

GEOSPATIAL ANALYSIS OF THE HETEROGENEITY IN NUTRITIONAL STATUS AMONG WOMEN OF CHILDBEARING AGE IN NIGERIA.

ABSTRACT

Malnutrition in women of childbearing age (WCBA) is a significant public health concern in Nigeria. This study employs a geospatial approach to investigate the spatial distribution and heterogeneity of nutritional status among WCBA across the country. We utilize data on various nutritional indicators obtained from National Demographic and Health Survey (NDHS, 2018) alongside relevant geospatial information. By employing spatial statistical methods, we aim to identify geographic clusters and disparities in the various Nutritional Status which are: Normal weight, overweight and obesity. This analysis will provide valuable insights into the geographical variations in WCBA's nutritional health and inform targeted interventions to address these disparities. Understanding the spatial patterns of malnutrition can guide policymakers to allocate resources effectively and design regionally-specific programs to improve maternal health outcomes and ensure optimal nutrition for women and their children in Nigeria.

Key words: Geospatial Analysis, Heterogeneity, Nutritional Status

1. INTRODUCTION

Good nutrition is crucial for both individual health and national development. Poor diets harm not just individuals but entire populations [1]. Our bodies show how well-nourished we are through physical health, bodily functions, and the presence of key nutrients [2]. The World Health Organization warns that many women, especially during childbearing years, lack essential nutrients in their diets [3]. Since women play a central role in family well-being, their health and nutrition are critical [4]. However, research shows that women of childbearing age (15-49) are particularly at risk of malnutrition in developing countries due to both social and biological factors [5].

Undernourished mothers are more likely to have stunted children, increasing their risk of illness and death [6]. Despite progress, malnutrition remains a major issue in Sub-Saharan Africa, as noted by the UN in 2015. Good nutrition is crucial for both mothers and children [7]. For mothers, poor nutrition makes them more susceptible to infections and hinders recovery from illness. The World Health Organization defines malnutrition as a cellular imbalance between nutrients consumed and the body's needs for growth, maintenance, and specific functions. In adults, malnutrition manifests as four main forms: underweight, overweight, obesity, and severe thinness [8]. They are typically evaluated using height and weight indices calculated as body mass index (BMI). A woman whose BMI is ≤ 16 kg/m² is considered to be severely thin; women with BMI of ≤ 18.5 kg/m² are said to be underweight. On the other hand, women whose BMI is ≥ 25 kg/m² are said to be overweight while those with BMI ≥ 30 kg/m² are considered obese.

Traditional statistical methods, like linear regression, focus on the average (mean) of a data set, which can be limiting when studying malnutrition. Malnutrition comes in various forms, measured at the extremes of the Body Mass Index (BMI) distribution: underweight and severe thinness at the lower end, and overweight and obesity at the upper end [9]. To better understand these extremes, researchers need statistical tools that analyze not just the average, but also the "tails" of the distribution. This allows for a more complete picture of how different factors influence various forms of malnutrition [10].

Modern statistical methods, like Bayesian Quantile Regression, address this need. These methods can consider various types of explanatory variables, including: Non-linear effects, Spatial effects and Traditional linear effects [1]. By combining these elements in a single analysis, researchers can gain a deeper understanding of the complex factors contributing to different forms of malnutrition.

[1] studied how malnutrition in Nigerian women of reproductive age affects their health, families, and the entire country. They examined different types of malnutrition (underweight, overweight, and obesity) using Body Mass Index (BMI). The researchers looked for patterns across different areas of Nigeria. They considered how social and economic factors like income and education influence these malnutrition rates. A special statistical method (Bayesian Quantile Regression) was used to analyze data from a national health survey (2013). This method helped them see not just average malnutrition rates, but also how these rates varied by location and social/economic factors. The study found that malnutrition patterns differed geographically, with neighboring states often having similar rates. Interestingly, the impact of social and economic factors also depended on the specific type of malnutrition. Overall, this research provides valuable information for policymakers working to improve women's nutrition in Nigeria. It highlights the importance of considering both location and social/economic factors when designing programs to address malnutrition.

Also, study by [10] explored malnutrition in Nepal, a challenge for many developing countries. They investigated factors linked to underweight, overweight, and obesity in Nepalese women using advanced statistical methods. Data from a national survey (2016) was used to analyze these issues at the provincial level. It was found that, women in urban areas and certain provinces (1, 3, and 4) were more likely to be overweight or obese. Conversely, women in rural municipalities and provinces 2 and 7 were more likely to be underweight. Wealthier women with primary education were more likely to be obese. Working women and those with access to clean water were less likely to be obese. Interestingly, improved sanitation and electricity access were associated with a higher risk of obesity. Women with access to newspapers and radio were less likely to be obese, suggesting a role for education and awareness.

A recent investigation by [5] employed a modified Bayesian Geospatial Quantile Regression Model to evaluate the nutritional status of women of reproductive age in Nigeria. Data from the 2018 Nigeria Demographic and Health Survey (NDHS) was analyzed using R software. This approach provided a more nuanced understanding of factors influencing nutritional well-being compared to traditional methods that focus solely on average nutritional levels. The study identified several key determinants impacting these women's nutritional health. These factors included age, residence (urban/rural), employment status, and household size. These findings underscore the multifactorial nature of malnutrition among women of reproductive age in Nigeria. For example, access to healthy food options may be limited in rural areas, while urban environments might pose challenges related to fast-paced lifestyles and readily available processed foods. In light of these insights, the authors emphasize the critical need for comprehensive

interventions to address malnutrition. Furthermore, interventions addressing broader determinants of health, such as access to healthcare or economic opportunities, may be necessary to indirectly improve women's nutritional well-being. By aligning interventions with the unique requirements of women of reproductive age in Nigeria, this research presents a promising approach to fostering improved nutritional outcomes for this critical population group. Enhanced nutritional well-being among mothers has the potential to translate into improved health for both mothers and children, ultimately contributing to national development and well-being.

This research investigates the nutritional status of reproductive-aged women in Nigeria through the creation of a geospatial map. This map is intended to be a critical resource for implementing state-specific nutritional intervention programs. The study expands upon simple mapping by incorporating analyses of risk factors associated with normal weight, overweight, and obesity among Nigerian women. It also considers the concept of spatial dependence, which refers to the potential clustering of malnutrition patterns in specific geographic areas. Additionally, the research employs a Bayesian Geospatial Quantile Regression Model (BGQRM) to identify factors influencing the various nutritional states, including any underlying spatial patterns. By providing insights into the geographically differentiated distribution of malnutrition across Nigerian states, this study aims to inform policymakers in developing targeted interventions. This will facilitate the creation of regionally-tailored nutrition programs that address the specific malnutrition burdens faced by different areas. Ultimately, the research seeks to contribute to the evidence-based planning and refinement of national nutrition action plans, with the overarching goal of mitigating the prevalence of various forms of malnutrition in Nigeria.

2.0 MATERIAL AND METHOD

This study leverages data from the 2018 Nigeria Demographic and Health Survey (NDHS), conducted by the National Population Commission (NPC). The NDHS aimed to generate comprehensive estimates of population and health indicators at national, zonal, and state levels across Nigeria's 36 states and the Federal Capital Territory (FCT). Consistent with standard demographic and health surveys, the NDHS included interviews with women aged 15-49 who were permanent residents or visitors in the selected households. Data collection employed two instruments: the Household Questionnaire, which gathered information on household dwelling characteristics, and anthropometric measurements (weight and height) of women used to calculate Body Mass Index (BMI).

2.1 STUDY OUTCOMES

Body Mass Index (BMI) will serve as the primary dependent variable in this investigation. Calculated by dividing weight in kilograms by height squared in meters (kg/m^2), BMI offers a widely employed metric for assessing adult nutritional status. Adhering to established World Health Organization (WHO)

classifications, we will categorize the BMI of reproductive-aged women into four distinct groups: Underweight: $<18.5 \text{ kg/m}^2$, Normal Weight: 18.5 kg/m^2 to 24.99 kg/m^2 , Overweight: $\geq 25.0 \text{ kg/m}^2$ and Obese: $\geq 30.0 \text{ kg/m}^2$. This categorization scheme facilitates a nuanced analysis of the various malnutrition levels present within the study population.

2.2 EXPLANATORY VARIABLES

This study will incorporate a comprehensive set of explanatory variables to explore the factors influencing women's nutritional status. These variables include: women's age (in years), women's highest educational attainment, household wealth index, household water source classified as protected or unprotected, type of household toilet facilities classified as improved or unimproved, whether or not the household has electricity, women's occupational working status, and access to mass media (whether or not the woman reads any newspapers/magazines, listens to radio or watches television), number of household members, type of family, type of place of residence and ethnicity. State-level analysis will be employed to examine geographic variations in women's nutritional status.

2.3 DATA ANALYSIS

This study will utilize a BGQRM approach for analysis. This method, implemented using the freely available software BayesX is well-suited for analyzing structured additive regression models and provides valuable insights into the factors influencing different quantiles (distribution tails) of the nutritional status outcome variable [11].

2.4 STATISTICAL MODEL

The analytical framework for this study is a regression model expressed in the following notation:

y_i : denotes the dependent variable, which represents the Body Mass Index (BMI) of the i -th respondent.

x_i : is a vector of categorical independent variables potentially influencing BMI.

v_i : is a vector of continuous independent variables that might influence BMI.

s_i : represents the spatial covariate, indicating the state of residence for the i -th respondent.

The overall regression model can be expressed as:

$$y_i = \eta_i + \varepsilon_t \tag{1}$$

Where

$$\varepsilon_i \sim F(\varepsilon_i|\theta)$$

And

$$\eta_i = x_i^T \beta + \sum_{k=1}^p f_k(v_{ki}) + f(s_i) + b_i \quad (2)$$

F represents an unknown source of error or unexplained variation in the data which may depend on some additional parameters θ , η_i reflects the predicted BMI for the i -th woman based on the model., β is a vector that captures the overall influence of different categorical variables, f_k is the k th smooth function assumed for nonlinear effects, $f(s_i)$ represents the spatial effect associated with the i -th woman's state of residence. and b_i accounts for any other random effects not explicitly included in the model. If the distribution of y_i is assumed to belong to the exponential family and its mean is linked to η_i through appropriate link function, the resulting model is termed structured additive regression (STAR) model.

For quantile regression model, given a fixed and known quantile $\tau \in (0,1)$, the τ th quantile of the error distribution in (1) is assumed zero, i.e. $F^{-1}(\tau|\theta) = 0$. The corresponding quantile function of the continuous variable Y_i is then:

$$Q_{Y_i}(\tau|x_i, v_i, s_i) = x_i^T \beta_\tau + \sum_{k=1}^p f_{\tau k}(v_{ki}) + f_\tau(s_i) + b_{\tau i} \quad (3)$$

To estimate the parameters of (3) above, a check function corresponding to

$$\underset{\eta_\tau}{\operatorname{argmin}} \sum_{k=1}^n \rho_\tau(y_i - \eta_{\tau i})$$

Where

$$\rho_\tau(u) = \begin{cases} u\tau, & \text{if } u \geq 0 \\ u(1-\tau), & \text{if } u < 0 \end{cases} \quad (4)$$

is required to be minimized [1]. To study different levels of women's BMI, we use a method called quantile regression with a check loss function. To draw reliable conclusions (Bayesian inference), we assume the errors follow a specific pattern (asymmetric Laplace distributions). This assumption helps us incorporate a prior knowledge with the data for better analysis, that is, $Y_i \sim \text{ALD}(\eta, \delta_0, \tau)$ where the parameter $\eta \in \mathbb{R}$ is the location parameter, $\delta_0 \in \mathbb{R}^+$ is the scale parameter and $0 < \tau < 1$ is the skewness parameter [12]. For the spatial covariate, Markov random field which is based on the idea of predefined neighbors for a spatial location u_i is considered. It assumes that two sites u_i and u_j are neighbors if they share common boundary. Letting n_i denote the number of neighbours for site u_i , the Markov random field prior is assumed for $f(u_i)$ as:

$$\{f(u_i) | f(u_j) \text{ for } j \neq i, \delta\} \sim N\left(\frac{1}{n} \sum_{j:j \neq i} f(u_j), \frac{1}{n_i \delta}\right) \quad (5)$$

This investigation leverages a Bayesian framework to capture potential non-linear relationships between continuous variables (e.g., age) and Body Mass Index (BMI). Specifically, we utilize a Bayesian penalized spline approach, drawing upon the methods outlined by [13,14]. This technique incorporates prior

knowledge about the expected behavior of the unknown smooth function while maintaining flexibility to model complex relationships. The Bayesian penalized spline approach constructs the unknown smooth function by approximating it with a polynomial spline of degree l_j . This spline function is further represented as a linear combination of B-spline basis functions evaluated at pre-determined knot locations. In contrast, the influence of categorical explanatory variables is assumed to be linear and modeled with a diffuse prior distribution.

Given the high dimensionality and inherent complexity of the posterior distribution, direct inference is computationally challenging. To address this, we employ a Markov chain Monte Carlo (MCMC) simulation using the Gibbs sampling algorithm. This technique allows us to draw numerous samples from the posterior distribution, enabling us to extract valuable insights into the relationships between the various factors and women's BMI in Nigeria.

UNDER PEER REVIEW

3.0 DATA ANALYSIS AND RESULTS

Table 1: Frequency distribution of the characteristics of women of childbearing age.

| Variable | Factor | Frequency | Percent |
|-------------------|---------------------|-----------|---------|
| Location | Rural | 8717 | 58.6 |
| | Urban | 6155 | 41.4 |
| | Total | 14872 | 100 |
| Education | No formal Education | 4809 | 32.3 |
| | Primary | 2368 | 15.9 |
| | Secondary | 6189 | 41.6 |
| | Tertiary | 1506 | 10.1 |
| Water | Unimproved | 5792 | 38.9 |
| | Improve | 9080 | 61.1 |
| Toilet | Unimproved | 6937 | 46.6 |
| | Improve | 7935 | 53.4 |
| Electricity | No | 6422 | 43.2 |
| | Yes | 8450 | 56.8 |
| Ethnicity | Others | 5411 | 36.4 |
| | Hausa | 4794 | 32.2 |
| | Igbo | 2603 | 17.5 |
| | Yoruba | 2064 | 13.9 |
| Household members | Below 3 | 2700 | 18.2 |
| | Between 3 and 6 | 6147 | 41.3 |
| | More than 6 | 6025 | 40.5 |
| News paper | No | 12604 | 84.7 |
| | Yes | 2268 | 15.3 |
| Radio | No | 6493 | 43.7 |
| | Yes | 8379 | 56.3 |
| Television | No | 7094 | 47.7 |
| | Yes | 7778 | 52.3 |
| Wealth index | Poorest | 2556 | 17.2 |
| | Poorer | 2867 | 19.3 |
| | Middle | 3295 | 22.2 |
| | Richer | 3265 | 22.0 |
| | Richest | 2889 | 19.4 |
| BMI | Underweight | 1665 | 11.2 |
| | Normal | 9119 | 61.3 |
| | Overweight | 2694 | 18.1 |
| | Obesity | 1394 | 9.4 |
| Family type | Monogamy | 7497 | 50.4 |
| | Polygamy | 7375 | 49.6 |
| Work | No | 5093 | 34.2 |
| | Yes | 9779 | 65.8 |

Table 1 displays the frequency distributions of women of reproductive age in Nigeria categorized by covariates. Among the 14,872 women examined, the majority (58.6%) resided in rural areas, while 41.4% lived in urban settings. Regarding education, 32.3% (equivalent to 4809 women) had no formal education, whereas 41.6% had completed secondary education, and 10.1% had achieved a higher level of education. As for water source, toilet facilities and presence of electricity in the households of the

respondents, many of the women sourced water from protected sources (61.1%), use improved toilet facilities (53.4%) and have electricity in their households (56.8%). From the analysis, it is evident that Hausa/Fulani has a percentage of 32.2%, while Igbo has 17.5%, Yoruba has 13.9% and other tribes have 36.4%. For household members, 18.2% has household member of one and two members, while 41.3% has household member of three to six and 40.5% has a household member greater than six. Regarding mass media, a significant portion of the women tune into the radio (56.3%) and watch TV (52.3%) at least once weekly. However, a vast majority (84.7%) do not engage with newspapers or magazines. In terms of economic status, approximately 22% of the women are in the middle to affluent wealth bracket, while 17.2% are categorized as being in the most economically disadvantaged households. The distribution is relatively balanced, with 19% each in the poorer and wealthiest household categories. In terms of body weight, 18.1% of the women are overweight, 9.4% are obese, 11.2% are underweight, and a majority (61.3%) fall within the normal weight range. Also, under the family type, both monogamy and polygamy has the same proportion of about 50%. Lastly, majority of the women (65.8%) are of the working class.

Table 2; Posterior mean estimates for the linear effects of normal, overweight and obesity among women of childbearing age-group (15 to 49 years).

| Variable | Normal | | Overweigh | | Obese | |
|---------------------------------|---------|------------------|-----------|------------------|---------|------------------|
| | Mean | 95% CI | Mean | 95% CI | Mean | 95% CI |
| Constant | 2.0805 | 1.8654, 2.2957 | 0.2373 | -0.0492, 0.5124 | -1.7732 | -2.2227, -1.3018 |
| Location (Rural) | | | | | | |
| Urban | -0.0159 | -0.1521, 0.1195 | 0.0856 | -0.0762, 0.2412 | 0.2556 | 0.0722, 0.4599 |
| Education (No Education) | | | | | | |
| Primary | 0.2229 | 0.0439, 0.4037 | 0.2661 | 0.0701, 0.4927 | 0.6044 | 0.3182, 0.8791 |
| Secondary | 0.1497 | -0.0277, 0.3212 | 0.2646 | 0.0480, 0.4684 | 0.5964 | 0.3116, 0.8971 |
| Tertiary | 0.1813 | -0.1156, 0.5013 | 0.3887 | 0.0393, 0.7232 | 0.7175 | 0.3158, 1.1164 |
| Water (not protected) | | | | | | |
| Protected | -0.1115 | -0.2315, 0.0049 | -0.2633 | -0.3996, -0.1226 | -0.3958 | -0.5821, -0.2323 |
| Toilet (Unimproved) | | | | | | |
| Improved | -0.1266 | -0.2506, 0.0089 | -0.1543 | -0.3084, 0.0157 | -0.1752 | -0.3857, 0.0125 |
| Electricity (No) | | | | | | |
| Yes | -0.0119 | -0.0821, 0.0646 | -0.0066 | -0.0869, 0.0801 | -0.1001 | -0.2054, -0.0005 |
| Ethnicity (Others) | | | | | | |
| Hausa | -0.5684 | -0.7157, -0.4130 | -0.9653 | -1.1694, -0.7559 | -0.8242 | -1.0778, -0.5715 |
| Igbo | 0.2691 | 0.0390, 0.5098 | 0.3594 | 0.0855, 0.6254 | 0.3330 | 0.0085, 0.6302 |
| Yoruba | -0.3171 | -0.5713, -0.0969 | -0.6209 | -0.9054, -0.3675 | -0.7478 | -1.0619, -0.4494 |
| Household Member (Below) | | | | | | |
| 3_6 | -0.1117 | -0.2689, 0.0386 | -0.2037 | -0.3949, -0.0280 | -0.3828 | -0.6050, -0.1672 |
| 7 up | -0.3047 | -0.4813, -0.1334 | -0.3040 | -0.5165, -0.0949 | -0.4921 | -0.7261, -0.2534 |
| News Paper (No) | | | | | | |
| Yes | -0.0282 | -0.2172, 0.1829 | 0.0183 | -0.2085, 0.2704 | 0.1830 | -0.0526, 0.4383 |
| Radio (No) | | | | | | |
| Yes | 0.0144 | -0.1080, 0.1466 | 0.0695 | -0.0682, 0.2245 | 0.2930 | 0.1047, 0.4783 |
| Television (No) | | | | | | |
| Yes | -0.0240 | -0.1750, 0.1209 | 0.1891 | 0.0048, 0.3840 | 0.3849 | 0.1544, 0.6019 |
| Wealth Index (Poorer) | | | | | | |
| Poor | 0.2535 | 0.0880, 0.4135 | 0.6392 | 0.4053, 0.8599 | 1.0532 | 0.6464, 1.4366 |
| Middle | 0.2852 | 0.0847, 0.4721 | 0.9650 | 0.7028, 1.2195 | 1.5570 | 1.1633, 1.9272 |
| Richer | 0.3426 | 0.1362, 0.5719 | 1.3483 | 1.0547, 1.6200 | 2.0467 | 1.6463, 2.4757 |
| Richest | 0.5827 | 0.3227, 0.8507 | 1.7511 | 1.4209, 2.0811 | 2.7991 | 2.3002, 3.2493 |
| Family type (Monogamy) | | | | | | |
| Polygamy | -0.0068 | -0.1273, 0.1230 | -0.1931 | -0.3289, -0.0377 | -0.2248 | -0.4080, -0.0435 |
| Work (No) | | | | | | |
| Yes | 0.1011 | -0.0153, 0.2147 | 0.1086 | -0.0411, 0.2537 | 0.1968 | 0.0055, 0.3820 |

The Bayesian analysis findings are displayed in Table 2 and include the mean estimates and 95% credible intervals for each of the three nutritional status forms that were taken into consideration.

Estimates of the place of residence on BMI showed that compared to rural, women residing in urban location were more likely to be obese (mean: 0.2556; 95% CI: 0.0722, 0.4599) and less likely to be overweight (mean: -0.0762; 95% CI: 0.2556). On education status, women with any form of education (primary, secondary or tertiary) are more likely to have effect on obese (mean: 0.6044; 95% CI: 0.3182, -0.8791), (mean: 0.5964; 95% CI: 0.3116, 0.8971), (mean: 0.7175; 95% CI: 0.3158, 1.1164) respectively as compared to women without education. Further, women from households that use improved toilet facilities and having access to protected water sources are significantly less likely to be overweight and obese but more likely to have a Normal weight (mean: -0.1115; 95% CI: -0.2315, 0.0049), and (mean: -0.1266; 95% CI: -0.2506, 0.0089) respectively. However, women having access to electricity were more likely to be overweight (mean: -0.0066; 95% CI: -0.0869, 0.0801) than having a Normal weight (mean: -0.0119; 95% CI: -0.0821, 0.0646). Furthermore, on ethnicity, women from the Hausa and Yoruba ethnic groups are more likely to have a Normal weight (mean: -0.5684; 95% CI: -0.7156, -0.4130), (mean: -0.3171; 95% CI: -0.5713, -0.0969) respectively. Also, women from the Igbo ethnic group are more likely to have effect on overweight (mean: 0.3594; 95% CI: 0.0855, 0.6254). On number in the household, women with 3 to 6 members in a household are likely to have a Normal weight (mean: -0.1117; 95% CI: -0.2689, 0.0386) and women with 7 and above members in an household are more likely to have effect on overweight (mean: -0.3040; 95% CI: -0.5165, -0.0949). Results for mass media reveal that women who listen to radio, watch television and read newspaper are less likely to have a normal weight but more likely to be overweight and obese when compared with those without such access. On the wealth index of participants, women with poorer wealth are likely to have more effect on obesity (mean: 1.0532; 95% CI: 0.6464, 1.4366), women with middle wealth are likely to have effect on obesity (mean: 1.5570; 95% CI: 1.1633, 1.9272), women with from richer wealth quintile are more likely to be obese (mean: 2.0467; 95% CI: 1.6463, 2.4757) and women with richest wealth are likely to have effect (mean: 2.7991; 95% CI: 2.3002, 3.2493). Furthermore, Women from polygamous families are likely to have a Normal weight (mean: -0.0068; 95% CI: -0.1273, 0.1230) than being overweight or obese. Lastly, Findings further show that, compared with non-working women, currently working women are significantly more likely to be obese (means: 0.1968; 95% CI: 0.0055, 0.3820).

Fig. 1 Maps of Nigeria showing the spatial effects of Normal Weight

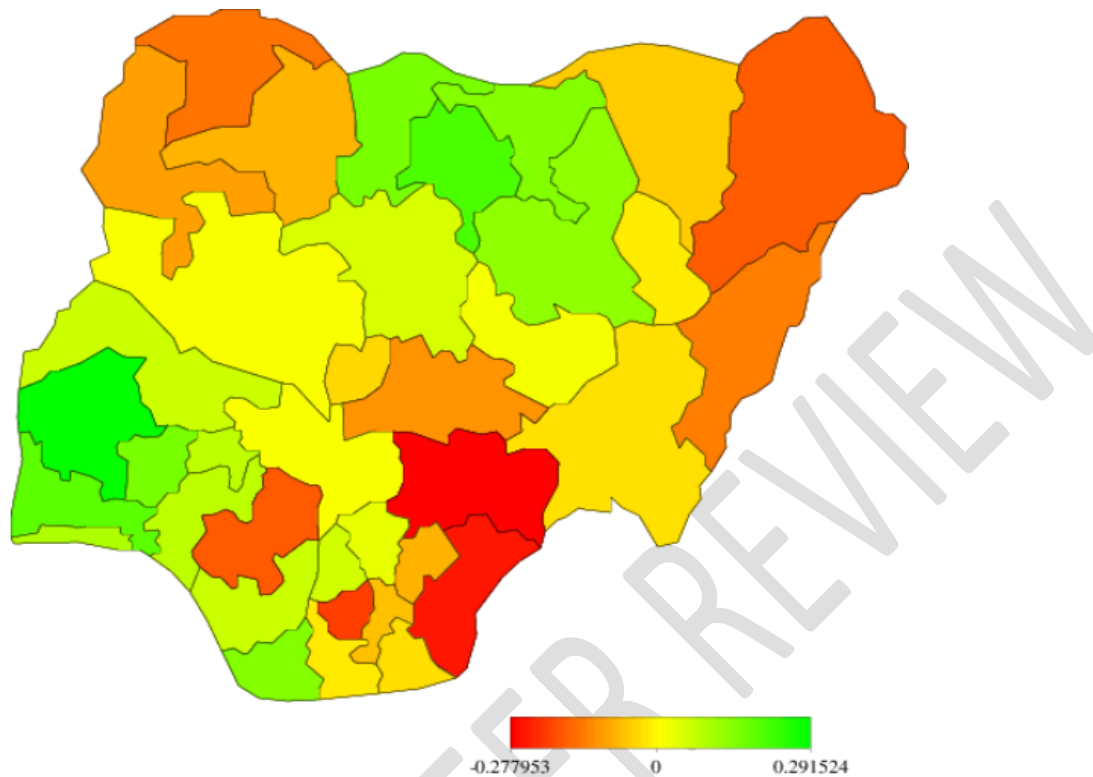


Figure 1 explores the geographic distribution of mothers with normal weight across Nigeria. The analysis reveals a concentration in some regions. All states in the southwest appear to have a positive association with normal weight. In other regions, the picture is less uniform. Only Kwara state shows a positive correlation in the north-central region, while Kaduna, Katsina, Kano, and Jigawa states exhibit positive associations in the northwest. Similarly, just Bauchi state in the northeast and Anambra state in the southeast have a positive link with normal weight. The south-south region shows a positive association in Delta and Bayelsa states.

These findings suggest potential geographic variations in factors influencing a healthy weight among mothers. Further investigation into these regional differences could be valuable for informing policies and programs that promote healthy weight across Nigeria.

Fig. 2 Maps of Nigeria showing the spatial effects of Overweight

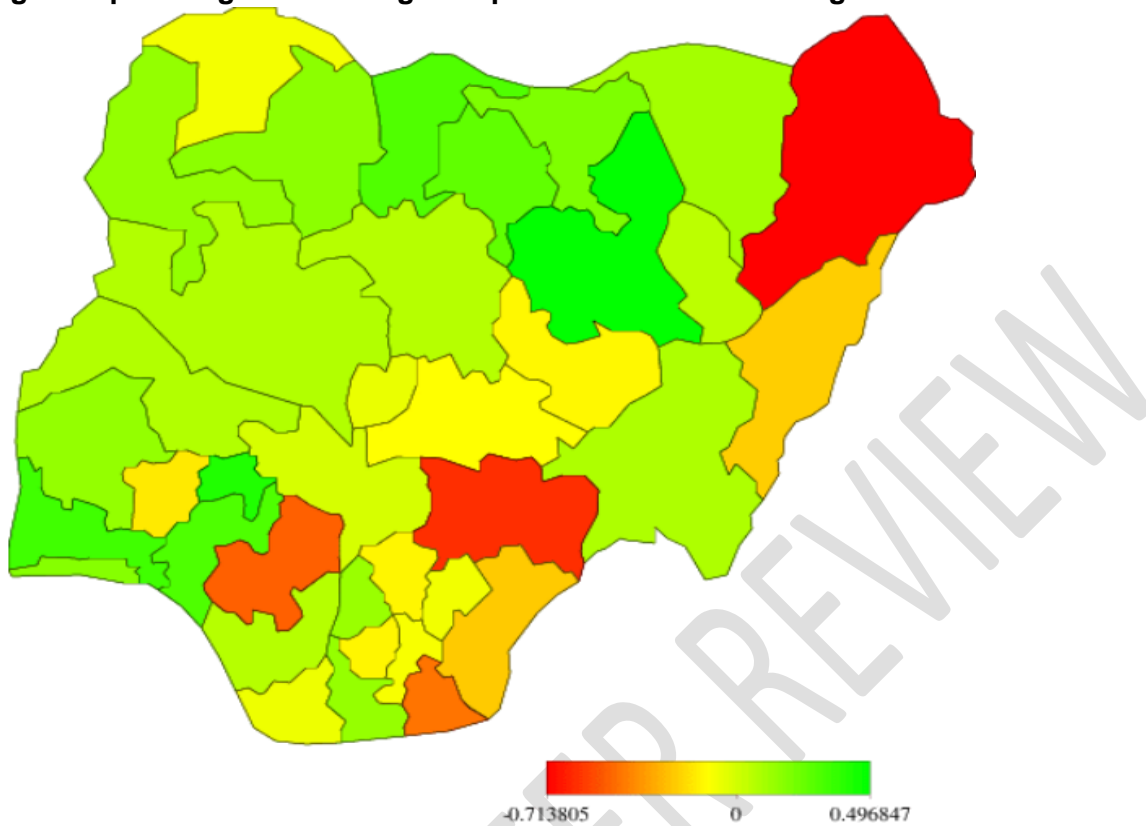


Figure 2 suggests regional disparities in the prevalence of overweight mothers across Nigeria. Southern regions appear to have a higher risk. All states in the southwest (except Osun) and Delta and Rivers states in the south-south exhibit a positive association with overweight. A similar trend is observed in the north-central region (except Kwara and Niger states) and the northwest (except Sokoto and Kaduna). In the northeast, all states except Borno and Adamawa show a positive correlation. The southeast seems to have a lower risk, with only Anambra state having a positive association with overweight.

These findings highlight potential geographic variations in factors contributing to overweight mothers. Understanding these variations could be crucial for designing targeted interventions to address overweight and obesity in different regions of Nigeria.

Fig. 3 Maps of Nigeria showing the spatial effects of Obesity

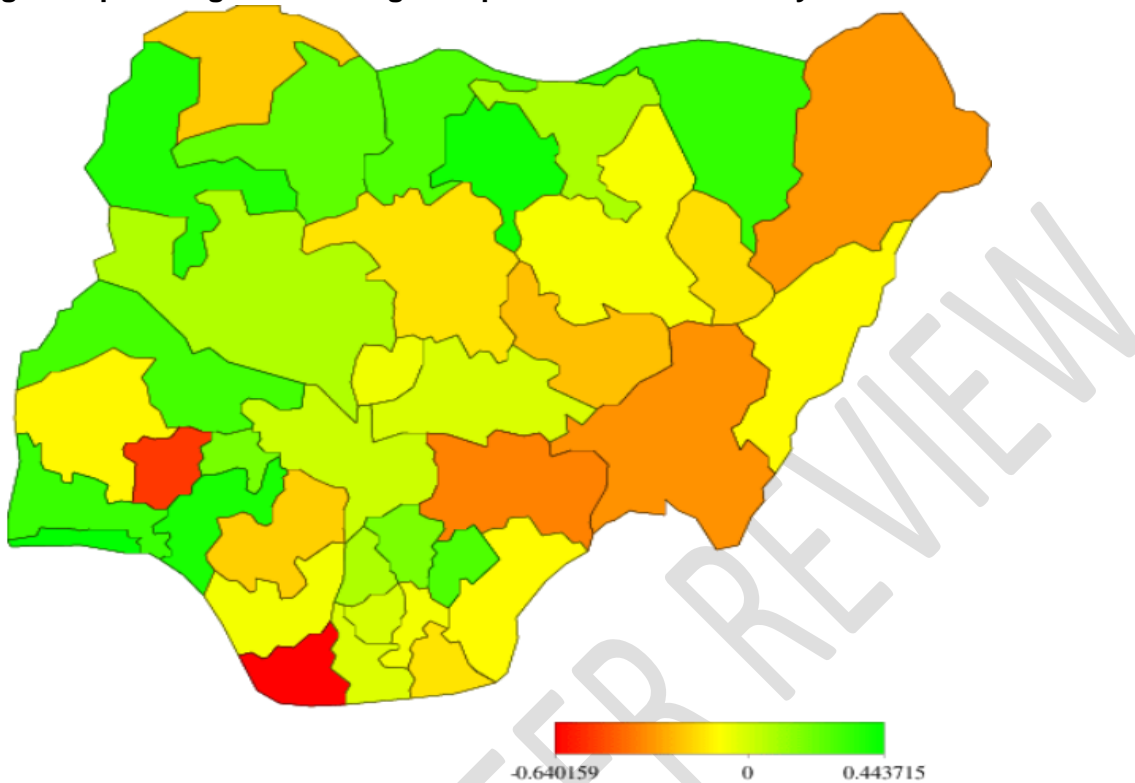


Figure 3 reveals geographic variations in the likelihood of maternal obesity across Nigeria. In the southwest, all states except Oyo and Osun show a positive association with maternal obesity. A similar trend is observed in the northwest (except Sokoto) and north-central (except Kwara and Niger). Interestingly, only Yobe state in the northeast exhibits a positive correlation with maternal obesity. In contrast, the southeast shows a lower risk, with only Imo and Anambra having a positive association. The south-south region appears to have the lowest risk, with no states showing a positive contribution to maternal obesity.

This suggests potential regional differences in factors influencing maternal weight. Further investigation into these variations could be valuable for tailoring nutrition interventions to specific regions of Nigeria.

4.0 DISCUSSION AND CONCLUSION

This study used a novel statistical method (Modified BGQRM) to explore how different factors influence various weight categories (Normal weight, overweight, obese) among women of reproductive age in Nigeria. This approach addresses limitations of previous studies that relied on simpler methods [15].

The findings show that women in urban areas are more likely to be overweight or obese. This might be linked to factors associated with urban living, such as higher income and education [16]. These factors could lead to less physical activity and more consumption of processed, calorie-dense foods.

This study aligns with previous research [1] by highlighting how urbanization and Westernization can contribute to both reduced physical activity and increased availability of calorie-dense foods like fast food and sugary drinks. These factors are known to influence weight gain. Interestingly, the study found that education levels were not a protective factor against overweight and obesity. In fact, the likelihood of being overweight or obese increased with higher education (similar to [17]). While education might enhance awareness of healthy habits, it might not translate into action due to time constraints or limited resources often associated with higher education and careers. This suggests a need for interventions that bridge the gap between knowledge and behavior change.

The study also explores the link between socioeconomic factors and weight. While higher socioeconomic status (SES) might provide access to leisure activities like television and internet use (positively associated with weight gain according to [18]), this study found a surprising result: women with access to safe water and improved sanitation facilities were more likely to maintain a normal weight.

This aligns with research from Kenya and sub-Saharan Africa [19,20]. Improved hygiene practices associated with better sanitation and access to clean water may decrease waterborne illnesses and contribute to overall health. Furthermore, access to clean water can improve dietary choices and food security, indirectly impacting weight [19, 20]. These findings highlight the multifaceted relationship between SES and weight, where access to certain resources can have both positive and negative consequences.

This study challenges the common assumption that access to mass media (radio, television, newspapers) translates to healthier weight. Contrary to expectations, the research suggests that women with greater exposure to mass media were less likely to be at a normal weight. This aligns with [1] findings, highlighting a potential disconnect between information access and behavior change. Mass media exposure might not translate into practical knowledge or overcome existing social and economic barriers to healthy choices.

Similar to mass media access, the study found a counterintuitive relationship between access to electricity and weight. Women with electricity at home were more likely to be overweight compared to those without. This finding echoes research from Bangladesh [21], suggesting that electricity facilitates the storage and preparation of processed foods through refrigerators and appliances. Furthermore, electricity access might be a marker for higher socioeconomic status, which has been linked to higher obesity rates in other studies [21]. These findings highlight the complex interplay between various factors

influencing weight and emphasize the need for interventions that address not just information access but also the practical challenges women face in adopting healthy behaviors.

The study also revealed intriguing ethnic variations in weight distribution. Hausa/Fulani and Yoruba women tended to have a healthier weight compared to Igbo women who were more likely to be obese. These differences might be rooted in diverse dietary practices, physical activity levels, and socioeconomic factors, as suggested by [22] and [23]. Further investigation into these ethnic variations could be valuable for tailoring nutrition interventions. The link between employment and weight also yielded surprising results. Nigerian working women were more likely to be overweight or obese compared to non-working women. This contrasts with studies in Bangladesh where non-employed women were more likely to be underweight [24]. The explanation might lie in the context of Nigeria, where employed women often have greater financial independence and decision-making power regarding food choices. Conversely, non-working women might rely on their husbands or families for food, potentially limiting dietary diversity.

In conclusion, this study presents a detailed analysis of the factors influencing the nutritional status of women in Nigeria. The findings, particularly the spatial distribution of nutritional status, can serve as a valuable resource for informing policy decisions and interventions aimed at promoting better nutrition and overall well-being for women of childbearing age in Nigeria.

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