Public Health in Practice 3 (2022) 100229

Contents lists available at ScienceDirect

Public Health in Practice

journal homepage: www.sciencedirect.com/journal/public-health-in-practice

Individual, household and area predictors of anaemia among children aged 6–59 months in Nigeria

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ARTICLE INFO

Keywords:
Iron deficiency anaemia
Under-five years
Determinants
Associations
Logistic regression
Predicted probabilities

ABSTRACT

Objectives: This study aims to determine the prevalence of anaemia among children aged 6–59 months in all states of Nigeria, including the Federal Capital Territory (FCT), and to quantify the predicted probabilities by individual, household and area factors.

Study design: This study is a secondary analysis of data sets from two national representative cross-sectional surveys in Nigeria: the Nigeria Demographic and Health Survey (2018 NDHS) and the National Human Development Index (2018 NHDR). The state human development index (HDI) and the state multidimensional poverty index (MPI) from the 2018 NHDR were incorporated into the 2018 NDHS.

Methods: The study included a weighted sample of 10,222 children aged 6–59 months. Both univariate and bivariate analyses were computed to determine the prevalence and factors associated with anaemia status, respectively. Multiple binary logistic regression analyses with adjusted predicted probabilities (APPs) were performed to quantify the predictors' probabilities.

Results: The prevalence of anaemia among children aged 6–59 months in Nigeria was 68.1% (6962/10,222). Zamfara state had the highest prevalence (84.0% [266/317]), while Kaduna state recorded the lowest (50.0% [283/572]). The APPs of being anaemic decreased from 82.9% (95% confidence interval [CI]: 80.0–85.8) for children aged 6–18 months to 60.6% (95% CI: 56.8–64.4) for children aged 43–59 months, when other predictors were held constant. The APP for a child of an anaemic mother is 10.2% points higher than the APP for a child whose mother is not anaemic. In addition, the APPs for children decreased as the age group of their mothers increased. A child from a state that is mildly deprived in the MPI has a lower APP (67.2% [95% CI: 62.2–72.2]) compared with a child from highly deprived MPI state (79.0% [95% CI: 73.4–84.5]).

Conclusions: Health strategies, including supplementation programmes, should be carried out at both ante-natal and post-natal clinics to reduce the prevalence of anaemia, especially in vulnerable population groups.

1. Introduction

Anaemia in children is a major global public health concern [1], especially in developing countries, and it is one of the major causes of childhood mortality [2–5]. The World Health Organisation (WHO) and the Centres for Disease Control and Prevention (CDC) [5] reported that about one-quarter of the world's population are anaemic, with expectant mothers and children under-five years of age being the most vulnerable [1,6]; however, since 2016, the global prevalence of anaemia has been increasing more than 40% annually [7]. The WHO recent classification indicated that any country with a prevalence of anaemia >40% can be classified as 'severe' [8]. The burden of anaemia in some developing countries is 400% times higher than in most developed countries [9]. In a recent multi-country study of 27 Sub-Sahara Africa (SSA) countries,

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https://doi.org/10.1016/j.puhip.2022.100229
Received 18 June 2021; Received in revised form 11 December 2021; Accepted 13 January 2022
Available online 20 January 2022

Moschovis et al. [10] reported an average prevalence of anaemia of 60% among children aged 6–59 months. Almost all the Demographic and Health Surveys conducted in the post-millennium development goals era on SSA countries reported prevalence of under-five years anaemia of >50% [6]. In 2018, the prevalence of anaemia among children aged <60 months in Nigeria was 68% [11], in 2016 this was 72% in Ethiopia [12], and 58.6% in Tanzania [13].

Although the causes of anaemia in children are multi-factorial, the primary cause in developing countries is iron deficiency, which accounts >50% of all cases [8,9]. Other causes of anaemia that are common in Africa, which often result in blood reduction in the body system, include infectious/non-communicable diseases, such as malaria fever, schistosomiasis, HIV-AIDS, tuberculosis, cancer, malnutrition and micronutrient deficiencies [1,4,6]. Several studies have also reported some important socioeconomic, demographic and area-related factors that are associated with the risk of developing anaemia [6].

Studies investigating the determinants of anaemia in under-5 years children in Nigeria are limited. A recent study by Ogunsakin et al. [14] examined the determinants of anaemia among children aged 6–59 months in Nigeria using 2018 Nigeria Demographic and Health Survey (NDHS) data considering the individual and contextual factors as predictors. Although this current study used the same data set, the approaches differ in several ways: (i) two state-level predictors extracted from the 2018 National Human Development Report (NHDR) were incorporated into the 2018 NDHS data set; (ii) the cut-off value used for determining anaemia status among children aged 6–59 months in Nigeria differed; (iii) at the multivariate level of analysis, the current study computed and interpreted the predicted probabilities of a child being anaemic in Nigeria.

The aim of the current study is to determine the prevalence of anaemia among children aged 6–59 months in all states of Nigeria, including the Federal Capital Territory (FCT), and to quantify the predicted probabilities of being anaemic by individual, household and area variables.

2. Methods

2.1. Study design

This study is a secondary analysis of data sets from the following two nationally representative cross-sectional surveys in Nigeria: the NDHS (2018) and the NHDR (2018). The two contextual variables were the state human development index (HDI) and the state multidimensional poverty index (MPI) from the 2018 NHDR and these were incorporated into the 2018 NDHS (the main data set).

In the 2018 NDHS, each of the 36 states and FCT of Nigeria were separated into urban and rural areas. An urban locality was classified as a population of ≥20,000 [15], resulting in the identification of 74 strata (with each state and FCT having urban and rural localities). The survey used a stratified two-stage cluster design on each stratum in accordance with the 2006 census enumeration area demarcation. During the first stage, a representative 1400 enumeration areas (EAs) were selected as the sampling units with probability proportional to the EA size, allowing this survey (with the largest sample size) to be compared with five previous surveys [15]. The second stage involved a complete listing of households in each of the selected 1400 EAs. A fixed number of 30 households were randomly selected from each EA using equal probability sampling. Overall, 11 EAs were excluded from the survey because of insecurity. A total of 41,668 households were selected for sampling, but only 40,427 households (representing a response rate of 99.4%) completed the survey [15], (see Fig. 1).

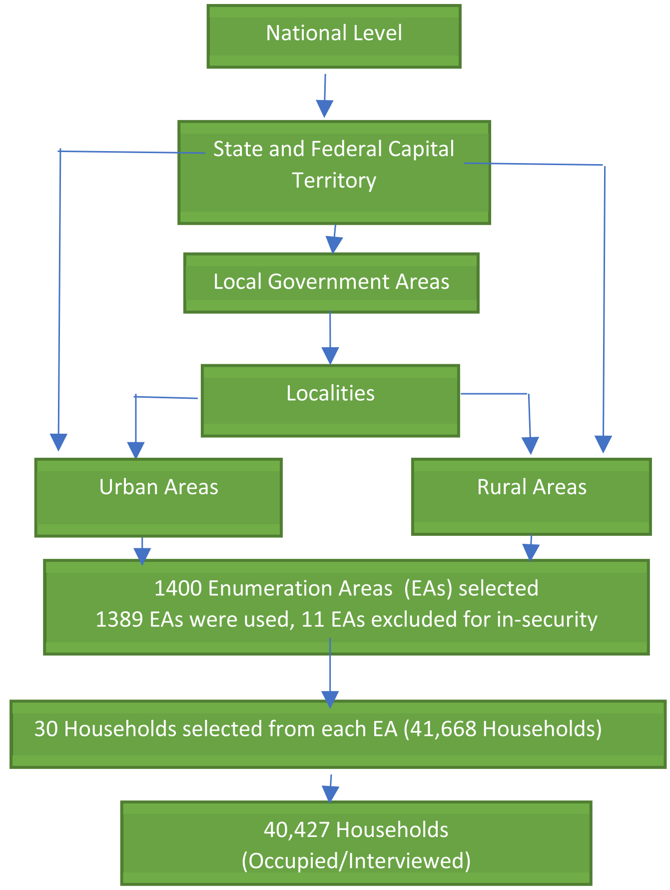

Fig. 1. Flowchart describing the sampling procedure.

2.2. Outcome or dependent variable

Anaemia Status: In Nigeria, the 2018 NDHS marked the first time that the DHS had collected data on haemoglobin (Hb) levels (anaemia) among women (15–49 years) and children (6–59 months), and the participants were taken from the subsample of households that were randomly selected for the male survey [15]. The anaemia status for children aged 6–59 months in Nigeria was determined by the altitude-adjusted Hb levels from a finger-prick test for children aged 12–59 months old or a heel-prick test for children aged 6–11 months. The blood samples were analysed with a Hb micro-cuvette using an on-site battery-powered portable HemoCue® analyzer, Hb 201+ device [14,15]. Children with Hb levels <11.0 g/dL (whether severe, moderate or mild anaemia) were classified as 'anaemic' and coded as '1', otherwise children were classified as 'not anaemic' and coded as '0' for the analysis. There were a total of 10,451 children aged 6–59 months in Nigeria who were included in survey; Hb levels were successfully computed for 10,188 children (representing a 97.4% response rate).

2.3. Predictor or independent variables

Several potential predictor variables arising from a scoping review of the predictors of anaemia among under-five years of age in SSA [6] were considered in the analysis. Table 1 defines and classifies these variables into the following categories: child-related variables, parental/caregiver-related variables and household/community-related variables.

Table 1
Description of the variables used in the analysis.

Variables	Definitions	Classifications
Child-related variables		
Age of the child	The age of the child (in months) on the day of the survey	6–18 months, 19–30 months, 32–42 months and 43–59 months
Sex of the child	The gender of the child at the birth	Male and female
Perceived Birth Size	This was the mother's percieved child's birth weight	Large, average and small
Birth Order	The child's rank among other children of the same mother	1st order, 2nd or 3rd order, 4th-6th order and 7th + order
Iron supplement	Whether the child has taken iron supplements in the last six months before the survey	No or Yes
Breastfeeding	Whether the child has been breastfed	Ever breastfed, not currently breastfed, never breastfed and still breastfeeding
Had Diarrhoea in the last 2 weeks before the survey	Whether the child been ill with diarrhoea	No or Yes
Had fever in last 2 weeks before the survey	Whether the child been ill with fever	No and Yes
The child had an acute respiratory illness (ARI) in the past 2 weeks before the survey	Whether the child has been ill with ARI	No or Yes
Vitamin A Consumption	Whether the child has ever taken vitamin A supplements in the last six months before the survey	No or Yes
Treatment for intestinal worms in the last 6 months	Whether the child took deworm tablets/syrup in the last 6 months before the survey took place	No or Yes
Nutritional Status	Whether the child is well nourished or poorly nourished (if the child had at least one of stunting, wasting, underweight, and overweight)	Well nourished and poorly nourished
Stunting	If a child is stunted	No or Yes
Wasting	If a child is wasted	No or Yes
Underweight	If a child is underweight	No or Yes
Overweight	If a child is overweight	No or Yes
Malaria status (RDT)	The child is confirmed to have malaria parasitaemia from results of rapid diagnostic test	No or Yes
Place of delivery	Type of facility where the child was delivered	Home, Public health facility, Private health facility and elsewhere
Parental/caregiver-related variables		
Mother's age group	Mother's age classified (in years)	15–24 years, 25–34 years and ≥35 years
Mother's age at first birth	The mother's age when she had her 1st child	10–19 years, 20–29 years and ≥30 years
Mother working Status	Whether the mother/caregiver of the child works	Not working and working
Mother's educational status	Mother/caregiver of the child's educational level of attainment	No education, Primary and Secondary & above
Father's educational status	Father of the child's educational level of attainment	No education, Primary and Secondary & above
Father's work status	Whether the child's father works	Not working and working
Mother's marital status	Mother's current marital status	Never in union, in union and divorced/ separated/widowed
Mother lives with a partner	Whether the mother resides with her partner	Living with partner and living alone
Mother slept under a mosquito net	If the mother slept under a mosquito net the night before the survey	No or Yes
Mother's body mass index (kg/m^2)	The body mass index classification of the mother	Normal, underweight, overweight and obese
Preceding birth interval	Interval in months between the child's birth and the previous child's birth	8–24 months, 25–35 months, 36–59 months and ≥60 months
Mother's anaemia status	Anaemia status of the mother	Normal and anaemic
Antenatal care attendance/health seeking	Number of antenatal care visits the mother attended during the child's pregnancy	None, less WHO recommended number and met WHO recommendation
Maternal autonomy	The extent to which the mother participates in decision making concerning her health, large household purchases	Less autonomy and more autonomy
Maternal ethnicity	The ethnic background of the child's mother/caregiver	Hausa/Fulani, Ibos, Yoruba and others
Religious status	The religious denomination of the mother	Catholic, other Christians, Muslim and others (traditional)
Mother's iron supplementation during pregnancy	The mother took an iron supplement during the child's pregnancy	No or Yes
Household-related variables		
Wealth status	The measure of household economic status. This is a composite measure of the living standard of the household. This was computed using principal component analysis of durable assets and housing characteristics	Poorest, poor, middle, rich and richest
The household had a mosquito bed net	Whether the household had a bed net or not	No or Yes
Household size	The number of people that lived in the household	0-3, 4–6, 7–9 and ≥10
Number of rooms for sleeping	The number of rooms available for sleeping in the household	1 room, 2 rooms, 3rooms, 4 rooms and ≥5 rooms
Number of children Under-5 years in the household	Number of children who are aged <5 years in the household	None or 1, 2, 3 and ≥ 4
Source of drinking water	Whether there is improved source of drinking water in the household, such as piped, bottled or protected well, or not (unimproved)	Unimproved and improved
Type of toilet facilities	Whether the household uses improved toilet facilities, such as flush or ventilated pit, or not (unimproved)	Unimproved and improved
Youngest child's stool disposal	The mode of disposing of stool is safe or not	Proper and improper
Type of floor materials	Natural and rudimentary (unimproved), or finished floor (improved)	Unimproved and improved
Type of roofing materials	Natural and rudimentary (unimproved), or finished roof (improved)	Unimproved and improved
Type of wall materials	Natural and rudimentary (unimproved), or finished wall (improved)	Unimproved and improved
Household head age group in years	The age group of the household head	<34 years, 35–44 years, 45–55 years and ≥56 years

(*continued on next page*)

Table 1 (*continued*)

Variables	Definitions	Classifications
Sex of Household Head	The gender of the household head	Male and female
Shared toilet facilities with other households	Whether the household use the same toilet with other people	No or Yes
Type of cooking fuel	Electricity, natural gas or biogas	Electricity & gas, and biofuel/mass
Under-5 slept under a mosquito net last night	Children under-5 years slept inside mosquito net	No children, all children, some children and no net
State Human Development Index (SHDI)	The human development index indicates the level of deprivation in each state of residence	Lowest SHDI, low SHDI, average SHDI, high SHDI and highest SHDI
Region of residence	The geopolitical zone of the child's place of residence	North Central, North East, North West, South East, South-South and South West
Place of residence	The location of the household, whether in the rural or urban	Rural and urban
State Multidimensional Poverty Index (SMPI)	The multidimensional poverty index indicates the level of multidimensional poverty in each state	Highly deprived, above-average deprived, average deprived, mildly deprived, and lowest deprived

RDT, rapid diagnostic test.

2.4. Statistical analyses

Three levels of statistical analysis were considered in this study: namely, univariate, bivariate and multivariate methods.

At the univariate analysis level, percentage and frequencies were used to describe the baseline characteristics of all variables used in the analysis.

At the bivariate analysis level, the Pearson's chi-square test was applied to establish the association between the predictor variables and anaemia status of children aged 6–59 months in Nigeria. All variables that were found to be significantly associated with anaemia status at a 5% level of significance were further scrutinised to determine which were potential independent predictors (crude odds ratios) of anaemia in children aged 6–59 months using a simple logistic regression technique.

At the multivariate analysis level, backwards stepwise logistic regression at $p < 0.2$ was used to determine the predictor variables that would be considered for further analyses at this level. All the predictors that filtered through this test were used in the multiple logistic regression (adjusted odds ratios). Furthermore, for ease of interpretation [16], the margins were constructed to determine the predictive probability of being anaemic at each mean of the factor category, while holding other predictors constant at their respective mean value.

2.5. Logistic regression

The main aim of this study is to predict the probability of a child aged 6–59 months in Nigeria being anaemic, in any of the predictor variables of interest, while holding other variables constant. The regression analysis statistical method was used for prediction. Linear regression is a section of regression analysis that considers outcome variables (dependent variables) that are continuous (interval variables or scale). However, when the outcome variable is dichotomous (categorical or binary), logistic regression is the superior statistical method.

For binary outcomes, such as the case in the current study, where 'no anaemia' is coded as '0' and 'anaemic' is coded as '1', the predicted values can only take the values of 0 or 1. On the other hand, linear regression for this type of outcome would provide results in the range of 0–1, unbounded [17] between -∞ and +∞, which would not be appropriate in these circumstances. The interpretations of the results differ when linear regression is used compared with when logistic regression is applied. For instance, in the case of a child being anaemic, linear regression will produce the predicted mean at any value of the independent variable. This is not the interest in the current study. This study wants to determine the probability that a child will suffer from anaemia if an independent variable is at a value of interest. Logistic regression can do this better.

$$P(Y_i = 1) = \frac{exp^{(\beta_0 + \beta_1 X_i)}}{1 + exp^{(\beta_0 + \beta_1 X_i)}} \tag{1}$$

Where: Y_i = the conditional probability that the outcome variable result into 1 (being anaemic as the condition of interest).

X_i = the predictor variable for a child *i.*

For meaningful interpretation, rather than just being interested in the prediction of the conditional probability that the outcome is present ('1'), the study may want to determine the conditional probability that the outcome is present over the probability that the outcome is not present ('0'). In this circumstance, a link function that can transform the conditional probability of S- Shape into a linear function type is required – logit transformation is favourable to make the function normal [3,18].

Now, consider the odds of having the outcome disease.

$$Odds = \frac{P(Y_i = 1)}{1 - P(Y_i = 1)} \tag{2}$$

This is the ratio between the probability of being in the state of interest over the probability of not being in the state.

$$\varphi_i = logit(Odds) = log\left[\frac{P(Y_i = 1)}{1 - P(Y_i = 1)}\right] \tag{3}$$

By substituting $P(Y_i = 1)$ in (1) into (3), it becomes

$$logit(Odds) = \beta_0 + \beta_i X_i + \mu \tag{4}$$

The β_i , which is the coefficient estimate could be interpreted as the effect of the predictor variable on the log-odds of being anaemic. In other words, it could mean the amount an increase (or decrease) of one unit in the predictor variable will produce as an expected increase (or decrease) in the log-odds of developing anaemia among children aged 6–59 months in Nigeria after adjusting for other covariates (in the case of multivariate analysis). The exponentiation of β_i gives the odds ratio. This refers to the amount one can multiply the probability of the outcome of interest occurring rather than not occurring [17].

Alternatively, we can convert the log-odds of the outcome of interest to the predicted probability of the outcome of interest for ease of interpretation [16,19] using:

$$Predicted\ probability\ (PP)\ \rho_i = \frac{e^{\varphi_i}}{1 + e^{\varphi_i}} \tag{5}$$

All computations were carried on Stata version 16 (College Station, TX: StataCorp LP) [20]. The units of analysis for this study are children (attached to the main individual respondent [i.e. mothers]), the weight proportion of v005/1,000,000 as formulated for Stata was used to account for under- and over-sampling. The listwise deletion technique in Stata is the default method of handling missing data in regression. This could apply since the missing mechanism was that of missing completely at random (MCAR). Thus, the mechanising of missing is not associated with the variables [3]. Any variables with >30% missing values were excluded from the analysis.

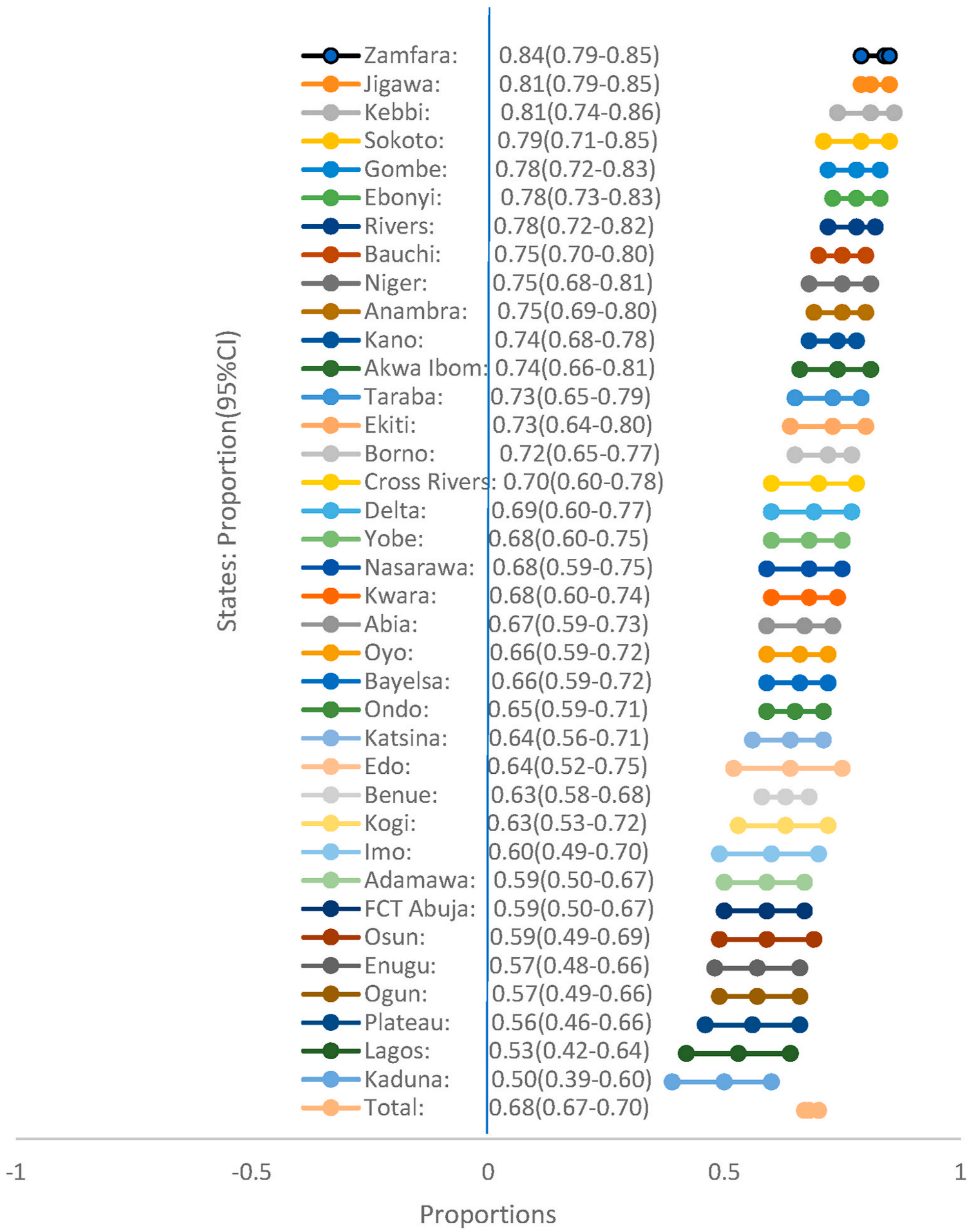

Fig. 2. Forest plot of the proportion of anaemic children aged 6–59 months in Nigeria by states. CI, confidence interval.

3. Results

3.1. Prevalence of anaemia

A total weighted sub-sample size of 10,222 children aged 6–59 months in Nigeria was reported in this study. The prevalence of anaemia in the sample was 68.1% (6962/10,222), while 31.9% (3260/10,222) were not anaemic. Fig. 2 shows the forest plot of the proportion of anaemic children of aged 6–59 months in Nigeria by states. Of the 36 states and FCT in Nigeria, Zamfara state had the highest proportion of anaemic children aged 6–59 months (84%; 95% confidence interval [CI]: 79–85), followed by Jigawa state (81%; 95% CI: 79–85). Lagos state (53%; 95% CI: 42–64) and Kaduna state (50%; 95% CI: 39–60) were the two states with the lowest proportion of anaemic children aged 6–59 months in Nigeria. In total, 59% (95% CI: 50–67) of children aged 6–59 months in the FCT were anaemic. So, by the WHO standard classification of anaemia prevalence, every state in Nigeria has severe anaemia status among children aged 6–59 months [21].

3.2. Univariate and Bivariate Analyses of Associations between Predictors and Anaemia Status

Table 2, 3 and 4 report the descriptive and Pearson's chi-square analyses of the association between the response and the predictor variables. Among the child-related predictors (Table 2), Pearson's chi-square analysis shows that there are strong statistically significant associations between the anaemia status of children aged 6–59 months in Nigeria and the age of the child, the gender, the birth order, duration of breastfeeding, the various comorbidities (fever, diarrhoea, acute respiratory diseases, malnutrition status and malaria status) and place of delivery. However, the perceived birth size of the child and intake of iron supplement in the 2 weeks before the survey were not statistically significantly associated with the anaemia status of children aged 6–59 months in Nigeria.

There were more children in the 43–59 months age group (28.5%) than in any other age group. Each of the four age groups had a proportion of more than 20% each. As the age of the children increased, the

Table 2
Univariate and bivariate analysis of associations between child-related predictors and anaemia status.

Child-Related Variables	Total	Anaemic status	
		No	Yes
	N (%)	N (%)	N (%)
Prevalence of Anaemia	10,222 (100)	3260 (31.9)	6962 (68.1)
Age of the child		Chi-square = 363.987	
	10,222 (100)	p < 0.001	
06–18 months	2819 (27.6)	573 (20.3)	2246(79.3)
19–30 months	2269(22.2)	623 (27.5)	1646 (72.5)
31–42 months	2215 (21.7)	843 (38.1)	1372(61.9)
43–59 months	2917 (28.5)	1220 (41.8)	1697 (58.2)
Sex		Chi-square = 11.8822	
	10,222 (100)	p = 0.0040	
Male	5230 (51.2)	1587 (30.3)	3643 (69.7)
Female	4992 (48.8)	1673 (33.5)	3318 (66.5)
Perceived birth size		Chi-square =8.2058	
	10,096 (98.8)	p = 0.0580	
Large	924 (9.2)	295 (31.9)	629 (68.1)
Average	7984 (78.7)	2582 (32.5)	5366 (67.5)
Small	1223 (12.1)	347 (28.4)	876 (71.6)
Ever had vaccination status		Chi-square = 13.1023	
	3302 (32.3)	p = 0.0035	
No	839 (25.4)	172 (20.5)	667 (79.5)
Yes	2462 (74.6)	659 (26.8)	1803 (73.2)
Birth order		Chi-square =51.80	
	10,222 (100)	p < 0.001	
1st order	1951 (19.1)	728 (37.3)	1223 (62.7)
2nd or 3rd order	3494 (34.2)	1142 (2.7)	2352 (67.3)
4th – 6th order	3223 (31.5)	978 (30.4)	2244 (69.6)
≥7th order	1553 (15.2)	411 (26.5)	1141 (73.5)
Duration of breastfeeding		Chi-square = 238.00	
	10,222 (100)	p < 0.001	
ever, but not currently	7467 (73.1)	2692 (36.0)	4775 (64.0)
never breastfed	171 (1.7)	61 (35.6)	110 (64.4)
still breastfeeding	2583 (25.3)	507 (19.6)	2076 (80.4)
Had diarrhoea in last 2 weeks		Chi-square = 41.5120	
	10,219 (99.9)	p < 0.001	
No	8865 (86.7)	2931 (33.1)	5933 (66.9)
Yes	1355 (13.3)	329 (24.3)	1025 (75.7)
Had fever in last 2 weeks		Chi-square = 123.29	
	10,219 (99.9)	p < 0.001	
No	7519 (73.6)	2630 (35.0)	4889 (65.0)
Yes	2701 (26.4)	630 (23.3)	2070 (76.7)
Had acute respiratory illness in past 2 weeks		Chi-square = 22.018	
	10,220 (100)	p < 0.001	
No	9610 (94.0)	3118 (32.4)	6492 (67.6)
Yes	610 (6.0)	141 (23.3)	4368 (76.7)
Took vitamin A supplements		Chi-square = 11.274	
	10,177 (99.6)	p = 0.0114	
No	5323 (52.3)	1618 (30.4)	3704 (69.6)
Yes	4854 (47.7)	1627 (33.5)	3227 (66.5)
Deworming treatment in the last 6 months		Chi-square = 48.453	
	10,169 (99.5)	p < 0.001	
No	7265 (71.4)	2169 (29.9)	5095 (70.1)
Yes	2905 (28.6)	1075 (37.0)	1830 (63.0)
Child took iron supplements		Chi-square = 2.8553	
	10,188 (99.7)	p = 0.1861	
No	8255 (81.0)	2604 (31.5)	5651 (68.5)
Yes	1973 (19.0)	648 (33.5)	1285 (66.5)
Nutritional status		Chi-square = 126.2	
	10,222 (100)	p < 0.001	
Well nourished	5705 (55.8)	2083 (36.5)	3622 (63.5)
Poorly nourished	4517 (44.2)	1177 (26.1)	3339 (73.9)
Stunting		Chi-square = 130.34	
	10,222 (100)	p < 0.001	
No	6304 (61.7)	2281 (36.2)	4023 (63.8)
Yes	3918 (38.3)	979 (25.0)	2938 (75.0)
Wasting		Chi-square = 41.30	
	10,222 (100)	p < 0.001	
No	9515 (93.1)	3112 (32.7)	6403 (67.3)

(continued on next page)

Table 2 (*continued*)

Child-Related Variables	Total	Anaemic status	
		No	Yes
	N (%)	N (%)	N (%)
Yes	707 (6.9)	148 (21.0)	558 (79.0)
Underweight		Chi-square = 124.98	
	10,222 (100)	p < 0.001	
No	7943 (77.7)	2753 (34.7)	5190 (65.3)
Yes	2278 (22.3)	507 (22.3)	1771 (77.7)
Overweight		Chi-square = 9.7556	
	10,222 (100)	p = 0.0157	
No	10,056 (98.4)	3189 (31.7)	6867 (68.3)
Yes	166 (1.6)	71 (43.1)	94 (56.9)
Malaria status (RDT)		Chi-square = 649.6	
	10,183 (99.6)	p < 0.001	
Negative	6566 (64.5)	2664 (40.6)	3902 (59.4)
Positive	3617 (35.5)	577 (16.0)	3040 (84.0)
Malaria status (blood smear)		Chi-square = 287.6	
	7445 (72.8)	p < 0.001	
No	5794 (77.8)	2121 (36.6)	3673 (63.4)
Yes	1651 (22.2)	239 (14.5)	1411 (85.5)
Place of delivery		Chi-square = 138.28	
	10,222 (100)	p < 0.001	
Home	5365 (38.2)	1459 (27.2)	3905 (72.8)
Public Health Facility	2987 (29.2)	1083 (36.2)	1906 (63.8)
Private Health Facility	1668 (16.3)	670 (40.2)	998 (59.8)
Somewhere else	200 (2.0)	48 (23.9)	152 (76.1)

Table 3
Univariate and bivariate analysis of associations between parental-related predictors and anaemia status.

Parental-related variables	Total	Anaemia status	
		No	Yes
	N (%)	N (%)	N (%)
Mother's age group		Chi-square = 34.615	
	10,222 (100)	p < 0.001	
15–24 years	2055 (20.1)	545 (26.5)	1509 (73.5)
25–34 years	5283 (51.7)	1737 (32.9)	3546 (67.1)
≥35 years	2884 (28.2)	977 (33.9)	1906 (66.1)
Mother's age at first birth		Chi-square = 116.26	
	10,222 (100)	p < 0.001	
10–19 years	5423 (53.1)	1492 (27.5)	3911 (72.5)
20–29 years	4386 (42.9)	1581 (36.0)	2805 (64.0)
≥30 years	411 (4.0)	186 (45.3)	225 (54.7)
Mother working status		Chi-square = 10.689	
	10,222 (100)	p = 0.0126	
Not working	2989 (29.2)	883 (29.5)	2106 (70.5)
Working	7232 (70.8)	2377 (32.9)	4855 (67.1)
Mother's educational status		Chi-square = 194.16	
	10,222 (100)	p < 0.001	
No education	3984 (39.0)	1000 (25.1)	2984 (74.9)
Primary education	1646 (16.10)	475 (28.9)	1171 (71.1)
Secondary & above	4592 (44.9)	1785 (38.9)	2806 (61.1)
		Chi-square = 0.9457	
Marital status	10,222 (100)	p = 0.6706	
never in union	171 (1.7)	51 (30.1)	119 (69.9)
in union	9767 (95.5)	3112 (31.9)	6655 (67.1)
widow/divorced/separated	284 (2.8)	97 (34.2)	187 (65.8)
Partner's educational status		Chi-square = 152.33	
	9637 (94.3)	p < 0.001	
No education	2884 (29.9)	686 (23.8)	2198 (76.2)
Primary education	1325 (14.8)	419 (29.4)	1006 (70.6)
Secondary education	5328 (55.3)	1967 (36.9)	3360 (63.1)
Father's occupation		Chi-square = 4.473	
	10,222 (100)	p = 0.1120	
Not working	305 (3.0)	80 (26.3)	225 (73.7)
Working	9916 (97.0)	3179 (32.1)	6736 (67.9)
Mother lives with a partner		Chi-square = 1.204	
	9767 (95.5)	p = 0.3892	
living with partner	8889 (91.0)	2817 (31.7)	6072 (68.3)
living alone	877 (9.0)	294 (33.5)	583 (66.5)

(*continued on next page*)

Table 3 (*continued*)

Parental-related variables	Total	Anaemia status	
		No	Yes
	N (%)	N (%)	N (%)
Mother slept under a mosquito net		Chi-square = 29.19	
	10,222 (100)	p < 0.001	
No	4684 (45.8)	1621 (34.6)	3063 (65.4)
Yes	5537 (54.2)	1639 (29.6)	3098 (70.4)
Mother's body weight index (kg/m^2)		Chi-square = 106.63	
	8763 (85.7)	p < 0.001	
Normal	5331 (60.8)	1591 (29.9)	3739 (70.1)
Underweight	888 (10.1)	211 (23.8)	676 (76.2)
Overweight	1670 (19.1)	636 (38.1)	1034 (61.9)
Obese	873 (10.0)	367 (42.0)	506 (58.0)
Preceding birth interval		Chi-square = 24.30	
	8252 (80.7)	p = 0.0009	
8–24 months	2196 (26.6)	657 (29.9)	1539 (70.1)
25–35 months	2895 (35.1)	840 (29.0)	2055 (71.0)
36–59 months	2363 (28.6)	724 (30.6)	1639 (69.4)
≥60 months	798 (9.7)	303 (38.0)	495 (62.0)
Mother's anaemia status		Chi-square = 245.14	
	10,090 (98.7)	p < 0.001	
Normal	4215 (41.8)	1707 (40.5)	2508 (59.5)
Anaemic	5874 (58.2)	1512 (25.7)	4363 (74.3)
Number of antenatal care visits		Chi-square = 55.655	
	6398 (62.6)	p < 0.001	
None	1344 (21.0)	300 (22.3)	1044 (77.7)
Less WHO recommendation	961 (15.0)	226 (23.5)	735 (76.5)
Met WHO recommendation	4092 (64.0)	1293 (31.6)	2799 (68.4)
Maternal autonomy		Chi-square = 44.075	
	10,222 (100)	p < 0.001	
Less autonomy	5082 (49.7)	1464 (28.8)	3618 (71.2)
more autonomy	5140 (50.3)	1796 (34.9)	3344 (65.1)
Maternal ethnicity		Chi-square = 66.778	
	10,222 (100)	p < 0.001	
Hausa/Fulani	4077 (39.9)	1157 (28.4)	2920 (71.6)
Ibos	1656 (16.2)	529 (31.9)	1127 (68.1)
Yoruba	1497 (14.6)	596 (39.8)	902 (60.2)
Others	2991 (29.3)	979 (32.7)	2013 (67.3)
Religious status		Chi-square = 41.0977	
	10,222 (100)	p < 0.001	
Catholic	1028 (10.1)	360 (35.0)	668 (65.0)
Other Christians	3458 (33.8)	1220 (35.3)	2239 (64.7)
Islam	5671 (55.5)	1658 (29.2)	4013 (70.8)
Others (traditional)	64 (6.0)	22 (34.8)	42 (65.2)
Mother's iron tabs during pregnancy		Chi-square = 10.135	
	6493 (63.5)	p = 0.0188	
No	1784 (27.5)	459 (25.7)	1324 (74.3)
Yes	4709 (72.5)	1401 (29.8)	3308 (70.2)

prevalence of anaemia decreased. There were more male (5230/10,222) than female (4992/10,222) children aged 6–59 months. Also, the prevalence of anaemia was higher among male (69.7%) than female (66.5%) children. Results in Table 2 also reveal that the proportion of anaemic children differed by the child's birth order. Children in the ≥7th birth order group were more likely to have anaemia (73.5%) than children in the other birth order groups. In total, 25.3% of children aged 6–59 months were still being breastfed, and >80% of these children were anaemic compared with 64.4% of children who had never been breastfed. Children delivered in health centres (whether a private health facility or public health facility) had a lower prevalence of being anaemic (59.8% and 63.8%, respectively) than those delivered at home (72.8%).

Table 3 shows the proportion of children aged 6–59 months in Nigeria who are suffering from anaemia in each category of the parental-related predictor variables. The mother's age, age at first birth, work status, educational level, body mass index, anaemia status, ante-natal care attendance, autonomy status, ethnicity and religious status were significantly associated with anaemia in children aged 6–59 months in Nigeria. Other parental-related variables considered were paternal education and work statuses. Paternal work status, mother's marital status and mother living with a partner were not statistically significantly associated with the anaemia status of children aged 6–59 months in Nigeria.

The majority of children aged 6–59 months in Nigeria were born to mothers in the 25–34 years age group (51.7%). However, the prevalence of anaemia was highest among children of mothers aged 15–34 years (73.5%). In fact, as the age group of the mother increased, the prevalence of anaemia decreased. In total, 53.1% (5423/10,222) of children aged 6–59 months were born to mothers who had their first baby between 10 and 19 years of age. Of these children, 72.5% were anaemic; whereas, for mothers who had their first birth aged ≥30 years, only 54.7% of their children were anaemic. The prevalence of anaemia among children aged 6–59 months in Nigeria decreased significantly with an increase in the mother's educational level.

In total, 58.2% (5874/10,222) of children aged 6–59 months in Nigeria were born to anaemic mothers; of these children, 74.3% were anaemic. For mothers who were not anaemic (41.8%), 59.5% of their children were anaemic. In terms of maternal ethnicity, 40% of the children in this study were born to Hausa/Fulani mothers, 16% to Ibos mothers, 14.6% to Yoruba mothers and 29% to mothers from other minority ethnic groups. Among the children of Hausa/Fulani mothers, over 71% were anaemic, followed by children of Ibos mothers (68% of children were anaemic), other ethnic minorities mothers (67% of

Table 4
Univariate and bivariate analysis of associations between household and area-related predictors, and anaemia status.

Household and area-related variables	Total	Anaemia status	
		No	Yes
	N (%)	N (%)	N (%)
Wealth status		Chi-square = 391.21	
	10,222 (100)	p < 0.001	
Poorest	1898 (18.6)	366 (19.3)	1532 (80.7)
Poor	1994 (19.5)	499(25.0)	1495 (75.0)
Middle	2151 (21.0)	718 (33.4)	1433 (66.6)
Rich	2154 (21.1)	731 (33.9)	1423 (66.1)
Richest	2023 (19.8)	945 (46.7)	1078 (53.3)
The household has a mosquito bed net		Chi-square = 18.217	
	10,222 (100)	p = 0.0015	
No	3123 (30.6)	1089 (34.9)	2034 (65.1)
Yes	7098 (69.4)	2171 (30.6)	4927 (69.4)
Household size		Chi-square = 32.078	
	10,222 (100)	p = 0.0006	
0-3 persons	982 (9.6)	329 (33.5)	653 (66.5)
4-6 persons	4851 (47.5)	1651 (34.0)	3200 (66.0)
7-9 persons	2472 (24.2)	758 (30.7)	1714 (69.3)
≥10 persons	1917 (18.8)	522 (27.2)	1394 (72.8)
Number of rooms for sleeping		Chi-square = 1.2757	
	10,222 (100)	p = 0.9405	
1 room	2813 (27.5)	894 (31.8)	1919 (68.2)
2 rooms	3498 (34.2)	1114 (31.9)	2383 (68.1)
3 rooms	2043 (20.0)	666 (32.6)	1378 (67.4)
4 rooms	988 (9.7)	317(32.1)	671 (67.9)
≥5 rooms	878 (8.6)	267 (30.5)	610 (69.5)
Number of children Under-5 years in the household		Chi-square = 73.199	
	10,222 (100)	p < 0.001	
None or 1 child	2716 (26.6)	950 (35.0)	1766 (65.0)
Two children	4326 (42.3)	1402 (34.3)	2844 (65.7)
Three children	2056 (20.1)	547 (26.6)	1510 (73.4)
Four children+	1123 (11.0)	282 (25.1)	842 (74.9)
Source of drinking water		Chi-square = 63.725	
	10,222 (100)	p < 0.001	
Unimproved	3095 (30.3)	814 (26.3)	2281 (73.7)
Improved	7127 (69.7)	2446 (34.3)	4680 (65.7)
Type of toilet facilities		Chi-square = 169.71	
	10,222 (100)	p < 0.001	
Unimproved	4622 (45.2)	1168 (25.3)	3454 (74.7)
Improved	5600 (54.8)	2092 (37.4)	3508 (62.6)
Youngest child's stool disposal		Chi-square = 0.0153	
	6436 (63.0)	p = 0.9200	
Proper	3621 (56.3)	1032 (28.5)	2590 (71.5)
Improper	2815 (43.7)	806 (28.6)	2009 (71.4)
Type of floor material		Chi-square = 152.06	
	10,222 (100)	p < 0.001	
Unimproved	2885 (28.2)	658 (22.8)	2227 (77.2)
Improved	7337 (71.8)	2602 (35.5)	4735 (64.5)
Type of roofing materials		Chi-square = 51.2785	
	10,222 (100)	p < 0.001	
Unimproved	1132 (11.1)	255 (22.5)	877 (77.5)
Improved	9090 (88.9)	3005 (33.1)	6084 (66.9)
Type of wall materials		Chi-square = 175.316	
	10,222 (100)	p < 0.001	
Unimproved	3282 (32.1)	755 (23.0)	2527 (77.0)
Improved	6940 (67.9)	2505 (36.1)	4434 (63.9)
Sex of household head		Chi-square = 0.7888	
	10,222 (100)	p = 0.4591	
Male	9127 (89.3)	2898 (31.8)	6229 (68.2)
Female	1095 (10.7)	362 (33.1)	733 (66.9)
Household head age group		Chi-square = 3.478	
	10,222 (100)	p = 0.5367	
>34 years	2838 (27.8)	873 (30.8)	1965 (69.2)
35–44 years	3959 (38.7)	1301 (32.9)	2658 (67.1)
45–55 years	2100 (20.5)	664 (31.6)	1436 (68.4)
≥56 years	1324 (13.0)	421 (31.8)	903 (68.2)
Shared toilet with other households		Chi-square = 0.1094	
	7756 (75.9)	p = 0.8216	

(*continued on next page*)

Table 4 (*continued*)

Household and area-related variables	Total	Anaemia status	
		No	Yes
	N (%)	N (%)	N (%)
No	4781 (61.6)	1624 (34.0)	3157 (66.0)
Yes	2975 (38.4)	1000 (33.6)	1076 (66.4)
Household had electricity		Chi-square = 217.23	
	10103 (98.8)	p < 0.001	
No	4310 (42.7)	1033 (24.0)	3277 (76.0)
Yes	5793 (57.3)	2193 (37.9)	3600 (62.1)
Type of cooking fuel		Chi-square = 205.47	
	10219 (99.9)	p < 0.001	
Electricity & Gas	1213 (11.9)	606 (49.9)	607 (50.1)
Biofuel/mass	9006 (88.1)	2653 (29.5)	6352 (70.5)
Under-5 slept under bed net		Chi-square = 48.145	
	10,149 (99.3)	p < 0.001	
No child	1320 (13.0)	426 (32.3)	894 (67.7)
All children	4734 (46.6)	1497 (31.6)	3236 (68.4)
Some children	999 (9.8)	229 (22.9)	771 (77.1)
No net in the house	3096 (30.5)	1073 (34.7)	2023 (65.3)
Region of residence		Chi-square = 74.7329	
	10,222 (100)	p < 0.001	
North central	1437 (14.1)	483 (33.6)	954 (66.4)
North east	1589 (15.5)	461(29.0)	1127 (71.0)
North west	2972 (29.1)	891 (30.0)	2081 (70.0)
South east	1334 (13.1)	406 (30.4)	928 (69.6)
South south	1886 (10.6)	301 (27.7)	786 (72.3)
South west	1802 (17.6)	718 (39.8)	1085 (60.2)
Type of Place of Residence		Chi-square = 126.24	
	10,222 (100)	p < 0.001	
Urban	4494 (44.0)	1697 (37.8)	2796 (62.2)
Rural	5727 (56.0)	1563 (27.3)	4164 (72.7)
State Human Development Index (SHDI)		Chi-square 79.553	
	10,222 (100)	p < 0.001	
Lowest SHDI	2157 (21.1)	601 (27.8)	1556 (72.2)
Low SHDI	2420 (23.7)	717 (29.6)	1702 (70.4)
Average SHDI	2239 (21.9)	719 (32.1)	1520 (68.9)
High SHDI	2690 (26.3)	903 (33.6)	1787 (66.4)
Highest SHDI	715 (7.0)	320 (44.8)	395 (55.2)
State Multidimensional Poverty Index (SMPI)		Chi-square 96.03	
	10222 (100)	p < 0.001	
Highly deprived SMPI	849 (8.3)	200 (23.6)	649 (76.4)
Above average deprived SMPI	3103 (30.4)	853 (27.5)	2250 (72.5)
Average deprived SMPI	2327 (22.8)	763 (32.8)	1563 (67.2)
Mildly deprived SMPI	1950 (19.1)	706 (36.2)	1244 (63.8)
Lowest deprived SMPI	1992 (19.5)	737 (37.0)	1254 (63.0)

children were anaemic) and Yoruba mothers had children with the lowest prevalence (60% of children were anaemic). Table 3 also reports that more children of Muslim mothers were anaemic than children from t other religious groups; 71% of children of Muslim mothers were anaemic compared with 65% of children of Catholic mothers, 64.7% of children of other Christian mothers and 65.2% of children of traditionalist mothers.

Household and area-related variables are other important factors for consideration. Table 4 reveals that household wealth status, whether the household had a mosquito bed net, the household size, the number of under-five years children in the household, under-five slept under a bed net, the region of residence, the place of residence, the state HDI and the state MPI were statistically significantly related to the anaemia status of children aged 6–59 months in Nigeria. However, the number of rooms for sleeping, the proper disposal of the youngest child's stool, the sex and age group of the household head, and the household sharing toilet facilities with other households were not statistically significantly associated with anaemia status of children aged 6–59 months in Nigeria.

Table 4 shows that the anaemia status of children aged 6–59 months in Nigeria varies by the household wealth. The household wealth is a proxy to the household socioeconomic status (SES). The anaemic status of children aged 6–59 months in Nigeria is inversely proportional to the level of the SES. The higher the SES, the lower the prevalence of anaemia. In total, 80.7%, 75%, 66.6%, 66.1% and 53.3% of children aged 6–59 months in Nigeria from the poorest, poor, middle, rich and richest households were anaemic, respectively. As the number of under-five children in the household increased, the prevalence of anaemia in children aged 6–59 months also increased.

An additional important factor to consider is the place of residence. There were more children from rural areas (56%) than urban areas (44%) considered in this analysis. The prevalence of anaemia among children aged 6–59 months from rural areas (73%) was higher than their counterparts in the urban areas (62%). In terms of state HDI, the prevalence of anaemia among children aged 6–59 months in Nigeria decreased as the level of state HDI increased. The prevalence of anaemia n the lowest, low, average, high and highest state HDIs was 72%, 70%, 69%, 66% and 55%, respectively. Also, the prevalence anaemia in children aged 6–59 months in Nigeria varied with the level of the state MPI. For example, children from a state with a highly deprived MPI had a prevalence of anaemia of 76%, followed by children from a state that is above average highly deprived in state MPI (72.5%) and the lowest prevalence was found among children from a state in the lowest deprived in state MPI (63%).

Table 5
Risk factor and predicted probability of anaemia status of children aged 6–59 months in Nigeria form a multiple logistic regression model (N = 6506).

Predictor Variables	AOR[a] (95% CI)	p-Value	APP (95% CI)	At sample means[b]
Child				
Sex of the child				
Male	1		0.745 (0.721–0.769)	0.515
Female	0.88 (0.670–1.153)	0.352	0.711 (0.685–0.736)	0.484
Age of the child				
6–18 months	1		0.829 (0.800–0.858)	0.310
19–30 months	0.68 (0.493–0.948)	0.022	0.767 (0.735–0.799)	0.207
31–42 months	0.43 (0.305–0.601)	<0.001	0.653 (0.615–0.692)	0.215
43–59 months	0.32 (0.229–0.438)	<0.001	0.606 (0.568–0.644)	0.268
Duration of breastfeeding				
ever breastfed, not currently breastfeeding	1		0.720 (0.694–0.745)	0.687
never breastfed	0.77 (0.460–1.302)	0.334	0.665 (0.550–0.781)	0.016
still breastfeeding	1.18 (0.913–1.514)	0.210	0.751 (0.713–0.790)	0.297
Had fever in last 2 weeks				
No	1		0.722 (0.699–0.745)	0.734
Yes	1.13 (0.954–1.348)	0.152	0.747 (0.716–0.777)	0.266
The child had an acute respiratory illness in the past 2 weeks				
No	1		0.725 (0.704–0.746)	0.941
Yes	1.35 (0.985–1.848)	0.062	0.781 (0.727–0.834)	0.059
Iron pill/syrup consumption				
No	1		0.723 (0.701–0.745)	0.812
Yes	1.17 (0.955–1.430)	0.130	0.753 (0.716–0.790)	0.188
Deworming in the last 6 months				
No	1		0.736 (0.714–0.758)	0.724
Yes	0.86 (0.723–1.060)	0.171	0.709 (0.673–0.745)	0.276
Nutritional Status				
Well nourished	1		0.707 (0.683–0.732)	0.556
Poorly nourished	1.27 (1.085–1.486)	0.003	0.754 (0.728–0.780)	0.443
Malaria status (RDT)				
Negative	1		0.633 (0.607–0.659)	0.646
Positive	3.51 (2.938–4.185)	<0.001	0.858 (0.838–0.878)	0.353
Interaction of sex & age				
Male*6–18 months			0.838 (0.804–0.871)	
Male*19–30 months			0.779 (0.741–0.818)	
Male*31–42 months			0.688 (0.641–0.736)	
Male*43–59 months			0.620 (0.572–0.669)	
Female*6–18 months			0.819 (0.782–0.856)	
Female*19–30 months	0.99 (0.666–1.460)	0.944	0.754 (0.709–0.798)	
Female*31–42 months	0.82 (0.556–1.208)	0.314	0.614 (0.564–0.665)	
Female*43–59 months	1.00 (0.703–1.433)	0.982	0.591 (0.542–0.639)	
Parental				
Mother's age group				
15–24 years	1		0.754 (0.705–0.804)	0.108
25–34 years	0.88 (0.665–1.159)	0.357	0.729 (0.705–0.753)	0.540
≥35 years	0.84 (0.619–1.134)	0.253	0.720 (0.690–0.750)	0.352
Mother's educational status				
No education	1		0.748 (0.719–0.777)	0.408
Primary education	1.03 (0.601–1.765)	0.914	0.753 (0.708–0.797)	0.174
Secondary & above	0.61 (0.360–1.017)	0.058	0.698 (0.659–0.737)	0.418
Paternal's educational status				
No education	1		0.733 (0.690–0.776)	0.311
Primary education	0.78 (0.513–1.180)	0.238	0.717 (0.676–0.759)	0.158
Secondary and above	0.85 (0.628–1.161)	0.313	0.730 (0.704–0.755)	0.531
Mother's body weight index (kg/m^2)				
Normal	1		0.730 (0.706–0.754)	0.604
Underweight	1.14 (0.902–1.451)	0.268	0.756 (0.714–0.798)	0.101
Overweight	0.88 (0.728–1.071)	0.206	0.705 (0.666–0.744)	0.192
Obese	1.03 (0.789–1.345)	0.826	0.736 (0.688–0.784)	0.103
Mother's anaemia status				
Normal	1		0.667 (0.638–0.696)	0.424
Anaemic	1.66 (1.440–1.912)	<0.001	0.769 (0.748–0.790)	0.576
Maternal Autonomy				
Less autonomy	1		0.737 (0.710–0.763)	0.517
More autonomy	0.92 (0.770–1.100)	0.357	0.720 (0.693–0.748)	0.483
Religious status				
Catholic	1		0.671 (0.609–0.734)	0.098
Other Christians	1.15 (0.866–1.516)	0.340	0.701 (0.664–0.738)	0.322
Islam	1.50 (1.056–2.133)	0.023	0.754 (0.724–0.784)	0.573
Others (traditional)	0.60 (0.274–1.307)	0.197	0.550 (0.365–0.735)	0.006
Preceding Birth Interval				
8–24 months	1		0.753 (0.724–0.783)	0.259
25–35 months	0.87 (0.724–1.048)	0.144	0.727 (0.699–0.755)	0.356
36–59 months	0.85 (0.701–1.031)	0.100	0.722 (0.694–0.751)	0.287

(*continued on next page*)

Table 5 (*continued*)

Predictor Variables	AOR[a] (95% CI)	p-Value	APP (95% CI)	At sample means[b]
≥60 months	0.71 (0.549–0.913)	0.008	0.684 (0.634–0.734)	0.098
Interactions of Maternal & Paternal Educational Levels				
no education & no education			0.771 (0.731–0.811)	
no education & primary			0.724 (0.656–0.792)	
no education & secondary+			0.742 (0.699–0.785)	
primary & no education			0.776 (0.695–0.857)	
primary & primary	0.91 (0.440–1.878)	0.797	0.711 (0.647–0.774)	
primary & secondary+	1.02 (0.538–1.914)	0.963	0.750 (0.692–0.809)	
secondary+ & no education			0.670 (0.569–0.772)	
secondary+ & primary	1.58 (0.792–3.137)	0.194	0.714 (0.644–0.784)	
secondary+ & secondary+	1.40 (0.799–2.442)	0.241	0.708 (0.675–0.741)	
Household and area				
Wealth status				
Poorest	1		0.775 (0.731–0.819)	0.192
Poor	0.92 (0.696–1.216)	0.559	0.760 (0.724–0.796)	0.193
Middle	0.72 (0.546–0.961)	0.026	0.714 (0.683–0.745)	0.209
Rich	0.75 (0.553–1.014)	0.062	0.721 (0.685–0.757)	0.217
Richest	0.58 (0.415–0.816)	0.002	0.667 (0.622–0.713)	0.190
Household size				
0–3 persons	1		0.642 (0.554–0.730)	0.036
4–6 persons	1.52 (1.026–2.260)	0.037	0.732 (0.706–0.758)	0.474
7–9 persons	1.41 (0.949–2.110)	0.089	0.717 (0.686–0.749)	0.277
≥10 persons	1.66 (1.089–2.541)	0.019	0.749 (0.712–0.786)	0.214
Under-five slept under a bed net				
No under-five	1		0.736 (0.695–0.777)	0.131
All children	0.97 (0.774–1.202)	0.748	0.729 (0.704–0.754)	0.454
Some children	1.32 (0.990–1.775)	0.059	0.787 (0.749–0.825)	0.115
No net in household	0.84 (0.653–1.073)	0.160	0.700 (0.667–0.733)	0.300
Region of residence				
North central	1		0.744 (0.701–0.787)	0.141
North east	0.64 (0.434–0.936)	0.022	0.649 (0.588–0.711)	0.161
North west	0.39 (0.258–0.574)	<0.001	0.528 (0.460–0.596)	0.295
South east	2.26 (1.623–3.147)	<0.001	0.868 (0.829–0.906)	0.128
South south	3.32 (2.336–4.707)	<0.001	0.906 (0.875–0.937)	0.100
South west	1.35 (0.967–1.874)	0.079	0.796 (0.746–0.846)	0.174
State Human Development Index (SHDI)				
Lowest SHDI	1		0.690 (0.631–0.749)	0.213
Low SHDI	1.53 (1.148–2.029)	0.004	0.773 (0.730–0.815)	0.247
Average SHDI	1.42 (0.975–2.054)	0.068	0.759 (0.722–0.796)	0.214
High SHDI	0.99 (0.656–1.497)	0.966	0.688 (0.641–0.736)	0.259
Highest SHDI	1.17 (0.625–1.199)	0.619	0.723 (0.622–0.825)	0.067
State Multidimensional Poverty Index (SMPI)				
Highly Deprived	1		0.790 (0.734–0.845)	0.085
Above average Deprived	0.90 (0.660–1.229)	0.510	0.772 (0.731–0.812)	0.309
Average Deprived	0.58 (0.387–0.863)	0.007	0.685 (0.643–0.726)	0.230
Mildly Deprived	0.55 (0.343–0.869)	0.011	0.672 (0.622–0.722)	0.188
Lowest deprived	0.72 (0.421–1.221)	0.221	0.729 (0.666–0.793)	0.188

AOR, Adjusted Odds Ratio; APP, Adjusted Predicted Probability; CI=Confidence Intervals; RDT, rapid diagnostic test.

[a] AOR – Adjusted odds ratio estimate for variables from multiple logistic regression adjusted for all the other 24 variables (these include 23 unique predictors, and two other interaction variables) in the model.

[b] The 'at sample means' column contains the proportion of the sample with that variable characteristic.

3.3. Predictors of anaemia status

This section presents the results of the predicted probabilities of a child aged 6–59 months in Nigeria having anaemia. Variables that were found to be associated with anaemia in children aged 6–59 months in Nigeria with chi-square ($p < 0.05$) were subjected to variable selection method. The backward stepwise selection method was then used at $p < 0.20$ [3,22,23] to select potential variables that are predictors of anaemia. In total, 24 variables were included in the multiple logistic regression model. The child-related factors included child's age, sex, malaria status, nutritional status, fever, acute respiratory infection status, duration of breastfeeding, deworming and child took iron pills/-syrup. The paternal-related factors were preceding birth interval, maternal religious status, age group, educational status, body mass index, anaemia status, autonomy level and paternal education status. Also included were household socioeconomic status (wealth quintile index), household size, if the household had a bed net, under-five slept under the bed net the night before the survey, household region of residence, the state MPI and the state HDI.

3.4. Test of multicollinearity and goodness of fit

A multicollinearity test was performed to check for the existence of a high correlation among the predictor variables. Two variables, 'household had bed net' and 'under-five years slept under bed net last night', were perfectly correlated ($r = 1.00$) and had a variance inflation factor (VIF) of 11.13 and 7.04, respectively. The mean VIF was 2.17. The variable 'household had bed net' was dropped and the new VIF ranged from 1.02 to 3.35, with a mean VIF of 1.17. Another variable, 'frequency of mother watching television', which was a significant predictor of anaemia in children aged 6–59 months in Nigeria was dropped from the model because one of the responses provided on the questionnaire appears not to be properly worded (watching television 'less than once a week') and could have resulted in participants selecting the incorrect response. The model was therefore fitted, while including the remaining potential predictors, using survey logistic regression design to account

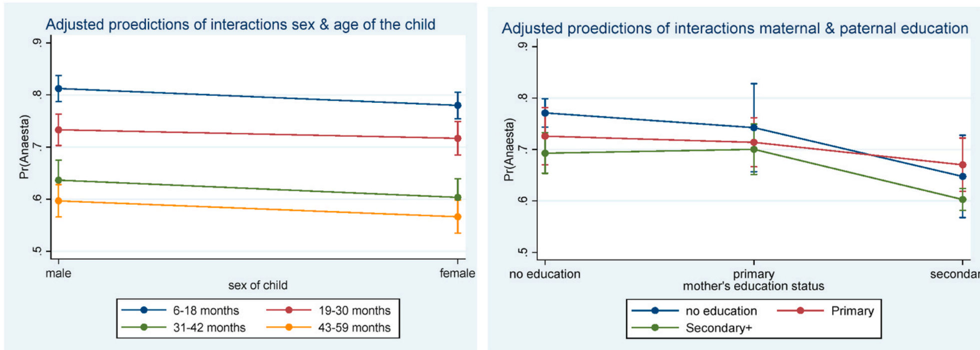

Fig. 3. Margin plots for interactions terms and anaemia status from unadjusted predicted probability: (a) child's age and sex and (b) paternal & maternal educational levels.

for both under- and over-sampling [24]. A test statistic for the goodness of fit was carried out using a method that takes into consideration the survey design estimate as proposed by Archer and Lemeshow [25], to compute F-adjusted mean residual goodness of fit of 1.285 and Prob > F = 0.240, suggesting that there is no statistically significant evidence to conclude no good fit. The final model was adjusted for 23 variables, including: child's sex, age, malaria status, nutritional status, fever, acute respiratory infection status, duration of breastfeeding, deworming, child's intake of iron pills/syrup; preceding birth interval, maternal religious status, age group, educational status, body mass index, anaemia status, autonomy level, paternal education status; household socioeconomic status (wealth quintile index), household size, under-five slept under bed net last, household region of residence, the state MPI and the state HDI.

Table 5 presents the results of the multiple logistic regression model to predict anaemia status in the study sample. In total, 23 risk factors or predictor variables were included in the model and Table 5 reports the adjusted odds ratios (AORs) and the adjusted predicted probabilities (APPs) of the included variables (the odds ratios and predicted probabilities for each risk factor are adjusted for the other 22 variables in the model). The 'at sample means' column is simply the proportion in the sample with that attribute or characteristic [26]. For example, for the sex of the child variables, 0.516 or 51.6% of the sample were male and 0.484 or 48.4% were female.

However, for interpretation, the APPs were used because they were potentially simpler to understand than coefficient estimates or AORs [16]. The APP represents the probability of an 'average' or 'typical' child in the sample having anaemia given they have the 'average' sample values of the risk factors or predictor variables. Strictly speaking, there is no such thing as an 'average' child in the study sample as you cannot be 51.6% male, this helps with the interpretation of results (a common practice, but not general [16]). The APPs tell us that if we have two otherwise-average children, one male and one female, that an 'average' female child has a lower predicted probability of being anaemic compared with their male counterpart (0.711 vs 0.745), with over 3% points lower holding other predictors constant at their means. What do we mean by 'average'? The average is defined as having the mean value of the other independent variables in the model, that is 31% aged 6–18 months, 20.7% aged 19–30 months, 21.5% aged 31–42 months, 26.8% aged 43–59 months, 68.7% had been breastfed, but were not currently breastfeeding, 1.6% had never breastfed, and 29.7% were still being breastfed at the time of the survey. Thus, the predicted probabilities show us how the average female child compares with the average male child, where the average is defined as having the mean values (or proportions with the characteristic) on all the other variables in the model.

The predicted probabilities for an average child who reported having fever 2 weeks before the survey (72.2%), had an acute respiratory illness in the past 2 weeks (72.5%), was poorly nourished (70.9%), diagnosed with *malaria parasitaemia* (75.3%), of having anaemia were higher than an average child who did not have any of these morbidities with over 3.0%, 2.2%, 2.7% and −3.0%, respectively, while other predictors were respectively held constant at their means. Concerning the interaction terms of child's gender and age groups, the predicted probability of an average male child (0.515) varied decreasingly as the age group increased. The same can be said of an average female child whose mean is set at 0.484, the predicted probability varied decreasingly from 83.8% points to 62.9% points. However, the average female's variations compared with that of an average male child were correspondingly lower across the age groups.

Another group of predictors reported in Table 5 are parental-related factors. The predicted probabilities of being anaemic for child of an average mother who is aged 15–24 years, 25–34 years and ≥35 years is 75.4%, 72.9% and 72.0%, respectively, and whose other covariates are held constant at their means. Also, a child of an average mother who has no education (74.8%) has a slight increase in the predicted probability than a child of an average mother who holds a primary education (75.3%) while holding other variables constant at their respective mean. Furthermore, a child of an average father who had primary education has a predicted probability of anaemia with 1.6% points lower than a child of an average father who had no education, and 1.3% points higher for a child of an average father who had secondary education and above. A child of an average anaemic mother has a predicted probability of 76.9% of being anaemic compared with a child of an average mother who has a normal Hb level, with a predicted probability of 66.7% when the values of other covariates are constant at their respective means. Table 5 further reveals that a child of an average mother who has more autonomy is less likely to be anaemic, with a predicted probability of 72.0%, compared with 73.7% for a child of an average mother who is less autonomous holding other predictors constant at their means. The predicted probability of being anaemic is higher for a child of an average mother whose religious affiliation is Islam compared to other religious groups. The higher an average mother's preceding birth interval, the lower the predicted probability of the child being anaemic at constant means of other predictors.

Wealth index, which is a proxy for household SES, is an important predictor considered in this analysis. A child aged 6–59 months in Nigeria from an average poorest household has the predicted probability of 1.16 times more likely of being anaemic compared with a child from an average richest quintile household wealth. Children aged 6–59 months in Nigeria have varied degrees of predicted probability of being anaemic from as low as 52.8% in the North-West geopolitical zone to as high as 90.6% in South-South geopolitical zone, with other predictors held constant at their means. Also, the findings in Table 5 shows that an average child aged 6–59 months from a state in Nigeria with the lowest, low, average, high and highest HDI has a predicted probability of being anaemic of 69.0%, 77.3%, 75.9%, 68.8% and 72.3%, respectively, when other predictors are held constant at their means. Lastly, the results show that an average child from a state that is mildly deprived in the

MPI has the lowest predicted probability of 67.2% of being anaemic compared with an average child from a state that is highly deprived in the MPI, with a predicted probability of being anaemic of 79.0%, when other independent variables are constant at their means.

Concerning the interaction terms of a child's gender and age groups, the predicted probability of a male child being anaemic decreases varyingly as age group increases. The same can be said that the predicted probability of a female child decreases varyingly across the age groups. However, the variations in females compared with males are correspondingly lower across the age groups (Fig. 3a). Children of parents whose father has secondary education and above, and the mother is at any level of educational status have correspondingly lower predicted probabilities of being anaemic compared with children whose father either has 'no' or 'primary' education, and the mother is at any level of educational status. In addition, the predicted probability of a child aged 6–59 months in Nigeria whose father has no education and whose mother has secondary education and above is lower than that of the child whose father has primary education and whose mother has a secondary education and above (Fig. 3b).

4. Discussion

This study aimed to determine the prevalence of anaemia in children aged 6–59 months in Nigeria. In addition, the predicted probability of anaemia in children aged 6–59 months in Nigeria was calculated based on child-, parental- household and area-related factors.

The prevalence of anaemia is very high in all states of Nigeria, including the FCT, resulting in the country being a severe anaemic nation [21]. This is comparable to most other countries in SSA [6]. After adjustment for all covariates having significant goodness of fit from a backward stepwise logistic regression, the child-related variables that are significant predictors of anaemia status among children aged 6–59 months in Nigeria include age, sex, duration of breastfeeding, deworming status, intake of iron pills/syrup, comorbidities of malaria, malnutrition, fever and acute respiratory infection.

The distribution of the predicted probabilities of being anaemic among children aged 6–59 months in Nigeria across all included predictors were lowest and highest among the geographical variables, with 0.528 and 0.906 for the North-West and South-South regions, respectively.

The predicted probability of anaemia was found to be inversely proportional to age group; the older the age group, the lower the predicted probability. This result is consistent with a similar finding by Reithinger et al. [27]. A possible reason for this finding is that in the developing countries where foods are served and eaten in a communal form, as the child gets older they have more scavenging power to get more food than younger siblings who often depend on breast milk, which lacks adequate nutrients.

Female children are less likely to be anaemic than male children, which corroborates with findings by Reithinger et al. [27] and Nkulikiyinka et al. [28]. A possible reason for this result is that in Africa, female children are often closer to their mothers in the kitchen than their male counterparts and, therefore, often have increased access to food when it is being cooked.

Children who have never been breastfed have a lower predicted probability of being anaemic than those who were breastfed and those who are still being breastfed. This result is similar to findings in Mohammed et al. [12]. This may relate to the fact that, in this study, there is a high prevalence of anaemic mothers, so most breast milk lacks the adequate nutrients for the breast-feeding child [29,30].

Children who have comorbidities (e.g. malnutrition, fever, malaria fever and acute respiratory infection) were found to be more likely to be anaemic than those who did not have any comorbidities. These findings are consistent with studies of malnutrition [31], malaria [32,33], fever [10,34] and diarrhoea [10,34–36]. As expected, taking iron supplements reduced the predicted probability of anaemia; however, this is contrary to the conclusions reached by Mohammed et al. [12].

Deworming children did not result in the child being less likely to have anaemia, which is similar to findings from previous studies [12,35].

Additionally, the current study found a significant interaction between the sex and age of the child. Across the nexus of child's age, female children were found to be corresponding less likely to be anaemic than male children. This may be connected with the fact that, at an early age, male children grow faster than female children, and therefore depletes Hb more rapidly [23].

In terms of parental-related predictors, children of older mothers were less likely to be anaemic in Nigeria, which is similar to results from previous studies [10,13,37]. Also, as the maternal education level increases, the predicted probability of the children being anaemic decreases. The significance of the interaction effects of both parent's educational level signified the relevance of educational level as a predictor of anaemia status of children aged 6–59 months [3], which agrees with the findings by Nambiema et al. [31].

A child from the richest household wealth quintile has the lowest predicted probability of being anaemic compared with children from other household wealth quintiles. The current study also established that the wealthier a household is, the less anaemic the children will be; this finding agrees with previous studies [10,12,38]. Wealthier households can afford basic healthcare services, good food and other household amenities that were the proxies for the construction of the wealth index for good living conditions [3]. Contrary to expectations, the current study revealed that children from homes without a bed net have a lower predicted probability of anaemia compared with homes where some children under-five years slept under a bed net. Furthermore, regional differences in the predicted probabilities of anaemia among children aged 6–59 months were reported to be higher in southern Nigeria (mostly agricultural) than in northern Nigeria (mostly pastoral). This finding is contrary to Mohammed et al. [12], who reported that children from the pastoral region have lower Hb levels than children in the agricultural region due to the high prevalence of malaria in the pastoral region [12,39]. Of the six geo-political regions, South-South has the highest predicted probability of anaemia, while North-West has the lowest. This finding is consistent with that of a previous study [40], but inconsistent with another recent study [14], probably because the recent study used a slightly different classification for anaemia among children aged 6–59 months in Nigeria.

5. Strength and limitations

The 2018 NDHS was the main data set for this study and was the first of the past six surveys in Nigeria to capture data for blood Hb concentration in children and mothers. The current study is among limited research that has used the classical regression analysis approach. This study used predicted probabilities to provide an easier approach to interpret the results of the relationships between the predictors and the outcome variable, instead of the seemingly difficult to understand log-odds and odd ratios.

There are several limitations in the current study that are worth noting. Firstly, as this study uses a cross-sectional data set, causal effects of the independent variables on the dependent variables could not be determined. Secondly, a single-level regression model was used. The initial check for random effect variations across the clusters (states of origin) in a two-level model showed that intraclass correlation was negligible (3.8%) compared with the standard threshold of 5% [41], so this study could not use multilevel logistic regression. Sensitivity analysis was not performed to justify the use of the single-level regression model. It is possible that the hierarchical effect could have been ignored in this study when the states and FCT were used as clusters.

6. Conclusions

This study has revealed the enormous severity of anaemia among children aged 6–59 months in Nigeria. The status of under-five years anaemia in Nigeria continues to increase. This is an indication of a serious public health problem in the country. The consequences of this could be daunting, putting the lives of this young generation at risk of mental, reduced cognitive development, poor social, academic and working inability as they grow older [21,40]. There has been a paucity of studies on anaemia in Nigeria; however, these are essential to provide data for informed decision making in public health strategies. The lack of research may relate to the fact that data on micronutrient deficiencies and blood Hb concentrations have only recently been captured in a nationally representative survey [21,42]. In addition, political commitment to address the problems of anaemia in children has been limited. For example, the National Policy on Food and Nutrition in Nigeria includes a target to reduce maternal anaemia during pregnancy by 27% between 2013 and 2025; however, there is no mention of any specific target for childhood anaemia in Nigeria [42].

To address anaemia among children under-five years of age in Nigeria, a multidimensional approach is required, including research to establish how the contributing factors are distributed across the population and identify the at-risk population groups. The current study contributes to this area of knowledge and public health policies should target the identified areas of concern. Iron deficiency anaemia has been identified in developing countries to be responsible for >50% of anaemia cases. This low blood Hb concentration has predisposing causes, indicating the co-existence of anaemia with other diseases in children. In this study, malaria and nutritional status were strong child-related determinants of anaemia. The government of Nigeria has made concerted efforts to address malaria infections among children and pregnant women through the distribution of free insecticide-treated nets. Unfortunately, the result of this strategy has not been optimal because the distribution of nets was not targeted the most vulnerable groups in the population. Most people who collected the bed nets did not need them, so they are kept at home unused. In addition, to address nutritional imbalances, micronutrient-fortified foods and bio-available iron-rich food should be made available to high-risk population groups [43,44]. Antenatal care attendance has increased in recent times among reproductive-aged women in Nigeria. Health strategies, including supplementation programmes, should be carried out at both ante-natal and post-natal clinics to reduce the prevalence of anaemia, especially in vulnerable population groups.

Ethical approval

The ethical approval to carry out this research study had been granted by the School of Health and Related Research (ScHARR) Ethics Committee of the University of Sheffield (Reference Number: 031534). This study is a secondary analysis of two nationally representative samples. Permission to use the data sets (2018 Nigeria Demographic and Health Survey and 2018 National Human Development Report) had been obtained from two organisations: the Inner City Fund (ICF)-International and the United Nations Development Programme (UNDP-Nigeria).

Funding

This study is an integral part of PEO's doctoral study at the School of Health and Related Research of the University of Sheffield, United Kingdom. The funding for the doctoral study was granted by TETFUND (Nigeria).

Author contributions

The conceptualisation of this study was done by PEO and KK; the formal drafting of manuscript was carried out by PEO; while, SJW, RJ and KK supervised, revised and edited the manuscript. All authors read and agreed to the published version of the paper.

Declaration of competing interest

The authors declare no conflict of interest.

Acknowledgements

The authors acknowledge the contributions received from the ScHARR community. PEO appreciates the Rector and the management staff of Niger State Polytechnic, Nigeria, for nominating him for the TETFUND (Nigeria) sponsorship of his doctoral programme.

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