

# Exclusive Breastfeeding Practice in Nigeria: A Bayesian Stepwise Regression Analysis

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**Abstract** Despite the importance of breast milk, the prevalence of exclusive breastfeeding (EBF) in Nigeria is far lower than what has been recommended for developing countries. Worse still, the practise has been on downward trend in the country recently. This study was aimed at investigating the determinants and geographical variations of EBF in Nigeria. Any intervention programme would require a good knowledge of factors that enhance the practise. A pooled data set from Nigeria Demographic and Health Survey conducted in 1999, 2003, and 2008 were analyzed using a Bayesian stepwise approach that involves simultaneous selection of variables and smoothing parameters. Further, the approach allows for geographical variations at a highly disaggregated level of states to be investigated. Within a Bayesian context, appropriate priors are assigned on all the parameters and functions. Findings reveal that education of women and their partners, place of delivery, mother's age at birth, and current age of child are associated with increasing prevalence of EBF. However,

visits for antenatal care during pregnancy are not associated with EBF in Nigeria. Further, results reveal considerable geographical variations in the practise of EBF. The likelihood of exclusively breastfeeding children are significantly higher in Kwara, Kogi, Osun, and Oyo states but lower in Jigawa, Katsina, and Yobe. Intensive interventions that can lead to improved practise are required in all states in Nigeria. The importance of breastfeeding needs to be emphasized to women during antenatal visits as this can encourage and enhance the practise after delivery.

**Keywords** Nigeria · Exclusive breastfeeding · Spatial analysis · Child nutrition · Stepwise regression

## Introduction

Due to its enormous benefits to the child and the mother, the practise of exclusive breastfeeding (EBF) has been recommended by WHO/UNICEF during the first 6 months of life. Thereafter, children can be given solid or semi-solid complimentary foods in addition to continued breastfeeding from age 6 months to 24 months (or more) until when the child is fully weaned. Breast milk is strongly recommended because it contains all the nutrients necessary for infants in the first few months of life and is uncontaminated. Its benefits to the child and the mother have been well documented [1, 2]. Supported by the health outcomes of exclusively breastfed infants and those who were never or only partially breastfed, the American Academy of Paediatrics, in a recent policy statement, reaffirms this recommendation [3]. The merits of EBF include a significant reduction in cases of infant morbidity and mortality in developing countries. Lower infant and child mortality would mean that fewer numbers of children need to be born

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to achieve a certain number of survivals. The implication is that women would, in general, have a reduced number of pregnancies thereby reducing exposures to the risks of maternal mortality which is the leading cause of death among women of reproductive age in developing countries [4]. Despite the gains of breastfeeding, EBF practise in Nigeria is still far below the WHO/UNICEF recommended 90 % coverage for children during the first 6 months of life in developing countries [5]. Even within sub-Saharan African countries, Nigeria has a lower rate compared with some countries [6, 7]. Of great concern is the fact that trend in EBF in Nigeria is in decline. From 17 % estimated in the 2003 Nigeria Demographic and Health Survey (NDHS), rates dropped to 13 % in 2008. The median duration (in months) of EBF is 2.5 in 1999. This increased to 3.7 in 2003 and then reduced to 1.7 in 2008 [8, 9].

The Nigerian government, in 2004, implemented with a National Policy on Population for Sustainable Development which seeks, among others, improvement in the reproductive health of all Nigerians at every stage of the life cycle. In line with the millennium development goals (MDGs), targets were set with the aim of reducing infant mortality rate to 35 per 1,000 births by 2015 and child mortality rate to 45 per 1,000 births by 2010 [10]. As at the end of 2010, the desired reduction in child mortality rate had not been achieved. Studies have linked breastfeeding practises with childhood illnesses and mortality. It has also been shown that EBF can reduce cases of infant mortality by up to 13 % in low-income countries [2, 11, 12]. Against this background, we set out to explore and understand possible determinants and spatial variations of EBF practise in Nigeria. This is an important study considering the urgency of intervention programmes required to reverse the present trend in order to achieve an improvement in maternal and child health. Knowledge of differences in EBF practise among states in Nigeria would assist health-care workers and policy makers in identifying locations that require priority interventions.

Several factors, ranging from socio-economic, biosocial, cultural, and attitudinal to demographic, have been identified to influence the type of health care practise especially EBF [13–15]. In a recent study, it was found that the prevalence of EBF at 1 and 3 months was relatively high among first-time mothers in a low-income peri-urban population of primiparous Peruvian women [16]. The study also show that, similar to previous studies conducted in developing countries, maternal education was negatively associated with EBF [14, 17]. Ojefeitimi [18] observed that, resulting from early introduction of infant formula, no mother who had attained more than primary education at the time of study would nurse her child for more than 3 months in Ile-Ife, Southwest Nigeria. Similarly, Davies-Adetugbo [19] observed that as a result of cultural

practises, EBF was considered dangerous to infants and, therefore, plain water was used as supplement to quench thirst and herbal teas given as food and medicine in rural Yoruba communities of South-western Nigeria.

The dataset for this study was derived from three waves of NDHS. In a Demographic and Health Survey (DHS), sample data often come from a multi-stage sampling scheme. Due to the hierarchical nature of these data, unobserved community factors such as traditional norms may influence breastfeeding attitudes of respondents that belong to the same cluster causing the data to be correlated in the cluster but uncorrelated between different clusters. Failure to take into account clustering in analysing data from a hierarchical population typically leads to underestimation of standard errors [20]. Hence, a modelling technique that accounts for this hierarchical nature of data provides more robust estimates than the usual traditional regression approach that has been widely used to study EBF in Nigeria and elsewhere. Therefore, a structured additive regression model that is capable of accounting for ‘within’ cluster correlation was used to explore possible relationship between EBF and some of its determinants.

In any regression situation where the dependence of the outcome variable is to be modelled on several explanatory variables, the better way to obtain a parsimonious model is to consider screening of variables. In this study, we adopt a technique that permits screening and selection of variables using Bayesian stepwise regression model. This technique permits the modelling of linear and nonlinear covariate effects, unobserved covariates, and spatial effects within a Bayesian approach. Also, the approach allows for flexible nonparametric modelling of the continuous covariates as the pattern is expected to change smoothly between time points. With this, hidden patterns such as peak and bumps will be established which would not have been possible with parametric models.

## Materials and Methods

### Data

This study is based on data from the 1999, 2003, and 2008 NDHS. The DHS is conducted to provide comprehensive and comparable information on demographic and health indicators with their determinants for women of reproductive age and their children below the age of 5 years. Among others, the survey is design to gather information on childhood nutrition and infant and child mortality. Data on child feeding practises are contained in the Child’s and Woman’s Nutrition Section of the Women’s Questionnaire. Women were asked, among other things, to name all the liquids/foods given to their children in the last 24 h. The

datasets used in this paper allow us to study trend in EBF practise in Nigeria between 1999 and 2008.

The sampling frame used for the surveys was based on the Population and Housing Census of the Federal Republic of Nigeria conducted in 1991 and 2006. The primary sampling unit referred to as cluster for the survey was defined on the basis of enumeration areas from the census frames. The NDHS sample was selected using a two-stage stratified design. At the first stage, a number of clusters were selected from the list of enumeration areas while households to participate in the survey were selected at the second stage. Data were collected from 3,552, 6,029, and 28,647 women in the 1999, 2003, and 2008 surveys respectively. Ethical approvals for the surveys were sought and obtained from the National Health Research Ethical

Committee, the apex Institutional Review Board in Nigeria. A dataset for this study was constructed from individual records of children included in the surveys. Datasets for infants aged 0–5 months were extracted from the pooled data. In all, 572, 617, and 2,924 infants fell into this age-group from the 1999, 2003, and 2008 surveys respectively. The dichotomous variable measuring EBF practise was constructed for these infants with indicator 1 if the infant had taken nothing else apart from breast milk in the last 24 h and 0 if otherwise. Table 1 presents detailed descriptions of all the covariates included in the analysis. Figure 1 presents map of Nigeria showing the location of the 36 states and Federal Capital Territory.

After controlling for the observed covariates, we adjusted for the unobserved heterogeneity using community and

**Table 1** Descriptive information about the variables in the model

Variables	Description of variables
<i>EBF</i>	Whether or not a woman practise exclusive breastfeeding: yes (n = 519; 12.6 %) no (n = 3,283; 79.8 %) missing (n = 311; 7.6 %)
<i>Zones<sup>a</sup></i>	Geopolitical zones: North Central (n = 687; 16.7 %); North East (n = 954; 23.2 %); North West (n = 1,136; 27.6 %); South East (n = 338; 8.2 %), South South (n = 518; 12.6 %) and South West (n = 480; 11.7 %)
<i>Urban</i>	Place of residence: urban (n = 1,141; 27.7 %) and rural (n = 2,972; 72.3 %)
<i>Educ</i>	Woman's educational attainment: no formal education (n = 1,997; 48.6 %); primary (n = 927; 22.5 %); secondary (n = 1,037; 25.2 %) and higher (n = 152; 3.7 %)
<i>Part_Edu</i>	Partner's educational attainment: no formal education (n = 1,580; 38.4 %); primary (n = 822; 20.0 %); secondary (n = 1,116; 27.1 %); higher (n = 414; 10.1 %) and missing (n = 181; 4.4 %)
<i>Sex</i>	Sex of the child: male (n = 2,059; 50.1 %) and female (n = 2,054; 49.9 %)
<i>ant_vist</i>	Antenatal visits for pregnancy: no visits (n = 1,497; 36.4 %); between 1 and 4 visits (n = 857; 20.8 %); five visits and more (n = 1,430; 34.8 %) and missing (n = 329; 8.0 %)
<i>Del_place</i>	Place of delivery: homes (n = 2,623; 63.8 %); govt/public hosp/clinic (n = 857; 20.8 %); private hosp/clinic (13.4 %); others (n = 74; 1.8 %) and missing (n = 6; 0.1 %)
<i>Ethn</i>	Ethnicity: Hausa/Fulani (n = 1,509; 36.7 %); Igbo (n = 451; 11.0 %); Yoruba (n = 400; 9.7 %) Others (n = 1,723; 41.9 %); missing (n = 30; 0.7 %)
<i>Rel</i>	Religion: Catholic/Other Christians (n = 1,685; 41.0 %); Islam (n = 2,329; 56.6 %); others (n = 82; 2.0 %); missing (n = 17; 0.4 %)
<i>Work</i>	Respondent's currently working: yes (n = 2,266; 55.1 %); no (n = 1,820; 44.2 %); missing (n = 27; 0.7 %)
<i>Parity</i>	Parity: 1 (n = 808; 19.6 %); 2-4 (n = 1,818; 44.2 %); 5 and above (n = 1,487; 36.2 %)
<i>Union</i>	Number of unions: once (n = 3,511; 85.4 %); more than once (n = 460; 11.2 %); missing (n = 142; 3.5 %)
<i>Poly</i>	Type of marriage: monogamy (n = 2,679; 65.1 %); polygamy (n = 1,224; 29.8 %); missing (n = 210; 5.1 %)
<i>Husb_liv</i>	Husband lives in house: yes (n = 3,519; 85.6 %); no (n = 380; 9.2 %); missing (n = 214; 5.2 %)
<i>Massmed<sup>b</sup></i>	Exposure to mass media: yes (n = 2,326; 56.5 %); no (n = 1,727; 42.0 %); missing (n = 60; 1.5)
<i>Year</i>	Year of study: 1,999 (n = 572; 13.9 %); 2,003 (n = 617; 15.0 %); 2008 (n = 2,924; 71.9 %)
<i>Agecont</i>	A continuous variable of mother's age at birth in years: min = 15, max = 49, mean = 27.37, SD = 6.89
<i>Part_age</i>	A continuous variable of partner's age in years: min = 18, max = 92, mean = 37.85, SD = 9.99
<i>Mar_dur</i>	Duration of marriage measured in years: min = 0, max = 41, mean = 19.15, SD = 7.29
<i>Age_mar</i>	Age at first marriage (continuous): min = 8, max = 45, mean = 17.40, SD = 4.42
<i>Age_birth</i>	Age at first birth (continuous): min = 10, max = 41, mean = 19.15, SD = 4.14
<i>Infant_age</i>	Age of infant in months (continuous): min = 0, max = 5, mean = 2.75, SD = 1.62
<i>State</i>	Respondent's State of resident divided into 36 states and a Federal Capital Territory

<sup>a</sup> Each of the zones consists of about six states making 36 altogether

<sup>b</sup> Yes if the mother listens to radio or watches television or reads newspaper at least once a week

**Fig. 1** Map of Nigeria showing the 36 states and Federal Capital Territory, Abuja



household random effects. This controls for the hierarchical nature of the survey data analysed. Traditional norms, common access to reproductive health programmes, and cultural approval of child feeding practise may jointly account for variations in EBF between communities. At the household level, social status, which may influence family decisions, could also constitute unmeasured explanatory factors that affect the decision to breastfeed exclusively.

**Statistical Analysis**

Bayesian hierarchical modelling was used to assess the association between EBF and its determinants in Nigeria. Consider observations  $(y_i, x_i, s_i, v_i, z_i)$ ,  $i = 1, \dots, n$ , where  $y_i$  is a binary response variable;  $y$  takes value 1 if the infant had taken no other thing except breast milk in the last 24 h prior to survey and 0 if otherwise,

$$y_i \sim \text{Bin}(n_i, p_i)$$

where  $p_i$  is the proportion of infants that were exclusively breastfed,  $x = (x_1, \dots, x_p)'$  is a vector of metrical covariates e.g. mother’s age at birth,  $s_i = (1, \dots, 37)$  the state (district) where infant  $i$  lived during the survey, vector  $v = (v_1, \dots, v_q)'$  of categorical covariates, and a further vector  $z = (z_1, z_2)$  of community and household random effects. The

logistic model with structured additive predictors is defined as

$$\log\left(\frac{p_i}{1 - p_i}\right) = t_{2003} + t_{2008} + \sum_{j=1}^p f_j(x_{ij}) + f_{spat}(s_i) + v_i'\beta + z_1 + z_2 \tag{1}$$

where  $f_1, \dots, f_p$  are nonlinear (unknown) smooth functions of the metrical covariates,  $f_{spat}$  is the effect of spatial covariates, and  $\beta_i = (\beta_1, \dots, \beta_L)'$  is a vector of fixed effect parameters for the categorical covariates. The values  $t_{2003}$  and  $t_{2008}$  are dummies for the second and third rounds of NDHS: 2003 and 2008 (with 1999 as the reference category). Bayesian structured additive regression of logit model is preferred in this study because of ease of interpretation and the possibility of computing posterior odds ratio directly from the Markov chain Monte Carlo (MCMC) output. Fitting Bayesian models via MCMC entails treating all parameters as randomly distributed according to some prior distribution. The posterior distribution is intractable, so MCMC algorithms are used to generate samples from this prior distribution which allow estimation and inference for the parameters [21].

Within a Bayesian context, all parameters and functions are considered as random variables upon which appropriate

priors are assumed. Independent diffuse priors are assumed on the fixed effects parameters. For the non-linear effects, Bayesian P-splines prior based on Lang and Brezger [22] and Brezger and Lang [23] was assumed. The P-splines prior allows for nonparametric estimation of  $f$  as a linear combination of basis function (B-spline). For the spatial effects, we chose a Gaussian Markov random field prior, which is common in spatial statistics [24]. This defines areas as neighbours if they share a common boundary and neighbouring areas are assumed to have similar patterns, such that the mean of area  $i$  is assumed to be an average of neighbouring areas, with variance as function of number of neighbours and spatial variance. The spatial variance was further assigned an inverse Gamma prior. Random effects were modelled by assuming exchangeable normal prior,  $z_{ij} \sim N(0, \tau_b^2)$ , where  $\tau_b^2$  is a variance component that incorporates over-dispersion and heterogeneity. For all variance components, an inverse gamma distribution with hyperparameters  $a$  and  $b$  is chosen. Standard choices of hyperparameters are  $a = 1$  and  $b = 0.005$  or  $a = b = 0.001$ . Sensitivity to choice of hyper-priors was investigated by varying the values of  $a$  and  $b$ . The results turned out to be indistinguishable. Findings reported in this paper are based on  $a = b = 0.001$ .

Bayesian stepwise regression was adopted to screen out variables that are less important in determining EBF practise in Nigeria. In realistically complex models, the decision as to which variables to be included in a model and the inclusion of continuous covariates whether as linear or nonlinear, etc., is difficult to make. Also, in a number of applications, such as this case study, one is confronted with many potential covariates of different types and lack of theory guiding the analysts as to the specification of promising models. In their efforts to contribute to this area, Belitz and Lang [25] proposed a Bayesian stepwise regression approach for regression models with structure additive predictors. Within the structured additive regression procedure [26, 27], stepwise regression simultaneously performs model selection and estimation with inference based on penalized likelihood. MCMC techniques are partly used for computing interval estimates. The algorithm for Bayesian variable selection technique determines whether a particular covariate enters the model, whether a metrical covariate enters the model linearly or nonlinearly, whether a spatial effect enters the model, whether a unit or cluster specific heterogeneity effects enters the model, selects complex interaction effects, and determines the degree of smoothness of nonlinear covariates, spatial, or cluster specific heterogeneity effects. Inference is based on penalized likelihood in combination with fast algorithms for selecting relevant covariates and model terms. Different models, based on subsets of the covariates, are compared via various goodness-of-fit criteria

e.g. Akaike's information criterion (AIC), Bayesian information criterion (BIC), or generalized cross validation (GCV). The algorithm procedure aims at minimizing the goodness-of-fit criterion and is repeated until the selected covariates and smoothing parameters do not change the criterion anymore. Detailed information about the modelling approach using Structured Additive Regression technique and the Bayesian stepwise approach has been implemented in BayesX—a software for Bayesian analysis using MCMC and Restricted Maximum Likelihood techniques [28].

## Data Analysis

Breastfeeding practise is known to depend on a number of factors such as mother's education and age at birth, antenatal visits, and geographical location of the mother. The decision as to which of these covariates should be included in an attempt to model the practise among Nigerian women, how the continuous covariates should enter the model (whether linear or nonlinear), and possible interactions of the covariates is often too difficult to make a priori. To incorporate variable selection and estimation of the smoothing parameters simultaneously, the stepwise regression object in Bayes-X was used for the analyses. A primary model that includes all possible covariates listed in Table 1 as well as interaction between mother's age at birth and partner's age, and spatial varying effect of mother's working status was specified. To control for the hierarchical nature of the data, random effects at household and community levels were also included. To estimate model parameters, 20,000 iterations were carried out after a burn-in sample of 5,000. We thinned every 10th iteration for parameter estimation. A more parsimonious model was obtained after the 8th iteration. The following variables were retained in the final model: time, region, mother's education, partner's education, place of delivery, husband lives at home, type of marriage, infant's age, mother's age, and spatial effect. This approach enabled us to determine which of the many suspected factors are closely related with EBF practise in Nigeria and which appear essentially irrelevant when other factors are taken into consideration. The variable selection approach also enabled us to determine the form in which the metrical covariates are to be included in the model and lead to the exclusion of the interaction term and geographical varying effects that were included in the original model. For instance, child's age, which was originally specified as nonlinear, was estimated as linear effect. The excluded variables from the final model are: type of place of residence, antenatal visits, ethnicity, sex of the child, religion, mother's working status, parity, number of unions, exposure to mass media, partner's age, marital duration, age at marriage, age at first

**Table 2** Posterior odds ratio, standard errors and 95 % credible intervals for the parameters in the final model

Variables	OR	SE	95 % credible intervals
<b>Year of study</b>			
1999	1		
2003	1.439	0.112	1.159, 1.801
2008	0.917	0.088	0.774, 1.092
<b>Region</b>			
North Central (ref)	1		
North East	0.470	0.747	0.096, 1.941
North West	0.761	0.493	0.320, 2.137
South East	1.164	0.548	0.375, 3.431
South South	1.138	0.393	0.540, 2.589
South West	1.148	0.404	0.538, 2.656
<b>Mother's education</b>			
No education (ref)	1		
Primary	0.868	0.111	0.700, 1.073
Secondary	1.097	0.107	0.886, 1.346
Higher	1.647	0.195	1.118, 2.387
<b>Partner's education</b>			
No education (ref)	1		
Primary	0.777	0.108	0.622, 0.959
Secondary	1.199	0.097	1.001, 1.457
Higher	1.328	0.141	1.005, 1.746
<b>Place of delivery</b>			
Others (ref)	1		
Homes	0.931	0.136	0.720, 1.234
Government hospitals/clinics	1.466	0.135	1.128, 1.935
Private hospitals/clinics	0.774	0.151	0.573, 1.052
<b>Husband lives at home</b>			
Yes (ref)	1		
No	0.931	0.085	0.790, 1.092
<b>Type of marriage</b>			
Monogamy (ref)	1		
Polygamy	0.898	0.068	0.787, 1.023
Infant's age (in months)	0.732	0.035	0.684, 0.783

birth, interaction between mother's age at birth and partner's age, and the spatial varying effect of mother's working status.

**Results**

Table 2 presents results of the fixed effects variables. Presented are the odds ratios, standard error, and 95 % credible intervals for the parameters. Results confirm the downward trend in EBF in Nigeria. A significant increase in odds of EBF was observed in 2003 compared with 1999,

while a non-significant decrease was evident in 2008 compared with 1999. Findings from the geopolitical zones reveal that when compared with the North Central region, the level of EBF practise is lower in North East and North West but higher in the three southern zones, though none is significant. Level of educational attainment was found to increase the practise with odds increasing with higher level of education both for women and their partners. Comparing with women who had no education, results show that women with only primary education were less likely to exclusively breastfeed their infants. Women who attained secondary and higher education were more likely to practise EBF. The result is, however, only significant for higher education. Similarly, women whose partners attained secondary and higher education have significantly higher odds of practising EBF. Place of delivery was also found to be associated with EBF practise. Women who delivered at government hospitals/clinics were significantly more likely to exclusively breastfeed their infants compared with those who gave birth in other places. Those who delivered at homes and private hospitals were less likely to practise EBF compared with women who delivered in other places.

Findings also reveal that the odds of exclusively breastfeeding an infant is non-significantly lower in households where husbands do not live with their wives compared with those who dwell together. Similarly, the odds are reduced for those in polygamous union compared with their counterparts in monogamous homes. As the infant increases in age, findings reveal that he will be about 27 % less likely to be exclusively breastfed. In order words, for every unit increase in age of infant, the likelihood of being exclusively breastfed significantly reduces by 27 %.

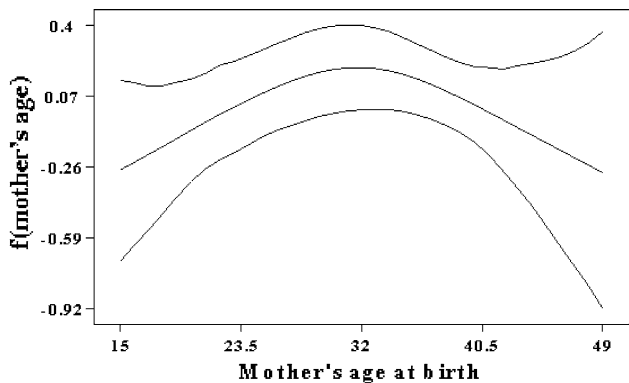
Figure 2 shows the nonlinear effect of mother's age at birth. Also included is the 95 % credible interval. An assumption of linear effect for mother's age at birth would have led to a spurious conclusion that can misinform policymakers. The practise of EBF rises with mother's age to peak around age 32 years. Thereafter, it reduces steadily. Younger women (mostly teenagers) and older women are contributing negatively to this important practise in Nigeria. Results for the spatial effects are presented in Fig. 3. Figure 3a, b show the crude (unadjusted) EBF practises according to states in Nigeria and the 95 % map of significance respectively while parts c and d are the net effects after adjusting for other covariates retained in the final model. From Fig. 3b, d, white shading signifies significant high effect and black signifies low effect, while the effect for those districts shaded in gray colour is not significant. Figure 3a shows that the practise of EBF is similar among neighbouring states in Nigeria. Specifically, the figure shows that the practise of EBF is significantly lower in almost all the states in the North East and North West

regions while all the states in the North Central except Niger and Benue, are associated with significantly higher practise. The net effect after adjusting for the covariates retained in the final model shows that the practise of EBF is

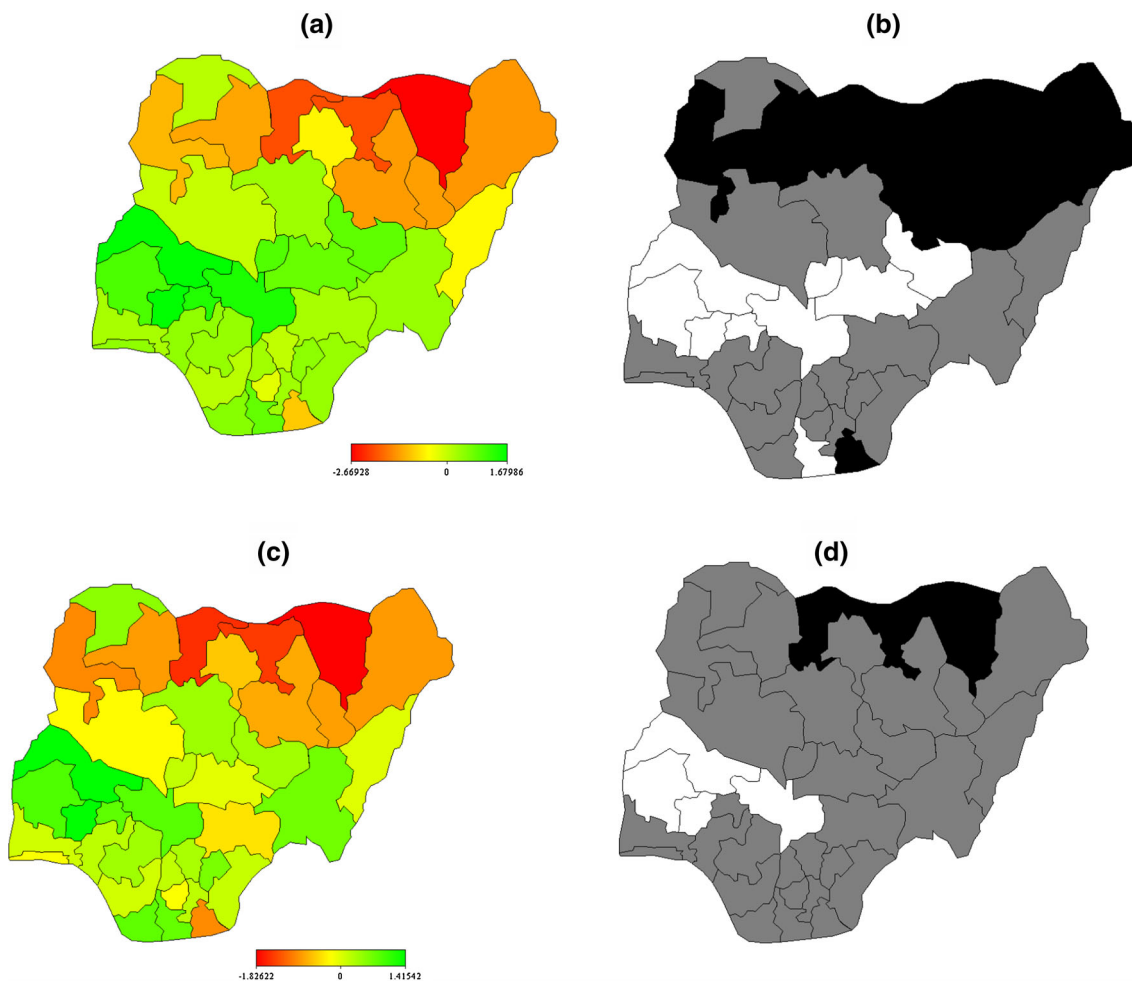
significantly higher in only the neighbouring Kogi, Kwara, Osun, and Oyo states while, on the other hand, the practise is significantly lower in Katsina, Jigawa, and Yobe states.

**Discussions of Results and Conclusion**

The superiority of breast milk over any other food nourishment for the human newborn and infant can hardly be challenged, and it has become more and more apparent over the years that it is the most ideal, safe, and complete food that a mother can provide for her newborn at very little cost. Regrettably, the prevalence of EBF practise in Nigeria is one of the lowest among developing countries. This study was designed to identify individual and contextual factors associated with the practise among Nigerian women while quantifying differences among geographical locations. Although a number of studies have investigated these determinants in Nigeria [15, 18, 29, 30], the novelty in our approach provides better insight into understanding



**Fig. 2** Posterior means of nonlinear effect of mother's age at birth with 95 % credible interval



**Fig. 3** Spatial effects at state (district) level for **a** crude exclusive breastfeeding practise and **b** its corresponding 95 % map of credible interval, **c** final model and **d** its corresponding 95 % credible interval

this topic with the aim of providing policy makers with tools to design effective interventions to address barriers to EBF at the level of the state. The study adopted a Bayesian stepwise approach that involves simultaneous selection of variables and smoothing parameters in structured additive regression models [25]. In this application, a more parsimonious model that excludes random effect at household level and geographical varying effect of working status of women, in addition to other covariates, was achieved. Therefore, the model interpretations could be assumed to be more objective.

Findings reveal a non-significant trend in the prevalence of EBF in Nigeria. Whereas an increase in the practise was observed between 1999 and 2003, it decreased in 2008. This shows that despite the emergence of a national health policy and the introduction of the Baby-Friendly Hospital Initiative across the country, trends toward a decrease in this important practise that were long observed in other parts of the world [19] still persist in Nigeria. A similar decline was first noticed in Nigeria in the late 1970s when compared to the 1960s [30]. Although breastfeeding is universal and prolonged in the country [9, 30], early introduction of supplements, especially water and teas to quench thirst and as medicine for variety of ailments, has continued to persist. This attitude might also be a product of the aggressive marketing of breast milk substitutes and the general belief that infants require supplementary feeding much earlier to speed up their postnatal growth [19, 29]. However, early supplementation increases the risk of losing the numerous advantages of EBF.

Education of the women and their partners was found to have influenced the practise of EBF, with higher educational levels increasing the odds. As a signal of change in the effect of education over time, this finding is contrary to results of studies conducted in some parts of Nigeria in the 1980s and 1990s [18, 29]. However, similar results were found in São Paulo, Brazil [31]. Educated women usually belong to the modernized subgroup of the population and are therefore well-informed about the benefits of EBF. Interventions to promote EBF in Nigeria may therefore be of particular benefit to less educated mothers if properly targeted. Place of delivery is another important factor found to influence breastfeeding behaviour. Women who delivered their babies at government/public hospitals/clinics were significantly more likely to practise EBF while those who delivered at private hospitals/clinics and homes were less likely to have breastfed their infants exclusively. An explanation for this might be that workers of government owned hospitals/clinics in Nigeria often benefit from lactation management training programmes, which have been shown to be adequate for imparting knowledge and improving the practise of EBF [30, 32]. Moreover, government hospitals/clinics are often more staffed with

professionals who provide necessary instructions to mothers on breastfeeding after delivery. As an intervention strategy, Nigerian Ministry of Health needs to monitor private health practitioners to ensure they are staffed with qualified personnel that can provide guidance to women on this life saving practise. Interventions that encourage women to receive antenatal care can also enhance hospital rather than home delivery should be considered as a means of improving EBF in Nigeria.

This study has shown a linear relationship between age of infants (in months) and EBF practise. As the infant increases in age, the rate of EBF decreases. This experience is similar to studies conducted in other developing countries [33–35]. Short birth interval and other economic factors in Nigeria that make women to quickly resume work few months after birth, might force mothers to introduce supplements to their infants early [35]. The nonlinear effect of mother's age at birth revealed an increase in chance of EBF with increasing maternal age until around 32 years and then a decrease thereafter. While it can be viewed that inexperience might have caused young women, the majority of whom were teenagers, to introduce supplements, economic hardship resulting from large family size might force older women to quickly resume their secular duties at the expense of the newborn. Studies conducted in Hong Kong and Malaysia also found that young women were less knowledgeable and skillful in breastfeeding [36, 37].

Though the variables measuring whether or not the husband lives at home and type of marital union the women belonged to were retained in the final model, findings do not show evidence of differences among their levels. However, in Malaysia, EBF was found to be more common among mothers with supportive husbands compared with those with non-supportive husbands [14]. Among the variables that were considered redundant and therefore dropped from the final model are visits for antenatal care, parity, and type of place of residence. One would expect that as women attend antenatal clinics during pregnancy, the importance of EBF would be emphasized to them and the resulting effect would be that women who had at least three antenatal visits should exclusively breastfeed for a longer period than those who attend fewer visits. First time mothers and women who reside in rural areas have been found, in other studies, to exclusively breastfeed their children at rates higher than women of higher parity and those who dwell in urban areas [14, 16, 35]. Further studies might therefore be required to unravel why these variables were not substantially contributing to this practise in Nigeria.

Findings also reveal lower odds of exclusively breastfeeding infants from the northern regions when compared to those from North Central. Results of spatial effects



further show that the practise is significantly higher in only four neighbouring districts out of the 37. Effective interventions that can lead to improved practise are therefore required in all the states. This findings emphasizes the urgent need to invest in this direction in order to improve EBF rates. Inclusion of random variation at community level in the final model also suggests that community participation in promoting EBF should not be ruled out as this has been shown to be crucial to healthy home behaviours [38].

### Limitations of the Study

This study suffers from a number of limitations which should be pointed out. As in any cross-sectional survey, the study lacks ability to make causal inference. The 24-h recall period adopted in computing the prevalence of EBF may be said to be free from recall error, but the approach measures current status and may cause the proportion of exclusively breastfed infants to be slightly overestimated, since some infants who are given other liquids irregularly may not have received them in the 24-h before the survey. Also, in computing the prevalence of breastfeeding, the study does not take into account breastfeeding practise among HIV positive mothers. Prior to 2009, HIV positive mothers were advised to avoid breastfeeding if they were able to afford, prepare, and store formula safely. Since that time, the World Health Organization (WHO) has recommended that all women, regardless of HIV status, practice EBF with HIV positive mothers or their infants receiving antiretroviral drugs throughout the period of breastfeeding and until the infant is 12 months old [39]. However, the DHS data analyzed are nationally representative which allows for studying spatial variation at the highly disaggregated level of state.

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