

Erosion behind the Volume: A Retrospective Longitudinal Analysis of the Resilience of Maternal Newborn and Child Health Services Following USAID exit in Nigeria

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Cite this article as: Justus Azunku Uzim. Erosion behind the volume: a retrospective longitudinal analysis of the resilience of maternal newborn and child health services following USAID exit in Nigeria. Texila Int J Public Health. 2026;14(3). <https://doi.org/10.21522/TIJPH.2013.14.03.Art026>

Received: 27.07.2026

Accepted: 31.08.2026

Published: 30.09.2026

Article Type: Original Research

Abstract *Nigeria's maternal, newborn, and child health (MNCH) services depend heavily on external donor funding, particularly from the United States Agency for International Development (USAID). Following December 2023 closure of USAID's flagship MNCH project in Bauchi State, and the global suspension in 2025, this study evaluates the impact on sustainability of MNCH services in a high-burden setting. Using a retrospective longitudinal design, the study analysed routine administrative data from 454 health facilities over a 48-month period (January 2022 - December 2025). Nine indicators were assessed using Wilcoxon signed-rank test and Interrupted Time Series analysis to examine performance during and after USAID implementation. The results showed that while absolute volumes on antenatal visits and facility deliveries continued to rise, critical coverage indicators, specifically Penta3 and fully immunized child (FIC) rates, recorded declines ($p < 0.05$). Multi-variable mixed-effects regression identified participation in the Basic Health Care Provision Fund (BHCPF) as the most consistent independent protective factor for resilience ($p < 0.001$), followed by location within Maternal Neonatal Mortality Reduction Innovation Initiative (MAMII) priority locations. Private and secondary health facilities demonstrated greater vulnerability to funding shocks. These findings suggest that tracking volume alone can mask the active erosion of quality of care after donor exit. The study concludes that MNCH sustainability is a direct consequence of domestic planning. Policy makers must prioritize stabilizers like the BHCPF and incorporate trend-based monitoring to safeguard gains post donor funding.*

Keywords *Basic Health Care Provision Fund (BHCPF), Donor Transition, Maternal Newborn and Child Health (MNCH), Nigeria, Sustainability, USAID.*

Introduction

For a long time, maternal, newborn, and child health (MNCH) services in low- and middle-income countries (LMICs) have remained critically dependent on external donor funding to sustain their operational continuity [1, 2]. This dependency is quite pronounced in Nigeria. The United States Agency for International Development (USAID) was the most significant external funder of Nigeria's health sector. In 2024 alone, Nigeria received \$876 million in development aid from USAID, the fifth largest donation in Africa. USAID's 2025 budget had earmarked 89.27% of its \$602.95 million to health-related programmes in Nigeria [3], underscoring heavy reliance on external support in the health sector. Often, this dependence results in a critical vulnerability. When donor funds are halted or suspended, health systems could face immediate and potentially severe disruptions across multiple functional domains [4, 5]. The effects of donor exit are well-documented in global health literature and can have dire consequences for life-saving interventions that are not well rooted in host country domestic institutional support [6, 7]. Such exit become a shock and potentially have negative and far-reaching impact on the quality and coverage of health services especially when domestic health institutions are weak, such as is the case in many Northern Nigeria States.

Bauchi state is one of the six states in North East Nigeria which has been plagued by poor health outcomes, rising poverty and insecurity. For over two decades, USAID has funded various high impact integrated service delivery and health systems strengthening projects in Bauchi state including programs on strengthening primary health care service delivery, health workforce management, social behaviour change, logistics and supply chains management, and health finance/governance projects. However, recent shifts in global donor funding priorities have led to withdrawal of USAID supported programs [8]. The decreased

resourcing due to this action potentially threatens the continuity of critical health services at health facility levels and ultimately negatively impact overall health outcomes of the populations they serve.

USAID's flagship MNCH project in Bauchi state officially closed in December 2023 after about six years of implementing MNCH services across the state. Many analysts have expressed concern that domestic resources will unlikely fully absorb the shortfall, most especially in Nigerian states already operating under severe financial constraints [9].

Modelling studies have evaluated the impact of USAID defunding on mortality, projecting that up to 14 million all-age deaths and 4.5 million deaths in under five children could result from the cut in USAID funding [10]. Despite growing concern about the consequences of the 2025 USAID programme closures, empirical evidence on the facility-level impacts of this withdrawal on Maternal Newborn and Child Health (MNCH) service delivery remains strikingly limited leaving a gap in context-specific, facility-level insights capable of informing corrective actions at grassroots level.

Bauchi State, Northeast Nigeria, is a setting already burdened by some of Nigeria's highest maternal and child mortality rates and poor MNCH indices [11], driven by weak health systems, high levels of poverty, low female education and socio-cultural barriers [11, 12], as well as characterized by deep dependence on donor funds to run health systems [13]. Health service utilization is usually affected by demand-side and supply-side factors such as availability of services, cost, quality and access to health facilities [14].

This study assessed whether the progress made in the utilization and quality of MNCH services during USAID have been sustained, flatlined or eroded after USAID's closure through a sustainability analysis of key MNCH indicators reported from health facilities

previously funded by USAID in Bauchi State Nigeria.

Context and Policy Implications

Health is on the concurrent legislative list in Nigeria, meaning that both the Federal and State governments can legislate on health issues. The Federal Ministry of Health and Social Welfare (FMOHSW) provides policy guidelines, domestication and implementation largely occur at the sub-national level. Both Federal and State governments have rolled out a number of initiatives to improve health outcomes and achieve universal health coverage (UHC), most notably the National Health Act (NHA) of 2014. This laid the foundation for establishing the Basic Health Care Provision Fund (BHCPF), launched in 2019 [15]. Under the BHCPF, at least one Primary Health Centre (PHC) per geographic ward is identified and upgraded (infrastructure, staffing, commodities, basic equipment) to provide the national basic minimum package of health services, and in addition, routinely financed every quarter through direct financing from a statutory deduction of 1% of the national consolidated revenue fund supplemented by contributions from international donors, the private sector, and other sources. Bauchi State has 212 BHCPF PHCs. FMOHSW also unveiled the Maternal and Neonatal Mortality Reduction Innovation Initiative (MAMII) in 2024 [16]. This is designed to concentrate efforts on reducing maternal mortality in 172 high-priority LGAs that contribute over 55% of Nigeria's maternal deaths through innovative, data-driven and community-centered approaches. Eleven of these 172 high priority LGAs are in Bauchi State. At State level, Bauchi has been part of a multi-partite Memorandum of Understanding with development partners and private philanthropic organizations leading to setting up a Basket Fund in 2015 [17]. The aim was to establish a sustainable financing mechanism where the state government and development partners

jointly funded priority primary healthcare (PHC) interventions while progressively increasing state ownership.

While there is a robust body of evidence showing the positive impact of donor-funded programs on MNCH service delivery in low- and middle-income countries [18, 19], very little evidence exists on the effects of donor withdrawal on health services. The existing body of evidence on the effects of donor transition is largely based on HIV/AIDS program transition in East Africa, with limited evidence on MNCH programs [20, 21] and none at the level of health facilities in Nigeria. The evidence is based on national or subnational aggregate data, qualitative case studies, or modelling, leaving a critical gap in empirical, facility-level comparative evidence on how donor exit impacts the volume, quality and continuity of MNCH service delivery.

The insights generated from this study have immediate practical implications for a range of stakeholders at various levels of the health system. For the State Government of Bauchi, information on the types of MNCH services and facilities most susceptible to donor withdrawal will allow the State Ministry of Health and Social Welfare (SMOHSW) and State Primary Health Care Development Board (SPHCB) to inform state resource allocation priorities, identify potential emergency mitigation interventions, and build transition planning capacity in anticipation of future aid exits. For the Federal Government of Nigeria, the study will provide evidence to guide the implementation of the NHA and the rollout of the BHCPF in a context-specific manner, and help build a nationally applicable donor transition policy framework - an existing gap in the literature [22]. A 2021 qualitative case study in Nigeria confirmed a lack of systems to absorb the cost of donor programs and ensure service delivery continuity [9]. This study will provide the empirical evidence from the health facilities themselves to inform and guide policy actions for service continuity. For development

partners, including the United Nations Children Fund (UNICEF), the World Health Organization (WHO), the World Bank, Bill and Melinda Gates Foundation (BMGF) and bilateral donors that may consider returning to northeastern Nigeria, the study will pinpoint the health system building blocks most significantly impacted by USAID's exit, and the service delivery bottlenecks which need the most urgent bridging. This knowledge will be essential in any future strategy for health investment in this setting - to be focused, cost-effective, and based on a documented need.

This study becomes a natural experiment in the wake of the 2025 US Government Executive Order which is both critical and timely. In January 2025, the United States Government issued an Executive Order (EO 14169) that immediately suspended and closed USAID operations worldwide [23], bringing to an abrupt halt over 20 years of uninterrupted USAID funding to Bauchi State's health sector. Modelling research has forecast devastating impacts of this withdrawal globally [10]. The findings of this study will be directly relevant to state and national policymakers and development partners responding to the post-USAID health system environment, and will establish Nigeria as an empirical case study to inform the global health community responding to the 2025 US government foreign aid exit.

Materials and Methods

The study is a retrospective quasi-experimental, health facility longitudinal analysis using routine administrative data with a segmented pre (January 2022 – December 2023) versus post (January 2024 – December 2025) comparison stratified by health facility characteristics. The unit of analysis is health facility-month ($n = 454$ health facilities by 48 months), aggregated to health facility pre and post summaries. The study is a paired analysis in which each health facilities aggregate summary after USAID funding serves as its own control.

Bauchi State is one of the six States in Northeast Nigeria. It is the fifth largest State in terms of geographic landmass (approximately 49,259 km²) and population, with an estimated population of 8.3 million people [24]. The state has 20 Local Government Areas (LGAs), 323 political wards, and six emirate councils. The LGAs are also divided into three geopolitical senatorial zones (North, Central and South). The State is ethnically and religiously diverse, with Islam and Christianity as the most widespread religions; Hausa, Jarawa, and Fulfulde as the most common languages; and more than 60 native languages. Livelihood of majority of the populace is mainly subsistence farming [25]. Over two decades, USAID's funding in Bauchi shifted from vertical interventions to integrated health systems strengthening. Major programs like Targeted States High Impact Project (TSHIP) and the Integrated Health Project (IHP) prioritized maternal health, financial risk protection, and workforce development. The strategy evolved from purchasing inputs to building sustainable domestic systems. The IHP was USAID's final flagship project focused on MNCH and health systems strengthening covering 476 health facilities across the entire state and was implemented between 2019 and 2023. Review of the sustainability of IHP's MNCH work is the basis of this study.

This study assessed nine key MNCH indicators across three domains.

Maternal Health: Monthly antenatal first visits (ANC 1), monthly deliveries in the health facility, monthly deliveries taken by skilled birth attendants (SBA), and percentage of deliveries taken by SBA (% SBA).

Neonatal Health: Monthly postnatal care visits for mothers within 3 days, monthly postnatal care visits for newborn within 3 days, babies with 4% chlorhexidine gel applied at birth for cord care.

Child Health: Monthly third dose of pentavalent vaccines given (Penta3), monthly fully immunized child under one year (FIC).

The study data were obtained from monthly routine administrative data from all 474 USAID-supported health facilities in Bauchi State, downloaded from the National Health Management Information System-District Health Information Software2 (NHMIS-DHIS2) over a four-year period (i.e., 48 time periods), and exported to Microsoft Excel for preliminary cleaning. Thereafter the data was loaded and imported to Python version 3.12.13 [26] utilizing the cloud-based Google Collaboratory environment [27] for further data cleaning and analysis. The USAID-IHP Master Facility List (MFL) was used to identify and categorize the health facilities by level of care (primary, secondary and tertiary), ownership (public versus private), senatorial zones (north, central and south), presence of government direct health facility financing through the BHCPF and location (urban versus rural). Additional information on MAMII LGAs was obtained from the Bauchi State Ministry of Health and Social Welfare, and included to identify whether each health facility was located within MAMII areas (yes or no).

Analysis involved data cleaning procedures to identify missing/incomplete data and outliers. Using the indicator for health facility deliveries as a proxy, 19 health facilities were identified to have >80% missing data and these were dropped. Additionally, data from the only tertiary health facility in the MFL was dropped as the number was statistically insignificant for reasonable analysis. The final analysis was based on 454 health facilities. There were 178,088 complete datapoints out of the expected 196,128 datapoints, implying the overall completeness of the dataset used for the final analyses was 90.76%. The indicator for total health facility deliveries had the highest data completion of 96.01%, while postnatal visits for newborns had the lowest level of completion at 66.29%. Out of 178,008 data points, 3,810 (2.14%) were identified as outliers using z-scores >3 method. The identified outliers were examined manually and

where they were determined as truly impossible values, these were replaced using mean imputation. A data validation issue was observed in 0.37% of the data, where the number of deliveries by SBA exceeded the total deliveries reported in a month (i.e., >100% for %SBA). A ceiling of 100% was applied to these datapoints by correcting their numerator and denominators. Shapiro-Wilk test was then used to test for normality of all the variables. The data for all the indicators was not normally distributed. Wilcoxon signed-rank test was used to compare statistically significant median absolute difference (MAD) in performance during USAID (January 2022 to December 2023) compared to after USAID (January 2024 to December 2025) for all the indicators. Mann Whitney U-test was used to compare the magnitude of change between binary facility characteristics (BHCPF status, ownership, urban/rural location, location in MAMII LGA and level of care) to identify any differences in the pattern of changes. While Kruskal Wallis test with Bonferroni-corrected pairwise post-hoc analysis was used to assess difference in subgroups with more than two categories (senatorial zone). Statistical significance for all tests were evaluated relative to an alpha level of 0.05 [28].

A complimentary interrupted-time series (ITS) analysis was conducted using Generalized Estimating Equations (GEE) with a Poisson distribution for count indicators and a Gaussian distribution with an identity link for percentage-based indicators, fitted to facility-level monthly panel data, with 48 monthly time points per facility. This was used to compare segmented regression trends before and after USAID exit, with interruption/transition point set at December 2023. The ITS models used an independence working correlation structure with cluster-robust standard errors to account for within-health facility correlation. Benjamini-Hochberg correction was then applied to account for multiple comparisons across indicators. Furthermore, because the

actual interruption point (December 2023) coincides with known seasonal dips in NHMIS data due to end-of-year holidays and health workers leave, a placebo falsification test was conducted to compare the level of change immediately after interruption with a historical unexposed point in December 2022 [29-31].

To further understand whether identified health facility characteristics are truly independent in influencing the change in MCH indicators or if they capture overlapping variance, a mixed-effect regression analysis with facility random effects for each MCH indicator was built using the median difference calculated for each facility as the dependent

variable and the categorical protective factors as independent variables [32].

Results

Of the 454 health facilities, 184 (40.53%) were located in the South, 140 (30.84%) in the North and 130 (28.63%) in the central senatorial zone of the State. Four hundred and thirty-one (94.93%) were primary, 428 (94.27%) were public health facilities, 392 (86.34%) were located in rural areas, 201 (44.27%) were implementing the BHCPF and 222 (48.90%) were within MAMII designated LGAs. The detailed distribution of the health facilities in this study is shown in Table 1.

Table1. Distribution of Health Facilities by Characteristics (N = 454)

Category of Health Facility	Count (n)	Percentage (%)
Level of Care		
Primary	431	94.93
Secondary	23	5.07
BHCPF Implementation		
No	253	55.73
Yes	201	44.27
Health facility is in MAMII LGA		
No	232	51.1
Yes	222	48.9
Ownership		
Public	428	94.27
Private	26	5.73
Location		
Rural	392	86.34
Urban	62	13.66
Senatorial Zone		
Central	130	28.63
North	140	30.84
South	184	40.53

By counts of service utilization volume, the maternal indicators recorded significant increases after USAID closure with slope changes of +0.66% per month for ANC1, +0.54% per month for total deliveries and +0.48% per month for deliveries taken by SBA (Table 2). However, two coverage/quality

indicators showed significant declines after USAID closure with negative slope changes of -2.24% per month for Penta3 and -1.49% per month for FIC, all $p < 0.05$. Postnatal visits for mother and newborn within 3 days and cord care for newborns showed declining trends but these were not statistically significant.

Percentage of deliveries by SBA showed no change (both medians at 100.0) despite a highly significant p-value ($p < 0.0001$) due to the ceiling effect applied to this indicator obscuring the true direction of change at the median. Therefore, a count of frequencies in the

medians before versus after was computed. Only one health facility (0.22%) recorded an increase, 29 (6.49%) recorded a decrease, and 417 (93.29%) facilities recorded no change in median facility-level coverage; signifying a net declining trend ($p < 0.0001$).

Table 2. Median (IQR) Coverage and Median Difference (95% CI) per Indicator, During vs. Post USAID Period

Indicator	Median During USAID (IQR)	Median After USAID (IQR)	Median Difference (95% CI)
Antenatal first visit	49.00 (30.00–81.00)	53.00 (33.00–88.00)	2.5 (1–3.5)
Health facility deliveries	25.00 (16.00–40.00)	31.00 (20.00–46.00)	2.5 (2–4)
Deliveries taken by SBA	25.00 (17.00–40.00)	30.00 (20.00–46.00)	2.5 (2–3)
Percentage of deliveries taken by SBA	100.00 (100.00–100.00)	100.00 (100.00–100.00)	0 (0–0)
Penta 3 doses given	28.00 (19.00–41.00)	28.00 (20.00–40.00)	0.5 (–0.5–1)
Fully Immunized <1 years	21.00 (13.00–32.00)	26.00 (18.00–37.00)	5.5 (4–6.5)
Postnatal visit within 3 days (Mothers)	29.00 (18.00–48.00)	36.00 (22.00–57.00)	4 (3–4.5)
Postnatal visit within 3 days (Newborn)	29.00 (18.00–48.00)	36.00 (22.00–57.00)	3.5 (2.5–4.5)
Newborn received cord care with 4% chlorhexidine gel	27.00 (19.00–42.00)	35.00 (23.00–50.00)	3 (2.5–4)

IQR = Inter quartile range, CI = Confidence Interval

Level of Care

There were significant differences in the magnitude of change after USAID by health facility level of care for six of nine indicators ($p < 0.05$), except for postnatal visits for mothers, FIC and Penta3 doses given. Post-hoc comparison using Bonferroni correction indicated that these differences were specifically attributed to significantly better performance among primary level facilities compared to secondary.

Senatorial Zone

There was significant difference by zone in eight of the nine indicators, except antenatal first visits ($p < 0.05$). The Bonferroni post-hoc comparison showed that facilities within the North and Central senatorial zones were significantly better sustained than those in the South for total deliveries, deliveries by SBA and postnatal visits ($p < 0.05$). However, the Central zone showed better sustainability for Penta 3 than the North and South ($p = 0.0011$);

while the North and South were significantly different from each other.

BHCPF, Ownership and MAMII

Health facilities implementing the BHCPF showed significantly better sustained performance in seven of the nine indicators ($p < 0.001$). For example, BHCPF facilities recorded a median difference of +8 compared to +4 in non-BHCPF health facilities for FIC ($p = 0.001$). Health facilities within MAMII designated LGAs showed significant increment in five of the nine indicators ($p < 0.05$) and public health facilities in four of the nine ($p < 0.001$). Privately owned health facilities showed an absolute significant decline in the postnatal care visits for newborns ($p = 0.0054$) and postnatal care visits for mothers ($p = 0.0044$).

Mixed-Effect Regression Analysis

Multivariable mixed-effects regression models were fitted to identify facility characteristics independently associated with changes in MNCH service utilization following USAID closure as shown in Table 3. Facility-specific random intercepts were included to account for clustering of repeated observations within health facilities. Diagnostic assessment indicated no evidence of problematic multicollinearity among the explanatory variables, with variance inflation factors ranging from 1.01 to 1.46.

Across the study outcomes, participation in the BHCPF was the characteristic most consistently associated with improvements in service utilization. After adjustment for ownership, level of care, senatorial zone and facility-level random effects, BHCPF-supported facilities recorded significantly greater increases in first antenatal care attendance ($\beta = 4.41$, $p = 0.016$), facility deliveries ($\beta = 2.87$, $p = 0.003$), deliveries conducted by SBA ($\beta = 2.94$, $p = 0.003$), % SBA ($\beta = 4.03$, $p = 0.024$), FIC ($\beta = 2.54$, $p = 0.006$), postnatal care visits for mothers

within three days of delivery ($\beta = 4.03$, $p = 0.005$), postnatal care visits for newborns ($\beta = 3.97$, $p = 0.005$), and cord care services ($\beta = 2.01$, $p = 0.037$). No statistically significant association was observed between BHCPF participation and Penta 3 vaccination ($\beta = 1.12$, $p = 0.188$).

Facility ownership was not associated with changes in most indicators after adjustment for other facility characteristics. The only exception was the proportion of deliveries attended by skilled birth attendants, for which ownership remained a significant predictor ($p < 0.001$).

Facility level demonstrated independent associations with several service indicators. Primary healthcare facilities showed significantly greater improvements in facility deliveries, deliveries attended by skilled birth attendants, fully immunized children, postnatal care for mothers, postnatal care for newborns, and cord care than facilities providing higher levels of care. However, facility level did not differ significantly for first antenatal care attendance, Penta 3 vaccination, or the proportion of deliveries attended by skilled birth attendants.

Geographical differences persisted for selected outcomes but were less pronounced after accounting for facility-level variation. Senatorial zone remained significantly associated with changes in immunization-related indicators, particularly Penta 3 vaccination and the proportion of fully immunized children, while associations with maternal health indicators were less consistent across the models.

The estimated random-effects variance indicated substantial heterogeneity in performance between health facilities across all models. Random-effect standard deviations ranged from 6.05 to 13.13, suggesting that a considerable proportion of the variation in service utilization remained attributable to facility-specific characteristics not captured by the measured explanatory variables.

Table 3. Multi-Variable Mixed-Effects Regression Analysis of Health Facility Characteristics Associated with Changes in Maternal and Child Health Service Utilization

Indicator	Model R ²	Adjusted R ²	F Statistic	Model p-value	BHCPF β (p-value)	Public Ownership β (p-value)	Primary Level β (p-value)	North Zone β (p-value)	South Zone β (p-value)
Antenatal first visit	0.024	0.013	2.18	0.056	4.41 (0.016)	-2.31 (0.612)	6.25 (0.142)	-2.40 (0.294)	-1.86 (0.393)
Health facility deliveries	0.074	0.063	6.99	<0.001	2.87 (0.003)	1.63 (0.476)	5.99 (0.008)	0.50 (0.678)	-2.92 (0.011)
Deliveries taken by SBA	0.093	0.083	9	<0.001	2.94 (0.003)	2.40 (0.313)	8.34 (<0.001)	0.19 (0.874)	-3.31 (0.005)
Percentage of deliveries taken by SBA	0.104	0.094	10.26	<0.001	4.03 (0.025)	23.20 (<0.001)	7.04 (0.090)	-0.53 (0.811)	-3.37 (0.111)
Penta 3 doses given	0.038	0.027	3.41	0.005	1.12 (0.189)	2.53 (0.341)	-2.27 (0.238)	-3.39 (0.002)	-3.18 (0.002)
Fully Immunized <1 years	0.043	0.032	3.88	0.002	2.54 (0.007)	4.30 (0.140)	-3.27 (0.121)	-2.69 (0.021)	-2.76 (0.013)
Postnatal visit within 3 days (Mothers)	0.062	0.051	5.8	<0.001	4.03 (0.005)	4.27 (0.239)	7.21 (0.029)	-0.25 (0.887)	-4.22 (0.013)
Postnatal visit within 3 days (Newborn)	0.072	0.061	6.75	<0.001	3.97 (0.005)	3.98 (0.270)	8.67 (0.009)	-0.11 (0.950)	-4.63 (0.006)
Newborn received cord care with 4% chlorhexidine gel	0.067	0.053	4.8	<0.001	2.01 (0.085)	4.11 (0.489)	7.04 (0.005)	0.77 (0.574)	-3.13 (0.024)

Discussion

The results provide a critical empirical evaluation of health system resilience in Bauchi State following the termination of USAID funding. By distinguishing between "level effects" (raw coverage) and "trend effects" (the trajectory of growth), this study shows that while some health gains appear sustained, the quality and coverage of essential services are actively eroding without donor support. The results confirm that the impact of the USAID closure is indicator-specific rather than uniform. While "headline" indicators like the raw counts of ANC1 and health facility delivery volumes showed continued growth, coverage-based indicators such as the proportion of skilled birth attendance, Penta3, and fully immunized children (FIC) underwent significant post-transition slope reversals. This aligns with some studies which highlight that rising absolute numbers of clinic visits or vaccine doses administered can give the illusion of system success, masking sub-national drop-offs in actual coverage and service delivery quality [33]. From a methodological standpoint, naive pre/post comparison would have falsely signalled sustenance, whereas incorporating trend-based and mixed-effects regression analysis unearths the genuine system performance post USAID.

The data identifies the BHCPF as the single most consistent protective factor, significant across seven of nine indicators. This underscores the premise that access to sustained domestic financing is a primary regulator of health system performance following a shock. However, a number of studies have evaluated the effectiveness of the fund, reporting mixed performance [15, 34]. Bauchi along with other states (Sokoto, Lagos, Kaduna, Kano and Plateau) have particularly been noted for proactive implementation, excelling in supportive supervision and efficient funds disbursement [34], while some other states like Borno, Yobe, Kogi, Zamfara and Nasarawa [34, 35] have not recorded significant improvement

to services with the BHCPF. Across all evaluated regions, even high-performing states grappled with suboptimal implementation in at least one thematic area; suggesting that the BHCPF is yet to reach its full potential. A recent technical analysis from the 2022 Comprehensive National PHC Assessment, which collected facility-level information from 3,531 BHCPF facilities nationwide, showed that BHCPF facilities operate at a very low mean technical efficiency (11%) [36]. The analysis specifically focused on assessing their technical efficiency in converting inputs, such as clinical staff and inpatient beds, into health outputs like immunizations and deliveries. This suggests that while the BHCPF currently functions as a vital stabilizer to prevent system collapse, it is not yet an optimizer of health outcomes.

Furthermore, the resilience of health facilities located in MAMII-designated LGAs provides some of the first facility-level outcome evidence for this recent federal initiative, confirming its role in buffering high-burden areas against service collapse.

In addition, the vulnerability of private facilities, which showed an absolute decline in postnatal care in this study, confirms structurally recurring fragility in public-private health arrangements documented in both Nigeria and Ethiopia. This reinforces the consensus that private-sector actors require deliberate integration into state-led financing rather than an assumption of passive resilience.

This study's findings are remarkably consistent with existing literature while offering sharper, more localized insights. The observed pattern, where service volume is maintained but quality indicators erode parallels findings from Ghana's Maternal and Child Health and Nutrition Improvement Project, suggesting that intra-country heterogeneity in donor-transition resilience is a recurring feature in West African health systems [37].

While these results provide a robust baseline, several questions remain that necessitate further investigation:

1. The Central senatorial zone Outlier: An important finding in this study was that the Central senatorial zone significantly outperformed both the North and South in Penta3 sustainability. Qualitative deep-dives are needed to explore the specific positive outlier mechanisms, such as superior cold-chain logistics, outreach strategies, or supervisory factors, that protected immunization gains in this zone so they can be replicated elsewhere.
2. Drivers of Technical Inefficiency: Given the suboptimal efficiency of BHC PF-funded facilities [36], future research should move beyond whether the fund protects services to why efficiency remains so low. Investigating the impact of catchment area population dynamics and subnational health allocations on service productivity is essential to ensure that increased domestic investment does not result in a waste of scarce resources.

Conclusion

In conclusion, this study validates the critical role of domestic financing and facility-tier integration as a primary determinant of health system resilience. The results show that while the system has not collapsed, it is losing ground on the most critical quality-of-care indicators. For policymakers in Nigeria and beyond, the message is clear: sustainability is not an accident of project design, but a direct consequence of the domestic service-delivery architecture existing at the moment of donor exit. This study also stands as a methodological pointer: a naive pre/post comparison would have signalled reassuring improvement, while trend-based analysis reveals genuine erosion. This is directly relevant to an active global crisis. Relying on simple coverage-level indicators, as many national HMIS dashboards and routine donor-transition monitoring

frameworks still do, would risk missing a genuine deceleration in service quality while headline numbers continue climbing due to population growth or residual momentum. With private facilities providing a substantial share of care across LMIC settings generally, this study's finding that private facilities absorbed the funding shock measurably worse than public facilities is a specific, actionable warning for the broader global health financing architecture currently being redesigned to ensure that mechanisms need explicit private-sector financing and supervisory tracks, not an implicit assumption that public-sector-oriented domestic financing reforms will carry private providers along by default.

Conflict of Interest

The author declares no competing interests.

Acknowledgement

The author gratefully acknowledges the support and collaboration of the Bauchi State Ministry of Health and Social Welfare and the Bauchi State Primary Health Care Development Board for their support during this study. Special appreciation is extended to the staff of the defunct USAID-funded Integrated Health Project for providing supporting materials, including the facility list used in identifying and categorizing the health facilities.

Ethical Approval

The data used for the study was routinely collected health service data extracted from the National Health Management Information System District Health Information Software 2 (NHMIS-DHIS2). The dataset was based solely on aggregated summaries and did not include any patient-level records that can be traced to individuals. There was no direct interaction with human subjects in the course of this study and no risk was posed to individual privacy or confidentiality. Ethical review and approval was sought and obtained from the Bauchi State

Health Research Committee, with approval number NHREC/TR/BAU-HREC/28/8/2023.

Author Contribution

JAU was fully responsible for conceptualization, collection, analysis and drafting the manuscript.

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Data Availability

The datasets generated and analysed for this study are available from the corresponding author upon reasonable request.

Funding

The study received no external funding.

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