectives of the study are as follows: -

1. To quantify the association between ANC coverage and iron–folic acid supplementation uptake among the estimated 264,506 pregnant women in Kogi State, applying both linear and logistic regression models to determine strength, direction, and statistical significance.
2. To determine the proportion of variance in supplementation uptake explained by ANC coverage, and assess its implications for RI programme performance, service integration, and public health impact.
3. To develop evidence-based recommendations for embedding supplementation delivery into ANC services, with targeted interventions for low-coverage wards, informed by dose–response patterns, regression outputs, and socio-ecological determinants.

Justification

Maternal undernutrition and anemia remain significant public health challenges in Nigeria, with iron–folic acid supplementation during pregnancy recognized by WHO, UNICEF, and Gavi as a cost-effective intervention to reduce anemia prevalence and prevent neural tube defects. Antenatal care (ANC) provides a critical platform for delivering supplementation, yet coverage gaps and weak integration with other maternal–child health services persist, particularly in sub-national contexts such as Kogi State.

Routine Immunization Supportive Supervision (RISS) offers a structured mechanism for monitoring service delivery, identifying bottlenecks, and strengthening integration between maternal health and immunization platforms. However, empirical evidence quantifying the relationship between ANC coverage and supplementation uptake and its implications for Routine Immunization (RI) performance remains limited. Addressing this gap is essential for designing context-responsive strategies that improve equity, optimize logistics, and enhance data quality across the socio-ecological spectrum, from individual health worker practices to policy-level frameworks.

In alignment with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, this study ensures methodological transparency, replicability, and disclosure of all sources of support. Hydra Tide Ltd provided technical and logistical support for data collation, quality assurance, and analytical processes, enabling rigorous application of PRISMA principles to the use of January–July 2025

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RISS data from 21 Local Government Areas in Kogi State. This partnership ensured adherence to international reporting standards, strengthened the robustness of findings, and enhanced the potential for evidence-based policy translation. By integrating ANC and supplementation performance analysis within the RISS framework, the study directly addresses national and global priorities for maternal–child health, contributing actionable insights for program managers, policymakers, and development partners.

Research Questions

1. Among pregnant women in the 21 LGAs of Kogi State, what is the measured association between antenatal care (ANC) coverage and iron–folic acid supplementation uptake during January–July 2025?
2. What is the effect of embedding supplementation delivery into routine ANC service workflows on supplementation coverage rates, compared with facilities without such integration?
3. How do service delivery disruptions including competing health activities, funding gaps, public holidays, and vaccine stockouts influence the strength of the ANC–supplementation linkage?
4. What is the relationship between RISS-verified data quality indicators (report completeness, tally accuracy) and the reliability of measured ANC–supplementation integration outcomes?

Research Hypothesis

H_0(Null): Programmatic integration factors (e.g., service workflow integration, supply chain reliability, counselling quality) do not mediate the relationship between ANC coverage and supplementation uptake.

H_1 (Alternative): Programmatic integration factors partially mediate the relationship between ANC coverage and supplementation uptake, such that higher ANC coverage is associated with greater supplementation uptake through improved integration mechanisms.

Definition of Key Terms

Term	Definition (Study Context)	SEM Linkage	Epidemiologic Relevance in RISS
Routine Immunization Supportive Supervision (RISS)	A structured, periodic assessment of health facilities using a standard checklist to monitor and improve routine immunization service delivery.	**Observed variable** representing the quality-of-service delivery; can be modelled as an exogenous factor influencing multiple outcomes.	Provides real-time program data for monitoring coverage, identifying gaps, and guiding interventions.
Antenatal Care (ANC) Coverage	The proportion of pregnant women who attend at least one ANC visit during pregnancy within a defined period.	**Exogenous predictor variable** in SEM; hypothesized to have direct and indirect effects on supplementation uptake.	Serves as a key determinant of maternal health service utilization and an entry point for integrated interventions.
Supplementation Uptake	The proportion of eligible women who receive recommended micronutrient supplementation (e.g., iron–folate) during pregnancy.	**Endogenous outcome variable** in SEM; influenced by ANC coverage and mediated by service integration factors.	Indicator of maternal nutrition intervention coverage; linked to improved pregnancy outcomes.

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Integration of Services	The deliberate inclusion of supplementation delivery within ANC workflows to maximise efficiency and coverage.	**Mediator variable** in SEM; explains part of the pathway between ANC coverage and supplementation uptake.	Enhances program efficiency and ensures multiple interventions reach the same target population.
Cold Chain Functionality	The ability of the vaccine storage and transport system to maintain required temperatures from supply to administration.	**Observed variable** that may act as a control or confounder in SEM; influences immunization service quality.	Critical for vaccine potency and immunization effectiveness.
Data Quality Verification (DQV)	The process of checking the accuracy, completeness, and consistency of reported immunization data.	**Measurement variable** in SEM; can be used to validate latent constructs like "program quality."	Ensures reliability of coverage estimates and supports evidence-based decision-making.
Structural Equation Modelling (SEM)	A statistical technique that tests complex relationships between observed and latent variables, including direct, indirect, and total effects.	The overarching analytic framework linking ANC coverage, integration, and supplementation uptake.	Allows simultaneous testing of multiple epidemiologic pathways and mediators in RISS data.

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LITERATURE REVIEW

Introduction

Routine Immunization Supportive Supervision (RISS) is typically evaluated with epidemiologic indicators that include coverage, session implementation, vaccine availability, cold chain functionality, and data quality, yet these outcomes are produced by layered social and system determinants. The Socio-Ecological Model (SEM) provides a structured way to interpret why gaps persist and where to intervene by examining factors at individual, interpersonal, organizational, community, and policy levels. Integrating SEM with epidemiologic monitoring turns descriptive metrics into actionable insights for program design and accountability [1–4].

Socio-ecological foundations for immunization systems are crucial for the public health relevance of the SEM, which posits that behaviors and system performance are shaped by nested contexts from individuals to policy environments. In immunization, this spans HRH competencies and motivation, supervisory relationships, facility management and logistics, community trust and mobilization, and governance and financing arrangements. RED/REW and GRISP explicitly emphasize multi-level action linked microplanning and outreach at facility/community interfaces, community partnerships, and ward-level management reflect the SEM architecture and offering practical anchors for epidemiologic indicators [5–6,14,15].

Individual, Interpersonal, Organizational, Community, Policy and Structural Level

Linkages to Epidemiologic Indicators

At individual level, competence and adherence represent HRH knowledge, skills, and protocol adherence are relevant to drive correct session delivery, safe vaccine handling, and accurate tallying and the epidemiologic manifestations include session completion rates, AEFI reporting, and internal consistency of tallies versus

summaries [3, 7,9,11]. Motivation and workload are linked to burnout, competing tasks, and incentives that influence session non-conduct and documentation quality; while the epi signals are the missed sessions, under-documentation, and error rates in data audits that affect the optimization of the scale-up of the uptake by vulnerable and hard-to-reach population [7–9]. The training and feedback derived from supervision coupled with targeted training are relevant for consistently improving the provider practices, reducing stock handling errors, data discrepancies, and increasing valid-dose coverage [7, 9, 11].

Supportive supervision quality encapsulating frequency, content, and relational quality (mentorship, problem-solving, joint data review), predicts sustained practice change; the epi outputs include improved session readiness scores, better cold chain practices, and narrowing of verification ratios over time [7–9]. Peer networks and CBHW linkages covering peer learning and functional ties with community mobilizers strengthen defaulter tracing and outreach efficiency; epidemiologically, this lowers dropout between antigen doses and increases timely vaccination [8,13,20]. Microplanning and operations involving high-quality RED/REW microplans, transport scheduling, and session planning correlate with higher planned-versus-conducted session ratios and ward coverage equity; dashboards should track microplan currency and fidelity [5, 6,19]. Cold chain management comprise preventive maintenance, temperature monitoring, and spare parts availability as are reflected in EVM scores and CCE functionality, condition the stock adequacy and session continuity [9,10,16].

Data systems and routines are operationalized through PRISM-informed determinants (technical, organizational, behavioral) and shape data completeness, timeliness, and accuracy; and the routine RDQA can quantify error domains and guide targeted fixes [11,12]. Resource allocation are linked to the facility petty cash, transport, and per diems which affects outreach conduct, visible in non-conduct reasons and outreach-to-fixed session ratios [3, 5,14]. Trust and demand generation are connected to the community engagement through reconciliation meetings, social mobilization, and local leadership involvement which increases attendance and reduces refusals; and the epi signals include improved age-appropriate immunization, reduced zero-dose prevalence, and stable session utilization [4,13,25].

Defaulter tracking systems are encapsulated in the functional line-listing, home visits, and reminder systems that translate into lower dropout (e.g., Penta1–Penta3, MCV1 uptake) and more balanced micro-catchment coverage [5,13,20]. Contextual barriers inclusive of geography, security, seasonality, and social norms influence unvisited wards and missed sessions; disaggregated analyses (urban–rural, hard-to-reach) reveal patterned gaps requiring tailored outreach [3–5,17]. Governance and accountability are linked to the functionality of Ward/LGA review meetings, performance contracts, and transparent dashboards that are associated with improved ward coverage and reduced intra-district inequities; and the epi focus include converging performance across wards and fewer persistent stockouts [4–6,21].

Financing and supply chains provide predictable operational funding, that affect last-mile distribution, and national stock management standards which reduce stockouts and cancellations; verified in stock adequacy rates and session continuity trends which can be under-optimized due to funding bottlenecks and weak political will [3,4,10,24]. National strategies and guidelines (IA2030, GRISP, RED/REW, and Nigeria's NSIPSS) articulate multi-level actions linkable to indicator frameworks for monitoring microplanning, equity, quality, and data systems [4–6,14,15].

Integrating SEM into Epidemiologic Monitoring and Improvement

Applied mixed-method diagnostics encapsulate the juxtaposition of routine indicators (coverage, dropout, stockouts, CCE uptime, verification ratios) with qualitative inquiry on motivation, supervision, logistics bottlenecks, and community perceptions and attributes causes at the correct SEM level [7–9, 11]. Disaggregated accountability cover the tracking indicators by LGA, ward, settlement type, and outreach modality that aligns with RED/REW equity audits to surface structural gaps [5,6,17]. Data quality by design institutionalizes the PRISM and RDQA cycles within supervision, using rapid feedback towards ensuring the correction of behavioral and organizational determinants of error [11,12]. Learning supervision provides the standardization of supportive supervision with job aids, on-the-spot coaching, and data use rituals (microplan checks, cold chain review, tally reconciliation) to convert visits into measurable quality gains [7–9, 11,14].

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Community co-production is linked to the formalizing ward focal reconciliation meetings, defaulter reviews, and community scorecards to reinforce demand and data validity, tightening the loop between service delivery and social accountability [5,13,29].

Table 2.0 The Socio-Ecological Model in Immunization System

SEM Level	Relevant Factors in RISS	Epidemiologic Linkages
Individual	HRH knowledge, skills, motivation, and adherence to protocols	Training coverage, error rates in data entry, adherence to microplans
Interpersonal	Supervisory relationships, peer mentoring, community-based health worker (CBHW) networks	Frequency and quality of supervision visits, peer review of data
Organizational	Facility leadership, cold chain maintenance, resource allocation	CCE functionality rates, vaccine availability, session implementation
Community	Community trust, engagement in defaulter tracking, local mobilization	Uptake rates, dropout rates, reconciliation meeting frequency
Policy/Structural	LGA-level accountability, funding flows, national immunization guidelines	Ward coverage rates, equity in service delivery, policy compliance

Implications for Program Design and Accountability

Mapping gaps at all levels links specific epidemiologic gaps (e.g., unvisited wards, stockouts, data discrepancies) to SEM drivers (financing delays, maintenance deficits, supervision quality, community trust) enables the selection proportionate interventions. Bundled interventions in the form of combining supervision strengthening with microplan improvement, maintenance protocols, and community engagement ensures the achievement of additive effects on session conduct, equity, and data integrity. Institutionalized review cycles are LGA-led quarterly reviews with SEM-tagged indicators to enable the maintenance on a multi-level determinants to achieve the prevention of regression in coverage and data quality [4–6, 11,14,15,21].

METHODOLOGY

Introduction

This facility-based, exploratory descriptive study was conducted based on RISS data between January and July 2025 from Kogi State, Nigeria. The study followed adapted PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) principles to ensure methodological transparency, reproducibility, and clarity in reporting. The assessment utilized secondary data routinely collected through the Routine Immunization Supportive Supervision (RISS) system, implemented with technical assistance from the World Health Organization (WHO).

Study Design

The study population comprised all health facilities visited by trained supervisors during the study period across all Local Government Areas (LGAs) in Kogi State. Supervisors completed a standardized RISS checklist each, during each visit, capturing data on Service delivery (planned vs. conducted routine

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immunization sessions), Vaccine availability and cold chain functionality, Waste management practices, Community engagement activities and Data quality verification

Eligibility criteria: All RISS checklists submitted between January and July 2025 were eligible. Records were excluded if they were incomplete or of poor quality.

Selection process: The n=505 checklists submitted to the central server with n=54 (11%) excluded, leaving n=451 records for analysis.

Study Area

Kogi State, located in North-Central Nigeria, covers approximately 29,833 km² and is bordered by 10 states and the Federal Capital Territory. The state capital, Lokoja, lies at the confluence of the Rivers Niger and Benue. The National Bureau of Statistics estimates the population at 5.78 million. The state is ethnically diverse (Igala, Ebira, Okun, Nupe, Bassa) and has a tropical climate with distinct wet and dry seasons. The economy is predominantly agrarian, with significant food and cash crop production, alongside mineral resources.

Method of Data Collection and Information Sources

Data were sourced from Routine Immunization Supportive Supervision (RISS) visits conducted across health facilities in Kogi State during the study period. Trained supervisors from National Primary Health Care Development Agency (NPHCDA) (16%), Kogi State Primary Health Care Development Agency (KSPHCDA) (12%), Local Government Health Authority (LGHA) (7%), World Health Organization (WHO) (64%) and UNICEF (1%) used a standardized checklist to record information on service delivery, vaccine availability, cold chain functionality, waste management, community engagement, and data quality.

Data Collection Procedure

During each facility visit, supervisors completed the RISS checklist and uploaded it directly to the WHO central server. Data were reviewed for completeness and accuracy. Only records meeting quality standards were retained for analysis.

Study Instrument

The RISS checklist is a semi-structured, WHO-deployed tool designed for uniform data capture across facilities. It includes both closed and open-ended fields (See Method of Data Collection and Information Sources).

Sampling Technique

A total population sampling approach was applied, including all eligible health facilities visited during the study period. No separate sample size calculation was required, as the dataset represented the entire accessible population. Only complete, good-quality records were analyzed.

Data Analysis

Data were analyzed using descriptive epidemiologic methods to generate frequencies, proportions, and measures of association. For the antenatal care (ANC)–supplementation analysis, both linear regression and binary logistic regression models were applied to quantify the strength of association, proportion of variance explained, Odds ratios (OR) and Statistical significance was set at $p < 0.05$.

Limitation

The study's reliance on secondary RISS data, exclusion of incomplete records, short seven-month timeframe, and focus on Kogi State may limit generalizability and preclude causal inference.

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Presentation of Data

Introduction

The findings from the analysis of Routine Immunization Supportive Supervision (RISS) data collected in Kogi State, Nigeria, between January and July 2025 are presented to provide a focus for analysis and interpretation. In line with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework, results are reported with clear documentation of data sources, inclusion and exclusion processes, and structured presentation of outcomes to ensure transparency and replicability.

TABLE 4.1 Primary Health Care Facilities RISS Trend (January-July 2025) (n=505)

LGA	Jan	Feb	Mar	Apr	May	Jun	Jul	Total RISS
ADAVI	2	1	4	1	13	3	4	28
AJAOKUTA	6	8	6	2	16	1	4	43
ANKPA	5	0	8	3	15	2	2	35
BASSA	3	6	2	2	9	0	2	24
DEKINA	4	3	3	1	10	1	3	25
IBAJI	3	2	2	2	10	1	3	23
IDAH	3	1	2	2	9	1	1	19
IGALAMELA-ODOLU	0	1	1	1	10	1	1	15
IJUMU	4	6	0	0	11	0	1	22
KABBA/BUNU	2	2	1	2	8	2	2	19
KOGI	3	2	3	7	15	1	4	35
LOKOJA	5	6	4	3	22	5	6	53
MOPA-MURO	0	0	9	3	6	2	1	21
OFU	3	2	4	2	11	1	1	24
OGORI/MAGONGO	0	1	0	1	6	0	1	9
OKEHI	4	4	5	4	13	2	3	35
OKENE	1	1	3	0	8	1	3	17
OLAMABORO	0	3	0	0	6	0	0	9
OMALA	0	1	1	1	3	0	1	7
YAGBA EAST	1	2	1	2	8	0	0	14
YAGBA WEST	0	1	1	0	20	3	3	28
Total	**49**	**53**	**60**	**39**	**229**	**27**	**46**	**505**

Source: [32]

The steps for the presentation follow the Data identification (all RISS checklists submitted during the study period), Screening and eligibility (Removal of incomplete or poor-quality records removed), Inclusion (Final dataset analyzed), Results (Descriptive statistics, integrated service delivery patterns, and regression model outputs).

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Table 4.2: Kogi State PHC Facilities RISS - Integrated Services (January-July 2025) (n=505)

LGA	ORS	PCM	Supplements	Vitamin A	Curative services	ANC	None	other	Total RISS
ADAVI	6	8	9	23	7	12	1	0	66
AJAOKUTA	26	28	31	37	28	33	0	2	185
ANKPA	9	15	4	13	21	21	0	0	83
BASSA	2	5	1	20	2	14	0	0	44
DEKINA	9	16	8	20	7	9	2	0	71
IBAJI	6	9	7	14	3	8	0	1	48
IDAH	8	10	10	11	13	13	1	1	67
IGALAMELA-ODOLU	5	7	5	8	4	5	1	0	35
IJUMU	12	12	12	15	14	16	0	2	83
KABBA/BUNU	10	10	12	10	7	15	1	0	65
KOGI	9	14	15	28	27	28	1	0	122
LOKOJA	25	23	25	48	31	27	1	3	183
MOPA-MURO	17	16	16	20	17	17	0	4	107
OFU	12	18	13	16	14	11	4	2	90
OGORI/MAGONGO	6	6	6	9	7	7	0	3	44
OKEHI	21	22	24	29	19	22	2	0	139
OKENE	7	8	6	15	12	12	2	0	62
OLAMABORO	5	4	5	6	2	5	2	0	29
OMALA	4	5	2	5	3	2	1	0	22
YAGBA EAST	13	12	13	13	11	10	0	1	73
YAGBA WEST	27	21	18	26	13	24	0	1	130
Total	**239**	**269**	**242**	**386**	**262**	**311**	**19**	**20**	**1748**

Source: [32]

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Table 4.3: RISS - Model Summary and Parameter Estimates (n=451)

Model	R^2 / Pseudo-R^2	F-statistic	p-value (Sig.)	Constant (β_0)	Slope (β_1 for ANC)
Linear	0.631	32.488	<0.0001	0.404	0.751
Logistic	0.398	12.576	0.002	0.289	0.939

Source:[32]

Note: Dependent variable: SUPPLEMENTATION (probability of clients receiving supplementation), Independent variable: ANC (antenatal care coverage)

PRISMA Flow of Data Records

- **Records identified:** n=505 RISS checklists submitted to the WHO central server.
- **Records excluded:** n=54 (11%) due to incompleteness or poor quality.
- **Records included in analysis:** n=451 (89%) complete, good-quality checklists.

Trends in RISS Visits by LGA

Table 4.1 shows the monthly distribution of RISS visits across LGAs. The highest total visits occurred in Lokoja (n=53), while the lowest were in Omala (n=7). May recorded the highest monthly visits (n=229), and June the lowest (n=27).

Integrated Services Delivered During RISS Visits

Table 4.2 summarizes the range of integrated services provided during RISS visits. The most frequently delivered service was Vitamin A supplementation (n=386), followed by ANC services (n=311). Only 19 visits recorded no additional services.

Statistical Modelling of ANC–Supplementation Relationship

Regression analysis was conducted to assess the association between ANC coverage and supplementation uptake (See Table 4.3).

Narrative Summary of Key Findings

1. **Geographic coverage:** 61% of RISS activities occurred in urban areas; 37% of wards were unvisited; only 3 LGAs achieved ≥80% ward coverage.
2. **Service delivery:** 95% of PHCs had updated REW microplans; 84% of planned RI sessions were conducted.
3. **Barriers to service delivery:** Competing activities (27%), lack of funds (21%), public holidays (20%), and vaccine stockouts (7%).
4. **Vaccine availability:** Adequate in 84% of facilities; notable stockouts for Rota (10%) and Hep-B/IPV/BCG (8%).
5. **Cold chain:** 91% pull system functionality; 89% maintenance compliance; 9% of CCE non-functional.
6. **Community engagement:** 89% reconciliation meetings; 97% defaulter tracking.
7. **Immunization coverage:** 91% of surveyed children appropriately immunized for age.
8. **Data quality:** 11% of reports discarded; discrepancies in Penta3 (8%) and Measles (5%) tallies.

Epidemiologic Interpretation

Linear model: ANC coverage explains **63%** of the variation in supplementation uptake (β_1=0.751, p<0.001).

Each unit increase in ANC coverage is associated with a **0.751 unit increase** in supplementation coverage.

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Logistic model: ANC coverage explains **40%** of the variability in supplementation odds (OR ≈ 2.56, p=0.002). Each unit increase in ANC coverage more than doubles the odds of supplementation.

Public health implication: ANC is a strong, statistically significant predictor of supplementation uptake, with a clear dose–response relationship and temporal plausibility.

Optimization of Integration

Given the high β_1 values in both models, integrating supplementation into every ANC contact

should be standardized as part of ANC service packages. Priority should be given to:

1. Scaling up ANC outreach in low-coverage wards.
2. Embedding supplementation delivery within ANC workflows.
3. Monitoring ANC–supplementation linkage indicators in RISS checklists.

The unexplained variance (37–60%) suggests other determinants such as supply chain reliability, counselling quality, and community demand also influence supplementation uptake and should be addressed in program design.

DISCUSSION

This facility-based, exploratory descriptive study applied an adapted **PRISMA framework** to the analysis of Routine Immunization Supportive Supervision (RISS) data from Kogi State, Nigeria, covering January–July 2025. Although PRISMA is traditionally used for systematic reviews, its core principles; clear eligibility criteria, transparent selection process, and structured reporting; were embedded in the study design to strengthen reproducibility and interpretability.

Transparency in Data Flow and Selection

The PRISMA-aligned flow process ensured that all n=505 RISS checklists submitted during the study period were accounted for, with explicit documentation of exclusions (n = 54; 11%) due to incompleteness or poor quality. This transparent reporting of both included and excluded records reduces the risk of hidden selection bias and allows readers to assess the completeness of the dataset. The final analytic sample (n = 451) thus represents a clearly defined, quality-assured subset of the total records.

Replicability through Standardized Instruments

The use of a WHO-deployed, standardized RISS checklist ensured uniform data capture across multiple supervisory teams and LGAs. This aligns with PRISMA's emphasis on reproducible methodology; another researcher with access to the same tool, timeframe, and inclusion criteria could replicate the study and expect comparable outputs.

Methodological Rigor in Reporting Results

The structured presentation of results from LGA-level visit trends (Table 4.1) to integrated service delivery patterns (Table 4.2) and regression model outputs (Table 4.3) represents PRISMA's requirement for clear, itemized reporting of findings. This approach allows for both granular (LGA-specific) and aggregate (state-wide) interpretation.

Epidemiologic Interpretation

The data reveal important service delivery patterns:

- **Coverage gaps**: 37% of wards were unvisited; only three LGAs achieved ≥80% ward coverage.

- **Service integration**: High delivery of Vitamin A (n = 386) and ANC services (n = 311) during RISS visits suggests strong potential for integrated health interventions.
- **Barriers**: Competing activities, funding gaps, and vaccine stockouts were the main reasons for missed RI sessions.
- **System performance**: Cold chain functionality was high (91%), but 9% of CCE were non-functional, indicating targeted maintenance needs.

The regression analyses provide robust evidence of the **ANC–supplementation linkage**:

- **Linear model**: ANC coverage explained 63% of the variance in supplementation uptake ($\beta = 0.751$, $p < 0.001$).
- **Logistic model**: Each unit increase in ANC coverage more than doubled the odds of supplementation ($OR \approx 2.56$, $p = 0.002$).

The epidemiologic presentation of this dose–response relationship, observed consistently that across both models, a plausible causal pathway: ANC attendance precedes and facilitates supplementation delivery is supported. The strength, consistency, and temporal plausibility of this association align with established public health causality criteria.

Implications for Program Optimization

Applying PRISMA's structured approach to program data analysis has practical benefits:

- **Integration opportunities**: Embedding supplementation into every ANC contact could yield synergistic coverage gains.
- **Targeted outreach**: Prioritizing ANC scale-up in low-coverage wards is likely to improve supplementation uptake.
- **Monitoring**: Including ANC–supplementation linkage indicators in RISS checklists would enable ongoing tracking of integration performance.
- **Addressing residual variance**: The unexplained 37–60% of supplementation uptake variance points to other determinants; such as supply chain reliability, counselling quality, and community demand; that require further investigation.

CONCLUSION

Conclusion

The integration of the Socio-Ecological Model (SEM) with the empirical RISS findings underscores that immunization system performance is the product of interlinked determinants operating at individual, interpersonal, organizational, community, and policy levels. The literature review established that epidemiologic indicators such as coverage, session implementation, vaccine availability, cold chain functionality, and data quality are shaped by layered social and system factors that include health worker competence, supervision quality, facility management, community trust, governance, and financing.

The data analysis, based on the PRISMA-aligned methodology, provided a transparent and replicable account of how these determinants manifest in practice. The data revealed both strengths such as high cold chain functionality, strong community engagement, and high age-appropriate immunization rates and persistent gaps, including unvisited wards, service interruptions due to competing activities and stockouts, and data quality discrepancies. The regression models demonstrated a strong, statistically significant association between antenatal care (ANC) coverage and supplementation uptake, exemplifying how integrated service delivery at the facility level can yield measurable public health gains.

Taken together, the SEM framework explains why these patterns occur, while the PRISMA-derived analysis shows where and to what extent they occur. This dual lens confirms that sustainable improvements in immunization outcomes require multi-level, bundled interventions: strengthening human resource capacity and

supervision, ensuring reliable supply chains, embedding integration of services like supplementation into ANC workflows, and institutionalizing community co-production and accountability mechanisms.

By linking conceptual determinants to measurable epidemiologic outputs, the study demonstrates that program design and monitoring must move beyond isolated indicators to address the structural and behavioural drivers of performance. This approach not only enhances the explanatory power of routine data but also provides a clear, evidence-based pathway for targeted, equitable, and sustainable improvements in immunization service delivery.

Performance management and learning

Recommendations for strengthening Immunization Systems include the following: -

1. Standardize and Institutionalize Supportive Supervision by developing and enforcement of national/LGA supervision protocols with clear frequency, content checklists, and mentorship components and embed on-the-spot coaching, data verification, and microplan review into every supervisory visit.
2. Enhance Health Worker Capacity and Motivation through the implementation of targeted, competency-based training linked to identified gaps from supervision and RDQA findings and introduce non-financial incentives (recognition, career progression) alongside workload balancing to reduce burnout.
3. Strengthen Peer Learning and Community-Based Health Worker (CBHW) Networks by formalizing peer review sessions and cross-facility learning exchanges and integrating CBHWs into defaulter tracking and outreach planning to improve timeliness and coverage.
4. Improve Microplanning Quality and Fidelity through ensuring that all facilities maintain current RED/REW microplans with accurate population estimates and outreach schedules and link microplan updates to quarterly review cycles and track implementation fidelity via dashboards.
5. Optimize Cold Chain and Logistics Management by establishing preventive maintenance schedules, rapid repair mechanisms, and spare parts availability and monitoring CCE functionality and temperature logs in real time to prevent avoidable stock losses.
6. Institutionalize Data Quality Assurance by embedding PRISM and RDQA tools into routine supervision, with rapid feedback loops for correcting errors and promoting a culture of data use at facility and LGA levels through regular data review meetings.
7. Secure Predictable Financing and Resource Flows through advocacy for timely release of operational funds, transport allowances, and outreach per diems and the tracking and publicly reporting funding flows to improve transparency and accountability.
8. Deepen Community Engagement and Co-Production by the formalization of ward-level reconciliation meetings with community leaders, women's groups, and youth representatives and using community scorecards to jointly track coverage, dropout, and service quality.
9. Strengthen Governance and Accountability Mechanisms/cadence through the institutionalization of LGA and ward performance review meetings with SEM-tagged indicators and use of transparent dashboards to track progress, highlight lagging areas, and trigger targeted support.
10. Integrate Services for Efficiency and Impact by the combination of immunization with ANC, growth monitoring, and supplementation to maximize contact opportunities and monitor integrated service delivery indicators to ensure gains in both coverage and quality.

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