Multinomial logistic regression analysis of the determinants of anaemia severity among children aged 6-59 months in Ghana: New evidence from the 2019 Malaria Indicator Survey

Desmond Klu (klud@uhas.edu.gh)
University of Health and Allied Sciences
Donatus Yaw Atiglo
University of Ghana
Aaron Kobina Christian
University of Ghana

Research Article

Keywords: Anaemia, Malaria Indicator Survey, Determinants, Children, Ghana

Posted Date: June 29th, 2022

DOI: https://doi.org/10.21203/rs.3.rs-1784429/v1

Additional Declarations: No competing interests reported.

Version of Record: A version of this preprint was published at BMC Pediatrics on February 27th, 2023. See the published version at https://doi.org/10.1186/s12887-023-03919-0.

Abstract

Background

Anaemia among children under age five is a major public health issue. Although anaemia prevalence is declining in Ghana, the severity among anaemic children is worsening. This study aims to investigate the determinants of anaemia severity among children aged 6 to 59 months in Ghana.

Method

The study utilized data from 1,258 children with anaemia from the 2019 Malaria Indicator Survey. The independent variables included child, maternal, health, household and system characteristics. Analyses were conducted at the univariate, bivariate and multivariate levels. At the multivariate level, three different multinomial logistic models were run to include interactive terms between selected independent variables. All tests were conducted at the 95% confidence level.

Results

The overall anaemia prevalence among children under age five was 43.5%. Of these, 2.6% were severely anaemic, and 48.5% and 48.9/5 had moderate and mild anaemia, respectively. The multinomial analysis showed that maternal, household, child and health system factors significantly predicted anaemia levels among children with anaemia. The results indicate that anemic children whose mothers reside in urban areas (AOR=3.87; C. I: 1.11-13.48), children whose mothers are unaware of NHIS coverage of malaria (AOR=3.00; C.: 1.31-6.88) were more likely to have severe anaemia. Again, a lower probability of being severely anaemic was found among anaemic children whose household heads were aged 30-39 years and children who tested negative for malaria. With regard to moderate anaemia level, children who belong to the poorest and poorer household wealth index had a higher likelihood of being moderately anaemic. Similarly, children with anaemia who were less than 12 months old (AOR=1.72; C. I: 1.06-2.80) and mothers of anaemic children who were not aware of NHIS coverage of malaria (AOR=1.33; C.I: 1.00-1.77) were more likely to have moderate anaemia levels. Furthermore, anemic children whose household heads were aged 50-59 years (AOR=0.52; CI: 0.29-0.93) and three-year-old anemic children (AOR=0.59; C.: 0.38-0.90) had a lower likelihood of being moderately anaemic.

Conclusion

The study findings show the importance of understanding the interaction among factors that influence anaemia levels among children under age five as critical in developing strategies and programmes aimed at addressing childhood anaemia.

Introduction

Anaemia is referred to as a condition in which the level of haemoglobin (Hb) in the body is below normal, leading to a reduction in the capacity of red blood cells to carry oxygen to body tissues [1,2].

Children are most affected, even though anaemia affects all population groups. The World Health Organization (WHO) reported that the global prevalence of anaemia in children was 60.2% in 2019 [3].

According to the WHO guidelines, anaemia in children aged under 5 years is defined as a haemoglobin concentration <110 g/L [2]. Anaemia levels are of three types, namely, mild, moderate and severe. Mild anaemia is associated with haemoglobin concentration levels in the interval of 10.0-10.9 g/dL, moderate 7.0-9.9 g/dL, and severe less than 7.0 g/dL [8]. Iron deficiency is considered the most common cause of anaemia; other causes include acute and chronic infections that result in inflammation and blood loss, deficiencies in other vitamins and minerals, especially folate, vitamin B12 and vitamin A, and genetically inherited traits, such as thalassaemia [4-6]. Other conditions, such as malaria, genetic disorders, and cancer, also play critical roles in anaemia [2,7].

Anaemia is often associated with increased risks for maternal and child mortality, especially in sub-Saharan Africa. Anaemia is estimated to have been responsible for 5% to 18% of underfive mortality in Africa [9]. Additionally, in the African region, an estimated 3.3% of children aged 6-59 months suffer from severe anaemia, and this estimate is twice the global prevalence rate [3]. Iron-deficiency anaemia negatively affects the cognitive and physical development of children [10,11] and results in symptoms such as fatigue, weakness, dizziness, heart failure and shortness of breath [12].

In Ghana, the national prevalence of anaemia among children aged 6-59 months has decreased over the years. For instance, childhood anaemia decreased from 75% in 2003 to 66% in 2014 according to the Ghana Demographic and Health Surveys (GDHS). More recently, childhood anaemia has further decreased from 52.7% in 2016 to 42.5% in 2019 according to the 2016 and 2019 Ghana Malaria Indicator Surveys (GMIS) report. These reductions in childhood anaemia prevalence could be attributed to malaria-related interventions, which have been associated with a 60% reduction in the risk of anaemia [13]. Despite the reduction in childhood anaemia, the levels of anaemia (severity) increased from 1.9% in 2016 to 2.6% in 2019 [14]. This calls into question the effective management of childhood anaemia in Ghana.

Using nationally representative malaria data (GMIS) provides a unique advantage over the other demographic and health survey (GDHS) because the GMIS specifically and in detail collected data on ownership and use of mosquito bed nets, assessed coverage of intermittent preventive treatment to protect pregnant women against malaria, identified practices and specific medications used to treat malaria, measured indicators of malaria knowledge and communication messages, and estimated the prevalence of malaria and anaemia among children aged 6-59 months. This gives more accurate and robust results and reflects the malaria and anaemia situation among vulnerable populations, such as children under age five in Ghana.

Several studies using nationally representative [15-25] and health facility-based data [26-29] have examined demographic, social, economic, household, nutritional, environmental, health system and spatial/geographical factors predicting childhood anaemia status.

Although evidence from the literature reveals that anaemia levels among children have multifactorial causes that negatively affect child health, the interaction effect among these factors at varied levels is understudied among anaemic children aged 6-59 months. As a result, the interactive effects of maternal, household, child and health system-related factors predicting anaemia levels among anaemic children under the age of five are not well understood. This study, therefore, examined the interactive effects of multiple related factors (maternal, household, child and health system) that predict anaemia levels among anaemic children aged 6-59 months in Ghana using evidence from the 2019 Ghana Malaria Indicator Survey.

Methods

Data for this study were obtained from the nationally representative 2019 Ghana Malaria Indicator Survey (GMIS), which was conducted from September 25 to November 24, 2019. We used data from the children's file. The GMIS collects information on malaria prevention (ownership and use of treated mosquito bed nets, coverage of intermittent preventive treatment to protect pregnant women against malaria), anaemia levels in pregnant women and children, malaria treatment and prevalence in Ghana. In this study, data on a weighted subsample of children who were tested and verified to be anaemic were extracted and analysed.

Study setting

Ghana is a West African country that shares boundaries with Burkina Faso to the north, the Gulf of Guinea to the south, Togo to the east, and La Cote d'Ivoire to the west. It has 16 administrative regions with a population of 30.8 million as of the 2021 Population and Housing census [30]. Accra is the capital of Ghana. Over the years, numerous interventions have been implemented in Ghana to combat anaemia, such as iron supplementation, food fortification, public education and sensitization, deworming, and parasitic infection management and prevention, especially among children under five years of age [31,32].

Survey and study participants

Details concerning the scope and methodology of the GMIS have already been published [14]. The GMIS is a nationally representative survey conducted by the Ghana Statistical Service (GSS), Ministry of Health (MOH) and National Malaria Control Programme (NMCP) of the Ghana Health Service with technical support from the Inner-City Fund (ICF) through the Demographic and Health Surveys (DHS) Program. The data collection was performed in two phases. The first phase comprised the household listing exercise, during which each of the 200 selected enumeration areas were visited, and information was recorded on structures. In addition, information on the names of household heads and the global positioning system (GPS) coordinates of clusters were collected. In the second phase, households and all eligible women (15-49 years) were interviewed, and children aged 6-59 months were tested for anaemia and malaria with consent from guardians or parents.

With regard to the determination of the anaemia level among children under age five, a single-use retractable, spring loaded, sterile lancet was used for the finger or heel prick. A drop of blood from the site was then collected in a microcuvette. Haemoglobin analysis was then conducted on site with a battery-operated portable HaemoCue 201+ analyser, which produces a result in less than one minute. Anaemia test results were recorded both in the Biomarker Questionnaire and on a brochure that was left with the household members that also contained information on the causes and prevention of anaemia. Parents or guardians of children with haemoglobin levels below 8 g/dl (severe anaemia) were advised to go to a health facility and a referral letter with the haemoglobin reading to show to the health worker at the facility. Informed consent was sought from respondents before collection of blood samples for testing anaemia.

Sampling and Sample size

The total number of children aged 6-59 months in the 2019 GMIS was 2,895. However, in this study, we limited the analysis to children who were tested and confirmed to be anaemic during the survey. Thus, the weighted sample of anemic children aged 6-59 months in the 2019 GMIS was 1,258.

Study variables

Outcome variable

The outcome variable for this study was anaemia levels among children aged 6-59 months. Anaemia is defined in this study as a reduced level of haemoglobin in the blood, decreases the amount of oxygen reaching the tissues and organs of the body and reduces their capacity to function. The categorization of anaemia level among children aged 6-59 months was severe, moderate, and mild.

Predictor variables

We considered maternal, household, child, and health system-related factors in this study. The rationale for choosing these factors at different levels is that they may influence the anaemia levels differently.

Maternal-related factors comprised the age of the mother (15-29, 30-39, 40-49), educational level of the mother (no education, primary, secondary/higher), mother's place of residence (urban, rural) and mother's ecological zone of residence(coastal zone, middle belt, northern zone). Others are mother's parity (1-3 children, 4-6 children, 7 or more children), religious affiliation of mother (Catholic, Protestant, Muslim, Pentecostal/Charismatic other Christian, Traditional/Spiritualist, no religion) and literacy level of mother (illiterate, literate).

Household-related factors

We considered the following household-level factors in the study: sex of household head (male, female), age of household head (20-29,30-39, 40-49, 50-59,60-69, 70+) and household wealth quintile (poorest, poorer, middle, richer, richest). The other variables included household source of drinking water, type of

toilet facility and type of cooking fuel used by the household. The measurement and classification of the variable '*household source of drinking water' and the type of toilet facility used* were guided by the WHO/United Nations International Children's Emergency Fund Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (WHO/UNICEF-JMP) classification of source of drinking water. For this study, the variable was classified into two categories: improved and unimproved sources of drinking water. In this study, the improved source of drinking water comprised pipe-borne water inside the dwelling, piped into the dwelling, pipe to yard/plot, piped to the neighbor's house/compound, tube well water, borehole, protected dug well, protected well, protected spring and rainwater collection, bottled water and sachet water. The unimproved source of drinking water in this study included unprotected wells, surfaces from spring, unprotected springs, rivers/dam, tanker trucks and carts with small tanks. The type of toilet facility was also categorized as improved or unimproved. The improved toilet facilities in this study comprised flushing to pipe sewers, flushing to septic tanks, flushing to pit latrines, flushing to unknown places, flushing to biodigesters, ventilated improved pit latrines (VIPs), pit latrines with slabs, pit toilet latrines and composting toilets. The unimproved toilet facility included flush to somewhere else, pit without slab/open pit, no facility, bush/field and hanging toilet/latrine. The type of household cooking fuel was categorized into the following: liquefied petroleum gas (LPG), charcoal, fuel wood and other cooking fuel (straw/shrub/grass, agricultural crops, and animal dung).

Child-related factors

The child-related factors considered in the study were sex of child(boy, girl), current age of child (less than 12 months, 1 year, 2 years, 3 years, 4 years), child slept under treated bednet (no, yes, household do not have bednet), allow child to be vaccinated against malaria (no, yes) and child malaria status (child tested negative for malaria, child tested positive for malaria).

Health system-related factors

We considered the following health system level factors in this study: coverage by the National Health Insurance Scheme (Yes, No), number of antenatal visits (no visit, 1-3 visits, 4+ visits), took SP to prevent malaria during pregnancy (no, yes) and awareness that malaria is covered under the NHIS (no, yes).

Statistical Analysis

The analyses of the data were performed in three stages using SPSS version 25. The first stage was the use of simple descriptive statistics to describe the outcome and predictor variables. The second stage involved a bivariate analysis or cross-tabulation of all the maternal, household, child, and health system-related factors against the anaemia level of children aged 6-59 months. In the third stage, we developed three different multinomial regression models to examine the interactive effect of maternal-, household-, child-, and health system-level factors on anaemia levels among children aged 6-59 months. Model I analysed the effect of maternal- and household-related factors, and model II analysed the effect of child- and health-level factors. The last model analysed how maternal, household, child and health

system-related factors interact to influence anaemia levels among children under age five in Ghana. All variables were considered statistically significant at the 95% confidence interval ($p < 0.05$).

Results

Anaemia prevalence and level among children under age five in Ghana

Figure 1 shows the prevalence of anaemia among children under age five in Ghana. Out of the 2,895 children aged 6-59 months, 43.5% were anaemic, while the remaining 56.5% were not anaemic. This prevalence is lower than what was found in the 2016 GMIS, with a prevalence of 52.7%. Figure 2 shows that 2.6% of children had severe anaemia, and 48.5% and 48.9% had moderate and mild anaemia, respectively. These anaemia levels are higher than those recorded in the 2016 GMIS, with 1.9% of children under age five being severely anaemic, 27.6% being moderately anaemic and 23.2% being mildly anaemic. In summary, although the prevalence of anaemia among children aged 6-59 months, as found in this study, is lower than that found in 2016, the levels of anaemia in this study are higher than those found in 2016.

Description of Predictor Variables in the Study

Table 1 shows the percentage distribution of maternal- and household-related factors used in this study. Approximately 49% of mothers with anaemic children are between the ages of 15-29 years, constituting the highest proportion of mothers in any of the age categories. Approximately 5 out of 10 mothers of anaemic children had attained a secondary or higher education level. Most (63.8%) mothers with anaemia reside in rural areas, and approximately 40% of them dwell in the coastal zone of Ghana. The majority (60.3%) of mothers with anaemic children under age five had 1-3 children, while the smallest proportion (7.3%) had seven or more children. With regard to religion, a higher proportion (39.3%) of mothers of anaemic children belong to the Pentecostal/Charismatic faith compared to other religious affiliations, while more than half (59.4%) of mothers of anaemic children are illiterate.

Concerning household-related factors, approximately 80% of children with anaemia belonged to male-headed households. The highest proportion (34.4%) of heads of household with anaemic children were between the ages of 30 and 39 years. Approximately 8 out of 10 children with anaemia belong to households that access improved sources of drinking water, while 59.4% of these anaemic children belong to households that access improved toilet facilities. Additionally, 54.1% of children with anaemia in 2019 belong to households that use fuelwood as a main type of cooking fuel. This proportion constituted the highest proportion compared to other types of household cooking fuel. The highest proportion (29.4%) of anaemic children belongs to the poorest household wealth index category, with the lowest proportion (10.1%) belonging to the richest wealth index.

Table 2 shows the percentage distribution of child and health system-related factors used in the study. A little than half (52.6%) of children with anaemia are boys, while approximately 27.1%, constituting the highest proportion, are 1-year-olds. Approximately 6 out of 10 anemic children aged 5 to 59 months slept

under treated bednet a night prior to the survey. The majority (95.3%) of parents or guardians indicated that they would allow their child to be vaccinated against malaria, and approximately 10% of children under age five tested positive for malaria during the survey.

Concerning health system-related factors, approximately 59% of children had anaemia health insurance coverage compared to 40.78% with no health insurance coverage. The majority (70.8%) of mothers attended antenatal care four or more times during pregnancy. With regard to taking sulfadoxine pyrimethamine (SP) at a health facility during pregnancy, approximately 7 out of 10 mothers indicated taking SP, while 74.9% were aware of NHIS coverage of malaria.

Association between maternal and household, child and health system-related factors and anaemia levels among children aged 6-59 months in Ghana

Table 3 shows the strength of association with chi-square analyses between maternal and household-related factors and anaemia levels among children aged 6-59 months in Ghana. Maternal-related factors, including the educational level of the mother (p=0.000), place of residence of the mother (p=0.006), ecological zone of residence of the mother (p=0.000), religious affiliation of the mother (p=0.001) and literacy level of the mother (p=0.001), were found to be significantly associated with anaemia levels at $p<0.05$. With regard to household-related factors, household source of drinking water (P=0.001), household type of toilet facility (p=0.000), household type of cooking fuel (p=0.000) and household wealth index (p=0.000) were significantly associated with anaemia levels among children aged 6-59 months in Ghana at $p<0.05$.

Table 4 presents the association between child- and health system-related factors and anaemia levels among children aged 6-59 months in Ghana. A significant association was established between current age of child (p=0.000), child malaria status (p=0.006), number of antenatal care visits (p=0.014), uptake of SP at health facility (p=0.001) and awareness of NHIS coverage of malaria (p=0.047) and level of anaemia among children under age five in Ghana.

Maternal and household-related factors influencing anaemia levels among anaemic children aged 6-59 months in Ghana

Table 5 shows the results of the multinomial logistics regression analysis of the maternal and household predictors of anaemia level among anaemic children aged 6-59 months in Ghana. The mother's ecological zone of residence was significant in predicting anaemia level among anaemic children under age five. The results indicate that mothers who reside in coastal zones of Ghana had lower odds (33% less) of having children suffering from moderate anaemia, relative to mild anaemia, compared to mothers who dwell in the northern zone of Ghana. Mother's religious affiliation was significant in predicting children's anaemia level. Compared to mothers with no religion, those who belong to the Pentecostal/Charismatic faith are 88% less likely to have children with severe anaemia than to have mild anaemia.

Furthermore, children under age five who belong to households with heads aged 30-39 years (AOR=0.23; C.: 0.06-0.92) were 77% less likely to be severely anaemic than household heads aged 70 years and above. Again, children under age five who belong to household heads aged 50-59 years (AOR=0.56; CI: 0.32-0.97) had lower odds of being moderately anaemic relative to household heads aged 70 years and above. This outcome clearly shows that children who dwell in households with younger heads have a lower probability of suffering from severe and moderate anaemia than older household heads.

There is a negative statistical relationship between the household wealth index and moderate anaemia levels among anaemic children aged 6-59 months. Anemic children who belong to the poorest (AOR=2.45; CI: 1.30-4.63), poorer (AOR=2.01; CI: 1.09-3.57) and middle (AOR=1.89; CI:1.07-3.34) household wealth index had a higher probability of being moderately anaemic compared to those who belong to the richest household wealth index.

Child and health system-related factors influencing anaemia levels among anaemic children aged 6-59 months in Ghana

Table 6 presents the results of multinomial logistics regression analysis of child and health system predictors of anaemia levels among anaemic children aged 6-59 months. The current age of the child and child malaria status significantly predicted anaemia levels among anaemic children. Anaemic children who are currently 3 years old (AOR=0.59; C.: 0.39-0.90) were 41% less likely to be moderately anaemic than the four-year-olds. Again, children who tested negative for malaria were (AOR=0.29; CI: 0.12-0.68) 71% less likely to be severely anaemic compared to their counterparts who tested positive for malaria. Regarding health system-related factors, mothers of anaemic children who were not aware of NHIS coverage of anaemia were 2.50 times more likely to have their children severely anaemic than mothers who were aware.

Effect of maternal, household, child and health system-related factors on anaemia level among anaemic children aged 5-69 months in Ghana

Table 7 presents the effect of all the factors considered in this study on levels of anaemia among anaemic children under age five in Ghana. When all factors (maternal, household, child and health system) were interacted, the resulting effect showed that place of residence of mothers, age of household head, child malaria status and mother's awareness of NHIS coverage malaria were significant predictors of severe anaemia among anaemic children under age five in Ghana. On the other hand, factors such as age of household head, household wealth index, age of child and mothers' awareness of NHIS coverage of malaria significantly predicted moderate anaemia among anaemic children in Ghana.

Interestingly, anemic children whose mothers reside in urban areas (AOR=3.87; C.: 1.11-13.48) were more likely to have severe anaemia than those living in rural areas. A lower probability of being severely anaemic was found among anaemic children whose household heads were aged 30-39 years (AOR=0.17; C.: 0.03-0.84) relative to older household heads (70 years and above). Children who tested negative for

malaria had lower odds (AOR=0.22; C. I: 0.08-0.61) of being severely anaemic compared to children who tested positive for malaria.

Anemic children whose mothers are unaware of NHIS coverage of malaria are more likely (AOR=3.00; C. I: 1.31-6.88) to have their anaemia level to be severe compared to those who are aware.

The results further showed that anaemic children whose household heads were aged 50-59 years (AOR=0.52; CI: 0.29-0.93) had a lower likelihood of being moderately anaemic than older household heads aged 70 years and above. Anaemic children who belong to poorest (AOR=2.46; C.I:1.17-5.20), poorer (AOR=2.37; C.I:1.22-4.64) and middle (AOR=2.07; C. I: 1.12-3.82) household wealth index had a higher likelihood of being moderately anaemic compared to those from the richest household wealth quintile. Similarly, children with anaemia who are less than 12 months old have higher odds (AOR=1.72; C. I: 1.06-2.80) of being moderately anaemic compared to anaemic children who are four years old. However, three-year-oldemic children (AOR=0.59; C.: 0.38-0.90) were 41% less likely to have moderate anaemia levels than four-year-old anaemic children. Again, mothers of anaemic children who are not aware of NHIS coverage of malaria (AOR=1.33; C. I: 1.00-1.77) were more likely to have their children's anaemia level moderate compared to those who are aware.

Discussion

Using the 2019 GMIS data, the study examined the independent effect of maternal, household, child and health system-related factors on anaemia levels among anaemic children aged 5-59 months in Ghana. To the best of our knowledge, this study is the first to study different related factors and how these factors affect each other to predict anaemia levels among anaemic children under age five using nationally representative data and considering the levels of severity of anaemia among children under age five in Ghana [14,33].

The results show that 43.5% of children under the age of 6-59 months are anaemic, out of which 2.6% were severely anaemic, 48.5% were moderately anaemic and 48.9% had mild anaemia. Even though the prevalence of anaemia among children aged 6-59 months in Ghana has decreased from 52.7% in 2016 [33] to 43.5% in 2019 [14], there has been an increase in the levels of anaemia among these children. For instance, severe anaemia increased from 1.9% in 2016 to 2.6% in 2019, moderate anaemia from 27.6% to 48.5% and mild anaemia from 23.2% to 48.5%. This increasing anaemia levels among children clearly shows poor management and treatment of anaemia in Ghana. The prevalence of anaemia among children 6-59 months in Ghana is higher than the global anaemia prevalence of 39.8% in 2019 [3] but lower than the prevalence (60.2%) of anaemia in children 6-59 months in the African region in 2019 [3]. Other studies conducted within the African region found similar anaemia levels among children aged 6-59 months using nationally representative data [18,34-36].

The increased levels of severe, moderate and mild anaemia among children under age five, as found in this study and other studies in Africa, raise the issue of low blood haemoglobin concentrations in children as a result of iron deficiency in diets, low iron supplement intake and poor feeding practices [2,20,29,37-

39]. Other studies also argued that malaria plays an essential role in the aetiology of anaemia coupled with high rates of Plasmodium falciparum parasite infection in the African region increases the risk of anaemia severity, especially among children under age five [40-44].

Maternal-related factors such as the mother's ecological zone of residence significantly predicted the likelihood of children becoming moderately anaemic, while the mother's religious affiliation predicted the severity of anaemia among children under the age of five. Thus, mothers with anaemic children who reside in coastal zones of Ghana are less likely to have their anaemic level moderate compared to those in the northern zone. These study findings are consistent with earlier studies that found high rates of anaemia among children in the northern part of Ghana [16,18,45]. Koram et al. [45] tried to provide an explanation of the severity of anaemia among children in the northern part of Ghana. They argued that repeated malaria infections may be a primary determinant of severe anaemia among infants and young children during the high malaria transmission season.

Mothers who belong to the Pentecostal/charismatic faith have a lower likelihood of their children becoming severely anaemic compared to those with no religious affiliations. Previous studies conducted in Ghana [46], Tanzania [26], Ethiopia [19] and Nigeria [22,25] also found mothers' religious affiliation to be a significant predictor of anaemia levels among children. Religious beliefs in food restrictions often deny mothers and their children potential dietary nutrients that have the potential to prevent anaemia. For instance, Ngimbudzi and colleagues [26] found that mothers attributed child anaemia to supernatural forces such as witchcraft or some foods (lemons, eggs, fish) eaten during pregnancy. However, after interacting maternal factors with household, child and health system factors, mother's place of residence and parity were significant in predicting the severity and moderateness of anaema among anaemic children aged 6-59 months in Ghana. Mothers who reside in urban areas are more likely to have their children suffer severe anaemia relative to those living in rural areas. This interesting finding supports the results of earlier studies [27,34,47] in sub-Saharan Africa, which found a higher risk of anaemia among children who reside in urban areas relative to their rural counterparts. The interesting nature of this finding calls for rethinking rural–urban variation in anaemia levels among children. Ncogo and colleagues [47] argued that rapid urbanisation, rural–urban migration and development of peri-urban areas give rise to health inequalities in urban areas. People who migrate to urban areas often settle in densely populated areas, and poor socioeconomic status and sanitation and limited access to quality health care make them vulnerable to many health problems. However, a number of studies have found contrary evidence where the severity of anaemia was found among children living in rural areas compared to urban areas within the Africa, North America and Asia regions [16,18,21,22,25,28,35,48].

Household factors such as age of household head and household wealth index were significant in predicting anaemia levels among children aged 6-59 months. Anaemic children whose household heads are aged 30-39 years are less likely to be severely anaemic, and those household heads aged 50-59 are less likely to be moderately anaemic compared to household heads 70 years and older. This finding is in contrast with previous studies, which found a higher risk of childhood anaemia among relatively younger

household heads [23,25]. Anaemic children from the poorest, poorer and middle household wealth index had a high probability of being moderately anaemic compared to children from the richest households. This finding is supported by the findings of other studies in sub-Saharan Africa [16,22,25,34-36,49-54]. The predominant explanation is that richer households can afford good quality healthcare services, live under proper sanitary conditions, consume more nutritious foods and are food secured. After interacting household factors with other factors, the age of household heads and wealth index were still significant in predicting anaemia levels among anaemic children aged 6-59 months in Ghana.

This study also found that anaemic children less than 12 months old were more likely to suffer anaemia at a moderate level than children who were four years old. However, the probability of being moderately anaemic is lower among children who are three years old than among those who are four years old. This implies that the risk of being anaemic is probably higher among newborns but reduces as they approach age five. This study's findings corroborate those of earlier studies [16,23,25,36,48-50]. After interacting it with other factors, the current age of the child was still significant in predicting anaemia levels among children under age five in Ghana. Furthermore, children under age five who tested negative for malaria were less likely to suffer severe anaemia before and after the interaction of other variables compared to those who had malaria. This result clearly emphasizes malaria as a major risk factor for anaemia among children aged 6-59 months. Earlier studies [55-58] that studied the dichotomous relationship between malaria and anaemia among children found malaria to be a major risk factor for the development of anaemia among children.

Health system factors such as awareness of NHIS coverage of malaria at the health facility (before and after interaction) significantly predicted levels of anaemia among children aged 6-59 months in Ghana. Mothers who are not aware of NHIS coverage on malaria at the health facility are more likely to have their children suffer severe and moderate anaemia compared to those who are aware. Similar findings were reported by previous studies [17,59-61]. These studies reported that health insurance coverage serves as a protective factor against childhood anaemia and improves child health outcomes.

Conclusion

Using multinomial logistic regression analysis, this study examined the interaction effect of maternal, household, child and health system factors on anaemia levels among anaemic children aged 6-59 months in Ghana. This study emphasizes the essence of various factors at different levels as far as the anaemia level among anaemic children under age five is concerned. After the interactions, it was established that anemic children whose mothers are residing in urban areas and religious affiliation (mother-related factors) have higher odds of being severely and moderately anaemic. Household-related factors such as household head aged 30-39 and 50-59 had lower odds of being moderately anaemic, while anaemic children belonging to the poorest, poorer and middle wealth index had a high probability of suffering from severe anaemia. Children less than 12 months old have a higher risk of severe anaemia, while children 3 years old and those who tested negative for malaria have a lower risk of suffering from moderate anaemia (child-related factors). Health system factors such as mothers who are unaware of

NHIS coverage on malaria are more likely to have their children suffer severe anaemia. These findings suggest that in the development of strategies, policies and programmes to prevent or eradicate childhood anaemia, factors should not be considered in isolation. These maternal, household, child and health system-related factors should be considered when developing interventions to improve and strengthen anaemia prevention strategies among children aged 6-59 months.

Abbreviations

AOR: adjusted odds ratio; CI: confidence interval; DHS: Demographic and Health Survey; GMIS: Ghana Malaria Indicator Survey; GPS: Global Positioning System; GSS: Ghana Statistical Service; iCCM: Integrated Community Case Management; ICF: Inner City Fund; IRB: Institutional Review Board; JMP: Joint Monitoring Programme; LPG: Liquified Petroleum Gas; MOH: Ministry of Health; NMCP: National Malaria Control Programme; NHIS: National Health Insurance Scheme; UNICEF: United Nations International Children Emergency Fund; WHO: World Health Organization

Declarations

Acknowledgements

We would like to acknowledge the staff and field officers at Ghana Statistical Service (GSS) for their invaluable contribution to this work.

Funding

None

Availability of data and materials

Datasets used for this study are openly available and can be accessed through https://dhsprogram.com/

Ethical approval and consent to participate

The Informed Consent Form (ICF) Institutional Review Board (IRB) and the Ghana Health Service Ethics Review Committeeapproved the protocol for the 2019 GMIS. We obtained permission from the ICF for the use of the datasets, and the terms of use were strictly adhered to. Informed consent was obtained from respondents before interviews were conducted. Again, all methods used were carried out in accordance with relevant guidelines and procedures.

Competing interests

The authors declare that they have no competing interests.

Consent for publication

Not applicable

Authors' contributions

DK conceptualized and designed the study and obtained the data. D. K and DYA analysed and interpreted the data. The entire manuscript was drafted by D.K and DYA. It was critically reviewed and revised by AKC andDYA. All authors approved the final version of the manuscript.

References

1. Grewal A. Anaemia and pregnancy: Anaesthetic implications. Indian Journal of Anaesthesia. 2010;54(5):380.
2. World Health Organization. Guideline: use of multiple micronutrient powders for home fortification of foods consumed by pregnant women. World Health Organization; 2011.
3. World Health Organization. The Global health Observatory: Prevalence of anaemia in women and children. 2020 report.
4. Stevens GA, Finucane MM, De-Regil LM, Paciorek CJ, Flaxman SR, Branca F, et al. Global, regional, and national trends in haemoglobin concentration and prevalence of total and severe anaemia in children and pregnant and non-pregnant women for 1995–2011: A systematic analysis of population-representative data. The Lancet Global Health. 2013;1(1):e16-e25.
5. World Health Organization. Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity. Geneva: World.
6. Stoltzfus RJ, Mullany L, Black RE. Iron deficiency anaemia. Comparative quantification of health risks: global and regional burden of disease attributable to selected major risk factors. 2004;1:163–209.
7. World Health Organization. Worldwide prevalence of anaemia 1993–2005: WHO global database on anaemia. Geneva: World Health Organization; 2008.
8. World Health Organization. United Nations Children's Fund/United Nations University 2001 Iron deficiency anaemia. Assessment, prevention and control: a guide for programme managers. Geneva: World Health Organization. 2012.
9. UNICEF., UNICEF. Nutrition Section, UNICEF. Programme Division, UNICEF. Division of Communication. Sustainable elimination of iodine deficiency: Progress since the 1990 World Summit for Children. Unicef; 2008.
10. Hurtado EK, Claussen AH, Scott KG. Early childhood anemia and mild or moderate mental retardation. The American journal of clinical nutrition. 1999 Jan 1;69(1):115-9.
11. Ai Y, Zhao SR, Zhou G, Ma X, Liu J. Hemoglobin status associated with performance IQ but not verbal IQ in Chinese preschool children. Pediatrics International. 2012 Oct;54(5):669–75.
12. Adekanmbi AF, Ogunlesi TA, Olowu AO, Fetuga MB. Current trends in the prevalence and aetiology of childhood congestive cardiac failure in Sagamu. Journal of tropical pediatrics. 2007 Apr 1;53(2):103-

6.
13. Korenromp EL, Armstrong-Schellenberg JR, Williams BG, Nahlen BL, Snow RW. Impact of malaria control on childhood anaemia in Africa–a quantitative review. Tropical Medicine & International Health. 2004 Oct;9(10):1050–65.
14. GSS, GHS. Ghana Statistical Service (GSS), Ghana Health Service (GHS), and ICF. 2020. Ghana Malaria Indicator Survey 2019. Accra, Ghana, and Rockville, Maryland, USA: GSS, GHS, and ICF. 2020
15. Gayawan E, Arogundade ED, Adebayo SB. Possible determinants and spatial patterns of anaemia among young children in Nigeria: a Bayesian semiparametric modelling. International health. 2014 Mar 1;6(1):35–45.
16. Borbor FM, Kumi-Kyereme A, Yendaw E, Adu-Opong A. A study of the determinants of anaemia among underfive children in Ghana. International Journal of Development Research, 2014 April 23; 4 (4): 858–867.
17. Dwumoh D, Essuman EE, Afagbedzi SK. Determinant of factors associated with child health outcomes and service utilization in Ghana: multiple indicator cluster survey conducted in 2011. Archives of Public Health. 2014 Dec;72(1):1–0.
18. Ewusie JE, Ahiadeke C, Beyene J, Hamid JS. Prevalence of anemia among under5 children in the Ghanaian population: estimates from the Ghana demographic and health survey. BMC public health. 2014 Dec;14(1):1–9.
19. Muchie KF. Determinants of severity levels of anemia among children aged 6–59 months in Ethiopia: further analysis of the 2011 Ethiopian demographic and health survey. BMC Nutrition. 2016 Dec;2(1):1–8.
20. Saaka M, Galaa SZ. How is dietary diversity related to haematological status of preschool children in Ghana?. Food & Nutrition Research. 2017 Jan 1;61(1):1333389.
21. Xin QQ, Chen BW, Yin DL, Xiao F, Li RL, Yin T, Yang HM, Zheng XG, Wang LH. Prevalence of anemia and its risk factors among children under 36 months old in China. Journal of tropical pediatrics. 2017 Feb 1;63(1):36–42.
22. Ogunsakin RE, Babalola BT, Akinyemi O. Statistical Modelling of Determinants of Anemia Prevalence among Children Aged 6–59 Months in Nigeria: A Cross-Sectional Study. Anemia. 2020 Nov 3;2020.
23. Keokenchanh S, Kounnavong S, Midorikawa K, Ikeda W, Morita A, Kitajima T, Sokejima S. Prevalence of anemia and its associated factors among children aged 6–59 months in the Lao People's Democratic Republic: A multilevel analysis. Plos one. 2021 Mar 25;16(3):e0248969.
24. Said FA, Khamis AG, Habib A, Yang H, He Z, Luo X. Prevalence and Determinants of Anemia among Children in Zanzibar, Tanzania: Analysis of Cross-Sectional Population Representative Surveys. Children. 2021 Dec;8(12):1091.
25. Obasohan PE, Walters SJ, Jacques R, Khatab K. Individual, household and area predictors of anaemia among children aged 6–59 months in Nigeria. Public Health in Practice. 2022 Jan 20:100229.

26. Ngimbudzi EB, Lukumay AM, Muriithi AW, Dhamani KA, Petrucka PM. Mothers' knowledge, beliefs, and practices on causes and prevention of anaemia in children aged 6–59 months: a case study at Mkuranga District Hospital, Tanzania. Open Journal of Nursing. 2016;6(04):342.
27. Gebreweld A, Ali N, Ali R, Fisha T. Prevalence of anemia and its associated factors among children under five years of age attending at Guguftu health center, South Wollo, Northeast Ethiopia. PloS one. 2019 Jul 5;14(7):e0218961.
28. Jembere M, Kabthymer RH, Deribew A. Determinants of Anemia Among Children Aged 6 to 59 Months in Dilla Town, Southern Ethiopia: A Facility Based Case Control Study. Global Pediatric Health. 2020 Nov;7:2333794X20974232.
29. Annan RA, Gyimah LA, Apprey C, Edusei AK, Asamoah-Boakye O, Aduku LN, Azanu W, Lutterodt HE. Factors associated with iron deficiency anaemia among pregnant teenagers in Ashanti Region, Ghana: A hospital-based prospective cohort study. Plos one. 2021 Apr 27;16(4):e0250246.
30. Ghana Statistical Service (GSS). 2021 Population and housing census general report: Population of regions and districts. Accra: Ghana Statistical Service; 2021.
31. Appiah PK, Nkuah D, Bonchel DA. Knowledge of and adherence to Anaemia prevention strategies among pregnant women attending antenatal care facilities in Juaboso district in Western-north region, Ghana. Journal of Pregnancy. 2020;2020.
32. SPRING. Reducing anemia in Ghana: The SPRING approach and lessons learned. Arlington: SPRING; 2017.
33. GSS, GHS. Ghana Statistical Service (GSS), Ghana Health Service (GHS), and ICF. 2017. Ghana Malaria Indicator Survey 2016. Accra, Ghana, and Rockville, Maryland, USA: GSS, GHS, and ICF. 2017.
34. Moschovis PP, Wiens MO, Arlington L, Antsygina O, Hayden D, Dzik W, Kiwanuka JP, Christiani DC, Hibberd PL. Individual, maternal and household risk factors for anaemia among young children in sub-Saharan Africa: a cross-sectional study. BMJ open. 2018 May 1;8(5):e019654.
35. Khulu C, Ramroop S. Key determinants of anemia among youngsters under five years in Senegal, Malawi, and Angola. International Journal of Environmental Research and Public Health. 2020 Jan;17(22):8538.
36. Tesema GA, Worku MG, Tessema ZT, Teshale AB, Alem AZ, Yeshaw Y, Alamneh TS, Liyew AM. Prevalence and determinants of severity levels of anemia among children aged 6–59 months in sub-Saharan Africa: A multilevel ordinal logistic regression analysis. PloS one. 2021 Apr 23;16(4):e0249978.
37. UNICEF. UNICEF at a Glance. Unicef; 2009.
38. Lutter CK, Daelmans BM, de Onis M, Kothari MT, Ruel MT, Arimond M, Deitchler M, Dewey KG, Blössner M, Borghi E. Undernutrition, poor feeding practices, and low coverage of key nutrition interventions. Pediatrics. 2011 Dec 1;128(6):e1418-27.
39. Christensen L, Sguassero Y, Cuesta CB. Anemia and adherence to oral iron supplementation in a sample of children assisted by the public health network of Rosario, Santa Fe. Arch Argent Pediatr.

2013 Aug 1;111(4):288 – 94.

40. Gething PW, Patil AP, Smith DL, Guerra CA, Elyazar IR, Johnston GL, Tatem AJ, Hay SI. A new world malaria map: Plasmodium falciparum endemicity in 2010. Malaria journal. 2011 Dec;10(1):1–6.
41. Manning L, Laman M, Rosanas-Urgell A, Michon P, Aipit S, Bona C, Siba P, Mueller I, Davis TM. Severe anemia in Papua New Guinean children from a malaria-endemic area: a case–control etiologic study. PLoS neglected tropical diseases. 2012 Dec 13;6(12):e1972.
42. Sumbele IU, Samje M, Nkuo-Akenji T. A longitudinal study on anaemia in children with Plasmodium falciparum infection in the Mount Cameroon region: prevalence, risk factors and perceptions by caregivers. BMC infectious diseases. 2013 Dec;13(1):1–0.
43. Sowunmi A, Fatunmbi B, Akano K, Wewe OA, Agomo C, Finomo F, Ebenebe J, Jiya N, Ambe J, Wammanda R, Ntadom G. Factors contributing to anaemia after uncomplicated falciparum malaria in under five year-old Nigerian children ten years following adoption of artemisinin-based combination therapies as first-line antimalarials. BMC infectious diseases. 2017 Dec;17(1):1–8.
44. Mwaiswelo RO, Mmbando BP, Chacky F, Molteni F, Mohamed A, Lazaro S, Mkalla SF, Samuel B, Ngasala B. Malaria infection and anemia status in underfive children from Southern Tanzania where seasonal malaria chemoprevention is being implemented. PloS one. 2021 Dec 2;16(12):e0260785.
45. Koram KA, Owusu-Agyei S, Utz G, Binka FN, Baird JK, Hoffman SL, Nkrumah FK. Severe anemia in young children after high and low malaria transmission seasons in the Kassena-Nankana district of northern Ghana. The American journal of tropical medicine and hygiene. 2000 Jun;62(6):670–4.
46. Dwumfour-Asare B, Kwapong MA. Anaemia awareness, beliefs and practices among pregnant women: a baseline assessment at Brosankro community in Ghana. Journal of Natural Sciences Research. 2013;3(15):1–9.
47. Ncogo P, Romay-Barja M, Benito A, Aparicio P, Nseng G, Berzosa P, Santana-Morales MA, Riloha M, Valladares B, Herrador Z. Prevalence of anemia and associated factors in children living in urban and rural settings from Bata District, Equatorial Guinea, 2013. PloS one. 2017 May 3;12(5):e0176613. Jan;17(22):8538.
48. Pita GM, Jiménez S, Basabe B, García RG, Macías C, Selva L, Hernández C, Cruz M, Herrera R, O'Farrill R, Calderius I. Anemia in children under five years old in Eastern Cuba, 2005–2011. Medicc Review. 2014;16:16–23.
49. Semedo RM, Santos MM, Baião MR, Luiz RR, da Veiga GV. Prevalence of anaemia and associated factors among children below five years of age in Cape Verde, West Africa. Journal of health, population, and nutrition. 2014 Dec;32(4):646.
50. Woldie H, Kebede Y, Tariku A. Factors associated with anemia among children aged 6–23 months attending growth monitoring at Tsitsika Health Center, Wag-Himra Zone, Northeast Ethiopia. Journal of nutrition and metabolism. 2015 Oct;2015.
51. Gari T, Loha E, Deressa W, Solomon T, Atsbeha H, Assegid M, Hailu A, Lindtjørn B. Anaemia among children in a drought affected community in south-central Ethiopia. PloS one. 2017 Mar 14;12(3):e0170898.

52. Islam GR. Association of socioeconomic status with childhood anemia among infant, toddler, and preschool children in Bangladesh. Value in Health Regional Issues. 2020 May 1;21:141-8.
53. Elmardi KA, Adam I, Malik EM, Ibrahim AA, Elhassan AH, Kafy HT, Nawai LM, Abdin MS, Kremers S. Anaemia prevalence and determinants in under 5 years children: findings of a cross-sectional population-based study in Sudan. BMC pediatrics. 2020 Dec;20(1):1–4.
54. Nankinga O, Aguta D, Kabahuma C. Trends and determinants of anemia in Uganda: further analysis of the Demographic and Health Surveys. DHS Working Papers. 2019(149).
55. Oladeinde BH, Omoregie R, Olley M, Anunibe JA, Onifade AA, Oladeinde OB. Malaria and anemia among children in a low resource setting in Nigeria. Iranian journal of parasitology. 2012;7(3):31.
56. Zerdo Z, Bastiaens H, Anthierens S, Massebo F, Masne M, Biresaw G, Shewangizaw M, Tunje A, Chisha Y, Yohannes T, Van Geertruyden JP. Prevalence and associated risk factors for asymptomatic malaria and anaemia among school-aged children in Dara Mallo and Uba Debretsehay districts: results from baseline cluster randomized trial. Malaria Journal. 2021 Dec;20(1):1–2.
57. Austin Morton Ntenda P, Chilumpha S, Tisungane Mwenyenkulu E, Flora Kazambwe J, El-Meidany W. Clinical malaria and the potential risk of anaemia among preschool-aged children: a population-based study of the 2015-2016Malawi micronutrient survey. Infectious diseases of poverty. 2019 Dec 1;8(06):28–38.
58. Akinbo FO, Omoregie R, Mordi R, Okaka CE. Prevalence of malaria and Anemia among young children in a tertiary Hospital in Benin City, Edo state, Nigeria. Fooyin Journal of Health Sciences. 2009 Nov 1;1(2):81 – 4.
59. Abrokwah AA. Social Health Insurance and Maternal and Child Health Outcomes in Developing Countries: The Case of Ghana.2017
60. Anaba EA, Abuosi AA, Azilaku JC, Nkrumah J. Association between health insurance membership and anaemia among children underfive years. Evidence from Ghana. Plos one. 2020 Sep 14;15(9):e0238792.
61. Bagnoli L. Does National Health Insurance Improve Children's Health? National and Regional Evidence from Ghana. ECARES Working Papers. 2017 Feb.

Tables

Table 1 Maternal and household characteristics of respondents

Maternal related factors	*Weighted Sample n= 1,258*	*%*
Age of mother		
15-29	623	49.5
30-39	514	40.9
40-49	121	9.6
Educational level of mother		
No education	335	26.6
Primary	311	24.7
Secondary+	613	48.7
Place of residence of mother		
Urban	455	36.2
Rural	803	63.8
Ecological zone of residence of mother		
Coastal zone	504	40.1
Middle Belt	397	31.5
Northern zone	357	28.4
Parity of mother		
1-3 children	759	60.3
4-6 children	407	32.4
7+ children	92	7.3
Religious affiliation of mother		
Catholic	80	6.3
Protestant	135	10.7
Pentecostal/Charismatic	494	39.3
Other Christian	155	12.3
Moslem	332	26.4
Traditional/Spiritualist	25	2.0
No religion	37	2.9
Literacy level of mothers		

Illiterate	748	59.4
Literate	511	40.6
Household related factors		
Sex of household head		
Male	891	79.8
Female	367	29.2
Age of household head		
20-29	203	16.1
30-39	433	34.4
40-49	301	23.9
50-59	150	11.9
60-69	86	6.8
70+	86	6.8
Household source of drinking water		
Improved water source	1075	85.4
Unimproved water source	183	14.6
Household type of toilet facility		
Improved toilet	748	59.4
Unimproved toilet	510	40.6
Household type of cooking fuel		
Liquefied Petroleum Gas (LPG)	160	12.7
Charcoal	388	30.8
Fuel wood	680	54.1
Other cooking fuel	31	2.4
Household Wealth Index		
Poorest	370	29.4
Poorer	295	23.5
Middle	265	21.1
Richer	201	15.9

Richest	127	10.1

Source: *Computed from the 2019 Ghana Malaria Indicator Survey (GMIS)*

Table 2 Child and health system characteristics of respondents

Child related factors	*Weighted Sample n= 1,258*	*%*
Sex of child		
Boy	662	52.6
Girl	596	47.4
Current age of child		
Less than 12 months	183	14.6
1 year	341	27.1
2 years	325	25.8
3 years	245	19.4
4 years	165	13.1
Child sleep under treated bednet		
Did not sleep	282	22.4
Sleep under net	811	64.4
Household do not have net	165	13.1
Allow child to be vaccinated		
Not allow vaccination	59	4.7
Allow vaccination	1200	95.3
Child Malaria Status		
Child tested negative for malaria	1131	89.9
Child tested positive for malaria	127	10.1
Health system related factors		
Health Insurance coverage		
Not covered	512	40.7
NHIS covered	746	59.3
Number of antenatal visits during pregnancy		
No ANC visits	287	22.8
1-3 visits	80	6.4
4+ visits	891	70.8
Took SP during pregnancy at health facility		

Did not take SP	348	27.7
Took SP	910	72.3
Awareness of NHIS coverage of malaria		
Not Aware	316	25.1
Aware	942	74.9

Source: *Computed from the 2019 Ghana Malaria Indicator Survey (GMIS)*

Table 3 Association between maternal, household-related factors and anaemia level of children under age five in Ghana

Source: *Computed from the 2019 Ghana Malaria Indicator Survey (GMIS)*

*P<0.05, **P<0.01, ***P<0.001

Table 4 Association between child, health system-related factors and anaemia level of children under age five in Ghana

Source: *Computed from the 2019 Ghana Malaria Indicator Survey (GMIS)*

*P<0.05, **P<0.01, ***P<0.001

Table 5 Odds ratios and confidence intervals for maternal and household factors affecting anaemia levels in children under age five (mild, moderate, and severe anaemia): Results from a multinomial logistic regression model

Factors	*Anaemia level of Children under five years in Ghana*			
	Severe	Moderate	Mild	P values
Maternal related Factors				
Age of mother				
15-29	2.9	50.6	46.5	0.143
30-39	1.8	47.1	51.2	
40-49	5.0	43.8	51.2	
Educational Level of mother				
No Education	5.1	56.1	38.8	0.000***
Primary	1.3	48.6	50.2	
Secondary+	2.0	44.2	53.8	
Place of residence of mother				
Urban	1.8	43.6	54.6	0.006**
Rural	3.1	51.2	45.6	
Ecological zone of residence of mother				
Coastal zone	2.0	44.0	54.0	0.000***
Middle Belt	1.3	46.0	52.8	
Northern zone	5.0	57.5	37.4	
Parity of mother				
1-3 children	2.2	48.0	49.8	0.174
4-6 children	2.7	51.2	46.1	
7+ children	5.5	40.7	53.8	
Religion of mother				
Catholic	5.0	43.8	51.2	
Protestants	1.5	49.6	48.9	

Pentecostal/Charismatic	1.2	45.3	53.5	0.001**
Other Christians	3.2	44.9	51.9	
Moslem	3.9	55.1	41.0	
Traditional/Spiritualist	0.0	41.7	58.3	
No Religion	10.8	56.8	32.4	
Literacy level of mother				
Illiterate	3.2	52.1	44.7	0.001**
Literate	2.0	42.9	55.1	
Household related factors				
Sex of household head				0.256
Male	2.9	49.7	47.4	
Female	2.2	45.5	52.3	
Age of household head				
20-29	3.4	51.2	45.3	0.094
30-39	1.2	47.1	51.7	
40-49	3.7	48.5	47.8	
50-59	4.0	43.6	52.3	
60-69	0.0	50.0	50.0	
70+	4.7	57.0	38.4	
Source of drinking water				
Improved	2.1	47.3	50.6	0.001**
Unimproved	6.0	54.9	39.1	
Type of toilet facility				
Improved	1.5	45.9	52.6	0.000***
Unimproved	4.3	52.3	43.4	
Type of cooking fuel				

Liquefied Petroleum Gas	0.0	38.8	61.3	
Charcoal	1.3	43.7	55.0	
Fuel wood	4.0	53.3	42.7	0.000***
Other cooking fuel	6.5	48.4	45.2	
Household wealth index				
Poorest	5.4	55.9	38.6	
Poorer	3.4	50.2	46.4	
Middle	1.1	48.3	50.6	0.000***
Richer	0.0	41.8	58.2	
Richest	0.0	33.9	66.1	

Factors	*Anaemia level of Children under five years in Ghana*			
	Severe	Moderate	Mild	P values
Child related Factors				
Sex of child				
Boy	3.0	49.8	47.1	
Girl	2.2	47.0	50.8	0.323
Current age of child				
Less than 12 months	1.6	57.9	40.4	
1 year	2.6	54.7	42.6	
2 years	3.4	50.9	45.7	0.000***
3 years	3.7	32.0	64.3	
4 years	0.6	44.8	54.5	
Child sleep under treated bednet				
Did not sleep	2.1	45.4	52.5	
Sleep under net	2.7	49.3	48.0	0.632
Household do not have net	3.6	49.4	47.0	
Allow child to be vaccinated				
Not allow vaccination	0.0	48.3	51.7	0.428
Allow vaccination	2.8	48.5	48.8	
Child Malaria Status				
Child tested negative for malaria	2.2	47.9	49.9	0.006**
Child tested positive for malaria	6.3	53.5	40.2	
Health system related factors				
Health Insurance coverage				
Not covered	2.7	48.5	48.7	0.997
NHIS covered	2.7	48.4	48.9	
Number of antenatal visits during pregnancy				
No ANC visits	2.4	40.4	57.1	

1-3 visits	2.5	43.2	54.3	0.014*
4+ visits	2.8	51.5	45.7	
Took SP during pregnancy at health facility				
Did not take SP	2.9	39.9	57.2	0.001**
Took SP	2.5	51.8	45.7	
Awareness of NHIS coverage of malaria				
Not Aware	4.1	51.4	44.4	0.047*
Aware	2.1	47.5	50.4	

Anaemia level of Children under five years in Ghana

Factors				
	Severe Anaemia		Moderate Anaemia	
Maternal related factors	Exp β	95% C. I	Exp β	95 C.I
Age of mother				
15-29	1.41	0.37-5.42	1.36	0.84-2.19
30-39	0.51	0.16-1.64	1.10	0.72-1.69
40-49 (RC)	0.00		0.00	
Educational Level of mother				
No Education	1.60	0.44-5.83	1.23	0.81-1.87
Primary	0.55	0.14-2.10	1.01	0.71-1.44
Secondary+ (RC)	0.00		0.00	
Place of residence of mother				
Urban	0.75	0.31-1.81	0.81	0.63-1.04
Rural (RC)	0.00		0.00	
Ecological zone of residence of mother				
Coastal zone	0.59	0.21-1.66	**0.67***	0.47-0.95
Middle Belt	0.41	0.13-1.33	0.70	0.49-1.01
Northern zone (RC)	0.00		0.00	
Parity of mother				
1-3 children	0.41	0.09-1.86	1.46	0.85-2.51
4-6 children	0.56	0.16-1.96	1.62	0.99-2.67
7+ children (RC)	0.00		0.00	
Religious affiliation of mother				
Catholic	0.39	0.08-2.01	0.57	0.24-1.34
Protestant	0.20	0.03-1.28	0.86	0.38-1.92
Pentecostal/Charismatic	**0.12****	0.03-0.55	0.69	0.33-1.46
Other Christian	0.33	0.07-1.65	0.75	0.34-1.66
Moslem	0.29	0.07-1.19	0.84	0.39-1.80

Traditional/Spiritualist	0.08	0.00-1.97	0.43	0.15-1.29
No religion (RC)	0.00		0.00	
Literacy level of mothers				
Illiterate	1.06	0.32-3.57	1.22	0.87-1.71
Literate (RC)	0.00		0.00	
Household related factors				
Sex of household head				
Male	1.17	0.47-2.89	1.14	0.87-1.48
Female (RC)	0.00		0.00	
Age of household head				
20-29	0.71	0.19-2.67	0.85	0.49-1.46
30-39	**0.23***	0.06-0.92	0.69	0.42-1.13
40-49	0.60	0.18-2.06	0.69	0.41-1.15
50-59	0.59	0.16-2.21	**0.56***	0.32-0.97
60-69	0.74	0.32-2.85	0.64	0.35-1.19
70+ (RC)	0.00		0.00	
Source of drinking water				
Improved	0.58	0.25-1.32	0.86	0.60-1.24
Unimproved(RC)	0.00		0.00	
Type of toilet facility				
Improved	0.73	0.33-1.59	0.96	0.74-1.26
Unimproved (RC)	0.00		0.00	
Type of cooking fuel				
Liquefied Petroleum Gas	0.84	0.96-5.11	1.18	0.46-3.02
Charcoal	0.76	0.11-5.41	1.04	0.45-2.39
Fuel wood	0.78	0.15-4.19	1.23	0.56-2.71
Other cooking fuel (RC)	0.00		0.00	
Household wealth index				
Poorest	0.27	0.10-0.64	**2.45****	1.30-4.63

Poorer	0.37	0.26. 0.75	**2.01***	1.09-3.67
Middle	0.54	0.38-0.92	**1.89***	1.07-3.34
Richer	0.52	0.46-0.98	1.46	0.88-2.44
Richest (RC)	0.00		0.00	

RC=Reference Category; ***p=0.000; **p=0.001; *p<0.05

Source: *Computed from 2019 Ghana Malaria Indicator Surveys (GMIS)*

Table 6 Odds ratios and confidence intervals for child and health system factors affecting anaemia levels in children under age five (mild, moderate, and severe anaemia): Results from a multinomial logistic regression model

Factors	*Anaemia level of Children under five years*			
	Severe Anaemia		Moderate Anaemia	
Child related factors	Exp β	95% C. I	Exp β	95 C.I
Sex of child				
Boy	1.61	0.77-3.34	1.15	0.91-1.45
Girl (RC)	0.00		0.00	
Current age of child				
Less than 12 months	4.35	0.29-66.10	1.59	1.00-2.51
1 year	7.43	0.59-94.10	1.44	0.96-2.16
2 years	8.57	0.70-104.69	1.25	0.84-1.86
3 years	7.54	0.62-91.57	**0.59***	0.39-0.90
4 years (RC)	0.00		0.00	
Child sleep under treated bednet				
Did not sleep	0.52	0.16-1.73	0.79	0.53-1.18
Sleep under net	0.75	0.28-2.01	0.95	0.67-1.35
Household do not have net (RC)	0.00		0.00	
Allow child to be vaccinated				
Not allow vaccination	0.16	0.01-5.25	1.04	0.60-1.79
Allow vaccination(RC)	0.00		0.00	
Child Malaria Status				
Child tested negative for malaria	**0.29****	0.12-0.68	0.76	0.52-1.13
Child tested positive for malaria (RC)	0.00		0.00	
Health system related factors				
Health Insurance coverage				
Not covered	0.93	0.45-1.92	0.98	0.77-1.24
NHIS covered (RC)	0.00		0.00	
Number of antenatal visits during pregnancy				
No ANC visits	0.53	0.11-2.55	1.17	0.65-2.11

1-3 visits	0.55	0.10-3.08	0.71	0.44-1.16
4+ visits (RC)	0.00		0.00	
Took SP during pregnancy at health facility				
Did not take SP	1.60	0.41-6.21	0.67	0.40-1.14
Took SP (RC)	0.00		0.00	
Awareness of NHIS coverage of malaria				
Not Aware	**2.50***	1.20-5.21	1.30	1.00-1.71
Aware (RC)	0.00		0.00	

RC=Reference Category; ***p=0.000; **p=0.001; *p<0.05

Source: *Computed from 2019 Ghana Malaria Indicator Surveys (GMIS)*

Table 7 Odds ratios and confidence intervals for maternal, household, child and health system factors affecting anaemia levels in children under age five (mild, moderate, and severe anaemia): Results from a multinomial logistic regression model

Anaemia level of Children under five years in Ghana

Factors				
	Severe Anaemia		Moderate Anaemia	
Maternal related factors	Exp β	95% C. I	Exp β	95 C.I
Age of mother				
15-29	1.19	0.24-5.87	1.07	0.62-1.83
30-39	0.66	0.18-2.52	1.02	0.63-1.63
40-49 (RC)	0.00		0.00	
Educational Level of mother				
No Education	1.19	0.28-5.03	1.19	0.77-1.86
Primary	0.42	0.09-1.85	0.97	0.66-1.42
Secondary+ (RC)	0.00		0.00	
Place of residence of mother				
Urban	**3.87***	1.11-13.48	0.95	0.69-1.31
Rural (RC)	0.00		0.00	
Ecological zone of residence of mother				
Coastal zone	1.25	0.38-4.14	0.78	0.52-1.19
Middle Belt	0.64	0.17-2.45	0.80	0.52-1.22
Northern zone (RC)	0.00		0.00	
Parity of mother				
1-3 children	0.40	0.07-2.19	1.54	0.86-2.74
4-6 children	0.53	0.13-2.09	1.69	1.00-2.87
7+ children (RC)	0.00		0.00	
Religious affiliation of mother				

Catholic	0.81	0.12-5.28	0.52	0.22-1.27
Protestant	0.37	0.04-2.83	0.88	0.38-2.05
Pentecostal/Charismatic	0.19	0.04-1.05	0.71	0.33-1.55
Other Christian	0.77	0.12-4.83	0.74	0.32-1.70
Moslem	0.62	0.11-3.35	0.88	0.40-1.94
Traditional/Spiritualist	0.16	0.01-5.20	0.50	0.16-1.54
No religion (RC)	0.00		0.00	
Literacy level of mothers				
Illiterate	0.63	0.16-2.43	1.20	0.84-1.71
Literate (RC)	0.00		0.00	
Household related factors				
Sex of household head				
Male	1.41	0.49-4.07	1.12	0.84-1.49
Female (RC)	0.00		0.00	
Age of household head				
20-29	0.75	0.16-3.49	0.74	0.41-1.32
30-39	**0.17***	0.03-0.84	0.64	0.37-1.09
40-49	0.50	0.12-2.04	0.66	0.38-1.14
50-59	0.41	0.09-1.82	**0.52***	0.29-0.93
60-69	0.38	0.09-1.92	0.61	0.32-1.19
70+ (RC)	0.00		0.00	
Source of drinking water				
Improved	0.41	0.16-1.06	0.84	0.57-1.24
Unimproved(RC)	0.00		0.00	

Type of toilet facility				
Improved	0.77	0.32-1.87	1.06	0.79-1.41
Unimproved (RC)	0.00			0.00
Type of cooking fuel				
Liquefied Petroleum Gas	0.49	0.21-1.43	1.40	0.52-379
Charcoal	0.32	0.03-3.46	1.10	0.47-2.70
Fuel wood	0.67	0.09-4.74	1.26	0.57-2.93
Other cooking fuel (RC)	0.00		0.00	
Household wealth index				
Poorest	0.21	0.01-2.79	**2.46***	1.17-5.20
Poorer	0.37	0.17-4.12	**2.37***	1.22-4.64
Middle	0.68	0.43-5.10	**2.07***	1.12-3.82
Richer	0.11	0.03-3.13	1.66	0.96-2.86
Richest (RC)	0.00		0.00	
Child related factors				
Sex of child				
Boy	1.42	0.63-3.22	1.15	0.91-1.47
Girl (RC)	0.00		0.00	
Current age of child				
Less than 12 months	5.65	0.33-96.34	**1.72***	1.06-2.80
1 year	9.48	0.69-131.09	1.45	0.94-2.23
2 years	10.12	0.77-133.84	1.18	0.78-1.80
3 years	10.85	0.84-139.94	**0.59***	0.38-0.90
4 years (RC)	0.00		0.00	

Child sleep under treated bednet				
Did not sleep	0.52	0.13-2.08	0.85	0.56-1.29
Sleep under net	0.40	0.12-1.28	0.76	0.52-1.11
Household do not have net (RC)	0.00		0.00	
Allow child to be vaccinated				
Not allow vaccination	0.13	0.00-4.97	1.14	0.64-2.01
Allow vaccination(RC)	0.00		0.00	
Child Malaria Status				
Child tested negative for malaria	**0.22****	0.08-0.61	0.75	0.50-1.13
Child tested positive for malaria (RC)	0.00		0.00	
Health system related factors				
Health Insurance coverage				
Not covered	0.96	0.42-2.19	1.02	0.79-1.31
NHIS covered (RC)	0.00		0.00	
Number of antenatal visits during pregnancy				
No ANC visits	0.27	0.05-1.53	1.04	0.56-1.92
1-3 visits	0.36	0.06-2.24	0.60	0.36-1.00
4+ visits (RC)	0.00		0.00	
Took SP during pregnancy at health facility				
Did not take SP	2.58	0.56-11.91	0.67	0.39-1.17
Took SP (RC)	0.00		0.00	
Awareness of NHIS coverage of malaria				

Not Aware	**3.00****	1.31-6.88	**1.33***	1.00-1.77
Aware (RC)	0.00		0.00	

RC=Reference Category; ***p=0.000; **p=0.001; *p<0.05

Source: *Computed from 2019 Ghana Malaria Indicator Surveys (GMIS*

Figures

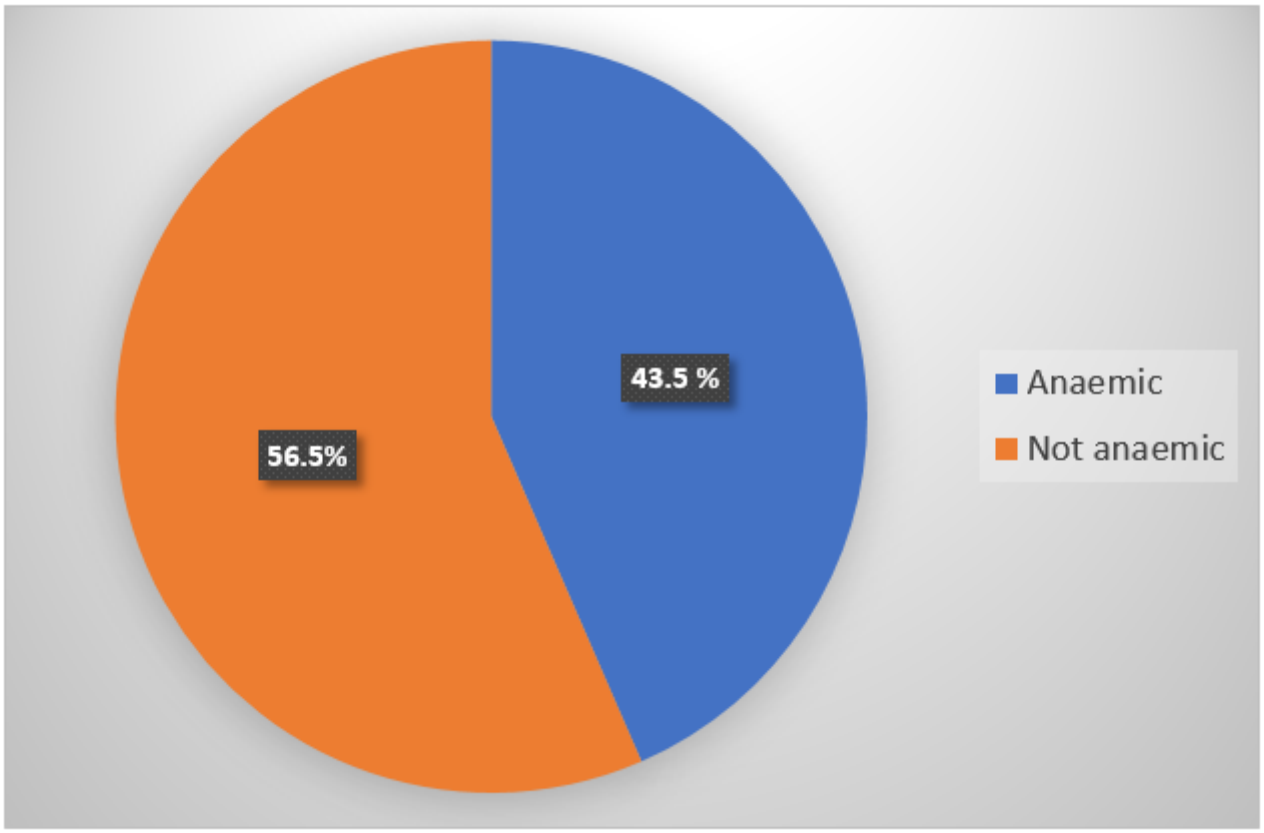

Figure 1

Anaemia prevalence among children under age five in Ghana

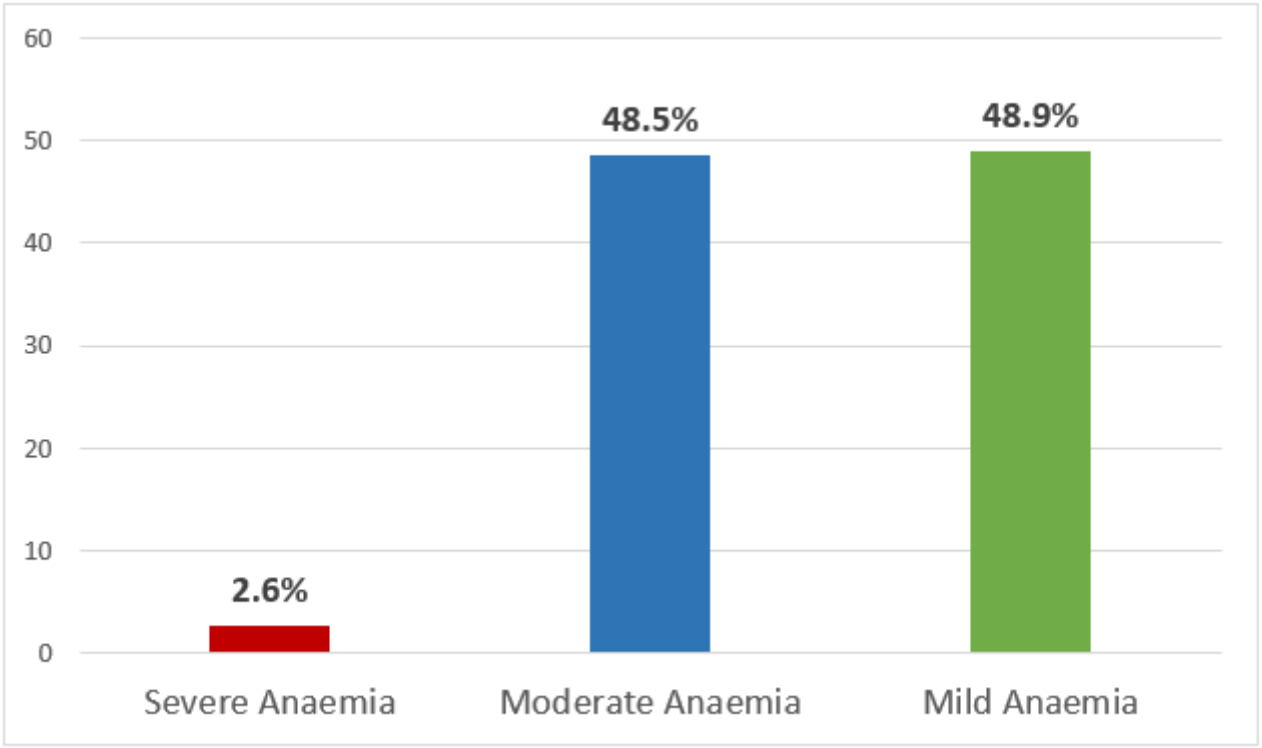

Figure 2

Anaemia level among children under age five in Ghana