Methodological Insights into Multi-level Logistic Modeling of Childhood Stunting and Wasting in Nigeria

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Abstract— Childhood stunting and wasting remain important public health challenges in Nigeria, with substantial socioeconomic, geographical and contextual inequalities. This study examined factors associated with childhood stunting and wasting among children under five years using pooled Nigeria Demographic and Health Survey (NDHS) data from 2003–2018. A pooled sample of children aged under five years from the 2003, 2008, 2013 and 2018 NDHS data was analyzed using multilevel logistic regression. Children were modeled at level 1 and primary sampling units (PSU/clusters) at level 2, with geographical region and survey year included as fixed effects. Adjusted odds ratios (AOR) with 95% confidence intervals (CI) were estimated, while PSU-level variance and intraclass correlation coefficients (ICC) were used to quantify residual contextual clustering. The final models included 37,229 children for stunting and 37,246 for wasting, distributed across 1,391 PSUs. Female children had lower odds of stunting (AOR = 0.73, 95% CI: 0.69–0.77) and wasting (AOR = 0.83, 95% CI: 0.78–0.89) than males. Stunting showed a strong age gradient, with higher odds among children aged 12–23 months (AOR = 3.29, 95% CI: 3.04–3.33), 24–35 months (AOR = 4.76, 95% CI: 4.35–5.20), 36–47 months (AOR = 3.79, 95% CI: 3.42–4.21), and 48–59 months (AOR = 2.62, 95% CI: 2.30–2.98). In contrast, wasting odds were lower among children aged 24–35, 36–47 and 48–59 months. Small birth size and maternal underweight were associated with higher odds of both outcomes, whereas higher maternal education and maternal overweight were associated with lower odds. Stunting also showed pronounced geographical and socioeconomic gradients, including substantially higher odds in the North West (AOR = 2.28, 95% CI: 2.06–2.53) and lower odds among children from the richest households (AOR = 0.60, 95% CI: 0.52–0.68). Wasting showed substantially lower adjusted odds in later survey rounds, particularly in 2018 (AOR = 0.21, 95% CI: 0.18–0.25). The estimated PSU-level ICC were 4.0% for stunting and 6.4% for wasting, indicating residual clustering within PSU after adjustment. Childhood stunting and wasting share several associated factors but exhibit distinct age, socioeconomic, geographical and temporal patterns. The findings support integrated but outcome-specific nutrition strategies addressing maternal education and nutritional status, early-life vulnerability, childhood illness, socioeconomic disadvantage and geographical inequalities. The observed PSU-level clustering further supports the importance of context-sensitive and community-oriented approaches to childhood undernutrition.

Keywords— Childhood undernutrition, Intraclass correlation, Multilevel logistic regression, Stunting, Wasting.

1 INTRODUCTION

Childhood undernutrition remains a major public health problem in Nigeria (John et. al., 2024). Stunting reflects chronic, long-term nutritional deprivation (De Sanctis et.al., 2021), while wasting reflects acute nutritional deficiency (Omar et. al.,2022). Although they may share determinants, their age patterns and associations with socioeconomic and contextual factors often differ (Asmare and Agmas 2022). Analyzing them separately is therefore important for targeted policy. The NDHS uses a clustered sampling design (Okigbo et. al, 2017), so children within the same primary sampling unit (PSU) may share environments. Single-level models ignore this clustering (Ntani et. al., 2021). Multilevel models can estimate both fixed-effect associations and residual between-PSU heterogeneity. In Nigeria, undernutrition is unequally distributed by child characteristics, maternal education, household wealth, and geography (Akombi et al., 2017; Agu et al., 2019). Recent work also shows contextual variation in stunting persists after adjusting for individual factors (Adeomi & Ikujenlola, 2026), suggesting community-level influences matter. While several Nigerian studies have used multilevel methods (Akombi et. at., 2017; Tesfaw and Fenta, 2022), few have directly compared stunting and wasting using pooled data across multiple NDHS rounds within a common framework. It remains unclear how much contextual clustering persists after adjusting for child, maternal, and household factors.

This study addresses this gap by analyzing pooled 2003, 2008, 2013 and 2018 NDHS data. We estimate separate multilevel logistic regression models for stunting and wasting among children <5 years to: estimate adjusted associations with child, maternal, household, geographical and temporal factors; compare patterns between the two outcomes; and quantify residual PSU-level variation using the ICC. This distinguishes individual-level associations from unexplained community clustering.

2 METHODOLOGY

For an optimum evaluation of childhood stunting and wasting, the logistic regression method that is adopted for analysis is the Multilevel Logistic Regression Models for childhood stunting and wasting.

2.1 Multilevel Logistic Regression

Previous studies have examined childhood undernutrition indicators (underweight, stunting, and wasting) separately using standard logistic regression models (Khan et al., 2019; Habaasa, 2015; Tekile et al., 2019; Nshimyiryo et al., 2019; Sultana et al., 2021; Kejo et al., 2018). While such approaches are useful for identifying associations between covariates and individual outcomes, they fail to account for the potential correlation between anthropometric indicators within the

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same child. Stunting and wasting were analysed separately because they represent distinct nutritional outcomes. This approach improves statistical efficiency and provides a more realistic representation of child nutritional status (Tesfaw & Dessie, 2022; Ene et al., 2015).

Multilevel logistic regression provides an appropriate framework for analysing hierarchically structured health data by allowing the probability of childhood undernutrition to vary across higher-level units while simultaneously estimating the effects of individual and contextual characteristics (Abebew et, al.,2023). DHS data from Nigeria exhibit strong clustering due to shared environmental, socioeconomic, and healthcare factors. Ignoring this clustering can lead to underestimated standard errors and misleading inferences. This framework accounts for both the correlation between multiple anthropometric outcomes and the hierarchical clustering of observations. The extent of clustering was assessed using the Intraclass Correlation Coefficient (ICC) derived from the estimated random-effect variance components.

2.2 Variables of the Study

Two different types of variables are used in the research; they are the outcome and the explanatory variables.

1. Outcome Variables

In assessing the undernutrition status of children, the basic anthropometric measurements of weight and height were considered. The NDHS collected data on the nutritional status of children by using the Anthropometric measurements of children under five, these were converted into Z-scores using the WHO Child Growth Standards (2006)**.** Stunting and wasting, were defined as height-for-age and weight-for-height below −2 SD of the WHO reference median, respectively.

2. Explanatory Variables

The explanatory variables used in this study were grouped into demographic variables (sex of child, age of child, size of the child etc), socio-economic variables (the mother's education, wealth index, place of residence, geographical region, and the mother's body mass index), and health related variables (source of water supply, type of toilet facility, occurrence of diarrhea, occurrence of fever). These factors were selected based on previous literature which found them to be related with malnourishment among children under five [Zewdie and Abebaw 2013; Akombi et al., 2017; Brhanie 2019].

2.3 Data source and preparation

This study used four rounds of the Nigeria Demographic and Health Survey (NDHS), conducted in 2003, 2008, 2013 and 2018. The analysis was based on the corresponding children's/Kids' Recode (KR) datasets (NGKR4BFL.DTA, NGKR53FL.DTA, NGKR6AFL.DTA, and NGKR7BFL.DTA, respectively), obtained from the Demographic and Health Surveys (DHS) Program. The KR files contain information on children born to interviewed women, including anthropometric measurements, child and maternal characteristics, household socioeconomic characteristics and selected health indicators.

The study population comprised children aged 0–59 months. Children with valid anthropometric measurements were eligible for the corresponding nutritional outcome analysis. Observations with missing or DHS-coded invalid/flagged anthropometric measurements were excluded from the relevant outcome analysis, while observations with missing explanatory variables were excluded from the corresponding multivariable model. The four survey datasets were harmonized to ensure consistent variable definitions and category coding and were subsequently appended to form a pooled dataset covering 2003–2018. Survey year was retained as an identifying variable for each survey round.

Stunting was defined as a height-for-age z-score below −2 standard deviations and wasting as a weight-for-height z-score below −2 standard deviations, based on the WHO Child Growth Standards. DHS special codes for invalid, flagged or implausible anthropometric observations were treated as unavailable.

The NDHS complex sampling design was incorporated into survey-based analyses using the child sample weights (v005), normalized by dividing by 1,000,000. The primary sampling unit (v021) and sampling stratum (v022) were specified to account for clustering and stratification, respectively. The survey sampling design was distinguished from the hierarchical structure specified for the multilevel statistical models.

2.4 Mathematical Properties of the Multilevel Logistic Model

This section establishes the mathematical validity of the multilevel logistic model used to analyze childhood stunting and wasting in Nigeria. Unlike deterministic transmission models, the present framework is probabilistic and hierarchical, reflecting the structure of the NDHS data. The results presented here ensure that the model is well-defined, identifiable, and suitable for inference.

2.5 Descriptive and Multilevel Analysis

Descriptive statistics (frequencies and percentages) were used to summarize the distribution of childhood undernutrition and explanatory variables. Because children sampled within the same primary sampling unit (PSU) may share contextual characteristics, multilevel logistic regression models with a random intercept for PSU were fitted to account for residual within-cluster correlation.

The data follow a three-level structure:

Level 1: Child (i)

Level 2: PSU (j)

Children were clustered within primary sampling units (PSUs), and a random intercept for PSU was included to account for residual between-cluster heterogeneity (equation 1).

Let Y_{ij} denote the nutritional status of child i in PSU j where $Y_{ij} = 1$ indicates stunting (or wasting) and $Y_{ij} = 0$ otherwise. Conditional on the probability

$$p_{ij} = P(Y_{ij} = 1) \quad (1)$$

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The outcome follows a Bernoulli distribution:
$Y_{ij}|p_{ij} \sim Bernoulli(p_{ij})$
The logit transformation is specified as equation (2)

$$log\left(\frac{p_{ij}}{1-p_{ij}}\right) = \beta_0 + X_{ij}^T\beta + \mu_j \quad (2)$$

where
X_{ij} is the vector of observed covariates, β_0 is the fixed intercept, β is the vector of fixed effect coeeficients, $u_j \sim N(0, \sigma_\mu^2$ is the PSU-specific random intercept.

2.6 Model Building Strategy

An intercept-only model was initially fitted to estimate the extent of between-PSU heterogeneity in childhood stunting and wasting. Subsequently, child-, maternal-, household-, and contextual-level covariates were introduced into the model to estimate adjusted associations with the outcomes.
The final models included child sex, child age group, birth size, illness status, maternal education, maternal BMI category, household wealth, place of residence, and survey year. Adjusted odds ratios (AORs) with corresponding 95% confidence intervals were reported.

2.7 Variance Decomposition and Intraclass Correlation (ICC)

The extent of residual clustering at the PSU level was quantified using the intraclass correlation coefficient (equation 3). Under the latent-variable formulation of the logistic mixed-effects model, the individual-level residual variance is assumed to be $\pi^2/_3$. Therefore,

$$ICC = \frac{\sigma_{PSU}^2}{\sigma_{PSU}^2 + \pi^2/_3} \quad (3)$$

The estimated ICC for stunting wasting, indicates residual between-PSU clustering after adjustment for the covariates included in the respective final models.

3 RESULTS

This section presents empirical results obtained from fitting the multilevel logistic model specified in methodology to pooled Nigeria Demographic and Health Survey data from 2003 to 2018. All models were estimated using maximum likelihood, accounting for the hierarchical structure of children nested within households and communities. Results are reported in terms of fixed-effect estimates, variance components, and intraclass correlation coefficients, which together quantify both observed and unobserved sources of heterogeneity in childhood stunting and wasting.
We first present descriptive summaries of the outcome variables and key covariates to provide context for subsequent model-based inference. We then report fixed-effect estimates from the multilevel logistic models, followed by estimates of household- and community-level variance components. Finally, intraclass correlation coefficients are used to assess the relative contribution of higher-level heterogeneity to the total variation in childhood undernutrition.

3.1 Descriptive Statistics

We present sample sizes by survey year and the prevalence of stunting and wasting concurrence in this section.

Table 1. Prevalence of stunting by selected covariates among children aged 0–59 months, NDHS 2003–2018

Characteristics	Category	2003(n=4293)	2008(n=8038)	2013(n=8842)	2018(n=4109)	pooled(n=25282)
Outcome	Stunted	35.1 (32.9–37.4)	33.5 (32.6–34.6)	32.1 (31.1–33.2)	32.1 (31.1–33.2)	35.0 (33.8–36.2)
Sex of child	Male	37.3 (34.4–40.3)	34.8 (33.5–36.1)	33.4 (32.2–34.7)	38.6 (36.9–40.3)	35.1 (34.3–35.9)
	Female	33.1 (30.5–35.8)	32.2 (31.1–33.5)	30.8 (29.6–32.1)	33.6 (32.0–35.3)	32.0 (31.2–32.7)
Age of child (months)	<6	6.3 (4.1–9.7)	15.5 (13.9–17.2)	12.6 (11.1–14.1)	18.2 (15.8–20.9)	14.8 (13.6–16.2)
	6–23	37.1 (33.7–40.8)	32.9 (31.3–34.1)	28.8 (27.5–30.1)	33.1 (31.1–35.0)	33.3 (32.1–34.4)
	24–59	41.2 (38.3–44.1)	37.9 (36.6–39.1)	37.7 (36.3–39.2)	41.2 (39.6–42.9)	39.4 (38.4–40.4)
Size of child	Lower than average	40.0(34.9-45.5)	39.0(36.9-41.3)	37.7(35.5-40.1)	43.8(40.6-47.1)	39.3(37.8-40.7)
	Average	36.5 (33.5–39.6)	33.4 (32.1–34.8)	33.5 (32.2–35.1)	35.4 (33.9–36.9)	34.1 (33.2–35.0)
	Larger than average	32.5 (29.4–35.8)	32.2 (30.9–33.4)	28.9 (27.7–30.2)	34.4 (32.5–36.5)	31.2 (30.3–32.0)
Breastfeeding	Yes	39.7 (37.2–42.3)	36.7 (36.1–38.1)	35.3 (34.1–36.7)	39.0 (37.4–40.6)	36.8 (35.9–37.6)
	No	28.9 (25.9–32.1)	28.3 (27.1–29.5)	26.1 (24.8–27.4)	30.2 (28.4–32.1)	27.7 (26.9–28.6)
Twin status	No	35.1 (32.8–37.2)	33.3 (32.3–34.3)	32.1 (31.0–33.1)	35.8 (34.5–37.1)	33.3 (32.6–34.1)
	Yes	43.2 (32.5–54.5)	41.1 (36.0–46.6)	35.0 (30.2–40.2)	48.3 (41.6–55.1)	40.1 (37.0–43.4)
Illness category	No illness	32.9 (30.2–35.7)	33.1 (32.1–34.2)	31.8 (30.8–33.1)	34.2 (33.1–35.6)	32.7 (31.9–33.5)
	Had illness	40.2 (37.3–43.1)	35.7 (33.8–37.8)	34.1 (32.1–36.1)	42.1 (39.8–44.3)	37.6 (36.4–38.8)
Maternal education	None	45.6 (42.5–48.7)	40.1 (38.6–41.6)	41.8 (40.3–43.3)	53.1 (51.2–54.9)	43.2 (42.2–44.2)
	Primary	34.5 (30.5–38.6)	34.7 (33.1–36.4)	30.3 (28.5–32.2)	37.4 (34.8–40.1)	33.2 (32.1–34.3)
	Secondary	20.4 (17.0–24.1)	24.6 (23.2–26.0)	20.4 (19.1–21.8)	23.2 (21.5–24.9)	22.3 (21.5–23.2)
	Higher	5.7 (2.9–11.1)	16.2 (13.9–18.9)	11.8 (7.7–14.2)	13.5 (10.9–16.7)	13.3 (12.0–14.8)
Autonomy level	Low	41.1 (37.8–44.4)	37.3 (36.1–38.6)	37.0 (35.3–38.8)	49.3 (47.1–51.9)	40.0 (38.5–41.6)
	Medium	35.6 (32.5–38.8)	28.7 (27.4–30.1)	32.1 (30.9–33.4)	36.1 (34.4–37.6)	33.9 (32.8–35.0)
	High	25.1 (21.2–28.5)	24.5 (20.9–28.6)	23.1 (21.3–25.1)	21.1 (19.1–23.4)	25.2 (23.8–26.7)
Maternal BMI category	Underweight	47.3 (41.5–53.2)	44.1 (41.8–46.3)	40.9 (38.4–43.5)	49.2 (45.5–52.9)	44.1 (42.5–45.6)
	Normal	37.2 (34.5–40.0)	34.9 (33.8–36.0)	34.6 (33.5–35.8)	40.0 (38.6–41.5)	35.8 (35.0–36.6)
	Overweight	24.2 (20.6–28.3)	24.9 (23.4–26.6)	22.9 (21.5–24.4)	24.0 (22.1–26.1)	23.8 (22.9–24.8)
Wealth index	Poorest	44.6 (40.4–48.9)	40.3 (38.3–42.2)	44.1 (42.7–47.2)	54.5 (51.8–57.0)	44.8 (43.4–46.2)

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	Poorer	43.3 (38.9–47.8)	40.1 (38.1–41.8)	39.2 (37.3–41.2)	48.4 (45.9–51.1)	41.2 (40.0–42.5)
	Middle	42.1 (37.1–47.2)	35.6 (33.7–37.5)	31.1 (29.1–33.0)	37.1 (34.6–39.4)	34.4 (33.1–35.6)
	Richer	29.1 (24.4–34.3)	28.4 (26.4–30.4)	23.6 (22.1–25.4)	26.7 (24.3–29.4)	26.1 (25.0–27.3)
	Richest	17.3 (14.1–20.9)	20.5 (18.8–22.4)	16.3 (14.8–17.9)	16.2 (14.0–18.6)	17.7 (16.7–18.8)
Region	North Central	30.9 (25.3–37.2)	35.4 (33.1–37.8)	26.5 (24.2–28.8)	27.8 (24.8–31.0)	30.0 (28.5–31.5)
	North East	40.6 (36.1–45.3)	40.1 (38.1–42.4)	35.4 (33.3–37.6)	47.9 (45.1–50.8)	39.4 (37.8–41.0)
	North West	48.1 (44.0–52.2)	41.1 (39.1–43.2)	45.8 (43.9–47.7)	55.8 (53.5–58.1)	46.1 (44.9–47.4)
	South East	18.7 (16.1–21.6)	17.5 (15.3–20.0)	13.8 (12.1–15.9)	18.0 (15.6–20.7)	16.3 (15.1–17.5)
	South South	15.9 (11.3–21.9)	26.0 (23.6–28.6)	16.3 (14.7–18.1)	19.8 (17.2–22.7)	20.6 (19.3–22.0)
	South West	23.7 (21.1–26.6)	27.1 (24.8–29.5)	20.6 (18.4–22.9)	22.9 (20.2–25.8)	23.6 (22.2–25.0)
Residence	Urban	27.1 (23.2–31.3)	26.0 (24.4–27.8)	23.2 (21.7–24.7)	26.3 (24.4–28.2)	24.9 (23.9–26.0)
	Rural	39.3 (36.6–42.1)	40.0 (37.5–41.4)	37.2 (35.9–38.6)	43.9 (42.3–45.5)	40.1 (38.1–41.9)
Household size	<4	34.7 (29.1–40.9)	30.7 (29.2–32.3)	27.8 (25.7–30.0)	30.2 (27.1–33.5)	29.2 (27.4–31.0)
	4–9	32.9 (30.5–35.5)	33.1 (31.8–34.1)	30.9 (29.7–32.0)	33.1 (31.7–34.5)	31.7 (30.7–32.7)
	10+	45.1 (40.1–50.3)	39.4 (37.6–41.4)	38.8 (37.0–40.6)	51.1 (48.2–54.1)	42.6 (41.0–44.1)

Table 2. Prevalence of wasting by selected covariates among children aged 0–59 months, NDHS 2003–2018

Characteristics	Category	2003(n=4293)	2008(n=8038)	2013(n=8842)	2018(n=4109)	pooled(n=25282)
Outcome	Wasted	8.7 (7.6–9.8)	11.5 (10.8–12.2)	16.1 (15.3–16.9)	6.9 (6.3–7.5)	12.4 (11.9–13.0)
Sex of child	Male	8.8 (7.1–10.4)	11.7 (10.9–12.6)	16.7 (15.8–17.7)	8.1 (7.2–8.8)	12.9 (12.4–13.6)
	Female	8.5 (7.2–10.2)	11.4 (10.6–12.2)	15.5 (14.6–16.4)	5.8 (5.0–6.6)	11.9 (11.3–12.5)
Age of child (months)	<6	6.1 (4.1–8.9)	12.6 (11.2–14.1)	20.1 (18.4–22.0)	6.9 (5.3–9.0)	10.2 (9.1–11.3)
	6–23	13.4 (11.1–16.1)	13.7 (12.8–14.7)	21.0 (19.8–22.2)	11.9 (10.1–13.4)	13.2 (12.4–14.0)
	24–59	6.5 (5.3–7.8)	10.1 (9.0–10.9)	12.7 (11.6–13.6)	4.0 (3.5–4.7)	7.7 (7.2–8.2)
Size of child	Lower than average	12.1 (9.5–15.1)	14.2 (12.8–15.7)	20.0 (18.3–21.9)	11.8 (9.9–14.0)	16.2 (15.2–17.2)
	Average	8.3 (6.9–10.1)	12.1 (11.0–12.9)	16.9 (15.7–17.1)	6.4 (5.7–7.3)	12.5 (11.8–13.2)
	Larger than average	7.9 (6.5–9.7)	10.5 (9.7–11.4)	14.2 (13.3–15.2)	5.7 (5.0–6.6)	11.2 (10.7–11.9)
Breastfeeding	Yes	6.7 (5.5–8.1)	10.1 (9.1–10.8)	13.1 (12.2–14.0)	4.5 (4.0–5.1)	10.0 (9.5–10.6)
	No	11.7 (9.7–14.1)	14.2 (13.3–15.2)	21.9 (20.8–23.0)	11.6 (10.3–13.0)	16.9 (16.2–17.6)
Twin status	No	8.5 (7.5–9.7)	11.3 (10.7–12.1)	16.0 (15.2–16.9)	6.8 (6.3–7.4)	12.4 (11.8–12.9)
	Yes	14.5 (9.1–22.3)	15.8 (12.3–20.1)	18.3 (14.9–22.2)	8.9 (6.0–13.0)	15.5 (13.5–17.8)
Illness category	No illness	7.6(6.4–9.0)	11.1 (10.3–11.7)	16.0 (15.1–16.9)	5.9 (5.3–6.5)	12.2 (11.7-12.8)
	Had illness	10.9 (8.8–13.4)	14.3 (12.8–16.1)	16.9 (15.5–18.5)	9.9 (8.6-11.3)	13.5 (12.7–14.4)
Maternal education	None	9.5 (8.2–11.2)	15.9 (14.8–17.1)	19.1 (18.1–20.4)	9.5 (8.4–10.6)	15.9 (15.1–16.6)
	Primary	8.8 (6.8–11.5)	9.6 (8.6–10.6)	14.7 (13.4–16.1)	5.5 (4.2–7.2)	9.7 (8.3–11.4)
	Secondary	5.6 (4.1–7.7)	7.1 (6.3–8.0)	13.1 (12.1–14.1)	5.2 (4.5–6.0)	7.8 (6.8–9.0)
	Higher	10.5 (6.5–16.7)	4.9 (3.8–6.5)	9.9 (8.1–12.1)	4.8 (3.5–6.6)	7.5 (5.5–10.3)
Autonomy level	Low	9.1 (7.5–10.9)	13.6 (12.7–14.6)	15.9 (14.8–17.2)	9.3 (8.0–10.8)	14.3 (13.3–15.4)
	Medium	8.6 (7.1–10.4)	8.8 (8.1–9.7)	17.3 (16.2–18.5)	6.7 (6.1–7.5)	13.7 (12.8–14.7)
	High	7.5 (5.6–10.3)	7.7 (5.8–10.2)	11.9 (10.8–13.2)	4.5 (3.7–5.7)	9.3 (8.4–10.2)
Maternal BMI category	Underweight	11.9 (9.0–15.6)	16.8 (15.1–18.7)	20.2 (18.3–22.3)	14.2 (11.9–16.8)	17.2 (16.1–18.4)
	Normal	8.3 (7.2–9.6)	12.1 (11.3–12.9)	16.9 (16.1–17.8)	7.1 (6.4–7.8)	13.0 (12.5–13.6)
	Overweight	7.4 (5.4–10.2)	7.9 (7.0–8.8)	12.8 (11.6–14.2)	4.2 (3.2–5.3)	9.2 (8.4–10.0)
Wealth index	Poorest	9.5 (7.6–11.9)	16.0 (14.4–17.7)	18.5 (17.1–20.1)	10.5 (9.2–12.1)	15.9 (14.9–16.8)
	Poorer	9.5 (7.6–11.7)	14.3 (12.9–15.7)	17.3 (15.9–18.9)	7.8 (6.6–9.2)	14.3 (13.4–15.2)
	Middle	7.7 (5.5–10.7)	10.0 (8.9–11.2)	15.2 (13.6–17.1)	6.9 (5.7–8.2)	11.4 (10.5–12.4)
	Richer	8.2 (6.2–10.8)	8.2 (7.2–9.4)	15.4 (13.9–17.1)	5.4 (4.2–6.9)	10.6 (9.7–11.6)
	Richest	7.8 (5.7–10.5)	7.8 (6.7–9.0)	12.9 (11.6–14.4)	4.3 (3.4–5.4)	9.2 (8.4–10.0)
Region	North Central	6.0 (4.5–7.8)	7.4 (6.3–8.8)	11.3 (9.9–12.9)	5.8 (4.7–7.1)	8.7 (7.8–9.6)
	North East	7.4 (5.7–9.6)	18.0 (15.9–20.4)	16.6 (14.9–18.5)	9.8 (8.4–11.5)	15.1 (14.0–16.3)
	North West	10.8 (8.8–13.1)	15.8 (14.3–17.4)	22.8 (21.2–24.6)	8.9 (7.7–10.3)	17.6 (16.5–18.8)
	South East	4.4 (2.5–7.7)	7.0 (5.9–8.4)	11.0 (9.7–12.3)	4.6 (3.7–5.7)	7.9 (7.1–8.7)
	South South	9.4 (6.0–14.4)	5.9 (4.8–7.2)	10.4 (9.0–12.1)	4.4 (3.3–5.8)	7.6 (6.8–8.5)
	South West	9.1 (6.9–12.0)	8.1 (7.0–9.4)	9.7 (9.0–12.1)	5.1 (3.7–6.6)	8.2 (7.5–8.9)
Residence	Urban	8.0 (6.3–10.1)	9.0 (8.0–10.2)	16.0 (14.6–17.5)	5.4 (4.7–6.3)	11.2 (10.3–12.2)
	Rural	8.8 (7.6–10.2)	12.7 (11.8–13.6)	16.1 (15.2–17.1)	8.0 (7.2–8.9)	13.1 (12.6–13.7)
Household size	<4	6.1 (3.9–9.2)	10.9 (9.8–12.0)	16.8 (15.1–18.7)	8.6 (6.8–10.8)	13.4 (12.1–14.8)
	4–9	8.8 (7.6–10.1)	11.1 (10.5–12.0)	15.3 (14.5–16.2)	6.3 (5.7–7.1)	12.3 (11.6–13.0)
	10+	8.9 (7.1–11.2)	13.9 (12.5–15.4)	18.5 (17.1–20.2)	8.2 (6.9–9.6)	14.9 (13.6–16.2)

3.2 Childhood Undernutrition Trends (Stunting and Wasting)

NDHS data from 2003 to 2018 indicate that childhood undernutrition remains a major public health concern in Nigeria. Stunting prevalence among children aged 0–59 months declined slightly from 35.1% in 2003 to 32.1% in 2018 although substantial disparities persisted across child, maternal, household, and regional characteristics (Nwosu and AAtaguba 2020;). In the pooled sample, stunting was more prevalent among older children, those reported to be smaller than average at birth, children of mothers with no formal education, children of underweight mothers, children from poorer households, rural residents, and children living in the North East and North West. (Lawal et. al., 2024). Wasting was more variable, peaking at 16.1% in 2013 and falling to 6.9% Pooled wasting prevalence was 12.4%, with higher prevalence among children aged 6–23 months, those reported to be smaller than average at birth, non-breastfed children, children of underweight mothers, children from poorer households, and children

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residing in the North East and North West. (Agu et al 2019;).

These findings highlight persistent inequalities in childhood undernutrition, emphasizing the need for targeted interventions addressing child, maternal, and household determinants.

3.3 Correlation Analysis

The correlation analysis indicated that most linear associations between study variables and child nutritional outcomes were weak. Among child-level factors, age showed small negative correlations with both stunting and wasting, suggesting a slight increase in undernutrition with increasing age, while birth weight exhibited almost no linear relationship with these outcomes. For maternal characteristics, mother's age was strongly positively correlated with total children ever born and number of living children, reflecting expected fertility patterns. Maternal education demonstrated modest positive correlations with antenatal care attendance and maternal BMI, indicating that more educated women may have better health-seeking behaviors and nutritional status. Cross-correlations between maternal and child variables were generally weak; however, maternal education showed small negative correlations with both stunting and wasting, suggesting a modest protective effect.

Table 3. Correlations between Maternal and Child Variable

Variable	Mothers age	Mothers BMI	ANC	Education	Total Children Born	Living Children	Age in Months	Birth Weight	Stunted	Wasted
Mothers age	1.000	0.105	0.040	0.018	0.705	0.684	0.178	-0.011	-0.038	-0.036
Mothers BMI	0.105	1.000	0.050	0.163	0.022	0.039	0.032	-0.024	0.063	0.061
ANC	0.040	0.050	1.000	0.217	-0.071	-0.046	0.023	-0.026	-0.009	-0.011
Education	0.018	0.163	0.217	1.000	-0.295	-0.218	-0.016	-0.051	-0.084	-0.092
Total Children Born	0.705	0.022	-0.071	-0.295	1.000	0.893	0.130	0.011	-0.006	-0.002
Living Children	0.684	0.039	-0.046	-0.218	0.893	1.000	0.146	-0.009	-0.014	-0.012
Age in Months	0.178	0.032	0.023	-0.016	0.130	0.146	1.000	-0.004	-0.100	-0.088
Birth Weight	-0.011	-0.024	-0.026	-0.051	0.011	-0.009	-0.004	1.000	0.007	0.008
Stunted	-0.038	0.063	-0.009	-0.084	-0.006	-0.014	-0.100	0.007	1.000	0.986
Wasted	-0.036	0.061	-0.011	-0.092	-0.002	-0.012	-0.088	0.008	0.986	1.000

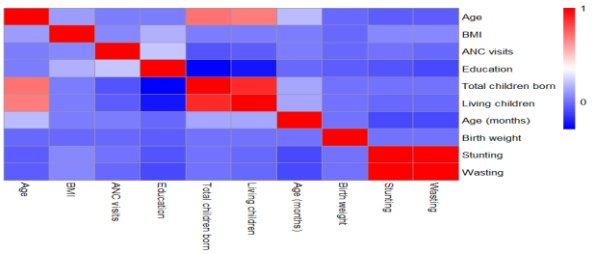

Fig. 1. Heat map of correlations between quantitative of Maternal and child Variable

Table 4. Adjusted odds ratios from the final multilevel logistic regression models

Variable	Reference Category	Stunting AOR (95%CI)	Wasting AOR (95%CI)
Sex	Male	0.73 (0.69-0.77)	0.83 (0.78-0.89)
Female			
Age in months	<12 months		
12-23 months		3.29 (3.04-3.54)	1.10 (1.01-1.20)
24-35 months		4.76 (4.35-5.20)	0.82 (0.74-0.91)
36-47 months		3.79 (3.42-4.21)	0.60 (0.53-0.69)
48-59 months		2.62 (2.30-2.98)	0.58 (0.49-0.69)
Birth size	Large		
Average		1.22 (1.15-1.30)	1.25 (1.15-1.35)
Small		1.54 (1.42-1.68)	1.46 (1.32-1.62)
Illness	No illness		
Any illness		1.12 (1.05-1.19)	1.09 (1.02-1.17)
Maternal Education	No Education		
Primary		0.91 (0.84-0.98)	0.89 (0.81-0.98)
Secondary		0.75 (0.68-0.81)	0.76 (0.68-0.85)
Higher		0.52 (0.44-0.60)	0.60 (0.48-0.75)
Maternal BMI	Normal		
Maternal underweight		1.21 (1.11-1.32)	1.29 (1.16-1.42)
Maternal overweight		0.81 (0.75-0.87)	0.82 (0.74-0.90)
Wealth	Poorest		
Poorer		0.94 (0.87-1.01)	0.99 (0.89-1.10)
Middle		0.90 (0.82-1.00)	0.94 (0.83-1.07)
Richer		0.74 (0.66-0.83)	0.90 (0.78-1.03)
Richest		0.60 (0.52-0.68)	0.96 (0.80-1.15)
Residence	Urban		
Rural	Rural	1.10 (1.01-1.20)	0.95 (0.85-1.06)
Region	North Central		
North East		1.33 (1.19-1.50)	1.59 (1.36-1.85)
North West		2.28 (2.06-2.53)	2.28 (1.96-2.64)
South East		0.54 (0.47-0.62)	1.05 (0.88-1.25)
South South		0.66 (0.58-0.75)	0.87 (0.73-1.03)
South West		0.87 (0.77-0.97)	0.98 (0.84-1.15)
Survey year	2003		
2008		1.21 (1.07-1.38)	0.46 (0.39-0.53)
2013		0.82 (0.72-0.93)	0.66 (0.57-0.76)
2018		0.88 (0.77-1.01)	0.21 (0.18-0.25)
PSU variance		0.14 (0.11-0.17)	0.23 (0.18-0.28)
ICC		4.0%	6.4%
N		37,229	37,246
PSUs		1,391	1,391

From table 4 Stunting among female children had about 27% lower odds of stunting than males (AOR 0.732, p<0.001). Compared with the reference age group, the odds of stunting were substantially higher at 12–23 months (AOR 3.285), 24–35 months (4.756), 36–47 months (3.791), and 48–59 months (2.622), all p<0.001. Small birth size, any illness, and maternal underweight were associated with higher odds, whereas higher maternal education, maternal overweight, and being in the richest wealth category were associated with lower odds. Rural residence was associated with slightly higher odds (AOR 1.101).

Wasting: The pattern was different. Female children had lower odds of wasting (AOR 0.831). The odds of wasting were lower among children aged 24–35, 36–47 and 48–59 months, whereas the association for 12–23 months was

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weak. Small birth size and maternal underweight were associated with higher odds, while higher maternal education and maternal overweight were protective. Unlike stunting, the richest wealth category and rural residence were not statistically significant.

Survey year was differentially associated with stunting and wasting. Compared with 2003, the adjusted odds of stunting were higher in 2008 (AOR 1.21, 95% CI: 1.07–1.38) but lower in 2013 (AOR 0.82, 95% CI: 0.72–0.93), while the 2018 estimate did not differ significantly from 2003 (AOR 0.88, 95% CI: 0.77–1.01). In contrast, wasting showed consistently lower adjusted odds in subsequent survey rounds, declining from 0.46 (95% CI: 0.39–0.53) in 2008 to 0.21 (95% CI: 0.18–0.25) in 2018 relative to 2003.

The estimated PSU-level variance was 0.14 for stunting and 0.23 for wasting, indicating residual between-PSU heterogeneity after adjustment, with greater clustering for wasting. 4.0% of the residual variation in stunting and 6.4% of the residual variation in wasting was attributable to differences between PSUs, on the latent scale of the logistic model.

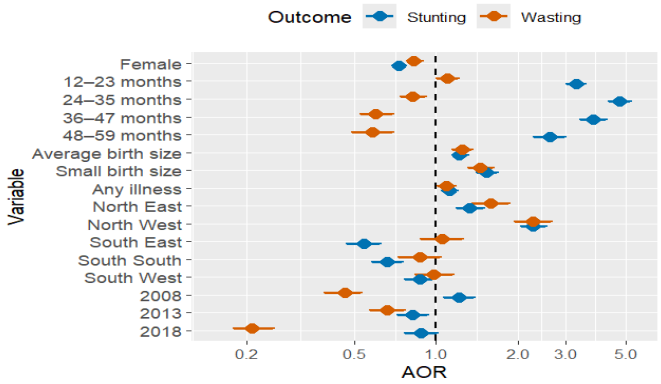

Fig. 2. Adjusted associations of child and geographical/temporal characteristics with stunting and wasting

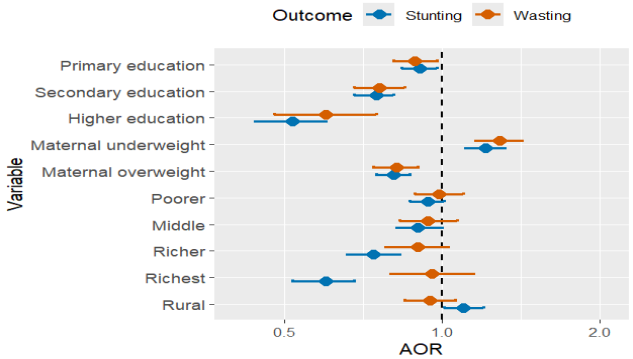

Fig. 3. Adjusted associations of maternal and socioeconomic characteristics with stunting and wasting

Figures 2 and 3 show that stunting and wasting exhibited both shared and divergent associations. Relative to infants <12 months, stunting odds rose sharply with age (peak AOR 4.76 at 24–35 months), whereas wasting odds declined. Girls had lower odds of both outcomes (stunting AOR 0.73; wasting AOR 0.83). Small birth size elevated odds of stunting (AOR 1.54) and wasting (AOR 1.46); recent illness showed weaker associations. Regional disparities were pronounced for stunting (North West AOR 2.28; South East AOR 0.54 vs North Central) but milder for wasting. Adjusted odds of wasting fell substantially across survey years (2018 AOR 0.21 vs 2003); reductions in stunting were modest. A graded inverse association with maternal education was observed for both outcomes (higher education: stunting AOR 0.52; wasting AOR 0.60). Maternal underweight has higher odds while maternal overweight has lower odds. Household wealth showed a clear inverse gradient with stunting (richest AOR 0.60) but little association with wasting. Rural residence was modestly associated with higher stunting odds only.

4 CONCLUSION

This study demonstrates that childhood stunting and wasting in Nigeria have overlapping but distinct patterns of association. Female sex, maternal education and maternal overweight were associated with lower odds of both outcomes, whereas small birth size, childhood illness and maternal underweight were associated with higher odds. Stunting showed particularly strong age, socioeconomic and geographical gradients, while wasting showed substantially lower adjusted odds among older children and across later survey rounds. The observed PSU-level clustering, particularly for wasting, indicates that contextual differences remain relevant after adjustment for individual and household characteristics. These findings support integrated but outcome-specific nutrition strategies that combine maternal education and nutrition interventions, early-life and child-health services, socioeconomic support and geographically targeted programmes, particularly in disadvantaged communities and regions with elevated undernutrition.

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