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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 Nigeria. (*Afr J Reprod Health* 2022; 26[11s]: 86-97).

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

Introduction

Under-five anaemia remains a major public health problem, particularly in low- and middle-income countries¹. Anaemia negatively affects the

cognitive development, growth and immune function of children²⁻⁴. Anaemia or low blood level is generally estimated by the amount of haemoglobin concentration in an individual⁵. 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 Africa⁴. In Africa, the prevalence of under-five anaemia varied by region with the highest prevalence in Central and West Africa¹.

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 infestations⁶⁻¹⁰. 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 NDHS¹³.

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-off⁵. 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 materials¹⁶. 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 variables²². 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 pills, 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% CI 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 (74.1-80.6) | 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 characteristics (child's) | | |
| 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%, respectively²³. 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 dependants is a recipe for malnutrition in the family²⁵.

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 females²⁸.

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 reports¹³.

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