



SPATIAL ANALYSIS OF THE RELATIONSHIP BETWEEN CONTRACEPTIVE USE AND UNDER-FIVE MORTALITY IN NIGERIA

Anthony Ike Wegbom¹, Olatunde Raimi¹, and Adeniyi Francis Fagbamigbe^{1,2*}

¹Department of Public Health Sciences, College of Medical Sciences, Rivers State University, Port Harcourt 500262, Nigeria.

²Department of Epidemiology and Medical Statistics, Faculty of Public Health, College of Medicine, University of Ibadan, Ibadan, Nigeria.

*Corresponding Author's Email: franstel74@yahoo.com

Cite this article:

Wegbom, A. I., Raimi, O., Fagbamigbe, A. F. (2026), Spatial Analysis of the Relationship between Contraceptive Use and Under-five Mortality in Nigeria. African Journal of Biology and Medical Research 9(1), 71-92. DOI: 10.52589/AJBMR-VD8JAD8F

Manuscript History

Received: 8 Jan 2026

Accepted: 10 Feb 2026

Published: 20 Feb 2026

Copyright © 2026 The Author(s).

This is an Open Access article distributed under the terms of Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International (CC BY-NC-ND 4.0), which permits anyone to share, use, reproduce and redistribute in any medium, provided the original author and source are credited.

ABSTRACT: *Background: Under-five mortality (U5M) in Nigeria continues to be high, while contraceptive use has not increased despite national and global commitments to improve reproductive health. This dual burden presents a significant public health concern, reflecting systemic weaknesses in linking family planning and child survival strategies. Understanding how contraceptive behaviour influences under-five mortality is essential to designing integrated interventions capable of improving maternal and child health outcomes. This study, therefore, examined the spatial dynamics between child mortality and contraceptive usage in Nigeria with a focus on the influence of geo-political contexts on both processes. The research drew attention to regional differences, considering the role of socio-cultural factors in shaping these outcomes. Methods: Data were drawn from the 2021 Nigeria Multiple Indicator Cluster Survey (MICS), a nationally representative dataset comprising 38,768 women aged 15–49 years, selected through a two-stage stratified cluster sampling design to ensure adequate precision across all six geopolitical zones. Life table Stata ltable techniques were used to estimate child mortality rates from censored survival data. A Spatial Bayesian ge-additive regression and the Frequentist Model were conducted to account for the geographical differences. Results: About two-thirds (62.2%) of the mothers were aged 25-34 years, 67.9% were rural residents, and 52.9% had given birth at home. The contraceptive prevalence rate (CPR) was 21.7%, while the under-five mortality rate was 101.8/1,000 live births. The spatial analysis showed regional differences in under-five mortality rates, with the northern states having higher posterior odds ratios, while states like Ogun (U5MR = 28 per 1,000; POR=1.40; 95% CrI=0.69–3.22) and Bayelsa (U5MR = 38 per 1,000; POR=1.58; 95% CrI =0.72–3.84) had lower rates and posterior odds ratios. In the completely adjusted Bayesian model, use of contraceptives remained protective, where mothers who utilized contraceptives were 15% lower to experience under-five mortality (aPOR: 0.85, 95% CrI: 0.72–0.98). Conclusion: The study highlights the relationship between maternal age, education, marriage, and place of residence, and the use of contraception and child survival in Nigeria. Therefore, low levels of contraceptive use remains a contributing factor to under-five mortality in Nigeria. Hence, targeted and context-defined reproductive health interventions are required to improve child survival outcomes in Nigeria.*

KEYWORDS: Child mortality; Contraceptive use; Nigeria 2021; Spatial analysis.



INTRODUCTION

Child death, particularly among children under the age of five years, remains a significant indicator of public health and national development (WHO, 2021; UN IGME, 2020). Known as the under-five mortality rate, it defines the probability of a child's death under the age of five, per 1,000 live births. Globally, over 5 million under-five deaths were recorded in 2020, translating to an alarming daily average of more than 13,800 deaths (UNICEF, 2020; World Bank, 2023). Despite recent improvements, the burden remains disproportionately high in low- and middle-income countries (LMICs), particularly in Sub-Saharan Africa (UNICEF, 2021; Wegbom et al, 2023). Nigeria is a case in point of such a struggle, accounting for nearly 28% of infant mortality in the Sub-Saharan zone, having an under-five mortality rate of 110 per 1,000 live births as of 2023–2024 (NDHS, 2023). Notwithstanding the efforts at improving maternal and child health, the country's success has continued to be non-uniform across its heterogeneous domains, with extensive spatial disparities in both the use of contraceptives and the survival rates of children (Wegbom et al, 2023).

Family planning is a cost-effective, evidence-based intervention for reducing child morbidity and mortality. Modern family planning methods, if well-spaced, can potentially prevent up to 1.8 million under-five deaths globally (Fagbamigbe et al., 2021). However, despite increased investments, Nigeria remains one of the countries with the lowest contraceptive prevalence rates globally. Only 20% of in-union women report use of any contraceptive, with a mere 15% using modern methods (Fagbamigbe et al., 2021; Wegbom et al, 2023).

Emerging evidence highlights the importance of spatially explicit analysis, revealing geographic variations in child mortality and contraceptive use prevalence across Nigerian regions and states (Akinyemi et al., 2021). Understanding where and why these inequalities in child mortality and contraceptive use exist is crucial for geotargeting interventions. The integration of spatial and multilevel analysis provides insight into not only the contribution of individual-level determinants (e.g., maternal education or household wealth) but also contextual, community-level factors (e.g., access to health care, geographic remoteness, or sociocultural norms) (Wegbom et al., 2022).

Therefore, this study aims to examine the geographical pattern and multilevel determinants of under-five mortality as it is associated with contraceptive use in Nigeria. It also tries to establish the potential mediators and moderators that affect these relationships, thereby informing evidence-based, region-specific policy and programmatic interventions.

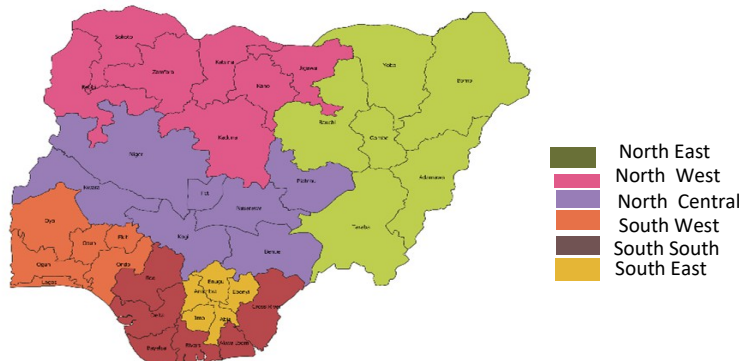
METHODS

Study setting and data source

The study was retrospective and cross-sectional in design, utilizing data from the nationally representative 2021 Nigeria Multiple Indicator Cluster Survey (MICS) conducted by the National Bureau of Statistics (NBS) in collaboration with the United Nations Children's Fund (UNICEF). Nigeria is administratively divided into 36 states and the Federal Capital Territory (FCT), which are further grouped into six geopolitical zones: North-East (NE), North-West (NW), North-Central (NC), South-East (SE), South-South (SS), and South-West (SW). Although these geopolitical zones have no formal administrative functions, they represent regions with distinct sociocultural, economic, and ecological characteristics. Each state is subdivided into Local Government Areas (LGAs), which were further divided into census enumeration areas (EAs) based on the 2006 National Population and Housing Census.

The MICS is a globally standardized household survey program designed to generate internationally comparable indicators on the health and well-being of women, children, and families. The 2021 Nigerian round of the survey provides comprehensive data on maternal and child health, fertility, contraceptive prevalence, and early childhood development, making it suitable for national and sub-national analyses (MICS, 2021).

Fig. 1: Map of Nigeria showing the 36 states and the Federal Capital Territory (FCT) and the 6 geopolitical zones of the country. (Authors' Drawing



Sampling Techniques

The 2021 Nigeria Multiple Indicator Cluster Survey (MICS 2021) employed a multi-stage, stratified cluster sampling technique using the sampling frame derived from the 2006 Population and Housing Census conducted by the National Population Commission (NPopC). The primary sampling units (PSUs), also known as enumeration areas (EAs), were selected from this census frame. Each of the 36 states and the Federal Capital Territory (FCT) was stratified into urban and rural areas to ensure national representativeness. In the first stage, 670,257 enumeration areas were selected with probability proportional to EA size. In the second stage, an equal allocation approach was adopted, assigning 50 clusters to each state and the FCT, resulting in a total sample of 37,000 households (50 clusters by 37 domains and 20 households per cluster). From these households, 40,326 eligible women aged 15–49 years were identified, of whom 38,768 were successfully interviewed, yielding a high response rate of



96.1% (MICS, 2021). Also, Birth history variables were analysed at the child level rather than the maternal level. Consequently, each live birth reported by respondents was treated as an individual observation. This resulted in a total analytic sample of 103,316 births contributed by 38,768 women in Nigeria.

Variables and Measurement

This study adopted the Mosley and Chen (1984) framework for the study of child survival in developing countries, which integrates socioeconomic, environmental, and biological determinants of child mortality (Mosley et al., 1984). The framework posits that socioeconomic and community-level factors influence child survival through a set of proximate determinants. The primary outcome variable was under-five mortality (U5MR), defined as the probability of dying before reaching five years of age (0–59 months), and coded as 1 if the child died before age five and 0 if the child survived beyond age five.

The explanatory variables examined in this study comprised socioeconomic, demographic, and proximate determinants relating to the mother, child, and household. Educational attainment was categorized as no formal education, primary, junior secondary, senior secondary, and higher. Maternal age was grouped into less than 25, 25–34, 35+ years. Household wealth index was measured using the standard composite index derived from household assets and categorized into quintiles (poorest, poorer, middle, richer, and richest). The number of births within the last five years was treated as a discrete count variable and further grouped as 0–1, 2–3, and ≥ 4 births for analysis. Type of place of residence was classified as urban or rural, while the place of delivery was categorized as home, public health facility, or private health facility.

Method of Data Analysis

Data obtained from the 2021 MICS are edited and cleaned rigorously to ensure accuracy for analysis. STATA version 18 SE, R Studio 4.4.3 and QGIS desktop 3.14.15 were utilized in performing the analysis. The dataset was coded and scored accordingly in accordance with the dependent and independent variables. We computed population-level childhood mortality estimates using MORTPAK (United Nations software for mortality measurement). In addition, we generated survival life tables from individual-level event data in Stata using the ltable command, following standard survival analysis procedures.

Analyzing the spatial variation of contraceptive use and child mortality, we controlled for geographical variation using a Bayesian Geo-Additive Regression Model with unadjusted and adjusted Posterior Odds Ratios (POR and aPOR) at 95% credible intervals (CrI). This approach was adopted modified methodological approach used by Fagbamigbe et al. (2021). The enhanced model estimates the under-five mortality outcome and considers individual-level risk factors and spatial effects within a hierarchical structure.

The information had two principal binary response variables: (1) child mortality, 1 if the child had died by age five and 0 otherwise, and (2) contraceptive use, 1 if using any method of contraceptive currently and 0 otherwise and Let $i = 1, \dots, S$ and $j = 1, \dots, n$ where $S (= 37)$ represents the total number of geographical units in Nigeria, comprising 36 states and the Federal Capital Territory (FCT).



A Bernoulli distribution was assumed for the response variable, and the probability of death was modeled through a binomial regression method with a logit function:

Mathematically,

$$y_{ij} \sim \text{Bernoulli}(\pi_{ij}) \text{ with } \mu_{ij} = E[Y_{ij}|\pi_{ij}] = \pi_{ij} \text{ and}$$

$$\text{Var}(Y_{ij}|\pi_{ij}) = \pi_{ij}(1 - \pi_{ij}) \dots\dots\dots 1$$

Also, the probability mass function (pmf) of the response is given by

$$f(y; \pi) = \pi^y(1 - \pi)^{1-y} \text{ for } y \in \{0, 1\} \dots\dots\dots 2$$

In the class of the semi-parametric geo-additive mixed models utilized in this study, the dependent variable y is a function of a group of covariates through a linear predictor ij linked to a function of its mean with a link function $g(ij)$.

Specifically, the model contained:

a Non-linear function for continuous predictors (i.e., mother's age).

- Fixed effects for categorical variables (i.e., wealth quintile, mother's education, place of delivery).
- Spatial effects account for regional variation in child mortality and contraceptive use.

A binary predictor for contraceptive use was included as a key explanatory variable in the child mortality model to assess its impact. Likewise, a separate model was fitted for contraceptive use to explore its spatial variation and determinants.

Therefore, the unadjusted model:

$$U5m_i \sim f_{str}(state_i) + f_{unstr}(state_i) \dots\dots\dots 3$$

Adjusted model

$$U5m_i \sim f_{str}(state_i) + f_{unstr}(state_i) + \text{Contraceptive use} + \text{Wealth Quintile} + \text{Mother's Education} + \dots + \text{Place of Delivery} \dots\dots\dots 4$$

The Frequentist Model

For comparison and robustness, a classical (frequentist) multivariable logistic regression model was also fitted. This model estimated Crude Odds Ratios (COR) and Adjusted Odds Ratios (AOR) with 95% Confidence Intervals (CI) to examine the association between contraceptive use and under-five mortality after adjusting for socio-demographic characteristics.

The frequentist model is expressed as:

$$\text{logit}(\pi_{ij}) = \alpha_0 + \alpha_1 \text{ContraceptiveUse}_{ij} + \sum_k \alpha_k X_{kij} \dots\dots\dots 5$$



Ethical Considerations

This study utilized secondary data obtained from the Nigeria Multiple Indicator Cluster Survey (MICS) 2021, which is publicly available through the UNICEF MICS data repository. Ethical approval for data collection, including informed consent procedures, confidentiality, and respondent protection, was obtained by the National Bureau of Statistics (NBS) in collaboration with UNICEF and other national agencies during the original MICS 2021 fieldwork. Approval of using the data for the study was sought and subsequently granted by the data originator through their website platform. The data sharing policy and safety were strictly adhered to as provided in the letter of approval obtained from the organisation.

RESULT

The distribution of demographic and socioeconomic characteristics of women is presented in Table 3.1a. A total of 38,768 women of reproductive age were included in the analysis, of whom 67.9% (26,339) resided in rural areas and 32.1% (12,429) in urban areas. Nearly half of respondents (45.8%; 17,785) were aged 25–34 years, while the remainders were either younger than 25 years (22.6%) or aged 35 years and above (31.6%). Most respondents (62.2%; 24,134) were currently married or in union, whereas 32.4% had never married and 5.4% were formerly married.

Additionally, 33.6% had completed senior secondary education, 30.9% had no formal education, and the rest were distributed across primary (14.9%), junior secondary (9.4%), and higher education (11.3%) levels. Also, 22.4% (8,708) belonged to the poorest wealth category, 22.8% (8,838) to the poorer category, and 22.0% (8,523) to the middle category, while 18.5% (7,156) and 14.3% (5,543) were classified as richer and richest, respectively.

Furthermore, 52.9% (17,423) of deliveries occurred at the respondent's home, 31.4% (10,334) in public health facilities, 8.5% (2,780) in private health facilities, and 7.1% (2,349) in other locations.

Moreover, 55.19% (21,418) had low media exposure, 24.38% (9,451) had medium exposure, and 20.39% (7,912) had high exposure. A majority of households, 80.54% (31,056), were Male-headed, while 19.46% (7,712) were Female-headed. Similarly, 54.51% (21,132) of household heads were Christians, 44.51% (17,256) were Muslims, and 0.98% (380) belonged to other religions.

Table 3.1a: Percentage and distribution of sociodemographic characteristics of the women

Variables	Frequency (N=38,768)	%
Area		
Urban	12,429	32.1
Rural	26,339	67.9
Maternal Age		
Less than 25	8,761	22.57
25-34	17,785	45.82
35+	12,266	31.60



Marital Status		
Currently married	24,134	62.2
Formerly married	2,078	5.4
Never married	12,556	32.4
Educational Status		
None	11,956	30.85
Primary	5,772	14.87
Junior secondary	3,634	9.37
Senior secondary	13,016	33.57
Higher/tertiary	4,390	11.33
Wealth Index		
Poorest	8,708	22.4
Poorer	8,838	22.8
Middle	8,523	22.0
Richer	7,156	18.5
Richest	5,543	14.3
Place of Delivery		
Public Health Facility	10,334	31.4
Private Health Facility Base	2,780	8.5
Respondent's Home	17,423	52.9
Others	2,349	7.1
Media Exposure		
Low	21,418	55.19
Medium	9,451	24.38
High	7,912	20.39
Sex of household head		
Male	31,056	80.54
Female	7,712	19.46
Religion of Household Head		
Christianity	21,132	54.51
Islam	17,256	44.51
Others	380	0.98

Table 3.1b presents the distribution of birth historical characteristics based on 103,316 reported live births. The results show that 28.0% (28,921) of births occurred after a two-year interval, 21.9% (22,669) occurred within less than two years of the preceding birth, 12.7% (13,160) followed a three-year interval, and 14.0% (13,388) occurred after four or more years, while first births accounted for 24.4% (25,178).

Birth order distribution indicates that 37.6% (38,854) were of order 2–3, 28.6% (29,599) were of order 4–6, 24.1% (24,873) were first births, and 9.7% (9,990) were of order seven or higher. In addition, slightly more than half of all births were Male (51.8%; 53,479), compared with 48.2% (49,837) Female births.

**Table 3.1b: Percentage and distribution of birth history, Nigeria**

Variables	Frequency	%
Previous birth interval		
First Birth	25,178	24.4
< 2 Years	22,669	21.9
2 Years	28,921	28.0
3 Years	13,160	12.7
4+ years	13,388	14.0
Birth order		
1	24,873	24.1
2-3	38,854	37.6
4-6	29,599	28.6
7+	9,990	9.7
Sex of child		
Male	53,479	51.8
Female	49,837	48.2

The pattern of contraceptive use, infant mortality rate, and under-five mortality rates is presented in Table 3.2 below. The results reveal that the total contraceptive prevalence rate (CPR) for Nigeria is 21.7%, with an infant mortality rate of 63.4 per 1,000 live births, and an under-five mortality rate of 101.8 per 1,000 live births. The CPR is higher in urban areas (31.8%) compared to rural areas (14.8%). In contrast, the infant mortality rate (71.5 per 1,000 live births), and under-five mortality rate (122.3 per 1,000 live births) are all higher in rural areas than in urban areas.

The data also show that CPR is highest among women aged 35 to 49, at 24.7%. Women under 20 years of age experience higher rates of infant mortality (87.6 per 1,000 live births), and under-five mortality (147.0 per 1,000 live births). Conversely, women between the ages of 20 and 34 experience the lowest rates of infant mortality (55.4 per 1,000 live births), and under-five mortality (90.4 per 1,000 live births). The results in Table 3.2 further indicate that children whose mothers use contraceptives are moderately distributed across previous birth intervals. Infant mortality (98.4 per 1,000 live births), and under-five mortality (147.5 per 1,000 live births) are highest among women with a previous birth interval of less than two years. Although the majority of women with higher or tertiary education report a CPR of approximately 36%, women with no education experience the highest rates of infant mortality (78.5 per 1,000 live births), and under-five mortality (141.8 per 1,000 live births). Similarly, the wealthiest women in the wealth index quintile report the highest CPR (36.7%), while the poorest women have the lowest CPR (9%). On the other hand, women in the poorer wealth index quintile experience the highest rates of infant mortality (76.2 per 1,000 live births), and under-five mortality (135.4 per 1,000 live births). Geographically, the children whose mothers use contraceptives in the South West is higher (35.4%), compared to their counterparts in the North East (9.8%). However, all Under-five mortality rates are highest in the North West (infant mortality rate: 88.7 per 1,000 live births, and under-five mortality rate: 157.6 per 1,000 live births) and lowest in the South West (infant mortality rate: 36.2 per 1,000 live births, and under-five mortality rate: 48.1 per 1,000 live births).

**Table 3.2 Patterns of Infant Mortality and Under-five Mortality in Nigeria.**

Variables	CPR (%)	Infant Mortality (per 1,000 live births)	Under-Five Mortality (per 1,000 live births)
Total	21.7	63.4	101.8
Area			
Urban	31.8	47.3	66.8
Rural	14.8	71.5	122.3
Mother's Age			
< 20 years	4.2	87.6	147.0
20–34 years	19.7	55.4	90.4
35–49 years	24.7	74.2	115.0
Birth Order			
1	24.2	61.3	94.0
2–3	39.4	46.2	76.6
4–6	28.8	65.7	108.8
7+	7.6	96.8	160.6
Previous Birth Interval			
First birth	21.8	63.1	96.2
< 2 years	19.8	98.4	147.5
2 years	21.2	54.9	100.6
3 years	22.6	52.3	88.1
4+ years	23.5	44.2	67.4
Maternal Education			
None	10.1	78.5	141.8
Primary	21.1	65.3	107.0
Junior secondary	23.1	56.8	92.0
Senior secondary	30.4	49.7	66.0
Higher/Tertiary	35.8	33.1	40.8
Wealth Index Quintile			
Poorest	9.3	74.1	133.0
Poorer	13.0	76.2	135.4
Middle	21.4	61.3	98.0
Richer	28.9	49.2	73.1
Richest	36.7	41.4	47.0



Sex of Child			
Male	–	68.1	108.7
Female	–	57.6	94.2
Maternal Media Exposure			
Not at all	11.0	77.9	137.6
< Once a week	18.0	64.8	110.3
≥ Once a week	27.0	51.7	85.7
Almost every day	36.0	39.1	59.3
Sex of Household Head			
Male	20.5	63.0	104.3
Female	24.0	56.2	91.8
Religion of Household Head			
Christianity	30.0	45.7	68.0
Islam	15.0	76.5	132.7
Others	20.0	59.8	96.1
Geopolitical Zone			
North Central	23.5	44.8	62.3
North East	9.8	67.9	114.7
North West	12.7	88.7	157.6
South East	30.5	27.1	54.2
South South	25.4	63.9	84.0
South West	35.4	36.2	48.1

NB: Contraceptive Prevalence Rate (CPR): Defined as the percentage of women aged 15–49 years currently using any method of contraception. For variables such as sex of household head and religion of household head, CPR reflects contraceptive use among women living in households within these categories.

Mortality Indicators: Infant mortality (deaths before age 1) and under-five mortality (deaths before age 5) are expressed per 1,000 live births. Rates are disaggregated by selected household and maternal characteristics.

Spatial Analysis of Child Mortality in Nigeria

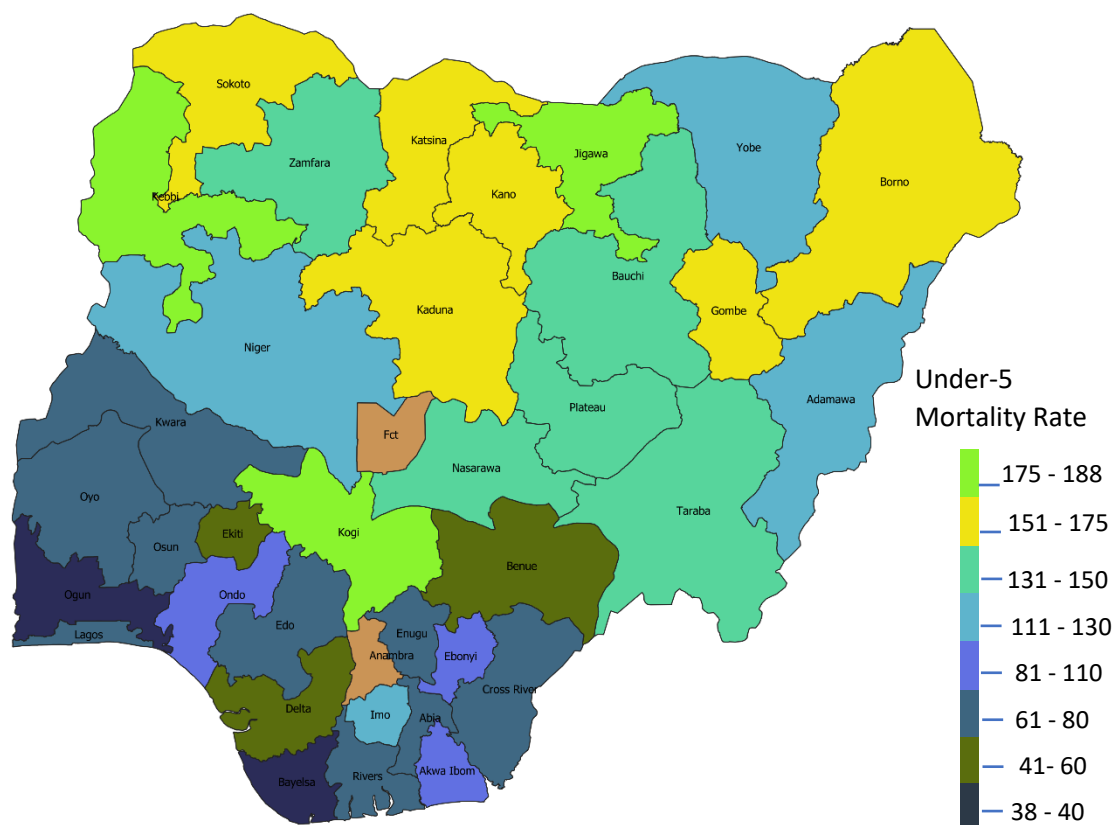
Table 3.3 and Figure 2 present the distribution of under-five mortality rates (U5MR) and unadjusted posterior odds ratios (POR) across states. The national U5MR was 132 per 1,000 live births (95% CI: 127–136).

Kebbi recorded the highest U5MR at 249 per 1,000 live births (95% CI: 221–281), followed by Jigawa (210; 95% CI: 182–242), Sokoto (173; 95% CI: 145–206), Katsina (172; 95% CI: 148–201), Kano (169; 95% CI: 150–190), Bauchi (144; 95% CI: 118–175), and Gombe (168 per 1,000 live births; 95% CI: 146–194). These states also exhibited elevated unadjusted POR values relative to the reference state (Anambra). For example, Kebbi had a POR of 10.90 (95% CrI: 6.14–22.73), Jigawa 7.85 (95% CI: 3.87–16.15), Sokoto 7.10 (95% CI: 3.65–16.12), Bauchi 6.03 (95% CI: 3.12–12.04), and Gombe 7.02 (95% CI: 3.32–13.99).

Additionally, several states in the North Central and North East zones showed elevated mortality levels, including Kaduna (162; 95% CI: 141–184), Kogi (188; 95% CI: 141–250), Plateau (133; 95% CI: 107–166), Nasarawa (141; 95% CI: 110–181), and Adamawa (129; 95% CI: 101–162). Their corresponding POR values ranged from 4.81 to 6.45, with credible intervals excluding unity.

However, Ogun recorded the lowest U5MR at 28 per 1,000 live births (95% CI: 14–43), followed by Bayelsa (38; 95% CI: 24–58), Ekiti (48; 95% CI: 31–72), Anambra (52; 95% CI: 36–70), and Delta (54; 95% CI: 34–86).

Figure 2: Spatial distribution of under-5 deaths across Nigerian states and the FCT. Dark blue to light green indicates extremely low mortality to Very High Mortality.



**Table 3.3: Distribution of under-5 mortalities by State in Nigeria and odds of under-5 mortality in each State**

State Name	n (%)	U5MR per 1,000 live births (%o) (95% CI)	Unadjusted (95% CrI)	POR
ANAMBRA (Ref)	469 (1.5)	52 (36–70)	1	
ABIA	483 (1.6)	78 (59–103)	3.20 (1.58–6.88) *	
ADAMAWA	1206 (3.9)	129 (101–162)	4.81 (2.38–9.93) *	
AKWA IBOM	796 (2.6)	106 (80–139)	4.52 (2.21–9.64) *	
BAUCHI	1254 (4.0)	144 (118–175)	6.03 (3.12–12.04) *	
BAYELSA	596 (1.9)	38 (24–58)	1.58 (0.72–3.84)	
BENUE	822 (2.6)	61 (41–93)	2.20 (1.11–4.64) *	
BORNO	1235 (4.0)	88 (67–115)	3.17 (1.44–6.61) *	
CROSS RIVER	363 (1.2)	72 (50–103)	3.28 (1.61–7.29) *	
DELTA	529 (1.7)	54 (34–86)	1.97 (0.91–4.52)	
EBONYI	720 (2.3)	101 (74–135)	3.62 (1.81–7.49) *	
EDO	485 (1.6)	70 (47–102)	2.93 (1.41–6.24) *	
EKITI	312 (1.0)	48 (31–72)	1.72 (0.78–3.85)	
ENUGU	543 (1.7)	79 (58–106)	3.50 (1.73–7.31) *	
GOMBE	1015 (3.3)	168 (146–194)	7.02 (3.32–13.99) *	
IMO	418 (1.3)	115 (92–144)	5.10 (2.50–11.02) *	
JIGAWA	1296 (4.2)	210 (182–242)	7.85 (3.87–16.15) *	
KADUNA	1154 (3.7)	162 (141–184)	6.31 (3.20–12.38) *	
KANO	1208 (3.9)	169 (150–190)	6.41 (3.24–12.53) *	
KATSINA	1198 (3.9)	172 (148–201)	6.12 (3.19–11.98) *	
KEBBI	1225 (3.9)	249 (221–281)	10.90 (6.14–22.73) *	
KOGI	796 (2.6)	188 (141–250)	6.45 (3.50–12.26) *	
KWARA	1027 (3.3)	73 (54–96)	3.05 (1.61–6.04) *	
LAGOS	770 (2.5)	68 (51–90)	2.91 (1.39–6.81) *	
NASARAWA	1212 (3.9)	141 (110–181)	5.18 (2.78–10.25) *	
NIGER	983 (3.2)	130 (102–166)	5.25 (2.69–10.42) *	
OGUN	591 (1.9)	28 (14–43)	1.40 (0.69–3.22)	
ONDO	547 (1.8)	95 (59–151)	2.80 (1.45–5.67) *	
OSUN	523 (1.7)	75 (48–116)	2.52 (1.27–5.13) *	
OYO	647 (2.1)	77 (50–118)	2.59 (1.32–5.25) *	
PLATEAU	961 (3.1)	133 (107–166)	5.34 (2.72–10.90) *	
RIVERS	538 (1.7)	76 (55–104)	3.08 (1.58–6.52) *	
SOKOTO	819 (2.6)	173 (145–206)	7.10 (3.65–16.12) *	
TARABA	1123 (3.6)	137 (115–164)	5.32 (2.79–10.51) *	
YOBE	1728 (5.6)	126 (104–153)	4.95 (2.31–10.02) *	
ZAMFARA	940 (3.0)	150 (127–178)	5.88 (3.18–11.83) *	
FCT	571 (1.8)	63 (43–94)	2.42 (1.19–5.09) *	
Total	31,103	132 (127–136)	--	

*Significant at $p < 0.05$, CI confidence interval, %o per 1000, U5MR Under-5 death, CrI credible interval, posterior odds ratio (POR)



Table 3.4 presents the associations between maternal and household factors and under-five mortality using unadjusted and adjusted odds ratios (ORs) from frequentist logistic regression. Mothers who used contraceptives had lower odds of under-five mortality compared with non-users (OR: 0.72; 95% CI: 0.61–0.85). Children born to mothers aged 25–34 years had 17% lower odds of dying before age five compared with children of mothers aged 15–24 years (OR: 0.83; 95% CI: 0.72–0.96), and the effect was stronger for children of mothers aged 35+ years (OR: 0.75; 95% CI: 0.64–0.88).

Children of currently married mothers exhibited 25% higher odds of under-five mortality compared with those of formerly married mothers (OR: 1.25; 95% CI: 1.02–1.53). Children of never-married mothers had 40% higher odds of dying before age five (OR: 1.40; 95% CI: 1.10–1.78). Compared with children whose mothers had no formal education, children of mothers with primary education had 22% lower odds of under-five mortality (OR: 0.78; 95% CI: 0.67–0.92).

Children from the richest households had 50% lower odds of under-five mortality compared with children from the poorest households (OR: 0.50; 95% CI: 0.42–0.60). Children born at home had 42% higher odds of dying before age five (OR: 1.42; 95% CI: 1.20–1.68), and those born in other non-healthcare settings had 75% higher odds (OR: 1.75; 95% CI: 1.40–2.20) compared with children born in public health facilities.

Bayesian Spatial Model Results

After controlling for spatial effects in the Bayesian geo-additive model, contraceptive use remained significantly associated with lower odds of under-five mortality. Children of mothers using contraceptives had 20% lower odds of dying before age five compared with children of non-users (POR: 0.80; 95% CrI: 0.68–0.95). For maternal age, children of mothers aged 35+ years had 20% lower odds of under-five mortality (POR: 0.80; 95% CrI: 0.68–0.94) relative to children of mothers aged 15–24 years. Children of mothers with secondary education had 35% lower odds (POR: 0.65; 95% CrI: 0.55–0.78), and those with higher education had 50% lower odds (POR: 0.50; 95% CrI: 0.40–0.63) compared with children of mothers without formal education.

In the fully adjusted Bayesian model, children of mothers who used contraceptives have 15% lower odds of under-five mortality (aPOR: 0.85; 95% CrI: 0.72–0.98). However children of mothers aged 35+ years still had 15% lower odds (aPOR: 0.85; 95% CrI: 0.72–1.00) compared with children of mothers aged 15–24 years.

Similarly, children from the richest households have 30% lower odds of under-five mortality than those from the poorest households (aPOR: 0.70; 95% CrI: 0.56–0.87). Mothers with six or more children had 50% higher odds of under-five mortality for their children (aPOR: 1.50; 95% CrI: 1.25–1.80) compared with mothers with fewer than two children. Additionally, children born at home had 30% higher odds of under-five mortality (aPOR: 1.30; 95% CrI: 1.08–1.56), while those born in other locations had the highest odds (aPOR: 1.55; 95% CrI: 1.22–1.95) compared with children born in public health facilities.

**Table 3.4: Unadjusted and Adjusted Factors Associated with Contraceptives and Under-5 Mortality in Nigeria**

Characteristics	Frequentist Approach (OR, 95% CI)	Bayesian Geo-Additive Model	
		Unadjusted (POR, 95% CrI)	Adjusted (aPOR, 95% CrI)
Contraception			
NotUsing Contraceptive	1		
Contraceptive Use	0.72 (0.61, 0.85)*	0.80 (0.68, 0.95)*	0.85 (0.72, 0.98)*
Maternal Age			
15-24	1		
25-34	0.83 (0.72, 0.96)*	0.88 (0.76, 1.02)	0.92 (0.80, 1.06)
35+	0.75 (0.64, 0.88)*	0.80 (0.68, 0.94)*	0.85 (0.72, 1.00)*
Marital Status			
Currently Married	1		
Formerly Married	1.25 (1.02, 1.53)*	1.15 (0.95, 1.38)	1.10 (0.92, 1.32)
Never Married	1.40 (1.10, 1.78)*	1.30 (1.02, 1.65)*	1.22 (0.98, 1.52)
Educational Level			
None	1		
Primary	0.78 (0.67, 0.92)*	0.85 (0.73, 1.00)*	0.90 (0.76, 1.07)
Secondary	0.52 (0.44, 0.61)*	0.65 (0.55, 0.78)*	0.70 (0.58, 0.84)*
Higher	0.35 (0.28, 0.44)*	0.50 (0.40, 0.63)*	0.55 (0.43, 0.70)*
Wealth Index			
Poorest	1		
Second	0.82 (0.72, 0.94)*	0.88 (0.76, 1.02)	0.90 (0.78, 1.04)
Middle	0.72 (0.62, 0.84)*	0.80 (0.68, 0.94)*	0.85 (0.72, 1.00)*
Fourth	0.62 (0.53, 0.74)*	0.72 (0.60, 0.86)*	0.75 (0.62, 0.91)*
Richest	0.50 (0.42, 0.60)*	0.65 (0.52, 0.80)*	0.70 (0.56, 0.87)*
Children Ever Born (CEB)			
Below 2	1		
2	1.12 (0.97, 1.30)	1.08 (0.93, 1.25)	1.05 (0.90, 1.22)
3-5	1.38 (1.20, 1.58)*	1.30 (1.12, 1.52)*	1.25 (1.08, 1.46)*
6+	1.62 (1.38, 1.90)*	1.55 (1.30, 1.85)*	1.50 (1.25, 1.80)*
Place of Delivery			
Public	1		
Private	0.85 (0.72, 1.01)	0.88 (0.75, 1.05)	0.90 (0.77, 1.08)
Respondent's Home	1.42 (1.20, 1.68)*	1.35 (1.12, 1.62)*	1.30 (1.08, 1.56)*
Others	1.75 (1.40, 2.20)*	1.60 (1.25, 2.00)*	1.55 (1.22, 1.95)*

Fig. 4 displays the total spatial effects for under-five mortality, with unadjusted estimates on the left and adjusted estimates on the right (a), alongside the corresponding 95% posterior significance map (b). The color gradient from light blue to light yellow represents increasing risk levels, while black indicates states with a significantly low risk of under-five mortality. White denotes a significantly high-risk state.

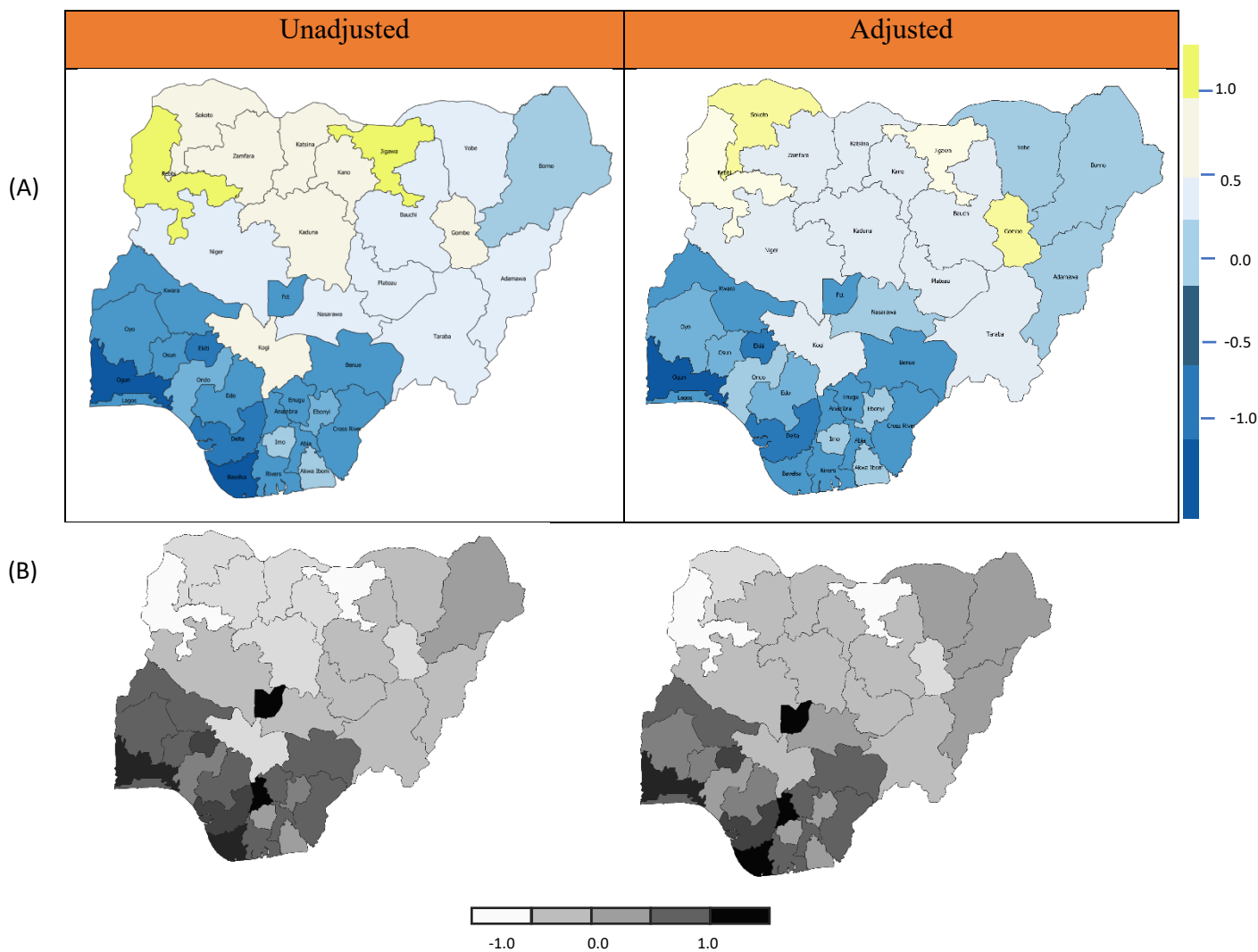
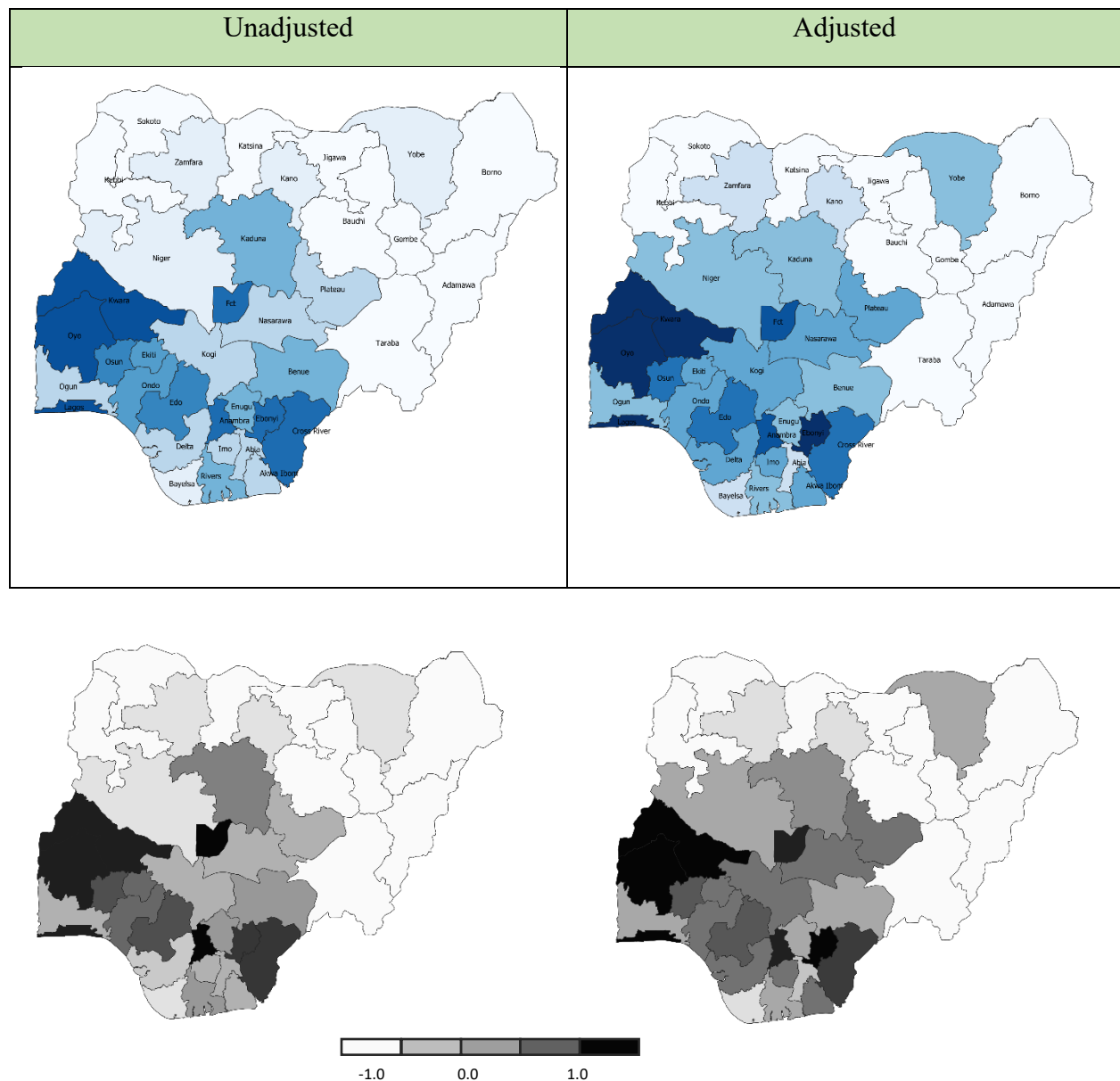


Fig. 5 displays the total spatial effects for Contraceptive Prevalence Rate, with unadjusted estimates on the left and adjusted estimates on the right (a), alongside the corresponding 95% posterior significance map (b). The colour gradient from dark blue to light blue represents increasing CPR, while black indicates states with a significantly high CPR. White denotes a significantly low-CPR state.





DISCUSSION

The analysis of this study reveals vast spatial disparities in under-five mortality (U5MR) in Nigeria, with the highest U5MR being recorded in northern states. These results align with a study where their results revealed variations in the north-south children's mortality rates (Akinyemi et al., 2016; Yusuf et al., 2022). These imbalances were confirmed by Bayesian spatial analysis since states with U5MR have also experienced aPOR with increased odds, and this is evidence of a greater probability of child deaths even after controlling for other people and household characteristics. This implies that more general structural factors like healthcare delivery and household wealth index may be associated with differences in child survival rates across regions (Wegbom et al., 2023). A study confirmed this trend by citing chronic regional disparities in the health condition of children, where northeast and northwest fall far behind southern regions owing to disparities in healthcare centres, sociocultural attitudes, and education (Wegbom et al., 2023; Adebowale et al., 2021).

An association was observed between contraceptive use and under-five mortality. Children of mothers who reported contraceptive use had lower odds of dying before age five in both the frequentist and Bayesian models. The models estimate indicated reduced mortality risk even prior to full adjustment, and this relationship remained after controlling other factors. Similar evidence has shown that contraceptive use contributes to improved child survival through birth spacing and the avoidance of high-risk pregnancies (Fagbamigbe et al., 2020). Evidence from rural Nigeria also links modern contraceptive practice with lower infant and neonatal mortality due to improved birth planning (Ahinkorah et al., 2021; Akinyemi et al., 2020). Improving access to contraceptive information and services in high-mortality settings may therefore support child survival.

Expanding access to and information about contraceptive methods, particularly in high-mortality areas, could therefore be an efficient means of reducing child deaths. Similarly, maternal age and marital status of women who use contraception were also significant under-five mortality determinants. Children born to older mothers (35 years and older) had lower odds of under-five mortality compared to children born to younger mothers (15–24 years). The model showed a reduction in mortality risk in children of older mothers, and this is supported by findings from research that older mothers are more likely to have better economic standing, access to healthcare, and experience in child-rearing (Adedini, et al., 2015; Babalola 2019). This is also supported by findings indicating that older women are likely to make reproductive choices, thus reducing the threats of child mortality (Ezeh et al., 2022; Babalola 2019).

The marital status of the mother was also significant, where the children of never-married mothers were shown to have an increased risk of mortality. This also indicated a higher risk of death among children of unmarried mothers, validating previous research showing that unmarried women have lower social and economic support, which has a negative effect on access to conventional health facilities and child survival (Uddin et al., 2019; Blackstone et al., 2017; Olatunji et al., 2022). Additionally, a study argued that regional poverty traps and economic shocks continue to influence disparities in under-five mortality, necessitating targeted economic empowerment programs (Olatunji et al., 2022).

Education and wealth status were strongly associated with child survival, confirming the importance of health outcomes. Children of mothers who had secondary education were



associated with lower odds of under-five mortality whereas children of mothers with higher education had lowered risk. This aligns with accounts from previous studies that demonstrate the reduction in healthcare-seeking behaviors by mothers, and higher control over childhood ailments with higher education by the mothers (Fagbemigbe et al., 2023; Serwanja et al., 2021). Similarly, wealth status was also significant, with children in the richest households being less likely to have died under the age of five compared to those from the poorest households. Economic status impacts healthcare access, nutrition, and standards of living, poverty reduction and income redistribution policy interventions are key in addressing child survival (Yusuf et al., 2022). The role of economic disparities in contributing to the survival of children has also been emphasized, and it was found that household wealth played an important role in the availability of maternal and child healthcare services, which ultimately had an impact on mortality results (Okonofua et al., 2023; Ononokpono et al., 2022).

The location of delivery was another important variable that influenced under-five mortality. Home-delivered children were associated with higher odds of under-five mortality compared to those born in public health centres. The model identified an increased risk of death among home births, with the highest risk occurring in those born in other non-health facilities. The findings agree with international evidence pointing to increased risk of birth complications, infection, and poor neonatal care with home births. Previous studies emphasize that, skilled delivery and maternal care are the key factors against neonatal death, particularly in rural areas (Fagbemigbe et al., 2023; Serwanja et al., 2021). The higher risk of death linked with home births highlights the need for encouraging facility delivery through improved health infrastructure, incentives, and maternal health education (Okonofua et al., 2023; Ononokpono et al., 2022). Increased coverage of skilled birth attendants in rural and poor areas would significantly reduce newborn and child under-five mortality (Yaya et al., 2023; Yaya et al., 2023; Fadeyibi et al., 2017).

CONCLUSION AND RECOMMENDATIONS

The analysis in this study considered the geographical spread and multilevel predictors of contraceptive use and under-five mortality in Nigeria. By including spatial analysis in the multilevel modelling framework, the analysis controlled interregional disparity and revealed where and how local settings and individual factors converge to influence child survival. Key results suggest maternal attributes like age, education level, marital status, parity, and residence highly influence both the use of contraceptives prevalence and under-five mortality. Far more critical were the spatial tendencies that revealed strongly persistent high clusters of mortality across the North-East and North-West, in step with low prevalence of contraceptive coverage, illustrating a geospatial disparity possible to ignore from conventional analyses.

One of the strongest conclusions is that recent use of contraceptives is a protective factor for under-five mortality by promoting birth spacing, avoiding high-risk births, and preventing unwanted births. Despite such amazing advances, there are stark regional disparities, especially in the north, where cultural resistance and lack of services remain potent barriers to access to contraceptives.

To counter the widespread regional disparities in contraceptive use and under-five mortality in this research, deploying regionally targeted interventions with high-priority assignment to high-burden areas such as Nigeria's North-East and North-West regions is important. These



areas, which all reported low contraceptive prevalence and high child mortality in the spatial analysis, require targeted policy responses, additional health investments, and community-based outreach initiatives. Scaling up family planning services within broader maternal and child health programs at the primary healthcare level must be accorded priority, particularly in rural and disadvantaged areas where access remains restricted. To support effective intervention planning, state and local governments must institutionalize geospatial monitoring systems that allow for real-time tracking of data and inform localized resource allocation.

Besides, improved access to modern contraceptives through robust supply chains and predictable commodity availability at the last mile is also required. Scaling up service delivery platforms such as mobile outreaches and facility-based counseling, especially in those regions with documented gaps in services, can also increase reach and coverage. Backing such supply-side initiatives, demand-side interventions based on the leveraging of religious, traditional, and community leaders' influence will be vital in offsetting sociocultural resistance to family planning.

Future studies and programming must explore longitudinal and mixed-method approaches to better capture the dynamic interaction between cultural norms, service delivery, and geographic context in shaping reproductive health outcomes. These findings support the call for a multi-faceted and spatially reactive approach to diminish under-five deaths and improve the use of contraception in Nigeria.

LIMITATIONS AND STRENGTHS

The analysis makes use of a large, country-representative dataset (MICS 2021), providing scope for spatial disaggregation and multilevel modelling. However, the cross-sectional design limits causal inference and some of the key variables like religion, partner, or cultural influence, or norms were not in the dataset. In addition, the spatial models capture macro-level patterns, but micro-level heterogeneity may not be fully captured. Despite these limitations, the use of both frequentist and Bayesian geo-additive models brings depth and robustness, and the analysis constitutes one of the first systematic explorations of geographic inequities in the use of contraceptives and under-five mortality in Nigeria.

Consent

This is not applicable because we used secondary data. Issues relating to the consent of the participants were already documented (MICS 2021)

Acknowledges

The authors appreciate UNICEF and the National Bureau of Statistics (NBS) for granting access to the 2021 Multiple Indicator Cluster Survey (MICS) data used in this analysis. We also appreciate the support received from Rivers State University, Port Harcourt, during this research work.

Competing Interests

The authors have declared that no competing interests exist



Author Contributions

IWA, RO, and FFA contributed to all aspects of this research work.

Funding information

The authors received no financial support for the research, authorship, and/or publication of this article.

REFERENCES

1. Ahinkorah, B. O., Budu, E., Seidu, A. A., Adu, C., Osei, D., & Yaya, S. (2021). Demographic and socioeconomic factors associated with contraceptive use among adolescent girls and young women in sub-Saharan Africa: A multilevel analysis. *PLOS ONE*, 16(1), e0245827. <https://doi.org/10.1371/journal.pone.0245827>
2. Adebawale, A. S., Fagbamigbe, A. F., Morakinyo, O., Obembe, T., Afolabi, R. F., & Palamuleni, M. E. (2021). Parental educational homogamy and under-five mortality in sub-Saharan Africa: Clarifying the association's intricacy. *Scientific African*, 7, e00255.
3. Adebawale, S. A., Yusuf, O. B., & Fagbamigbe, F. A. (2019). Socioeconomic inequalities in childhood mortality in Nigeria: Trends and drivers. *African Population Studies*, 33(2).
4. Adedini, S. A., Odimegwu, C., Imasiku, E. N., & Ononokpono, D. N. (2015). Unmet need for family planning: Implications for under-five mortality in Nigeria. *Journal of Health, Population, and Nutrition*, 33(1), 187–206.
5. Akinyemi, J. O., Bamgboye, E. A., & Ayeni, O. (2019). Trends and patterns of neonatal mortality in Nigeria: Implications for child survival. *BMC Pediatrics*, 19(1), 1–10.
6. Akinyemi, J. O., Odimegwu, C. O., & Adebawale, A. S. (2016). The effect of family structure on child mortality in Nigeria. *Genus*, 72(1), 1–24. <https://doi.org/10.1186/s41118-016-0003-7>
7. Akinyemi, J. O., Odimegwu, C. O., & Adebawale, A. S. (2020). Urban–rural variations in neonatal mortality: Evidence from 67 countries in sub-Saharan Africa. *Health & Place*, 63, 102339. <https://doi.org/10.1016/j.healthplace.2020.102339>
8. Akinyemi, Y. O., Solanke, M. O., & Odimegwu, A. A. (2021). Regional differences in contraceptive use and childhood mortality in Nigeria: A spatial analysis. *African Population Studies*, 35(1), 1–15.
9. Babalola, S. (2019). The effects of contraceptive use on maternal and child health in Nigeria. *African Journal of Reproductive Health*, 23(2), 53–63.
10. Doctor, H. V., Bairagi, R., Findley, S. E., Helleringer, S., & Dahiru, T. (2018). Maternal education and child under-five mortality in Nigeria: The roles of socioeconomic status and birth intervals. *Health Education & Behavior*, 45(5), 732–741. <https://doi.org/10.1177/1090198118775485>
11. Ezeh, A. C., Okonofua, F., & Fagbamigbe, A. F. (2022). Birth intervals and child mortality in West Africa: An analysis of DHS data. *African Population Studies*, 36(2), 65–84.
12. Fagbamigbe, A. F., Hurricane-Ike, E., & Yusuf, O. B. (2020). Regional differences and determinants of child mortality in Nigeria: An analysis of the 2018 Demographic and Health Survey. *BMC Public Health*, 20, 1384.



13. Fagbamigbe, A. F., Adeniyi, & Nnanatu, Chibuzor. (2021). Modelling the spatial distribution and the factors associated with under-five mortality in Nigeria. *Spatial Demography*, 10. <https://doi.org/10.1007/s40980-021-00078-7>
14. Fadeyibi, O., Alade, M., Adebayo, S., Erinfolami, T., Mustapha, F., & Yaradua, S. (2017). Household structure and contraceptive use in Nigeria.
15. GBD 2019 Under-5 Mortality Collaborators (2020). Global, regional, and national progress towards Sustainable Development Goal 3.2 for under-5 mortality. *The Lancet*, 396(10258), 1160–1204.
16. Mosley, W. H., & Chen, L. C. (1984). An analytical framework for the study of child survival in developing countries. *Population and Development Review*, 10(Supplement), 25–45.
17. National Bureau of Statistics (NBS) and United Nations Children’s Fund (UNICEF). (2021, August). Multiple Indicator Cluster Survey 2021, Survey Findings Report. Abuja, Nigeria: NBS and UNICEF.
18. National Population Commission (NPC) [Nigeria] and ICF. (2024). Nigeria Demographic and Health Survey 2023–24 (Preliminary Report). Abuja, Nigeria and Rockville, Maryland, USA: NPC and ICF.
19. Obasanjo A. B., Tadesse T. Z., Frimpong, J. B., Seidu, A.-A., & Ahinkorah, B. O. (2021). Spatial distribution and factors associated with modern contraceptive use among women of reproductive age in Nigeria: A multilevel analysis. <https://doi.org/10.1371/journal.pone.0258844>
20. Okonofua, F., Adeyemi, A., & Ezech, A. (2023). Contraceptive use and fertility control in rural and urban communities of Lagos, Nigeria. *Nigerian Postgraduate Medical Journal*, 30(1), 31–39.
21. Olatunji, A. O., Omisakin, O. A., & Ayinde, O. C. (2022). The determinants of health facility delivery in Nigeria: Evidence from 2018 NDHS. *African Population Studies*, 36(1), 6847–6862. <https://doi.org/10.11564/36-1-1936>
22. Ononokpono, D. N., & Ntoimo, L. F. C. (2022). Geospatial differentials in under-five mortality in Nigeria: A Bayesian approach. *Demographic Research*, 46, 975–1004. <https://doi.org/10.4054/DemRes.2022.46.33>
23. Opeyemi Fadeyibi, Mayowa Alade, Samuel Adebayo, Temitope Erinfolami, Fatimah Mustapha, and Saudatu Yaradua (2017). Household Structure and Contraceptive Use in Nigeria.
24. Sarah, R. B., & Juliet, I. (2017). Determinants of contraceptive use among Nigerian couples: Evidence from the 2013 Demographic and Health Survey. *Blackstone and Iwelunmor Contraception and Reproductive Medicine*, 2:9. <https://doi.org/10.1186/s40834-017-0037-6>
25. Serwanja, Q., Musaba, M. W., & Mukunya, D. (2021). Prevalence and factors associated with modern contraceptive utilization among female adolescents in Uganda. *BMC Women’s Health*, 21, 61. <https://doi.org/10.1186/s12905-021-01206-7>
26. Uddin, J., Hossin, M. Z., & Pulok, M. H. (2019). Factors associated with child mortality in Nigeria: Evidence from the 2013 Demographic and Health Survey. *PLOS ONE*, 14(2), e0211819. <https://doi.org/10.1371/journal.pone.0211819>
27. United Nations Children’s Fund (UNICEF) (2021). State of the World's Children 2021. UNICEF, New York.
28. United Nations Inter-agency Group for Child Mortality Estimation (UN IGME) (2020). Child Mortality Report. UNICEF, WHO, World Bank Group, and UN-DESA Population Division.



29. Wegbom, A. I., Bademosi, A., Edet, C. K., Green, K. I., Sapira-Ordu, L., & Fagbamigbe, A. F. (2022). Rural–urban disparities in birth interval among women of reproductive age in Nigeria. *Scientific Reports*, 12, 17488. <https://doi.org/10.1038/s41598-022-22142-y>
30. Wegbom, A. I., Edet, C. K., Osaro, B. O., Oji, A. L., Onyema, C., & Samuel, G. K. (2023). Determinants of short birth intervals in Northern and Southern Nigeria: Analysis of Demographic and Health Survey data. *International Journal of Health Sciences and Research*, 13(7), 321–331. <https://doi.org/10.52403/ijhsr.20230744>
31. World Bank. (2023). Mortality Rate, Under-5 (per 1,000 Live Births) – Nigeria. World Bank Data. <https://data.worldbank.org>
32. World Health Organization. (2021). *Levels and Trends in Child Mortality*. UNICEF, New York.
33. Yusuf, A., Ibrahim, M., & Bello, S. (2022). Factors influencing modern contraceptive use among Nigerian women: A multilevel analysis. *BMC Women's Health*, 22(1), 45.
34. Yaya, S., Bishwajit, G., Okonofua, F., & Uthman, O. A. (2018). Under-five mortality patterns and associated maternal risk factors in sub-Saharan Africa: A multi-country analysis. *PLOS ONE*, 13(10), e0205977.
35. Yaya, S., Uthman, O. A., & Bishwajit, G. (2023). Modern contraceptive use among unmarried girls aged 15–19 years in South Western Nigeria: Results from a cross-sectional baseline survey for the Adolescent 360 (A360) impact evaluation. *Reproductive Health*, 20(1), 25.
36. Yaya, S., Uthman, O. A., & Bishwajit, G. (2023). When do Nigerian women of reproductive age initiate and what factors influence their contraceptive use? A contextual analysis. *Open Access Journal of Contraception*, 14, 55–65.