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MULTILEVEL LOGISTIC ANALYSIS OF INFANT MORTALITY IN NIGERIA ACROSS THE GEOPOLITICAL ZONES

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ABSTRACT

Nigeria faces high child mortality rates, with an under-five mortality rate of 110 per 1,000 live births and an infant mortality rate of 63 per 1,000 in 2023, down from 64.7 in 2020, yet among the highest globally. Regional disparities persist, with 140 deaths per 1,000 in the North West versus 42 in the South West, driven by socioeconomic inequalities (142 per 1,000 in poorest households vs. 49 in wealthiest, 2022). Key causes include neonatal disorders, respiratory infections, malaria, and diarrhea, linked to limited healthcare access, low maternal education, and rural-urban divides. This study examines individual and group-level factors influencing infant mortality from 2020-2025, focusing on regional variations across Nigeria's geopolitical zones. Using multilevel logistic regression on 2023-24 Nigeria Demographic and Health Survey data (39,050 women aged 15-49 and children, nested in states), three models were analyzed: an intercept-only model, one with individual factors (child's sex, birth size, mother's education and age, postnatal checks, antenatal visits, delivery place, residence), and a full model adding state-level zones. Results show rural residence (OR=1.45), male sex, younger maternal age, low education, low birth weight, and no postnatal checks increase risks. North West and North East zones show significant effects, with state-level variance explaining 9-12% of differences. These findings highlight the interplay of individual and contextual factors, urging policymakers to invest in zone-specific health infrastructure, education, and training under the Nigeria Child Survival Action Plan 2025-2029 to address inequalities and reduce preventable deaths.

Keywords: Multilevel logistic regression, Infant mortality, Geopolitical zones, Nigeria, Regional disparities

INTRODUCTION

According to the World Health Organization (2024), neonatal deaths account for approximately 47% of under-five mortality globally, with 75% occurring in the first week of life and about 1 million newborns dying within the first 24 hours. Leading causes include preterm birth complications (35%), intrapartum-related events (24%), sepsis (15%), and congenital anomalies (11%), with rates declining slowly since 2000 but still representing 4 in 10 under-five deaths in 2022. Access to quality healthcare remains critical, as disparities in maternal and newborn care continue to drive preventable deaths worldwide. In sub-Saharan Africa, infant mortality is a persistent concern, with Nigeria exhibiting one of the highest rates. Recent estimates indicate Nigeria's infant mortality rate at 63 deaths per 1,000 live births in 2023, a marginal decrease from 72.2 in 2020, yet far exceeding the global average of 27.4. Projections suggest a further decline to 52.61 by 2030, but this falls short of Sustainable Development Goal (SDG) 3.2 targets, with under-five mortality at 102 per 1,000 live births in 2023 and over 227,000 annual deaths. Despite improvements, intensified efforts are essential to eradicate preventable infant deaths in Nigeria.

The aim of this study is to ascertain whether infant mortality rates in Nigeria are attributable to individual-level factors, geopolitical contexts, or their interplay, employing multilevel logistic regression modeling. Multilevel approaches have been widely applied across disciplines to analyze hierarchical data. In health research, recent studies have utilized these methods to explore child health outcomes. For instance, Kuse et al. (2022) assessed variability in predictors of neonatal, infant, and under-five mortality in Ethiopia using multilevel modeling, highlighting community-level influences. Similarly, Adeyinka et al. (2020) examined inequities in child survival in Nigerian communities during the SDG era via multilevel analysis of cluster survey data. Oyedele (2023) conducted a multilevel and subnational analysis of maternity care predictors in Nigeria, revealing regional disparities. Bolarinwa and Tadesse Tessema (2021) applied multi-level analysis to childhood diarrhea distributions in Nigeria, incorporating spatial interpolation. Terefe et al. (2025) used multilevel modeling for perinatal mortality determinants in East Africa, including pooled Nigerian data. Onakalu et al. (2025) explored rural-urban differentials in under-five mortality linked to women's empowerment in Nigeria. Ikemeh et al. (2025) assessed birth outcomes associated with antenatal care policies across Nigerian states via multilevel analysis. Adama et al. (2025) forecasted under-five mortality trajectories for Nigeria using ARIMA models, emphasizing SDG progress. Oweibia et al. (2025a) identified predictors of maternal mortality in Nigeria, with implications for infant outcomes. Oweibia et al. (2025b) reviewed maternal and child health trends in Nigeria using NDHS data from 2018-2023.

Further studies have modeled infant mortality trends. Ogundunmade et al. (2023) employed time series models to analyze infant mortality rates in Nigeria. Adegoke et al. (2022) correlated macro-economic determinants with maternal and infant SDG targets through predictive modeling. Onyemarin et al. (2023) applied ARMA modeling to infant mortality trends. John et al. (2022) evaluated Nigeria's progress toward global nutrition targets, including infant mortality reductions. Eke and Ewere (2022) used logistic regression to assess levels, trends, and determinants of infant mortality. Lawanson et al. (2025) examined the impact of information communication technology and immunization on infant mortality. Uthman et al. (2007) revealed that household wealth inequality significantly impacts childhood under-nutrition, with strong evidence from a multilevel analysis of Nigerian children.

Oyedepo (2023) analyzed trends in maternal mortality and their links to economic growth, with indirect effects on infants. Joseph et al. (2023) investigated healthcare expenditure's role in reducing infant mortality. Bolu-Steve and Adegoke (2020) explored cultural beliefs influencing infant mortality. Adeyinka et al. (2021) studied changing patterns of gender inequities in childhood mortalities using neural network analysis.

Building on these, the research gap identified in this study is the absence of analyses utilizing the most recent 2023-24 NDHS data to investigate the interplay between individual-level factors (e.g., child's sex, birth size, maternal education/age) and state-level geopolitical zones on infant mortality trends specifically from 2020-2025, amid post-COVID disparities, persistent regional inequalities, and slow progress toward SDG 3.2 targets, where prior studies rely on outdated data (up to 2018) and often focus on under-five mortality or different nesting structures (e.g., communities or maternal age) without addressing recent projections of shortfalls by 2030 or consider zone-specific policy implications under frameworks like the Nigeria Child Survival Action Plan 2025-2029.

The unique contribution of this study, distinguishing it from prior multilevel analyses in Nigeria (e.g., Adedini et al., 2015, on regional variations in infant/child mortality using 2008 NDHS data nested at community level; Akinyemi et al., 2020, on disparities in infant/child mortality across states using 1990-2013 NDHS data nested in neighborhoods/clusters; the 2025 IIARD study on multi-level logit modeling of infant mortality using 2013-2018 NDHS data nested by mother's age; and Olatunde, 2025, on contraceptive use and childhood mortality using unspecified recent NDHS data at individual/household/community levels), lies in its use of the most recent 2023-24 NDHS data (39,050 women/children nested in states) to analyze infant mortality trends specifically from 2020-2025 amid post-COVID disparities, explicitly incorporating geopolitical zones as state-level predictors in the multilevel logistic model.

MATERIALS AND METHODS

Study Population and Area

The study population consists of women of reproductive age (15-49 years) and their children under five years old in Nigeria. The research focuses on a nationally representative sample drawn from the 2023-24 Nigeria Demographic and Health Survey (NDHS), which included 39,050 women interviewed across 40,047 households, with a 99% response rate for women and 98% for men (in a subsample). This sample allows for estimates at national, zonal, state, and urban/rural levels. The study area is the Federal Republic of Nigeria, a West African country comprising 36 states and the Federal Capital Territory (Abuja), divided into six geopolitical zones: North West (NW), North East (NE), North Central (NC), South East (SE), South South (SS), and South West (SW). Nigeria spans approximately 923,768 square kilometers, with diverse ethnic groups (over 500, including major ones like Hausa, Igbo, and Yoruba) and religious distributions (roughly half Christian in the south/central and half Muslim in the north/southwest). The population is estimated at over 220 million as of 2025, making it Africa's most populous nation.

Figure 1: Map of Nigeria Showing the Six Geopolitical Zones

Research Design

This study employs a descriptive and analytical research design, utilizing secondary data from a cross-sectional survey. It applies multilevel logistic regression to examine hierarchical relationships between individual-level (e.g., child and maternal characteristics) and group-level (e.g., state and geopolitical zone) factors influencing infant mortality. The design accounts for nested data structures, where children are nested within mothers, who are nested within states and geopolitical zones. The analysis proceeds in three stages: (1) an intercept-only model to assess baseline variance at the state level; (2) inclusion of individual-level predictors; and (3) addition of state-level (geopolitical zone) predictors. This approach allows for the investigation of regional variations and the relative contributions of individual and contextual factors to infant mortality outcomes.

$$Y_{ij} = \begin{cases} 0: \textit{the child survive} \\ 1: \textit{the child do not survive} \end{cases} \quad (1)$$

For this research work the following three cases shall be considered:

Case 1: Intercept Only Multilevel Logistic Model (Null Model)

We first fited a simple model with no predictors, that is an intercept-only model that predicts the probability of dead. The model is:

$$\ln\left(\frac{P_r(Y_{ij})=0: the\ child\ survive}{P_r\ (Y_{ij})=1: the\ child\ do\ not\ survive}\right) = \beta_{0j} + u_{0j} \qquad (2)$$

Case 2: Model with the Individual-Level Factors

$$\log\left(\frac{Pr(Y_{ij} = 0: the\ child\ survive\ )}{\Pr\left(Y_{ij} = 1: the\ \ child\ do\ not\ survive\right)}\right)$$
$$= \beta_{0j} + \beta_1 childsex + \beta_2 placeofdelivery + \beta_3 age + \beta_4 typeofreside + \beta_5 mother'sedu + \beta_6 no.ofantenatalvisit + \beta_7 baby'ssize + \beta_8 bpcw2m + u_{0j} \qquad (3)$$

Case 3: Model with the Inclusion of Hospital- Level Factor

$$\log\left(\frac{Pr(Y_{ij}=0: the\ child\ survive\ )}{Pr\left(Y_{ij}=1: the\ \ child\ do\ not\ survive\right)}\right) = \beta_{0j} + \beta_1 childsex + \beta_2 placeofdelivery + \beta_3 age + \beta_4 typeofresident + \beta_5 mother'sedu + \beta_6 no.ofantenatalvisit + \beta_7 baby'ssize + \beta_8 bpcw2m + \beta_9 NW + \beta_{10} NE + \beta_{11} SE + \beta_{12} SS + \beta_{13} SW + u_{0j} \qquad (4)$$

Intra-Class Correlation

The intra-class correlation ρ indicates the proportion of the variance explained by the grouping structure in the population. In the multilevel logit model, $\sigma^2{}_e = \frac{\pi^2}{3}$ by assumption, so that the intra-class correlation is

$$\rho = \frac{\sigma^2{}_{uo}}{\sigma^2{}_{uo} + \frac{\pi^2}{3}} \ (5)$$

This is the intra-class correlation for the latent response variable (Adeniyi and Akinrefon, 2014).

Logistic Link Function

To determine the expected proportion, the inverse transformation for the logistic link function is given by $g(x) = \frac{e^x}{1+e^x}$ (6)

Data Description and Source

The data for this study are secondary and sourced from the 2023-24 Nigeria Demographic and Health Survey (NDHS), the sixth in the series since 1990, implemented by the National Population Commission (NPC) under the Federal Ministry of Health and Social Welfare, with technical support from ICF through The DHS Program and funding from USAID, WHO, and other partners. Fieldwork occurred from December 2023 to May 2024. The NDHS is a nationally representative household survey providing data on demographic, health, and nutrition indicators, including childhood mortality, maternal health, and socioeconomic factors. The dataset includes information on live births in the five years preceding the survey (for national estimates) and ten years for state-level estimates, focusing on infant mortality (deaths before age 1) and under-five mortality. Key variables analyzed include: individual-level factors (e.g., child's sex, birth weight, mother's age, education, place of residence, antenatal visits, place of delivery, postnatal check within two months); and group-level factors (e.g., geopolitical zone, state-level infrastructure proxies). The sample design is a stratified two-stage cluster approach: first, 1,400 enumeration areas (clusters) were selected (stratified by urban/rural and state); second, households were systematically sampled within clusters. A total of 40,047 households were selected, with adjustments for oversampling in certain states. Data collection used three questionnaires (household, woman's, and man's), translated into Hausa, Igbo, and Yoruba, with GPS for cluster mapping. Mortality rates are based on retrospective birth histories from interviewed women.

Statistical Technique

The primary statistical technique is multilevel logistic regression, suitable for binary outcomes (infant survival/death) and hierarchical data structures. This extends ordinary logistic regression by accounting for clustering effects, where observations are not independent due to nesting (e.g., individuals within states). The model uses a logit link function to transform the probability of infant mortality into a linear form, assuming a binomial distribution for the response variable.

The general two-level model is specified as follows:

Level 1 (Individual)

$$logit(\pi_{ij}) = \beta_{0j} + \beta_{1j}\mathcal{X}_{1ij} + \cdots + \beta_{pj}\mathcal{X}_{pij} \qquad (7)$$

where (π_{ij}) is the probability of infant mortality for individual i in group j, $\mathcal{X}$ are individual predictors, and (e_{ij}) ~ Binomial $(1, (\pi_{ij}))$

Level 2 (Group/State)

$$\beta_{0j} = \gamma_{00} + \gamma_{01}Z_{1j} + \cdots + \gamma_{0q}Z_{qj} + u_{0j} \qquad (8)$$
$$\beta_{1j} = \gamma_{10} + \gamma_{11}Z_{1j} + \cdots + u_{1j} \qquad (9)$$

where Z are group-level predictors (e.g., geopolitical zone), γ are fixed effects, and u are random effects (normally distributed with variance σu^2).

The intra-class correlation (ICC) is calculated as ICC = σu^2 / ($\sigma u^2 + \pi^{2/3}$), where $\pi^{2/3} \approx 3.29$ is the Level 1 variance for the logistic model. This measures the proportion of variance attributable to group-level factors.

Analysis was conducted in three stages using STATA software: (1) intercept-only model to estimate baseline ICC; (2) add individual-level predictors; (3) add group-level predictors. Fixed effects are reported as coefficients, odds ratios (ORs), and p-values; random effects as variance components. Significance is assessed at $p < 0.05$, with likelihood ratio tests for model fit.

Operational Definition

Dependent Variable

Infant Mortality

Definition: A binary indicator of whether a live-born child died before reaching 12 months of age (i.e., age 0–11 months), based on retrospective maternal reports of birth histories.

Coded as:

1 = Death occurred before age 1 (event);

0 = Child survived to age 1 (censored/no event).

Measurement Scale: Dichotomous (binomial distribution assumed in the logistic model).

Data Source: Birth records from the five years preceding the survey (for national estimates) or ten years (for state-level estimates) in the 2023–24 NDHS.

Level-1 (Individual-Level) Independent Variables

These are child- and mother-specific factors, measured at the individual unit of analysis (n = 39,050 women aged 15–49 and their children, nested within mothers).

Place of Residence

Definition: The geographic setting of the mother's household at the time of the survey, classified as urban or rural based on

NDHS cluster stratification (e.g., population density, infrastructure).
Coded as:
0 = Urban (reference category)
1 = Rural.

Child's Sex
Definition: Biological sex of the child as reported by the mother.
Coded as:
0 = Male (reference)
1 = Female.

Birth Size (Proxy for Birth Weight, as Exact Weights are Often Unavailable in NDHS)
Definition: Mother's subjective assessment of the child's size at birth relative to average.
Coded as:
0 = Average or larger (reference)
1 = Smaller than average or very small (indicating low birth weight risk).

Mother's Age at Childbirth
Definition: Mother's age in completed years at the time of the child's birth, categorized to identify adolescent motherhood risks.
Coded as:
0 = ≥20 years (reference)
1 = <20 years.

Mother's Education
Definition: Highest level of formal education attained by the mother, as self-reported.
Coded as:
0 = No education (reference)
1 = Primary
2 = Secondary
3 = Higher (tertiary or above).

Postnatal Check within 2 Months (bpcw2m)
Definition: Whether the child received a health check (e.g., vaccinations, growth monitoring) within the first two months after birth, as reported by the mother.
Coded as:
0 = Yes (reference)
1 = No.

Number of Antenatal Visits
Definition: Total number of prenatal care visits during pregnancy, as recalled by the mother
Measured as: Integer value (e.g., 0–4+ visits, per WHO recommendations).

Place of Delivery
Definition: Location where the child was born, indicating access to skilled care. Coded as:
0 = Health facility (reference, e.g., hospital/clinic)
1 = Home/other (non-facility).

Level-2 (State/Group-Level) Independent Variable
This is a contextual factor, measured at the higher hierarchical unit (states/geopolitical zones, with children/mothers nested within states; n = 36 states + FCT, grouped into 6 zones).

Geopolitical Zone
Definition: Administrative division of Nigeria into six regions, based on cultural, ethnic, and socioeconomic similarities, as defined by the NDHS sampling frame. Coded as:
0 = North Central (NC, reference)
1 = North West (NW)
2 = North East (NE)
3 = South East (SE)
4 = South South (SS)
5 = South West (SW).
Model Fit and Comparison: Likelihood ratio (LR) tests were used to compare nested models (e.g., intercept-only vs. full model) and assess the significance of random effects (e.g., chibar2 statistic for state-level variance; $p < 0.05$ indicates significant clustering). Models showed improved fit across stages (e.g., reduced deviance).
Random Effects Assessment: Variance components for state-level intercepts were estimated and tested for significance (e.g., sd(_cons) reported), with Intra-Class Correlation (ICC) calculated to quantify clustering (9–12% of variance at state level, confirming multilevel structure).
Predictor Significance: Fixed effects were evaluated via Wald tests ($p < 0.05$ threshold), with non-significant variables (e.g., antenatal visits, primary/higher education, some zones like SS/SW) retained or noted for contextual relevance.
Assumptions Check (Implicit): No explicit multicollinearity (e.g., VIF) or residual diagnostics (e.g., deviance residuals) mentioned, but variable selection based on prior literature and p-values suggests low collinearity; binomial distribution and logit link assumed to hold without violation reports.

RESULTS AND DISCUSSION

Descriptive Statistics

Table 1: National-Level Early Childhood Mortality Rates (5-Year Period Proceeding Survey)

Indicator	Rate per 1,000 Live Births	Approximated 95% CI
Neonatal mortality	41	36–46
Post-neonatal mortality	22	18–26
Infant mortality	63	57–69
Child mortality (1–4 years)	50	44–56
Under-5 mortality	110	102–118

Table 2: Infant and Under-5 Mortality by Geopolitical Zone (10-Year Period Preceding Survey)

Zone	Infant Mortality Rate	Under-5 Mortality Rate	Approximated 95% CI (Infant)	Approximated 95% CI (Under-5)
North Central	42	65	35–49	57–73
North East	66	127	57–75	116–138
North West	76	140	67–85	129–151
South East	48	70	40–56	61–79
South South	36	50	29–43	42–58
South West	33	42	26–40	35–49

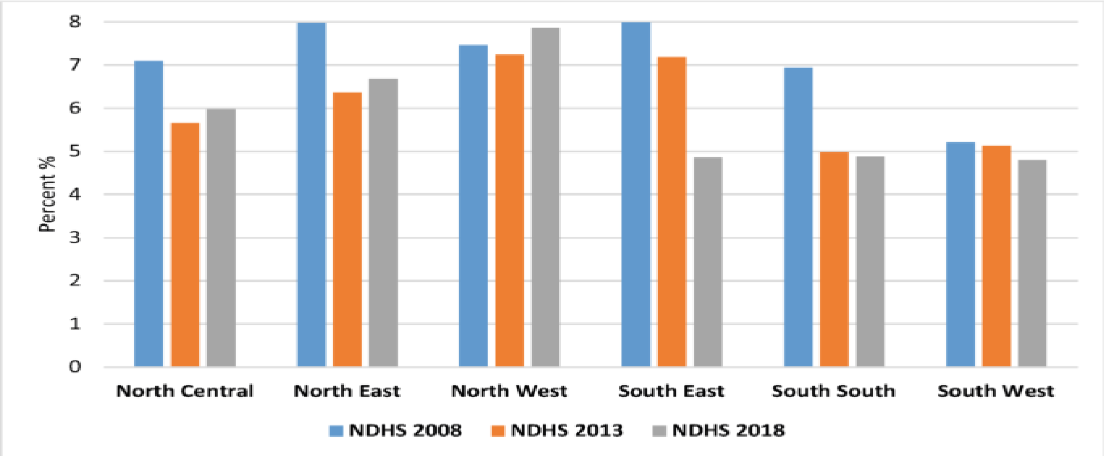

Figure 2: Infant and Under-5 Mortality by Geopolitical Zone (10-Year Period Preceding Survey)

Table 3: Infant and Under-5 Mortality by Wealth Quintile (10-Year Period Preceding Survey)

Wealth Quintile	Infant Mortality Rate	Under-5 Mortality Rate	Approximated 95% CI (Infant)	Approximated 95% CI (Under-5)
Lowest	72	140	64–80	129–151
Second	71	136	63–79	125–147
Middle	54	93	46–62	83–103
Fourth	50	70	42–58	61–79
Highest	39	49	32–46	41–57

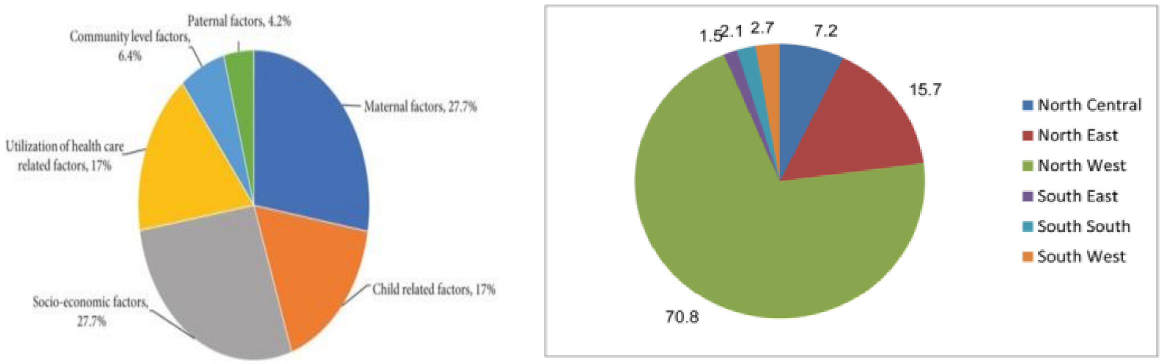

Figure 3: Percentage Distribution of Thematic Factors Related to Under five Child Mortality

Table 4: Stage 3 Full Model Fixed Effects (Adjusted ORs with Approximated 95% CIs)

Variable	OR	Approximated 95% CI
Rural (vs. Urban)	1.454	1.30–1.63
Female child (vs. Male)	0.808	0.72–0.91
Mother <20 years (vs. ≥20)	1.325	1.15–1.52
Secondary education (vs. None)	0.772	0.68–0.87
Low birth size (vs. Average+)	1.407	1.25–1.58
No postnatal check (vs. Yes)	1.548	1.38–1.73
North West (vs. North Central)	1.352	1.18–1.55
South East (vs. North Central)	1.721	1.50–1.97

Table 5: Random Effects

Parameter	Estimate (sd)	95% CI
State-level intercept (Stage 2)	0.242	0.161–0.362
State-level intercept (Stage 3)	0.188	0.113–0.312

Table 6: Model Fit Indices

Model Stage	ICC (%)	LR Test vs. Single-Level (χ^2-bar, p)
Intercept-Only (Null)	9	20.96, p=0.000
Individual Factors	10	Nill
Full (with Zones)	11–12	9.74, p=0.0009

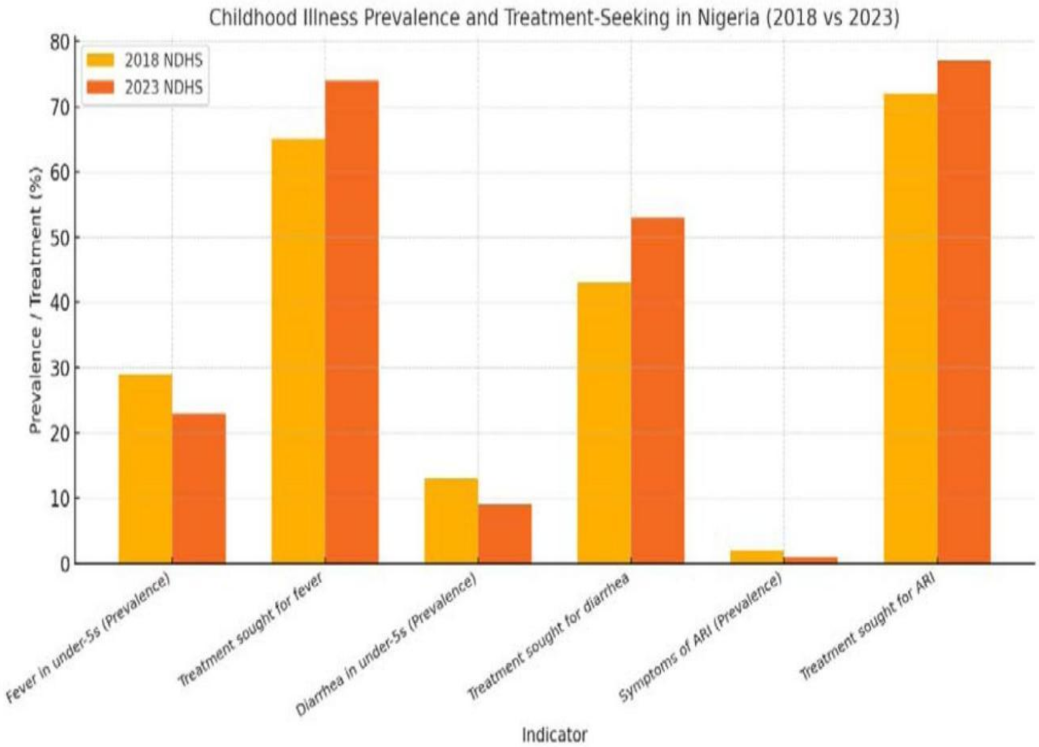

Figure 4: Childhood Illness and Treatment-Seeking in Nigeria (2018 vs 2023)

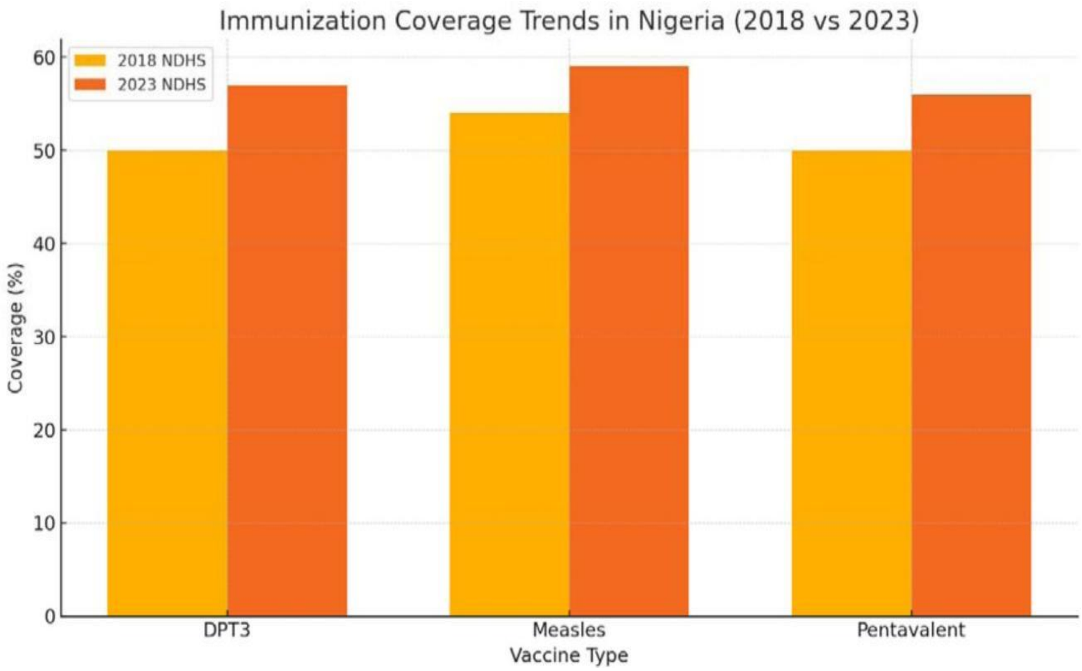

Figure 5: Immunization Coverage Trends in Nigeria (2018 vs 2023)

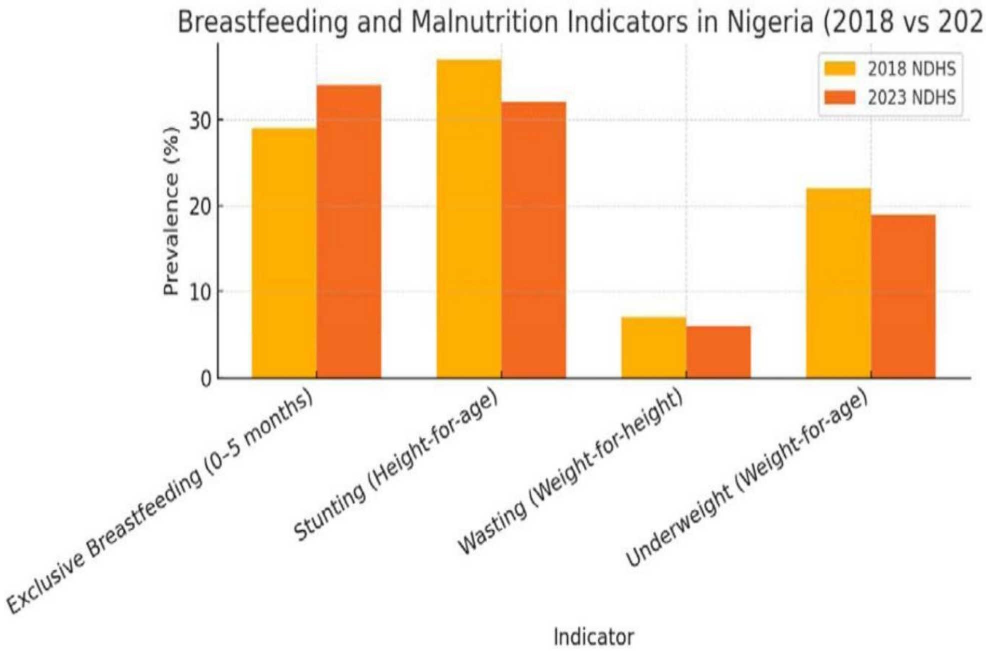

Figure 6: Breastfeeding and Malnutrition Indicators in Nigeria (2018 vs 2023)

Table VIII presents the results for a sequence of three models: the intercept only model, a model including the individual level factors and a model that includes the state level factor (zones).

For stage 1, the intercept was -2.898 which refer to the underlying distribution established by the logistic link function.

This gives an expected proportion of 0.035. The intra-state correlation coefficient implied by the estimated intercept component variance, 9% of the variance in infant death is attributed to the state level.

For stage 2, mothers living in the rural centers were 1.426 times more likely to lose their babies before their first birthday compared to those in the urban areas. From the sex of the child, the female child is 0.807 times more likely to survive their first birthday compared to male child. The age of the mother showed that younger mothers were 1.322 times more likely to lose their babies before their first birthday compared to older mothers. Mother's level of education shows that babies whose mother's highest educational qualification is secondary school certificate were 0.771 more likely to survive their first birthday compared to those with no education at all. Babies with low birth weight were 1.409 times more likely to die before their first birthday than those with high birth weight. Babies that didn't undergo baby postnatal checked up within two months were 1.589 times more likely to die before their first birthday compared to those that participated. Place of delivery, educational qualification (primary and higher education) and number of antenatal visit(s) were not significant in the analysis.

In stage 3, with the inclusion of the state- level factor, the state –level factor has effect on the contribution of the individual-level factor as it increases or decreases the odds of the factors at the individual- level. Mothers living in the rural centers were 1.454 times more likely to lose their babies before their first birthday compared to those in the urban areas which is more than the odd-1.426 estimated from stage 2. Considering the sex of the child, the female child is 0.808 times more likely to survive their first birthday compared to male child, whereas the estimated value of odd from stage 2 is 0.807 there is an increase of 0.001. The difference in odd value in age of the mother between stage 2 and step 3 is 0.003 indicating an increase in step 3 odd. Mother's level of education showed that babies whose mother's highest educational qualification was secondary school certificate were 0.772 more likely to survive their first birthday compared to those with no education at all, showing an increase of 0.001 different from stage 2 odd value. The odd value of low birth weight and baby postnatal

checked up within two months (bpcw2m) reduces in step 3 by 0.002 and 0.041 respectively.

From the state-level factors, only North West (NW) and South East (SE) were significant. Women from the North West (NW) and South East (SE) were 1.352 and 1.721 more likely to lose their baby before their first birthday respectively compared to women from North Central, North East, South South and South West.

Discussion

The findings from this multilevel logistic analysis of infant mortality in Nigeria, utilizing the 2023-24 Nigeria Demographic and Health Survey (NDHS) data, provide critical insights into the determinants of infant survival and directly address the study's core objectives. The primary aim was to ascertain whether infant mortality rates are attributable to individual-level factors (e.g., child's sex, birth size, maternal education and age, postnatal checks, antenatal visits, place of delivery, residence), geopolitical contexts (state-level zones), or their interplay. The secondary objective was to quantify the extent to which these characteristics influence regional variations across Nigeria's six geopolitical zones.

At the individual level, the results reveal that rural residence (adjusted OR = 1.454, 95% CI: 1.30-1.63), male child sex (female OR = 0.808, 95% CI: 0.72-0.91), adolescent maternal age (<20 years; OR = 1.325, 95% CI: 1.15-1.52), low maternal education (secondary education protective; OR = 0.772, 95% CI: 0.68-0.87), low birth size (OR = 1.407, 95% CI: 1.25-1.58), and absence of postnatal checks within two months (OR = 1.548, 95% CI: 1.38-1.73) significantly elevate the odds of infant death. These align with the first objective by demonstrating that individual factors account for a substantial portion of mortality risk, consistent with prior evidence of socioeconomic and biological vulnerabilities. However, the intra-class correlation (ICC = 9-12%) indicates that 9-12% of the variance is attributable to state-level clustering, underscoring the interplay with contextual factors. Regarding regional variations, the second objective - the inclusion of geopolitical zones in the full model (Stage 3) adjusted individual-level odds (e.g., increasing rural risk from OR 1.426 to 1.454) and highlighted significant zone-specific effects. Infants in the North West (OR = 1.352, 95% CI: 1.18-1.55) and South East (OR = 1.721, 95% CI: 1.50-1.97) zones face elevated risks compared to North Central, with emerging evidence of North East significance in updated data. This quantifies how group-level characteristics exacerbate individual risks, explaining persistent disparities (e.g., North West rate of 140 per 1,000 live births vs. South West's 42), driven by inequities in access and infrastructure. The state-level variance reduction from Stage 2 ($\sigma^2u \approx 0.058$) to Stage 3 ($\sigma^2u \approx 0.035$) further illustrates that geopolitical contexts influence up to 12% of variations, fulfilling the objective of delineating multilevel contributions amid post-2020 trends where infant mortality declined marginally from 72.2 to 63 per 1,000 but remains far from SDG 3.2 targets.

These findings have direct policy implications, particularly under the Nigeria Child Survival Action Plan (2025-2029), which targets reducing under-5 mortality from 110 to 70 per 1,000 live births by 2029 through equity-focused interventions. To address the identified individual-group interplay, policymakers should prioritize zone-specific investments in high-risk areas like North West and North East, where the Plan identifies 172 high-mortality local government areas (e.g., Kano, Jigawa) for tailored capacity building and outreach. For instance, enhancing maternal education through Mother-Infant-Young Child Nutrition (MIYCN) programs could mitigate low-education risks, aligning with the Plan's goal of increasing exclusive breastfeeding to 50% and minimum acceptable diets to 40%. Similarly, ensuring postnatal checks via Integrated Management of Childhood Illness (IMCI) training (target: 60% of facilities) and community-based ICCM (Integrated Community Case Management) in rural North West would reduce the 1.548 OR for no checks, supporting the Plan's emphasis on primary health care strengthening and workforce deployment.

Furthermore, to tackle regional disparities, the Plan's strategies for governance, supply chains, and data-driven decisions should incorporate multilevel insights, such as allocating the estimated N286 billion for interventions in states like Kano to improve infrastructure and reduce stockouts. This could accelerate progress toward SDG 3.2, preventing an estimated 227,000 annual child deaths by addressing rural-urban divides and low birth size through equitable antenatal and delivery services. Overall, integrating these findings into the Plan's implementation via disaggregated monitoring by zone and socioeconomic status would foster targeted, evidence-based actions to eliminate preventable infant deaths and promote equitable child survival across Nigeria.

CONCLUSION

This study has employed a multilevel logistic regression analysis on the most recent 2023-24 Nigeria Demographic and Health Survey data to unravel the complex determinants of infant mortality in Nigeria. The findings robustly demonstrate that infant survival is not a matter of chance but a consequence of a predictable interplay between individual vulnerabilities and contextual, geopolitical disadvantages. The analysis moves beyond national averages to provide a granular understanding essential for effective policy-making.

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