

Anemia Prevalence and its Associated Risk Factors using Ten East African Countries: A Recent data from Demographic and Health Survey

Denekew **Bitew Belay**^{1,2*} Nigussie **Adam Birhan**^{3†}, Tilahun **Yemanu Birhan**⁴, Yegnanew **A. Shiferaw**⁵, Ding-Geng **Chen**^{2,6}

¹Department of Statistics, Bahir Dar University, Bahir Dar, Ethiopia.

²Department of Statistics, University of Pretoria, Pretoria, South Africa.

³Department of Statistics, Injibara University, Injibara, Ethiopia.

⁴Department of Epidemiology and Biostatistics, Institute of Public Health, College of Medicine and Health Science, University of Gondar, Gondar, Ethiopia.

⁵Department of Statistics, University of Johannesburg, Johannesburg, South Africa.

⁶Arizona State University, College of Health Solutions, Phoenix, AZ, USA.

ABSTRACT

Introduction: Anemia, defined as a low level of hemoglobin in the blood, is a sign of inadequate nutrition as well as poor health in children. It affects about 269 million (39.8%) children under the age of five worldwide and it is a significant risk factor for poor health and nutrition in children. The main aim of this study was to assess the prevalence and contributing factors of anemia among children aged 6–59 months in Eastern Africa.

Methods: The research was conducted between 2010 and 2023 across ten East African countries. To identify potential factors associated with anemia, a multilevel logistic regression model was used.

Results: The prevalence of anemia in Eastern Africa was 54.26%, with the highest in Tanzania (70.32%) and the lowest in Rwanda (36.64%). A multilevel multivariable logistic regression model revealed that factors like child age in months 12-23 (AOR = 0.623; 95% CI: 0.581-0.669), female (AOR = 0.914; 95% CI: 0.880-0.949), stunted (AOR = 1.289; 95% CI: 1.234-1.347), underweight (AOR = 1.232; 95% CI: 1.163-1.306), two under-five children (AOR=1.068; 95% CI: 1.023-1.116), 2-3 birth order (AOR=1.096; 95% CI:1.034-1.162), having fever (AOR=1.410; 95% CI: 1.343-1.481), having diarrhea (AOR=1.066; 95% CI: 1.009-1.125), vitamin A supplementation (AOR =0.899; 95% CI: 0.863-0.937), primary educated mother (AOR=0.819; 95% CI: 0.775-0.865), anemic mother (AOR =1.844; 95% CI: 1.768-1.923), toilet facility (AOR = 0.879; 95% CI = 0.835-0.926), middle wealth index (AOR =0.876; 95% CI: 0.830-0.925), mother had occupation (AOR=0.930;95%CI: 0.892-0.971) and high community poverty (AOR = 1.047; 95% CI: 1.006-1.089) were significantly associated with anemia in Eastern Africa.

Conclusion: The prevalence of anemia among children aged 6–59 months was still high in the region, indicating a continuing public health concern. Child age, sex, nutritional status (stunting and underweight), recent illness (fever

Key words: Anemia; Children; Multilevel analysis; Prevalence

***Corresponding Author:**

denekew.t.h@gmail.com

†These two authors contributed equally to this work



and diarrhea), maternal education, anemia status, and occupation, household wealth, toilet facilities, vitamin A supplementation, and community poverty levels have statistically significant association with anemia. These findings underscore the urgent need for comprehensive interventions targeting both child nutrition and broader socio-economic and environmental determinants to effectively reduce the burden of anemia in the region.

INTRODUCTION

Anemia, defined as a low level of hemoglobin in the blood, is a sign of inadequate nutrition as well as poor health in children.¹⁻³ In impoverished nations, anemia is a possible cause of illness and mortality among children.^{1,4} Anemia affects 269 million (39.8%) children under the age of five worldwide, with Africa accounting for 60.2% of these children.⁵ Reducing the global burden of anemia is one of the WHO's six nutrition goals for the period 2012–2025.⁶⁻⁸ However, in Africa, a malaria-endemic continent, anemia remains one of the most serious public health issues.^{9,10} Anemia affects 46–66% of children under the age of five in underdeveloped nations, with Southeast Asia (65.5%) having the largest proportion of children affected¹¹ and 21.9% in the Western Pacific Region.¹²

Anemia negatively impacts children's development, including mental, physical, motor, and language development, as well as coordination, immunological function, and academic achievement, leading to social and emotional delays and increased risks to their overall well-being.¹³⁻¹⁶ To combat childhood anemia, governments have developed and implemented anemia prevention programs integrated into routine child health services and community-based nutrition intervention programs. However, pediatric anemia remains a major public health concern in these countries^{7,14,17} and there is a need to understand the factors that influence this status. To reduce the burden of anemia among children under the age of five, it is critical to explore the aggregated prevalence and its causes among children under the age of five in Eastern Africa. It is critical to conduct analyses using nationally representative Demographic and Health Survey (DHS) data from East African countries to discover the shared factors across countries.

Though there are studies conducted on anemia in East African countries,^{10,18} these were mainly using binary logistic regression, and are unable to capture the pooled prevalence and associated factors of anemia among under-five children in East Africa. Our study introduces a novel approach multilevel logistic regression to assess the variation of anemia in East Africa. Multilevel analysis account the hierarchical structure of the data, where children are nested within households, and households are further nested within clusters. Standard regression models assume independence of observations, which is often violated in hierarchical data. The findings of this study could aid in the development of evidence-based public health policies to reduce the incidence of anemia in under-five children in East Africa.

METHODS

Data source and study population

Upon registration and specification of the analysis's purpose, the dataset was obtained from the Demographic and Health Survey (DHS) website (<https://www.dhsprogram.com>). The DHS provides a range of datasets covering information on males, females, children, births, and households. For this study, the child dataset (KR file) was utilized, encompassing all children born five years prior to the survey within the chosen enumeration area. The most recent data from the DHS covers the period from 2010 to 2023 and was collected from ten countries in East Africa. These countries include Burundi, Ethiopia, Madagascar, Malawi, Mozambique, Rwanda, Tanzania, Uganda, Zambia, and Zimbabwe (as shown in Figure 1). Notably, while there are about 19 countries in the WHO East Africa region, only 15 have available DHS data. However, four countries never conducted DHS in their history, and the other two countries did not have anemia-recorded variables in their DHS data. Two countries performed their DHS several years before our study period, and one country did not have publicly available data (Figure 1) and we used similar approach as previous study.^{19,20} The DHS program uses standardized techniques, including field protocols, manuals, and identical questionnaires, to collect data that can be compared across countries.

In this study, children under the age of five during the survey period were included. Those children and mother with no measured hemoglobin were excluded from the study. Therefore, the total sample size from the pooled (appended) data analyzed in this study was 51,099 children aged 6–59 months, and the total number of children aged 6–59 months from each country was ranged from 2,338 in Tanzania to 8,074 Zimbabwe (Figure 1).

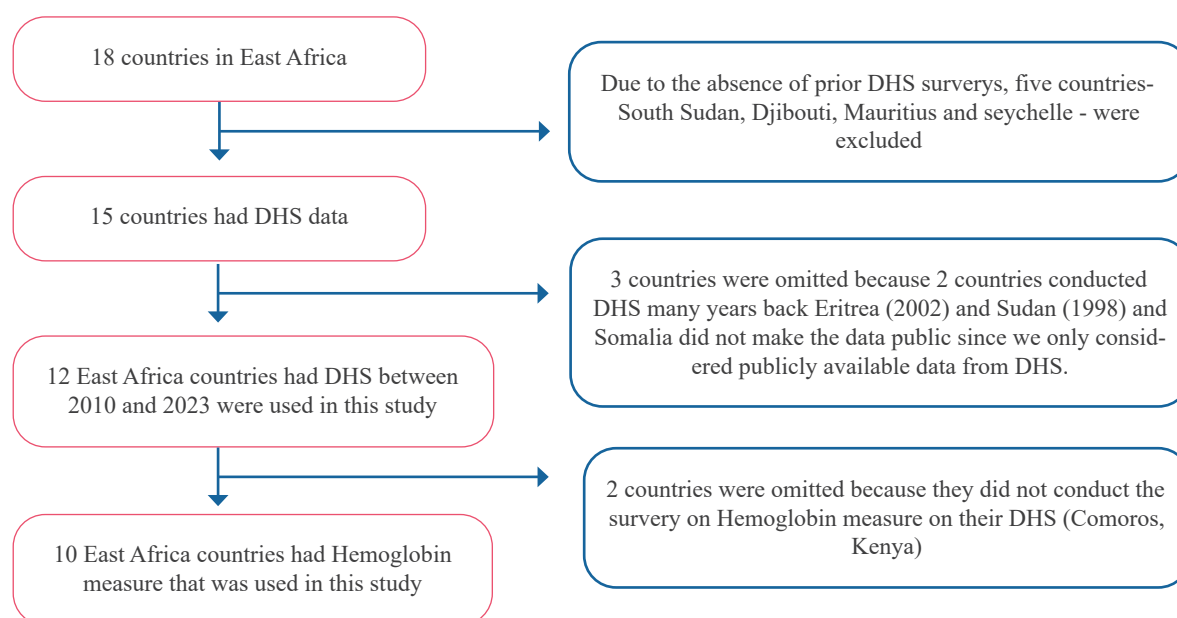


Figure 1. Diagrammatic representation for the compilation of countries surveyed in East Africa.

Study variables

Outcome variable

The outcome variable in this study was the anemia status of children aged 6–59 months categorized into two by adjusted concentration hemoglobin level > 11 g/dL, considered as non-anemic = 0 and concentration hemoglobin level ≤ 11 g/dL as anemic=1. The hemoglobin levels were determined onsite using a portable analyzer that runs on batteries and requires a finger prick. After adjusting for smoking status and altitude, the anemia status was assessed based on the hemoglobin content in the blood.^{9, 21}

Associated Factors

The selection of possible associated factors was guided by the extensive literature review and their availability in the Demographic and Health Survey (DHS) dataset. In this study, both the individual-level and community-level factors were included as risk factors. The individual-level risk factors included were the age of the child (0=6-11, 1=12-23, 2=24-35, 3=36-47 and 4=48-59), sex of the child (0=Male and 1=Female), number of children under five (0=One, 1=Two and 2=three and more), size of birth (0=smaller than average, 1=Average and 2=larger than average), Vitamin A supplementation (0=No and 1=yes), stunting status of the child (0=normal and 1=stunted), underweight status of the child (0=normal and 1=Underweighted), family size (0=Less than 5, 1=5-8 and 2=Above 8), birth order of the child (0=First, 1=2-3, 2=4-5 and 3=6 and above), type of birth (0=single and 1=multiple), having fever last two weeks before the survey date (0=No and 1=Yes), having diarrhea last two weeks before the survey date (0=No and 1=Yes), mothers' anemia status (0=Not anemic and 1=Anemic), current age of mother (0=15-24, 1=25-34 and 2=35-49), mother's educational level (0=No education, 1=Primary and 2=Secondary & higher), mother's marital status (0=unmarried, 1=married and 2=separated) source of drinking water (0=Not improved and 1=Improved), type of toilet facility (0=Not improved and 1=Improved), wealth index of family (0=Poor, 1=Middle and 2=Rich), and media exposure (0=No and 1=Yes). The community variables were place of residence (0=Urban and 1=Rural), literacy (0=low and 1=high), and poverty (0=low and 1=high). In this study, media exposure was measured by combining three factors: watching television, listening to the radio, and reading newspapers. Media exposure was classified as present if a mother had been exposed to at least one of the three media types and absent if she had no exposure.

The educational level of women in the community was determined by the proportion of mothers who attended primary, secondary, or higher education within the cluster. The combined educational attainment of individual mothers was used to represent the overall educational status of women within the cluster. This data was then categorized as high or low based on the distribution of the proportion values calculated for each community. A histogram was used to check the distribution, and if the aggregate variable had a normally distributed mean value, that was used as a cut-off point for categorization. If not, a normally distributed median value was used. Community poverty status is defined as the proportion of households in the wealth index (an aggregation of poorer and poorest categories) within the cluster derived from the data. The aggregated proportion of the poor was categorized into two groups based on the national median value as low and high poverty levels.

Data management and Analysis

The data were extracted and analyzed using STATA 14 software. Descriptive statistics were computed to describe the characteristics of study participants. Cross-tabulation, frequencies, and percentages are reported. The sample data represents multiple stages of a hierarchical population. In this hierarchy, children are nested within households, and households are nested within clusters, with some level of correlation within groups. To fully leverage and understand the underlying heterogeneity in each country about the pooled prevalence of anemia, we employed the model which can accommodate the hierarchical nature of our data, where data are structured hierarchically individual children nested within households, households within clusters, and clusters within countries. Traditional regression models, such as standard logistic regression, assume independence of observations, which does not hold in hierarchical datasets. By applying multi-level analysis, we benefitted to account the intra-cluster correlations and unobserved contextual effects, leading to more accurate and generalizable findings. Therefore, multilevel models were used to overcome the analytical challenges that arise when data are hierarchically organized. Specifically, a two-level mixed-effect logistic regression model was used to assess the independent (fixed) effects of explanatory factors and the random effects at the community level on anemia. The individual-level and community-level variables associated with anemia were checked independently in the bi-variable multilevel logistic regression model, and multilevel mixed-effects logistic regression analysis was considered for the final individual-level and community-level model adjustments. In the multivariable multilevel analysis, variables with a p-value of less than 0.05 were considered statistically significant.²² Model comparison and goodness of fit were assessed based on the Likelihood Ratio (LR) test and deviance (-2LLR) values as the models were nested. Finally adjusted odds ratio with a 95% confidence interval was reported for the best-fit model.

Model building

In this study, we fitted four different models using different assumptions. The first model was the null model, with no explanatory variables, and this is used to check variation in the community and provide evidence to assess random effects at the community level. More over this model (Model I), unadjusted model, assumes no confounding and does not have control for variables which is fitted with no explanatory variables. The second model (Model II) was fitted using individual level variables. The third model (Model III) is fitted by adjusting for community-level factors. These two Models, Model II and Model III which are adjusted models, assume the existence of relationships between risk factors and outcome; and tried to quantify the effects of each risk factor on the outcome variable. Finally, the fourth model was fitted using potential candidate factors from the community-level and individual-level variables together. This model (Model IV) assumes hierarchical structure in the data and individuals within the same cluster share common characteristics which may affect anemia. Then we made a comparison of these four models using deviance value and chose the best model for the final analysis and conclusion.

Parameter Estimation Method

For the fixed effects analysis, the study assessed the association between explanatory variables and the likelihood of anemia at both the community and individual levels. The results were presented as adjusted odds ratios with 95% confidence intervals. Measures of variation, such as community-level variance with standard deviation, intra class correlation coefficient (ICC), a proportional change in variance (PCV), and median odds ratio (MOR), were used in relation to random effects. These measures help to quantify the relationship between the explanatory variables and anemia.

The intra-class correlation indicates the proportion of variance explained by the grouping structure in the population. When the logistic model is used, the residuals at level one (child level) are assumed to follow the standard logistic distribution, with mean 0 and variance $\frac{\pi^2}{3}=3.29$. This is expressed as $ICC = \frac{\sigma_{\mu 0}^2}{\sigma_{\mu 0}^2 + \frac{\pi^2}{3}}$, where $\sigma_{\mu 0}^2$ is the variance of the higher level (country).

The commonly used odds ratio (OR) scale is designed to be translated into the median odds ratio from the area-level variance. When two locations are randomly selected, the MOR is the median value of the odds ratio between the areas with the highest and lowest levels of risk. The MOR represents the increased risk, in median, that would occur if moving to another location with a higher risk. It can be calculated as follows: $MOR = \exp(\sqrt{(2 \times VA)} \times 0.6745)$ where VA is the area-level variance and 0.6745 is the 75th percentile of the cumulative distribution function of the normal distribution with mean 0 and variance 1. Whereas the proportional change in variance is calculated as $PCV = \left[\frac{(VI-VB)}{VI} \right] * 100$; ²³ where VI is the variance of the initial model and VB is the variance of the model with more terms. ²⁴

RESULTS

The Prevalence of Anemia in Eastern Africa

In this study, the overall prevalence of anemia among children aged 6–59 months in ten East African countries was 54.26% (95% CI: 0.538-0.547). The prevalence of anemia was varied across countries; it was highest in Tanzania (70.32%) and lowest in Rwanda (36.64%) (Table1). We also presented the prevalence of anemia using forest plot with its corresponding 95% CI for all countries including the overall regional prevalence of anemia (Figure 2).

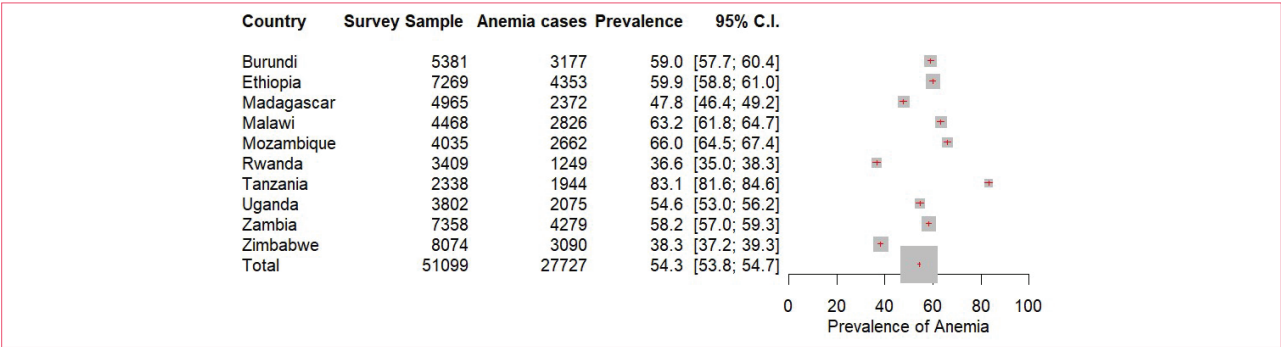


Figure 2. Forest plot of anemia prevalence with its 95% CI for each country and its regional prevalence.

Table 1. Prevalence of Anemia among Under-Five Children in Eastern African countries Based on Demographic and Health Survey Data (2010–2023)

Country	Survey year	N	Proportion of Anemia		Percentage
			Non-anemic proportion (%)	Anemic proportion (%)	
Burundi	2016-17	5,381	2204 (40.96)	3177 (59.04)	10.53
Ethiopia	2016	7,269	2916 (40.12)	4353 (59.88)	14.23
Madagascar	2021	4,965	2593 (52.23)	2372 (47.77)	9.72
Malawi	2015-16	4,468	1642 (36.75)	2826 (63.25)	8.74
Mozambique	2011	4,035	1373 (34.03)	2662 (65.97)	7.90
Ruanda	2019-20	3,409	2160 (63.36)	1249 (36.64)	6.67
Tanzania	2022	2,338	694 (29.68)	1944 (70.32)	4.58
Uganda	2016	3,802	1727 (45.42)	2075 (54.58)	7.44
Zambia	2018	7,358	3079 (41.85)	4279 (58.15)	14.40
Zimbabwe	2015	8,074	4984 (61.73)	3090 (38.27)	15.80
Total		51,099	23372 (45.74)	27727 (54.26)	100

In this study 51,099 children aged 6–59 months were included in analysis, of which 25,598 (50.09%) were males. The majority of children (24.29%) were between 12 and 23 months and the majority (76.16%) of the children were living in rural areas. In terms of nutritional status, (37.92%) of children were stunted. The majority (45.91%) of the mothers had attained a primary level of education, and (47.95%) were aged 25–34 years. About (48.25%) and (48.13%) of participants were from countries with high community poverty levels and low community literacy levels, respectively (Table 2).

Table 2. Descriptive characteristics of children aged 6–59 months in East Africa based on DHS.

Variable	Categories	frequency (n)	Percentage	chi square (p-value)
Age of child	6-11	6360	12.45	3100 (<0.001)
	12-23	12413	24.29	
	24-35	11686	22.87	
	36-47	10357	20.27	
	48-59	10283	20.12	
Sex of child	Male	25598	50.09	25.12 (<0.001)
	Female	25501	49.91	
Size of child at birth	Smaller than average	8629	16.89	30.46 (<0.001)
	Average	25620	50.14	
	Larger than average	16850	32.98	
Vitamin A supplementation	No	18354	35.92	70.88 (<0.001)
	Yes	32745	64.08	
Stunting status of child	Normal	31721	62.08	367.34 (<0.001)
	Stunted	19378	37.92	
Underweight status of child	Normal	42678	83.52	342.90 (<0.001)
	Underweighted	8421	16.48	
Family size	Less than 5	15986	31.28	11.22 (0.004)
	5-8	28391	55.56	
	Above 8	6722	13.15	
Birth order of child	First	11530	22.56	66.34 (<0.001)
	2-3	19117	37.41	
	4-5	11321	22.16	
	6 and above	9131	17.87	

Table 2 (continued).

Variable	categories	AOR	95% CI	P-value
Birth type	Single	49707	97.28	4.92 (0.026)
	Multiple	1392	2.72	
Having fever	No	40165	78.60	459.56 (<0.001)
	Yes	10934	21.40	
Having diarrhea	No	42674	83.51	288.26 (<0.001)
	Yes	8425	16.49	
Number of under five children	One	20570	40.26	163.25 (<0.001)
	Two	22678	44.38	
	Three and more	7851	15.36	
Mother education status	No education	12495	24.45	701.85 (<0.001)
	Primary	23461	45.91	
	Secondary & higher	15143	29.63	
Mother anemia status	Not anemic	35080	68.65	1300 (<0.001)
	Anemic	16019	31.35	
Mother age	15-24	14267	27.92	209.29 (<0.0001)
	25-34	24503	47.95	
	35-49	12329	24.13	
Mother occupation	No	21490	42.06	63.28 (<0.0001)
	yes	29609	57.94	
Source of drinking water	Not improved	17261	33.78	125.62 (<0.001)
	Improved	33838	66.22	
Type of toilet facility	Not improved	12347	24.16	192.22 (<0.001)
	Improved	38752	75.84	
Residence	Urban	12180	23.84	156.90 (0.001)
	Rural	38919	76.16	
Media exposure	No	21246	41.58	258.08 (<0.001)
	Yes	29853	58.42	
Wealth index of family	Poor	23323	45.64	410.31 (<0.001)
	Middle	9404	18.40	
	Rich	18372	35.95	
Marital status	Unmarried	2567	5.02	6.24 (0.044)
	Married	37206	72.81	
	Separated	11326	22.16	
Community poverty	Low	26445	51.75	49.13 (<0.001)
	High	24654	48.25	
Community literacy	Low	26503	51.87	59.46 (<0.001)
	High	24596	48.13	

Determinants of anemia among children aged 6–59 months

The model with the smallest deviance was better suited to the data. Based on this criterion, model IV was selected, and the final analysis was conducted using this model (Table 03). The results showed that the age of the child, sex of the child, nutritional status (stunting, underweighting), number of under-five children, birth order of the child, vitamin A supplementation, fever before the date of the survey, mother's educational level, mother's anemia status, current age of mother, type of toilet facility, wealth index of family, and community poverty level had significant effects on anemia among children aged 6–59 months in East Africa (Table 04).

The multilevel multivariable analysis outcome revealed that children in the age group of 12-23, 24-35, 36-47, and 48-59 months were 0.623 times (AOR = 0.623; 95% CI: 0.581-0.669), 0.343 times (AOR = 0.343 ;95% CI: 0.320-0.369), 0.260 times (AOR = 0.260 ;95% CI: 0.241-0.279), and 0.202 times (AOR = 0.2082;95% CI: 0.187-0.217), less likely to be anemic than children in the age range of 6-12 months, respectively. Female children were 0.914 times less likely to be anemic than compared to male (AOR = 0.914; 95% CI: 0.880-0.949). Stunted children were 1.289 (AOR =1.289; 95% CI: 1.234-1.347) times more likely to be anemic as compared to non-stunted children. Similarly, underweight children were 1.232 times (AOR = 1.232; 95% CI: 1.163-1.306) more likely to be anemic as compared to normal-weight children.

The odds of developing anemia were 1.068 (AOR=1.068; 95% CI: 1.023-1.116) and 1.144 (AOR =1.144; 95% CI: 1.072-1.222) times higher among households with two and above two children. The odds of developing anemia whose childbirth order 2-3, 4-5 and 6+ were 1.096 times (AOR=1.096; 95% CI:1.034-1.162) times higher, 1.142 (AOR=1.142; 95% CI: 1.058-1.233), and 1.162 (AOR =1.162; 95% CI: 1.061-1.272) times higher than first, respectively.

Children who had a history of fever two weeks prior data collection were 1.410 times more likely to be anemic than those without fever (AOR=1.410; 95% CI: 1.343-1.481). Children who had a history of diarrhea two weeks prior data collection were 1.066 times more likely to be anemic than those without diarrhea (AOR=1.066; 95% CI: 1.009-1.125). Similarly, children who took vitamin A supplementation were 0.899 (AOR =0.899; 95% CI: 0.863-0.937) times less likely to be anemic than those who did not receive vitamin A supplementation. Children with primary education mothers, and with secondary and above education, were 0.819 times (AOR=0.819; 95% CI: 0.775-0.865) and 0.786 times (AOR=0.786; 95% CI: 0.733-0.844) less likely to be anemic than children with mothers of no education. Children born to anemic mothers had 1.844 (AOR =1.844; 95% CI: 1.768-1.923) times higher odds of anemia compared with children born to non-anemic mothers. On the other hand, the odds of being anemic for children from households with a middle wealth index family was 0.876 (AOR =0.876; 95% CI: 0.830-0.925) and the wealth index family was 0.851 (AOR = 0.851; 95% CI: 0.803-0.903) times lower than a child born from poor wealth index family. Compared with the type of toilet facility, the likelihood of having anemia was 0.879 times lower for children from families with improved toilets (AOR = 0.879; 95% CI = 0.835-0.926). In this study, the mother's age was also significantly associated with anemia in children. The odds of being anemic of a child from a mother with age group between 25-34 years was 0.885 (AOR =0.885; 95% CI: 0.837-0.936) and 35-49 years were 0.808 (AOR=0.808; 95% CI: 0.747-0.874) times less likely than those children whose mother age was between 15-24 years respectively. Children of mothers who had occupation had 0.930 times less odds of being anemic compared to the children of mothers who had no occupation (AOR=0.930;95%CI: 0.892-0.971). Those Households with high community poverty levels had 1.047(AOR = 1.047; 95% CI: 1.006-1.089) times higher odds of having anemia compared to their counterparts (Table 04).

The association test for the fixed effects and random intercept is shown in Table 3. The results of the empty model indicated a significant variation in the odds of anemia among the population ($\tau=0.440$; $p<0.001$).

Table 3. Variability at community level and model comparison for anemia assessment among under-five children in Eastern Africa

Parameter	Null model	Model II	Model III	Model IV
Community level variance	0.440	0.345	0.441	0.345
ICC	0.056	0.035	0.056	0.035
MOR	1.529	1.456	1.529	1.456
PCV (%)	reference	21.591	27.826	27.826
Model comparison				
Log likelihood ratio	-34189.20	-31573.74	-33119.98	-31569.76
Deviance (-2LL)	68378.4	63147.48	66239.96	63139.52

Table 4. Multilevel analysis of anemia status and associated risk factors among under-five children in East Africa based on DHS

Variable	categories	AOR	95% CI	P-value
Age of child	6-11 (ref)	1.00		
	12-23	0.623	(0.581-0.669)	<0.001**
	24-35	0.343	(0.320-0.369)	<0.001**
	36-47	0.260	(0.241-0.279)	<0.001**
	48-59	0.202	(0.187-0.217)	<0.001**
Sex of child	Male (ref)	1.00		
	Female	0.914	(0.880-0.949)	<0.001**
Size of children at birth	Smaller than average(ref)	1.00		
	Average	0.960	(0.909-1.014)	0.141
	Larger than average	0.968	(0.913-1.026)	0.274
Vitamin A supplementation	No (ref)	1.00		
	Yes	0.899	(0.863-0.937)	<0.001**
Number of under five children	One (ref)	1.00		
	Two	1.068	(1.023-1.116)	<0.001**
	Three and more	1.144	(1.072-1.222)	<0.001**
Birth type	Single (ref)	1.00		
	Multiple	0.985	(0.874-1.109)	0.798
Stunting status of child	Normal (ref)	1.00		
	Stunted	1.289	(1.234-1.347)	<0.001**
Underweight status	Normal (ref)	1.00		
	Underweight	1.232	(1.163-1.306)	<0.001**
Family size	<5 (ref)	1.00		
	5-8	1.002	(0.954-1.052)	0.935
	> 8	0.950	(0.881-1.024)	0.180
Birth order of child	1 (ref)	1.00		
	2-3	1.096	(1.034-1.162)	0.002
	4-5	1.142	(1.058-1.233)	0.001
	6+	1.162	(1.061-1.272)	0.001
Having fever	No (ref)	1.00		
	Yes	1.410	(1.343-1.481)	<0.001**
Having diarrhea	No (ref)	1.00		
	Yes	1.066	(1.009-1.125)	0.022
Mother educational level	No education (ref)	1.00		
	Primary	0.819	(0.775-0.865)	<0.001**
	Secondary+	0.786	(0.733-0.844)	<0.001**

Table 4 (continued).

Variable	categories	AOR	95% CI	P-value
Mother occupation status	No (ref)	1.00		
	Yes	0.930	(0.892-0.971)	0.001
Mother anemia status	Not anemic (ref)	1.00		
	Anemic	1.844	(1.768-1.923)	<0.001**
Current age of mother	15-24 (ref)	1.00		
	25-34	0.885	(0.837-0.936)	<0.001**
	35-49	0.808	(0.747-0.874)	<0.001**
Source drinking water	Not improved (ref)	1.00		
	Improved	0.969	(0.926-1.013)	0.169
Availability of toilet facility	No (ref)	1.00		
	Yes	0.879	(0.835-0.926)	<0.001**
Wealth index of family	Poor (ref)	1.00		
	Middle	0.876	(0.830-0.925)	<0.001**
	Rich	0.851	(0.803-0.903)	<0.001**
Media exposure	No (ref)	1.00		
	Yes	0.990	(0.948-1.035)	0.670
Marital status of mother	Single (ref)	1.00		
	Married	1.034	(0.942-1.134)	0.487
	Separated	1.009	(0.914-1.113)	0.865
Residence	Urban (ref)	1.00		
	Rural	0.949	(0.897-1.004)	0.069
Community poverty	Low (ref)	1.00		
	High	1.047	(1.006-1.089)	0.023*
Community Literacy	Low (ref)	1.00		
	High	0.996	(0.957-1.035)	0.822

The analysis revealed that the variables at the individual and population levels accounted for 27.826% of the community variance in the null model, with a PCV of 27.826%. The MOR was 1.529, indicating that the likelihood of anemia was 1.529 times higher for participants who moved from lower-risk to higher-risk categories. This finding supported the existence of significant variation in anemia among the various populations in the countries considered in the study.

DISCUSSION

The study aimed to analyze the prevalence and contributing factors of anemia among children aged 6-59 months in Eastern Africa countries using DHS data from 2010 to 2023. This study found that the overall prevalence of anemia among children aged 6-59 months in 10 ten East African countries was 54.26% (95% CI: 0.538-0.548), which is consistent with findings from studies conducted in Ghana (54.0%)²⁵ and Ethiopia (58%).¹⁸ The results of the present study were lower than studies conducted in South Africa (75.0%) (29) and Northeast Ethiopia (66.6%).¹¹ However, the current study revealed a higher proportion of anemia as compared to the studies conducted in Nepal (49.5%),²⁷ South-East Nigeria (49.2%),²⁸ and Ethiopia (46%).²⁹ The difference in prevalence may be the result of different study designs; earlier studies were conducted in a limited area of the study population within a single

population, while the current study focused on recent data from the DHS dataset covering a broad range of populations and the difference in the availability of healthcare facilities.³⁰ Besides, the higher prevalence of anemia in the current study could be attributed to the recent resurgences of malaria in East Africa due to climate change.³¹ However, geographic differences demonstrated that anemia is a serious public health problem in East Africa. The geographical difference of anemia across the regional states might be attributable to the regional variation of food consumption preferences,³² the occurrence of communicable diseases.³³ The results of this study indicate that the likelihood of experiencing anemia is lower in older children than in younger children, which agrees with studies conducted in Southern Ethiopia,³⁴ Northern Ethiopia,³⁵ Uganda,¹⁰ Cameroon,³⁶ India,³⁷ and Hunan Province.³⁸ Children of a certain age may consume additional foods containing specific micronutrients, which improves hemoglobin levels.¹⁴ The possible reason may be due to younger children may be prone to certain infectious diseases that affect the absorption and utilization of relevant micronutrients in their bodies.³⁹ Furthermore, nutritional imbalance may be another reason for the increased risk of anemia in younger children, as they require a high nutritional demand due to their rapid growth during the first two years of life in combination with rapid expansion of blood volume, younger children may suffer from at least one micronutrient deficiencies (Vitamin B12, folate, or iron) which leads to the onset of anemia.⁴ The other reason may be due to the low concentration of iron and other micronutrients in breast milk that cannot be sufficient for daily requirement of child growth,⁴⁰ and may also be a cause for red blood cell hemolysis and loss of appetites, which exacerbate the problem.⁴¹

Similarly, this study highlighted that female children were less likely to be anemic as compared to male children. This finding is consistent with studies reported in Bangladesh,⁴² Northeast Ethiopia¹¹ and Ethiopia.² The possible reason may be evidence in different report suggested that the level of testosterone is higher in boys than girls during pre-puberty stage.⁴³ Testosterone is a known stimulator of erythropoiesis and enhanced metabolism.⁴⁴ The high level of testosterone in male infants stimulates growth speed during their first few months of life may lead to increased micronutrient needs than girls.⁴⁵ Failing to address this heightened demand with suitable iron-rich complementary foods at this crucial stage could raise the risk of iron deficiency anemia among male children in comparison to their female counterparts.¹¹

Likewise, this study indicated that stunted children were more likely to be anemic than non-stunted children, in agreement with other studies conducted in Northern Ethiopia¹¹ and Ethiopia.¹⁴ Similarly, the likelihood of being anemic was high for underweight children, consistent with previous studies in Ethiopia.^{18, 46} Since stunting and underweight are indicators of short-term and long-term malnutrition, suggesting that malnourished children experience a higher risk of developing anemia as well as other infectious diseases than nourished children, a similar finding was published in Cameroon³⁶ and Northern Ethiopia.³⁵ There could be another reason for this, as anemia and malnutrition often have similar underlying causes. It is likely that multiple forms of malnutrition would be present in a child, which could exacerbate the development of anemia in a synergistic manner.¹⁰ Furthermore, malnourished individuals may experience reduced nutrient absorption, further contributing to the onset and worsening of anemia, particularly in regions where poverty and food insecurity are widespread, such as East Africa. Similarly, as birth order increases, the risk of anemia increases, in line with a

previous study.⁴⁷

Moreover, children who had a history of fever two weeks before the survey were more likely to be anemic, in line with a previous study in Ethiopia¹⁸ and in urban slum areas of Indonesia.⁴⁸ This may be due to fever being associated with infectious and parasitic diseases, which in turn contributed to diminishing the hemoglobin level of children which result in anemia due to destruction of RBCs.⁴⁹⁻⁵¹ Another reason may be inadequate food intake due to loss of hunger during the febrile period, which may lead to an increase in the anemic level of children.

The odds of being anemic were less likely for children whose mothers were educated, and this finding is consistent with previous studies conducted in Northeast Ethiopia,¹¹ Cameroon,³⁶ Ethiopia,⁹ Southwest Ethiopia,⁵² and Uganda.¹⁰ This may be due to educated mothers having adequate healthcare, nutrition knowledge, and paying more attention to child-rearing practices than uneducated mothers. Furthermore, they ensure a hygienic environment for children, possess a greater understanding of caregiving, and exhibit increased requirements for a nutritious diet.³⁴

The findings of this study indicate that children with anemic mothers are more likely to experience anemia themselves compared to those with non-anemic mothers, which is consistent with previous studies.^{18, 53, 54} This association may be attributed to the shared socioeconomic status of the family, impacting both children and their mothers and leading to anemia due to expected exposure to certain risk factors. This may be due to the fact that mothers and their children shared common socioeconomic status and environment, which can influence access to nutritious food, healthcare, and living conditions. These factors may increase the risk of anemia for both children and their mothers due to inadequate nutrition, higher exposure to infections, and limited healthcare access. Furthermore, breast milk is the main source of nutrients during the early stages of life. Thus, the association of maternal anemia with child may be, due to the low nutrients content of the breast milk of anemic mothers.⁵⁵ Children from middle-aged (25–34 years old) and older women (35–49 years old) mothers were less likely to be anemic compared to children from younger (15–24 years old), in line with a study conducted in Ethiopia.¹⁸ The reason for this might be that younger mothers are mostly faced with challenges with childcare due to limited resources and poor childcare practices that lead to poor health outcomes.⁵⁶

The odds of anemia among children were lower in the middle and rich categories of wealth index, consistent with previous studies conducted in Ethiopia,^{1,9} northeast Ethiopia,¹¹ and northern Ethiopia.³⁸ This could be because families of middle and high economic standing can afford essential necessities like clean water, healthcare, and nutritious food, all of which are crucial for ensuring proper child health.⁵⁷ In contrast, families with lower economic status may struggle to provide these basic needs and might be less inclined to seek early treatment for anemia.

Limitation and strength of study

The DHS surveys are conducted in different years across countries, which may introduce temporal

inconsistencies in anemia prevalence and associated factors. Although DHS follows standardized and rigorous sampling procedures, some countries may have variations in response rates, data completeness, and sample representativeness, which could introduce selection bias. To mitigate this, we applied sampling weights provided by DHS to ensure representativeness at national and regional levels. Differences in healthcare infrastructure, measurement techniques, and anemia screening methods across countries might contribute to measurement bias. To minimize this, we relied on DHS-standardized anemia measurement protocols (hemoglobin testing using HemoCue) and used a consistent analytical framework across all countries. The other limitation of this study is that excluding the genetic and environmental factors that are not captured in the DHS dataset. Future studies are recommended to incorporating genetic predisposition data, environmental exposures, and longitudinal studies to better understand the multifactorial nature of anemia in East Africa, as these variables may contribute to variations across different populations. Additionally, integrating biomarker analyses and geospatial assessments could provide more comprehensive insights into these missing aspects.

CONCLUSION

The prevalence of Anemia in Eastern Africa remains high, presenting a sustained challenge to achieving adequate health outcomes in the region. Age of child, sex of child, nutritional status (stunting, underweighting), birth order, having fever and diarrhea two weeks before the date of survey, Vitamin A supplementation, mother's education status, mother's anemic status, mother's age, availability of toilet facility, community poverty level, and wealth index of family were determinants of anemia among children aged 6-59 months in East Africa. These findings underscore the urgent need for comprehensive interventions, such as vitamin A supplement promotions, targeted nutritional programs, and poverty alleviation, improving toilet facility and wealth index of family, which may represent a potential consideration to reduce the burden of anemia.

Abbreviations

AOR, Adjusted odds ratio; DHS, Demographic health survey; ICC, Intra-class correlation coefficient; LLR, Log-likelihood ratio; LR: Likelihood ratio; PCV: Proportional change in variance; MOH, Ministry of health; MOR, Median odds ratio; WHO, World health organization.

Ethical Consideration

Not Applicable

Consent for Publication

Not applicable

Data Availability

This study relies on data from the DHS program, which has systematically collected and provided comprehensive and reliable information on population, health, HIV, and nutrition through over 400 surveys across 90 countries. The data used in this study was obtained from the DHS repository and is available for access at www.measuredhs.com.

Conflict of Interest

The authors declare that they have no competing interests.

Funding Information

This work is partially based upon research supported by the South Africa National Research Foundation (NRF) and South Africa Medical Research Council (SAMRC) (South Africa DSTNRF-SAMRC SARCHI Research Chair in Biostatistics, Grant number 114613). Opinions expressed and conclusions arrived at are those of the author and are not necessarily to be attributed to the NRF and SAMRC.

Author Contributions

DBB, NAB, TYB, and YAS were involved in the study design, data extraction, analysis, and drafting of the manuscript; DC was involved in study design, advising through each stage, and reviewing the manuscript. All authors have read and approved the final manuscript.

ACKNOWLEDGMENT

The authors would like to thank the DHS measure program for providing all the relevant secondary data used in this study.

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