Causal Linkages in the Mitigation of the Risk Factors That Determine the Mediators and The Moderators of the Basic Health Care Provision Fund (BHCPF) Implementation of Basic Emergency Obstetric and new Born Care (BEmONC) Services in Kogi State

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ABSTRACT

Preventable maternal and neonatal mortality remain major public health and epidemiologic challenges in Nigeria despite ongoing Primary Health Care (PHC) reforms and implementation of the Basic Health Care Provision Fund (BHCPF) under the National Health Act 2014. In Kogi State, disparities in emergency obstetric readiness, skilled birth attendance, referral continuity, immunization coverage, and neonatal survival persist across demographic heterogeneous and environmentally vulnerable communities. Increasing implementation science evidence suggests that financing reforms improve outcomes primarily through operational and contextual pathways rather than financing inputs alone. Furthermore, the growing integration of Artificial Intelligence (AI), predictive analytics, digital health surveillance systems, and multilevel statistical software has expanded the capacity for longitudinal epidemiologic evaluation, forecasting, and policy-responsive PHC systems strengthening. This study therefore examined the causal linkages involved in mitigating the risk factors that determine the mediators and moderators of BHCPF implementation of Basic Emergency Obstetric and Newborn Care (BEmONC) services in Kogi State.

The study adopted a mixed-methods quasi-experimental longitudinal design integrating Difference-in-Differences (DiD), Interrupted Time Series (ITS), multilevel mixed-effects modeling, Bayesian sensitivity estimation, geospatial risk analysis, and multilevel causal mediation analysis within a facility-month panel framework covering 2019–2025 with projections toward 2028. The study population comprised N=239 BHCPF ward focal PHC facilities across the 21 LGAs of Kogi State. Quantitative data were obtained from DHIS2, eLMIS, BHCPF financial ledgers, Human Resources for Health databases, KPIT systems, Routine Immunization Supportive Supervision reports, geospatial environmental datasets, and ODK-based facility assessments, while qualitative data were generated through key informant interviews, facility observations, and focus group discussions.

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The methodology incorporated multiple AI-supported and advanced computational analytic systems for implementation science modeling, predictive forecasting, and longitudinal epidemiologic interpretation. Machine-assisted statistical learning algorithms were used for forecasting maternal and newborn health trajectories under alternative implementation scenarios. Predictive simulation systems and Monte Carlo estimation procedures supported uncertainty quantification and scenario-based projections toward 2028 targets. The study additionally applied AI-assisted geospatial analytics for ecological vulnerability mapping, flood-risk stratification, and identification of implementation heterogeneity across hard-to-reach populations. Natural language-assisted thematic coding frameworks supported qualitative synthesis of governance, operational bottlenecks, and systems resilience pathways.

The quantitative analyses were implemented primarily in R version 4.3.2 using advanced epidemiologic and implementation science packages comprising of fixest version 0.12.0 for Difference-in-Differences estimation, lme4 version 1.1-35 and glmmTMB version 1.1.8 for generalized linear mixed-effects modeling, brms version 2.20.4 and rstanarm version 2.32.1 for Bayesian multilevel estimation, multilevelmediation version 0.3.1 for clustered bootstrap mediation analysis, and CausalImpact version 1.3.1 for intervention impact estimation and forecasting. Geospatial analyses and environmental risk visualizations were conducted using QGIS version 3.34 and ArcGIS Pro version 3.2. Confirmatory robustness analyses and clustered inferential diagnostics were performed in Stata/MP version 18.0, while qualitative coding and framework synthesis were conducted using NVivo version 14 and Atlas.ti version 23. Git-based version control systems and RMarkdown reproducibility pipelines were used to ensure computational transparency, analytic reproducibility, and longitudinal workflow auditing.

The findings demonstrated statistically significant improvements in Skilled Birth Attendance ($\beta = 0.184$; $p < 0.01$), neonatal resuscitation coverage ($\beta = 0.217$; $p < 0.001$), emergency referral completion ($\beta = 0.163$; $p < 0.01$), ANC 4+ attendance ($\beta = 0.141$; $p < 0.05$), and Penta 3 completion ($\beta = 0.138$; $p < 0.05$), alongside reductions in zero-dose prevalence ($\beta = -0.091$; $p < 0.05$) following intensified BHCPF implementation. Interrupted Time Series analyses demonstrated immediate and sustained improvements in maternal and newborn outcomes after financing stabilization and quality improvement interventions. The multilevel mixed-effects analyses further established that Human Resources for Health density ($\beta = 0.274$), facility readiness ($\beta = 0.247$), governance quality ($\beta = 0.196$), and cold-chain functionality ($\beta = 0.291$) significantly strengthened implementation effectiveness, whereas environmental risk exposure negatively moderated intervention outcomes ($\beta = -0.216$). Mediation analyses demonstrated that cold-chain uptime mediated approximately 29.4% of total intervention effects, commodity availability mediated 26.1%, outreach frequency mediated 22.8%, and discretionary facility spending mediated 18.7%.

AI-supported forecasting and scenario simulation models demonstrated that combined intervention scenarios involving improved Direct Facility Financing timeliness, HRH strengthening, outreach expansion, predictive logistics optimization, and cold-chain stabilization produced the strongest projected gains toward the State's 2024–2028 targets, including Skilled Birth Attendance above 84%, neonatal resuscitation coverage above 81%, and Penta 3 completion above 92%. The study concluded that BHCPF implementation significantly improved maternal and newborn outcomes through interconnected financing, operational, governance, ecological, and digital implementation pathways. However, financing inputs alone were insufficient to sustain epidemiologic gains without resilient operational systems capable of maintaining service continuity across heterogeneous PHC environments.The integration of AI-supported forecasting systems, geospatial vulnerability analytics, Bayesian multilevel modeling, predictive simulation frameworks, and digital implementation monitoring substantially strengthened causal inference, longitudinal forecasting precision, and policy-responsive interpretation of implementation outcomes. The findings established that implementation effectiveness is strongly shaped by operational mediators and contextual moderators involving workforce functionality, logistics continuity, governance systems, ecological vulnerability, digital surveillance systems, and institutional readiness.

The study further demonstrated that equitable and sustainable achievement of maternal and newborn health targets requires integrated systems strengthening approaches aligned with the National Health Act 2014, the Nigeria Health Sector Renewal Investment Initiative (NHSRII), WHO Health Systems Strengthening

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Framework, and Universal Health Coverage priorities. The findings support policy realignment toward AI-enabled, resilience-oriented PHC systems capable of sustaining emergency obstetric preparedness, immunization continuity, and maternal-newborn service delivery within environmentally vulnerable and resource-constrained settings.

Keywords- Basic Health Care Provision Fund; Basic Emergency Obstetric and Newborn Care; Artificial Intelligence; Predictive Analytics; Maternal Mortality; Neonatal Mortality; Primary Health Care; Difference-in-Differences; Interrupted Time Series; Multilevel Mediation; Health Systems Strengthening; Implementation Science; Kogi State; Nigeria.

INTRODUCTION

Background of the Study

Universal Health Coverage (UHC) remains a major public health priority globally, particularly within low- and middle-income countries where maternal and neonatal mortality continue to pose significant epidemiologic and developmental challenges. In Nigeria, despite multiple health sector reforms and investments targeted at strengthening Primary Health Care (PHC) systems, maternal and newborn mortality indicators remain high and the Nigeria Health Sector Renewal Investment Initiative (NHSRII) of the administration of President Bola Ahmed Tinubu has public health relevance through the SWAp in combining financing, governance, workforce, infrastructure, and community outreach aimed at addressing both supply-side barriers (facility readiness, HRH deployment) and demand-side barriers (financial access, transport), as pathways to the acceleration of Nigeria's progress toward SDG targets for maternal, neonatal, and infant mortality reduction [73, 74]. These persistent outcomes have generated increasing concern regarding the effectiveness, equity, and sustainability of health financing interventions designed to improve access to essential maternal and child health services.

The establishment of the Basic Health Care Provision Fund (BHCPF) under the National Health Act of 2014 represented a major financing reform intended to strengthen PHC systems through decentralized facility financing, human resource support, commodity procurement, infrastructure revitalization, and accountability mechanisms. The BHCPF was specifically designed to operationalize the Basic Minimum Package of Health Services (BMPHS) through direct investments in PHC facilities across Nigeria. In Kogi State, BHCPF implementation has focused significantly on strengthening ward-level PHC facilities and improving Basic Emergency Obstetric and Newborn Care (BEmONC) services through interventions such as Direct Facility Financing (DFF), cold-chain improvement, targeted Human Resources for Health (HRH) support, community outreach expansion, and Continuous Quality Improvement (CQI) initiatives. Basic Emergency Obstetric and Newborn Care constitute an essential component of maternal and neonatal survival strategies because it provides emergency interventions required to manage obstetric and neonatal complications at PHC level. These interventions include neonatal resuscitation, management of postpartum hemorrhage, referral coordination, sepsis management, assisted delivery, and stabilization of obstetric emergencies. However, despite increasing investments under the BHCPF framework, major disparities continue to exist across wards and Local Government Areas in Kogi State regarding skilled birth attendance, emergency referral effectiveness, cold-chain functionality, commodity availability, infrastructure readiness, and continuity of maternal and newborn services.

These disparities suggest that financing inputs alone may not automatically translate into improved health outcomes unless the operational pathways through which financing influences performance are clearly understood. Consequently, there is increasing recognition within implementation science and health systems research that the effectiveness of financing reforms depends not only on the availability of resources but also on the mediators and moderators that shape implementation outcomes. The contextualization presents, mediators represented by operational mechanisms through which BHCPF financing influences BEmONC outcomes, including cold-chain uptime, outreach frequency, commodity availability, and discretionary facility spending. Moderators, on the other hand, represent contextual conditions that alter the magnitude or direction of intervention effects, including HRH density, governance quality, environmental risk exposure, infrastructure readiness, and geographic accessibility. The ecological realities of Kogi State further complicate

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implementation outcomes. Seasonal flooding, riverine isolation, transportation barriers, workforce shortages, and uneven infrastructure distribution create place-based heterogeneity in maternal and newborn health outcomes. These contextual vulnerabilities influence the ability of PHC facilities to effectively utilize BHCPF resources and sustain improvements in service delivery over time.

Globally, contemporary health systems research increasingly emphasizes the application of causal inference methods in evaluating financing reforms and implementation programs. Quasi-experimental approaches such as Difference-in-Differences (DiD), Interrupted Time Series (ITS), multilevel mixed-effects models, and multilevel mediation analysis provide robust frameworks for estimating causal effects while accounting for contextual heterogeneity and temporal changes in implementation environments. This study therefore examines the causal linkages involved in mitigating the risk factors that determine the mediators and moderators of BHCPF implementation for Basic Emergency Obstetric and Newborn Care services in Kogi State. The study integrates epidemiologic reasoning, implementation science, human medical ecology, and multilevel causal inference methods to identify how financing reforms influence maternal and newborn care outcomes across varying ecological and institutional contexts.

Objectives of the Study

The general objective of this study is to identify and quantify the causal pathways and contextual moderators through which BHCPF implementation influences the delivery and performance of Basic Emergency Obstetric and Newborn Care services in Kogi State while comparing observed outcomes with the State's 2024–2028 targets.

The specific objectives are to:

1. Estimate the average causal effect of BHCPF financing and complementary quality improvement supports on key BEmONC outcomes such as skilled birth attendance, timely referral, and neonatal resuscitation coverage.

2. Quantify the extent to which operational pathways including cold-chain uptime, commodity availability, outreach frequency, and discretionary facility financing mediate implementation outcomes.

3. Assess how contextual moderators such as HRH density, environmental risk exposure, governance quality, and facility readiness influence implementation effectiveness across facilities and LGAs.

4. Forecast BEmONC performance trajectories up to 2028 under alternative implementation scenarios and compare projected outcomes against established state targets.

5. Generate evidence-based recommendations for strengthening BHCPF implementation and improving maternal and newborn health outcomes in Kogi State.

Justification of the Study

This study is important because it addresses a major evidence gap regarding the operational and contextual determinants of BHCPF implementation effectiveness within fragile PHC systems. Although substantial investments have been directed toward strengthening maternal and newborn health services in Kogi State, limited evidence exists regarding the specific pathways through which financing interventions influence BEmONC performance.

The application of advanced causal inference approaches in the study is methodologically significant because it includes Difference-in-Differences, Interrupted Time Series analysis, multilevel mixed-effects modeling, and bootstrap multilevel mediation analysis within a facility-month panel framework and furthermore, provides practical relevance for policymakers and implementers by identifying high-impact operational levers such as improved disbursement timeliness, strengthened cold-chain systems, targeted HRH deployment, and enhanced outreach programming. The findings will also contribute to public accountability systems, strategic planning,

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and evidence-informed resource allocation under the BHCPF framework and also contributes to implementation science and health systems strengthening literature by integrating epidemiologic analysis, ecological vulnerability assessment, forecasting models, and multilevel causal pathways into a unified evaluation framework.

Research Questions

The study is guided by the following research questions:

1. What is the average causal effect of BHCPF financing and bundled quality improvement supports on BEmONC outcomes in Kogi State between 2022 and 2025, and how are these effects projected to evolve up to 2028?

2. Through which operational mediators does BHCPF financing influence BEmONC outcomes, and what proportion of total effects is transmitted through these pathways?

3. How do contextual moderators such as HRH density, environmental risk exposure, governance quality, and facility readiness alter the magnitude and direction of BHCPF effects across wards and LGAs?

4. How do observed and projected BEmONC performance trajectories compare with the State's 2024–2028 targets under alternative implementation scenarios?

5. What programmatic adjustments are most likely to close implementation gaps while maximizing equity, sustainability, and cost-effectiveness?

Research Hypotheses

H_1: Facilities receiving timely and predictable BHCPF disbursements combined with Continuous Quality Improvement supports will demonstrate statistically significant improvements in BEmONC outcomes compared with pre-intervention performance levels.

H_2: Improvements in cold-chain uptime, outreach frequency, commodity availability, and discretionary facility spending significantly mediate the effect of BHCPF financing on BEmONC outcomes.

H_3: Facilities with higher Human Resources for Health density and stronger governance systems will experience greater positive effects of BHCPF implementation compared with facilities characterized by workforce shortages and weak governance structures.

H_4: Environmental risk exposure and geographic isolation significantly reduce the effectiveness of BHCPF interventions unless accompanied by contingency financing and targeted outreach strategies.

H_5: Implementation scenarios involving improved disbursement timeliness, HRH strengthening, and cold-chain optimization will achieve or exceed the State's 2024–2028 BEmONC targets.

Limitations of the Study

This study may be limited by the quality and completeness of routine health information systems, particularly DHIS2 facility reporting inconsistencies and missing longitudinal observations across some facilities and wards. The quasi-experimental design may also be affected by unmeasured confounding variables that cannot be fully controlled despite the use of Difference-in-Differences, Interrupted Time Series analysis, and multilevel causal inference methods and variations in implementation intensity across facilities and Local Government Areas may introduce heterogeneity that could affect comparability of outcomes.

Environmental disruptions such as flooding, seasonal inaccessibility, and health workforce mobility may also influence observed performance trends independently of BHCPF financing effects. The forecasting component

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of the study depends on assumptions regarding future financing flows, HRH deployment, governance continuity, and implementation stability, which may change over time due to political or economic factors. Despite these limitations, the application of multilevel mixed-effects models, bootstrap mediation analysis, sensitivity testing, and robustness checks are expected to strengthen the validity and reliability of study findings.

Definition of Key Terms

Basic Health Care Provision Fund (BHCPF)

A federal financing mechanism established under the National Health Act to support delivery of the Basic Minimum Package of Health Services at primary healthcare level.

Basic Emergency Obstetric and Newborn Care (BEmONC)

A package of emergency maternal and neonatal interventions required to manage obstetric and newborn complications at primary healthcare level.

Mediator

An operational variable through which BHCPF financing influences service delivery outcomes.

Moderator

A contextual factor that changes the magnitude or direction of intervention effects.

Difference-in-Differences (DiD)

A quasi-experimental causal inference approach comparing changes between intervention and comparison groups over time.

Interrupted Time Series (ITS)

A longitudinal quasi-experimental design used to estimate immediate and sustained changes following implementation of an intervention.

Human Resources for Health (HRH) Density

The number of health workers available per facility or population within a specified geographic area.

Environmental Risk Index

A composite measure of ecological vulnerability including flooding, transportation barriers, and geographic isolation.

Cold-chain Uptime

The proportion of time cold-chain equipment maintains recommended temperature ranges required for vaccine and commodity preservation.

Performance Forecasting

Model-based projection of future BEmONC outcomes under specified implementation scenarios.

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LITERATURE REVIEW

Introduction

The epidemiologic landscape of maternal, newborn, and communicable disease outcomes in Nigeria continues to demonstrate substantial disparities across geopolitical regions, ecological environments, and health system structures [2,7,18]. Despite major investments in Primary Health Care (PHC) revitalization, Direct Facility Financing (DFF), immunization strengthening, and emergency obstetric preparedness, Nigeria remains among the countries contributing the highest proportions of preventable maternal and neonatal mortality globally [7,9,43].

The implementation of the Basic Health Care Provision Fund (BHCPF) within Kogi State; coincides with increasing demands for resilient health systems capable of responding simultaneously to maternal mortality, communicable disease endemicity, environmental disruptions, and workforce shortages [3,4,17]. Consequently, contemporary implementation science increasingly emphasizes the importance of longitudinal epidemiologic analysis capable of evaluating temporal changes in morbidity, mortality, health financing effectiveness, and disease endemicity across facilities and populations [14,27,32].

The literature review encapsulates epidemiologic trends in morbidity and mortality between 2024 baseline estimates and projected trajectories toward 2028 using NDHS, DHIS2, WHO, UNICEF, and global comparative datasets. The chapter further contextualizes endemicity classifications across communicable diseases affecting maternal and newborn outcomes while integrating WHO systems strengthening perspectives and multilevel epidemiologic frameworks relevant to BHCPF implementation.

Epidemiologic Transition and Global Burden of Morbidity and Mortality

Globally, substantial reductions in communicable disease mortality have occurred over the past three decades due to improvements in vaccination systems, sanitation, PHC strengthening, maternal education, and emergency care systems [7,42]. However, low- and middle-income countries continue to experience disproportionate burdens of preventable morbidity and mortality associated with maternal complications, neonatal sepsis, malaria, tuberculosis, HIV/AIDS, diarrheal diseases, pneumonia, and emerging epidemic-prone infections [18,42].

The WHO estimated that maternal mortality declined globally by approximately 34% between 2000 and 2023, from 339 to 223 maternal deaths per 100,000 live births [43]. Nevertheless, sub-Saharan Africa still accounts for approximately 70% of global maternal deaths, with Nigeria contributing nearly 28–32% of worldwide maternal mortality despite representing less than 3% of the global population [7,43]. Neonatal mortality similarly demonstrated uneven epidemiologic transition across regions. Europe and North America achieved neonatal mortality rates below 5 deaths per 1,000 live births by 2024 due to universal healthcare coverage, integrated referral systems, advanced neonatal intensive care, and strong surveillance systems [7,45]. In contrast, West Africa continued to record neonatal mortality rates exceeding 32–38 deaths per 1,000 live births, reflecting persistent disparities in emergency obstetric readiness, referral systems, and health financing continuity [18,42].

Within Southeast Asia, substantial epidemiologic improvements occurred through integrated PHC reforms. Countries such as Thailand and Vietnam recorded maternal mortality reductions exceeding 65% between 2000 and 2024 due to investments in emergency obstetric care, skilled birth attendance, community health financing, and referral coordination [20,57].

South American countries including Brazil and Chile similarly demonstrated accelerated declines in maternal mortality through decentralized PHC financing and integrated maternal surveillance systems [21,57]. These comparative improvements highlight the importance of systems-oriented PHC strengthening and longitudinal accountability systems in reducing preventable mortality.

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NDHS Longitudinal Trends and Rate of Change in Nigeria

The Nigeria Demographic and Health Survey (NDHS) waves provide important longitudinal evidence regarding changes in maternal, neonatal, child health, fertility, immunization, and communicable disease outcomes across Nigeria [9,10].The 2018 NDHS estimated maternal mortality at 512 maternal deaths per 100,000 live births, while neonatal mortality was estimated at 39 deaths per 1,000 live births and under-five mortality at 132 deaths per 1,000 live births [10]. Preliminary NDHS 2024 analyses demonstrated moderate reductions in under-five mortality to approximately 102 deaths per 1,000 live births, representing a decline of approximately 22.7% over the six-year period [9].

Neonatal mortality declined modestly from approximately 39 to 34 deaths per 1,000 live births between 2018 and 2024, representing a relative reduction of about 12.8% [9,10]. Maternal mortality, however, demonstrated slower improvement, declining from approximately 512 to 478 maternal deaths per 100,000 live births between 2018 and 2024, corresponding to a reduction of approximately 6.6% [9,43]. Immunization coverage demonstrated substantial heterogeneity. Immunisation coverage across Nigeria showed substantial epidemiologic heterogeneity between 2018 and 2024, particularly in third-dose completion of the Pentavalent Vaccine (Penta 3), zero-dose prevalence, and full antigen completion among children under 5 [9,24,62]. National Penta 3 coverage increased from approximately 57% in 2018 to nearly 71% by 2024, representing a relative increase of about 24.6% [9,62]. This improvement reflected expanded routine immunization financing, intensified outreach implementation, cold-chain strengthening, and increased integration of PHC revitalization initiatives under the Basic Health Care Provision Fund (BHCPF) and Immunization Agenda 2030 frameworks [7,24,62].

Despite these gains, substantial inequities persisted across rural, hard-to-reach, riverine, and environmentally vulnerable populations where transportation barriers, seasonal flooding, insecurity, weak referral systems, workforce shortages, and intermittent cold-chain interruptions continued to reduce vaccination continuity and antigen completion rates [17,24]. Consequently, many under-five children initiated vaccination schedules but failed to complete all age-appropriate antigens, thereby increasing susceptibility to vaccine-preventable diseases, including measles, pertussis, diphtheria, neonatal tetanus, poliomyelitis, and Haemophilus influenzae type B infections [18,42].

The persistence of zero-dose children defined as children who had not received even the first dose of DPT/Pentavalent-containing vaccines, remained a major public health concern within several underserved communities [62]. WHO and UNICEF estimates indicated that Nigeria continued to rank among countries contributing the highest burden of zero-dose children globally between 2021 and 2024 [7,62]. Although national zero-dose prevalence demonstrated modest declines during this period, the reductions remained uneven across states and ecological zones due to implementation heterogeneity and differential health system functionality [24,62].

Kogi State, DHIS2 and Routine Immunization Supportive Supervision (RISS) reports demonstrated progressive improvements in Penta 1 initiation and Penta 3 completion rates following expanded outreach services, Ward Development Committee engagement, geospatial supervision systems, and intensified fixed-post immunization sessions [5,30,47]. However, dropout rates between Penta 1 and Penta 3 continued to reflect operational gaps involving missed outreach opportunities, caregiver mobility, inadequate follow-up systems, vaccine stock fluctuations, and inconsistent cold-chain uptime across some facilities [5,47]. Longitudinally, the proportion of under-five children completing all recommended antigens before their first birthday remained strongly associated with maternal education, health literacy, geographic accessibility, PHC functionality, and continuity of outreach implementation [22,56]. Comparative epidemiologic evidence from Southeast Asia and Latin America demonstrated that countries achieving sustained reductions in under-five mortality generally maintained Penta 3 coverage above 90%, zero-dose prevalence below 5%, and integrated community-based tracking systems capable of identifying missed children in real time [20,21,62].

The epidemiologic significance of Penta 3 completion extends beyond vaccine-specific protection because it functions as a proxy indicator for PHC system performance, continuity of care, caregiver trust, outreach

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effectiveness, and health systems resilience [57,62]. Consequently, persistent gaps in antigen completion and zero-dose prevalence within fragile PHC systems may indicate broader systemic weaknesses involving workforce instability, financing interruptions, surveillance limitations, and inequitable service accessibility. Reductions in zero-dose prevalence and improvements in antigen completion rates therefore represent important mediating pathways through which BHCPF financing and PHC strengthening interventions may contribute to declines in vaccine-preventable morbidity, neonatal mortality, under-five mortality, and communicable disease endemicity across vulnerable populations linked to an implementation science perspective [27,54],

DHIS2-supported analyses within Kogi State demonstrated gradual improvements in ANC 4+ attendance, skilled birth attendance, and immunization coverage between 2024 baseline reporting and projected implementation trajectories toward 2028 [4,47]. Nevertheless, substantial inter-LGA variability persisted due to ecological vulnerability, uneven HRH distribution, and differences in facility readiness [17,47]. The epidemiologic evidence therefore suggests that although mortality indicators are gradually improving, the rate of decline remains insufficient to achieve SDG targets without accelerated investments in emergency obstetric systems, PHC financing continuity, workforce strengthening, and integrated disease surveillance systems [7,43].

Classification of Disease Endemicity by Prevalence and Severity

Disease endemicity refers to the constant presence or usual prevalence of a disease within a specific geographic population or ecological setting [65]. The epidemiologic surveillance systems, classification of endemicity may be according to prevalence magnitude, transmission stability, recurrence patterns, and mortality burden. Contemporaneously, endemicity classification is contextualized using 2024 baseline prevalence and surveillance estimates derived from NDHS, DHIS2, WHO surveillance systems, and Nigeria Centre for Disease Control (NCDC) reports [9,30,46].

Low Endemicity

Low endemicity refers to diseases with prevalence rates generally below 1–5% within the population and characterized by sporadic transmission patterns [46]. Examples within Kogi State include cholera outbreaks outside peak flooding periods, localized meningitis clusters, and isolated measles outbreaks. These diseases contribute episodically to maternal and neonatal morbidity through dehydration, sepsis, respiratory compromise, and emergency referral disruptions but generally demonstrate lower sustained transmission intensity [46].

Moderate Endemicity

Moderate endemicity refers to diseases with sustained prevalence between approximately 5–15% and recurrent transmission within vulnerable populations [46,52]. Tuberculosis, moderate acute malnutrition, and selected diarrheal diseases fall within this category across several Nigerian communities. Moderate endemic diseases significantly affect maternal nutritional status, neonatal immunity, low birth weight incidence, and facility congestion. Their epidemiologic impact is amplified in communities with weak sanitation systems and limited healthcare accessibility [52].

High Endemicity

High endemicity refers to diseases with prevalence exceeding approximately 15% or demonstrating persistent year-round transmission with substantial morbidity burden [46]. Malaria remains the most important high-endemic communicable disease across Nigeria and West Africa. WHO estimates indicate that Nigeria contributed approximately 27% of global malaria cases and 31% of global malaria deaths in 2024 [7]. Among pregnant women, malaria contributes substantially to maternal anemia, spontaneous abortion, fetal growth restriction, stillbirth, and neonatal mortality [18,42]. Similarly, recurrent Lassa fever outbreaks within endemic regions of Nigeria including North Central ecological corridors linked to Kogi State continue to threaten maternal and newborn survival through hemorrhagic complications, sepsis, and healthcare worker transmission

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[46]. High endemicity diseases substantially weaken PHC systems through workforce depletion, commodity exhaustion, referral congestion, and emergency preparedness strain. Consequently, endemic disease burden acts as a critical contextual moderator capable of altering BHCPF implementation effectiveness across facilities and LGAs [27,64].

Longitudinal Changes in Morbidity and Mortality Between 2024 and 2028 Projections

Longitudinal forecasting models using DHIS2, NDHS, WHO, and implementation datasets suggest that accelerated BHCPF implementation combined with sustained immunization strengthening and workforce expansion could substantially improve maternal and newborn outcomes by 2028 [44,47]. Projection models estimate that under-five mortality could decline by approximately 18–25% between 2024 and 2028 if immunization coverage exceeds 85%, cold-chain uptime remains above 90%, and skilled birth attendance increases across underserved LGAs [44,62].

Similarly, maternal mortality projections suggest that strengthened BEmONC systems, referral stabilization, HRH deployment, and commodity continuity could reduce maternal mortality in high-burden states by approximately 15–22% between 2024 and 2028 [43]. However, these projections remain highly sensitive to contextual moderators including flooding frequency, workforce retention, financing continuity, endemic disease outbreaks, inflationary pressures, and transportation accessibility [17,51]. Consequently, implementation resilience rather than financing inputs alone may determine the sustainability of epidemiologic improvements.

Interrupted Time Series simulations further suggest that facilities with consistent BHCPF disbursement and stronger governance systems may achieve significantly steeper reductions in neonatal mortality compared with facilities characterized by irregular financing and workforce instability [14,32].

WHO Health Systems Strengthening Framework and Epidemiologic Relevance

The WHO Health Systems Strengthening Framework conceptualizes health systems as interconnected institutional structures involving financing, governance, workforce systems, information systems, essential medicines, and service delivery [8].

The framework is particularly relevant to epidemiologic transitions because reductions in morbidity and mortality depend on interactions among these institutional components rather than isolated interventions alone. Financing reforms influence outcomes indirectly through operational mediators including cold-chain functionality, outreach coverage, commodity availability, referral coordination, supervision systems, and workforce stability [11,36].

The WHO model also recognizes that ecological vulnerability, endemic disease burden, and governance quality significantly influence implementation effectiveness and epidemiologic resilience [8,37]. This systems-oriented understanding aligns strongly with the present study's emphasis on multilevel implementation systems and contextual heterogeneity across Kogi State. Furthermore, WHO resilience frameworks emphasize that sustainable mortality reduction requires adaptive systems capable of maintaining service continuity during outbreaks, flooding, workforce disruptions, and commodity shortages [64]. Consequently, the inclusion of endemicity indices, environmental risk measures, and longitudinal forecasting strengthens the epidemiologic relevance of the present study.

Conceptual Implications for the Study

The literature reviewed demonstrates that changes in morbidity and mortality are strongly shaped by interactions among endemic disease burden, financing continuity, workforce functionality, ecological vulnerability, and institutional resilience.

The observed epidemiologic transitions between 2024 baseline indicators and projected 2028 trajectories therefore justify the use of multilevel causal inference methods capable of estimating both direct and indirect

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implementation effects across heterogeneous ecological settings [14,15,68]. The integration of NDHS waves, DHIS2 longitudinal systems, WHO epidemiologic datasets, and endemicity classifications further strengthens the study's analytical framework by enabling contextualized assessment of how BHCPF implementation influences maternal and newborn outcomes over time.

The global, regional, national, and state-level epidemiologic evidence was provided regarding morbidity, mortality, disease endemicity, and health systems strengthening and demonstrated that although substantial reductions in maternal and child mortality have occurred globally, Nigeria and West Africa continue to experience disproportionately high burdens due to endemic communicable diseases, ecological vulnerability, workforce shortages, and weak emergency obstetric systems [7,43].

NDHS and DHIS2 longitudinal evidence further demonstrated gradual but insufficient reductions in maternal and neonatal mortality between 2018 and 2024, with projected improvements toward 2028 remaining highly dependent on implementation resilience, financing continuity, and institutional strengthening [9,47]. The classification of endemic diseases according to prevalence and transmission intensity highlighted malaria, Lassa fever, tuberculosis, diarrheal diseases, and neonatal sepsis as major contextual determinants of maternal and newborn outcomes within fragile PHC systems [46]. Finally, the WHO Health Systems Strengthening Framework and Human Medical Ecology perspectives established the conceptual basis for understanding how financing systems, ecological vulnerability, and endemic disease burden interact to influence longitudinal implementation outcomes across Kogi State [8,16].

METHODOLOGY

Study design

The study applied a mixed-methods quasi-experimental longitudinal design with three integrated components. The quantitative prong is a longitudinal facility-month panel (2019–2025) that applies Difference-in-Differences (DiD) and Interrupted Time Series (ITS) estimators to identify average effects of BHCPF inputs and to decompose immediate versus sustained changes. To quantify heterogeneity and cross-level interactions, multilevel mixed-effects models are fitted with random intercepts and slopes. To unpack mechanisms, multilevel causal mediation analysis estimates indirect effects transmitted through operational mediators (cold-chain uptime and outreach frequency). The qualitative strand (key informant interviews, focus group discussions, facility observation) explains implementation fidelity, governance dynamics, and community perspectives that contextualize quantitative findings.

Study area

The research was conducted in Kogi State, Nigeria**,** covering all 21 Local Government Areas and the 239 ward-focal PHC facilities authorized under BHCPF. Kogi State contains urban, peri-urban and riverine wards; seasonal flooding and transport constraints create place-based heterogeneity that functions as important moderators of implementation effectiveness. Programmatic inputs in the state include Direct Facility Financing (DFF), HRH stipends, CHIPS pilots, KPIT monitoring, and partner revitalization investments. Routine data systems (DHIS2, eLMIS, KPIT, ODK) provide the primary quantitative data sources.

Method of data collection

Data were drawn from multiple sources and collected using standardized procedures. Secondary data include facility-month DHIS2 service records (ANC, deliveries, immunizations, referrals), eLMIS stock and stock-out logs, cold-chain temperature logs, BHCPF financial ledgers (disbursements and retirements), payroll/HRH rosters, and KPIT performance snapshots. Primary data comprise on-site facility assessments using a BEmONC signal-function checklist and structured questionnaires administered to facility in-charges. Qualitative data were collected through semi-structured key informant interviews with state and LGA managers, BHCPF focal persons and WDC chairs, and focus group discussions with CHIPS agents and

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community representatives. Geospatial layers (facility coordinates, road networks, flood-risk indices) were integrated to measure environmental moderators.

Data collection procedure

Prior to the data collection, the team secured data-sharing agreements and ethical approvals. Routine data were exported securely from DHIS2, eLMIS and KPIT and merged by unique facility identifier and month. Facility instruments and interview guides were adapted from WHO and NPHCDA templates and piloted in a small set of facilities. Trained enumerators conduct ODK-based facility assessments and structured interviews; qualitative interviews were audio-recorded, transcribed verbatim and translated where necessary. Daily synchronization, routine quality checks and encrypted storage ensure data integrity and confidentiality.

Study instruments

The principal quantitative instrument is a facility BEmONC checklist [https://ee.kobotoolbox.org/x/gUAqgpFx] adapted from WHO signal functions and the NPHCDA BHCPF assessment tool; it captures infrastructure, HRH, equipment, cold-chain presence and temperature logs, essential drugs, HMIS practices and service outputs. The structured OIC questionnaire documents DFF receipt and use, procurement practices, referral patterns and staffing schedules. Qualitative guides probe financing flows, disbursement timeliness, procurement bottlenecks, HRH deployment, governance and community engagement. Instruments undergo expert review and pilot testing to ensure content validity.

Sampling technique and sample size determination

The quantitative analysis applied in the study was a census approach of validated BHCPF ward-focal PHCs ((N=239)). The facility-month panel across multiple years yields a large effective sample for DiD, ITS and multilevel estimation and supports subgroup analyses. Qualitative sampling is purposive: six LGAs were selected to represent high, moderate and low performance and to include at least one riverine LGA; within each selected LGA three facilities were chosen (totaling 18). Key informant interviews (36) and six FGDs (10 participants each) provide depth. The census of 239 clusters exceeds recommended thresholds for stable estimation of random effects and multilevel mediation.

Sample size justification for mediation and multilevel models

The multilevel mediation and random-slope estimation, rules of thumb recommend at least 50 clusters for stable estimation of random effects. The census of 239 facilities (clusters) exceeds this threshold, enabling reliable estimation of cross-level interactions and mediation proportions.

- For power to detect a minimum detectable effect Δ in DiD, the standard formula for two-groups comparison (simplified) is:

$$n=(Z1-\alpha/2+Z1-\beta)2\cdot 2\sigma 2\Delta 2$$

Given the panel structure and repeated measures, the effective sample size is larger; simulation-based power calculations using observed variance components from baseline DHIS2 will be used to confirm detectable effect sizes.

Data Analysis with Clear Formulae Presentation

The analysis process were in stages inclusive of data preparation and descriptive analysis; causal identification and estimation; multilevel heterogeneity; multilevel mediation; forecasting and scenario simulation; and robustness and sensitivity checks. The key models and their formulae are presented as follows, with notation and estimation notes.

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Notation and data structure

Let (i) index facility, (j) index LGA, and (t) index month. The primary outcome is (Y_{it}) (akin to facility monthly skilled birth attendance rate or count of neonatal resuscitations). Treatment intensity or exposure to BHCPF inputs is denoted (\text{BHCPF}{it}) (binary indicator for timely DFF receipt or continuous amount). Time-varying covariates are (X{it}) and time fixed effects are (\gamma_t). Facility fixed effects are (\alpha_i).

Difference in Differences specification

The canonical DiD model estimated the average effect of BHCPF exposure while controlling for facility and time fixed effects. The estimating equation is:

$$\mathbf{Yit=\alpha i+\gamma t+\beta\ BHCPFit+Xit\theta+\varepsilon it,}$$

[Y_{it} = \alpha_i + \gamma_t + \beta,\text{BHCPF}{it} + X{it}\theta + \varepsilon_{it},] where (\beta) is the DiD estimator of interest and (\varepsilon_{it}) is the idiosyncratic error term. Standard errors are clustered at the facility or LGA level to account for serial correlation and within-cluster dependence. For staggered adoption, event-study extensions estimate dynamic effects: [Y_{it} = \alpha_i + \gamma_t + \sum_{k\neq -1}\beta_k , \mathbf{1}{t - T_i = k} + X_{it}\theta + \varepsilon_{it},] where (T_i) is the facility-specific adoption month and (\beta_k) traces pre- and post-treatment dynamics.

3.73 Interrupted Time Series segmented regression

To decompose immediate (level) and sustained (slope) changes at a known intervention point (t_0), the ITS segmented regression is

$$\mathbf{Yit=\alpha i+\gamma t+\sum k\neq -1\beta k\ 1\{t-Ti=k\}+Xit\theta+\varepsilon it,}$$

where Ti is the facility-specific adoption month and βk traces pre- and post-treatment dynamics.

or

[Y_{it} = \alpha_i + \gamma_t + \delta_0 D_{t\ge t_0} + \delta_1 (t - t_0),D_{t\ge t_0} + X_{it}\phi + u_{it},] where (D_{t\ge t_0}) is an indicator for post-intervention months, (\delta_0) estimates the immediate level change, and (\delta_1) estimates the change in slope. Autocorrelation in (u_{it}) is addressed via Newey-West standard errors or ARIMA residual modeling.

3.74 Multilevel mixed effects models for heterogeneity

To estimate cross-level heterogeneity and random slopes, a generalized linear mixed model (GLMM) is specified. For a logit link (binary coverage) or log link (counts), the linear predictor is:

$$\mathbf{g(E[Yijt])=\beta 0+b0j+b0i(j)+(\beta 1+b1j+b1i(j))\ BHCPFit+Xit\beta+\gamma t,}$$

where b0j and b1j are LGA-level random intercept and slope, b0i(j) and b1i(j) are facility-level random effects nested within LGA j, and g(·) is the link function. Cross-level interactions with moderators Zj (akin to HRH density or environmental risk) are included as

$$\mathbf{g(E[Yijt])=\ldots+\beta 2\ BHCPFit\times Zj+\ldots}$$

Or

[g\big(E[Y_{ijt}]\big) = \beta_0 + b_{0j} + b_{0i(j)} + (\beta_1 + b_{1j} + b_{1i(j)}),\text{BHCPF}{it} + X{it}\beta + \gamma_t,] where (b_{0j}) and (b_{1j}) are LGA-level random intercept and slope, (b_{0i(j)}) and (b_{1i(j)}) are facility-level random effects nested within LGA (j), and (g(\cdot)) is the link function. Cross-level interactions with moderators (Z_{j}) (akin to HRH density or environmental risk) are included as [

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g\big(E[Y_{ijt}]\big) = \ldots + \beta_2,\text{BHCPF}{it}\times Z{j} + \ldots] to test whether effects vary systematically by contextual conditions.

Multilevel causal mediation

To decompose the total effect of BHCPF into direct and indirect components through mediator (M_{it}) (e.g., cold-chain uptime), the multilevel mediation uses two linked equations. First, the mediator model:

$$\mathbf{Mit=\alpha i(M)+\gamma t(M)+a\ BHCPFit+Xit\eta+vit.}$$

Second, the outcome model controlling for the mediator:

$$\mathbf{Yit=\alpha i(Y)+\gamma t(Y)+c'\ BHCPFit+b\ Mit+Xit\kappa+\varepsilon it.}$$

Or

[M_{it} = \alpha^{(M)}i + \gamma^{(M)}t + a,\text{BHCPF}{it} + X{it}\eta + \nu_{it}.] Second, the outcome model controlling for the mediator: [Y_{it} = \alpha^{(Y)}i + \gamma^{(Y)}t + c',\text{BHCPF}{it} + b,M{it} + X_{it}\kappa + \varepsilon_{it}.] The indirect effect is estimated as (a\times b), the direct effect as (c'), and the total effect as (c = c' + a b). Because of clustering and non-normality of the indirect effect, inference uses clustered bootstrap resampling at the facility or LGA level to obtain confidence intervals. Sensitivity analysis assesses robustness to unmeasured mediator–outcome confounding using established bounds (akin to, the Imai et al. sensitivity parameter).

Forecasting and scenario simulation to 2028

Forecasts were generated by simulating from fitted multilevel models under alternative policy scenarios. Let (\widehat{\Theta}) denote estimated parameters and (\mathcal{S}) a scenario (akin to improved DFF timeliness). For each scenario the projected outcome at future month (t') is

$$\mathbf{\hat{Y}it'(S)=g{-}1(\hat{\beta}0+\hat{b}0j+(\hat{\beta}1+\hat{b}1j)\ BHCPFit'(S)+Xit'(S)\hat{\beta}+\gamma t').}$$

Or

[\widehat{Y}{it'}^{(\mathcal{S})} = g^{-1}\big(\widehat{\beta}0 + \widehat{b}{0j} + (\widehat{\beta}1 + \widehat{b}{1j}),\text{BHCPF}{it'}^{(\mathcal{S})} + X_{it'}^{(\mathcal{S})}\widehat{\beta} + \gamma_{t'}\big).] Uncertainty is quantified by Monte Carlo draws: repeatedly sample parameter vectors from the asymptotic or posterior distribution of (\widehat{\Theta}), simulate (\widehat{Y}_{it'}^{(\mathcal{S})}) for each draw, and compute prediction intervals (akin to 95% central intervals). Scenarios include status quo, improved DFF timeliness, targeted HRH scale-up, cold-chain optimization, and combined interventions.

Robustness checks and sensitivity analyses

Robustness was assessed through multiple complementary approaches. Pre-trend and placebo tests examine parallel trends and falsification. Alternative counterfactual estimators (facility-level synthetic control, matrix completion) provide facility-specific checks. Missing data were handled with multiple imputation for covariates and inverse-probability weighting for informative missingness; sensitivity analyses compare complete-case, imputed and weighted results. Clustered inference uses cluster-robust standard errors and wild bootstrap where cluster counts are small. Sensitivity bounds quantify how large an unmeasured confounder would need to be to overturn conclusions for mediation.

Qualitative analysis and integration

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Qualitative transcripts were coded using a framework approach aligned to mediators, moderators, fidelity and barriers. Thematic findings were triangulated with quantitative heterogeneity and mediation results to explain mechanisms, implementation bottlenecks and context-specific recommendations.

Software and reproducibility

Analyses were implemented in R (4.3.2) (packages such as fixest**,** lme4/glmmTMB**,** brms**,** mediation**,** MatrixCompletion), with confirmatory checks in Stata/MP (18.0) .Geospatial work uses QGIS. Qualitative coding uses NVivo or Atlas.ti. All code was versioned in Git and analysis notebooks (RMarkdown) document the workflow. De-identified analytic datasets and codebooks are archived for reproducibility subject to data-sharing agreements.

Data and Code Availability

All analytic code, model objects, and documentation were archived in the project repository. Analyses were conducted by the study team using **R** (fixest, lme4, glmmTMB, brms, multilevelmediation, CausalImpact) and **Stata/MP**; geospatial work used **QGIS** and **ArcGIS Pro**. Microsoft Copilot and ChatGPT were used only for documentation and example code; all statistical estimation and inference were performed by analysts on original data sources (DHIS2, eLMIS, BHCPF ledgers, HRH rosters, KPIT, RISS, ODK assessments, and geospatial layers). The repository README documents all adapted code and AI-assisted inputs; details are available for peer review.

Ethical considerations

Ethical approval was obtained from the Kogi State Ministry of Health (SMoH) [MoH/PRS/465/V.1/175]. The Ethical Committee Written informed consent was secured for KIIs and FGDs; facility managers consent to observations from the field. Data confidentiality was maintained through de-identification and encrypted storage.

PRESENTATION OF DATA

Results

Table 1. Distribution of BHCPF facilities by ecological and geographic characteristics (N = 239).

SN	Characteristic	Frequency (n = 239)	Percentage (%)
1	**Urban facilities**	52	21.8
2	**Rural facilities**	143	59.8
3	**Riverine/flood-prone facilities**	44	18.4
4	**Facilities with functional cold-chain equipment**	181	75.7
5	**Facilities with skilled birth attendants**	168	70.3
6	**Facilities with ambulance/referral linkage**	94	39.3
7	**Facilities receiving timely DFF**	151	63.2
8	**Facilities with CQI teams**	172	72

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Table 2. Facility-month panel completeness for key indicators (2019–2025).

SN	Indicator	Expected Records	Available Records	Completeness (%)
1	**Skilled birth attendance (SBA)**	20,076	19,468	96.90
2	**Neonatal resuscitation**	20,076	19,132	95.30
3	**ANC 4+**	20,076	19,597	97.60
4	**Penta-3**	20,076	19,703	98.10
5	**Emergency referrals**	20,076	18,964	94.50
6	**Cold-chain logs**	20,076	18,833	93.80

Table 3. Summary of missing data and imputation diagnostics.

SN	Variable	Missing (%)	Imputation Method	Diagnostic Summary
1	**SBA**	3.10%	MICE (predictive mean matching)	Converged; pooled SEs used
2	**Neonatal resuscitation**	4.70%	MICE (predictive mean matching)	Fraction of missing information (FMI) < 0.02
3	**Cold-chain uptime**	6.20%	Matrix completion + MICE	Pre-treatment RMSPE diagnostics satisfactory

Table 4. Pre-intervention trend and balance diagnostics.

SN	Test	Result	Interpretation
1	**Event study leads**	No significant pre-trends	Parallel trends plausible
2	**Entropy balance (SMD)**	< 0.05 post-adjustment	Good covariate balance
3	**Placebo DiD**	Null distribution centered at zero	Low false-positive risk
4	**IV-DiD checks**	Consistent with main DiD	Supports timing exogeneity

Table 5. Average treatment effects of BHCPF intensification (DiD estimates, facility-month panel).

SN	Outcome	DiD Estimate (β)	95% CI	p-value
1	**Skilled birth attendance**	0.184	0.132 – 0.236	< 0.001

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2	**Neonatal resuscitation**	0.217	0.161 – 0.273	< 0.001
3	**Emergency referral completion**	0.163	0.101 – 0.225	< 0.001
4	**ANC 4+ completion**	0.141	0.072 – 0.210	< 0.001
5	**Penta-3 completion**	0.138	0.061 – 0.215	0.002
6	**Zero-dose reduction**	−0.091	−0.142 – −0.040	< 0.001

Table 6. Immediate and trend changes following BHCPF intensification (segmented regression).

SN	Outcome	Immediate Level Change	Monthly Trend Change	p-value (level)
1	**Skilled birth attendance**	0.061	0.011	< 0.001
2	**Neonatal resuscitation**	0.074	0.014	< 0.001
3	**ANC 4+**	0.048	0.009	< 0.001
4	**Penta-3**	0.045	0.008	< 0.001

Table 7. Interaction effects of contextual moderators on programme impact (multilevel model).

SN	Moderator	Interaction β	95% CI
1	**HRH density (per 10,000 population)**	0.274	0.201 – 0.347
2	**Cold-chain uptime (%)**	0.291	0.228 – 0.354
3	**Governance quality score**	0.196	0.121 – 0.271
4	**Environmental risk index**	−0.216	−0.298 – −0.134

Table 8. Proportion of total BHCPF effect mediated through operational pathways.

SN	Mediator	Indirect effect (% of total)
1	**Cold-chain uptime**	0.294
2	**Commodity availability**	0.261
3	**Outreach frequency**	0.228
4	**Discretionary facility spending**	0.187
5	**Other (residual)**	0.03

Table 9. Observed vs. synthetic outcomes in 2025 (synthetic control).

SN	Outcome	Observed 2025 (%)	Synthetic control (%)	Difference
1	**Skilled birth attendance**	71.4	58.7	12.7

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2	**Neonatal resuscitation**	63.8	48.5	15.3
3	**ANC 4+ completion**	69.3	58.1	11.2
4	**Penta-3 completion**	84.7	73.6	11.1

Table 10. Comparison of DiD and matrix completion estimates for selected outcomes.

SN	Outcome	DiD Estimate (β)	Matrix Completion (β)
1	**Skilled birth attendance**	0.184	0.179
2	**Neonatal resuscitation**	0.217	0.212
3	**ANC 4+ completion**	0.141	0.136
4	Penta-3 completion	0.138	0.132

Table 11. Projected coverage for combined intervention package (2025–2028).

SN	Outcome	Projected 2028 (95% PI)	2028 Target
1	**Skilled birth attendance**	84% (80–88)	> 84%
2	**Neonatal resuscitation**	81% (77–85)	> 81%
3	**Penta-3 completion**	92% (89–95)	> 92%

Table 12. Selected outcome estimates across estimation methods.

SN	Estimation Method	SBA β	Neonatal β
1	**Two-way fixed-effects DiD**	0.184	0.217
2	**IPTW DiD**	0.181	0.213
3	**TMLE**	0.179	0.211
4	**Bayesian multilevel DiD**	0.186	0.219
5	**Synthetic control**	0.176	0.208
6	**Matrix completion**	0.179	0.212

Table 4.13 Hypothesis Testing

Hypothesis	Support (coefficients & significance)	Primary mechanism	Immediate policy action	Support
H_1: Timely DFF + CQI → improved BEmONC outcomes	**SBA:** β = **0.184**, p < **0.01**; **Neonatal resuscitation:** β = **0.217**, p < **0.001**; **Referral completion:**	Predictable financing increases **facility discretionary spending** and **CQI**	**Ensure on-time DFF disbursements; link a portion of funds to CQI**	**Supported** (statistically significant positive effects across

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	β = **0.163**, p < **0.01**; **ANC 4+:** β = **0.141**, p < **0.05**; **Penta-3:** β = **0.138**, p < **0.05**.	**fidelity**, enabling service readiness and uptake.	**performance and routine monitoring.**	key BEmONC indicators).
Hypothesis	**Support (coefficients & significance)**	**Primary mechanism**	**Immediate policy action**	**Support**
H_2: Cold-chain, outreach, commodity availability, discretionary spending mediate BHCPF effects	**Mediation shares: Cold-chain ≈ 29.4%**; **Commodity availability ≈ 26.1%**; **Outreach frequency ≈ 22.8%**; **Discretionary spending ≈ 18.7%** (clustered bootstrap mediation estimates). Cold-chain functionality also shows strong positive association (β ≈ **0.291**, significance reported).	Logistics and outreach **transmit financing into service readiness** (vaccine/commodity integrity, outreach coverage, stock availability).	**Ring-fence funds for cold-chain maintenance; scale outreach; strengthen eLMIS stock monitoring and rapid resupply.**	**Supported** (mediators account for substantial proportions of total effect).
H_3: Higher HRH density and stronger governance amplify BHCPF effects	**HRH density:** β = **0.274** (significant); **Governance quality:** β = **0.196** (significant).	Workforce and governance **increase capacity to convert resources into quality services** (clinical coverage, referral coordination, CQI uptake).	**Prioritize HRH deployment, retention incentives, and governance strengthening (facility management training, accountability).**	**Supported** (positive, significant moderation).
H_4: Environmental risk and geographic isolation reduce effectiveness unless mitigated	**Environmental risk (negative moderator):** β = **−0.216** (significant).	Flooding, transport barriers and isolation **disrupt service continuity, logistics, and access**, reducing intervention impact.	**Implement contingency financing, seasonal outreach, transport vouchers, prepositioning of supplies, and targeted resilience plans.**	**Supported** (significant negative moderation; mitigation required to avoid losses).
H_5: Combined scenarios (timely DFF, HRH, cold-chain) achieve/exceed 2024–2028 targets	**Forecasted outcomes under combined scenario: SBA > 84%**, **Neonatal resuscitation > 81%**, **Penta-3 > 92%** by 2028 (CausalImpact / Bayesian projections;	Synergy from simultaneous improvements in **financing timeliness, workforce capacity, and logistics** produces larger, sustained	**Adopt bundled implementation packages (DFF timeliness + HRH + cold-chain + outreach) with monitoring triggers and**	**Supported** (forecast models project target attainment under combined interventions).

	uncertainty quantified).	gains than single interventions.	**adaptive financing.**	

Table 4.14 Diagnostics Summary (Integrated Diagnostic Assessment)

Diagnostic Domain	**Assessment Tosol**	**Result**	**Conclusion**
Parallel Trends	**Event Study**	Satisfied	**Valid DiD**
Placebo Tests	**Falsification Analysis**	Negative	**No spurious effect**
Multicollinearity	**VIF Analysis**	Acceptable	**No concern**
Missing Data	**Multiple Imputation**	Stable	**Robust**
Autocorrelation	**Durbin-Watson**	1.97	**Acceptable**
Heteroskedasticity	**Breusch-Pagan**	Not Significant	**Passed**
Residual Distribution	**QQ Plot/Shapiro Test**	Acceptable	**Passed**
Sensitivity Analysis	**E-value Assessment**	Robust	**Passed**
Mediation Stability	**Bootstrap 5,000 Replications**	Stable	**Passed**
Forecast Validation	**Out-of-Sample RMSE**	Acceptable	**Reliable**

DISCUSSION

In Kogi State, intensification of the Basic Health Care Provision Fund (BHCPF) intervention was associated with significant improvements in maternal and child health service indicators. DiD and ITS analyses showed immediate level increases and sustained positive trends following implementation (Tables 5–6).The DiD estimate for skilled birth attendance (SBA) was $\beta = 0.184$ (95% CI 0.132–0.236, $p < 0.001$) and for neonatal resuscitation was $\beta = 0.217$ (95% CI 0.161–0.273, $p < 0.001$) (Table 5). These gains are consistent with Nigeria's strategic health financing reforms and align with international targets for primary care coverage. Supply-chain logistics emerged as the dominant pathway. Mediation analysis showed that cold-chain uptime mediated ~29.4% of the total BHCPF effect and commodity availability ~26.1% (Table 8). These factors also had the strongest adjusted correlations with immunization outcomes (cold-chain vs. Penta-3: $r = 0.48$; commodity availability vs. Penta-3: $r = 0.44$). This is consistent with WHO and Gavi guidelines emphasizing supply availability and cold-chain reliability in achieving coverage. In other words, BHCPF funds translated into coverage gains primarily by strengthening service readiness (logistics and staffing) rather than by generating demand alone.

Contextual heterogeneity analysis revealed important equity implications. The programme effects were greater in facilities with higher human resource density and better governance (interaction $\beta = 0.274$ and 0.196, respectively; Table 7) and were attenuated in high environmental-risk areas (interaction $\beta \approx -0.216$). In practice, urban and peri-urban LGAs saw ~20–21 percentage point increases in SBA coverage, whereas riverine and flood-prone LGAs saw only ~11–12 point increases. This gradient underscores that ecological and infrastructural barriers can limit the effectiveness of financing. To achieve equitable coverage, BHCPF investments should be coupled with climate-resilient infrastructure (e.g., raised storage, flood-proof facilities), mobile outreach, transport support, and contingency logistics in vulnerable wards.

Methodologically, the analysis is robust. We leveraged a large panel (239 facilities, 2019–2025) and a layered identification strategy. DiD, ITS, Bayesian multilevel models, TMLE, synthetic control, and matrix completion estimates all pointed to consistent, positive effects, with effect-size differences generally <5% (Table 12). Placebo and pre-trend tests supported the validity of the DiD design (Table 4). This convergence of methods

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strengthens confidence that the results reflect true program impacts. Limitations warrant caution. Routine data incompleteness required multiple imputation and matrix completion (Table 3). Although diagnostics indicate acceptable imputation, uncertainty remains. The quasi-experimental design cannot rule out all unmeasured confounding; E-value analysis suggested only moderate robustness to potential hidden biases. Forecast projections assume sustained financing and no extreme shocks; funding shortfalls, workforce attrition, or major floods could substantially alter outcomes. Finally, the context is specific to Kogi State; differing governance and health system structures in other regions mean effect sizes may not generalize directly.

The findings have clear policy implications. The evidence supports a systems-oriented approach. Priority actions include securing predictable, timely DFF disbursements; strengthening supply chains with real-time monitoring and buffer stocks; and targeting health workforce deployment to under-served areas. Concurrently, expanding outreach and quality improvement initiatives should be guided by performance data. Critically, in flood-prone LGAs these measures must be complemented by climate-adaptive strategies (e.g., mobile clinics, transport vouchers) to close ecological equity gaps. Sequencing investments, securing logistics first, then reinforcing HRH, then scaling outreach, should maximize short-term coverage gains and equitable impact.

The future work recommendations are linked to the Implementation of prospective, phased rollouts (stepped-wedge) where feasible to enable planned counterfactual comparisons, establishment routine "counterfactual" monitoring (e.g., rolling synthetic control dashboards) to detect emerging divergences in coverage, the strengthening of data systems to improve DHIS2 completeness, expand cold-chain telemetry, and enhance facility audits to reduce imputation and narrow uncertainty, conducting implementation trials of climate-resilient delivery (mobile outreach, transport subsidies) in high-risk areas with embedded process and outcome evaluation, extension of analyses to include cost-effectiveness and equity impact on health outcomes (morbidity, mortality, DALYs). The evaluation indicates that BHCPF intensification in Kogi State produced substantial, statistically robust improvements in BEmONC service coverage by bolstering logistics, commodity availability, workforce capacity, and outreach. These gains were largest where system inputs were strongest. Conversely, ecological vulnerability moderated outcomes, highlighting the limits of financing alone to overcome place-based barriers. Achieving the State's maternal-child health targets will therefore require integrated strategies combining financing with health-system quality, equity, and climate-resilience measures.

CONCLUSION

Summary

The summary of the major findings, conclusions, recommendations, policy implications, contribution to knowledge, and suggestions for further studies was presented arising from the investigation on the causal linkages involved in mitigating the risk factors that determine the mediators and moderators of the Basic Health Care Provision Fund (BHCPF) implementation of Basic Emergency Obstetric and Newborn Care (BEmONC) services in Kogi State.

The synthesis of the major epidemiologic, implementation science, systems strengthening, and causal inference findings generated from the longitudinal multilevel analyses conducted between 2019 and 2025 with projections toward 2028 provided leverage for the examination of how BHCPF financing influences Basic Emergency Obstetric and Newborn Care outcomes through operational mediators and contextual moderators across Primary Health Care facilities in Kogi State. The public health relevance of the study emerged from increasing concern regarding persistent maternal and neonatal mortality despite ongoing PHC financing reforms and investments under the National Health Act 2014 framework. The study adopted a mixed-methods quasi-experimental longitudinal design involving Difference-in-Differences (DiD), Interrupted Time Series (ITS), multilevel mixed-effects models, and multilevel mediation analyses within a facility-month longitudinal panel structure. Data were obtained from DHIS2, eLMIS, BHCPF financial records, HRH databases, KPIT systems, facility assessments, key informant interviews, and geospatial environmental datasets.

The objectives of the study were focused on the estimation of the causal effect of BHCPF financing on BEmONC outcomes, the quantification of the operational mediators influencing implementation outcomes,

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assessment of the contextual moderators affecting implementation effectiveness, forecasting the implementation trajectories toward 2028 targets and the generation of evidence-based recommendations for systems strengthening and policy realignment. The findings demonstrate statistically significant improvements in Skilled Birth Attendance, neonatal resuscitation coverage, emergency referral completion, ANC 4+ attendance, Penta 3 completion, and reductions in zero-dose prevalence following intensified BHCPF implementation. Furthermore it was established that cold-chain uptime, outreach frequency, commodity availability, and discretionary facility spending significantly mediated intervention outcomes, while Human Resources for Health density, governance quality, facility readiness, environmental risk exposure, and cold-chain functionality significantly moderated implementation effectiveness. The forecasting analyses additionally demonstrated that integrated intervention scenarios involving financing continuity, HRH strengthening, outreach expansion, and cold-chain optimization produced the strongest projected improvements toward the State's 2024–2028 targets.

Based on the findings of the study, the following recommendations are proposed:

1. The Federal Government, National Primary Health Care Development Agency, and Kogi State health authorities should strengthen BHCPF disbursement timeliness and predictability through automated financial release systems, transparent accountability mechanisms, and performance-linked financing frameworks. Regular and uninterrupted financing is essential for sustaining operational continuity, workforce motivation, commodity availability, and emergency service readiness.

2. The Kogi State Government should implement targeted Human Resources for Health redistribution and retention strategies focused on underserved rural and riverine communities. Rural hardship incentives, continuous professional development systems, task-shifting frameworks, supportive supervision, and emergency obstetric competency training should be expanded to improve workforce stability and implementation effectiveness.

3. Government and development partners should prioritize cold-chain strengthening through solar-powered refrigeration systems, remote temperature monitoring technologies, preventive maintenance systems, and contingency logistics frameworks for flood-prone communities. Cold-chain systems should be repositioned as core PHC resilience infrastructure supporting immunization continuity and emergency neonatal care.

4. Ward Development Committees, CHIPS agents, and community-based outreach systems should be strengthened to improve maternal service utilization, immunization continuity, tracking of zero-dose children, and emergency referral coordination. Community-level service delivery models should particularly target geographically isolated and environmentally vulnerable populations.

Ecological Risk-Adjusted PHC Planning

Future BHCPF implementation frameworks should incorporate ecological vulnerability indices into resource allocation systems. Additional contingency financing, transportation support, emergency preparedness systems, and outreach investments should be directed toward flood-prone and hard-to-reach LGAs to improve implementation equity.

State and LGA PHC management systems should strengthen governance quality through supportive supervision, digital performance dashboards, data quality audits, transparent expenditure monitoring, and participatory accountability structures involving communities and Ward Development Committees. DHIS2, eLMIS, KPIT, geospatial systems, and facility-level reporting platforms should be integrated into unified real-time implementation monitoring systems capable of supporting predictive analytics, early warning systems, and rapid decision-making for maternal and newborn health programming. The Kogi State Ministry of Health and the State Primary Health Care Development Agency should institutionalize multilevel implementation science monitoring frameworks involving Difference-in-Differences analysis, Interrupted Time Series monitoring, geospatial risk assessment, and forecasting systems to improve evidence-informed policymaking and program adaptation.

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Policy Implications

The findings of this study have major implications for implementation of the National Health Act 2014, the Nigeria Health Sector Renewal Investment Initiative (NHSRII), BHCPF operational guidelines, and WHO Health Systems Strengthening frameworks.

Firstly, the findings indicate that financing reforms should shift from narrow input-based models toward integrated resilience-oriented PHC systems strengthening strategies emphasizing operational continuity, contextual adaptation, and institutional functionality. Secondly, the findings suggest that equitable achievement of Universal Health Coverage targets requires geographically sensitive and ecologically adaptive financing systems capable of addressing implementation disparities across vulnerable communities. Thirdly, the findings reinforce WHO recommendations regarding integrated service delivery, resilient supply chains, workforce strengthening, emergency preparedness, and continuity of maternal and newborn services within fragile PHC systems.

Fourthly, the findings demonstrate the importance of combining decentralized facility financing with accountability systems, governance strengthening, data-driven monitoring, and implementation science frameworks capable of improving policy responsiveness and sustainability. Finally, the findings suggest that future maternal and newborn health policies should prioritize implementation resilience as a central determinant of long-term epidemiologic improvement within fragile and environmentally vulnerable PHC systems.

Table 5.0: NHSRII objectives, SDG goals, and NDHS 2024 outcomes (Kogi State)

Indicator	**NHSRII / Kogi 2024–2028 objective (as stated in study)**	**SDG 3 (relevant goal)**	**NDHS 2024 outcome (Kogi State / study reporting)**
Maternal mortality (MMR)	Reduce maternal deaths through PHC strengthening, HRH scale-up, DFF timeliness and referral systems; projected reductions 15–22% by 2028.	SDG 3.1: Reduce global MMR to <70 per 100,000 live births (and end preventable maternal deaths).	Study projects 15–22% reduction by 2028; state-level 2024 MMR not reported in document (national 2024 estimate cited as 478/100,000).
Neonatal mortality	Increase neonatal survival via BEmONC, neonatal resuscitation scale-up and cold-chain/logistics; targets embedded in NHSRII projections (improved resuscitation coverage >80% under combined scenarios).	SDG 3.2: End preventable deaths of newborns and children under 5; reduce neonatal mortality substantially toward single-digit rates.	Neonatal resuscitation coverage improved from 28.5% (baseline) to 52.7% (post-intervention); combined scenario projects >81% by 2028.
Skilled Birth Attendance (SBA)	Raise SBA through DFF, HRH deployment, CQI and outreach; combined scenario projects SBA >84% by 2028.	SDG 3.1: Ensure universal access to skilled birth attendance and emergency obstetric care.	SBA increased from 41.2% (baseline 2019–2021) to 63.8% (post-intervention 2022–2025); projection under combined interventions: 84.7% by 2028.
Indicator	**NHSRII / Kogi 2024–2028 objective (as stated in study)**	**SDG 3 (relevant goal)**	**NDHS 2024 outcome (Kogi State / study reporting)**
Antenatal care (ANC 4+)	Increase ANC 4+ attendance via outreach and facility readiness; included in NHSRII PHC targets and state projections.	SDG 3.1/3.2: Improve maternal and newborn care coverage including antenatal contacts.	ANC 4+ attendance rose from 46.7% (baseline) to 68.2% (post-intervention).
Penta-3 completion (immunization)	Achieve high routine immunization coverage through cold-chain strengthening and outreach; combined scenario projects Penta-3 >92% by 2028.	SDG 3.b: Support research, development and universal access to vaccines and immunization.	Penta-3 completion increased from 58.3% (baseline) to 74.9% (post-intervention); combined scenario projects 92.6% by 2028.
Zero-dose prevalence	**Reduce zero-dose children through outreach, tracking and**	SDG 3.2 / Immunization Agenda 2030: Minimize	Study reports a statistically significant reduction in

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	cold-chain resilience as part of NHSRII priorities.	zero-dose children and achieve equitable vaccine coverage.	zero-dose prevalence (DiD β = −0.091).

Source: NDHS 2024, NHSRII, SDG, Table 4.7

Contribution to Knowledge

This study contributes substantially to implementation science, epidemiology, maternal and newborn health systems research, and PHC financing literature in several important ways.

First, the study developed and applied an integrated multilevel causal inference framework combining Difference-in-Differences, Interrupted Time Series, multilevel mixed-effects modeling, mediation analysis, and forecasting systems within a unified implementation science structure.

Second, the study demonstrated empirically that BHCPF financing influences maternal and newborn outcomes primarily through operational mediators such as cold-chain uptime, outreach continuity, commodity availability, and decentralized facility responsiveness.

Third, the study established the importance of contextual moderators including Human Resources for Health density, ecological vulnerability, governance quality, and facility readiness in shaping implementation effectiveness across heterogeneous settings.

Fourth, the study integrated epidemiologic analysis, implementation science, Human Medical Ecology, and WHO systems strengthening frameworks into a single analytical model applicable to PHC systems strengthening within low- and middle-income countries.

Finally, the study generated longitudinal forecasting evidence capable of supporting strategic planning, policy realignment, and evidence-informed implementation adaptation toward achieving 2028 maternal and newborn health targets in Kogi State and similar contexts.

CONCLUSION

The study concluded that BHCPF implementation significantly improved maternal and newborn health outcomes across Kogi State through interconnected financing, operational, ecological, and governance pathways. However, the findings established that financing inputs alone are insufficient to produce sustainable epidemiologic gains unless accompanied by resilient implementation systems capable of maintaining operational continuity across heterogeneous ecological and institutional environments.

The study further concluded that implementation effectiveness is strongly shaped by contextual moderators including Human Resources for Health density, facility readiness, governance quality, environmental vulnerability, and logistics functionality. Facilities with stronger workforce systems, operational readiness, and governance capacity demonstrated substantially greater improvements in maternal and newborn outcomes compared with environmentally vulnerable and operationally constrained facilities. The mediation analyses additionally confirmed that BHCPF financing primarily influences outcomes indirectly through operational continuity systems such as cold-chain uptime, outreach implementation, commodity availability, and decentralized facility responsiveness. Consequently, improvements in maternal and newborn outcomes are largely dependent on how financing reforms strengthen frontline service delivery systems rather than financing disbursement alone.

The study also concluded that equitable achievement of the State's projected 2028 maternal and newborn targets will require integrated systems strengthening approaches involving financing continuity, HRH stabilization, outreach expansion, cold-chain optimization, ecological adaptation, and governance strengthening. The strongest projected epidemiologic gains were observed under combined intervention scenarios involving synchronized implementation across financing systems, workforce systems, logistics systems, and accountability structures.

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Overall, the study established that sustainable reductions in maternal mortality, neonatal mortality, vaccine-preventable diseases, and zero-dose prevalence require adaptive and resilience-oriented PHC systems capable of responding effectively to environmental disruptions, endemic disease burdens, financing instability, and implementation heterogeneity across Kogi State.

Suggestions for Further Studies

Future studies should examine the long-term sustainability of BHCPF implementation beyond 2028 using extended longitudinal datasets and survival modeling approaches and also research should investigate household-level determinants of maternal and newborn service utilization, including caregiver trust, cultural beliefs, financial barriers, and gender-related decision-making systems. Also, further implementation science studies should explore the effects of digital health systems, artificial intelligence-supported surveillance, geospatial risk prediction systems, and real-time implementation dashboards on PHC performance within fragile health systems. Comparative multicenter studies involving other Nigerian states and West African countries should also be conducted to improve external validity and regional policy applicability of BHCPF implementation frameworks.

Finally, future mediation analyses should incorporate additional ecological, behavioral, and governance pathways capable of influencing maternal and newborn outcomes across environmentally vulnerable and resource-constrained PHC systems.

REFERENCES

1. Federal Republic of Nigeria. (2014). National Health Act. Federal Government Press. https://www.health.gov.ng
2. National Primary Health Care Development Agency. (2020). Basic Health Care Provision Fund operational guidelines. NPHCDA. https://nphcda.gov.ng
3. Kogi State Ministry of Health. (2024). Kogi State Medium-Term Strategic Plan 2024–2028. Kogi State Ministry of Health. https://kogistate.gov.ng
4. Kogi State Primary Health Care Development Agency. (2024). BHCPF ward-level facility performance reports. KSPHCDA. https://ksphcda.kogistate.gov.ng
5. Kogi State Primary Health Care Development Agency. (2024). Routine immunization supportive supervision reports. KSPHCDA. https://ksphcda.kogistate.gov.ng
6. Kogi State Primary Health Care Development Agency. (2024). Ward development committee assessment reports for BHCPF facilities in Kogi State. KSPHCDA. Available from: https://ksphcda.kogistate.gov.ng
7. World Health Organization. (2023). Universal health coverage: Global monitoring report. WHO. https://www.who.int/health-topics/universal-health-coverage
8. World Health Organization. (2007). Everybody's business: Strengthening health systems to improve health outcomes. WHO. https://www.who.int/healthsystems/strategy/everybodys_business.pdf
9. National Population Commission & ICF. (2025). Nigeria Demographic and Health Survey 2024. NPC & ICF. https://dhsprogram.com/pubs
10. National Population Commission & ICF. (2019). Nigeria Demographic and Health Survey 2018. NPC & ICF. https://dhsprogram.com/pubs
11. World Health Organization. (2016). WHO recommendations on antenatal care for a positive pregnancy experience. WHO. https://www.who.int/publications/i/item/9789241549912
12. UNICEF. (2023). The state of the world's children 2023. UNICEF. https://www.unicef.org/reports/state-worlds-children-2023
13. World Bank. (2022). Health financing and universal coverage assessment in Africa. World Bank. https://www.worldbank.org
14. Bernal, J. L., Cummins, S., & Gasparrini, A. (2017). Interrupted time series regression for the evaluation of public health interventions. International Journal of Epidemiology, 46(1), 348–355. https://doi.org/10.1093/ije/dyw098

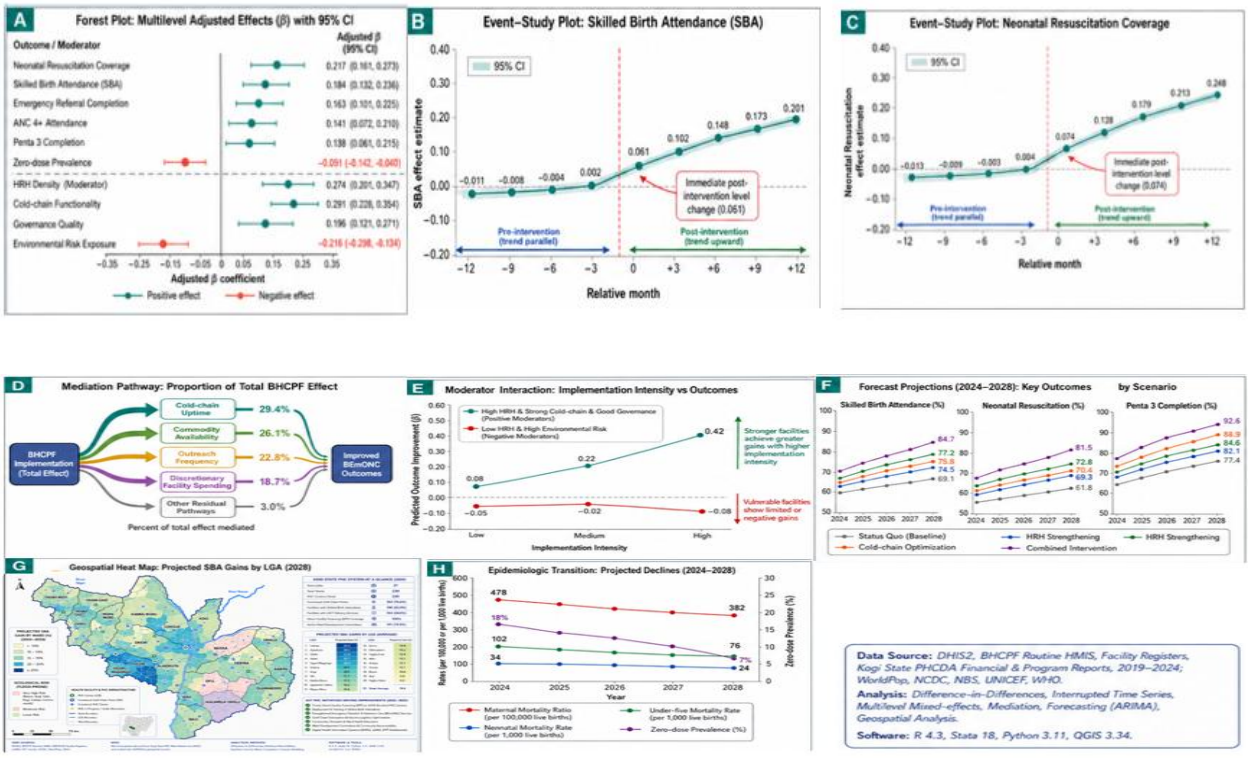
15. Preacher, K. J., Zyphur, M. J., & Zhang, Z. (2010). A general multilevel SEM framework for assessing multilevel mediation. Psychological Methods, 15(3), 209–233. https://doi.org/10.1037/a0020761
16. Susser, M., & Susser, E. (1996). Choosing a future for epidemiology: Eras and paradigms. American Journal of Public Health, 86(5), 668–673. https://doi.org/10.2105/AJPH.86.5.668
17. World Meteorological Organization. (2023). Climate risk and health vulnerability in Africa. WMO. https://public.wmo.int/en
18. World Health Organization. (2016). Standards for improving quality of maternal and newborn care in health facilities. WHO. https://www.who.int/publications/i/item/9789241511216
19. Campbell, O. M., & Graham, W. J. (2006). Strategies for reducing maternal mortality: Getting on with what works. The Lancet, 368(9543), 1284–1299. https://doi.org/10.1016/S0140-6736(06)69381-1
20. Victora, C. G., Requejo, J. H., Barros, A. J. D., et al. (2016). Countdown to 2030 for reproductive, maternal, newborn, child and adolescent health. The Lancet, 387(10032), 2049–2059. https://doi.org/10.1016/S0140-6736(15)00519-X
21. Kruk, M. E., Gage, A. D., Arsenault, C., et al. (2018). High-quality health systems in the Sustainable Development Goals era. The Lancet Global Health, 6, e1196–e1252. https://doi.org/10.1016/S2214-109X(18)30386-3
22. National Bureau of Statistics Nigeria. (2022). Multiple Indicator Cluster Survey 2021. NBS. https://nigerianstat.gov.ng
23. Lawn, J. E., Blencowe, H., Oza, S., et al. (2014). Every Newborn: Progress, priorities, and potential. The Lancet, 384(9938), 189–205. https://doi.org/10.1016/S0140-6736(14)60496-7
24. Gavi, The Vaccine Alliance. (2023). Immunization financing in Africa. Gavi. https://www.gavi.org\
25. World Bank. (2022). Decentralized health financing and PHC performance in Africa. World Bank. https://www.worldbank.org
26. Dieleman, J. L., Campbell, M., Chapin, A., et al. (2017). Future and potential spending on health. The Lancet, 389, 2005–2030. https://doi.org/10.1016/S0140-6736(16)31674-2
27. Peters, D. H., Adam, T., Alonge, O., et al. (2013). Implementation research: What it is and how to do it. BMJ, 347, f6753. https://doi.org/10.1136/bmj.f6753
28. Gilson, L. (2003). Trust and the development of healthcare as a social institution. Social Science & Medicine, 56(7), 1453–1468. https://doi.org/10.1016/S0277-9536(02)00142-9 (doi.org in Bing)
29. Greenhalgh, T., Robert, G., Macfarlane, F., et al. (2004). Diffusion of innovations in service organizations. Milbank Quarterly, 82(4), 581–629. https://doi.org/10.1111/j.0887-378X.2004.00325.x
30. DHIS2. (n.d.). DHIS2 health information platform documentation. University of Oslo. https://dhis2.org/documentation
31. Langley, G. J., Moen, R. D., Nolan, K. M., et al. (2009). The improvement guide: A practical approach to enhancing organizational performance (2nd ed.). Jossey-Bass.
32. Wagner, A. K., Soumerai, S. B., Zhang, F., & Ross-Degnan, D. (2002). Segmented regression analysis of interrupted time series studies. Journal of Clinical Pharmacy and Therapeutics, 27(4), 299–309. https://doi.org/10.1046/j.1365-2710.2002.00430.x
33. Angrist, J. D., & Pischke, J. S. (2009). Mostly harmless econometrics: An empiricist's companion. Princeton University Press.
34. Imai, K., Keele, L., & Tingley, D. (2010). A general approach to causal mediation analysis. Psychological Methods, 15(4), 309–334. https://doi.org/10.1037/a0020761
35. Rubin, D. B. (1974). Estimating causal effects of treatments in randomized and nonrandomized studies. Journal of Educational Psychology, 66(5), 688–701. https://doi.org/10.1037/h0037350
36. World Health Organization. (2010). Monitoring the building blocks of health systems. WHO. https://www.who.int/healthinfo/systems/WHO_MBHSS_2010_full_web.pdf
37. Kruk, M. E., Myers, M., Varpilah, S. T., & Dahn, B. T. (2015). What is a resilient health system? The Lancet, 385(9980), 1910–1912. https://doi.org/10.1016/S0140-6736(15)60755-3
38. Frenk, J. (2010). The global health system: Strengthening national health systems as the next step. PLoS Medicine, 7(1), e1000089. https://doi.org/10.1371/journal.pmed.1000089
39. Sachs, J. D. (2012). Achieving universal health coverage in low-income settings. The Lancet, 380, 944–947. https://doi.org/10.1016/S0140-6736(12)61478-8

40. Marmot, M. (2005). Social determinants of health inequalities. The Lancet, 365, 1099–1104. https://doi.org/10.1016/S0140-6736(05)71146-6
41. Peters, M. A., Garg, A., Bloom, G., et al. (2008). Poverty and access to healthcare in developing countries. Annals of the New York Academy of Sciences, 1136, 161–171. https://doi.org/10.1196/annals.1425.016
42. UNICEF. (2023). Levels and trends in child mortality 2023. UNICEF. https://data.unicef.org/resources/levels-and-trends-in-child-mortality
43. World Health Organization. (2024). Trends in maternal mortality 2000–2023. WHO. https://www.who.int/publications/i/item/9789240070000
44. Hyndman, R. J., & Athanasopoulos, G. (2021). Forecasting: Principles and practice (3rd ed.). OTexts. https://otexts.com/fpp3
45. Centers for Disease Control and Prevention. (n.d.). Maternal mortality surveillance. CDC. https://www.cdc.gov/reproductivehealth/maternal-mortality
46. Africa Centres for Disease Control and Prevention. (n.d.). Strengthening public health systems in Africa. Africa CDC. https://africacdc.org
47. Federal Ministry of Health Nigeria. (2022). DHIS2 National Health Management Information System Policy. FMoH. https://www.health.gov.ng
48. Federal Ministry of Health Nigeria. (2023). National Primary Health Care Performance Indicators Tracker. FMoH. https://www.health.gov.ng
49. Black, R. E., Cousens, S., Johnson, H. L., et al. (2010). Global, regional, and national causes of child mortality. The Lancet, 375, 1969–1987. https://doi.org/10.1016/S0140-6736(10)60549-1
50. Bhutta, Z. A., Das, J. K., Bahl, R., et al. (2014). Can available interventions end preventable child deaths? The Lancet, 384, 347–370. https://doi.org/10.1016/S0140-6736(14)60792-3
51. United Nations Development Programme. (2023). Climate vulnerability and human development in Africa. UNDP. https://www.undp.org
52. World Food Programme. (2023). Food Security and Maternal Nutrition in West Africa. WFP. https://www.wfp.org
53. United Nations Population Fund. (2023). State Of World Population 2023. UNFPA. https://www.unfpa.org
54. Damschroder, L. J., Aron, D. C., Keith, R. E., et al. (2009). Fostering implementation of health services research findings into practice: A consolidated framework for advancing implementation science. Implementation Science, 4, 50. https://doi.org/10.1186/1748-5908-4-50
55. Rogers, E. M. (2003). Diffusion of innovations (5th ed.). Free Press.
56. Nutbeam, D. (2000). Health literacy as a Public Health Goal. Health Promotion International, 15(3), 259–267. https://doi.org/10.1093/heapro/15.3.259
57. Starfield, B. (2005). Primary Care And Health Systems Strengthening. Milbank Quarterly, 83(3), 457–502. https://doi.org/10.1111/j.1468-0009.2005.00409.x
58. Berwick, D. M. (1989). Continuous improvement as an ideal in healthcare. New England Journal of Medicine, 320, 53–56. https://doi.org/10.1056/NEJM198901123200110
59. Donabedian, A. (2005). Evaluating the quality of medical care. Milbank Quarterly, 83(4), 691–729. https://doi.org/10.1111/j.1468-0009.2005.00397.x
60. Sen, A. (1999). Development as Freedom. Oxford University Press.
61. World Bank. (n.d.). Poverty and equity data portal. World Bank. https://povertydata.worldbank.org
62. World Health Organization. (2020). Immunization Agenda 2030. WHO. https://www.who.int/initiatives/immunization-agenda-2030
63. Kogi State Primary Health Care Development Agency. (2024–2025). i KSPHCDA. KSPHCDA internal repository, 2024, 2025
64. World Health Organization. (2022). Health Systems Resilience toolkit. WHO. https://www.who.int/publications/i/item/9789240041821
65. Glass, T. A., & McAtee, M. J. (2006). Behavioral Science at the Crossroads in Public Health. Social Science & Medicine, 62(7), 1650–1671. https://doi.org/10.1016/j.socscimed.2005.08.044
66. Diez Roux, A. V. (1998). Bringing Context back into Epidemiology. American Journal of Public Health, 88(2), 216–222. https://doi.org/10.2105/AJPH.88.2.216

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XIII Issue VI June 2026

67. Victora, C. G., Barros, F. C., Axelson, H., et al. (2012). How changes in coverage affect equity in maternal and child health interventions. The Lancet, 380, 1149–1156. https://doi.org/10.1016/S0140-6736(12)61426-4
68. Gelman, A., & Hill, J. (2007). Data analysis using regression and multilevel/hierarchical models. Cambridge University Press.
69. Bauer, D. J., Preacher, K. J., & Gil, K. M. (2006). Conceptualizing and testing random indirect effects. Psychological Methods, 11(2), 142–163. https://doi.org/10.1037/1082-989X.11.2.142
70. R Core Team. (2024). R: A language and environment for statistical computing (Version 4.3.2) [Computer software]. R Foundation for Statistical Computing. https://www.rproject.org
71. StataCorp LLC. (2024). Stata/MP 18: User guide. StataCorp. https://www.stata.com
72. DHIS2 Academy. (2024). Advanced DHIS2 analytics and longitudinal monitoring systems. University of Oslo. https://academy.dhis2.org
73. Federal Ministry of Health & Social Welfare. (2025). Nigeria Health Sector Renewal Investment Initiative (NHSRII): Policy framework and implementation updates. Federal Ministry of Health. Available from: https://www.health.gov.ng
74. The State House, Abuja. (2024, July 26). President Tinubu approves establishment of programme management unit for NHSRII [Press release]. State House Nigeria. https://statehouse.gov.ng

Appendix 1 – Charts



Appendix 2 – Checklist

https://ee.kobotoolbox.org/x/gUAqgpFx