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Hierarchical modelling of factors associated with anaemia among under-five children in Nigeria

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Abstract

This study used a nationally representative cross-sectional data from 2018 Nigeria Demographic Health Survey (NDHS) to investigate the prevalence and factors associated with anaemia in children aged less than five years in Nigeria. Anaemia was defined as haemoglobin level <11.0g/dl, while explanatory variables included parental profile, social and environmental factors. Descriptive analyses and multivariable Poisson regression models were fitted using Stata 15 software. Associated factors were quantified using Prevalence Ratio (PR) with 95% confidence interval (CI). Of the 5834 children aged 6-59 months, 51.9% were male. The prevalence of anaemia among under-five children was 71.6% (95% CI: 69.9-73.2). Childhood anaemia was associated with history of maternal anaemia (PR 1.06; CI 1.05-1.08); having underweight mothers (PR 1.02; CI 1.00-1.05); being a Muslim (PR 1.05; CI 1.02-1.08), Igbo (PR 1.07; CI 1.01-1.14) and Hausa (PR 1.04; CI 1.01-1.07) ethnic group. Further, children from South-South (PR 1.09; CI 1.06-1.13) and South-West (PR 1.06; CI 1.02-1.10) and those currently breastfeeding (PR 1.06; CI 1.04-1.07) had higher risk of anaemia. However, children from middle (PR 0.94; CI 0.91-0.97), or higher wealth indices were less likely to have anaemia. Maternal socio-economic and nutritional characteristics were identified as key predictors of under-five anaemia. Strategies are needed to mitigate the effect of poverty and tweak new and existing nutritional intervention programs to make them responsive to socio-cultural peculiarities across the various geo-political regions of Nigeria. *(Afr J Reprod Health 2022; 26[11s]: 86-97).*

Keywords: Anaemia, under-five children, maternal characteristics, household characteristics Nigeria

Résumé

Cette étude a utilisé des données transversales représentatives à l'échelle nationale de 2018 Nigeria Demographic Health Survey (NDHS) pour étudier la prévalence et les facteurs associés à l'anémie chez les enfants âgés de moins de cinq ans au Nigeria. L'anémie a été définie comme un taux d'hémoglobine < 11,0 g/dl, tandis que les variables explicatives comprenaient le profil parental, les facteurs sociaux et environnementaux. Des analyses descriptives et des modèles de régression de Poisson multivariés ont été ajustés à l'aide du logiciel Stata 15. Les facteurs associés ont été quantifiés à l'aide du rapport de prévalence (PR) avec un intervalle de confiance (IC) à 95 %. Sur les 5834 enfants âgés de 6 à 59 mois, 51,9 % étaient de sexe masculin. La prévalence de l'anémie chez les enfants de moins de cinq ans était de 71,6 % (IC à 95 %: 69,9-73,2). L'anémie infantile était associée à des antécédents d'anémie maternelle (PR 1,06; IC 1,05-1,08) ; avoir des mères présentant une insuffisance pondérale (PR 1,02 ; IC 1,00-1,05) ; être un groupe ethnique musulman (PR 1.05 ; CI 1.02-1.08), Igbo (PR 1.07 ; CI 1.01-1.14) et haoussa (PR 1.04 ; CI 1.01-1.07). De plus, les enfants du Sud-Sud (PR 1,09; IC 1,06-1,13) et du Sud-Ouest (PR 1,06 ; IC 1,02-1,10) et ceux qui allaitent actuellement (PR 1,06 ; IC 1,04-1,07) avaient un risque plus élevé d'anémie. Cependant, les enfants d'indices de richesse moyens (PR 0,94; IC 0,91-0,97) ou supérieurs étaient moins susceptibles de souffrir d'anémie. Les caractéristiques socio-économiques et nutritionnelles maternelles ont été identifiées comme des prédicteurs clés de l'anémie des moins de cinq ans. Des stratégies sont nécessaires pour atténuer l'effet de la pauvreté et modifier les programmes d'intervention nutritionnelle nouveaux et existants pour les rendre sensibles aux particularités socioculturelles dans les différentes régions géopolitiques du Nigéria. *(Afr J Reprod Health 2022; 26[11s]: 86-97).*

Mots-clés: Anémie, enfants de moins de cinq ans, caractéristiques maternelles, caractéristiques du ménage Nigéria

Introduction

Under-five anaemia remains a major public health problem, particularly in low- and middle-income countries[1]. Anaemia negatively affects the cognitive development, growth and immune function of children[2-4]. Anaemia or low blood level is generally estimated by the amount of haemoglobin concentration in an individual[5]. Data published jointly by the Department of Nutrition

for Health and Development of the WHO, and the United States Centers for Disease Control and Prevention in 2008 showed the global prevalence of anaemia was 24.8%, with a level of 67.6% in sub-Saharan Africa[4]. In Africa, the prevalence of under-five anaemia varied by region with the highest prevalence in Central and West Africa[1].

Nigeria is one of the countries in West Africa with the highest burden of under-five anaemia. Both community and facility-based studies have shown that under-five anaemia is a major cause of morbidity and mortality in the country with a prevalence as high as 15%[6-8]. The commonest causes of anaemia in under five age group include malaria, haemoglobinopathies (sickle cell disease), septicaemia and malnutrition from poor feeding and parasitic infestations[6-10]. Most mortalities occur due to moderate or severe anaemia in this age group[8,11,12]. Factors associated with under-five anaemia include lack of knowledge about causes of anaemia by the parents, poor health seeking behaviour, poverty, low parental socioeconomic and educational status, and lack of access to quality care[8,11,12].

However, the prior studies did not explore other possible explanatory factors that could potentially explain childhood anaemia such as breastfeeding practices, malnutrition (wasting and stunting of growth), use of iron supplement, vitamin A, mother's anaemic status, and other household characteristics. It is important that a robust analysis of risk factors covering biological, social and economic factors are considered together in order to fully understand their influence on the burden of anaemia among under-five children in Nigeria. This study utilized the 2018 Nigeria Demographic Health Survey data to re-assess the prevalence and factors associated with childhood anaemia in the country.

Methods

Study setting

Administratively, Nigeria is divided into 36 States and the Federal Capital Territory. These States are further grouped into six geo-political regions (North Central, North East, North West, South East, South West and South South). Under-five children constitute 16.7% of Nigeria's population.

Data source

The data used was from the 2018 Nigeria Demographic Health Survey (NDHS). The NDHS is a cross-sectional study that collect information aimed at providing reliable and up-to-date estimates of key health indicators. The NDHS used a stratified two-stage cluster sampling method where all the 36 States and the Federal Capital Territory were divided into urban areas based on a population size of 20000 or more and classified as rural if otherwise. The first stage involved the selection of 1400 Enumeration Areas (EAs) based on the 2006 EA census frame with probability proportional to EA size. Respondents were sampled from 40427 households selected in the first stage. All women aged 15-49 years in selected households were interviewed about their reproductive history, family planning and other health indices. Data collected about under-five from their mothers/caregivers includes anthropometric characteristics, healthcare utilisation (vaccination and treatment of childhood illnesses). Biological samples were collected for malaria testing and haemoglobin level. Detailed description of the field procedure are available in the full report of the 2018 NDHS[13].

Data management

Description of variables

The outcome variable was anaemia status (yes vs no) of children between 6 to 59 months. During the NDHS 2018 data collection, the HemoCue®Hb 201+ device was used to measure the haemoglobin levels from a drop of blood taken from a finger prick and from a heel prick for children within 6-59 months. In this study, anaemia status was classified according to the WHO cut-off[5]. A child whose haemoglobin level in grams per decilitre (g/dl) is <11.0g/dl was considered anaemic. The haemoglobin levels were adjusted for altitude in enumeration areas that were above 1000 metres.

The explanatory variables were classified into three blocks – distal, intermediate and proximate factors. The distal factors (Block 1) included socio-economic variables which included source of water and type of sanitation facility classified as unimproved (unprotected well, unprotected spring and surface water – river/dam/pond/stream/canal/irrigation); improved

(public tap/standpipe, tube well or borehole, protected well, protected spring, rainwater, tanker truck and cart with small tank, bottled and sachet water) and piped (piped into dwelling, piped into yard/plot and piped into neighbour). The type of sanitation facility were classified as unimproved (flush to somewhere else, pit latrine – without slab / open pit, bucket toilet, hanging toilet/latrine, open defecation – no facility/bush/field) and improved (flush to piped sewer system, flush to septic tank, flush to pit latrine, flush to unknown location, ventilated improved pit, pit latrine with slab, composting toilet[14,15]. Type of cooking fuel was categorized as clean (electricity, liquefied petroleum gas (LPG), natural gas) and polluted (kerosene, coal, lignite, charcoal, wood, straw/grass, agricultural crop and animal waste).

Housing condition or materials was classified as either improved, partially, totally improved based on the floor, wall, and roof materials. Each of these housing materials were categorized as either unimproved or improved. The flooring materials which were made-up of earth, sand, dung, rudimentary, wood planks, palm, and bamboo were considered as unimproved materials while cement, ceramic tiles, vinyl asphalt strips, parquet and polished wood were classified as improved materials. The wall materials classified as unimproved materials were no wall, cane/palm/trunks, dirt, rudimentary, bamboo with mud, stone with mud, uncovered adobe, plywood while improved wall materials were cement, stone with lime or cement, cement blocks and bricks. Roofing materials were also classified if built with cement or roofing shingles and unimproved if there were no roof, thatch or palm leaf, sod, rudimentary, rustic mat, palm or bamboo, wood planks, wood or other materials.

The housing condition were then defined as unimproved if the floor, wall and roof materials were made with unimproved materials and as partially improved if only one or two of the housing materials were improved and classified as totally improved when all the floor, wall and roof materials were built with improved materials[16]**.** Other socioeconomic variables considered were household wealth quintiles (poorest, poorer, middle, richer, and richest), mother's level of education (primary, secondary, and tertiary), father's level of education (none, primary, secondary, tertiary, and women not in union), household size (≤6 vs >6).

The intermediate factors (Block Two) consisted of maternal characteristics, breastfeeding practices and micronutrient supplements. Maternal characteristics considered were mother's age in years , the body mass index (BMI) of mothers calculated as the weight in kilograms divided by the square of the height in meters and classified as (underweight, <18.5; normal, 18.5-24.9; overweight, 25.0-29.9 and obese, ≥30), marital status (never/formerly in union vs currently in union), number of under 5 children (1, 2, and ≥3), use of insecticide treated net (ITN) the night before survey (no, mother and some under-five, mother and all under-five children), type of delivery (normal, caesarian), mother's anaemia status (not anaemic vs anaemic), residence (urban vs rural), religion (Christian, Muslim, and others), ethnicity (Fulani, Hausa, Igbo and Yoruba). Breastfeeding practices and micronutrient supplements considered were time to initiation of breastfeeding (<1 hour vs ≥1 hour), currently breastfeeding (yes vs no), took iron supplements (yes vs no) and child took vitamin A in the last 6 months before survey (yes vs no).

The proximate factors (Block 3) comprised of child's characteristics: child age in months., sex (male vs female), reported birth size (very large/large, average, and small/very small), report of diarrhea (no vs yes - in the last 2 weeks of survey). The nutritional indices: stunting (yes vs no) and wasting (yes vs no) were classified using a Z-score cut-off point of <-2 Standard deviation (SD) from the population median. Similarly, child BMI measured as weight-for-age (WAZ) were computed as (underweight: <-2SD; Normal: -2.0-2.0, overweight:2.0-3.0 and obese: >3SD)[17,18].

Statistical analysis

To determine the factors associated with anaemia in under five children, a prevalence ratio was estimated with mixed effect Poisson regression using three levels of hierarchical structures, that was proposed by Silva *et al*[19]. For the hierarchical model, Model 1 included only the distal factors (Block 1), while Model 2 included the intermediate factors (Block 2) and adjusted for Block 1 factors. Model 3 comprised of the proximate factors and

adjusted for both the distal and proximate factors. The bivariate analysis of all factors associated with anaemia were initially conducted and the crude prevalence ratios (cPR) and their 95% confidence interval were estimated. Thereafter, multivariable mixed effect Poisson models were fitted using the hierarchical conceptual framework with three blocks of explanatory factors; similar method have been used in previous studies[20, 21]. Only variables that were statistically significant in the bivariate analysis with a p-value<0.1 were considered in the multivariable hierarchical mixed-effect Poisson models. The multicollinearity diagnostics among variables were performed using a variance inflation factor cut-off of 5, there were no collinearity among variables[22]. Statistical analysis was performed adjusting for complex survey design using Stata (Stata Corp, College Station, Texas, Version 15.0), and p-value<0.05 were used for the interpretation of results.

Results

Children characteristics

This study involved 5,834 children aged 6-59 months. About 36.1% of children were within 12-23 months of age and 51.9% were males. About 4 out of 10 children (37.8%) children were stunted while 7.4% were underweight and 15.2% of children were reported to have had diarrhea in the last two weeks before data collection (Table 1).

Maternal characteristics

Regarding the maternal characteristics,4.1% of the mothers were adolescents (<20 years) and almost half (47.8%) were aged between 25 to 34 years. One in 10 mothers were underweight - that is, too thin for their height while about three in 10 mothers were either overweight or obese. More than half of the mothers (57.6%) were anaemic.

Only 3.0% of mothers delivered through a caesarean section. Almost half (49.5%) of mothers with at least one under-five child did not utilize or had an ITN for sleeping. About 23.3% of household had at least three children who are under-five years of age and 16.7% were first-time mothers. On feeding practices, 47.4% of mothers initiated breastfeeding within the first one hour after birth, 40.4% of children are currently breastfeeding and about half (49.4%) of the children took vitamin A in the last six months while only 19.7% of children were given iron spills, sprinkles or syrup (Table 2).

Housing characteristics

Nearly half of the families did not have access to improved sanitary facilities; 26.7% of families used an unimproved source of water; and 12.3% used clean fuel for cooking. For housing conditions, 6 in 10 of families lived in houses classified as improved, while 31.7%, 28.1% and 11.1% of families lived in houses with an unimproved wall, floor and roof materials respectively. As regards family setting, mothers of 37.8% and father of 27.9% of children had no formal education while 5.82% of mothers were currently not in union and four in 10 of families had more than six members living as household (Table 3).

Prevalence of childhood anaemia

The prevalence and 95% confidence interval of anaemia among the under-five children was 71.6% (95% CI: 69.9-73.2), and it varied across the background characteristics. The children born into families with unimproved source of water (78.1%; 95% CI: 75.4-80.6), sanitary facilities (77.1%; 95% CI: 75.0-79.0), floor (80.9%; 95% CI: 78.6-83.1), wall (79.6%; 95% CI: 77.2-81.8), roof (79.4%; 95% CI: 75.8-82.7) and polluted fuel (73.8%; 95% CI: 72.2-75.4) had higher prevalence of anaemia. There was a negative linear trend between under five anaemia and household wealth quintiles, smaller household size, and parent education. Children in the poorest household (82.9; 95% CI: 80.3-85.2), whose mother (79.2%; 95% CI: 76.9-81.2), or father had no education (80.7%; 95% CI: 78.3-83.0) and with more than six members in the household (75.0%; 95% CI: 72.4-77.3) had a higher prevalence of anaemia.

Factors associated with childhood anaemia

In the multivariate hierarchical model, the distal factors associated with higher risk of anaemia were use of polluted fuel for cooking (PR 1.05; 95% CI 1.01-1.09) and household wealth quintile. Children from middle (PR 0.94; 95% CI 0.91-0.97), richer (PR 0.94; 95% 0.91-0.98) and richest households (PR 0.92; 95% CI 0.87-0.96) were less likely to be anaemic compared to those in the poorest

Table 1: Prevalence of anemia and crude prevalence ratio (PR) according to children characteristics, NDHS 2018

Child characteristics	Frequency (%)	Prevalence, % (95% CI) p-value	Crude PR (95% CI) p-value
Child age (months)		p<0.001	p<0.001
0-11	1095 (18.7)	78.2 (75.1-81.0)	1.0 Reference
12-23	2111 (36.1)	78.4 (76.2-80.5)	1.00(0.98-1.02)
24-35	1404 (24.0)	68.6 (65.5-71.5)	0.95(0.92-0.97)***
36-47	770 (13.2)	61.8 (57.2-66.3)	0.91(0.88-0.94)***
48-59	469 (8.0)	50.4 (45.1-55.7)	0.84(0.81-0.88)***
Child sex		p=0.011	p=0.011
Male	3037 (51.9)	73.4 (71.1-75.5)	1.0 Reference
Female	2812 (48.1)	69.7 (67.5-71.8)	0.98(0.96-0.99)**
Birth size		p=0.095	p=0.049
Large	2019 (34.5)	71.2 (68.6-73.7)	1.00(0.98-1.02)
Average	3110 (53.2)	70.9 (68.6-73.1)	1.0 Reference
Small	720 (12.3)	75.8 (71.9-79.3)	1.03(1.01-1.05)**
Stunting		p<0.001	p<0.001
No	2208 (37.8)	67.9 (65.6-69.8)	1.0 Reference
Yes	3641 (62.2)	77.7 (75.3-80.0)	1.06(1.04-1.08)***
Wasting		p<0.001	p<0.001
No	5337 (91.2)	70.7 (68.9-72.3)	1.0 Reference
Yes	512 (8.8)	81.4 (77.0-85.1)	1.06(1.04-1.09)***
BMI		p<0.001	**p<0.001**
Underweight	436 (7.4)	79.6 (74.5-83.9)	1.05(1.02-1.08)**
Normal	5263 (90.0)	71.2 (69.4-72.8)	1.0 Reference
Overweight/Obese	150 (2.6)	62.9 (54.4-70.7)	0.95 (0.91-1.00)*
Had Diarrhea		p<0.001	p<0.001
No	4931 (84.3)	70.5 (68.7-72.2)	1.0 Reference
Yes	918 (15.7)	77.5 (74.1-0.80.6)	1.04(1.02-1.06)***

PR: prevalence ratio; CI: confidence interval; ***p<0.001 **p<0.05 *p<0.10.

households. Similarly, children whose fathers had primary education were 3% less likely to have anaemia compared to those with no formal education (Model 1). In Model 2, which adjusted for intermediate factors (Block 2) and distal factors (Block 1), children whose mother had 2 or more under-fives were 3% and 5% more likely to be anaemic compared to only one under-five child. Children with anaemic mothers (PR 1.06; 95% CI 1.05-1.08) and underweight mothers (PR 1.02; 95% CI 1.00-1.05) had higher risk. In addition, those who were Muslims (PR 1.05; 95% CI 1.02-1.08) compared to Christians; Hausa (PR 1.04; 95% CI 1.01-1.07) and Igbo (PR 1.07; 95% CI 1.01-1.14) compared to Fulani were also associated with higher risk of anaemia. Children currently breastfeeding (PR 1.06; 95% CI 1.04-1.07), reside in the South South (PR 1.09; 95% CI 1.06-1.13) and South West (PR 1.06; 95% CI 1.02-1.10) compared to North Central were more likely to be anaemic. The risk of anaemia was 4% and 6% lesser among children whose mothers were between age 35-39 and 45-49 years compared to adolescent mothers.

In Model 3 which considers the proximate factors while adjusting for other variables, female children (PR 0.98; 95% CI 0.97-1.00) had a lower risk of anaemia relative male children. Children aged 24 to 35 months, 36 to 47 months and 48 to 59 months had 4%, 6% and 11% lower risk respectively of being anaemic compared to children who were between 6-11 months. Similarly, stunted (PR 1.03; 95% CI 1.01-1.05) and wasted (PR 1.04; 95% CI 1.00-1.07) children had a higher risk of anaemia. However, overweight, or obese children (PR 0.95; 95% CI 0.90-0.99) had a lower risk of anaemia.

Discussion

Under five anaemia remains a public health challenge in Nigeria. In this study, we found that about seven out of ten under-fives had anaemia and it was common among children from low socioeconomic class and in household with many

Table 2: Prevalence of anemia and crude prevalence ratio according to maternal characteristics, breastfeeding practices, and micronutrient supplements, NDHS 2018

Maternal characteristic	Frequency (%)	Prevalence, % (95% CI) p-value	Crude PR (95% CI) p-value
Mother's age		**p<0.001**	**p<0.001**
15-19	238 (4.1)	81.0 (74.3-86.3)	1.0 Reference
20-24	1010 (17.3)	76.5 (73.0-79.6)	0.97(0.94-1.01)
25-29	1497 (25.6)	73.0 (70.1-75.7)	0.96(0.92-0.99)**
30-34	1304 (22.3)	70.1 (66.9-73.0)	0.94(0.90-0.98)**
35-39	1122 (19.2)	67.0 (63.4-70.5)	0.92(0.89-0.96)***
40-44	476 (8.1)	69.9 (64.9-74.4)	0.94(0.90-0.98)**
45-49	202 (3.5)	65.1 (57.2-72.2)	0.91(0.86-0.97)**
BMI		**p<0.001**	**p<0.001**
<18.5 (underweight)	588 (10.1)	81.5 (77.4-85.0)	1.04(1.02-1.06)***
18.5-24.9 (normal)	3521 (60.2)	74.3 (72.4-76.1)	1.0 Reference
25.0-29.9 (overweight)	1159 (19.9)	65.5 (61.4-69.4)	0.95(0.93-0.97)***
30.0 (obese)	580 (9.9)	57.2 (52.3-61.9)	0.90(0.87-0.93)***
Marital union		p=0.212	p=0.228
Never/ Formerly in union	340 (5.8)	68.3 (62.7-73.4)	1.0 Reference
Currently in union	5509 (94.2)	72.0 (70.1-73.5)	1.02(0.99-1.06)
Children <5years old		**p<0.001**	**p<0.001**
1	2285 (39.1)	65.1 (62.5-67.6)	1.0 Reference
2	2199 (37.6)	72.6 (70.2-74.9)	1.05(1.03-1.07)***
≥3	1364 (23.3)	80.9 (77.8-83.6)	1.10(1.07-1.12)***
Birth order		p=0.147	p=0.140
1	978 (16.7)	69.8 (65.9-73.3)	1.0 Reference
2-3	1959 (33.5)	70.6 (68.0-73.0)	1.00(0.98-1.03)
4-5	1432 (24.5)	71.4 (68.4-74.3)	1.01(0.98-1.04)
≥6	1480 (25.3)	74.3 (71.4-77.0)	1.03(1.00-1.05)**
Use of ITN		**p<0.001**	**p<0.001**
No or no net in household	2894 (49.5)	68.5 (66.2-70.7)	1.0 Reference
Mother & some children U5	360 (6.2)	84.8 (80.1-88.6)	1.10(1.07-1.13)***
Mother & all children U5	2595 (44.3)	73.2 (71.1-75.2)	1.03(1.01-1.04)**
Type of delivery		**p<0.001**	**p<0.001**
Normal	5672 (97.0)	72.1 (70.5-73.7)	1.0 Reference
Caesarean	177 (3.0)	55.3 (45.5-64.7)	0.90(0.85-0.96)**
Mother's anaemia status		**p<0.001**	**p<0.001**
Not anaemic	2481 (42.4)	63.7 (61.2-66.1)	1.0 Reference
Anaemic	3368 (57.6)	77.4 (75.5-79.2)	1.08(1.07-1.10)***
Residence		**p<0.001**	**p<0.001**
Urban	2638 (45.1)	65.6 (62.9-68.5)	1.0 Reference
Rural	3211 (54.9)	76.4 (74.4-78.2)	1.06(1.04-1.09)***
Religion		**p<0.001**	**p<0.001**
Catholic	2625 (44.9)	67.1 (64.7-69.3)	1.0 Reference
Islam	3189 (54.5)	75.4 (73.1-77.5)	1.05(1.03-1.07)***
Others	35 (0.6)	65.2 (50.2-77.6)	0.99(0.91-1.08)
Ethnicity		**p<0.001**	**p<0.001**
Fulani	397 (6.8)	76.6 (71.8-80.9)	1.0 Reference
Hausa	1701 (29.1)	76.2 (72.8-79.3)	1.00(0.97-1.03)
Igbo	870 (14.9)	70.7 (66.4-74.7)	0.97(0.93-1.00)*
Yoruba	977 (16.7)	62.9 (58.2-67.4)	0.92(0.89-0.96)***
Other ethnic minorities	1904 (32.6)	71.3 (69.9-73.2)	0.97(0.94-1.00)**
Region		**p<0.001**	**p<0.001**
North Central	831 (14.2)	70.8 (67.3-74.0)	1.0 Reference
North East	917 (15.7)	76.1 (72.9-79.0)	1.03(1.00-1.06)**
North West	1636 (28.0)	73.9 (70.2-77.3)	1.02(0.99-1.05)
South East	679 (11.6)	71.3 (66.7-75.5)	1.00(0.97-1.04)
South South	631 (10.8)	74.3 (69.9-78.1)	1.02(0.99-1.05)
South West	1156 (19.8)	64.1 (59.4-68.5)	0.96(0.93-0.99)**

Time to breastfeeding		**p=0.065**	**p=0.065**
<1 hour	2773 (47.4)	70.1 (67.7-72.3)	1.0 Reference
≥1 hour	3076 (52.6)	73.0 (70.7-75.1)	1.02(1.00-1.04)*
Currently breastfeeding		**p<0.001**	**p<0.001**
No	3484 (59.6)	65.7 (63.5-67.8)	1.0 Reference
Yes	2365 (40.4)	80.3 (78.4-82.1)	1.09(1.07-1.10)***
Iron supplements		p=0.187	p=0.195
No	4694 (80.3)	72.1 (70.2-73.8)	1.0 Reference
Yes	1155 (19.7)	69.7 (66.4-72.8)	0.99(0.97-1.01)
Vitamin A		**p<0.001**	**p<0.001**
No	2957 (50.6)	74.1 (71.9-76.2)	1.0 Reference
Yes	2892 (49.4)	69.0 (66.8-71.1)	0.97(0.95-0.99)***

PR: prevalence ratio; 95% CI: confidence interval of 95%; ***p<0.001 **p<0.05 *p<0.10

Table 3: Prevalence of anaemia and crude prevalence ratio according to household and socioeconomic characteristics of children, NDHS 2018

Socioeconomic characteristics	Frequency (%)	Prevalence, % (95% CI) p-value	Crude PR (95% CI) p-value
Source of water		**p<0.001**	**p<0.001**
Unimproved	1561 (26.7)	78.1 (75.4-80.6)	1.0 Reference
Improved	4088 (69.9)	69.3 (67.3-71.2)	0.95(0.93-0.97)***
Piped	199(3.4)	67.8 (58.5-75.9)	0.94(0.89-0.99)**
Type of toilet facilities		**p<0.001**	**p<0.001**
Unimproved	2646 (45.2)	77.1 (75.0-79.0)	1.0 Reference
Improved	3203 (54.8)	67.1 (64.8-69.3)	0.94(0.93-0.96)***
Cooking fuel		**p<0.001**	**p<0.001**
Clean	717 (12.3)	55.7 (50.7-60.6)	1.0 Reference
Polluted	5132(87.7)	73.8 (72.2-75.4)	1.12(1.08-1.15)***
Main floor material		**p<0.001**	**p<0.001**
Unimproved	1645 (28.1)	80.9 (78.6-83.1)	1.0 Reference
Improved	4204 (71.9)	67.9 (65.9-69.9)	1.12(1.08-1.15)***
Main wall material		**p<0.001**	**p<0.001**
Unimproved	1856 (31.7)	79.6 (77.2-81.8)	1.0 Reference
Improved	3993 (68.3)	67.9 (65.7-69.9)	0.93(0.92-0.95)***
Main roof material		**p<0.001**	**p<0.001**
Unimproved	651 (11.1)	79.4 (75.8-82.7)	1.0 Reference
Improved	5198 (88.9)	70.6 (68.8-72.3)	0.95(0.93-0.97)***
Housing material		**p<0.001**	**p<0.001**
Unimproved	492 (8.4)	80.2 (76.2-83.7)	1.0 Reference
Partially improved	1849 (31.6)	78.7 (76.2-81.1)	0.99(0.97-1.02)*
Totally improved	3508 (60.0)	66.6 (64.4-68.8)	0.92(0.90-0.95)***
Wealth quintiles		**p<0.001**	**p<0.001**
Poorest	1067 (18.2)	82.9 (80.3-85.2)	1.0 Reference)
Poorer	1130 (19.3)	79.2 (76.2-82.0)	0.98(0.96-1.00)*
Middle	1209 (20.7)	69.3 (66.0-72.4)	0.93(0.90-0.95)***
Richer	1251 (21.4)	69.3 (65.6-72.7)	0.93(0.90-0.95)***
Richest	1192 (20.4)	59.0 (55.1-62.8)	0.87(0.85-0.89)***
Mother's education		**p<0.001**	**p<0.001**
No education	2209 (37.8)	82.9 (80.3-85.2)	1.0 Reference
Primary	937 (16.0)	79.2 (76.2-82.0)	0.96(0.94-0.99)**
Secondary	2146 (36.7)	69.3 (66.0-72.4)	0.93(0.91-0.95)***
Tertiary	557 (9.5)	69.3 (65.6-72.7)	0.88(0.85-0.91)***
Father's education		**p<0.000**	**p<0.001**
No education	1633 (27.9)	80.7 (78.3-83.0)	1.0 Reference
Primary	786 (13.4)	70.5 (66.2-74.4)	0.94(0.92-0.97)***
Secondary	2195 (37.5)	69.3 (66.7-71.7)	0.94(0.92-0.96)***
Tertiary	894 (15.3)	62.8 (58.4-67.0)	0.90(0.87-0.93)***
Not in union	340 (5.82)	68.3 (62.7-73.4)	0.93(0.90-0.96)***
Household size		**p<0.001**	**p<0.001**
≤6	3490 (60.0)	69.3 (67.2-71.4)	1.0 Reference
>6	2359 (40.0)	75.0 (72.4-77.3)	1.03(1.01-1.05)***

PR: prevalence ratio; CI: confidence interval; ***p<0.001 **p<0.05 *p<0.10.

Table 4: Hierarchical multivariable mixed effect Poisson regression for factors associated with anaemia in children, Nigeria DHS 2018

Variable	Model 1 PR (95% CI)	Model 2 PR (95% CI)	Model 3 PR (95% CI)
Distal level (Socio-economic)			
Source of water			
Unimproved	1.0 Reference	1.0 Reference	1.0 Reference
Other improved	1.00(0.98-1.02)	1.00(0.98-1.01)	1.00(0.98-1.01)
Piped	1.02(0.96-1.07)	1.02(0.97-1.07)	1.01(0.97-1.06)
Type of toilet facilities			
Unimproved	1.0 Reference	1.0 Reference	1.0 Reference
Improved	0.99 (0.97-1.01)	1.00(0.98-1.02)	0.99(0.98-1.01)
Cooking fuel			
Clean	1.0 Reference	1.0 Reference	1.0 Reference
Polluted (Mixed/Biomass)	1.05(1.01-1.09)**	1.03(1.00-1.07)*	1.03(1.00-1.07)*
Housing material			
Unimproved	1.0 Reference	1.0 Reference	1.0 Reference
Partially improved	1.02(1.00-1.05)*	1.03(1.01-1.06)**	1.03(1.01-1.06)**
Totally improved	1.02(0.98-1.05)	1.02(0.99-1.06)	1.02(0.99-1.06)
Wealth quintiles			
Poorest	1.0 Reference	1.0 Reference	1.0 Reference
Poorer	0.98(0.96-1.00)	0.98(0.96-1.00)*	0.98(0.96-1.01)
Middle	0.94(0.91-0.97)***	0.94(0.91-0.97)***	0.94(0.91-0.97)***
Richer	0.94(0.91-0.98)**	0.95(0.91-0.99)**	0.95(0.92-0.99)**
Richest	0.92(0.87-0.96)**	0.93(0.89-0.98)**	0.93(0.89-0.98)**
Mother's educational level			
No education	1.0 Reference	1.0 Reference	1.0 Reference
Primary	1.00(0.97-1.03)	0.99(0.96-1.02)	0.99(0.97-1.02)
Secondary	0.99(0.96-1.01)	0.98(0.95-1.01)	0.98(0.95-1.01)
Tertiary	0.97(0.92-1.01)	0.98(0.93-1.02)	0.98(0.93-1.02)
Father's educational level			
No education	1.0 Reference	1.0 Reference	1.0 Reference
Primary	0.97(0.94-1.00)**	0.96(0.94-0.99)**	0.97(0.94-0.99)**
Secondary	0.99(0.97-1.01)	0.99(0.97-1.01)	0.99(0.96-1.01)
Tertiary	0.98(0.95-1.02)	0.99(0.95-1.02)	0.99(0.95-1.02)
Not in union	0.97(0.94-1.01)	0.98(0.94-1.02)	0.99(0.95-1.02)
Household size			
<=6	1.0 Reference	1.0 Reference	1.0 Reference
>6	1.01 (0.99-1.02)	1.00(0.98-1.02)	1.00(0.98-1.02)
Intermediate (Maternal, Breastfeeding and feeding practices)			
Mother's age (years)			
15-19		1.0 Reference	1.0 Reference
20-24		0.99(0.95-1.03)	1.00(0.96-1.03)
25-29		0.98(0.95-1.02)	0.99(0.96-1.03)
30-34		0.98(0.94-1.01)	0.98(0.95-1.02)
35-39		0.96(0.92-1.00)**	0.97(0.94-1.01)
40-44		0.98(0.94-1.02)	1.00(0.96-1.04)
45-49		0.94(0.89-1.00)**	0.97(0.92-1.02)
BMI			
<18.5 (Too thin for height)		1.02(1.00-1.04)**	1.02(1.00-1.04)

18.5-24.9 (normal)	1.0 Reference	1.0 Reference
25.0-29.9 (overweight)	0.98(0.96-1.00)	0.98(0.96-1.01)
≥30.0 (obese)	0.95(0.92-0.99)**	0.96(0.92-0.99)**
Children <5years in HH		
1	1.0 Reference	1.0 Reference
2	1.03(1.00-1.05)**	1.02(1.00-1.03)
≥3	1.05(1.03-1.08)***	1.04(1.01-1.06)**
Mother & Children U5 slept under ITN		
No or no net in HH	1.0 Reference	1.0 Reference
Mother & some children U5	1.04(1.01-1.07)**	1.03(1.01-1.06)**
Mother & all children U5	1.02(1.00-1.03)*	1.01(1.00-1.03)
Type of delivery		
Normal	1.0 Reference	1.0 Reference
Caesarean	0.97(0.91-1.04)	0.97(0.91-1.03)
Mothers' anaemia status		
Not anaemic	1.0 Reference	1.0 Reference
Anaemic	1.06(1.05-1.08)***	1.06(1.05-1.08)***
Residence		
Urban	1.0 Reference	1.0 Reference
Rural	1.01(0.99-1.03)	1.01(0.99-1.03)
Religion		
Catholic	1.0 Reference	1.0 Reference
Islam	1.05(1.02-1.08)**	1.04(1.01-1.07)**
Others	0.98(0.90-1.06)	0.97(0.90-1.05)
Ethnicity		
Fulani	1.0 Reference	1.0 Reference
Hausa	1.04(1.01-1.07)**	1.04(1.01-1.07)**
Igbo	1.07(1.01-1.14)**	1.07(1.01-1.13)**
Yoruba	1.01(0.96-1.06)	1.01(0.96-1.06)
Other ethnic minorities	1.03(1.00-1.06)*	1.03(1.00-1.06)*
Region		
North Central	1.0 Reference	1.0 Reference
North East	0.98(0.95-1.01)	0.98(0.95-1.00)
North West	0.95(0.92-0.98)**	0.94(0.91-0.97)**
South East	1.04(0.98-1.10)	1.04(0.98-1.09)
South South	1.09(1.06-1.13)***	1.09(1.05-1.12)***
South West	1.06(1.02-1.10)**	1.05(1.01-1.09)**
Time to breastfeeding		
<1 hr (Within one 1 hr)	1.0 Reference	1.0 Reference
>=1 hr	1.00(0.99-1.02)	1.00(0.99-1.02)
Currently breastfeeding		
No	1.0 Reference	1.0 Reference
Yes	1.06(1.04-1.07)***	1.02(1.00-1.04)*
Vitamin A		
No	1.0 Reference	1.0 Reference
Yes	1.00(0.99-1.02)	1.00(0.98-1.02)
Proximate (child's characteristics)		
Child age (months)		
5-11		1.0 Reference

12-23	1.00(0.98-1.03)
24-35	0.96(0.94-0.99)**
36-47	0.94(0.90-0.97)**
48-59	0.89(0.85-0.93)***
Child sex	
Male	1.0 Reference
Female	0.98(0.97-1.00)**
Birth size	
Large	1.01(0.99-1.03)
Average	1.0 Reference
Small	1.01(0.99-1.04)
Stunting	
No	1.0 Reference
Yes	1.03(1.01-1.05)**
Wasting	
No	1.0 Reference
Yes	1.04(1.00-1.07)**
BMI	
Underweight	0.97(0.93-1.01)
Normal	1.0 Reference
Overweight/Obese	0.95(0.90-0.99)**
Had Diarrhea	
No	1.0 Reference
Yes	1.01(0.99-1.03)

Model 1: anaemia and distal factors
Model 2: anaemia, distal and intermediate factors
Model 3: anaemia, distal characteristics, intermediate and proximate factors

children. Other associated factors include nutrition-related growth deficiencies such as wasting and stunting, and maternal malnutrition. Use of polluted fuel for cooking and advanced maternal age (35 years and above) were associated with high-risk of under-five anaemia. In contrast, father's education, child obesity or overweight and being a female were associated lower risk of anaemia. It is also evident from the results that under-five anaemia varied by geo-political region and religious background of the children.

The prevalence of anaemia among children under-five in this study were similar to the 1991 but higher than the 2011 and 2016 WHO national estimates for Nigeria. In 1991, 2011 and 2016, the WHO estimated that the prevalence of anaemia among under five children in Nigeria was 79.8%, 71.4% and 68.3%, respectively[23]. The findings that children from the poorest and poorer households were more likely to be anaemic has also been previously reported in other settings and this further corroborate the association between anaemia and socioeconomic class[3,24]. It has been reported that under-five anaemia is more prevalent among household with large number of children and family size [20,25]. Poor economic status and large number of defendants is a recipe for malnutrition in the family[25].

In this study, the prevalence of anaemia was highest among children that were less than two years and it declined with advancing age. Although the role of gender of children as a risk factor for anaemia has not been universally reported, our study showed a lower prevalence and risk of anaemia among female children compared to male participants like other studies[24,27]. One plausible explanation that has been offered was high rate of X-linked diseases such as glucose-6 phosphate dehydrogenase among males than females[28].

There are potential limitations to the interpretation of the findings in this study. This was a cross-sectional analysis of factors associated with under-five anaemia, which makes it difficult to draw a causal relationship. Third, other competing exploratory variables that could potentially be a cause of under-five anaemia were

not included in the model. For example, information on dietary recall of the children were not considered which could explain the relationship between malnutrition and anaemia. Despite these limitations, the study provided robust evidence on the current national prevalence of anaemia among children under the age of five years and the associated factors. The study considered wide range of factors – social, biological, micronutrients and environmental characteristics. These findings have some implications for policies and programs on children health and survival in Nigeria. There is urgent need to frontally address maternal and childhood malnutrition given its association with anaemia and a risk for childhood mortality. Strategies are needed to mitigate the effect of poverty on children health because most of the factors associated with under-five anaemia are direct or indirect consequences of poor household economic conditions. Region and ethnicity remained as significant associated factors despite adjustment for other variables. This underscored the critical need to tweak new and existing nutritional intervention programs and make them responsive to socio-cultural peculiarities across the various geo-political regions of Nigeria. Faith-based and community-based organizations can be engaged for the purpose advocacy on maternal and child nutrition.

Ethical consideration

The survey protocol was reviewed and approved by the National Health Research Ethics Committee of Nigeria (NHREC) and the ICF Institutional Review Board. The details of the survey implementation and methodology are available in the NDHS reports[13].

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