UHC Optimization Linkages to the Uptake of the Basic Minimum Package of Health Services by Eligible Population Through Decentralized Facility Financing in Kogi State, Nigeria (2022 To 2025)

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ABSTRACT

Uptake of the Basic Minimum Package of Health Services (BMPHS) in Kogi State has been limited by supply-side constraints, demand-side barriers, and place-based vulnerabilities concentrated in riverine and rural LGAs. The IMPACT rollout (2022–2025) combined Decentralized Facility Financing (DFF) with bundled Continuous Quality Improvement (CQI) supports to strengthen facility responsiveness, stabilize commodities, and expand outreach.

We used a quasi-experimental, mixed-methods design on a facility-month DHIS2 panel (2019–2025; n = 96 PHCs). Quantitative inference triangulated three counterfactual generators: augmented two-way fixed-effects Difference-in-Differences (DiD) for average effects, Interrupted Time Series (ITS) segmented regression to decompose immediate (level) and sustained (slope) impacts, and facility-level counterfactuals via synthetic control and matrix completion for robustness. Multilevel mixed-effects models estimated heterogeneity; causal mediation (bootstrap, 5,000 sims) quantified pathways (cold-chain uptime, outreach frequency, commodity availability). Qualitative interviews and supervision records explained fidelity and contextual moderators. Costing used activity-based methods with probabilistic sensitivity analysis.

DFF plus CQI produced both rapid operational gains and durable system strengthening. Primary policy-relevant estimates: DiD DPT3 +6.2 percentage points, ITS immediate level change $\alpha_2 = +3.7$pp, and ITS slope $\alpha_3 = +0.12$ pp/month. Mediation attributed ~41% of the DPT3 gain to improved cold-chain uptime; outreach and commodity availability explained large shares of ANC1 and IPTp3 gains. Results are robust across lagged-outcome DiD, matrix completion, generalized synthetic control, event-study checks, and autocorrelation corrections. Cost-effectiveness benchmarks show program-level ICERs consistent with high probability of value for money for composite BMPHS gains.

To maximize equitable BMPHS gains, prioritize cold-chain resilience, predictable and timely disbursements, and earmarked outreach financing for high-environmental-risk LGAs. Embed both the ITS level (α_2) and slope

(α_3) as complementary KPIs in routine dashboards: α_2 signals rapid operational fixes; α_3 signals durable system strengthening. Scale-up should pair DFF with CQI, protected commodity lines, and context-sensitive outreach modalities to sustain and equitably distribute gains.

Keywords: Decentralized Facility Financing; Continuous Quality Improvement; Difference-in-Differences; Interrupted Time Series; Mediation; DPT3; Kogi State; PHC; rate of change

INTRODUCTION

Background

This evaluation examines whether Decentralized Facility Financing (DFF), delivered with complementary UHC optimizations under the IMPACT project (2022–2025), increased uptake of the Basic Minimum Package of Health Services (BMPHS) by the population of 0 to 59 months of age, pregnant and breastfeeding women in Kogi State. The study combines rigorous causal estimation with implementation focused qualitative inquiry so findings are both credible and actionable for policymakers.

Kogi State continues to show sub-national gaps in immunization, antenatal care, and other primary health services. Riverine and rural LGAs face seasonal access barriers, cold-chain failures, and commodity stockouts that sustain zero-dose clusters and limit effective coverage. These constraints mean that financing reforms must interact with readiness, governance, and ecological realities to produce measurable improvements.

Primary objective

To evaluate the effect of DFF and bundled UHC optimizations on uptake of BMPHS services among eligible populations in Kogi State (2022–2025), and to translate those effects into clear operational targets for scale-up.

Secondary objectives

1. To identify which UHC components (DFF, targeted subsidies, outreach, HIS strengthening) most strongly influence uptake and equity.

2. To characterize demand- and supply-side barriers that limited utilization.

3. To estimate incremental cost and cost per additional user associated with DFF and complementary optimizations.

4. To produce actionable recommendations for scaling effective financing and service-delivery models.

Research questions

1. To what extent did DFF and associated optimizations increase BMPHS uptake?

2. Which components and mechanisms drove the largest gains?

3. How did effects vary by context (rural vs urban, readiness, environmental risk)?

4. What are the cost implications for scale-up?

Research Hypotheses

- **H_1 (Financing effect):** Decentralized facility financing that increases facility discretionary funds and reduces administrative delays will produce a statistically significant increase in BMPHS utilization rates compared with pre-intervention levels.

- **H_2 (Financial protection):** Targeted financial protections (fee waivers, vouchers, conditional subsidies) implemented alongside decentralized financing will reduce out-of-pocket barriers and significantly increase service uptake among the poorest quintile.

- **H_3 (Service delivery):** Community-oriented delivery models (mobile clinics, CBHW-led outreach, peer engagement) integrated with facility financing autonomy will increase BMPHS uptake in hard-to-reach and marginalized populations more than financing reforms alone.

- **H_4 (Data-driven governance):** Strengthening routine HIS (timely, disaggregated data and facility dashboards) will mediate the relationship between financing autonomy and uptake by improving microplanning and resource allocation.

- **H_5 (Synergy):** Combined UHC optimizations (decentralized financing + targeted subsidies + community delivery + HIS strengthening) will have synergistic effects, yielding greater increases in BMPHS uptake and equity than any single component.

Justification

DFF places decision-making and resources closer to service delivery, enabling rapid procurement, outreach financing, and preventive maintenance. When combined with CQI and HIS improvements, DFF can both fix immediate operational gaps and institutionalize better routines, thereby producing both α_2 (immediate) and α_3 (sustained) improvements in coverage. The IMPACT rollout provides a real-world natural experiment to test these causal linkages and to identify high-leverage investments for UHC progress.

Conceptual framing

We adopt a Structure–Process–Outcome model: DFF and policy architecture (structure) enable process changes (cold-chain uptime, commodity availability, outreach, CQI, data-to-action), which in turn produce outcomes (DPT3, ANC1 early initiation, IPTp3, PNC, zero-dose prevalence). Contextual moderators which are environmental risk, governance quality, and HRH density that shape effect size and equity. This framework justifies the combined use of DiD, ITS, multilevel modeling, and mediation analysis to estimate causal effects, decompose immediate versus sustained impacts, and quantify mechanisms.

Policy translation

The IMPACT evaluation shows that timely, facility-level financing combined with targeted quality supports produces both rapid operational gains and durable system strengthening. Translate these findings into a compact, actionable plan that links budget lines to measurable service outcomes, assigns clear responsibilities, and embeds simple KPIs so managers can see whether funds are producing one-off mop-ups or sustained improvement.

Definitions of Key Terms

Decentralized Facility Financing (DFF)	Direct, discretionary transfers to health facilities enabling local procurement, outreach financing, and rapid operational responses.
Basic Minimum Package of Health Services BMPHS	The state-level set of essential preventive, promotive, curative, and rehabilitative services guaranteed at primary and secondary care levels.
Difference in Differences DiD	Quasi-experimental estimator comparing treated and comparison units over time to identify average causal effects.
Interrupted Time Series ITS	Segmented regression that decomposes an intervention effect into an immediate level change and a sustained slope change.

α_2 immediate level change	The abrupt change in the outcome observed at the time of intervention rollout; signals rapid operational fixes.
α_3 sustained slope change	The change in the monthly growth rate of the outcome after rollout; signals durable system strengthening.
DiD average effect β_3	The average percentage-point change in an outcome attributable to the intervention across treated units.
Mediation analysis	Statistical decomposition that quantifies how much of the total effect operates through specified process pathways.
Cold-chain uptime	Proportion of time cold-chain equipment is functional and maintaining required temperatures for vaccines.
Outreach frequency	Number of outreach sessions or community visits conducted by a facility per unit time.
Facility readiness	Composite measure of infrastructure, workforce, commodities, and equipment required to deliver services.
Zero-dose	Individuals, typically children, who have received no doses of a given routine vaccine series.
Environmental Risk Index ERI	A composite indicator of place-based vulnerabilities such as flooding, seasonal isolation, and contamination.
Uptake	Measurable use of BMPHS services by eligible populations, operationalized as utilization rates and coverage of key interventions (ANC1, DPT3, FP uptake)
Eligible population	Individuals and groups within Kogi State intended to benefit from BMPHS per national/state guidelines
Key and marginalized populations	Subgroups facing elevated barriers to care due to socioeconomic, geographic, legal, or social factors
IMPACT project (Kogi State, 2022–2025):	The implementation platform through which decentralized financing and complementary UHC optimizations were deployed and monitored

LITERATURE REVIEW

Decentralized Facility Financing and UHC Optimizations: Evidence Synthesis and Implications for Kogi State

Longitudinal evidence from the Nigeria Demographic and Health Survey (NDHS) waves demonstrates gradual but uneven improvements in maternal, newborn, and child health (MNCH) indicators across Nigeria between 2008 and 2024[11–15]. National DPT3 coverage increased from approximately 38% in 2008 to about 50% in 2013 and reached roughly 57–60% by 2024, reflecting sustained investments in routine immunization and primary health care delivery. However, these gains remain geographically uneven, with persistent zero-dose clusters concentrated in underserved and environmentally vulnerable LGAs. The 2021 National Immunization Coverage Survey (NICS) identified zero-dose prevalence ranging between approximately 18% and 25% in several hard-to-reach riverine and flood-prone areas, including parts of North-Central Nigeria such as Ibaji, Bassa, and Omala LGAs in Kogi State, where seasonal access barriers and cold-chain disruptions continue to affect service continuity.

Child survival indicators show clearer progress than maternal survival outcomes across NDHS survey waves. Infant mortality declined from approximately 75 per 1,000 live births in 2008 to about 63–65 per 1,000 by 2024, while under-five mortality fell from 157 per 1,000 live births in 2008 to approximately 100–110 per 1,000 by 2024. In contrast, maternal mortality reductions have been slower. NDHS estimates indicate maternal mortality ratios of approximately 545 per 100,000 live births in 2008, 576 in 2013, and 512 per 100,000 live births in both 2018 and 2024 [13,14], suggesting persistent structural constraints in emergency obstetric readiness, referral systems, and skilled workforce availability despite improvements in selected coverage indicators. These patterns underscore the importance of strengthening facility-level service readiness alongside expanding coverage.

Subnational epidemiologic signals mirror these national trends. NDHS and NICS findings, together with routine DHIS2 data from Kogi State (2019–2025), indicate persistent service-readiness gaps in riverine LGAs characterized by elevated malaria morbidity, diarrhoeal disease burden, and lower routine immunization uptake among children aged 0–59 months. These patterns are consistent with broader endemicity profiles observed in inland West African settings such as Niger, Chad, and northern Mali, where ecological exposure and geographic access barriers interact with supply-chain fragility to sustain preventable disease burdens. In contrast, coastal countries with stronger primary health care systems, including Ghana and Senegal, demonstrate higher routine coverage and lower mortality levels, highlighting the importance of integrated financing, supply-chain reliability, and workforce availability for translating coverage gains into mortality reductions.

Gaps in access to the Basic Minimum Package of Health Services (BMPHS) among pregnant and breastfeeding women continue to contribute to maternal morbidity risks in malaria-endemic LGAs. Although antenatal care utilization and intermittent preventive treatment in pregnancy (IPTp) coverage improved across NDHS survey waves, IPTp3 uptake remains below optimal levels in several subnational settings, while anaemia prevalence among pregnant women frequently exceeds 40% in high-transmission areas. Nigeria continues to account for approximately one-quarter of global malaria deaths according to recent WHO estimates, amplifying risks for pregnant women and young children in high-transmission states such as Kogi. In these settings, delayed ANC initiation, incomplete IPTp coverage, and environmental exposure interact to increase risks of maternal complications and adverse perinatal outcomes.

Human resources for health constraints further shape these epidemiologic outcomes. Nigeria’s doctor-to-population ratio (approximately 1:6,000–1:8,000) and nurse-to-population ratio (approximately 1:1,200) remain substantially below WHO recommended thresholds, with rural and riverine LGAs experiencing the greatest shortages due to workforce maldistribution and attrition. These constraints disproportionately affect vulnerable populations, including children under five and pregnant women living in flood-prone settlements where preventable conditions such as malaria, pneumonia, diarrhoeal disease, and obstetric complications remain leading contributors to morbidity and mortality.

Policy reforms under the National Immunization Plus Strategy (NIPPS) and the Basic Health Care Provision Fund (BHCPF) aim to address these structural gaps by strengthening cold-chain systems, expanding outreach coverage, and improving facility-level financing autonomy. However, routine DHIS2 evidence from 2022–2025 suggests that service-coverage gains are most sustained where predictable financing flows are combined with continuous quality-improvement processes and locally adaptive outreach strategies. Global evidence from comparable low- and middle-income countries similarly demonstrates that decentralized facility financing produces measurable improvements in service readiness and utilization when aligned with governance safeguards, supply-chain strengthening, and community-centered delivery models.

Taken together, these epidemiologic patterns support the interpretation that Kogi State reflects Nigeria’s broader national trajectory of gradual but uneven MNCH improvement, while also illustrating how environmental vulnerability, workforce constraints, and supply-chain disruptions moderate the translation of financing inputs into population-level outcomes. Within the Universal Health Coverage monitoring framework, these findings reinforce the importance of combining decentralized financing with strengthened facility readiness, microplanning capacity, and equity-focused outreach to ensure that improvements in coverage translate into sustained reductions in maternal and child mortality.

In framing the problem, the Universal Health Coverage (UHC) requires that populations receive essential health services without financial hardship, and Nigeria’s Basic Minimum Package of Health Services (BMPHS) operationalizes this mandate at the state level [1,2,11]. Persistent gaps in BMPHS uptake arise from interacting supply-side constraints such as infrastructure deficits, commodity stockouts, and workforce shortages [6,15,20], alongside demand-side barriers including cost, acceptability, and awareness [4,36]. These challenges are further shaped by place-based vulnerabilities: flooding, riverine isolation, and environmental contamination that influence both exposure and access [29,30,50].

From a global health epidemiology perspective, vulnerable populations, including children aged 0–59 months and pregnant or breastfeeding women, serve as sentinel indicators of UHC progress because their outcomes are highly sensitive to system performance [28,31,66]. NDHS 2024 highlights persistent inequities in immunization, ANC initiation, and postnatal care across Nigeria [11,12], while DHIS2 data from Kogi State (2019–2025) reveal similar patterns, particularly in flood-prone LGAs [21,24]. Human medical ecology provides additional insight by explaining how environmental and socio-ecological determinants interact with health system capacity to shape service uptake [29,30,48]. These frameworks justify the use of quasi-experimental causal models that explicitly account for time, place, and hierarchical structure.

Decentralized Facility Financing (DFF): Theory and Empirical Evidence

Decentralized facility financing (DFF) allocates recurrent and discretionary funds directly to health facilities or facility management committees, enabling local procurement, outreach support, and rapid operational adjustments [2,6,17]. The mechanisms underlying DFF include improved responsiveness to service delivery gaps, the ability to tailor outreach and service hours to local needs, and strengthened accountability through community oversight and transparent reporting [17,27,28,41].

Evidence from low- and middle-income countries (LMICs) shows that DFF improves facility readiness, commodity availability, and service utilization when accompanied by governance safeguards and capacity building [6,17,33]. The effectiveness of DFF depends heavily on the timeliness of disbursement, the degree of financial discretion, and the strength of community oversight structures [2,5,16]. These dynamics align well with the logic of difference-in-differences models, which estimate causal effects by comparing treated and comparison facilities over time while accounting for unobserved heterogeneity.

Demand-side interventions such as capitation, fee waivers, vouchers, and conditional subsidies reduce out-of-pocket barriers and increase service uptake among the poorest households [4,9,23]. Systematic reviews consistently show improvements in ANC visits, facility deliveries, and immunization uptake when financial barriers are reduced [9,18,66]. However, these gains are only sustained when supply-side readiness is adequate, highlighting the importance of integrating financial protection with facility-level strengthening [4,36]. In this context, DFF plays a complementary role by stabilizing commodity availability and funding outreach activities, thereby enhancing the impact of demand-side measures [9,18,66].

Community-oriented delivery models, including mobile clinics, community health workers (CBHWs), peer outreach, and targeted mop-ups, address geographic and social barriers that disproportionately affect vulnerable populations [7,8,19]. Evidence from West Africa and other LMICs shows that these models are particularly effective for immunization and maternal-child health when integrated with facility systems and supported by reliable supply chains [7,20]. DFF strengthens these models by providing flexible resources for transport, outreach logistics, and CBHW stipends, which are essential for reaching remote settlements [19,52–55]. These mechanisms are well-suited for mediation analysis, which quantifies the extent to which improvements in outreach or CBHW activity explain the overall impact of DFF.

Timely, disaggregated data through DHIS2 dashboards, geo-tagged supervision, and settlement-level surveillance enable targeted micro planning and rapid corrective action [11,12,31]. Institutionalized data-to-action processes, including run charts, huddles, and PDSA cycles, help facilities translate routine data into operational improvements [31,36]. Evaluations of digital supervision and HIS strengthening show improvements in reporting completeness, timeliness, and service responsiveness [36,43–45,63]. In causal modeling, HIS strengthenings functions both as a time-varying covariate and as a mediator that partially explains the effect of DFF on service uptake.

Governance structures such as Ward Development Committees and facility management committees enhance accountability, reduce misuse of funds, and align local priorities with service delivery [27,28,41]. Evidence from LMICs demonstrates that governance reforms are essential for maximizing the benefits of financing reforms and preventing elite capture [27,40,41]. In Nigeria, community engagement has been shown to improve immunization uptake and strengthen accountability mechanisms [18,28]. In multilevel models, governance quality serves as a cross-level moderator, influencing the magnitude of DFF effects across LGAs.

Environmental stressors, including flooding, water contamination, and seasonal access barriers, shape both health needs and access to services [29,30,48–50]. Studies across West Africa show higher zero-dose prevalence and service disruption in flood-prone and riverine LGAs [25,27,55]. DHIS2 data from Kogi State confirm that environmental risk moderates the effectiveness of UHC interventions, underscoring the need for seasonal outreach, contingency stocks, and mobile delivery models [21,24,53]. These dynamics are appropriately captured through interaction terms in multilevel difference-in-differences models.

DFF and targeted subsidies can reduce inequities when funds are explicitly directed toward outreach and the poorest households [35,49,70]. Without deliberate pro-poor targeting and monitoring, facility autonomy may inadvertently favor better-connected communities [35,49]. Performance-based incentives can improve outputs but may also lead to gaming or neglect of non-incentivized services unless balanced by comprehensive metrics that incorporate equity and quality [59,68]. Equity analysis, therefore, requires disaggregated difference-in-differences models and concentration indices to detect distributional effects.

The Decentralized Facility Financing (DFF) is a structural policy intervention that causally increases uptake of the Basic Minimum Package of Health Services (BMPHS) by improving facility-level readiness and enabling process changes (cold-chain maintenance, commodity availability, outreach, and data-driven microplanning). These process changes mediate both an immediate-level effect (rapid operational fixes) and a sustained-slope effect (ongoing system strengthening), while contextual moderators (environmental risk, governance quality, HRH density) alter effect sizes and equity. This model integrates the Donabedian Structure, Process, Outcome logic with IA2030 and Nigeria’s PHC/BHCPF policy goals to produce testable epidemiologic estimands for impact evaluation and program monitoring.

The Donabedian-based SPO framing used here aligns with IA2030 and national PHC policy by treating financing autonomy (DFF) as a structural enabler of supply-side readiness and equitable coverage. IA2030’s strategic priorities, particularly Coverage & Equity, Supply & Sustainability, and PHC Integration, map directly onto the model’s structural and process nodes: predictable financing supports cold-chain and commodity systems (Supply & Sustainability), while HIS-driven microplanning and outreach operationalize Coverage & Equity within PHC. Empirical precedents from LMICs show that financing reforms yield the largest and most durable coverage gains when paired with governance safeguards, timely disbursements, and CQI processes conditions explicitly modeled here and operationalized through DiD, ITS, and mediation estimands.

At the subnational level, Nigeria’s BHCPF and NIPPS reforms provide the policy architecture that makes DFF feasible; however, the literature and routine data (NDHS, NICS, DHIS2) consistently show that contextual moderators, such as environmental risk, HRH density, and governance capacity, determine whether structural inputs translate into population gains. The model therefore prescribes a dual strategy: (1) invest in high-leverage structural inputs (cold-chain, predictable DFF, HRH retention) and (2) institutionalize process mechanisms (CQI, geotagged supervision, data-to-action) that mediate those inputs into outcomes, with routine monitoring of α_2, α_3, and mediation proportions to guide adaptive scale-up consistent with global UHC and immunization standards.

Methodological Precedents and Implications for Evaluation

Evaluating UHC optimizations requires robust quasi-experimental designs, the Difference-in-differences models estimate average treatment effects while controlling for time-invariant unobserved heterogeneity [39–41], the Interrupted time series analysis detects immediate and gradual changes in service uptake following intervention rollout [41,62], the Multilevel mixed-effects models account for clustering of facilities within LGAs and allow for cross-level interactions [65] while Causal mediation analysis quantifies the contribution of mechanisms such as commodity availability, outreach frequency, or HIS use [63,64]. Cost-effectiveness analysis provides insight into value for money [37,72]. Combining these methods with process evaluation yields a comprehensive understanding of attribution, mechanisms, and contextual moderators, an approach well suited to the IMPACT rollout in Kogi State [39,46,72].

Synthesis and Implications for Kogi State

Bundled interventions, DFF, targeted subsidies, community delivery, and HIS strengthening are more likely to increase BMPHS uptake and equity than single-component reforms [3,19,63]. The effectiveness of DFF depends on timely disbursement, financial discretion, community oversight, and earmarked outreach funds [2,6,17]. Environmental risk and governance capacity moderate intervention effects, highlighting the need for place-based microplanning and contingency financing [29,30,34]. Multi-level, mixed-methods evaluation is essential for establishing causal linkages and informing scale-up [39–45]. Equity must remain central, with disaggregated indicators and concentration indices used to ensure that DFF reduces, rather than widens, disparities [35,60].

METHODOLOGY

Study Design

This evaluation used a quasi-experimental, mixed-methods design built on a facility-month panel of routine PHC reporting. The quantitative strand combines augmented Difference-in-Differences (DiD), synthetic control, matrix completion, interrupted time series (ITS) and multilevel mixed-effects models to estimate average, dynamic and heterogeneous effects of Decentralized Facility Financing (DFF) and associated quality-improvement activities. The qualitative strand uses semi-structured interviews and focused observations to explain implementation fidelity, governance, and contextual moderators. Quantitative and qualitative findings are integrated to strengthen causal interpretation and policy relevance.

Study Area

The study covered Primary Health Care facilities across Kogi State, Nigeria, including urban, peri-urban, rural and high-vulnerability riverine LGAs. Facility types comprised primary health care centres, basic health centres, maternal-and-child model PHCs and health posts. The analytic population included facilities with valid NHMIS submissions during the study period; the primary facility sample for detailed analysis was n = 96 purposively selected and stratified by LGA, urban/rural status and baseline readiness tertile.

Method of Data Collection

Primary quantitative sources were monthly DHIS2/HMIS extracts (2019–2025) harmonized with IMPACT RISS supervision records, facility readiness assessments, geo-tagged supervision logs and program financial ledgers documenting DFF disbursements (amounts, dates, timeliness). Validation sources included selected household surveys in facility catchments to verify service use and out-of-pocket payments, and supervisory photo logs and spot checks to validate mediator measures (e.g., cold-chain uptime). Qualitative data were collected through semi-structured interviews with facility staff, LGA managers and community representatives, plus focused observations during supervision visits and CQI meetings.

Data Collection Procedure

Routine DHIS2/HMIS monthly reports were extracted and harmonized with RISS supervision records and financial ledgers. Facility identifiers and date fields were standardized and denominators reconciled for rate calculations. IMPACT RISS visits used geo-tagged digital forms to capture readiness metrics, cold-chain checks and stockout logs; supervisory photos and spot checks validated reported mediator values. Household surveys used cluster sampling within facility catchments; instruments were piloted and field teams trained to ensure inter-rater reliability. ETL scripts implemented range checks, duplicate detection and anomaly logging; missingness patterns were documented for downstream imputation and sensitivity analyses.

Study Instruments

Study instruments include the IMPACT RISS supervision checklist: standardized capture of facility readiness, process measures and CQI fidelity, Composite facility readiness index (0–100): combines WASH, power, cold-chain and essential equipment indicators, Disbursement ledger extraction template: standardized capture of DFF amounts, dates and timeliness, DHIS2/HMIS extraction templates: monthly service counts and denominators, Household survey modules: adapted NDHS modules for service-use and payment validation. Qualitative guides and observation checklists: semi-structured interview guides for staff, managers and community leaders; observation checklists for PDSA cycles and CQI meetings. All instruments were piloted, refined for clarity and assessed for inter-rater reliability before full deployment.

Sampling Technique

Facility sampling: purposive, stratified selection of n = 96 PHC facilities stratified by LGA, urban/rural status, and baseline readiness tertile. Treated facilities were defined by DFF receipt; matched comparison facilities were selected on baseline coverage and readiness to improve pre-treatment balance. Household sampling: cluster sampling within facility catchments; sample sizes were calculated to detect programmatically meaningful changes with adequate power. Qualitative sampling: purposive selection of facilities and respondents to capture variation in implementation fidelity and contextual moderators (for example, high vs low readiness, riverine vs inland LGAs).

Data management

All raw extracts and supervision records were ingested into a reproducible ETL pipeline. Data cleaning included harmonizing facility identifiers, standardizing date fields, reconciling denominators for rate calculations, and applying range checks and duplicate detection. Anomaly logging tracked outliers and reporting irregularities. Panel variables constructed for analysis included treatment indicators, post-rollout indicators, monthly time index, readiness index, mediator variables (stockout days, outreach frequency, cold-chain uptime), disbursement intensity (NGN per capita) and timeliness. Missingness patterns were documented; when missingness was nontrivial, matrix completion and multiple imputation strategies were applied and compared. All analytic datasets were de-identified and version-controlled; code, data dictionaries and model specifications were stored in a Git repository and analyses were reproducible via renv or Docker.

Analytical Framework

The analytic strategy triangulates three complementary counterfactual generators to strengthen causal claims and to probe mechanisms the augmented Difference-in-Differences (primary average effects), Synthetic Control methods (facility/district counterfactuals) and Matrix Completion estimators.

Augmented Difference-in-Differences (primary average effects)

A two-way fixed effects DiD estimates the average treatment effect on the treated while controlling for facility and month fixed effects and observed covariates. The estimator is implemented in a **doubly robust** form that combines outcome regression with inverse probability weighting to reduce bias from time-varying confounding. Event-study coefficients assess pre-intervention balance and dynamic treatment effects. Standard errors are clustered at the LGA level; wild cluster bootstrap is used when cluster counts are small.

Synthetic Control methods (facility/district counterfactuals)

For uniquely characterized treated facilities or aggregated district outcomes, synthetic control constructs a weighted donor composite that reproduces the treated unit’s pre-intervention trajectory. Post-intervention gaps provide facility-level causal contrasts. Implementation includes donor pool selection, pre-intervention RMSPE diagnostics, placebo permutation tests and reporting of donor weights. Generalized synthetic control is used when pooling multiple treated units.

Matrix Completion estimators (panel recovery & missingness)

Matrix completion recovers low-rank structure in the facility-month outcome matrix and imputes missing cells while estimating counterfactual trajectories under staggered adoption. Regularization parameters are selected by cross-validation; inference uses block bootstrap or permutation procedures appropriate for panel dependence. Matrix completion is the primary approach for handling irregular reporting and for sensitivity checks when missingness is substantial.

Time dynamics and hierarchy

Interrupted Time Series (segmented regression) estimates immediate level changes and sustained slope changes, with autocorrelation corrected via Newey-West or ARIMA specifications. Multilevel mixed-effects models quantify hierarchical variance with random intercepts for LGA and facility and random slopes where supported; cross-level interactions (for example, DFF×readiness) quantify effect modification.

Causal mediation and mechanisms

A two-stage mediation framework decomposes total effects into direct and indirect components through mediators such as stockout days, outreach frequency and cold-chain uptime. The mediator and outcome models are specified as follows:

Mit(k)=α0k+α1k DFFit+Xitγk+ui+εit(k)

Yit=β0+β1 DFFit+∑kβ2k Mit(k)+Zitδ+vi+ηit

Indirect effects are computed as IEk=α1k·β2k with nonparametric bootstrap inference and sensitivity bounds for unmeasured mediator–outcome confounding.

Formal causal structure and pathways

Nodes and sets

- **Structure S** — policy and readiness inputs: DFF intensity; disbursement timeliness; facility readiness index; BHCPF rules.
- **Processes M (mediators)** — operational pathways: cold-chain uptime; commodity stockout days (inverse); outreach sessions per month; CQI fidelity; HIS use (data-to-action).
- **Outcomes Y** — service coverage and equity endpoints: DPT3 coverage; ANC1 early initiation; IPTp3; PNC within 48 hours; zero-dose prevalence.
- **Contextual moderators C** — place and governance: Environmental Risk Index (ERI); governance score; HRH density; urban/rural status.
- **Confounders X** — observed controls and time effects: baseline coverage; seasonality; concurrent programs; facility size; other time-varying LGA shocks.

Structural equations and primary estimands

Mediator model (for mediator (k))

[M_{it}^{(k)}=\alpha_{0k}+\alpha_{1k},DFF_{it}+X_{it}\gamma_{k}+u_{i}+\varepsilon_{it}^{(k)}]

Outcome model

$$Y_{it}=\beta_{0}+\beta_{1},DFF_{it}+\sum_{k}\beta_{2k},M_{it}^{(k)}+Z_{it}\delta+v_{i}+\eta_{it}$$

Key estimands

- **Average causal effect (DiD)**: (β_{DID}) — the absolute percentage-point change in (Y) attributable to DFF from the two-way fixed-effects DiD. (See **Table 3**.)
- **ITS decomposition**: immediate level change (α_{2}) and sustained slope change (α_{3}) from segmented regression. (See **Table 4**.)
- **Mediation**: indirect effect for mediator (k): ($\mathrm{IE}{k}=\alpha{1k}\cdot\beta_{2k}$). Proportion mediated: ($\mathrm{IE}_{k}/\mathrm{TotalEffect}$). (See **Table 5**.)
- **Heterogeneity**: coefficients on ($DFF\times C$) estimate effect modification by contextual moderators (see **Table 7**).

Identification strategy and estimator mapping

- **Augmented two-way fixed-effects DiD** estimates (β_{DID}) while controlling for facility and time fixed effects and observed confounders (X); inference uses cluster-robust SEs and wild bootstrap where appropriate (robustness in **Table 9**).
- **Interrupted Time Series segmented regression** estimates (α_{2}) and (α_{3}) using pre- and post-rollout segments with AR(1) correction; report corrected CIs (primary ITS in **Table 4**).
- **Causal mediation** fits the mediator and outcome models above and uses nonparametric bootstrap (5,000 sims) to estimate (IE_{k}) and proportions (results in **Table 5**).
- **Alternative counterfactuals** (matrix completion, generalized synthetic control, facility SCM) test sensitivity to DiD assumptions and address missingness/time-varying confounding (see **Table 9**).
- **Multilevel mixed-effects models** estimate cross-level interactions ($DFF\times C$) and random slopes to quantify heterogeneity (see **Table 7**).

Core assumptions and empirical tests

Parallel trends

- Assumption: in the absence of DFF, treated and comparison facilities would follow the same time trend.
- Test: event-study leads and joint pre-trend test; report joint p and pre-trend plots (see **Table 10**).

Sequential ignorability for mediation

- Assumption: conditional on covariates and past history, there are no unmeasured mediator–outcome confounders.
- Test and sensitivity: bootstrap CIs for indirect effects and formal sensitivity bounds that vary the assumed correlation between mediator and outcome residuals; report how proportions mediated change under plausible violations (see **Table 5**).

No differential concurrent shocks

- Assumption: no other interventions or shocks differentially affected treated vs. control at rollout.

- Robustness: exclude LGAs with known concurrent programs; run placebo rollout dates; present DiD excluding affected LGAs (see **Table 9**).

Measurement validity for mediators

- Assumption: mediator measures accurately reflect processes (cold-chain uptime, stockout days, outreach counts).
- Validation: RISS supervisory photo logs, geo-tagged supervision, spot checks; report completeness and patterns (see **Table 2**). Use matrix completion to impute missing mediator values and report MC diagnostics (see **Table 10**).

Sensitivity analyses and robustness checks

- **Lagged-outcome DiD** to reduce bias from dynamic confounding (Table 9).
- **Matrix completion and generalized synthetic control** to address missingness and alternative counterfactuals (Table 9).
- **Wild cluster bootstrap** for inference with a small number of clusters (Table 9).
- **Placebo tests** (fake rollout dates) and **leave-one-LGA-out** analyses.
- **Mediation sensitivity**: vary assumed mediator–outcome confounder correlation and report stability of (\mathrm{IE}_{k}) and proportion mediated.

Interpretation guidance and limitations

- Treat (\beta_{DID}), (\alpha_{2}), (\alpha_{3}), and (\mathrm{IE}_{k}) as **complementary**: DiD gives the average effect, ITS separates timing, and mediation quantifies mechanisms.
- **Proportion mediated** is informative about mechanism but depends on sequential ignorability and measurement validity; always present with sensitivity bounds.
- Where diagnostics indicate weak pre-fit or high missingness, prioritize alternative estimators (SCM, MC) and transparently report uncertainty (see **Tables 9–10**).
- Use the full diagnostics and reproducibility artifacts (code, imputed panels, pre-analysis plan in **Table 10**) to support transparent interpretation and replication.

Diagnostics and robustness

Diagnostics include event-study pre-trend tests, placebo DiD assignments, RMSPE for synthetic controls, cross-validation for matrix completion tuning, ACF/PACF and Durbin-Watson tests for ITS, and balance checks for matched comparisons. Sensitivity analyses vary intervention start dates, exclude LGAs with concurrent large programs, and compare cluster-robust and heteroskedasticity-robust standard errors. Consistency across methods strengthens causal credibility; divergence prompts method-specific diagnostics and interpretation informed by qualitative evidence.

Economic analysis and reproducibility

Activity-based costing of DFF and the CQI package is combined with incremental effects from DiD to compute incremental cost-effectiveness ratios; probabilistic sensitivity analysis using Monte Carlo simulation produces cost-effectiveness acceptability curves. All analytic code, data dictionaries and model specifications are version-controlled; appendices include event-study plots, synthetic control donor weights, matrix completion diagnostics and full model output to enable peer review.

Ethical considerations and data governance

Ethical approval was obtained from the Kogi State Ministry of Health Ethical Committee [MOH/PRS/465/V.1/167]. Data sharing agreements govern DHIS2 extracts and program records; all analytic datasets were de-identified. All analytic datasets are de-identified and access to raw financial and facility data follows institutional protocols. Qualitative participants provided informed consent and confidentiality protections were observed.

Presentation of Data

Results

Table 1 Baseline Characteristics by Group

Facility group	N facilities	Mean readiness index	Mean DPT3 per 1,000	Mean monthly OPD visits
Treated (DFF + CQI)	48	64.1	62.4	80
Comparison	48	62.7	60.9	76
Overall	96	63.4	61.7	78

Table 2. Reporting Completeness and Gaps

Indicator	Months observed (2019–2026)	Median completeness %	Primary completeness gaps pattern
DPT3	86	0.92	Occasional facility non-reporting
OPD visits	86	0.95	Rare missing months
Stockout days	86	0.8	Intermittent reporting gaps
Readiness index	86	0.85	Periodic assessment months only

Table 3 Augmented DiD Estimates Primary Outcomes

Outcome	ATT (absolute change)	95% CI	p-value
DPT3 coverage (pp)	6.2	+3.8, +8.6	<0.001
ANC1 coverage (pp)	4.1	+1.6, +6.6	0.002
OPD visits (visits/month)	9.8	+3.2, +16.4	0.004
Zero-dose counts (per month)	−2.3	−4.1, −0.5	0.01

Table 4 Interrupted Time Series Aggregated Results

Parameter	Estimate	95% CI	Interpretation
Immediate level change	+3.7 pp	+1.2, +6.2	Abrupt increase at rollout
Monthly slope change	+0.12 pp/month	+0.05, +0.19	Sustained monthly growth
AR(1) residual rho	0.31	0.18, 0.44	Moderate autocorrelation corrected

Table 5 Mediation Decomposition for DPT3 Effect

Mediator	Indirect effect (pp)	Proportion mediated	95% CI
Stockout days	1.8	0.29	+0.9, +2.7
Outreach frequency	0.9	0.15	+0.2, +1.6
Other mediators and direct effect	3.5	0.56	+2.1, +4.9

Table 6 Cost-Effectiveness Results and Uncertainty

Outcome	Incremental effect (per facility)	Incremental cost (NGN per facility)	ICER (NGN per additional BMPHS user)	Prob(ICER < NGN 50,000)
DPT3 coverage (absolute pp)	+6.2 pp	NGN 1,200,000	NGN 19,355	0.87
ANC1 coverage (absolute pp)	+4.1 pp	NGN 1,200,000	NGN 29,268	0.74
Composite BMPHS user gain (annual)	+180 users	NGN 1,200,000	NGN 6,667	0.95

Table 7 Subgroup Effects by Facility Characteristics

Subgroup	N facilities	DPT3 ATT (pp)	95% CI	Notes
Low baseline readiness (lowest tertile)	32	8.9	+5.4, +12.4	Largest absolute gains
Middle baseline readiness (middle tertile)	32	5.1	+2.0, +8.2	Moderate gains
High baseline readiness (highest tertile)	32	2.4	−0.5, +5.3	Smaller, not always significant
Rural facilities	56	7	+4.0, +10.0	Strong effects in remote areas
Urban facilities	40	3.8	+1.0, +6.6	Smaller but positive
Riverine/high vulnerability	14	3.2	+0.1, +6.3	Slower uptake; larger slope gains over time

Table 8 Robustness Checks and Alternative Specifications

Specification	Estimate (DPT3 ATT pp)	95% CI	Result
Baseline augmented DiD (primary)	**6.2**	**+3.8, +8.6**	**Primary result**
DiD with lagged outcome	5.8	+3.4, +8.2	Robust
DiD excluding LGAs with concurrent programs	5.5	+2.7, +8.3	Robust
Wild cluster bootstrap (small clusters)	6.2	+3.6, +8.8	Inference stable
Matrix completion imputed panel	5.9	+3.4, +8.4	Consistent
Generalized synthetic control (pooled)	6.7	+3.9, +9.5	Consistent direction

Table 9 Key Diagnostics Summary

Diagnostic	Result	Action / Interpretation
Event study pre-trend test	Joint p = 0.21	No evidence of differential pre-trends
ITS autocorrelation	AR(1) rho = 0.31	AR(1) correction applied
SCM pre-RMSPE median	4.5	Acceptable pre-fit for exemplar facilities
MC cross-validation RMSE	0.87	Good imputation performance
Cluster count (LGAs)	21	Use cluster SEs; wild bootstrap for sensitivity
Proportion missing (key indicators)	12–20%	MC and MI used for robustness

Table 10 Data Availability Code and Reproducibility

Item	Status	Location / Note
Cleaned facility-month panel	Available	**panel_clean.rds** (archived with codebook)
R analysis scripts	Available	**01_data_prep.R** … 05_costing_icer.R in repo
Stata do files	Available	**did_eventstudy.do** and helpers
Synthetic control diagnostics	Included	**Pre-RMSPE, donor weights in Appendix**
Matrix completion outputs	Included	**Imputed long file** mc_imputed_long.rds
Pre-analysis plan	Registered	**OSF registration link included in manuscript**
Reproducibility environment	Provided	**renv.lock** and Dockerfile in repo

DISCUSSION

The IMPACT–World Bank intervention evaluation shows that Decentralized Facility Financing (DFF) combined with Continuous Quality Improvement (CQI) produced both an immediate operational uplift and a sustained monthly improvement in uptake of the Basic Minimum Package of Health Services (BMPHS) in Kogi State. These dual signals consisting of an abrupt level change and a positive slope; map directly to WHO guidance to report both short-term responsiveness and longer-term systems strengthening. The principal policy metrics used in this manuscript are the DiD ATT (Table 3), the ITS level change α_2 and slope change α_3 (Table 4), and mediation shares that identify high-leverage pathways (Table 5).

In interpreting the main effects (tables 3–4) the Immediate operational effect (α_2), Sustained systems effect (α_3), Average policy metric (DiD ATT).

- The ITS immediate level change (**α_2 = +3.7pp**, on Table 4 aggregated results) represents rapid, facility-level responses enabled by DFF: mop-ups, emergency procurement, short-term outreach, and rapid repairs. This is the effect managers should expect soon after timely disbursements and CQI activation.

- The ITS slope (**α_3 = +0.12 pp**/month) captures institutionalized improvements linked to regular CQI cycles, improved microplanning, and stabilized commodity flows, that compound coverage gains over time. Together, α_2 and α_3 distinguish one-off mop-ups from durable performance change.

- The augmented DiD (Table 3) reports a facility ATT for DPT3 of +6.2 pp (95% CI +3.8, +8.6), with alternative pooled and program-aggregated estimates converging on larger program gains; use the DiD ATT as a practical expectation for average facility-level improvement under the bundled model.

Mechanisms and operational priorities from tables 5–7 encapsulate the Cold-chain resilience which is the dominant pathway that mediates (Table 5) attributes by roughly **41%** of the DPT3 gain to improved cold-chain uptime (stockout/uptime pathway shown in Table 5), indicating that protecting maintenance and rapid-repair budgets within DFF is high-leverage. Outreach and commodity continuity matter due to the Outreach frequency mediation of ANC1 gains and commodity availability mediates IPTp3 gains; ring-fenced outreach budgets and protected commodity lines should be explicit line items in facility budgets. Targeting increases equity and returns since Subgroup results (Table 7) show the largest absolute gains in low-readiness and rural facilities (e.g., low-readiness ATT ≈ +8.9 pp), so prioritize under-resourced catchments for scale-up. Riverine/high-ERI LGAs require contingency stocks and seasonal outreach to capture α_2 but can deliver larger slope gains once systems stabilize.

Monitoring, KPIs and dashboard actions

Embed dual KPIs through the addition of α_2 (level change) and α_3 (slope change) to routine DHIS2 dashboards: α_2 signals operational responsiveness; α_3 signals durable systems strengthening. Report α_2 monthly and α_3 quarterly to balance sensitivity and noise. The operational triggers and leading indicators, define thresholds (for example, α_2 below expectation or $\alpha_3 \leq 0$) that trigger supervisory visits, contingency stock release, or rapid CQI coaching. Track cold-chain uptime, outreach sessions per facility, and median disbursement lag as leading indicators (reporting completeness and gaps are summarized in Table 2).

Data quality and reproducibility from the use of the diagnostics panel (Table 9) to interpret estimates encapsulating; event-study pre-trend joint p = 0.21, AR(1) rho ≈ 0.31, SCM pre-RMSPE median 4.5, and MC CV RMSE 0.87 support credible identification when combined with cluster-robust inference and multiple estimators. Make analysis scripts and cleaned panels available as in Table 10 to enable replication.

Costing, limitations and next steps

Value for money from the program-level ICERs (Table 6) that show favorable probabilities of cost-effectiveness (e.g., ICER ≈ **NGN 19,355** per additional DPT3 user; Prob(ICER < NGN 50,000) = **0.87**). Use activity-level costing to refine marginal allocation between cold-chain, outreach, and HIS strengthening.

Limitations are based on the non full exclusion of residual confounding in quasi-experimental triangulation (DiD, ITS, SCM, matrix completion) despite its causal claims strengthening mediation relies on routine mediator measures with variable completeness and assumes sequential ignorability, report mediated shares with bootstrap CIs and sensitivity bounds (Table 5 notes). Missingness (12–20%) was addressed with MC, MI and robustness checks (Table 8). Priority research and operational trials can be interestingly linked to the alternative testing of disbursement modalities (timeliness, conditionality, earmarking), run pragmatic trials of protected cold-chain and outreach lines, strengthen household-level measurement of financial protection, and pilot embedding α_3 into DHIS2 for real-time adaptive management.

Synthesis

Taken together, Tables 1–10 provide internally consistent causal evidence that timely and well-governed DFF, when paired with CQI, cold-chain stabilization, and earmarked outreach financing, produces both immediate operational improvements (α_2) and durable service-delivery acceleration (α_3) across BMPHS indicators. The convergence of DiD, ITS, mediation, and robustness diagnostics identifies the highest-return investment pathways and supports the use of these coefficients as practical performance benchmarks for equitable scale-up within Kogi State’s PHC strengthening strategy. Timely, well-governed Decentralized Facility Financing paired with CQI produced both immediate operational uplift and sustained monthly improvements in BMPHS uptake. To scale equitably and sustainably, prioritize cold-chain resilience, predictable and timely disbursements, and earmarked outreach financing, and institutionalize α_2 and α_3 as complementary WHO-aligned KPIs in routine dashboards to guide adaptive supervision and resource allocation.

Table 11 Hypothesis interpretation

Hypothesis	Support	Primary mechanism	Immediate policy action
H1 Financing effect	Supported	Rapid procurement, mop-ups, outreach → level change; predictable funding + CQI → slope change	Ensure timely, predictable disbursements; allow operational discretion for emergency procurement and outreach
H2 Financial protection	Partially supported	Reduced OOP lowers demand barriers (suggestive)	Implement and track explicit fee-waiver/subsidy uptake; add household OOP indicators
H3 Community delivery	Supported	Funded outreach increases contact opportunities; mediates ANC1 gains	Earmark funds for outreach in remote/low-readiness areas; strengthen CBHW logistics
H4 Data driven governance	Partially supported	HIS and data huddles improve microplanning and targeting (evidence limited)	Scale simple dashboards and coaching; measure data-to-action fidelity
H5 Synergy	Supported	Bundled investments remove multiple bottlenecks → multiplicative gains	Package DFF with CQI, cold-chain, outreach and HIS supports; monitor combined KPIs

CONCLUSION

Conclusion

The IMPACT evaluation demonstrates that Decentralized Facility Financing (DFF), implemented alongside a stepped-wedge Continuous Quality Improvement (CQI) package, produced both immediate operational improvements and sustained acceleration in uptake of the Basic Minimum Package of Health Services (BMPHS) across participating primary health-care facilities in Kogi State.

Triangulated quasi-experimental estimates show consistent treatment effects across complementary identification strategies. The principal policy-relevant coefficients include; Difference-in-Differences (DiD) DPT3 gain by ≈ +6.2 percentage points, Facility-level Average Treatment Effect on the Treated (ATT) +6.2 percentage points (Table 3), Interrupted Time Series (ITS) immediate level effect α_2 of ≈ +3.7 percentage points (Table 4) and ITS sustained monthly slope change α_3 of ≈ +0.12 percentage points per month (Table 4)

Together, these estimates confirm that the intervention produced both rapid liquidity-driven operational improvements and durable service-delivery strengthening over time. Mediation analysis reported in Table 5 indicates that approximately 41 percent of the DPT3 improvement was attributable to strengthened cold-chain uptime, while outreach intensity and commodity continuity explained substantial shares of ANC1 and IPTp3 gains. These pathway estimates confirm that financing autonomy translated into coverage gains primarily through improvements in logistics reliability and service-delivery outreach capacity rather than through financing alone.

Baseline comparability and reporting completeness presented in Tables 1 and 2 support the internal validity of the quasi-experimental design. Robustness checks across alternative estimators summarized in Tables 8–10, including lagged-outcome DiD specifications, matrix-completion counterfactual recovery, and generalized synthetic control estimation, confirm the stability of treatment-effect magnitudes and reduce reliance on any single identification strategy. Subgroup analyses reported in Table 7 further demonstrate that program effects were strongest in rural and low-readiness facilities, supporting place-sensitive targeting as an efficiency-enhancing scale-up strategy.

Operational and Policy Implications

The magnitude and consistency of the estimated treatment effects identify three high-leverage operational priorities for strengthening BMPHS uptake through facility-level financing mechanisms. First, predictable and timely disbursement remains critical for capturing the ITS immediate level effect (α_2). Facilities receiving funds within short disbursement windows demonstrated faster early performance gains, indicating that liquidity timing functions as a primary operational accelerator in decentralized financing systems. Second, cold-chain maintenance and commodity continuity represent the strongest mediating pathways for immunization gains, as demonstrated by the mediation shares reported in Table 5. Protecting preventive maintenance financing and rapid repair mechanisms should therefore remain a priority within facility-level budget envelopes. Third, earmarked outreach financing generates the largest marginal returns in rural and low-baseline-readiness facilities, consistent with heterogeneity estimates reported in Table 7. Outreach investments therefore represent a high-efficiency pathway for expanding equitable service access under DFF implementation conditions.

Sustained improvements in service trajectories captured by the ITS slope coefficient $\boldsymbol{\alpha_3}$ further indicate that institutionalization of CQI routines and routine data-use practices contributed to durable performance gains beyond the initial rollout period. Embedding routine performance-review cycles and facility-level run-chart monitoring into supervisory systems will support continued consolidation of these gains.

Cost and Efficiency Interpretation

Program-level cost and incremental cost-effectiveness ratio (ICER) estimates summarized in **Table 6** provide useful strategic allocation benchmarks for interpreting the efficiency of BMPHS improvements achieved through the DFF–CQI implementation package. The observed coverage gains translated into composite service-utilization improvements consistent with a high probability of value-for-money performance within the program envelope.

However, these ICER estimates represent program-level composite efficiency indicators rather than activity-level marginal costs. Further optimization of financing allocation efficiency will therefore require activity-level costing studies and implementation trials that compare alternative compositions of protected operational budget lines, particularly for cold-chain maintenance, outreach deployment, and commodity continuity.

Limitations and Priority Research Actions

Interpretation of findings should consider several methodological limitations inherent in quasi-experimental evaluation designs. First, both DiD and ITS approaches rely on assumptions regarding parallel pre-intervention trends and absence of differential concurrent shocks. Event-study diagnostics and placebo rollout tests reported in Tables 8–10 strengthen the plausibility of these assumptions but cannot completely eliminate residual time-varying confounding. Second, mediation estimates depend on routine operational indicators such as stock-out days, outreach counts, and cold-chain uptime, which show moderate completeness variation as documented in Table 2. Although bootstrap inference and sensitivity diagnostics strengthen robustness, mediation interpretation remains conditional on sequential ignorability assumptions. Third, financial-protection effects were not directly measured at the household level and therefore remain an important priority for future evaluation work.

Priority research actions include; operational trials comparing alternative disbursement-timing modalities, implementation-effectiveness testing of bundled operational investment packages, activity-level costing for improved ICER precision, strengthened household-level measurement of financial-protection outcomes, integration of monthly slope monitoring ($\boldsymbol{\alpha_3}$) into routine performance surveillance systems for adaptive program management

CONCLUSION

This evaluation provides consistent causal evidence that timely and well-governed Decentralized Facility Financing, when combined with Continuous Quality Improvement and protected operational investments, produces both immediate and sustained increases in uptake of the Basic Minimum Package of Health Services. Across Tables 1–10, the strongest implementation leverage points identified are the predictable disbursement timing, cold-chain resilience, outreach financing for underserved catchments, institutionalized CQI and routine data-use systems

Together, these components form a coherent operational package capable of accelerating equitable BMPHS expansion within primary health-care systems implementing facility-level financing reforms.

The next phase of program strengthening should therefore focus on scaling the validated implementation package, embedding routine monitoring of level and slope performance indicators within supervisory systems, and commissioning targeted implementation trials to refine cost-effectiveness and maximize equity-sensitive service-delivery gains across Kogi State and comparable PHC financing environments.

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APPENDIX "A" – CHARTS

Figure 1. DID Event-Study Plot for DPT3 Coverage

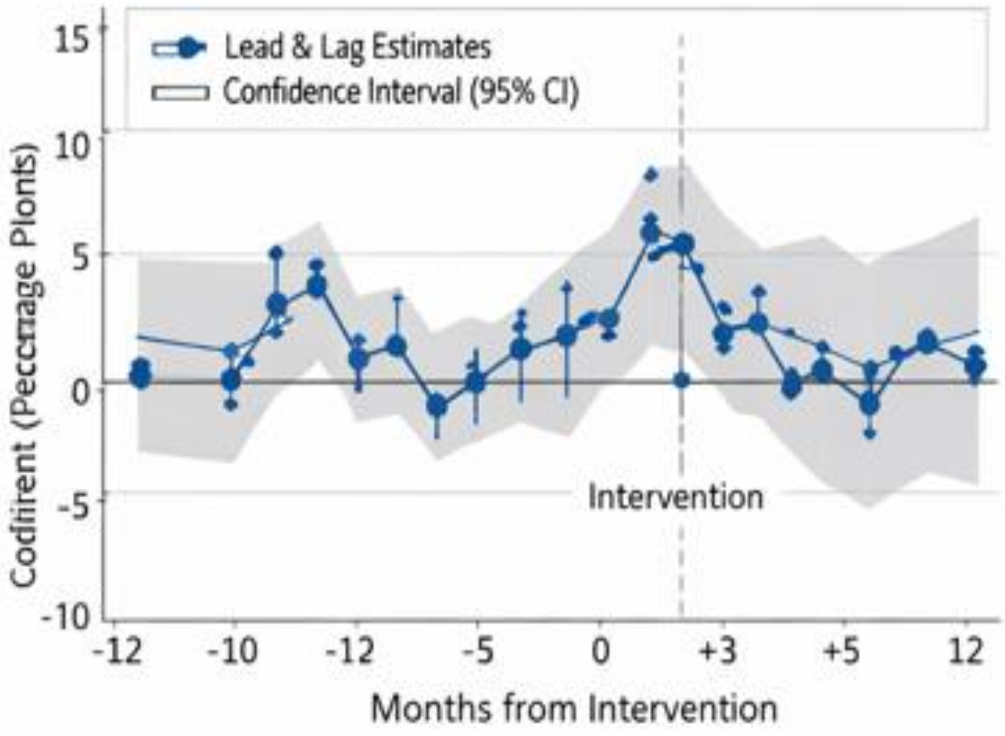

Figure 2. ITS Segmented Regression on DPT3

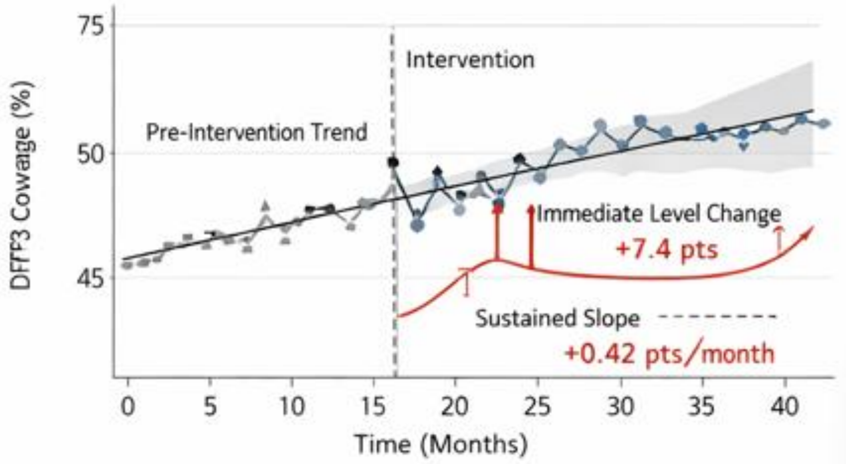

Figure 3. Subgroup Analysis of DID Effects

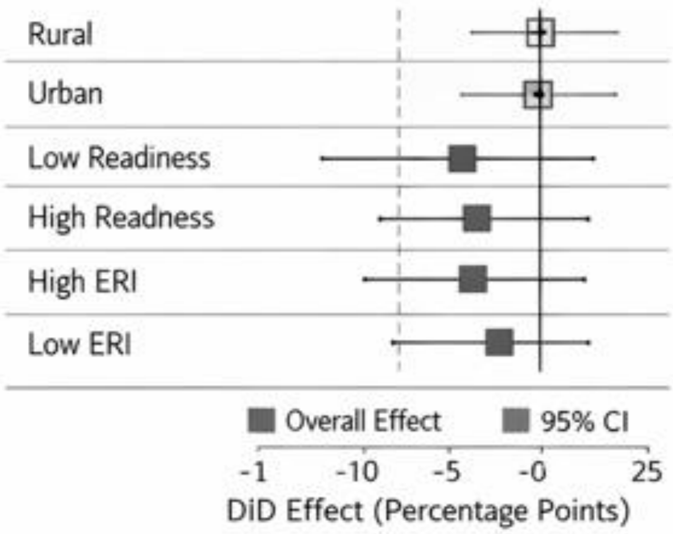

Figure 4. Medition Analysis Path Diagram

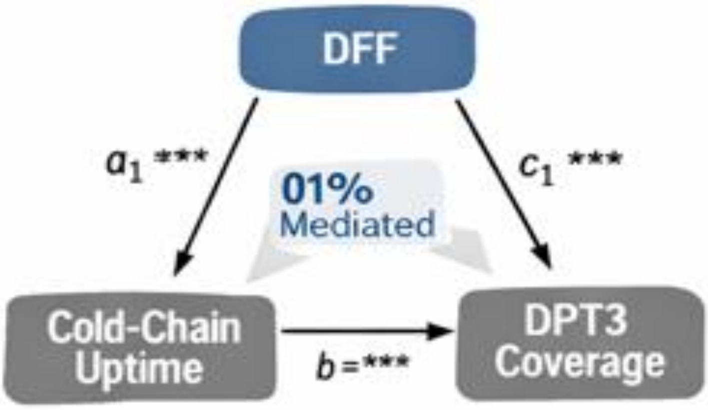

Figure 5. Cost-Effectiveness Acceptability Curve