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RESEARCH

Spatial pattern and determinants of unmet need of family planning in Nigeria

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Background: Nigeria still grapples with low family planning (FP) use and a high fertility rate. This study explores the factors associated with the unmet need for FP and the coldspots of unmet need for FP in Nigeria.
Methods: The 2013 Nigerian Demographic Health Survey (NDHS) data was used to investigate the unmet need for FP in Nigeria. A geo-additive model was specified to simultaneously measure the fixed, nonlinear, spatial and random effects inherent in the data. The fixed effect of categorical covariates was modelled using the diffuse prior, the nonlinear effect of continuous variable was modelled using the P-spline with second-order random walk, the spatial effects followed Markov random field priors while the exchangeable normal priors were used for the random effect of the community. The binomial distribution was used to handle the dichotomous nature of the dependent variable.
Results: North East (OR: 1.8404, CI: 1.6170, 2.0941), North West (OR: 1.1145, CI: 1.1454, 1.1789), primary education (OR: 1.0441, CI: 0.9680, 1.1286), Hausa (OR: 2.7031, CI: 2.3037, 3.1513), birth interval greater than 12 months (OR: 1.0909, CI: 1.0447, 1.1379), community (OR: 1.6733, CI: 1.5261, 1.7899) and states (OR: 6.0879, CI: 2.5995, 29.6274) significantly increased the unmet need for FP.
Conclusion: The unmet need for FP in Nigeria is positively associated with the Northern region, low level of education and birth interval.

Keywords: Bayesian inference, binomial, family planning, geo-additive model, Nigeria

Introduction

One of the major targets of the Millenium Development Goals (MDGs) is to improve maternal health. Family planning (FP) has been described as a means to achieving all the MDGs.[1,2] Family planning programmes are now widely considered a key part of any comprehensive development strategy.[3] Family planning not only gives couples the freedom to space and plan the number of children they wish, but also contributes to the health and overall quality of life of the population.[4] The two main metrics in use to measure FP success are contraceptive prevalence and unmet need[i].[5] Given past high rates of fertility, the number of women expected to enter the reproductive age group in the next 10 years will increase by some 35%, resulting in a 33% increase in the annual number of pregnancies (USAID 2006). A significant percentage of these pregnancies are either mistimed or unintended. A major reason for this is the low use of FP and the high rates of unmet need for FP. Reducing unmet need for FP would also reduce the number of infant and child deaths by reducing the percentage of high-risk births. Addressing the need for FP worldwide would prevent 53 million unintended pregnancies each year, protecting the health of women and their children.[6] Each year, there would be 25 million fewer abortions and 150 000 fewer maternal deaths (Population Action International 2010).

Current reports show that many countries have met the MDGs 2015 deadline. The unmet need for FP still varies considerably among regions and countries, but the most disturbing finding is that in some countries it is still on the increase. Regionally, much of Eastern and Southern Asia, Central and South America are on track to reach the MDGs deadline[5] while in sub-Saharan Africa fulfilling unmet need for FP remains a persistent challenge (Madsen, Kuang and Ross 2014).[3] In Western and Middle Africa, the levels of unmet need for FP have remained essentially unchanged for over 20 years.[7–9] Like many sub-Saharan countries, Nigeria still grapples with a low contraceptive rate and a high fertility rate.[6] With a population of approximately 150 million, an annual population growth rate of 3.2%, and a total fertility rate of 5.7, Nigeria is set to double its population in 22 years if nothing is done to reverse the demographic momentum.[10] The percentage of women with more than five children who are not using contraceptives is as high as 83.8%; in rural areas it is as high as 91.5% compared with urban areas at 73.2%.[11] The region with the lowest contraceptive use is the North West (over 95%) while in the South West the figure is about 60%. Although substantial progress has been made to increase the unmet need for FP in Nigeria which rose by 16% in 2008 to 20% in 2013. This increase is still relatively small compared with that in some other countries.[11]

The unmet need for FP is prevalent in Nigeria, but the magnitude and severity of its effect differs among the six geo-political zones. Therefore, it is imperative to channel and demonstrate the spatial spread of unmet need for FP for proper targeting and identification of where its prevalence is rampant. Unfortunately, most empirical studies on unmet need for FP in Nigeria have focused mainly on the country at large, which often masked the variation at the state level. Identifying the spatial pattern of unmet need for FP at the state level helps to identify the spread, which in turn will help the government in targeting the states that are most affected in providing interventions.

Model-based analyses are becoming important sources of global information, largely because of the absence of reliable national-level empirical data in most sub-Saharan Africa countries. Unmet need for FP has attracted attention in the literature.[12–20] These studies have established the presence of linear, nonlinear, spatial and random effects in variables used to model unmet need for FP individually. This study explores a model to simultaneously capture the different effects in a single model.

The two burning issues considered are:

i. To investigate the coldspots of FP among the 36 states and Federal Capital Territory (FCT) of Nigeria.

ii. To determine the factors that affect unmet need for FP in Nigeria.

Geo-additive model

Consider the geo-additive model specified as:

$$\eta_r = f_1(x_{r1}) + \ldots + f_k(x_{rk}) + f_{spat}(s_r) + u_r'\gamma + b_g \quad (1)$$

where

η_r is the geo-additive predictor

$f_{i,i=1,\ldots,k}$ is the nonlinear effect of metrical or continuous covariates x

$f(spat)$ is the spatially correlated effect of location Sr

u is the fixed effect of categorical variables γ

b_g, $g \in \{1, \ldots, G\}$ are uncorrelated (unstructured) random effects to model unobserved heterogeneity

For the continuous/metrical covariates, we assume penalized splines (P-spline) prior with second-order random walk.[21,22]

$$f(x) = \sum_{t=1}^{k} \alpha_t B_t(x) \quad (2)$$

where

$B_t(x)$ are B-splines, α_t are defined to follow a first-order or second-order random walk prior. The second-order random walk is given as

$$\alpha_t = 2\alpha_{t-1} - \alpha_{t-2} + \varepsilon_t \quad (3)$$

with Gaussian errors $\varepsilon_t \sim N(0, \tau_\varepsilon^2)$ where τ_ε^2 controls the smoothness of f. This variance is estimated jointly with the coefficients of the basis function by assigning a weakly informative inverse Gamma prior with $\tau_\varepsilon^2 \sim IG(\varepsilon, \varepsilon)$. A suitable choice of diffuse prior is assumed for the fixed effect of categorical covariates given as

$$p(\gamma)\alpha\ const \quad (4)$$

The spatial effects follow Markov random field priors.[23]

$$\{f_{spat}(s_r) \,|\, f_{spat}(t); t \neq i, \tau_s^2\} \sim N\left(\sum_{t \in \partial_i} \frac{f_{str}(t)}{N_i}, \frac{\tau_s^2}{N_i}\right) \quad (5)$$

where

N_i is the sum of adjacent sites

τ_s^2 is the spatial variance which controls the spatial smoothness

The random effects b_g were modelled from exchangeable normal priors, $b_{ij} \sim N(0, \tau_b^2)$

where τ_b^2 is the variance that accounts for overdispersion and heterogeneity.

We assigned highly dispersed but proper prior for all variance components. An inverse Gamma distribution with hyperparameters a and b is chosen, such that $\tau^2 \sim IG(a,b)$. Standard choices of hyperparameters are $a = 1$ and $b = 0.005$ or $a = b = 0.001$(which is close to Jeffrey's non-informative prior) (Fahmeir and Lang, 2001; Kazembe 2009).[22,24] These values can be varied to examine the sensitivity of the choices of hyperparameters to the inverse Gamma distribution.

Letting $\alpha = (f, f_{spat})$, τ to represent the vector of all variance components, and β is the vector of fixed effects parameters, then the posterior probability distribution is given as

$$p(\alpha, \tau, \beta | y)\ \ \alpha\ \ p(y|\alpha, \beta, \tau)p(\alpha)p(\beta)p(\tau) \quad (6)$$

where

$p(y|\alpha, \tau, \beta)$ is the likelihood function of the data given the parameters of the model (based on the dependent variable)

$p(\alpha)\ p(\beta)\ p(\tau)$ are the prior densities of all the parameters

The Bayesian framework based on Markov Chain Monte Carlo (MCMC) simulation techniques from full conditionals for nonlinear, spatial, fixed effects and smoothing parameters will be used for the posterior analysis. The Deviance Information Criterion (DIC)[25] is employed for comparison of the models. The DIC is defined as

$$DIC = \bar{D}(\theta) + pD \quad (7)$$

where

$\bar{D}$ is the posterior mean of the deviance

pD is the effective number of parameters (not equal to degrees of freedom)

Small values of $\bar{D}$ and pD indicate a better and parsimonious model respectively. The model with the lowest DIC is the best.

Data

The study followed a quantitative and cross-sectional design. The data used for this study were drawn from the Nigerian Demographic and Health Survey (NDHS) 2013. The 2013 NDHS was conducted by the National Population Commission (NPC) with funding support from the US Agency for International Development (USAID), the United Nations Population Fund (UNFPA) and the United Kingdom Department for International Development (DFID). Technical support was provided by Intermediate Care Facility (ICF) International. The 2013 NDHS sample was selected using a three-stage stratified design consisting of 904 clusters, 372 urban areas and 532 rural areas. In the 2013 NDHS data set, 40 320 households were selected, of which 38 522 were interviewed. In the interviewed households, 39 902 women in the childbearing age (15–49 years) and 18 229 men were found eligible for the interview. This represents a response rate of 99% for households, 98% for women and 95% for men. This study is based on the survey data with all participant identifiers removed. Although different covariates on population and health issues in Nigeria were presented in the comprehensive and well-detailed data set, we focused on the number of women who were not on any type of contraceptives. Table 1 presents the different types of family planning methods available and their percentage usage in Nigeria. Of all the women surveyed 85.1% were not on any family planning method.

The traditional method of FP generally means methods such as withdrawal and periodic abstinence, which do not require contraceptive or clinical procedures, while the folkloric method involves the use of strings and herbs. The modern FP methods include the

Table 1: Frequency of women on family planning

Current use by method used	Frequency	Percentage (%)
No method	26 798	85.1
Folkloric method	201	0.6
Traditional method	1437	4.6
Modern method	3046	9.7
Total	31 482	100

pill, condoms, diaphragms, foaming tablets, jelly, implants and sterilisation.

The socio-economic variables used as explanatory variables in explaining unmet need for FP are grouped into category A (categorical variables) and category B (continuous variables):

Category A: region, place of residence, educational attainment of both mother and partner, religion, ethnicity, marital status, wealth index, total children ever born, effect of advert on family planning (radio, television, newspaper/magazine), visited by family planning worker, visited health facility, at health facility told about family planning, birth interval and place of delivery.

Category B: Body mass index (BMI), current age of respondent.

Data analysis and presentation of results

Data analysis

Given a dichotomous variable that classifies current use of any method of FP into 'Yes' or 'No', this follows a binomial distribution whose dependence is modelled through a logit link model given as:

$$y_{ij}/\gamma, b_i \sim Bin(n_i, \pi_i)$$

where

$$\pi_i = \Pr(Y_i = 1/\eta_i) = \frac{e^{\eta_i}}{1 + e^{\eta_i}}$$

$$\log it(\pi_i) = \log\left(\frac{\pi_i}{1 - \pi_i}\right) = \eta_i$$

$$\eta_i = w'\gamma + f'x + f(spat) + b_i \quad (8)$$

where

η_i is the mean number of women who are not currently on FP

$w'\gamma$ is the vector of fixed effect of the categorical covariates of Category A

$f'x$ is the vector of unknown smooth functions for Category B that are continuous and nonlinear

$f(spat)$ is the spatial effect

b_i is the community effect

We considered four models to investigate the best approach to identify the coldspots of FP using variants of (8). In the first model (M1), all the effects of the categorical variables (Category A), and continuous effect of Category B, were estimated linearly. We used effect coding for all the categorical variables. In the second model (M2) we included the spatial effect to identify the coldspots for current use of FP across the states. In the third model (M3) we introduced unobserved random effects of community while (M4) explains the linear effect of the categorical variables, the nonlinear effect of continuous variables, the spatial effect and the unobserved random community effect.

The four models were implemented in BayesX version 2.1 (www.stat.uni-muenchen.de/~bayesx.html).[26] We carried out 20 000 iterations with the first 2000 considered as a burn-in sample. We thinned every 10th iteration of the remaining 18 000 used for parameter estimation. Convergence and mixing were monitored through plotting and estimation of sampling paths and autocorrelation. Sensitivity analysis was carried out by varying the hyperparameters. The different choices of hyperparameters considered were a = 1 and b = 0.005, a = b = 0.005 and a = b = 0.001 (default).[27] We report the latter as the results were less sensitive to variation of the choices of the parameters.[28]

Presentation and discussion of results

The major results of the four models are presented in Table 2 from the variants of (8). Model 1 gave a parsimonious model of 34.792 effective number of parameters while the best model based on least DIC of 18278.505 is M4. The regression coefficients were almost similar in the other three models. Precision is enhanced in M4, therefore we present in Table 3 the posterior estimates and 95% credible intervals (CI) of M4 which gave the best fit.

The posterior results showed that theSouth East (OR: 0.8590, CI: 0.7366, 0.9945) is 86% less likely to contribute to high unmet need for FP than the North Central region. The South South (OR: 0.7302, CI: 0.6635, 0.8037) and South West (OR: 0.9796, CI: 0.8868, 0.9013) are 73% and 98% less likely to be associated with unmet need for FP than the North Central region. The credible intervals for the South Eastern, South South and South Western region show a significant lower association with unmet need for FP. The

Table 2: Summary of diagnostic accuracy of the four models

Model	$\bar{D}$	pD	DIC
M1: All variables fixed	19651.091	34.792	19720.675
M2: All variables fixed + spatial effect	18949.863	63.906	19077.675
M3: All variables fixed + spatial + community effect	17334.733	506.390	18347.514
M4: All categorical variables fixed + spatial + nonlinear of continuous variable + community effect	17224.803	526.851	18278.505

Note: $\bar{D}$ is the posterior mean of the deviance, pD is the effective number of parameters, DIC is the deviance information criterion.

Table 3: Posterior estimates of M4 within 95% credible interval (CI)

Variable	OR	SD	95% CI
Constant	7.2001	0.1633	(5.1810, 9.9652)
Region			
North Central (Ref.)	1.0000		
North East	1.8404	0.0661	(1.6170, 2.0941)**
North West	1.1145	0.0769	(1.1455, 1.1789)**
South East	0.8590	0.0779	(0.7366, 0.9945)*
South South	0.7302	0.0489	(0.6635, 0.8037)*
South West	0.9796	0.0576	(0.8868, 0.9013)*
Place of residence			
Rural (Ref.)	1.0000		
Urban	0.9086	0.0220	(0.8693, 0.9480) *
Educational attainment			
No education (Ref.)	1.0000		
Primary	1.0441	0.0384	(0.9680, 1.1286)
Secondary	0.8018	0.0315	(0.7534, 0.8543)*
Higher	0.6430	0.0546	(0.5767, 0.7179)*
Ethnicity			
Other ethnic groups (Ref.)	1.0000		
Yoruba	0.5115	0.0551	(0.4608, 0.5697)*
Ibo	0.7539	0.0651	(0.6674, 0.8613)*
Hausa	2.7031	0.0798	(2.3037, 3.1513)**
Wealth index			
Poorest/poorer (Ref.)	1.0000		
Middle class	0.9891	0.0316	(0.9306, 1.0529)*
Richer/richest	0.7183	0.0325	(0.6737, 0.7647)*
Religion			
None/traditional (Ref.)	1.0000		
Christianity	0.7131	0.0801	(0.6051, 0.8322)*
Islam	1.0647	0.0811	(0.9063, 1.2455)
Marital status			
Others (Ref.)	1.0000		
Married and living with partner	0.9102	0.0392	(0.9357, 1.0895)
Partner's education			
No education (Ref.)	1.0000		
Primary	0.9252	0.0377	(0.8596, 0.9968)*
Secondary	0.9324	0.0329	(0.8735, 0.9968)*
Higher	0.9324	0.0425	(0.7704, 0.9997)*
Working status			
Not working (Ref.)	1.0000		
Working	0.9738	0.0232	(0.9307, 1.0186)
Number of children			
Greater than three (Ref.)	1.0000		
Less than three	0.8390	0.0232	(0.8011, 0.8763)*
Heard of family planning on radio			
No (Ref.)	1.0000		
Yes	0.9123	0.0236	(0.8692, 0.9558)*
Heard of family planning on television			
No (Ref.)	1.0000		
Yes	1.0371	0.0268	(0.9850, 1.0941)

(Continued)

Table 3: (*Continued*)

Variable	OR	SD	95% CI
Heard of family planning in newspaper/magazine			
No (Ref.)	1.0000		
Yes	0.8762	0.0318	(0.8242, 0.9336)*
Visited by family planning worker			
No (Ref.)	1.0000		
Yes	0.9045	0.0256	(0.8599, 0.9508)*
Heard about family planning at health facility			
No (Ref.)	1.0000		
Yes	0.8795	0.0302	(0.8272, 0.9323)*
Birth interval			
Less than 12 months (Ref.)	1.0000		
Greater than 12 months	1.0909	0.0220	(1.0447, 1.1379)**
Place of delivery			
Home (Ref.)	1.0000		
Public hospital	0.9578	0.0257	(0.9114, 0.9917)*
Private hospital	0.8495	0.0303	(0.8016, 0.9020)*
Continuous/metrical covariates			
Current age	0.9929	0.0021	(0.9890, 0.9969)*
Body mass index	0.9914	0.0041	(0.9835, 0.9993)*
Random component			
Community	1.6733	0.0507	(1.5261, 1.7899)**
Spatial component			
States	6.0879	0.5984	(2.6000, 29.6274)**

Notes: OR= odds ratio; SD = standard deviation.
*Negatively significant.
**Positively significant.

North Eastern (OR: 1.8404, CI: 1.6170, 2.0941) and North Western (OR: 1.1145, CI: 1.1455, 1.1789) regions are more likely to give an 84% and 12% significant increase of unmet need for FP than the North Central region. The North Eastern and Western regions seems to account for unmet need in Nigeria. There is about 91% likelihood that women who reside in the urban areas (OR: 0.9086, CI: 0.8693, 0.9480) are less likely to contribute to unmet need for FP than women who reside in rural areas. The posterior estimates for women with higher and secondary education are (OR: 0.6430, CI: 0.5767, 0.7179) and (OR: 0.8018, CI: 0.7534, 0.8543) respectively. As the level of education of a woman increases, so there is a reduction in unmet need for FP compared with women with no education. Women with primary education (OR: 1.0441, CI: 0.9680, 1.1286) are 4% more likely to increase unmet need for FP than women with no education. This suggests that women with higher education are better exposed than women without any education who believe in the myths that surround contraceptive use. The Hausa tribe is strongly associated with unmet need for FP, which is about three times higher than the other ethnic groups excluding the Yoruba and Ibo tribes. The Yoruba tribe is 50% less likely to be associated with unmet need for FP. The Hausa tribe suggests a significant increase in unmet need for FP while the Yoruba and Ibo tribes are not significantly associated with unmet need for FP at 95% CI.

Considering the wealth index, the middle class (OR: 0.9891, CI: 0.9306, 1.0529), and richer/richest class (OR: 0.7183, CI: 0.6737, 0.7647) are 99% and 72% less likely to contribute to unmet need for FP compared with women from the poorer/poorest class. This suggests that the wealthy people do not significantly contribute to unmet need for FP compared with poor people. The Christianity (OR: 0.7131, CI: 0.6051, 0.8322) result showed a significant lower association with unmet need for FP. Women who are married and living with a partner are 91% less likely to contribute to unmet need for FP. Partners with primary (OR: 0.9252, CI: 0.8596, 1.0032), secondary (OR: 0.9324, CI: 0.8735, 0.9968) and higher education (OR: 0.9324, CI: 0.7704, 0.9997) are 93% less likely to be highly associated with unmet need for FP than partners with no education. Women who are working are 97% less likely to contribute to unmet need for FP than women who are not gainfully employed. Women with fewer than three children (OR: 0.8390, CI: 0.8011, 0.8763) are 84% less likely to contribute to unmet need for FP than women with more than three children. The effect of aggressive advertising cannot be overemphasised, with odds and CI of information on FP on the radio (OR: 0.9123, CI: 0.8692, 0.9558), TV (OR: 1.0371, CI: 0.9850, 1.0941), newspaper/magazine (OR: 0.8762: CI: 0.8242, 0.9336), visited by FP worker (OR: 0.9045, CI: 0.8599, 0.9508), health facility (OR: 0.9268, CI: 0.8793, 0.9734). However, the lower significant results are on the radio, newspaper/magazine, visited by FP worker and visited health facility which are 91, 88, 91, and 93% less likely to contribute to unmet need for FP in Nigeria. From the results, this implies that disseminating information on FP through the radio, newspaper/magazines and maybe door-to-door visit by a health worker have far-reaching effects in reducing the unmet need for FP. The place of delivery has an encompassing effect on both child and maternal health. Giving birth at public (OR: 0.9578, CI: 0.9114, 0.9962) or private (OR: 0.8495, CI: 0.8016, 0.9020) hospitals suggests 96% or 85% significant reduction in unmet need for FP as opposed to giving birth at home.

The posterior estimate of current age (OR: 0.9929, CI: 0.9890, 0.9969) of respondent (in years) suggests a significant decrease in unmet need for FP. Young women do not actually have a desire for FP, which makes the unmet need for FP very high; as the years go by, the older women — whether 'spacers or limiters' — tend to go for FP. This is further corroborated by Figure 1, which shows a steady decline in the unmet need for FP. The effect of BMI (OR: 0.9914, CI: 0.9835, 0.9993) was also explored and a similar trend was noticed. This means that high BMI can significantly reduce the unmet need for FP (Figure 2).

The posterior estimate of the random effect of community (OR: 1.6733, CI: 1.5261, 1.7899) suggests 67% likelihood of a significant increase in unmet need for FP. The maps for the spatial effect are presented in Figure 3 while Figure 4 shows the labelled states on a map of Nigeria. Black denotes regions with strictly negative CI, white denotes regions with strictly positive CI and grey depicts the insignificant CI. Sokoto, Kebbi, Katsina, Kano, Jigawa, Yobe, Bauchi, Borno, Adamawa and Bayelsa are positively associated with a high unmet need for FP while Lagos, Oyo, Kwara, Kaduna, Federal Capital Territory, Nasarrawa, Benue, Enugu, Cross River, Anambra, Imo,

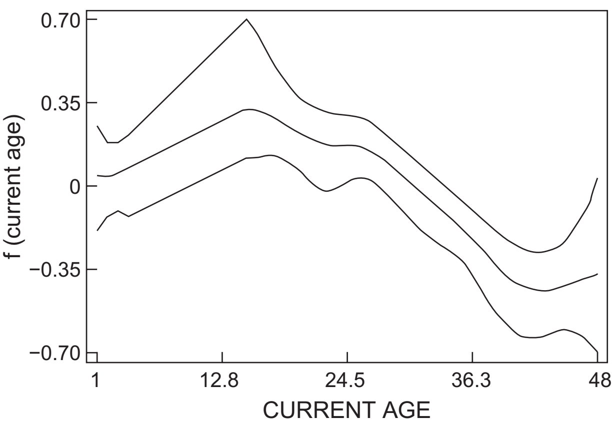


Figure 1: Nonlinear effect of current age on unmet need for FP at 95% CI.

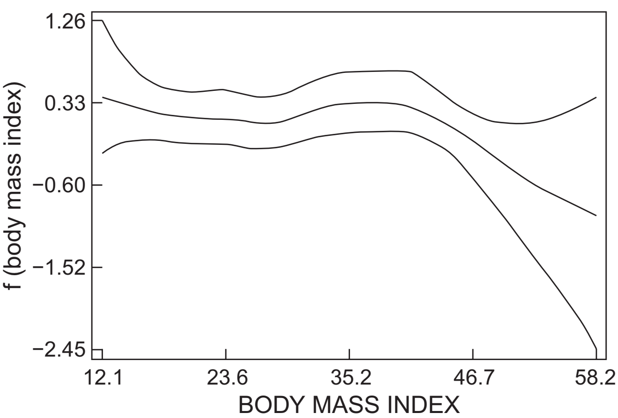
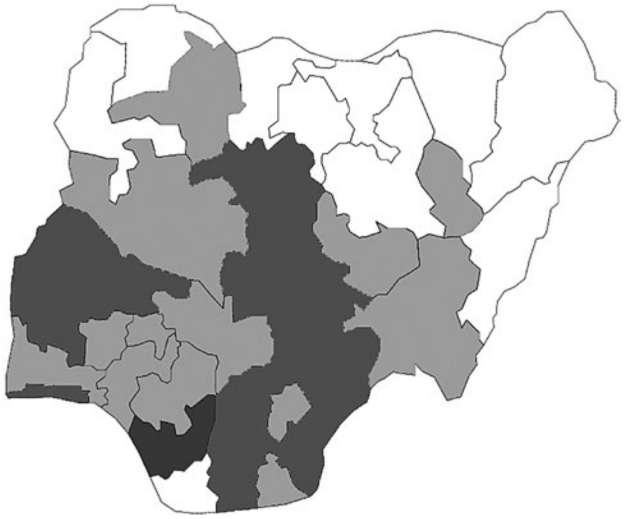


Figure 2: Nonlinear effect of BMI on unmet need for FP at 95% CI.



Note: White denotes states with strictly positive CI (significant high risks), black denotes states with strictly negative CI (significant low risks) and grey denotes states with insignificant risk of unmet need for FP.

Figure 3: Posterior estimate of spatial pattern of unmet need for FP in Nigeria at 95% CI.

Figure 4: Labelled map of Nigeria[28]

Abia, Rivers are the states responsible for low unmet need for FP. Unmet need for FP is insignificant in the other states.

Summary and conclusion

The geo-additive model was used to investigate the factors and coldspots of unmet need for FP. We used a logit-link model for the response variable of whether a woman is currently on any FP or not by using the 2013 Nigerian Demographic Health Survey (NDHS) data. The diffuse prior was used for the fixed effect of categorical variables, with penalised spline with second random walk for the continuous variables; spatial effects followed Markov random field priors while the exchangeable normal priors were used for the random effect of the community. Four models (M1–M4) were implemented in BayesX software. M4 gave the least DIC, hence the best fit. The Bayesian framework based on Markov Chain Monte Carlo (MCMC) simulation techniques from full conditional was used for estimation of the unknown posterior distribution. The North East, North West, birth interval greater than 12 months, community and states increased unmet need for FP significantly while South East, South South, South West, urban, woman with secondary/higher education, Yoruba and Ibo tribe, middle, richer and richest wealth index, Christianity, partner with primary/secondary/higher education, having fewer than three children, heard of FP on radio, magazine/newspaper or at health facility, visited by health worker, visited health facility, gave birth at public or private hospital, age and BMI reduced unmet need for FP significantly. From the results, the coldspots of unmet need for FP to be targeted by government, policy-makers and stakeholders are the Sokoto, Kebbi, Katsina, Kano, Jigawa, Yobe, Bauchi, Borno, Adamawa and Bayelsa states of Nigeria.

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Competing interests – None.

Ethical approval – Not required.

Note

i. Unmet need for FP as a woman who is fecund, sexually active, not using any contraceptive methods, and does not want a child for at least two years ('spacers') or does not want more children at all ('limiters') (USAID 2006).

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