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Socioeconomic and Demographic Study of the Determinants of Anaemia Prevalence Among Women in Nigeria

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ABSTRACT

Anaemia remains a significant public health issue among women of reproductive age, especially in developing countries like Nigeria. This study examines the influence of socio-economic and demographic factors on anaemia among women in Nigeria using data from the 2018 Nigeria Demographic and Health Survey (NDHS). Variables analyzed include age, marital status, body mass index (BMI), education level, wealth index, pregnancy status, contraceptive use, region, place of residence, ethnicity, media exposure, and access to improved water. We first used descriptive statistics and Pearson's chi-square tests to explore links between women's anaemia status and key factors like residence, education, and wealth. Variables showing significant associations at this stage were then examined further with a partial proportional odds model, chosen to properly handle the ordered categories of anaemia severity (non-anaemic, mild, moderate, severe).Among the women surveyed, 41% had no anaemia, while 27% showed mild anaemia, 30% moderate anaemia, and 2% severe anaemia. Rural living, lower education evels, poorer household wealth, current pregnancy, lack of improved water access, and certain regional differences all raised the odds of severe anaemia significantly. The study concludes that socio-economic inequalities play a significant role in the burden of anaemia among women in Nigeria. Targeted interventions focusing on education, economic empowerment, and improved healthcare access are essential to reduce anaemia prevalence.

Keywords: Anaemia; Socio-economic Factors; Nigeria; NDHS; Ordinal Regression

1. Introduction

Anaemia is a state in which one's body is short of red blood cells or the capacity to transport oxygen from the lungs to the other parts of the body. The causes of anaemia include, but are not limited to, nutritional deficiencies, genetic conditions, illnesses, parasites, and menstruation. Research has it that anaemia affects women more than men all over the world, including Nigeria. From the findings of Gardner and Kassebaum (2020), anaemia is a major public health problem in Nigeria, where it was estimated that 48.2% of women aged 15- 49 years are anemic.

More than 500 million women of childbearing age around the world have anaemia. Nigeria has one of the highest rates in sub-Saharan Africa, where more than 50% of women have it. This ongoing problem harms the health of mothers, raises the chances of bad pregnancy outcomes, and keeps the cycle of poverty and stunted child development going from one generation to the next. It is a major public health issue. Investigating the socio-economic and demographic determinants of anaemia in Nigeria is pertinent for policy formulation, as it guides targeted interventions within the National Anaemia Reduction Policy, addresses the deficiency in ordinal analyses utilising recent NDHS data, and rectifies the absence of partial proportional odds modelling to reflect the differential impacts across varying levels of anaemia severity.

Anaemia is prevalent in Nigerian women of childbearing age, and it is related to morbidity and mortality because it has adverse effects on pregnancy outcomes and children's learning abilities (Karami et al., 2022). Anaemia is a significant health problem, prevalent among women in Nigeria and it has social and economic impacts on them. A cross-sectional

study conducted by Keokenchanh et al. (2021) revealed that anaemia is highly prevalent among women in the reproductive age in Nigeria, with a prevalence of 42% nationally, while the highest prevalence was reported in the Northern region of the country. The high prevalence of anaemia can be due to the following reasons including low diet, poor health facilities and low economic status. Also, according to Jasim et al. (2020), anaemia affects women in pregnancy and childbirth since it acts as a risk factor for both domains. Anaemia during pregnancy leads to maternal morbidity and mortality, preterm birth, and low birth weight; therefore, it is essential to address it (Majeed et al., 2022).Effiong and Udom (2025) study looked at pregnant women visiting antenatal clinics in Calabar. IT checked how common anaemia and malaria were, and how often they occurred together. They found that both problems are still very widespread there, showing malaria's heavy toll on anaemia in Nigeria's high-risk areas. This points to the importance of tackling connected causes—like parasites, poor nutrition, and social factors—in strategies to fight anaemia among women of childbearing age.

2. Methodology

This study used secondary data from the 2018 Nigeria Demographic and Health Survey (NDHS). The Partial Proportional Odds Model (PPOM) was selected because anaemia severity is ordinal (non-anaemic, mild, moderate, severe), but the proportional odds assumption of the standard ordered logit model was violated by key variables. This assumption requires the effect of each predictor to be consistent across all cumulative odds splits; violations occur when relationships differ by severity threshold. Variables such as rural residence, education level, wealth index, pregnancy status, and improved water access violated this assumption, as confirmed by Brant tests ($p < 0.05$ for these predictors), necessitating PPOM to relax proportionality for those while maintaining it for others. Data were analyzed using descriptive statistics, Pearson's chi-square tests for associations, and PPOM via the 'vgam' package in R

2.1 Variable Description

2.1.1 Dependent variable

The respondent's anaemia level is the dependent variable. Women with a hemoglobin level of less than 12 g/dL were considered anemic. The anaemia level of respondents was recoded into an ordinal variable as mild, moderate, severe, and non-anemic. According to Mayang S. et al. (2001), anaemia was categorized as mild (hemoglobin (Hb) of 10.0–11.9 g/dL), moderate (Hb of 7.0–9.9 g/dL), and severe (Hb < 7.0 g/dL).

2.1.2 Independent variables

The variables were grouped into demographic and socio-economic factors based on the conceptual framework for anaemia determinants. The demographic characteristics included the age of the respondent, marital status (never in a union, married/living with a partner, and divorced/separated/widowed), body mass index (BMI) (underweight, healthy weight, and overweight), modern contraceptive use (yes and no), region (North-Central, North-East, North-West, South-East, South-South, and South-West), place of residence (urban or rural), and ethnicity (Hausa, Yoruba, Igbo, and others). The total children ever born (0, 1, 2–4, and ⩾5) were regrouped into four categories of parity (nulliparity, primiparity, multiparity, and grand multiparity), correspondingly (Daniel Chukwuemeka et. al. 2022). BMI was converted from a numeric to a categorical variable based on the World Health Organization (WHO). BMI less than 18.5, between 18.5 and 25, and those greater than 25 were regrouped into Underweight, healthy weight, and overweight, respectively. Also, the age of the respondent was converted into five (5) categorical-based variables namely: 15 – 19, 20 – 24, 25 – 29, 30 – 34, and ≥ 40.

The socio-economic included are highest education (no education, primary, secondary, and higher), wealth index (poorest, poor, moderate, rich, richest), the main source of drinking water (unimproved and improved) and media exposure (yes and no).

2.2 Bivariate Analysis

2.2.1 Chi-square (χ^2)

A Pearson's Chi-square (χ^2) test for independence is a non-parametric statistical technique for testing whether two categorical variables are related or not. The test compares the observed frequencies of the variables in a sample with the expected frequencies under the null hypothesis, which is usually that the variables are independent. The test statistic of is given by;

$$\chi^2 = \sum \frac{(O-E)^2}{E} \quad (1)$$

where O is the observed frequency and E is the expected frequency

2.3 Statistical Models

2.3.1 Ordinal Logistic Regression

Ordinal logistic regression or simply ordinal regression is a statistical modelling technique for testing hypotheses about the nature of the relationship between one or more independent variables and one ordinal dependent (response or outcome) variable (Long, J. S., and J. Freese. 2006). It is an extension of binary logistic regression and is suitable for modelling the relationship between independent variables and an ordinal outcome variable with more than two categories.

In this study, the technique is used to capture the ordinal nature of the dependent variables (non-anemic, mild, moderate, and severe anaemia). The model assumes that;

- The dependent variable is measured on an ordinal level.
- The independent variable(s) can be either continuous, categorical, or ordinal.
- No high correlation between two or more independent variables (multi-collinearity)
- Each independent variable has the same effect at each cumulative split of the ordinal dependent variable (Proportional Odds). If the relationship between all pairs of groups is consistent, only one set of coefficients is needed, meaning there is just one model. However, if this assumption is violated, different models are required to describe the relationship between each pair of outcome groups. The ordinal logistic model is also called the proportional odds model (POM).

Given an ordinal response variable Y with J categories, let X be a vector of explanatory variables with p elements, suppose $P(Y \leq j \mid X)$ is the cumulative probability of the response variable being in category j or lower, given the explanatory variables and $P(Y > j \mid X)$ is the complementary probability of the response variable being in category j+1 or higher, given the explanatory variables the model is expressed as;

$$\log\left(\frac{P(Y\leq j|X)}{P(Y>j|X)}\right) = \alpha_j + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_p X_p \quad (2)$$

Where, α_j is the intercept for the jth category, j=1..., J−1, and β_i is the coefficient for the ith explanatory variable, i=1..., p.

2.3.2 Generalised Ordered Logistic Regression

The general ordered logistic model extends the ordered logistic regression model. It is used for ordinal response variables when the proportional odds assumption may not apply. This model allows different thresholds between categories (Richard Williams, 2006).

For this study, the partial proportional odds model was employed because the assumption of proportional odds holds for some predictors.

2.3.3 Partial Proportional Odds Model (PPOM)

This model relaxes the proportional odds assumption for some predictions while maintaining it for others. This is useful when some predictors meet the proportion odds assumption, but others do not. The PPOM permits nonproportional odds for a subset of q of the p-predictors (q ≤ p). We may define the PPOM cumulative probability as follows:

$$\log\left(\frac{P(Y\leq j|X)}{P(Y>j|X)}\right) = \alpha_j + x_i^{'}\beta + t'\gamma_j \quad (3)$$

Where $t'$is a vector q covariates $(1by\ q)$ that contain the values of observation i on that subset of the p independent variables for which the assumption of proportionality is either not met or is to be tested, and $\gamma_j$is the vector of the regression coefficient with the dimension $(1by\ q)$, which is associated with the q covariates. As a result, $t'\gamma_j$ is the increase that is associated with the jth cumulative logit $(1 \leq j \geq j-1)$, where $\gamma_1 = 0$. If the values of $\gamma_i = 0$ for all j, Then this model reduces to POM. (Richard Williams, 2006)

2.4 Model Evaluation

This section involves assessing how well a model fits the data and how accurately it predicts outcomes.

2.4.1 Test for Multicollinearity

Multicollinearity happens when two or more variables are highly correlated. Testing for multicollinearity is also important when fitting POM models, just like in other regression models. For this study, the variance inflation factor is used to assess multicollinearity.

2.4.2 Variance Inflation Factor (VIF)

Variance inflation factor (VIF) is a measure of multicollinearity in a regression analysis. It indicates the degree to which correlations among predictors inflate variance. It is expressed as,

$$VIF = \frac{1}{1-R_i^2} \quad (4)$$

Where $\boldsymbol{R_i^2}$ represents the unadjusted coefficient of determination for regressing the ith independent variable on the remaining ones.

The general rule of thumb for the VIF test is that if the VIF value is greater than 10, then there is multicollinearity.

2.4.3 Test for Proportional ODDS

This section explains the test used to evaluate the proportional odds assumption. Testing for proportional odds is important because the model's validity and interpretability depend greatly on this assumption.

The null hypothesis for the testing of the proportional odds assumption is given by

$$H_0: \beta_1 = \beta_2 = \cdots \beta_{J-1}$$

The null hypothesis is rejected when $p - value\ < 0.05$.

2.4.4 Wald Test

The Wald test is a statistical test used to assess the significance of individual coefficients in a regression model. It evaluates whether the estimated coefficient of a predictable variable is different from zero and tests the parallel lines assumption.

Given the likelihood function of the cumulative of the ordinal logistic model as;

$$L(\theta; x, y) = \prod_{i=1}^{n} \prod_{j=1}^{K} (\gamma_{ij} - \gamma_{ij-1})^{I(y_i=j)} \quad (5)$$

Where $\theta^T = (\alpha_1, \beta_1^T, \dots, \alpha_{j-1}, \beta_{j-1}^T)$ includes all parameters.

Based on the asymptotic distribution of $\hat{\theta}$, the null hypothesis for the Wald test can be written in a matrix form

$$L * \left(\beta_1^T, \beta_2^T, \dots \beta_{j-1}^T\right)^T = 0 \quad (6)$$

where $L = \begin{pmatrix} I_{s\times s} & 0_{s\times s} & \cdots & 0_{s\times s} & -I_{s\times s} \\ 0_{s\times s} & I_{s\times s} & \cdots & 0_{s\times s} & -I_{s\times s} \\ \vdots & \vdots & \cdots & \vdots & \vdots \\ 0_{s\times s} & 0_{s\times s} & \dots & I_{s\times s} & -I_{s\times s} \end{pmatrix}$ is an $(J-2)\times(J-1)$ block matrix, $I_{s\times s}$ is the $s \times s$ identity matrix, and $0_{s\times s}$ is the $s \times s$ with all entries 0.

Let V be the estimated asymptotic variance of $(\beta_1^T, \beta_2^T, \dots \beta_{j-1}^T)$, then the asymptotic variance of $L * \left(\beta_1^T, \beta_2^T, \dots \beta_{j-1}^T\right)^T$ is $L * V * L^T$.

Hence, Wald's statistics can be defined as

$$s_{Wald} = (\beta_1^T, \beta_2^T, \dots \beta_{j-1}^T) L^T (L * V * L^T)^{-1} L * \left(\beta_1^T, \beta_2^T, \dots \beta_{j-1}^T\right)^T \quad (7)$$

The Wald statistics follow a χ^2 distribution with $(J-2)$ degrees of freedom.

3. Result

3.1 Characteristics of respondents

Table 1 provides a summary of the characteristics of the study participants in 2018. The table details respondents' attributes, such as age, gender, education level, and region. The age distribution indicates that the 25-29 years group is the most prevalent, making up 28.26% of all respondents. Conversely, the 15-19 years group was the least represented, comprising only 3.99%. The wealth index distribution shows respondents are fairly evenly spread across different economic levels. The middle wealth group is the largest at 22.03%, followed by the poorest at 21.29%, the poorer at 20.71%, the richer at 20.21%, and the richest at 15.76%. Regarding marital status, most respondents are married or living with a partner (94.68%), with widowed individuals accounting for 3.31%. About 47.24% have had more than five children, while only around 0.80% have not given birth yet. Furthermore, 41.20% of respondents have a healthy weight. However, more than half are underweight (57.02%), with overweight individuals being the least common at 1.75%. Education levels vary widely; the highest percentage (40.19%) have no formal education, followed by those with secondary education (34.56%). Approximately 62% live in rural areas, and 59.40% have access to media. Although 25.91% of respondents are from Nigeria's northwest, 16.71% are Igbo, and about 12.36% are Yoruba. The proportions of respondents who are currently pregnant, breastfeeding, and using contraceptives are 13.09%, 52.09%, and 18.92%, respectively. Additionally, around 66% have access to improved water sources.

Table 1: Summary of respondent characteristics

Characteristics		frequency	Percentage (%)
Age group	15 – 19	511	3.99
	20 – 24	2,273	17.73
	25 – 29	3,623	28.26
	30 - 34	2,975	23.21
	35 – 39	2,203	17.19
	≥ 40	1,234	9.63
Current marital status	Never in union	258	2.01
	Married/living with partner	12,137	94.68
	widowed/divorced/separated	424	3.31
Body mass index	Underweight	7,310	57.02
	Healthy weight	5,281	41.20
	Overweight	224	1.75
Parity	Nulliparity	102	0.80
	Primiparity	1,771	13.82
	Multiparity	4,890	38.15
	Grand Multiparity	6,056	47.24
Religion	Christianity	5,773	45.03
	Islamic	6,998	54.59
	Others	48	0.37
Place of residence	Urban	4,819	37.59

	Rural	8,000	62.41
Wealth index	Poorest	2,729	21.29
	Poorer	2,655	20.71
	Middle	2,824	22.03
	Richer	2,591	20.21
	Richest	2,020	15.76
Education level	No education	5,152	40.19
	Primary	2,134	16.65
	Secondary	4,430	34.56
	Higher	1,103	8.60
Ever terminated a pregnancy	No	11,030	86.04
	Yes	1,789	13.96
Currently pregnant	No	11,141	86.91
	Yes	1,678	13.09
Currently Breastfeeding	No	6,142	47.91
	Yes	6,677	52.09
Current use of contraceptive	No	10,394	81.08
	Yes	2,425	18.92
Access to media	No	5,204	40.60
	Yes	7,615	59.40
Water source	Unimproved	4,399	34.32
	Improved	8,420	65.68
Ethnicity	Hausa	4,955	38.65
	Igbo	2,142	16.71
	Yoruba	1,584	12.36
	Others	4,138	32.28
Region	North-central	2,230	17.40
	North-east	2,399	18.71
	North-west	3,321	25.91
	South-east	1,723	13.44
	South-south	1,337	10.43
	South-west	1,809	14.11

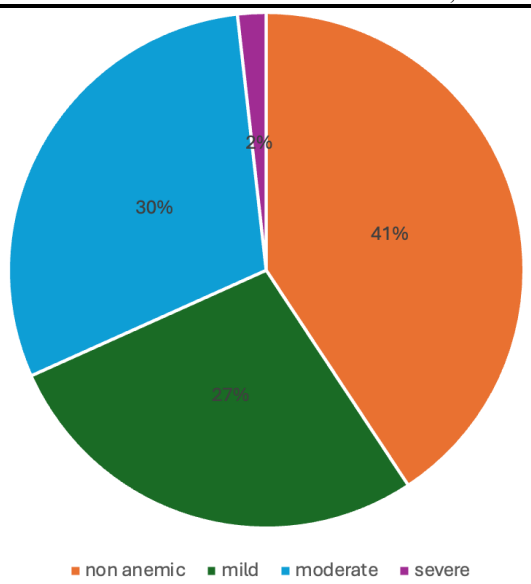

Figure 1: Severity of anaemia among women in Nigeria

The anaemia prevalence among 12,819 women in Nigeria in 2018 is shown in Figure 1. The figure displays the distribution of anaemia severity among women. Non-anemic women made up about 41% of the population. While 30% had moderate anaemia, 27% had mild anaemia; the severe category (2%) had the lowest percentage. This indicates that approximately 59% of the total population was anemic.

3.2 Prevalence of Severity of Anaemia Among Women in Nigeria

The prevalence of non-, mild, moderate, and severe anaemia among women, as well as the relationship between anaemia levels and various characteristics, are shown in Table 4. Across age groups, the highest prevalence of severe anaemia was observed in the 15-19 years group (1.96%), while the lowest was in the 25-29 years group (1.32%). Additionally, respondents who are underweight have a higher prevalence of being non-anemic (43.31%) compared to those with a healthy weight (37.28%) and overweight individuals (36.40%). Severe anaemia is most common among those with a

healthy weight (2.39%). Furthermore, women with no education have the highest prevalence of moderate (33.99%) and severe (2.97%) anaemia, while women with higher education have the lowest prevalence of moderate (51.95%) and severe (1.27%) anaemia.

However, the chi-square test indicates there is a significant association between the severity of anaemia with women's age, body mass index, parity, place of residence, wealth index, education level, pregnancy status, use of contraceptives, access to media, water source, ethnicity, and religion (p-value < 0.01). In contrast, marital status, breastfeeding, and ever-terminated pregnancy were not significantly associated with the severity of anaemia among women.

Table 2: Prevalence of severity of anaemia among women

		Not anemic	Mild	Moderate	Severe	χ^2	P-value
		n (%)	n (%)	n (%)	n (%)		
Characteristics		15 - 19	177(34.64)	152(29.75)	172(33.66)	10(1.96)	33.34
Age group	20 - 24	906(39.86)	608(26.75)	721(31.72)	38(1.67)		0.004
	25 – 29	1,535(42.37)	985(27.19)	1,055(29.12)	48(1.32)		
	30 - 34	1,168(39.26)	849(28.54)	888(29.85)	70(2.35)		
	35 – 39	891(40.44)	625(28.37)	647(29.37)	40(1.82)		
	≥ 40	541(43.84)	316(25.61)	354(28.69)	23(1.86)		
Current marital status	Never in union	104(40.31)	74(28.68)	75(29.07)	5(1.94)	7.75	
	Married/living with partner	4,947(40.76)	3,358(27.67)	3,621(29.83)	211(1.74)		0.26
	Widowed /divorced/ separated	167(39.39)	103(24.29)	141(33.25)	13(3.07)		
Body mass index	Underweight	3,166(43.31)	2,005(27.43)	2,039(27.89)	100(1.37)	73.44	
	Healthy weight	1,969(37.28)	1,460(27.65)	1,726(32.68)	126(2.39)		0.00
	Overweight	83(36.40)	70(30.70)	72(31.58)	3(1.32)		
Parity	Nulliparity	48(47.06)	21(20.59)	29(28.43)	4(3.92)	22.01	
	Primiparity	718(40.54)	489(27.61)	538(30.38)	26(1.47)		0.01
	Multiparity	2,069(42.31)	1,310(26.79)	1,440(29.45)	71(1.45)		
	Grand Multiparity	2,383(39.35)	1,715(28.32)	1,830(30.22)	128(2.11)		
Place of residence	Urban	2,210(45.86)	1,277(26.50)	1,261(26.17)	71(1.47)	94.46	
	Rural	3,008(37.60)	2,258(28.23)	2,576(32.20)	158(1.98)		0.00
Wealth index	Poorest	921(33.75)	780(28.58)	972(35.62)	56(2.05)	202.77	
	Poorer	1,016(38.27)	733(27.61)	854(32.17)	52(1.96)		0.00
	Middle	1,113(39.41)	821(29.07)	842(29.82)	48(1.70)		
	Richer	1,111(42.88)	707(27.29)	726(28.02)	47(1.81)		
	Richest	1,057(52.33)	494(24.46)	443(21.93)	26(1.29)		
Education level	No education	1,851(35.93)	1,438(27.91)	1,751(33.99)	112(2.17)	151.47	
	Primary	867(40.63)	605(28.35)	621(29.10)	41(1.92)		0.00
	Secondary	1,927(43.50)	1,200(27.09)	1,241(28.01)	62(1.40)		
	Higher	573(51.95)	292(26.47)	224(20.31)	14(1.27)		
Ever terminated a pregnancy	No	4,494(40.74)	3,050(27.65)	3,277(29.71)	209(1.89)	6.70	
	Yes	724(40.47)	485(27.11)	560(31.30)	20(1.12)		0.08
Currently pregnant	No	4,627(41.53)	3,052(27.39)	3,265(29.31)	197(1.77)	26.59	
	Yes	591(35.22)	483(28.78)	572(34.09)	32(1.91)		0.00
Currently Breastfeeding	No	2,482(40.41)	1,682(1,682)	1,877(30.56)	101(1.64)	3.29	
	Yes	2,736(40.98)	1,853(27.75)	1,960(29.35)	128(1.92)		0.35
Current use of contraceptive	No	4,042(38.89)	2,868(27.59)	3,274(31.50)	210(2.02)	106.49	
	Yes	1,176(48.49)	667(27.51)	563(23.22)	19(0.78)		0.00
Access to media	No	1,989(38.22)	1,497(28.77)	1,606(30.86)	112(2.15)	26.87	
	Yes	3,229(42.40)	2,038(26.76)	2,231(29.30)	117(1.54)		0.00
Water source	Unimproved	1,713(38.94)	1,213(27.57)	1,410(32.05)	63(1.43)	19.89	
	Improved	3,505(41.63)	2,322(27.58)	2,427(28.82)	166(1.97)		0.00
Ethnicity	Hausa	1,862(37.58)	1,357(27.39)	1,622(32.73)	114(2.30)	136.76	
	Igbo	768(35.85)	606(28.29)	726(33.89)	42(1.96)		0.00
	Yoruba	763(48.17)	445(28.09)	359(22.66)	17(1.07)		
	Others	1,825(44.10)	1,127(27.24)	1,130(27.31)	56(1.35)		
Region	North-central	967(43.36)	607(27.22)	635(28.48)	21(0.94)	149.41	
	North-east	943(39.31)	693(28.89)	720(30.01)	43(1.79)		0.00
	North-west	1,339(40.32)	871(26.23)	1,031(31.04)	80(2.41)		
	South-east	579(33.60)	499(28.96)	608(35.29)	37(2.15)		
	South-south	517(38.67)	343(25.65)	449(33.58)	28(2.09)		
	South-west	873(48.26)	522(28.86)	394(21.78)	20(1.11)		

South-west

3.3 Predictors of Severity Levels of Anaemia Among Nigerian Women

The proportional odds model was considered to determine the factors influencing the severity of anaemia among women in Nigeria. The model assumes that there is no multicollinearity and the correlation between the dependent and independent variables does not change for the categories of the dependent variable (parallel line assumption). The results from the test for multicollinearity and parallel assumptions are presented in Tables 3 and 4.

Table 3 shows the result of the multicollinearity assessment of the explanatory variables. The table shows the variance inflation factor (VIF) and tolerance, which measure how much the variance of an estimated regression coefficient increases due to collinearity. The VIFs of all the explanatory variables are below 3, indicating no multicollinearity. Also, the tolerance for the explanatory variables was relatively high, indicating no multicollinearity.

Table 3: Multicollinearity assessment of the explanatory variables

Variable	VIF	Tolerance	R-Squared
Age group	1.69	0.5932	0.4068
Body mass index	1.18	0.8443	0.1557
Marital status	1.02	0.9814	0.0186
Parity	1.66	0.6039	0.3961
Place of residence	1.43	0.7009	0.2991
Wealth index	2.52	0.3976	0.6024
Education Level	2.10	0.4771	0.5229
Ever terminated a pregnancy	1.02	0.9850	0.0150
Currently pregnant	1.25	0.8019	0.1981
Currently breastfeeding	1.27	0.7898	0.2102
Use of modern Contraceptive	1.17	0.8551	0.1449
Region	1.22	0.8189	0.1811
Access to media	1.22	0.8166	0.1834
Water source	1.27	0.7846	0.2154
Race/Ethnicity	1.20	0.8330	0.1670
Mean VIF	1.44		

Table 4: Result for the test of parallel line assumption

Independent variable	p>Chi-square
Age group	
15-19 (Ref)	0
20-24	0.238
25-29	0.247
30-34	0.642
35-39	0.645
>=40	0.187
Current marital status	
Never in union (Ref)	0
Married/living with partner	0.685
widowed/divorced/separated	0.129
Body mass group	
Underweight (Ref)	0
Healthy weight	0.876
Overweight	0.034
Parity	
Nulliparity (Ref)	0
Primiparity	0.021
Multiparity	0.027
Grand Multiparity	0.044
Place of residence	
Urban (Ref)	0
Rural	0.421
Wealth index	
Poorest (Ref)	0
Poorer	0.392
Middle	0.254
Richer	0.073
Richest	0.135
Education level	
No education (Ref)	0
Primary	0.422
Secondary	0.868
Tertiary	0.308

Ever terminated pregnancy	
No (Ref)	0
Yes	0.035
Currently pregnant	
No (Ref)	0
Yes	0.449
Currently Breastfeeding	
No (Ref)	0
Yes	0.307
Region	
North-central (Ref)	0
North-east	0.180
North-west	0.000
South-east	0.186
South-south	0.006
South-west	0.069
Access to media	
No (Ref)	0
Yes	0.016
Water source	
Unimproved (Ref)	0
Improved	0.000
Ethnicity	
Hausa (Ref)	0
Igbo	0.608
Yoruba	0.624
Others	0.985
Overall	χ^2= 130.2 p-value = 0.000

Table 4 presents the result of Wald tests of parallel line assumption. The result indicates a significant result (χ^2= 130.2, p-value < 0.05) for POM, suggesting that the parallel regression assumption is violated for the model. The violation of this assumption can lead to misinterpretation of the model coefficient. The results also show that 8 (Age group, marital status, place of residence, educational level, currently pregnant, currently breastfeeding, and ethnicity) out of the 14 variables meet the parallel lines assumption. Therefore, the partial proportional odds model (PPOM), which is a generalized ordinal regression that relaxes the parallel line assumption, was used. An insignificant test statistic (χ^2 = 53.67, p-value = 0.2661) for the Wald test for the PPOM indicates that the model does not violate the parallel lines assumption.

Table 5 presents the result of the fitted partial proportional odds model (PPOM). From the result, the women aged 40 and above tend to have significantly lower odds (OR = 0.755, p-value < 0.01) compared to women in the age group (15-19) years, suggesting that a woman aged 40 and above is less likely to have severe anaemia. Also, the odd ratios for healthy-weight women are consistently positive and statistically significant but increase across thresholds. This means that a woman with a healthy weight has less likelihood to have severe anaemia compared to an underweight woman, with the greatest difference being that healthy-weight women are highly likely to be non-anemic or mild. Although the odd ratio of each parity category decreases across the thresholds, only odd ratios in the first threshold were significant, indicating that as the parity of a woman increases, the likelihood of having severe anaemia reduces. More so, women living in rural residents have significantly higher odds (OR = 1.178, p-value < 0.01) compared to women in urban residents, indicating a woman living in a rural residence is associated with a greater likelihood of having severe anaemia. Moreover, as the wealth index increases, the odds generally decrease. Women in the poorer (OR = 0.857, p-value < 0.01) and middle (OR = 0.788, p-value < 0.01) categories have significantly lower odds compared to women in the poorest category, suggesting that as the wealth index of a woman increases, the likelihood of having severe anaemia reduces while women in richer (OR = 0.699, p-value < 0.01) and richest (OR = 0.531, p-value < 0.01) categories increase across the thresholds, suggesting that a woman in this categories have less likelihood to have severe anaemia compare to a woman in the poorest category. However, women with primary (OR = 0.795, p-value < 0.01), secondary (OR = 0.763, p-value < 0.01), and tertiary (OR = 0.670, p-value < 0.01) education levels have significantly lower odds compared to those with no education, indicating that as the education level of a woman increases, the likelihood of having severe anaemia reduces. In contrast, women who are currently pregnant have higher odds (OR = 1.184, p-value < 0.01) compared to those who are not pregnant, suggesting that a pregnant woman is associated with a greater likelihood of having severe anaemia. Furthermore, the odd ratios for the variable "using modern contraceptives" are consistently positive and statistically significant but decline across thresholds. This means that a woman using modern contraceptives has more likelihood to have severe anaemia compared to a woman not using it, with the greatest difference being that woman using modern contraceptives are less likely to be non-anaemic or mild. Conversely, the improved water source effect is negative but gets larger across thresholds. Hence, women who have access to improved water tend to be less likely to have severe anaemia

compared to women who have access to unimproved water are females, with the greatest differences being that women with improved water are less likely to be in the moderate or severe anemic categories. Additionally, women who belong to the Igbo (OR = 0.894, p-value > 0.05) and Yoruba (OR = 0.831, p-value > 0.05) ethnic categories have insignificant lower odds compared to Hausa. But other ethnic groups have significantly lower odds (OR = 0.676, p-value < 0.01) compared to Hausa. This suggests that a woman from the other ethnic group is less likely to have severe anaemia.

Table 5: PPOM for the association between socio-economic and demographic characteristics and severity of anaemia among women in Nigeria.

Characteristics	1vs2,3,4 Odd ratio. (SE)	1,2vs3,4 Odd ratio. (SE)	1,2,3 vs4 Odd ratio. (SE)
Age group			
15-19 (ref)	0	0	0
20-24	0.902(0.084)	0.902(0.084)	0.902(0.084)
25-29	0.833(0.080)	0.833(0.080)	0.833(0.080)
30-34	0.926(0.094)	0.926(0.094)	0.926(0.094)
35-39	0.868(0.092)	0.868(0.092)	0.868(0.092)
>=40	0.755**(0.086)	0.755**(0.086)	0.755**(0.086)
Current marital status			
Never in union (ref)	0	0	0
Married/living with partner	1.006(0.122)	1.006(0.122)	1.006(0.122)
widowed/divorced/separated	1.120(0.168)	1.120(0.168)	1.120(0.168)
Body mass group			
Underweight (Ref)	0	0	0
Healthy weight	1.122**(0.045)	1.168**(0.049)	1.706**(0.243)
Overweight	1.025(0.129)	1.025(0.129)	1.025(0.129)
Parity			
Nulliparity	0	0	0
Primiparity	1.597*(0.332)	1.149(0.254)	0.375(0.206)
Multiparity	1.579*(0.326)	1.183(0.259)	0.410(0.215)
Grand Multiparity	1.680*(0.351)	1.192(0.264)	0.594(0.309)
Place of residence			
Urban (Ref)	0	0	0
Rural	1.178**(0.049)	1.178**(0.049)	1.178**(0.049)
Wealth index			
Poorest (Ref)	0	0	0
Poorer	0.857**(0.045)	0.857**(0.045)	0.857**(0.045)
Middle	0.788**(0.046)	0.788**(0.046)	0.788**(0.046)
Richer	0.699**(0.05)	0.741**(0.055)	1.111(0.215)
Richest	0.531**(0.045)	0.592**(0.053)	1.043(0.263)
Education level			
No education	0	0	0
Primary	0.795**(0.043)	0.795**(0.043)	0.795**(0.043)
Secondary	0.763**(0.043)	0.763**(0.043)	0.763**(0.043)
Tertiary	0.670**(0.056)	0.670**(0.056)	0.670**(0.056)
Ever terminated pregnancy			
No (Ref)	0	0	0
Yes	1.068(0.057)	1.088(0.061)	0.583(0.138)
Currently pregnant			
No (Ref)	0	0	0
Yes	1.184**(0.065)	1.184**(0.065)	1.184**(0.065)
Currently Breastfeeding			
No (Ref)	0	0	0
Yes	0.968(0.036)	0.968(0.036)	0.968(0.036)
Use of modern contraceptive			
No (Ref)	0	0	0
Yes	0.792**(0.040)	0.713**(0.041)	0.453**(0.114)
Region			
North-central (Ref)	0	0	0
North-east	0.808**(0.050)	0.808**(0.050)	0.808**(0.050)
North-west	0.655**(0.046	0.743**(0.053)	1.142(0.186)
South-east	1.638**(0.170)	1.638**(0.170)	1.638**(0.170)
South-south	1.537**(0.112)	1.830**(.136)	2.061**(0.45)
South-west	0.971(0.081)	0.971(0.081)	0.971(0.081)
Access to media			
No (Ref)	0	0	0
Yes	1.013(0.042)	1.079(0.047)	0.749*(0.107)

Water source			
Unimproved (Ref)	0	0	0
Improved	1.158**(0.051)	1.104**(0.05)	1.878**(0.296)
Ethnicity			
Hausa (Ref)	0	0	0
Igbo	0.894(0.096)	0.894(0.096)	0.894(0.096)
Yoruba	0.831(0.082)	0.831(0.082)	0.831(0.082)
Others	0.676**(0.039)	0.676**(0.039)	0.676**(0.039)
Constant	1.556(0.395)	0.598(0.158)	0.031**(0.017)

*1= Not Anemic, 2= Mild, 3= Moderate, 4=Severe. *Significant at 95% confidence level. **significant at 99% confidence level. Wald test ($\chi^2 = 53.67$, p-value = 0.2661) is insignificant at a 5% confidence level.*

4. Discussion

The high anaemia prevalence among women in the current study tallies with evidence of high prevalence from previous African studies.

In contrast, other African studies found low anaemia prevalence among women. (Kibret KT et al., 2019; Gona PN et al., 2021; Hakizimana D, et al., 2019; Habyarimana F, et al., 2020; Hailu BA, et al., 2021). Since anaemia prevalence greater than 40% constitutes a severe public health problem. (McLean E, et al., 2009) These study findings indicate that anaemia among women is a fatal public health problem in Nigeria. Consequently, increased maternal mortality, poor birth outcomes, and reduced productivity due to anaemia among reproductive-age women might persist in Nigeria. (Horton S, Ross J., 2003; Cook RL, et al. 2017) The study findings of significant regional differences in anaemia prevalence and severity among women are consistent with evidence that residing in specific regions or provinces increased the odds of being anemic in other low and middle-income countries (LMICs). (Zegeye B, 2021; Nankinga O, Aguta D., 2019) Similarly to this finding, anaemia prevalence among women was higher in the Northern regions than in Southern regions in a previous Nigerian study.

This study finding that rural residence predicted an increased risk of anaemia and its severity is consistent with increased odds of having severe anemic among women (Assefa E., 2021; Kibret KT, 2019; Abate TW, 2016; Nankinga O and Aguta D, 2019) in prior studies but differs from other studies where a rural residence is protective (Teshale AB, et al., 2020) or urban residence is a risk factor. (Correa-Agudelo E, 2021) Low access to mass media in rural areas resulting in inequitable access to health information might contribute to the risk of being anemic even though media exposure was only significant for moderate anaemia among women in the fitted model. (Abubakar I et al., 2022) Second, Nigerian women residing in urban areas are more likely to be overweight/obese, while rural women are more likely to be either underweight or overweight. (Akokuwebe ME and Idemudia ES., 2021) Third, rural women are less likely to use modern contraceptives compared to urban women. (Ekholuenetale M, et al. 2021) In this study, being underweight and non-use of contraceptives increased the odds of being anemic among women.

This study findings that low education increased the odds of being anemic and anaemia severity among women agreed with evidence from prior studies on women, (Hailu BA, et al., 2021; Ogunsakin RE, et al., 2021) whereas educational attainment was protective of being severely anaemic. (Owais A, et al., 2021; Nti J, et al., 2021; Teshale AB, et al., 2020) As stated elsewhere, (Ogunsakin RE, et al., 2021; Kibret KT, et al., 2019) high education helps women to improve their nutrition and sanitary practices, hence reducing the risk of anaemia.

This study's findings that household socio-economic status predicted severity among women highlight the protective role of wealth and the influence of poverty in being anemic. This finding agrees with existing evidence that being rich reduced the likelihood of severe anaemia among women (Owais A, et al., 2021; Assefa E., 2021; Nti J, et al., 2021; Teshale AB, et al., 2020; Hakizimana D, et al., 2019; Nankinga O, Aguta D., 2019) High socio-economic status improves women's access to improved water, education, healthy weight, as well as better media exposure, which contribute to the prevention of anaemia among women. (Chaparro CM, Suchdev PS., 2019)

The use of modern contraceptives reduces the risk of severe anaemia as reported in several prior studies among women (Owais A, et al., 2021; Teshale AB et al., 2020; Hakizimana D, et al., 2019;) Conversely, contraceptive use increased the likelihood of being severely anemic. (Nti J, et al., 2021) Evidence from the literature indicates that the prevalence of anaemia declines with increasing duration of use of modern contraceptives in one of three ways. (Gebremedhin S. and Asefa A, 2019) First, spacing births reduces nutritional stress associated with successive pregnancies, preventing maternal iron depletion. Second, some contraceptives modify the iron status, which lowers the risk of being anemic. Third, iron-containing contraceptives provide iron supplementation to prevent iron deficiency anaemia. Further studies are needed to determine which of these factors plays a greater role in predisposing women in Nigeria to the severity of anaemia. (Gebremedhin S. and Asefa A, 2019)

Similar to findings in Ethiopia, normal body weight reduced the likelihood of severe anaemia among women in this study. (Tsehayu A, et al., 2022) However, being underweight increases the risk of anaemia among women. (Assefa E, 2021; Hakizimana D, et al., 2019; Correa-Agudelo E, 2021; Habyarimana F, et al., 2020) Anaemia, due to being underweight,

might result from undernourishment, but poor dietary diversity was not included as a predictor of being anemic in this study. Further studies are required to determine the relationship between micronutrient-rich diets, BMI and severity of anaemia among women in Nigeria.

Furthermore, our finding that lack of media exposure increased the likelihood of being moderately anemic among women is consistent with evidence from a preceding study. (Keokenchanh S, et al. 2021) Access to media is associated with awareness of the value and availability of health services, (Abubakar I, et al., 2022; Igbinoba AO, et al., 2020) information on diets and nutrition, and an increased likelihood of contraceptive use. (Ajaero CK, et al., 2016; Yaya S, Bishwajit G, 2020) Furthermore, the finding that age 40 and above reduced the odds of developing severe anaemia among women contrasts evidence of reduced odds of anaemia among this age group in Ethiopia. (Kibret KT, et al. 2019).

5. Conclusion

Anaemia is still a big problem in Nigeria. Policies should be centred on education, alleviation of poverty, and enhancement of maternal health. Interventions based on evidence include:

- Improve access to healthcare in rural areas by sending out mobile clinics and paying for iron supplementation programs. This is in line with Nigeria's National Anaemia Reduction Policy, which says that the risk of severe anaemia is 1.8 times higher in rural areas.
- Promote education and nutrition literacy: Include anaemia prevention in school curricula and community health campaigns, focusing on groups with low levels of education (OR=2.1 for severe anaemia).
- To help poor people get out of poverty, expand conditional cash transfer programs that are linked to maternal health check-ups for poor families (OR=2.5 risk).
- Improve the infrastructure for water and sanitation: Speed up WASH investments in areas with poor water quality (OR=1.4 risk).
- Integrating maternal health: Require preconception and antenatal screening with complimentary treatment during pregnancy (OR=1.6 risk), thereby endorsing SDG 2 and 3.
- To lower Nigeria's 58% anaemia rate among women and reach national health goals, we need these multisectoral policies that deal with socio-economic inequalities right away.

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