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ORIGINAL RESEARCH

Identification of Factors Influencing Anemia among Children Aged 6–59 Months in Ethiopia Using Ethiopia Demographic and Health Survey 2016 Data

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Background: Anemia is the most common nutritional problem and a widespread micro-nutrient-deficiency disorder on a global scale. In Ethiopia, childhood anemia is highly prevalent and a major public health concern. This study aimed to identify factors associated with anemia among children aged 6–59 months in Ethiopia.

Methods: Data weres extracted from the 2016 Ethiopia Demographic and Health Survey (EDHS). We found records for 8,603 children aged 6–59 months in the data set. After 448 had been excluded due to incomplete records, 8,155 children were included in the final analysis. Pearson's χ^2 was used to assess associations between each factor and categorical outcome variables. Multivariate logistic regression analyses were done to determine factors associated with anemia, and significant associations were declared at $p\leq0.05$ for the final model.

Results: More than half (51.5%) the children were male and the overall mean age was 31.85 ±15.66 months. Mean hemoglobin concentration was 10.37±17.55 g/dL. The overall prevalence of anemia was 56.6%: 3.7%, 30.4%, and 22.5% severe, moderate, and mild anemia, respectively. Increased child age, decreased maternal age, lowest rung on wealth index, mother living alone, mother engaged in outside work, increased birth order, decreased birth interval, one antenatal care visit, severe stunting, and severe underweight were significantly associated with anemia.

Conclusion: The prevalence of anemia in this study was the highest of all EDHS reports. It had increased since the preceding report (EDHS 2011), and remains the main public health concern in Ethiopia. Comprehensive intervention strategies should be put in place and tailored to different levels of government (national, regional, and district) including household- and individual-level interventions for combating childhood anemia by focusing on the identified risk factors.

Keywords: anemia, associated, children, EDHS 2016, Ethiopia

Background

Globally, anemia is the most common nutritional concern and widespread public health micro-nutrient-deficiency disorder, and affects more than 2 billion people. According to the World Health Organization (WHO), it is one of the top ten health concerns in the world.[1,2] It affects both developed and developing countries, with major consequences for human health, as well as social and economic development.[3,4]

Childhood anemia is a condition where a child has insufficient hemoglobin (<11 g/dL) to provide adequate oxygen to body tissue.[5] In children, anemia results

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in low oxygenation of brain tissue, which in turn leads to impaired cognitive function, growth, and psychomotor development. This leads to reduced academic achievement and low income-earning potential in their adulthood.[6] Although anemia can occur at any time and at all stages of the life cycle,[7] anemia in aged <5 years is in terms of its morbidity and mortality.[8]

Globally, 43% of preschool children are anemic.[9] A study conducted in sub-Saharan Africa revealed that the prevalence of anemia among children aged 6–59 months was 59%, ranging from 23.7% in Rwanda to 87.9% in Burkina Faso.[10] In Ethiopia, childhood anemia is a big public health concern. The trend of anemia among children aged 6–59 months declined from 54% in 2005 to 44% in 2011, but increased to 56.6% in the 2016 Ethiopia Demographic and Health Survey (EDHS).[11]

Though several studies have been conducted in various settings in the country, most have lacked consistency, used unrepresentative sample and poor laboratory testing methods (Sahliheillage method) for hemoglobin determination, and did not include associated factors in the data collected. With the high prevalence of childhood anemia in Ethiopia, identifying and addressing associated factors could be an important step in designing successful intervention strategies at the national level. Therefore, this study was designed to assess factors associated with anemia among children aged 6–59 months in Ethiopia to inform health authorities at different levels of government on risk factors to be targeted and measures to be taken to prevent and control childhood anemia.

Methods

Data Source, Study Setting, Study Design, and Population

EDHSs are conducted every 5 years. The 2016 EDHS was the fourth and most recent in Ethiopia, following the 2000, 2005, and 2011 EDHSs. The 2016 EDHS was conducted on a nationally representative sample of nine regional states and two city administrations, subdivided into 68 zones, 817 districts, and 16,253 kebeles (lowest local administrative units of the nation). The full data set of EDHS 2016 is available and accessible on the DHS program website: http://dhsprogram.com/data/dataset/EthiopiaStandard-DHS_2016.cfm. Children 6–59 months of age with hemoglobin-level records were included in this study. A community-based cross-sectional study design was used. The children were selected randomly.

Sample-Size Determination and Sampling Procedure

Study participants selected using a stratified two-stage cluster design and enumeration areas were the sampling units for the first stage. In this stage, 645 enumeration areas were randomly selected: 202 in urban areas and 443 in rural areas. In the second stage, a fixed number of 28 households per cluster were selected randomly for each enumeration area. The 18,060 households were randomly selected, and 16,650 households were eligible and interviewed. Additional information about the methodology of EDHS 2016 can be accessed in the published report of the main findings of the survey.[11]

Every child in the selected households was included, and data were collected on various health and nutrition variables, in addition to measurement of hemoglobin levels for children aged 6–59 months. As our focus in this study was in these children, we extracted the EDHS 2016 data set. We found data records for 8,603 children in this age-group. After exclusion of 448 due to incomplete records, 8,155 were included in the final analysis (Figure 1).

Dependent Variable

The outcome variable was anemia status of children aged 6–59 months.

Independent Variables

Selection of the independent variables was guided by the literature and availability of the variables in the data set.[12–16] Some of the independent variables for anemia among children 6–59 months follow.

Maternal Characteristics

Maternal age, educational status, antenatal care follow-up, currently living with husband or not, engaged in paid work or not, deworming during pregnancy, and body-mass index (BMI; kg/m^2) data were gathered.

Household Characteristics

These comprised a wealth index (poorest, poor, middle, rich, and richest), number of household members, number of under five children aged <5 years in the household, sex of household head, and residence.

Child Characteristics

These comprised child age, birth order, birth interval, birth status (single/multiple), recent diarrhea, stunting, wasting, underweight, and vitamin A supplementation in the preceding 6 months.

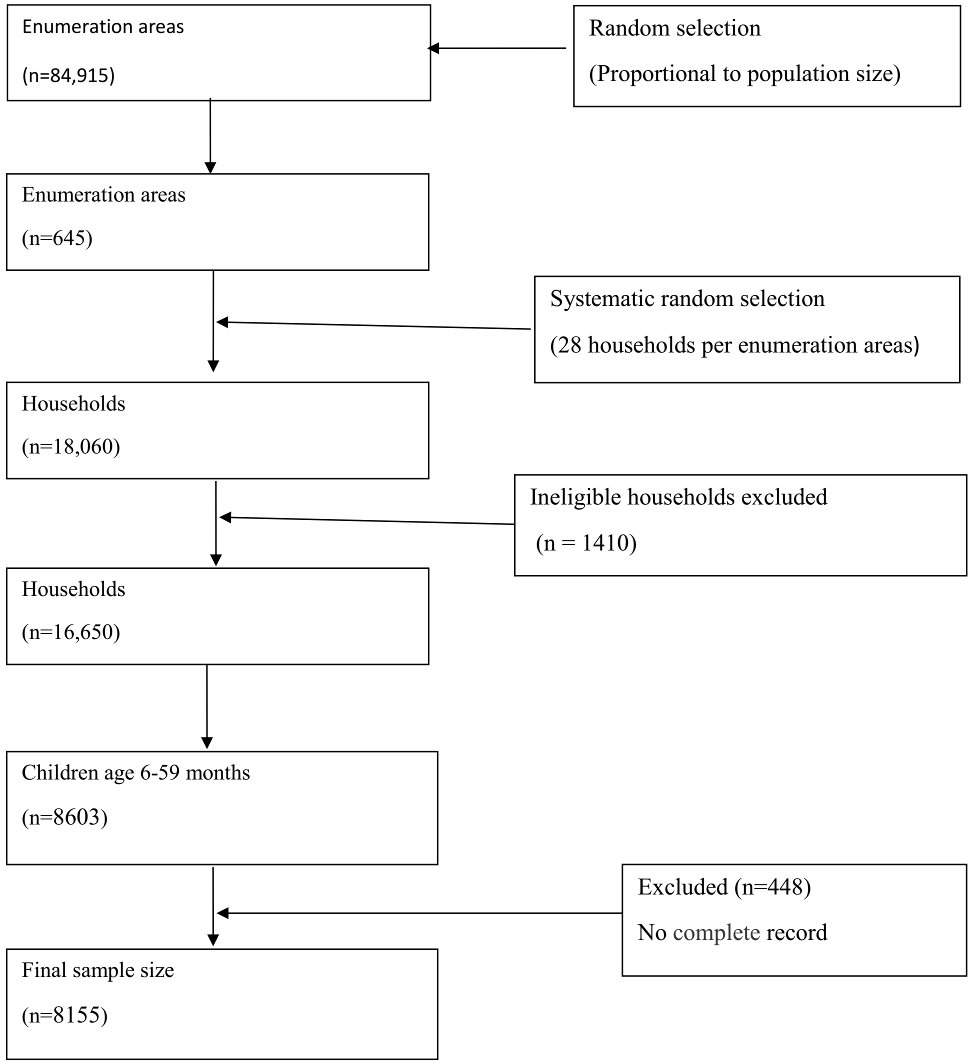


Figure 1 Flowchart of sample-selection technique (n=8,155).

Hematologic Measurement

Blood samples were drawn from the finger or heel, and hemoglobin level for each child was measured adjusted to altitude with a HemoCue 201 analyzer. Anemia was defined as hemoglobin <11 g/dL, and categorized into mild, moderate, and severe anemia by measures of 10–<11 g/dL, 7–<10 g/dL, and <7 g/dL, respectively.[11]

Anthropometric Measurements

The height of children aged <24 months was measured during the EDHS in a recumbent position to the nearest 0.1 cm using a measuring board with an upright wooden base and movable headpieces. Children ≥24 months were measured standing upright. Data collectors used a stadimeter for height measurement, with subjects positioned at the Frankfurt plane and the four points (heel, calf, buttock, and shoulder) touching the vertical stand and without shoes. Weight was measured using a digital scale with children in light clothes and without shoes. The validity of the weighing scale was checked before starting in the morning and between each measurement using a known weight. Height- and weight-measuring devices were placed on a level surface. All anthropometric measurements were done in triplicate and average values used for further analyses. Underweight, stunting, and wasting were calculated using the WHO child-growth standards and defined as WAZ, HAZ, and WHZ <−2.0 SD, respectively.[16]

Wealth Index

A wealth index in the EDHS survey was calculated based on household-asset data to categorize individuals into five wealth quintiles (poorest, poor, medium, rich, and richest). Variables included in the wealth index were ownership of selected household assets (television, bicycle, or car), size of agricultural land, quantity of livestock, and materials used for house construction.[17]

Data Analysis

After data had been extracted, we checked for completeness and consistency and performed preliminary analyses. Sample weights were applied in all analyses (due to the two-stage cluster sampling design in the EDHS data set) to correct for the unequal probability of selection among the strata.[11] Data analysis was carried out using Stata 14. Descriptive statistics wwere used for frequencies and percentages for categorical variables and means ± SD for continuous variables. χ^2 and Students *t*-tests were used to assess significant differences in categorical and continuous variables, respectively.

Bivariate logistic regression was fitted to check for presence or absence of association between each independent variable and anemia. Those explanatory variables with p-<0.05 on bivariate analysis were included in the final multivariate logistic regression analysis to adjust for confounding and to identify final factors associated with anemia. Backward logistic regression was used for multivariate analysis. The goodness of fit of the final logistic model was tested using Hosmer–Lemeshow test at $p>0.05$. Results for outcome measures are indicated with ORs and 95% CIs. Significance was declared at $p\leq0.05$ for the final logistic regression model.

Ethics Considerations

The study proposal got ethical approval from the Tigray Health Research Institute, and a formal letter of permission was obtained from the DHS Program website to access the data set (http://www.measuredhs.com).

Results

Sociodemographic and Other Characteristics of Mothers

Half (49.6%) the mothers/caregivers of the children were aged 20–29 years, and 64.7% were Illiterate. A majority (81.9%) were rural residents, and 71.4% were not currently in paid work. More than a third (36.7%) of households were classified within the poorest rank of the wealth index. A third (33.6%) of mothers had not visited antenatal care (ANC) units, and 37.1% reported the recommended number of ANC visits (four and above) during their recent pregnancy. A quarter (24.7%) of mothers were underweight, and one in ten (9.3%) overweight and obese. Half (50.8%) the households had four to six family members, 79.1% were headed by the man (Table 1).

Characteristics of Children

Data on 8,155 children were included in the analysis. More than half (51.5%) were male, and mean age was 31.85±15.66 months, with no significant mean age

Table 1 Sociodemographic and Other Characteristics of Mothers, EDHS 2016 (n=8,155)

		n	%
Age (years)	<20	243	3.0%
	20–24	1,592	19.5%
	25–29	2,456	30.1%
	30–34	1,864	22.9%
	35–39	1,299	15.9%
	40–44	535	6.6%
	≥45	166	2.0%
Education	None	5,277	64.7%
	Primary	2,065	25.3%
	Secondary	525	6.4%
	Tertiary	288	3.5%
BMI	Underweight	2,016	24.7%
	Normal	5,383	66.0%
	Overweight	578	7.1%
	Obese	171	2.1%
ANC follow-up	Zero	1,803	33.6%
	One	245	4.6%
	Two	395	7.4%
	Three	933	17.4%
	Four and above	1,995	37.1%
Engaged in paid work	Yes	2,330	28.6%
	No	5,825	71.4%
Residence	Rural	6,681	81.9%
	Urban	1,474	18.1%
Number of household members	<4	876	10.7%
	4–6	4,143	50.8%
	7–9	2,626	32.2%
	≥10	510	6.3%
Sex of household head	Male	6,447	79.1%
	Female	1,708	20.9%
Wealth index	Poorest	2,996	36.7%
	Poor	1,416	17.4%
	Middle	1,175	14.4%
	Rich	1,005	12.3%
	Richest	1,563	19.2%

Abbreviations: BMI, body-mass index; ANC, antenatal care.

difference between the sexes (p=0.107). In sum, 81.9% were rural residents. More than a third (36.5%) were born first or second. The mean birth interval was 38.29±22.15, significantly higher (38.66±22.06) for girls than boys (37.93±22.24; p=0.001). More than a third (35.5%) of households had only one child aged <5 years, and 45.6% households had two. The prevalence of stunting, underweight, and wasting was 38%, 24%, and 10%, respectively. The prevalence of stunting was significantly higher (39.4%) in boys than girls (36.6%; p=0.014), as was the prevalence of wasting (10.8% vs 9.1%, p=0.026). Less than half (47.9%) participants had had vitamin A supplements in the preceding 6 months, and only 2.4% had multiple birth status. Around 11.8% reported recent diarrhea (Table 2).

Prevalence of Anemia Stratified by Sex

The overall prevalence of anemia was 56.6%: 3.7%, 30.4%, and 22.5% severe, moderate, and mild, respectively (Figure 2). Mean hemoglobin concentration was 10.37±17.55 g/dL, with no significant difference between the sexes (p=0.355). Anemia was most prevalent in Somali state, followed by Afar and Oromia states, with prevalence of 73.9%, 70.4%, and 62.4%, respectively. The lowest prevalence (41.2%) was found in Amhara state (Figure 3). Anemia prevalence significantly decreased with age (p<0.001): 73.5% for the lowest range (6–11 months) and 40.0% for the highest (48–59 months). As child age increased, so did hemoglobin concentration (r=~0.3, Figure 4). Anemia prevalence also significantly decreased with increased birth interval (p<0.001). Prevalence was 52.6%, 63.0%, and 50.0% among firstborn children, lowest birth interval (<24 months), and highest birth interval (≥48 months), respectively. Anemia prevalence significantly increased with increasing birth order of the child (p<0.001), with a prevalence of 52.7% for first and 59.8% for the highest (eighth and above). Anemia prevalence significantly increased with increasing number of children-aged 5 years in the household (p<0.001) with prevalence of 50.6%, 58.1%, and 64.9% in households with one, two, and three or more children aged <5 years, respectively.

Children who had had recent diarrhea showed significantly higher (61.9%) anemia prevalence than those who had not (55.9%; p<0.001). Children who had been supplemented with vitamin A in the preceding 6 months had significantly lower (54.0%) anemia prevalence than those who had not (59.1%; p<0.001). Anemia prevalence among children also significantly increased with increasing severity of stunting, underweight, and wasting (p<0.001). With regard to nutritional status, the highest prevalence of anemia was among severely wasted children, followed by severely underweight and severely stunted children: 73.2%, 71.1%, and 64.9%, respectively.

Significantly higher anemia prevalence was documented among rural children (58.4%) than urban children (48.3%; p<0.001). Anemia significantly and consistently decreased with increasing maternal age (p<0.001), with the highest (68.3%) prevalence among the lowest age-group (<20 years) and the lowest (44.0%) among the highest age-group (≥45 years). As the literacy of the mother increased, anemia prevalence among children consistently and significantly decreased (p<0.001), with prevalence of 59.2%, 54.8%, 47.6%, and 39.6% among mothers who could not read or write and those with primary, secondary, and tertiary education, respectively. Anemia significantly decreased with increasing wealth index of the household (p<0.001). The highest prevalence (65.7%) was documented in the poorest households, and the lowest (46.6%) in the richest households. As nutritional status of the mother (indicated by BMI) increased, anemia prevalence among children significantly decreased (p<0.001). However, a slight shift was observed for obese mothers. Prevalence was highest (61.4%) among children of underweight mothers, followed by normal (55.8%) and overweight (48.6%) mothers, and slightly increased (51.5%) among children of obese mothers (Table 3, Figure 5).

Factors Associated with Anemia

On multivariate logistic regression analysis, increased child age, decreased maternal age, poorest rank of wealth index, mother living alone, mother engaged in outside work, increased birth order, decreased birth interval, one ANC visit, severe stunting, and severe underweight were identified as significant predictors of anemia (Table 4).

The odds of developing anemia in the age-groups 6–11, 12–23, 24–35, and 36–47 months were 6.194 (95% CI 4.622–8.301), 4.202 (95% CI 3.267–5.404), 2.155 (95% CI 1.667–2.787), and 1.499 (95% CI 1.141–1.968) times, respectively, those of children in the oldest age-group (48–59 months). Those born fourth and fifth, sixth and seventh, and eighth and above had around 37% (AOR 1.368, 95% CI 1.086–1.723), 50% (AOR 1.504, 95% CI 1.140–1.984), and 80% (AOR 1.795, 95% CI 1.290–2.495), respectively, higher odds of developing anemia than firstborns. The odds of developing anemia among

Table 2 Characteristics of Children Stratified by Sex (n=8,155)

		All, n (%)	Male, n (%)	Female, n (%)	χ^2	*p*
Sex		8,155 (100%)	4,197 (51.5%)	3,958 (48.5%)	NA	NA
Ag, months (mean ± SD)		31.85±15.66	32.12±15.59	31.56±15.73	1.614[a]	0.107
Age, months	6–11 12–23 24–35 36–47 48–59	963 (11.8%) 1,813 (22.2%) 1,772 (21.7%) 1,736 (21.3%) 1,871 (22.9%)	486 (11.6%) 897 (21.4%) 931 (22.2%) 901 (21.5%) 982 (23.4%)	477 (12.1%) 916 (23.1%) 841 (21.2%) 835 (21.1%) 889 (22.5%)	4.986	0.289
Residence	Rural Urban	6,681 (81.9%) 1,474 (18.1%)	3,432 (81.8%) 765 (18.2%)	3,249 (82.1%) 709 (17.9%)	0.136	0.712
Birth order	1st 2nd 3rd 4th/5th 6th/7th 8th and above	1,594 (19.5%) 1,386 (17.0%) 1,211 (14.8%) 1,920 (23.5%) 1,287 (15.8%) 757 (9.3%)	826 (19.7%) 705 (16.8%) 606 (14.4%) 1,010 (24.1%) 651 (15.5%) 399 (9.5%)	768 (19.4%) 681 (17.2%) 605 (15.3%) 910 (23.0%) 636 (16.1%) 358 (9.0%)	3.129	0.680
Recent diarrhea	Yes No	961 (11.8%) 7,182 (88.2%)	519 (12.4%) 3,672 (87.6%)	442 (11.2%) 3,510 (88.8%)	2.811	0.094
Children aged <5 years in household	1 2 3 and more	2,880 (35.5%) 3,696 (45.6%) 1,528 (18.9%)	1,521 (36.4%) 1,868 (44.8%) 784 (18.8%)	1,359 (34.6%) 1,828 (46.5%) 744 (18.9%)	3.369	0.186
Birth interval, months (mean ± SD)		38.29±22.15	37.93±22.24	38.66±22.06	3.398[a]	0.001*
Birth interval	First <24 months 24–35 months 36–47 months 48–59 months	1,603 (19.7%) 1,594 (19.5%) 2,109 (25.9%) 1,304 (16.0%) 1,545 (18.9%)	829 (19.8%) 823 (19.6%) 1,132 (27.0%) 650 (15.5%) 763 (18.2%)	774 (19.6%) 771 (19.5%) 977 (24.7%) 654 (16.5%) 782 (19.8%)	8.224	0.084
Stunting	Severe Moderate Normal	1,332 (17.3%) 1,593 (20.7%) 4,772 (62.0%)	727 (18.4%) 829 (21.0%) 2,393 (60.6%)	607 (16.2%) 765 (20.4%) 2,376 (63.4%)	8.524	0.014*
Underweight	Severe Moderate Normal	576 (7.6%) 1,245 (16.4%) 5,776 (76.0%)	302 (7.7%) 673 (17.3%) 2,922 (75.0%)	274 (7.4%) 572 (15.5%) 2,854 (77.1%)	5.911	0.052
Wasting	Severe Moderate Normal	196 (2.3%) 561 (7.4%) 6,842 (90.0%)	106 (2.7%) 314 (8.1%) 3,474 (89.2%)	90 (2.4%) 247 (6.7%) 3,368 (90.9%)	7.303	0.026*
Vitamin A supplementation in last 6 months	Yes No Do not know	3,686 (47.9%) 3,879 (50.5%) 124 (1.6%)	1,894 (47.9%) 1,995 (50.5%) 65 (1.6%)	1,792 (48.0%) 1,884 (50.4%) 59 (1.6%)	0.052	0.975
Birth status	Single Multiple	7,503 (97.6%) 186 (2.4%)	3,857 (97.5%) 97 (2.5%)	3,646 (97.6%) 89 (2.4%)	0.04	0.841

Notes: *Significant association; [a]Student's *t*-test.
Abbreviation: NA, not applicable.

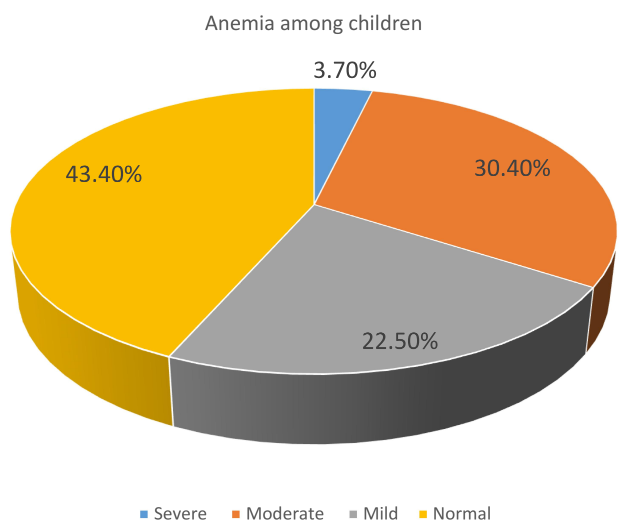
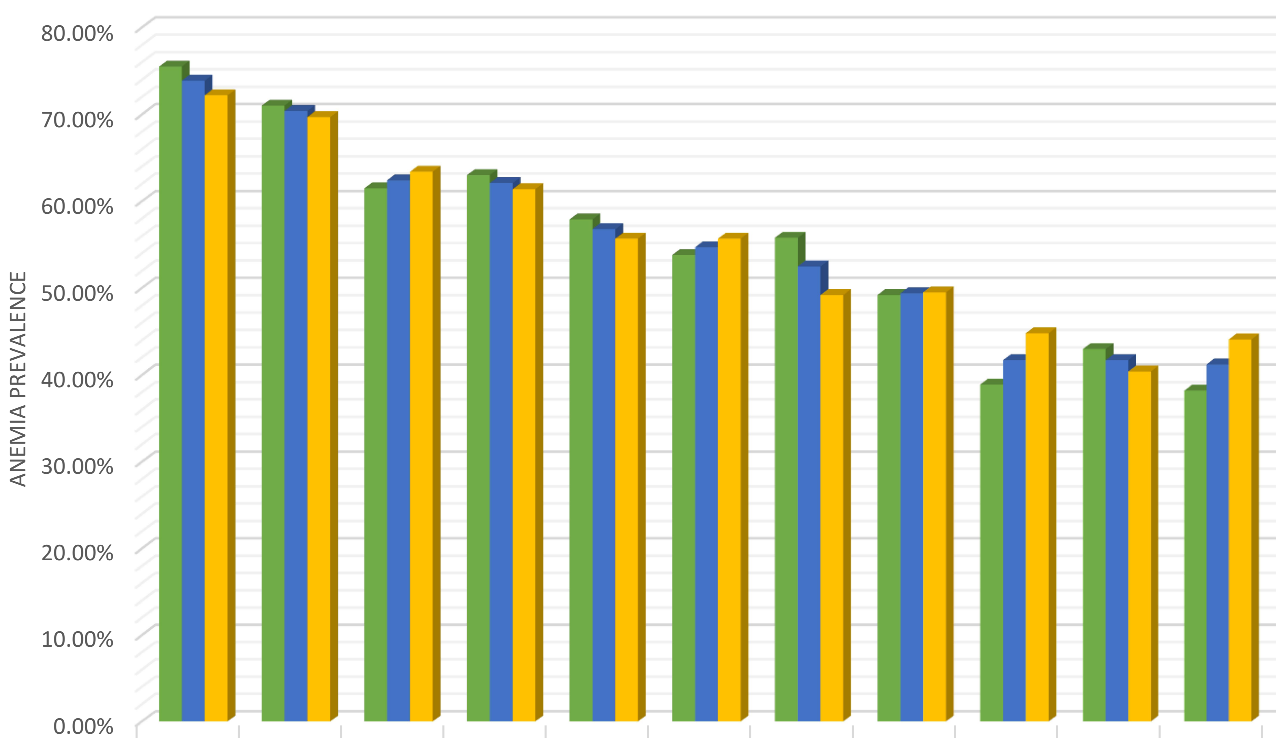


Figure 2 Severity of anemia (n=8,155).

children with birth intervals of <18, 18–23, and 24–35 months were 1.715 (95% CI 1.259–2.336), 1.593 (95% CI 1.223–2.075), and 1.425 (95% CI 1.174–1.730) times, respectively, those of children with the greatest birth interval (≥48 months). Severely stunted and severely underweight children were 1.467 (95% CI 1.142–1.885) and1.458 (95% CI 1.044–2.035) times, respectively, as likely to be anemic as normal children.

Children from mothers aged <20, 20–29, and 30–39 years were 3.409 (95% CI 1.143–10.726), 1.643 (95% CI 1.211–2.229), and 1.293 (95% CI 1.006–1.662) times, respectively, as likely to be anemic as children whose mothers were in the highest age-group (40–49 years). The odds of developing anemia among children whose mothers were not living with their husband were 1.308 (95% CI 1.024–1.670) times those of children whose mothers were living with their husband. Children from mothers engaged in paid work were 1.251 (95% CI 1.073–1.462) times as likely to be anemic as children of housewives. Children whose mothers had had only one ANC visit during pregnancy were 1.501 (95% CI 1.017–1.216) times as likely to develop anemia as children whose mothers had had the recommended number of ANC visits. Children from the poorest households were around 1.552



	Somali	Afar	Oromiya	Dire Dawa	Harari	Gambella	Tigray	SNNPR	Addis Ababa	Benishangul	Amhara
Male	75.50%	71.00%	61.50%	63.00%	57.90%	53.80%	55.80%	49.20%	38.90%	43.00%	38.20%
Total	73.90%	70.40%	62.40%	62.10%	56.80%	54.70%	52.50%	49.40%	41.70%	41.70%	41.20%
Female	72.20%	69.70%	63.40%	61.40%	55.70%	55.70%	49.20%	49.50%	44.80%	40.40%	44.10%

Figure 3 Anemia distribution regional states stratified by sex, (n=8,155).

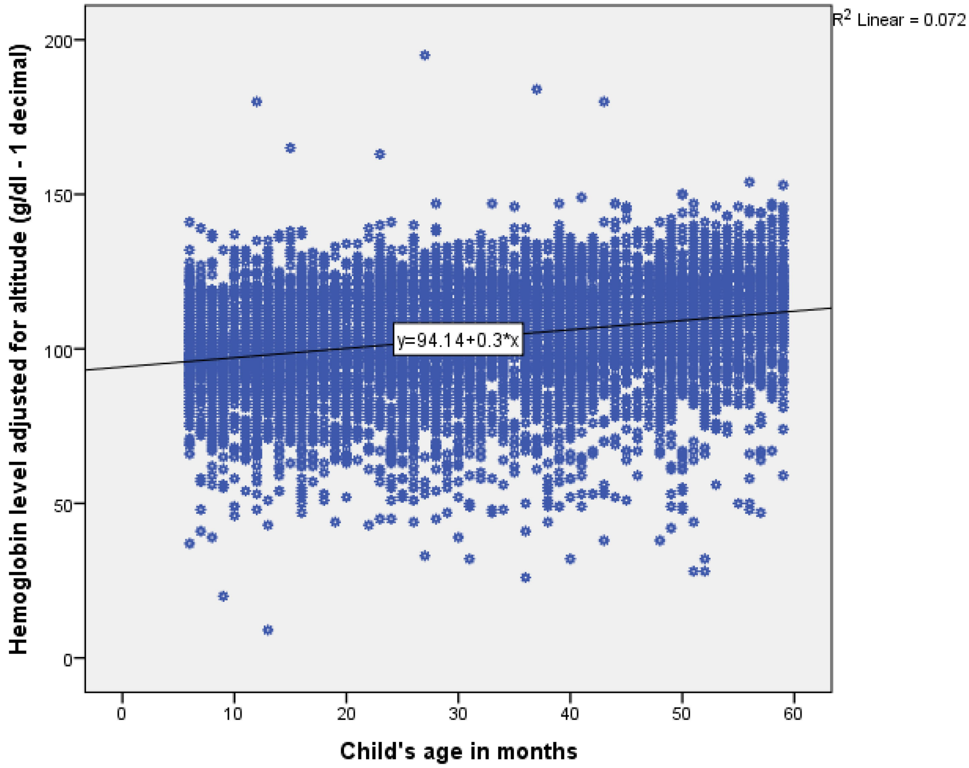


Figure 4 Trend of hemoglobin concentration (n=8,155).

(95% CI 1.235–1.950) as likely to be anemic as children from the richest households (Table 4).

Discussion

This study assessed factors associated with anemia among children aged 6–59 months in Ethiopia. Anemia in children is a major public health problem and among the most common causes of child death in Ethiopia.[18] The overall prevalence of anemia in the present study was 56.6%: 3.7%, 30.4%, and 22.5% severe, moderate, and mild anemia, respectively. Even though a high rate of breastfeeding has been reported in Ethiopia, breast milk is low in iron content. Cereal (plant)-based food is commonly consumed in Ethiopia, and is low in iron content and has poor bioavailability, due to phytate (which can mask iron observation) and other inhibitors.[11] The magnitude of anemia found in this study was severe according to WHO classification.[19] The present finding is in agreement with studies done in developing countries. The present study finding was similar to a study from Uganda (58.8%) and[20] Bangladesh national representative data (51.9%)[21] and higher than studies done in Gondar, Ethiopia (28.6%)[22] and Honduras (39%)[23] on children. However, the result of the present study is lower than studies conducted in Togo (84.6%)[24] and Ghana (78.4%).[26] The difference in prevalence might be due to variations in sample size, parent sociodemographic status, geographic location, sampling techniques, socioeconomic status, type of diet consumed by children, and other associated factors.

With an increase in child age, the risk of anemia decreased in all age categories. A similar effect ohas been observed in previous studies.[21–23,25–27] A possible reason for the elevated level of anemia in younger children might be low balanced dietary intake that is in sufficient to satisfy the relatively higher iron requirement due to rapid growth.[28] An additional reason could be that younger children in Ethiopia depend mostly on breast milk, which is poor in iron content, and complementary food is entirely plant-based which is poor in bioavailability and rich in absorption inhibitors like phytate. Another possible reason might be poor infant- and young child–feeding practices.[29] Iron stores are generally depleted by the age of 6 months, while blood volume doubles from 4 to 12 months after birth. Dietary sources of iron are crucial to keep up with the rapid rate of red blood–cell synthesis, and anemia may

Table 3 Anemia Status of Children Stratified by Sex (n=8,155)

		Anemia			χ^2/t	p
		All, n (%)	Male, n (%)	Female, n (%)		
Sex		4,617 (56.6%)	2,391 (57.0%)	2,226 (56.2%)	0.440	0.507
Hemoglobin, g/dL (mean ± SD)		10.37±17.55	10.35±17.69	10.39±17.39	0.925[a]	0.355
Anemia	Severe Moderate Mild	303 (3.7%) 2,483 (30.4%) 1,831 (22.5%)	157 (3.7%) 1,313 (31.3%) 921 (21.9%)	146 (3.7%) 1,170 (29.6%) 910 (23.0%)	3.415	0.332
Age (months)	6–11 12–23 24–35 36–47 48–59	708 (73.5%) 1,250 (68.9%) 1,040 (58.7%) 870 (50.1%) 749 (40.0%)	356 (73.3%) 627 (69.9%) 540 (58.0%) 461 (51.2%) 407 (41.4%)	352 (73.8%) 623 (68.0%) 500 (59.5%) 409 (49.0%) 342 (38.5%)	466.730	<0.001*
Residence	Rural Urban	3,905 (58.4%) 712 (48.3%)	2,009 (58.5%) 382 (49.9%)	1,896 (58.4%) 330 (46.5%)	50.604	<0.001*
Birth order	First Second Third 4th and 5th 6th and 7th 8th and above	840 (52.7%) 746 (53.8%) 705 (58.2%) 1,106 (57.6%) 767 (59.6%) 453 (59.8%)	460 (55.7%) 371 (52.6%) 358 (59.1%) 580 (57.4%) 391 (60.1%) 231 (57.9%)	380 (49.5%) 375 (55.1%) 347 (57.4%) 526 (57.8%) 376 (59.1%) 222 (62.0%)	24.248	<0.001*
Recent diarrhea	Yes No	595 (61.9%) 4,015 (55.9%)	325 (62.6%) 2,063 (56.2%)	270 (61.1%) 1,952 (55.6%)	12.468	<0.001*
Number ofchildren aged <5 years	1 2 3 and more	1,456 (50.6%) 2,146 (58.1%) 992 (64.9%)	787 (51.7%) 1,085 (58.1%) 507 (64.7%)	669 (49.2%) 1,061 (58.0%) 485 (65.2%)	89.146	<0.001*
Birth interval	First <24 months 24–35 months 36–47 months ≥48 months	843 (52.6%) 1,005 (63.0%) 1,275 (60.5%) 721 (55.3%) 773 (50.0%)	462 (55.7%) 523 (63.5%) 672 (59.4%) 344 (52.9%) 390 (51.1%)	381 (49.2%) 482 (62.5%) 603 (61.7%) 377 (57.6%) 383 (49.0%)	78.291	<0.001*
Stunting	Severe Moderate Normal	864 (64.9%) 902 (56.6%) 2,567 (53.8%)	476 (65.5%) 481 (58.0%) 1,285 (53.7%)	389 (64.1%) 422 (55.1%) 1,281 (53.9%)	52.968	<0.001*
Underweight	Severe Moderate Normal	410 (71.1%) 752 (60.4%) 3,107 (53.8%)	217 (71.1%) 411 (61.1%) 1,577 (54.0%)	193 (70.5%) 341 (59.6%) 1,532 (53.7%)	83.292	<0.001*
Wasting	Severe Moderate Normal	143 (73.2%) 361 (64.4%) 3,777 (55.2%)	83 (78.2%) 204 (64.9%) 1,925 (55.4%)	60 (67.4%) 157 (63.8%) 1,852 (55.0%)	48.612	<0.001*
Vitamin A supplementation in past 6 months	Yes No	2,095 (54.0%) 2,450 (59.1%)	1,084 (54.3%) 1,267 (59.3%)	1,011 (53.6%) 1,183 (58.8%)	21.448	<0.001*
Birth status	Single Multiple	4,504 (56.5%) 113 (60.1%)	2,328 (56.8%) 63 (64.9%)	2,176 (56.3%) 50 (54.9%)	0.955	0.329

(*Continued*)

Table 3 (Continued).

		Anemia			χ^2/t	p
		All, n (%)	Male, n (%)	Female, n (%)		
Maternal age (years)	<20	166 (68.3%)	83 (69.2%)	83 (67.5%)	49.378	<0.001*
	20–24	952 (59.8%)	507 (61.0%)	445 (58.5%)		
	25–29	1,416 (57.7%)	729 (57.8%)	687 (57.5%)		
	30–34	1,051 (56.4%)	547 (57.5%)	504 (55.3%)		
	35–39	697 (53.7%)	354 (52.8%)	343 (54.6%)		
	40–44	262 (49.0%)	134 (49.6%)	128 (48.3%)		
	≥45	73 (44.0%)	37 (40.2%)	36 (48.6%)		
Maternal education	No education	3,122 (59.2%)	1,617 (59.5%)	1,505 (58.8%)	68.113	<0.001*
	Primary	1,131 (54.8%)	587 (55.2%)	544 (54.3%)		
	Secondary	250 (47.6%)	124 (45.8%)	126 (49.6%)		
	Tertiary	114 (39.6%)	63 (42.9%)	51 (36.2%)		
Sex of household head	Male	3,616 (56.1%)	1,851 (55.9%)	1,765 (56.2%)	3.487	0.062
	Female	1,001 (58.6%)	540 (60.8%)	461 (56.2%)		
Wealth index	Poorest	1,968 (65.7%)	1,034 (66.8%)	934 (64.5%)	189.483	<0.001*
	Poor	802 (56.6%)	411 (56.4%)	391 (56.9%)		
	Middle	608 (51.7%)	330 (53.7%)	278 (49.6%)		
	Rich	511 (50.8%)	236 (47.2%)	275 (54.5%)		
	Richest	728 (46.6%)	380 (47.1%)	348 (46.0%)		
BMI of the mother	Underweight	1,238 (61.4%)	620 (61.5%)	618 (61.3%)	37.197	<0.001*
	Normal	3,004 (55.8%)	1,562 (56.3%)	1,442 (55.2%)		
	Overweight	281 (48.6%)	151 (48.1%)	130 (49.2%)		
	Obese	88 (51.5%)	53 (54.1%)	35 (47.9%)		

Notes: *Significant association; [a]Student's *t*-test.
Abbreviation: BMI, body-mass index.

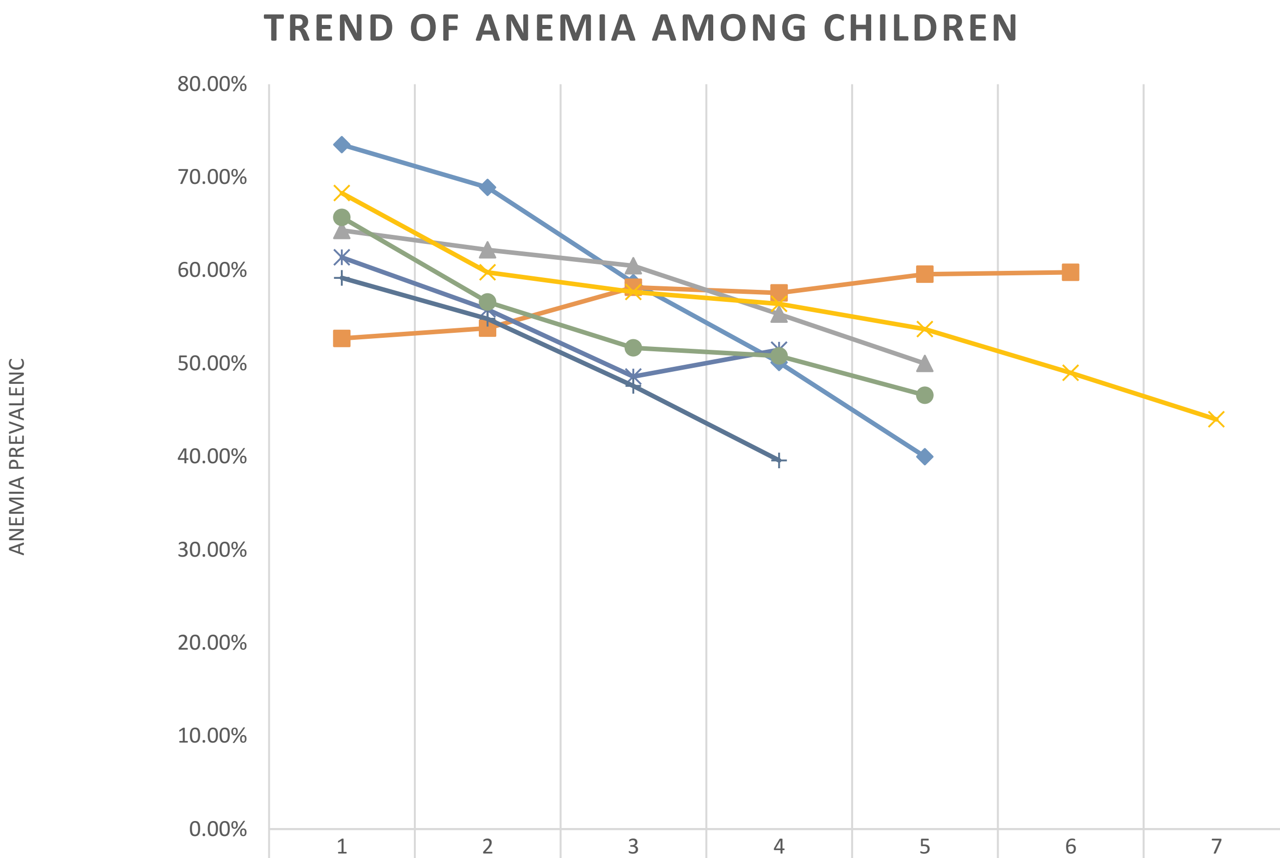
result if dietary sources are inadequate.[30,31] In addition, frequent childhood infection, due to high susceptibility, can lead to iron malabsorption, which leads to anemia.

Children born of younger mothers were at high risk of childhood anemia, which is consistent with previous study findings.[10,32] This might be due to lack of knowledge on feeding diversified food to children according to recommended standards. Mothers themselves may have high iron requirements, which could lead to competition with their children for the limited iron intake. Severely stunted and underweight children were more likely to be anemic than their normal counter parts. This finding is consistent with studies conducted elsewhere.[21,27,33,34] This could be due to anemia or undernutrition, which often have synergism associations with socioeconomic status, sanitation, infections, parasitic diseases, and diet.[35]

Children from the poorest households were 1.6 times as likely to develop anemia as those from the richest ones. This is in line with studies from Bangladesh and Ethiopia. Children from poor families and food-insecure households are at higher risk of developing anemia than their counterparts.[21,34,36] Children from richest and middle-class households have lower average hemoglobin concentration than those from the poorest households.[37] The reason could be that the poorest households cannot afford iron-rich animal-based foods and may have poor personal hygiene and environmental sanitation, which leads to infection and micronutrient malabsorption.

Increased birth order was significantly associated with increased childhood anemia, which is in line with previous studies conducted elsewhere.[38,40,41] This might be due to the distribution of scarce resources within the family and related to maternal exhaustion of micronutrients. Mild maternal iron deficiency and anemia have few significant repercussions on the iron status of the newborn, but severe anemia does have a strong influence.

Birth interval was negatively associated with childhood anemia. The greater the birth interval, the lower the risk of developing anemia among children. This was in line with study findings in other African countries. The effect of the



	1	2	3	4	5	6	7
Child age	73.50%	68.90%	58.70%	50.10%	40.00%		
Birth order	52.70%	53.80%	58.20%	57.60%	59.60%	59.80%	
Birth interval	64.30%	62.20%	60.50%	55.30%	50.00%		
Metral age	68.30%	59.80%	57.70%	56.40%	53.70%	49.00%	44.00%
BMI of the mother	61.40%	55.80%	48.60%	51.50%			
Wealth index of HH	65.70%	56.60%	51.70%	50.80%	46.60%		
Educational status	59.20%	54.80%	47.60%	39.60%			

Figure 5 Trends of anemia with respect to child, maternal, and household factors (n=8,155).

birth-interval variable on the index child's hemoglobin level was positive. With every month's increase of from the preceding birth, there is a gain of 0.15 g/dL hemoglobin.[42,44] This might be due to short birth interval causing distribution problems among siblings and parents not being able to take better care of their children, compromising the breastfeeding duration of the previous child.[45] The mother herself may be biologically exhausted from frequent births, and this could also negatively affect the nutritional status and hemoglobin level of the newborn as a result of the intergenerational link.[46]

Children born of mothers who had had only one ANC visit were 1.5 times as likely to be anemic as children from mothers with the recommended number of ANC visits (four and above). A study conducted in Gondar (Ethiopia) found that home delivery was significantly associated with childhood anemia,[22] while one from Addis Ababa, indicated that having no ANC visits was significantly associated with maternal anemia. This could be due to the benefit of the recommended number of ANC visits for early diagnosis and treatment of maternal anemia, maternal folate and iron supplementation, provision of deworming medication, malaria prevention, diagnosis, and management, and provision of nutrition counseling, all of which could have a significant impact on childhood anemia. Therefore, mothers should attend the recommended number of ANC visits during the entire period of pregnancy to minimize the risk of childhood anemia.

Table 4 Factors Associated with Anemia on Bivariate and Multivariate Logistic Regression (n=8,155)

		Anemia		COR (95% CI)	*p*	AOR (95% CI)	*p*
		Yes, n (%)	No, n (%)				
Age of child, months	6–11	708 (73.5)	255 (26.5)	4.717 (3.923–5.671)	<0.001*	6.194 (4.622–8.301)	<0.001*
	12–23	1,250 (68.9)	563 (31.1)	3.328 (2.890–3.832)	<0.001*	4.202 (3.267–5.404)	<0.001*
	24–35	1,040 (58.7)	732 (41.3)	2.139 (1.866–2.453)	<0.001*	2.155 (1.667–2.787)	<0.001*
	36–47	870 (50.1)	866 (49.9)	1.500 (1.310–1.719)	<0.001*	1.499 (1.141–1.968)	0.004*
	48–59	749 (40.0)	11,22 (60.0)	1		1	
Sex	Male	2,391 (57.0)	1,806 (43.0)	1.037 (0.947–1.136)	0.435		
	Female	2,226 (56.2)	1,732 (43.8)	1		1	
Maternal age, years	<20	166 (68.3)	70 (31.7)	2.618 (1.877–3.652)	<0.001*	3.409 (1.143–10.726)	0.038*
	20–29	2,368 (58.5)	1,680 (41.5)	1.537 (1.301–1.816)	<0.001*	1.643 (1.211–2.229)	0.001*
	30–39	1,748 (55.3)	1,415 (44.7)	1.337 (1.128–1.585)	0.001*	1.293 (1.006–1.662)	0.044*
	40–49	335 (47.8)	366 (52.2)	1		1	
Residence	Urban	712 (48.3)	762 (51.7)	1		1	
	Rural	3,905 (58.4)	2,776 (46.1)	1.339 (1.188–1.510)	<0.001*	1.432 (0.078–26.408)	0.809
Maternal education	Illiterate	3,122 (59.2)	2,155 (40.8)	1.832 (1.413–2.375)	<0.001*	1.440 (0.077–26.789)	0.807
	Primary	1,131 (54.8)	934 (45.2)	1.506 (1.151–1.970)	0.003*	1.164 (0.063–21.635)	0.919
	Secondary	250 (47.6)	275 (52.4)	1.191 (0.874–1.624)	0.269	1.349 (0.068–26.680)	0.844
	Higher	114 (39.6)	174 (60.4)	1		1	
Number of HH members	<4	494 (56.4)	382 (43.6)	1			
	4–6	2,262 (54.6)	1,881 (45.4)	0.871 (0.745–1.017)	0.080		
	7–9	1,555 (59.2)	1,071 (40.8)	1.037 (0.881–1.221)	0.662		
	≥10	306 (60.0)	204 (40.0)	1.124 (0.889–1.421)	0.330		
Sex of HH head	Male	3,616 (56.1)	2,831 (43.9)	1		1	
	Female	1,001 (58.6)	707 (41.4)	1.202 (1.072–1.348)	0.002*	1.128 (0.863–1.473)	0.378
Wealth index	Poorest	1,968 (65.7)	1,028 (34.3)	2.182 (1.911–2.491)	<0.001*	1.552 (1.235–1.950)	<0.001*
	Poor	802 (56.6)	614 (43.4)	1.317 (1.133–1.530)	<0.001*	1.001 (0.784–1.278)	0.993
	Middle	608 (51.7)	567 (48.3)	1.050 (0.898–1.228)	0.539	0.802 (0.628–1.025)	0.079
	Rich	511 (50.8)	494 (49.2)	1.022 (0.868–1.204)	0.796	0.831 (0.646–1.070)	0.151
	Richest	728 (46.6)	835 (53.4)	1		1	
Currently living with husband	Yes	3,802 (56.2)	2,960 (43.8)	1		1	
	No	581 (63.0)	341 (37.0)	1.454 (1.248–1.693)	<0.001*	1.308 (1.024–1.670)	0.032*
Mother currently working	Yes	1,172 (50.3)	1,158 (49.7)	0.702 (0.632–0.771)	<0.001*	1.251 (1.073–1.462)	0.006*
	No	3,445 (59.1)	2,380 (40.9)	1		1	
Birth order of child	1st	840 (52.7)	754 (47.3)	1		1	
	2nd	746 (53.8)	640 (46.2)	1.010 (0.869–1.175)	0.893		
	3rd	705 (58.2)	506 (41.8)	1.158 (0.990–1.355)	0.066	1.258 (0.994–1.592)	0.057
	4th/5th	1,106 (57.6)	814 (42.4)	1.148 (0.999–1.321)	0.052	1.368 (1.086–1.723)	0.008*
	6th/7th	767 (59.6)	520 (40.4)	1.263 (1.081–1.475)	0.003*	1.504 (1.140–1.984)	0.004*
	8th and above	453 (59.8)	304 (40.2)	1.288 (1.072–1.548)	0.007*	1.795 (1.290–2.495)	0.001*
Birth status	Single	4,504 (56.5)	3,463 (43.5)	1			
	Multiple	113 (60.1)	75 (39.9)	1.031 (0.765–1.388)	0.842		
Birth interval, months	<18	427 (64.3)	237 (35.7)	1.958 (1.608–2.385)	<0.001*	1.715 (1.259–2.336)	0.001*
	18–23	578 (62.2)	352 (37.8)	1.810 (1.521–2.154)	<0.001*	1.593 (1.223–2.075)	0.001*
	24–35	1,275 (60.5)	834 (39.5)	1.582 (1.380–1.814)	<0.001*	1.425 (1.174–1.730)	<0.001*
	36–47	721 (55.3)	583 (44.7)	1.266 (1.088–1.475)	0.002*	1.115 (0.904–1.374)	0.308
	≥48	773 (50.0)	772 (50.0)	1		1	

(*Continued*)

Table 4 (Continued).

		Anemia		COR (95% CI)	p	AOR (95% CI)	p
		Yes, n (%)	No, n (%)				
ANC follow-up(s)	Zero	1,112 (61.7)	691 (38.3)	1.445 (1.261–1.655)	<0.001*	1.115 (0.923–1.345)	0.258
	One	165 (67.3)	80 (32.7)	1.903 (1.408–2.572)	<0.001*	1.501 (1.017–1.216)	0.041*
	Two	248 (62.8)	147 (37.2)	1.398 (1.111–1.758)	0.004*	1.156 (0.862–1.549)	0.333
	Three	565 (60.6)	368 (39.4)	1.227 (1.044–1.444)	0.013*	1.152 (0.933–1.422)	0.187
	Four and above	1,070 (53.6)	925 (46.4)	1		1	
Deworming during pregnancy	Yes	181 (56.2)	141 (43.8)	1		1	
	No	2,953 (58.9)	2,061 (41.1)	1.182 (0.936, 1.492)	0.161		
Recent diarrhea	Yes	602 (61.9)	371 (38.1)	1.201 (1.042, 1.385)	0.011*	0.928 (0.756–1.139)	0.475
	No	4,015 (55.9)	3,167 (44.1)	1		1	
Vitamin A in last 6 months	Yes	2,095 (54.0)	1,788 (46.0)	1		1	
	No	2,450 (59.1)	1,697 (40.9)	1.302 (1.187–1.428)	<0.001*	1.029 (0.886–1.195)	0.705
Level of stunting	Severe	864 (64.9)	468 (35.1)	1.609 (1.414–1.830)	<0.001*	1.467 (1.142–1.885)	0.003*
	Moderate	902 (56.6)	691 (43.4)	1.122 (0.999–1.259)	0.052	1.178 (0.973–1.425)	0.092
	Normal	2,567 (53.8)	2,205 (46.2)	1		1	
Level of underweight	Severe	410 (71.1)	166 (28.9)	2.187 (1.819–2.628)	<0.001*	1.458 (1.044–2.035)	0.027*
	Moderate	752 (60.4)	493 (39.6)	1.315 (1.166–1.484)	<0.001*	1.041 (0.840–1.289)	0.714
	Normal	3,107 (53.8)	2,669 (46.2)	1		1	
Level of wasting	Severe	143 (73.2)	53 (26.8)	2.312 (1.698–3.148)	<0.001*	1.380 (0.818–2.326)	0.227
	Moderate	361 (64.4)	200 (35.6)	1.487 (1.254–1.764)	<0.001*	1.088 (0.813–1.456)	0.570
	Normal	3,777 (55.2)	3,065 (44.8)	1		1	

Note: *Significant association.
Abbreviations: HH, household; ANC, antenatal care.

Limitations

A limitation of this study was its cross-sectional design, which does not allow the identification of precedence in time between exposure and outcome (chicken–egg dilemma). There were missing values for some variables in the data set. The authors might have failed to consider some important factors that could affect interpretation of the results, and due to the retrospective nature of the data and verbal reports, recall bias might have been introduced.

Conclusion

Increased child age, decreased maternal age, poorest rank of wealth index, mother living alone, mother engaged in outside work, increased birth order, decreased birth interval, one ANC visit only, severe stunting, and severe underweight were identified as significant predictors of childhood anemia. The prevalence of anemia in this study was the highest from all EDHS reports, which makes it the main public health concern in Ethiopia. Comprehensive intervention strategies should be in place tailored to different levels of government for combating childhood anemia by focusing on the identified risk factors. We advise that health authorities design different nutrition-intervention initiatives like multimineral supplementation (mineral sprinkle), nutrition education, and continuous monitoring of the anemia status of children. In addition, further longitudinal study is needed to rule out the cause-and-effect relationship between childhood anemia and various explanatory variables.

Abbreviations

ANC, antenatal care; BMI, body-mass index; EDHS, Ethiopia Demographic and Health Survey; HH, household; WHO, World Health Organization.

Data Sharing Statement

The main part of the data generated or analyzed during this study is included in this article, and if necessary the data are accessible from the corresponding author (AG).

Author Contributions

All authors contributed to data analysis, drafting or revising the article, have agreed on the journal to which the article will be submitted, gave final approval to the version to be published, and agree to be accountable for all aspects of the work.

Disclosure

The authors declare that they have no conflicts of interest for this work.

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