Risk factors of severity levels of Anemia among children aged 6 to 59 months in Ethiopia

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Background

Anemia is a condition characterized by a low level of hemoglobin in the blood [1]. Although it affects individuals in all stages of life, preschool children and pregnant women are the most heavily affected. Anemia is a widespread public health problem, and severe anemia is a significant cause of childhood mortality [2]. World Health Organization (WHO) considers anemia prevalence over 40% as a major public health problem, between 20 and 40% as a medium-level public health problem, and between 5 and 20% as a mild public health problem [1]. High prevalence of anemia and its consequences for children's health, especially for their growth and development, have made anemia an important public health problem, given the difficulty in implementing effective measures for controlling it [3]. Therefore, it is important to understand the scope and strength of individual risk factors for anemia in populations where anemia is common to design more effective interventions [3, 4]. Its etiology involves many factors such as socioeconomic, nutritional, demographic, environmental and cultural characteristics, and the actions required encompass pertinent and relevant matters within the context of public health [3, 5].

Different levels of severity of anemia (i.e. mild, moderate and severe) are sometimes combined for analysis and reporting. However, they should be reported separately to provide more complete information as the differences between them are meaningful theoretically as well as empirically.

The WHO estimated that 1.6 billion people were anemic worldwide, and approximately two-thirds of preschool children in Africa and south East Asia were anemic [6]. Furthermore, according to WHO report, more than half of the world's preschool-age children (56.3%) reside in countries where anemia is a major public health problem [6, 7]. In sub-Saharan Africa, it is a major public health problem among preschool-age children. In this region, much of the national prevalence is estimated to be above 40% among this group [8]. In Ethiopia, more than four out of ten under-five children (44%) were anemic in 2011[9]. From these, about 21% of children were mildly anemic, 20% were moderately anemic, and 3% were severely anemic.

Even if it has dropped from 54 percent in 2005, it was a major public health problem according to WHO criteria. Even though the government of Ethiopia applied tremendous efforts to minimize the prevalence of child anemia, the prevalence was still high. Many researches had been conducted to show its prevalence and associated factors. However, some of the studies were derived from research conducted in specific localized groups which were not representative of entire Ethiopia [10-12]. Even though the study conducted by Dereje Habte was representative of Ethiopia, it focused only on maternal determinants of anemia where socio-demographic and nutritional factors were not studied [13]. Hence, until now there were no population based studies permitting generalization about the different severity levels of anemia and its principal determinants among children in Ethiopia.

Therefore, the present study aimed at identifying and analyzing the risk factors associated with different severity levels of anemia among children aged 6 to 59 months in Ethiopia. It was hoped that the results of the study will help to improve policy makers' understanding of the determinants of childhood anemia in the country and will allow better identification of children at risk of anemia. Consequently, it will serve as an important tool for effective and efficient application of rational planning and allocation of resources for preventive and control actions against anemia among children in the country.

Methods

Study design and sample size

The study was further analysis of 2011 Ethiopian Demographic and Health survey (EDHS). It was based on 7636 children aged 6 to 59 months from a database that has been compiled as part of the survey.

Variables and source of data

The 2011 EDHS data were obtained from Central Statistical Agency (CSA), Addis Ababa, Ethiopia. The principal objective of the 2011 EDHS was to provide current and reliable data on fertility and family planning behavior, child mortality, adult and maternal mortality, children’s nutritional status, use of maternal and child health services, knowledge of HIV/AIDS, and prevalence of HIV/AIDS and anemia [5]. Hemoglobin testing was conducted on women age 15-49 and children 6-59 months. In this study the outcome variable was anemia status of children aged 6 to 59 months categorized into three: severe or moderate, mild, and non-anemic. Anemia status was determined based on hemoglobin concentration in blood adjusted to altitude. Adjusted concentration 10.0-10.9 g/dl was considered as mild anemia, 7.0-9.9 g/dl as moderate anemia and less than 7.0 g/dl as severe anemia.

This study tried to include the most important expected risk factors of anemia from various literature reviews [3, 5, 10-18] & [19 as cited in 20], and their theoretical justification from the source of data [9]. The explanatory variables at individual and household levels to be analyzed were child's size at birth, sex of child, child’s age, stunting status of child, wasting status of child, mother’s educational level, husband/partner’s education level, mothers’ anemia status, mothers' age, mothers’ marital status, mothers’ current employment status, place of residence, religion of child, source of drinking water, number of under-5 children in the household and child's birth order.

Method of analysis

Ordinal logistic regression model was employed because of child anemia status; categorized into three groups- severe/ moderate, mild, and non-anemic; is ordered. Specifically, proportional odds model (POM) was employed because of the following appealing features: (a) it is invariant under several categories as only the signs of the regression coefficients change when the coding of the response variable are inverted [21, 22]; (b) it is invariant under collapsibility of the ordered categories as the regression coefficients do not change when response categories are collapsed or the category definitions are changed [16]; and (c) it produces the most easily interpretable regression coefficients as $\exp(-\beta)$ is the homogenous odds ratio (OR) over all cut-off points summarizing the effects of the explanatory variables on the response variable in one single frequently used measure [21].

The POM model for the categorical variable Y with C ordered categories and a collection of P explanatory variables for the $\boldsymbol{l}^{th}$ subject $\boldsymbol{X}_{\boldsymbol{l}}' = (x_{1\boldsymbol{l}}, x_{2\boldsymbol{l}}, \dots, x_{p\boldsymbol{l}}), \boldsymbol{l} = 1, 2, \dots, n$ is given as:

$$logit[Y_{\boldsymbol{l}} \leq i|x_{\boldsymbol{l}}] = log\left[\frac{\pi_i(X_{\boldsymbol{l}})}{1-\pi_i(X_{\boldsymbol{l}})}\right]$$

$$= \alpha_i - \beta_1 x_{1\boldsymbol{l}} - \dots - \beta_p x_{p\boldsymbol{l}} = \alpha_i - \boldsymbol{X}_{\boldsymbol{l}}'\beta$$

$$for\ i = 1, 2, \dots, c-1;\ l = 1, 2, \dots, n$$

where $\pi_i(X_{\boldsymbol{l}}) = Pr\ (Y_{\boldsymbol{l}} \leq i|X_{\boldsymbol{l}})$ and β is a column vector of P regression coefficients and α_i is $\boldsymbol{i}^{th}$ intercept coefficient.

To choose the best fit model, we used the AIC values, BIC values, and Deviance test. Once the best model has been chosen, test of parallelism was assessed. A non-significant chi-square test of parallelism was taken as evidence that the logit surfaces are parallel and that the odds ratios can be interpreted as constant across all possible cut-off points of the outcome variable.

Statement of consent

The consent was obtained from each respondent to participate before any information is asked during 2011 EDHS.

Results

From the sampled children, 28.6%, 21.7% and 49.7% were severely or moderately anemic, mildly anemic, and non-anemic, respectively.

The percentage distribution of child anemia status by the levels of selected explanatory variables was shown in Table 1. For instance, out of children who resided in rural areas, 48.4% were not anemic, 22.0% were mildly anemic, and 29.6% were severely or moderately anemic. These figures were 56.7%, 19.9% and 23.5% for those children who resided in urban areas, respectively.

For the purpose of selecting candidate predictors for the multiple ordinal logistic regression model, 16 uni-variable ordinal logistic regression models were developed. The result indicated that the variables sex (p-value=0.122) and marital status (p-value=0.605) were not significant at 5% level. Hence, in order to check whether sex and marital status have interaction or confounding effect with other covariates we considered two models: Model I containing all the 16 covariates while Model II excludes sex and marital status from the analysis. As shown in Table 2, the deviance based chi-square test provided a chi-square value of 1429.661 (p-value<0.0005) for Model II and 1432.196 (p-value<0.0005) for Model I which would imply that both models had good fit. Furthermore, the Pearson and deviance test statistics were found to be insignificant for both models. This was a further indication that both models had good fit.

The deviance test statistic was calculated as:

$$D = -2[\ln(L_I) - \ln(L_{II})] = 14182.418 - 13966.509 = 215.909$$

Table 1: Percentage distribution of anemia status within categories of covariates

Variables	Categories	Child's Anemia status		
		Severe/ moderate	Mild	Non-anemic
Mother's anemia status	Severe/moderate	44.0%	22.2%	33.8%
	Mild	37.4%	23.9%	38.7%
	Non-anemic	25.2%	21.1%	53.6%
Stunting status of Child	Severe	37.1%	22.9%	40.0%
	Moderate	26.8%	21.7%	51.5%
	Non-stunted	25.8%	21.1%	53.0%
Child age grouped	6 - 11	43.0%	26.5%	30.5%
	12 - 23	40.9%	22.9%	36.2%
	24 - 35	30.3%	21.9%	47.8%
	36 - 47	22.6%	20.5%	57.0%
	48 - 59	15.6%	19.3%	65.1%
Type of place of residence	Rural	29.6%	22.0%	48.4%
	Urban	23.5%	19.9%	56.7%
Source of drinking water	Improved	26.5%	20.6%	52.9%
	Non-improved	30.8%	22.8%	46.4%
Wasting status of Child	Severe	45.4%	21.1%	33.5%
	Moderate	36.6%	25.4%	38.0%

Non-wasted	27.3%	21.3%	51.4%

The percentage value of the Chi-square distribution with two degrees of freedom and level of significance 1% is 9.21. Since the deviance test statistic was significant at 1% level, we concluded that Model II fitted better than Model I.

AIC values for Model I and II were 14242.418 and 14026.509, while the BIC values were 14468.52 and 14234.73, respectively. Since Model II had smaller values of both AIC and BIC, we doubly concluded that it fitted the data better. The estimates of significant covariates of the final multiple ordinal logistic regression was given in Table 3.

Table 2: Results of deviance based tests of model adequacy

	Model	-2 Log Likelihood	Chi-Square	df	p-value
Model I	Intercept Only	15614.614			
	Final	14182.418	1432.196	30	.000
Model II	Intercept Only	15396.171			
	Final	13966.509	1429.661	28	.000

From the results the Chi-square test statistic was not significant at 5% level (p-value=0.071). Therefore, there is no enough evidence to reject the null hypothesis for the final model. Thus, the proportional odds assumption appeared to have held for the final model.

The study revealed that religion, wasting status and stunting status of the child, current employment status of mother, educational status of partner, age of child, number of children under 5 in the household, source of drinking water and mother's anemia status were significant determinants of child anemia in Ethiopia at 5% level.

Table 3: Parameter estimates for significant covariates in the final model

							95% CI of OR	
	Variables	Categories	β	OR	S. E.	p-value	L B	UB
Thr.	Child's anemia status	severe/ moderate	-1.80	6.05	0.146	0.000	4.56	8.08
		Mild	-.718	2.05	0.144	0.000	1.54	2.75
Loc.	Source of Water supply	Improved	0.135	0.87	0.049	0.006	0.79	0.96
		Non Improved (ref.)	0a	.	.	.	.	.
	Religion	Orthodox	0.975	0.38	0.055	0.000	0.34	0.42
		Protestant	0.824	0.44	0.064	0.000	0.39	0.50
		Muslim (ref.)	0a	.	.	.	.	.
	No. of under five children in the household	3 or above	-0.26	1.30	0.07	0.000	1.13	1.49
		Two	-.155	1.17	0.055	0.005	1.05	1.30
		one (ref.)	0a	.	.	.	.	.
	Mother's anemia status	Severe or moderate	-0.61	1.84	0.088	0.000	1.55	2.18
		Mild	-0.45	1.57	0.061	0.000	1.40	1.77
		Non-anemic (ref.)	0a	.	.	.	.	.
	Husband/ Partner's education level	secondary or higher	-0.04	1.04	0.095	0.667	0.86	1.26
		Primary	0.154	0.86	0.053	0.004	0.77	0.95

	illiterate (ref.)	0a	.	.	.	.	.
Mother's employment status	Not working	-.125	1.13	0.051	0.015	1.02	1.25
	Working (ref.)	0a	.	.	.		
Child age group	6 -11	-1.62	5.05	0.088	0.000	4.25	5.99
	12 – 23	-1.38	3.97	0.073	0.000	3.45	4.57
	24 – 35	-.745	2.11	0.071	0.000	1.83	2.42
	36 – 47	-.383	1.47	0.07	0.000	1.28	1.68
	48 – 59 (ref.)	0a	.	.	.	.	.
Child wasting status	Severe	-.349	1.42	0.136	0.01	1.09	1.85
	Moderate	-0.26	1.30	0.081	0.001	1.11	1.52
	not wasted (ref.)	0a	.	.	.	.	.
Child Stunting status	Severe	-0.65	1.92	0.059	0.000	1.71	2.15
	Moderate	-.235	1.26	0.058	0.000	1.13	1.41
	not stunted (ref.)	0a	.	.	.	.	.

Discussions

In this study, data on a total of 7636 children with complete information on the variables which were considered important for the analysis was utilized. For the purpose of selecting candidate predictors for the multiple ordinal logistic regression model, 16 uni-variable ordinal logistic regression models were developed. Based on results of uni-variable analysis two models were considered. All Deviance based test, AIC values and BIC values showed model including only significant variables from the uni-variable analysis fitted the data better and it was considered for the final analysis. From the proportional odds assumption test, the likelihood of being severely/moderately anemic as compared to being mildly anemic or non-anemic and the likelihood of being severely/moderately anemic or mildly anemic as compared to being non-anemic is similar for a given variable keeping all others among variables studied.

The result indicated that severely stunted children were 1.92 (OR =1.92; 95% CI: 1.71 - 2.15; p-value<0.0005) times more likely to be severely/moderately anemic as compared to non-stunted children holding all other variables constant. The OR could be as low as 1.71 and as high as 2.15 with 95% confidence. Similarly, moderately stunted children were 1.26 (OR =1.26; 95% CI: 1.13 – 1.41; p-value<0.0005) times more likely to be severely/moderately anemic as compared to those who are non-stunted. This result was consistent with the findings that stunting was associated with increased risk of anemia in children 6 to 59 months, and that anemia prevalence in children with stunting was twice that of children with normal stature [14]. It was also consistent with the findings that stunted children were 2.7 times more likely to be anemic than their counterpart (Adjusted OR = 2.7; 95% CI: 1.20–6.05) [10]. This finding was also similar with other studies conducted in Bangladesh [23], Brazil [24], and Burma [25]. This could be because under-nourished children are often anemic [24], low hemoglobin level has compromising effect of the linear growth [26], and coexisting of other micronutrient deficiencies and stunting may increase the development of anemia by synergism association.

From Table 3, we also observed that the status of wasting was significantly related with the anemia status of children. As compared to non-wasted children, being severely/moderately anemic was 1.42 (OR =1.42; 95% CI: 1.09 – 1.85; p-value=0.01) and 1.30 (OR =1.30; 95% CI: 1.11 – 1.52; p-value=0.001) times more likely for severely wasted and moderately wasted children, respectively. Since stunting and wasting are long-term and short-term indicators of malnutrition, the implication of the results was that under-nourished children experience higher risk of developing anemia as compared to nourished children.

The model results also showed that the age of children was a significant predictor of children anemia. The estimated OR=5.05 (OR =5.05; 95% CI: 4.25 – 5.99; p-value<0.0005) implied that the likelihood of children in the age range of 6 to 11 months being severely/moderately anemic was 5.05 times than those in the age range of 48 to 59 months, holding all other variables constant. The odds ratio could be as low as 4.25 and as high as 5.99 with 95% confidence. Similarly, the likelihood of children in the age range of 12 to 23 months being severely/moderately anemic was 3.97 (OR =3.97; 95% CI: 3.45 – 4.57; p-value<0.0005) times than those in the age range of 48 to 59. The study's result was consistent with the result of various studies. For instance, it was found that children under 2 years of age were at higher risk for anemia [15] . Similarly, it was observed that children less than 24 months old presented 3.61 times greater risk of being anemic than children aged 24 months or more [16]. Furthermore, age less than 12 months was reported as a risk factor for mild anemia [17].

The results revealed that the odds of being severely/moderately anemic were higher for children from non-employed mothers, whose households used non-improved source of drinking water, whose mothers' partners/husbands were illiterate, from households with two or more under-5 children, and whose mothers were severely/moderately anemic. These results were consistent with various findings. Children of working mothers were at lower risk of anemia [14], the occurrence of anemia was 1.68 times higher for children from households that consume untreated water as compared to those children from households that consume treated water [14], education has a relationship with the capacity to grasp the knowledge needed for adequate healthcare and nutrition for children, just as it provides a chance to enter the labor market and probably better socioeconomic conditions [18], children who have two or more siblings aged less than five years can have a higher risk for anemia [19] as cited in [20], and maternal anemia was associated with increased risk of anemia in children 6 to 59 months [14].

Conclusions

The study result showed that the likelihood of being severely/moderately anemic as compared to being mildly anemic or non-anemic and the likelihood of being severely/moderately anemic or mildly anemic as compared to being non-anemic was similar for a given variable keeping all others among variables studied. The study revealed that nutritional status of the child (wasting status and stunting status), current employment status of mother, religion, educational status of partner, age of child, number of children under 5 in the household, source of drinking water and mother's anemia status were the most important determinants of child anemia in Ethiopia. Based on results of this study, we recommended for a number of interventions required to reduce high prevalence of anemia for children in Ethiopia. These include: First, Policies and plans have to be put in place to reduce the prevalence of mothers' anemia. Secondly, Efforts like health, nutritional and family planning education, and follow up of both long term and short term nutritional status should be made to young aged children. Third, Improve partners' access to education in all areas to enhance the quality of care and attention they can provide to their children. Finally, Efforts should be made to improve access to safe drinking water and job opportunities to mothers.

Abbreviations

AIC: Akaike's Information Criteria; AIDS: Acquired Immunodeficiency Syndrome; BIC: Bayes' Information Criteria; D: Deviance test statistic; DV: Dependent Variable; EDHS: Ethiopian demographic and health survey; HIV: Human Immunodeficiency Virus; OR: Odds Ratio.

POM: Proportional Odds model; WHO: World Health Organization; CSA: Central Statistical Agency;

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