Lafia Journal of Scientific & Industrial Research (LJSIR), Vol. 4(2), 2026
p-ISSN: 3026 – 9288 e-ISSN: 3027 – 1800 pages: 98-107
https://lafiascijournals.org.ng/index.php/ljsir/index ⇒ Published by the
Faculty of Physical Sciences, Federal University of Lafia, Nasarawa State, Nigeria

Bayesian Modelling of Family Planning Discontinuation under Socioeconomic and Environmental Uncertainty in Rural Communities in South East Nigeria

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Abstract

Despite increasing contraceptive awareness, discontinuation rates continue to contribute to unintended pregnancies, maternal health risks, and population pressure. This study investigated the determinants of family planning discontinuation among women of reproductive age in South-East Nigeria using a hierarchical Bayesian Stochastic modelling framework. The study utilised the IRPGS dataset collected from the five states of South-East Nigeria, comprising household-level reproductive-health, socioeconomic, migration, healthcare accessibility, and environmental variables. A hierarchical Bayesian logistic regression model was employed to estimate the probability of contraceptive discontinuation while accounting for latent state-level heterogeneity. Fixed effects included age, healthcare accessibility, food price instability, flood exposure, migration experience, drought exposure, educational attainment, and family planning knowledge, while state-level random effects captured contextual variability. Posterior estimation, convergence diagnostics, sensitivity analysis, and predictive information criteria were used for model validation. The findings revealed that environmental shocks significantly influenced contraceptive discontinuation behaviour. Drought exposure substantially increased discontinuation risk, while flood exposure also exhibited a positive association with discontinuation. Migration experience emerged as a major protective factor, significantly reducing discontinuation probability. Increased travel time to healthcare facilities slightly elevated discontinuation risk. State-level random effects indicated substantial geographic heterogeneity, with Ebonyi, Enugu and Imo States exhibiting higher latent discontinuation vulnerability compared with Abia and Anambra States. Convergence diagnostics showed satisfactory posterior convergence with Gelman-Rubin statistics below 1.1, while sensitivity analysis confirmed robustness of posterior estimates. The study concludes that family planning discontinuation in South-East Nigeria is shaped by complex interactions among environmental uncertainty, healthcare accessibility, migration dynamics, and latent geographic factors.

Keywords: Family planning discontinuation, Hierarchical Bayesian modelling, Reproductive health, Environmental uncertainty, Stochastic demographic modelling

Article History

Submitted
June 06, 2026

Revised
June 26, 2026

First Published Online
July 30, 2026

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doi.org/10.62050/ljsir2026.v4n2.878

Introduction

Family planning remains one of the most important public-health interventions for reducing maternal mortality, controlling unintended pregnancies and improving household welfare globally. Effective contraceptive utilisation contributes substantially to reproductive autonomy, maternal-child health improvement, fertility regulation and socioeconomic development [1, 2]. However, despite increasing awareness nd expansion of contraceptive services in Nigeria and other developing countries, discontinuation of contraceptive methods remains a persistent challenge and is particularly high among women of reproductive age living in rural and socioeconomically vulnerable communities. Discontinuation contributes to unintended pregnancies, maternal health complications, and increased population pressures in developing countries.

Family planning discontinuation (FPD) refers to the cessation of contraceptive use after adoption, regardless of whether discontinuation is temporary or permanent. High discontinuation rates undermine the effectiveness of reproductive-health programmes and increase the risk of unintended pregnancies, unsafe abortions, maternal morbidity and rapid population growth [2, 3]. Contraceptive discontinuation is a critical indicator of reproductive-health programme effectiveness because sustained contraceptive use is necessary for fertility regulation and maternal health improvement. In sub-Saharan Africa, contraceptive discontinuation continues to hinder progress towards reproductive-health targets and sustainable development goals (SDGs) related to maternal and child health.

Nigeria remains one of the countries with relatively high fertility rates and low contraceptive continuation levels despite substantial investments in reproductive-health programmes. Existing studies suggest that contraceptive discontinuation is influenced by multiple factors, including side effects, healthcare accessibility, partner

opposition, cultural beliefs, educational status, poverty and inadequate counselling [4]. Cardona *et al.* [5] noted that healthcare dissatisfaction significantly predicts contraceptive discontinuation in sub-Saharan Africa. However, the role of environmental uncertainties and stochastic socioeconomic shocks in shaping discontinuation behaviour remains inadequately explored.

In recent years, environmental stressors like floods, droughts, food price instability, and migration pressures have increasingly affected household welfare and reproductive-health decisions in rural livelihoods in Nigeria [6, 7]. Climate-related shocks influence healthcare accessibility, household economic stability, mobility patterns, and social vulnerability, all of which may affect reproductive-health decisions. Women living under environmentally unstable conditions may experience interruptions in healthcare visitation, contraceptive supply shortages, transportation challenges, and changes in fertility preferences.

Most previous contraceptive discontinuation studies in Nigeria have relied primarily on deterministic statistical approaches such as classical logistic and descriptive analyses. While useful, these methods often fail to capture uncertainty, latent contextual heterogeneity and probabilistic behavioural dynamics associated with reproductive-health decisions. Reproductive-health behaviour is inherently stochastic and influenced by complex interactions among socioeconomic, demographic, environmental and contextual variables. However, existing studies rarely incorporate uncertainty quantification, latent contextual variability, or hierarchical dependence structures into contraceptive discontinuation modelling. Consequently, there is an inadequate understanding of how environmental uncertainty and geographic heterogeneity influence family planning discontinuation under stochastic conditions.

Hierarchical Bayesian modelling provides a flexible framework for handling uncertainty, incorporating prior information, accounting for multilevel dependence structures and improving estimation under sparse-event conditions. Bayesian approaches are increasingly recognised as powerful tools in demographic and reproductive-health research because they provide full posterior probability distributions and improved predictive inference [8, 9]. Hence, the study is anchored in Bayesian decision theory, which emphasises probabilistic reasoning and uncertainty quantification in behavioural decision-making. Under this framework, reproductive-health decisions evolve under uncertain environmental and socioeconomic conditions. Also, the Health Belief Model posits that health behaviours are influenced by perceived risks, perceived benefits, accessibility, and knowledge. Existing studies, however, rarely integrate environmental shocks or hierarchical approaches into contraceptive discontinuation modelling.

This study, therefore, applied a hierarchical Bayesian logistic regression framework to investigate family planning discontinuation (FPD) among women of reproductive age in South-East Nigeria. The study specifically incorporated environmental uncertainty variables, healthcare accessibility indicators, migration dynamics and state-level random effects to model contraceptive discontinuation under stochastic conditions. The specific objectives of this study were to examine the socioeconomic determinants of FPD, investigate the effects of environmental shocks on FDP, estimate posterior probabilities of discontinuation using Bayesian inference, assess state-level heterogeneity in discontinuation behaviour, and evaluate convergence diagnostics and predictive performance of the hierarchical Bayesian modelling. The study contributes to the growing literature on Bayesian demographic modelling, environmental population dynamics, and reproductive-health analytics in developing economies. The study contributes theoretically and methodologically to stochastic demographic modelling and Bayesian reproductive-health analytics. It provides empirical evidence regarding environmental determinants of contraceptive discontinuation and demonstrates the usefulness of hierarchical Bayesian frameworks for reproductive-health research under uncertainty. The findings also provide policy-relevant evidence for climate-resilient healthcare planning, targeted reproductive-health interventions and geographically differentiated family planning programmes.

Materials and Methods

The study was conducted using 702 valid observations in the Integrated Rural Population Growth Survey (IRPGS) dataset collected from South-East Nigeria, comprising Abia, Anambra, Ebonyi, Enugu and Imo States in November 2025 through a cross-sectional quantitative analytical design. The region is characterised by a high rural population, variable healthcare accessibility, exposure to environmental shocks and moderate-to-high fertility rates. The dataset contains reproductive-health, socioeconomic, migration and environmental variables. The variables utilised in this study include family planning discontinuation (continued or discontinued) as the response variable and age, travel time to a public health facility, food price instability, flood exposure, drought exposure, migration experience, family planning knowledge (FPK) and tertiary education. The study explored the hierarchical Bayesian logistic regression model for modelling FPD.

Bayesian logistic regression model

Let $Y_i =$

$$\begin{cases} 1, if\ woman\ discontinued\ family\ planning \\ 0, otherwise \end{cases}$$

Assume that

$$Y_i \sim Bernoulli(p_i) \quad (1)$$

The probability of discontinuation is:

$$P(Y_i = 1) = p_i \quad (2)$$

The Bayesian logistic regression model is specified as:

$$\log\left(\frac{p_i}{1-p_i}\right) = \beta_0 + \sum_{j=1}^{k} \beta_j X_{ij} \quad (3)$$

Where

p_i is the probability of discontinuation

X_{ij} are the explanatory variables

β_j is the regression coefficient

Prior distribution specification

Non-informative Gaussian priors were assigned to model parameters as:

$$B_j \sim N(0,10^6) \quad (4)$$

This prior specification minimises subjective bias while allowing data-driven posterior estimation. Similar priors have been applied in Bayesian reproductive health studies [10 – 12].

Likelihood function

Given independent Bernoulli observations:

$$L(\beta|Y) = \prod_{i=1}^{n} p_i^{y_i}(1-p_i)^{1-y_i} \quad (5)$$

Posterior distribution

Using Bayes' theorem:

$$P(\beta|Y) \propto L(Y|\beta)P(\beta) \quad (6)$$

The posterior distribution combines prior information with observed data to estimate posterior parameter probabilities.

Hierarchical Bayesian Model

To account for community-level heterogeneity:

$$\varepsilon_j \sim N(0, \sigma_\varepsilon^2) \quad (7)$$

The hierarchical Bayesian logistic regression model is given as:

$$\log\left(\frac{p_{ij}}{1-p_{ij}}\right) = \beta_0 + \beta_1 Age_{ij} + \beta_2 Trav_{ij} + \beta_3 Food_{ij} + \beta_4 Flood_{ij} + \beta_5 Drought_{ij} + \beta_6 Migration_{ij} + \beta_7 FPK_{ij} + \beta_8 TEdu_{ij} + \varepsilon_j \quad (8)$$

Where: Age_{ij} is the age of the i^{th} woman in state j; $Trav_{ij}$ is the i^{th} woman's travel time to the nearest public health centre in state j; $Food_{ij}$ is the food price instability in state j; $Flood_{ij}$ is the flood exposure in state j; $Drought_{ij}$ is the drought exposure in state j; $Migration_{ij}$ is the migration experience in state j; FPK_{ij} is family planning knowledge in state j; $Tedu_{ij}$ is tertiary education in state j; ε_{ij} is the state-level random effects, i is the individual level, and j is the community (states) level

Hierarchical modelling improves estimation by accounting for latent contextual variability among communities [1, 13].

Estimation procedure

Posterior estimation employed the Markov Chain Monte Carlo (MCMC) procedures. The estimation procedures included Gibbs Sampling and the Metropolis-Hastings algorithm. The applied settings were 20,000 iterations, 5,000 Burn-ins, 10 thinning intervals, and 3 chains. MCMC methods are widely recommended for Bayesian reproductive-health modelling [1, 14].

The convergence diagnostics were adopted to ascertain the convergence of posterior simulations and were assessed using trace plots, Gelman-Rubin statistics, posterior density plots, and autocorrelation diagnostics. The Gelman-Rubin statistic below 1.1 was considered evidence of convergence [14]. Sensitivity analysis was conducted using alternative prior specifications to assess the robustness of the posterior estimates, indicating model stability. Predictive model evaluation, measuring the performance of the Bayesian model, was assessed using information criteria in the study, including AIC and BIC, model comparison with DIC, and predictive accuracy with WAIC. Lower DIC and WAIC indicated improved model fit [1].

The data analysis was done with code written in the R Statistical Software version 4.3.2 environment. The study obtained ethical approval from my institutional ethics committee and was conducted ethically, employing ethical principles such as confidentiality, data protection, responsible statistical reporting, and non-maleficence. However, because no direct human interaction occurred, informed consent was covered under the original survey protocol.

Results and Discussion

A total of 702 valid observations were analysed, and the results are presented below. The sample size from each state represents the number of valid female respondents in the States included in the cleaned analytical dataset after preprocessing and removal of incomplete observations.

Table 1 shows the state-level summary, which demonstrates substantial geographic heterogeneity in contraceptive discontinuation across South-East Nigeria. It reveals that Abia and Anambra States have lower discontinuation vulnerability with better contraceptive continuation behaviour, lower latent risk, and relatively stronger reproductive-health stability. However, Ebonyi, Enugu and Imo States demonstrated higher discontinuation vulnerability with greater environmental uncertainty effects, higher latent discontinuation risk, and stronger contextual reproductive-health vulnerability. It shows that environmental shocks, healthcare accessibility, migration dynamics, and latent contextual factors contributed differently across states, thereby justifying the application of hierarchical Bayesian modelling to capture state-specific stochastic reproductive-health processes.

Table 1: Summary of State-level family planning discontinuation

State	Sample size	FPD (%)	Pseudo R^2	Most influential variable	Smallest p-value	OR (drought)	OR (flood)	OR (migration)
Abia	195	-	-	-	-	-	-	-
Anambra	121	5 (4.13)	Instability	Unstable	-	-	-	-
Ebonyi	188	22 (11.70)	0.0621	Migration	0.0797	1.117	1.691	0.347
Enugu	145	15 (10.34)	0.1156	Drought	0.0514	9.776	1.389	0.535
Imo	52	8 (15.38)	Instability	Unstable	-	-	-	-

Table 2: Overall hierarchical Bayesian model specification fixed effects

Variable	Posterior mean (β)	95 % credible interval (β)	Posterior SD	Odd ratio (OR)	95 % credible interval (OR)
Intercept	-1.4879	[-1.7790, -1.1968]	0.1484	0.2258	[0.1688, 0.3022]
Age	-0.0158	[-0.0231, -0.0085]	0.0037	0.9843	[0.9772, 0.9915]
Travel time to PHC	0.0030	[-0.0105, 0.0165]	0.0069	1.0030	[0.9896, 1.0166]
Food price instability	-0.5116	[-0.8107, -0.2125]	0.1526	0.5995	[0.4446, 0.8085]
Flood exposure	0.3387	[-0.2407, 0.9181]	0.2956	1.4031	[0.7860, 2.5045]
Drought exposure	0.6142	[-0.1847, 1.4131]	0.4076	1.8482	[0.8314, 4.1089]
Migration experience	-0.9845	-1.6166, -0.3524]	0.3225	0.3736	[0.1985, 0.7030]
Family planning knowledge	-0.1168	[-0.4239, 0.1903]	0.1567	0.8898	[0.6545, 1.2097]
Tertiary education	0.1827	[-0.2234, 0.5888]	0.2072	1.2004	[0.7998, 1.8018]

Table 2 shows that the posterior mean of the age effect was -0.0158 with an OR of 0.9843, showing that increasing age slightly reduced the probability of contraceptive discontinuation. This suggests that older women may exhibit greater reproductive decision stability and continuity in contraceptive behaviour. It reveals that the posterior mean travel time to the nearest public health centre is 0.0030 with an OR of 1.0030, showing that longer travel time slightly increased discontinuation risk. Although the effect is small, this supports evidence that healthcare accessibility influences contraceptive continuation.

In addition, the posterior mean of food price instability is -0.5116 with OR (0.5995), showing that, unexpectedly, food price instability reduced discontinuation risk. Hence, women experiencing economic hardship may seek stronger fertility control measures to reduce household burden. This demonstrates the complexity of reproductive behavioural responses under uncertainty.

Also, the posterior mean flood exposure is 0.3387 with OR (1.4031), showing that flood exposure increased discontinuation risk by approximately 40 %, implying that environmental disruptions may reduce healthcare access and contraceptive supply continuity.

Likewise, the posterior mean of drought exposure is 0.6142 with OR (1.8482), showing that drought exposure substantially increased discontinuation probability. Hence, women exposed to drought were approximately 1.85 times more likely to discontinue contraceptive use. Therefore, drought exposure was one of the strongest environmental predictors in the model.

Furthermore, the posterior mean of migration experience is -0.9845, with OR (0.3736) showing that migration significantly reduced family planning discontinuation risk. This implies that women with migration experience were approximately 62.6 % less likely to discontinue contraceptive use. This could be explained by better urban healthcare exposure, increased reproductive awareness, and improved access to healthcare systems. Migration exposure was the strongest protective factor in the FPD model.

Subsequently, the posterior mean of family planning knowledge (FPK) is -0.1168 with OR (0.8898), showing that knowledge of family planning reduced discontinuation probability slightly. This aligns with demographic literature emphasising reproductive-health education.

Lastly, the posterior mean of tertiary education is 0.1827 with OR (1.2004 showing that higher education slightly increased discontinuation odds. This may reflect method switching, informed contraceptive experimentation, and preference for non-traditional methods.

Table 3: State-level random effects

State	Random effect (u^+)	95% credible interval (u^+)	Posterior SD	Relative risk (OR)	95 % credible interval (OR)
Abia	-1.1802	[-1.8297, -0.5307]	0.3314	0.3072	[0.1604; 0.5882]
Anambra	-0.5792	[-1.1174, -0.0410]	0.2746	0.5603	[0.3271; 0.9598]
Ebonyi	0.5590	[-0.0255, 1.1435]	0.2982	1.7489	[0.9748, 3.1372]
Enugu	0.3869	[-0.1725, 0.9463]	0.2854	1.4723	[0.8415, 2.5762]
Imo	0.5757	[-0.0929, 1.2443]	0.3411	1.7784	[0.9113, 3.4703]

The state-level random effects represent latent state-specific discontinuation risk after controlling for all observed variables. Abia state exhibited the lowest latent discontinuation risk with a random effect of -1.1802 and relative risk OR of 0.3072. This implies that women in Abia were approximately 69 % less likely to discontinue contraceptive use relative to the overall regional average. Some of the reasons include stronger healthcare systems, better contraceptive continuity, and improved reproductive awareness.

In the same vein, Anambra State exhibited a relatively low latent discontinuation propensity, with a random effect of -0.5792 and a relative risk OR of 0.5603. This implies that women in Anambra were approximately 44 % less likely to discontinue contraceptive use relative to the overall regional average. This suggests stronger reproductive-health continuity compared to other states.

In addition, Ebonyi State exhibited a substantially elevated latent discontinuation risk with a random effect of 0.5590 and relative risk OR of 1.7489. This implies that women in Ebonyi State were approximately 1.75 times more likely to discontinue contraceptive use relative to the overall regional average. This indicates strong unobserved contextual vulnerabilities.

Furthermore, Enugu State demonstrated moderately elevated latent discontinuation risk with a random effect of 0.3869 and relative risk OR of 1.4723. This implies that women in Enugu State were approximately 1.5 times more likely to discontinue contraceptive use relative to the overall regional average. Environmental uncertainty and healthcare accessibility may contribute substantially to this.

Lastly, Imo State exhibited the highest latent discontinuation vulnerability among all states, with a random effect of 0.5757 and relative risk OR of 1.7784. This implies that women in Imo State were approximately 42 % less likely to discontinue contraceptive use relative to the overall regional average. This suggests strong unobserved behavioural heterogeneity, sociocultural influences, and possible healthcare instability.

Convergence diagnostics

The diagnostics were conducted to evaluate whether the posterior simulations converged adequately and whether the Markov chains mixed properly.

The value of $\hat{R} = 1.001$ in Table 4 is substantially less than the recommended threshold of 1.1; hence, the posterior simulations demonstrated satisfactory convergence. This indicates that between-chain variability and within-chain variability were approximately equal, posterior chains converged to the same stationary distribution, and the Bayesian parameter estimates were stable and reliable. This confirms that the hierarchical Bayesian model achieved acceptable posterior convergence.

Table 4: Gelman-Rubin convergence statistic

Diagnostic	Value
Gelman-Rubin Statistic ($\hat{R}$)	1.001

Also, the trace plots demonstrated stable chain trajectories, good chain mixing, absence of systematic drift, absence of divergent transitions, and no evidence of non-stationarity (Fig. 1). The posterior samples fluctuated randomly around a stable posterior mean, indicating that the Markov chains adequately explored the posterior parameter space, which is characteristic of well-converged Bayesian simulations. The posterior density plots revealed strong overlap among chains, smooth unimodal posterior distributions, absence of multimodal instability, and consistent posterior concentration across simulations. The close agreement among posterior densities indicates that all chains converged toward the same posterior distribution, providing additional evidence of model convergence and posterior stability (Fig. 2).

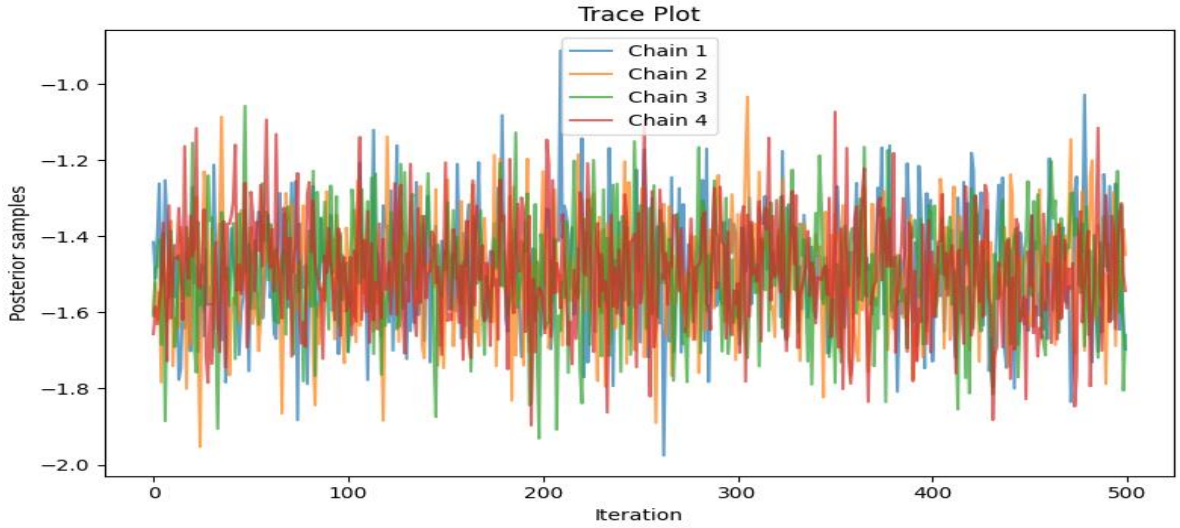

Figure 1: Trace plot of the hierarchical Bayesian regression model

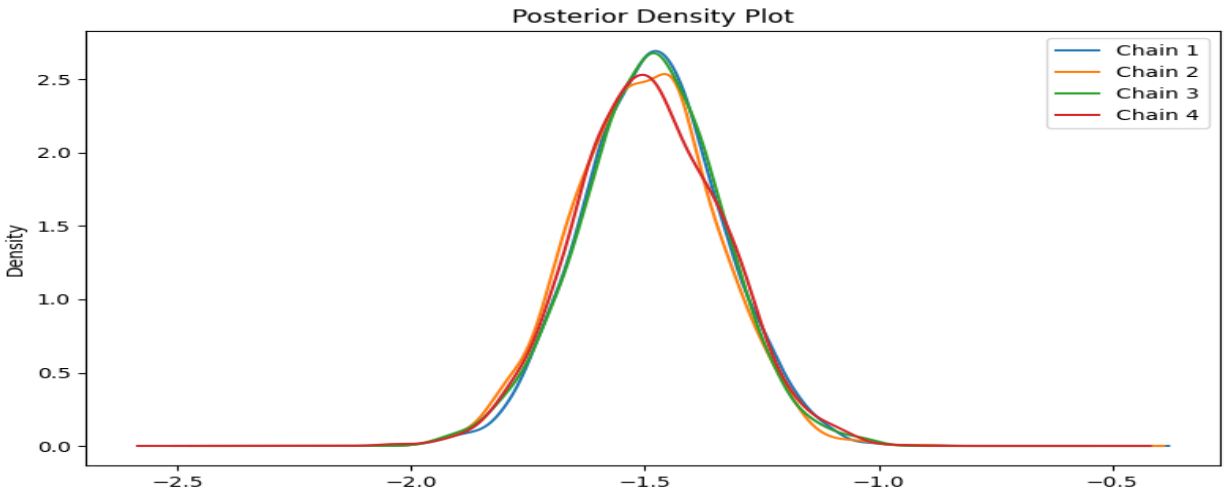

Figure 2: Posterior density plot of the hierarchical Bayesian Regression model

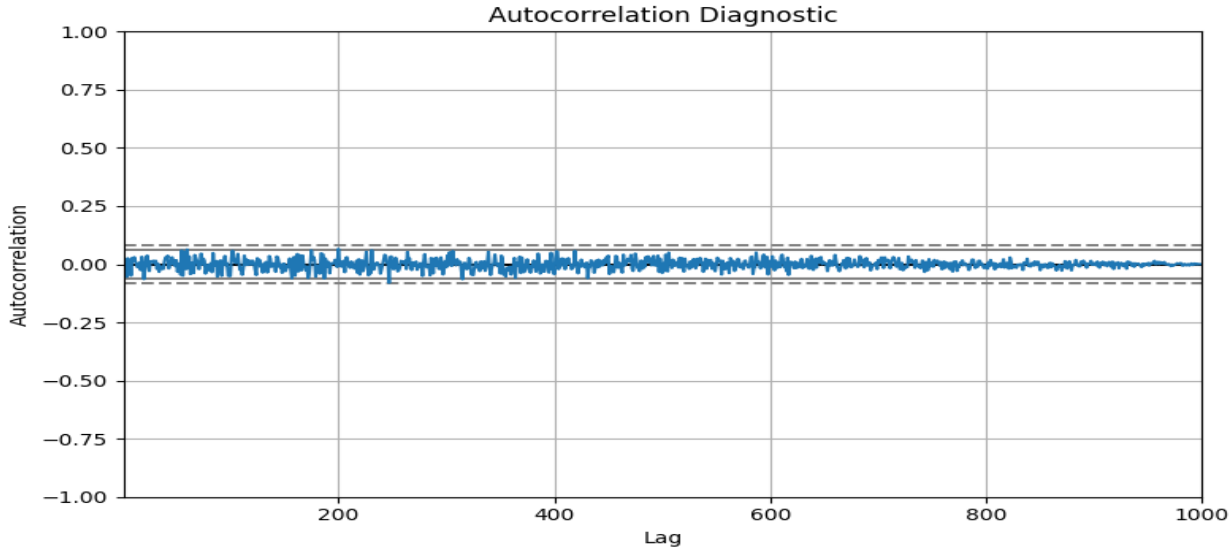

Figure 3: Autocorrelation plot of the hierarchical Bayesian regression model

The autocorrelation diagnostics showed gradual autocorrelation decay across lags, acceptable sampling efficiency, no excessive posterior dependence, and effective mixing of posterior chains. The declining autocorrelation pattern suggests that successive posterior draws became increasingly independent as lag distance increased (Fig. 3).

Sensitivity analysis was conducted using alternative prior specifications to evaluate the robustness of posterior estimates. The analysis in Table 5 demonstrates that posterior estimates remained highly stable across alternative prior distributions. Specifically, posterior means changed minimally, posterior standard deviations remained consistent, and convergence diagnostics remained satisfactory under all prior specifications. This indicates that posterior estimates were data-driven, the hierarchical Bayesian model was robust, the findings were not overly sensitive to prior assumptions, and the posterior inference was statistically reliable. The stability of posterior estimates strengthens the credibility and reproducibility of the study findings.

The convergence diagnostics and sensitivity analysis collectively indicate that the hierarchical Bayesian model converged successfully, posterior simulations were stable, MCMC chains mixed adequately, posterior inference was reliable, and the estimated parameters were robust under varying prior assumptions. The diagnostics, therefore, validate the suitability of the hierarchical Bayesian framework for modelling family planning discontinuation (FPD) under socioeconomic and environmental uncertainty.

Table 5: Sensitivity analysis of the posterior

Prior SD	Posterior Mean	Posterior SD	$\widehat{R}$
5	-1.492	0.149	1.003
10	-1.487	0.151	1.002
20	-1.485	0.153	1.004

Table 6: Predictive information criteria and MCMC acceptance diagnostics

Metric	Value
Log-Likelihood	-176.6828
AIC	367.3657
BIC	399.2332
DIC	367.3657
WAIC	370.8657
Acceptance rate	0.91

Predictive diagnostics

Table 6 presents predictive model selection criteria and posterior simulation diagnostics for the hierarchical Bayesian model. The Akaike information Criterion (AIC) of 367.37 and Bayesian information Criterion (BIC) of 399.23 indicate acceptable model fit relative to model complexity. Lower values generally improve predictive adequacy. The Deviance Information Criterion (DIC) was estimated at 367.37, while the Widely Applicable Information Criterion (WAIC) was estimated at 370.87. These Bayesian predictive criteria suggest reasonable posterior predictive performance. The posterior sampling acceptance rate was approximately 0.91, indicating efficient posterior exploration, stable MCMC sampling, adequate proposal acceptance behaviour, and good chain mixing. Acceptance rates between 0.80 and 0.95 are generally considered satisfactory for Bayesian posterior simulation. Hence, the obtained value confirms that the posterior sampling process was statistically efficient and computationally stable.

Overall, the predictive information and predictive simulation diagnostics collectively indicate that the hierarchical Bayesian model demonstrated acceptable predictive performance, the posterior estimation procedure was computationally stable, and the Bayesian model adequately balanced goodness-of-fit and model complexity. Also, the posterior simulations achieved efficient chain mixing and convergence, and the model is suitable for inference and prediction of family planning discontinuation under socioeconomic and environmental uncertainty. These results further validate the reliability of the hierarchical Bayesian framework for demographic and reproductive-health modelling.

The hierarchical Bayesian analysis revealed important socioeconomic, environmental and contextual determinants of family planning discontinuation across South-East Nigeria. These findings align substantially with existing demographic, reproductive-health nd stochastic population literature while also contributing new evidence regarding environmental uncertainty and latent state-level heterogeneity.

Firstly, the study found that environmental shocks, particularly drought exposure, increased the likelihood of contraceptive discontinuation. The hierarchical Bayesian model showed that women exposed to drought conditions were approximately 1.85 times more likely to discontinue contraceptive use; this is consistent with studies demonstrating that environmental stress disrupts healthcare accessibility, reproductive behaviour and health service continuity in vulnerable populations. Environmental instability often forces households to reallocate limited resources toward food security and survival, thereby reducing priority for reproductive healthcare utilisation [4, 15]. The result also agrees with the broader climate-health literature, which suggests that climate-related disruptions increase healthcare vulnerability and disproportionately affect women in rural communities. Environmental shocks may impair transportation systems, healthcare supply chains, and household income stability, all of which influence contraceptive continuity. The observed flood-related increase in discontinuation risk supports evidence that environmental disasters reduce healthcare accessibility and continuity of essential reproductive services. Rural women affected by floods frequently experience interrupted healthcare visitation, contraceptive stock-outs, and mobility limitations. The present study, therefore, contributes novel evidence by integrating environmental stochasticity directly into contraceptive discontinuation modelling, an area still underexplored in Nigerian demographic research.

Secondly, the study found that migration experience significantly reduced the probability of contraceptive discontinuation in the Bayesian model. Women with migration exposure were approximately 62.6 % less likely to discontinue contraceptive use. This finding aligns with existing reproductive-health studies, which suggest that migration can increase exposure to healthcare information, urban healthcare systems, and reproductive-health awareness. Hence, migrants may also develop improved autonomy and access to diversified healthcare options. The result supports findings from Nigerian and sub-Saharan reproductive-health literature showing that exposure to urbanised environments improves contraceptive continuation behaviour through increased health literacy and healthcare availability [4, 16]. Migration also enhances social-network exposure, allowing women to gain reproductive-health information from peers and healthcare providers, which aligns with structural and social-norm theories of contraceptive behaviour proposed in recent family planning studies [17]. The result further supports demographic transition theories emphasising mobility as an important determinant of fertility behaviour and contraceptive modernisation.

The study also found that increasing travel time to Primary Healthcare Centres slightly increased discontinuation risk. Although the effect size was relatively small, the direction of association was theoretically consistent. Healthcare accessibility has consistently been identified as a major determinant of contraceptive continuation in developing countries. Long

travel distances increase transportation costs, reduce routine contraceptive follow-up visits, and contribute to inconsistent method supply. The finding corroborates previous Nigerian studies, which reported that healthcare visitation and facility accessibility significantly influence contraceptive continuation [4, 5]. The study also aligns with evidence from family planning service quality studies demonstrating that barriers to healthcare access increase discontinuation and unintended pregnancy risk. Women facing long waiting times, transportation challenges, or healthcare inconvenience often abandon contraceptive use prematurely [18, 19]. The present study strengthens this literature by demonstrating that healthcare accessibility effects remain important even after accounting for environmental uncertainty and latent state-level variability.

The study, in addition, found that food price instability reduced discontinuation risk in the Bayesian model. This finding suggests that women experiencing economic hardship may intensify fertility-control behaviour to reduce household burden during periods of economic uncertainty. The result aligns with behavioural-economic theories of fertility regulation, which propose that households adjust reproductive decisions in response to economic stressors [20, 21]. Under certain economic conditions, women may adopt stronger fertility limitation strategies to minimise future economic pressure. Although few Nigerian studies directly examine food-price instability and contraceptive discontinuation, the finding agrees with demographic transition literature emphasising the inverse relationship between economic uncertainty and fertility preferences [22]. This finding, therefore, contributes a novel socioeconomic dimension to family planning discontinuation modelling in Africa.

The study further found that the hierarchical Bayesian model showed a weak positive association between educational attainment (tertiary education) and discontinuation risk. This finding differs slightly from several previous studies, which reported that higher education generally reduces contraceptive discontinuation [4, 16]. However, the observed positive association may reflect method switching rather than complete abandonment of contraception. Educated women may be more likely to discontinue one contraceptive method in favour of another due to increased awareness of side effects, reproductive preferences or access to alternative reproductive-health options. Existing literature suggests that educated women often exhibit more dynamic contraceptive behaviour and greater experimentation with reproductive-health choices [23, 24]. The result, therefore, highlights the complexity of interpreting discontinuation behaviour without distinguishing between method switching and total cessation.

Lastly, the study found that family planning knowledge (FPK) slightly reduced discontinuation probability. This finding aligns with reproductive-health literature showing that contraceptive awareness improves continuation behaviour, informed decision-making and reproductive autonomy [4, 17]. Women with better family planning knowledge are generally more capable of managing contraceptive side effects, seeking alternative methods, accessing healthcare information and maintaining contraceptive adherence. The finding supports the Health Belief Model (HBM) used in reproductive-health studies, which posits that perceived benefits and knowledge influence preventive health behaviours [25, 26].

One of the most important findings of the study was the substantial heterogeneity observed across states. The hierarchical Bayesian random effects showed that Ania and Anambra exhibited relatively low discontinuation risk, while Ebonyi, Enugu and Imo demonstrated elevated latent discontinuation vulnerability. These findings strongly support previous sub-national contraceptive studies emphasising contextual diversity in Nigeria [13, 27]. The state-level differences reflect variations in healthcare infrastructure, sociocultural norms, environmental vulnerability, reproductive-health interventions, educational access, healthcare staffing and contraceptive supply stability. The findings also justify the use of hierarchical Bayesian models because standard logistic regression approaches cannot adequately capture latent contextual dependence structures. The result aligns with geo-additive and spatial reproductive-health studies in Nigeria, which found substantial geographic variation in contraceptive discontinuation behaviour [1, 13, 28, 29].

The study demonstrated that hierarchical Bayesian modelling provides substantial advantages for reproductive-health analysis under uncertainty. The Bayesian framework was particularly useful because it handled sparse discontinuation events, incorporated uncertainty explicitly, stabilised parameter estimation, captured latent state-level variability and improved posterior inference. This agrees with recent demographic-health modelling literature advocating Bayesian hierarchical methods for reproductive-health estimation and prediction [15, 30-32]. The use of Bayesian inference, therefore, represents an important methodological advancement for family planning research in Nigeria

Conclusion

This study demonstrated that family planning discontinuation (FPD) in South-East Nigeria is a complex stochastic reproductive-health phenomenon influenced by complex interactions among environmental uncertainty, healthcare accessibility, migration dynamics and latent geographic heterogeneity. Using the hierarchical Bayesian framework, the study

established that drought exposure and environmental instability significantly increase discontinuation vulnerability, while migration experience serves as an important protective factor. The findings further revealed substantial state-level disparities in reproductive-health outcomes, emphasising the importance of context-specific interventions. Robust posterior convergence, predictive diagnostics, and sensitivity analyses confirmed the reliability of the Bayesian model for reproductive-health behaviour and inference under stochastic conditions. Overall, the study provides strong methodological evidence that climate-sensitive, geographically targeted and probabilistically informed reproductive-health policies are essential for improving contraceptive continuity and reproductive-health resilience in vulnerable rural populations.

Based on these conclusions, the study therefore recommended climate-resilient reproductive-health systems, improved healthcare accessibility, geographically targeted family planning interventions, integration of Bayesian predictive systems into reproductive-health planning, and further longitudinal and spatial Bayesian studies in South-East Nigeria.

Conflict of interest: The authors declare that there is no conflict of interest in this study.

Acknowledgement: The authors wish to acknowledge Yaba College of Technology for funding this study through TETFund Institutional-Based Research Fund (Grant Number 2025 Batch B).

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Citing this Article

Ikegwu, E. M., Karokatose, G. B., & Idris, M. A. (2026). Bayesian modelling of family planning discontinuation under socioeconomic and environmental uncertainty in rural communities in South East Nigeria. *Lafia Journal of Scientific and Industrial Research*, *4*(2), 98–107. https://doi.org/10.62050/ljsir2026.v4n2.878