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Research Article

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Posted Date: March 25th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-357665/v1

Multilevel Modeling to identifying associated factors for Anemia Status with Women under Reproductive Age in Ethiopia

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Abstract

Background: *In developing country like Ethiopia as a whole and globally Anemia is the most common public problem caused by nutritional deficiency diseases among women at reproductive age. Hence, this study was determining the regional variation and associated factors of anemia status among women at reproductive age in Ethiopia using multilevel model.*

Method: *A cross-sectional study was conducted among 14489 women enrolled in Ethiopia demographic and health survey of 2016 which nested under nine regions and 2 administrative city .The data was entered into Stata version-14 for cleaning and data analysis. Binary and multilevel logistic regression was carried out for variables to determine associated factors with anemia status of women and its regional variations at ascertained of 5% level.*

Result: *The random intercept with fixed effect of the covariates multilevel model was considered as best fit of the data set based on Akaike information criteria when compared with other candidates models. In determining the potential factors associated with anemia status of women, the study indicated that women who use improved source of drinking water (OR=1.98, 95%CI=1.05, 3.72), being in middle wealth index (OR=0.25, 95%CI=0.10, 0.63), being in rich wealth index (OR=0.42, 95%CI=0.19, 0.94), having age at 1st birth in 20-24 years(OR=0.24, 95%CI=0.11, 0.53), having number of living children 1-2(OR=3.68, 95%CI=3.48, 4.98), having number of living children 3-4(OR=3.03, 95%CI=2.48, 4.05)and used government place of* *delivery(OR=0.96, 95%CI=0.22, 1.70) were significantly related to anemia status of women at 5 % level of significance.*

Conclusions: *The findings of this study showed that wealth index, age of women at 1st birth, number of living children, source of drinking water and place of delivery were potential covariates associated to anemia status of women and there were regional variability. It is recommended that health workers should be give attention to these proximate determinants on anemia at regional level.*

Key words: *Random effect model; Anemia status; Ethiopia demographic and health survey.*

1. Background

Anemia is the most common nutritional deficiency disease and the global health issue with disproportionately high prevalence in women which is a major health problem as worldwide and more in developing countries. According to [1], anemia affects the lives of over 30% of the world's population occurring at all stages of life cycle but the burden of the problem is higher in pregnant women particularly in developing countries. Residence, educational status, iron supplementation during pregnancy, and meal frequency per day were statistically associated with anemia among the pregnant women. The most vulnerable groups for anemia is adolescent females who grow rapidly and in addition have their first menstruations with iron losses, women of reproductive age who lose iron with their menstrual periods, pregnant women with an increased need for iron and lactating women as reported by [2] .

The prevalence of anemia among pregnant women is about 38% (32.4 million pregnant women), and non-pregnant women is about 29% (496.3 million non-pregnant women)), and for all women of reproductive age is about 29% (528.7 million women of reproductive age) as estimated in

2011 globally. More than 468 million non-pregnant women suffer from anemia of those women 80 million live in Europe, America and the remaining 388 million in more or less developing regions of the world[2, 3]. The proportion of women with anemia is different from country to country and across regions this were evidenced by study reported prevalence 28% in East Africa[4],49.5%-69% in India[5-7] , 37.6% in Nepal [8],41.3% in Bangladesh[9], 36-40% in some parts of Ethiopia[1, 10] and 40% in Korea[11].The reason for risk of developing anemia among women of reproductive age are source of drinking water, contraception use, smoking status and body mass index[12].

In sub-Saharan Africa the causes of anemia during pregnancy are iron and diet deficient and infections such as malaria, hookworm, and increasingly human immunodeficiency virus[13]. In addition to this, age of mother, age at pregnancy, age at marriage, number of deliveries, number of children, family size, educational status of mother, and occupation of mother were associated with anemia[14]. In East Africa, the most important public health issue is anemia during pregnancy because the potentially adverse effects on maternal and child health where the predominant cause of anemia were body mass index, iron deficiency and infectious disease[15]. In developing countries including Ethiopia the cause of anemia for woman is multifactorial such as nutritional deficiencies of iron, vitamin B12 and parasitic diseases like malaria and hookworms. Those factors are varies greatly by geographical location, season and dietary practices[16, 17]. According to the Ethiopian Demographic and Health Survey of 2011 report, 17% of reproductive age women are estimated to be anemic and 22% of the pregnant women are anemic [18].

Logistic regression is widely used to model the outcomes of a categorical dependent variable and the models are supported by variety of link functions such as logit, clog-log, log and reciprocal[19] . The type of response variable determines the distribution and link function for the model. Since the response variable for this study is binary outcome data the logit link function has been used. To model the hierarchical population variations in which one of successive sampling from each level, multilevel logistic regression is an appropriate model [20]. Multilevel model was used to the hierarchically structured data in which the units at one level are clustered with the units of the next higher level by allowing the simultaneous examination of the effects of group level and individual level variation dependence of observations within and between groups variations [21]. In multilevel research, the data structure in the population is hierarchical, and the sample data are a sample from this hierarchical population.

In spite of the fact that, several studies have been done on assessment and examined anemia using summary measure of statistics, cox regression model and binary logistic regression to predict the effect of associated factors on women with anemic under reproductive age by ignoring unobservable heterogeneity of random effect due to women nested in higher level regions. In addition, some researcher conducted their study on cross sectional study at small scale geographical area, hospital and administrative city/zone in Ethiopia to identify the determinants of anemic women which may not invite for interventions as national wide. In this study, the lower levels are women under reproductive age as units that were nested within units at higher level (regions). Hence, the current study considered national geographical area with nine regions and two administrative city that have multi-culture and ethnic setting in Ethiopia and employed Multilevel logistic regression model which allow to estimate the effect of both individual characteristics and cluster characteristics of women with anemia in Ethiopia to make valid inferences on regional variability that pave way for interventions.

2. Methods and Materials

2.1. Study area, Design and period

This study conducted in Ethiopia which is found in the horn of Africa. The geographical location of Ethiopia is bordered by Kenya to the South, Somalia and Djibouti to the East, Eritrea to the North and Sudan and South Sudan to the west. The country has nine regional states of Federal and two administrative cities. A cross-sectional study conducted to assess determinants that associated with anemia status among women enrolled in Ethiopia demographic and health survey 2016 during the census from January 18, 2016 to June 27, 2016.

2.2. Source of the Data and Sampling design

The data in this study was obtained from the 2016 Ethiopian Demographic and Health Survey which conducted by Central Statistical Agency. The survey was conducted in Ethiopia as part of the worldwide Demographic and Health Survey project. The principal objective of the survey was to give reliable data on marriage, fertility, family planning, child, adult and maternal mortality, nutrition, maternal and child health, knowledge of HIV/AIDS and prevalence of anemia. The sample for the 2016 EDHS was designed to provide population and health indicators at the national (urban and rural) and regional levels. To select the samples, sampling frame were taken from the 2007 Population and Housing Census that conducted by Ethiopian central statistical Agency. Two-stage Stratified sampling in which each region was stratified into urban and rural areas, giving 21 sampling strata in the first stage and samples of Enumeration Areas (EAs) were selected independently in each stratum in the second stage. Based on the 2007 census a total of 645 enumeration Areas including 443 in rural areas and 202 in urban areas were selected with probability relative to the enumeration area size. An equal probability systematic selection was applied in the second stage to select a fixed number of 28 households per cluster.

This two stage scenario of sampling showed that the data has hierarchical structure and its hierarchy follows individuals or hemoglobin tested women in the reproductive age as level-one and region as level-two in which individuals women are nested under regions. The target population for this study was all women in the reproductive age (15-49) years who have tested with hemoglobin levels during the EDHS, 2016 in Ethiopia.

2.3. Variables Description and Measurement

Response variable: The dependent (response) variable is woman anemia status. One question from the EDHS used to examine the dependent variable, which is woman in reproductive age at the time of interview "having anemia or normal". The response was binary which have two categories, namely: having anemia or normal (non-anemic) and coded as zero if woman is normal and coded as 1 if woman had anemia.

Independent Variables: Broadly, the researcher grouped the variables into two: socioeconomic demographic and maternal related determinants, which contribute to woman experiencing anemia as listed in Table 1.

Table 1: Description of Socioeconomic demographic and maternal related variables in this study

Variables	**Factor Categories**
Source of water supply	0=unimproved ,1= improved
Duration of current pregnancy	Continues
Region	0=Tigray,1=Afar ,2=Amhara ,3= Oromia ,4=Somalia, 5=BenishangulGumuz,6=SNNPR,7=Gambela,8=Harari, 9=Addis Adaba,10=Dire Dawa
Number of Tetanus injection before birth	Count

Wealth index	0=Poor,1=Middle,2=Rich
Place of residence	0=urban ,1=rural
Age groups of mother	0=15-19,1=20-24,2=25-29,3= 30-34,4=≥35
Place of delivery	0=home,1=Government health Center, 2=private health center
Educational level of Woman	0=no education,1=primary, 2=secondary,3=higher
Number of household members	Count
Succeeding birth interval (months)	Continues
Age of Woman at 1st birth	0=15-19,1=20-24,2=25-29,3= 30-34,4=≥35
Menstruated in last six weeks	0=no,1=yes
Number of living children	0=no child,1=1-2 children,2=3-4 children,3= ≥5 children
At health facility, told of family planning	0=no ,1=yes
Number of antenatal visits during pregnancy	Continues
Birth in last five years	0=no child,1= 1-2 children,2=>=3 children

2.4.Method of Data Analysis

To illustrate and determine the factors associated with women anemia status from the EDHS 2016 data set multilevel logistic regression and logistic regression were applied. In addition, regional variation also determined among women using multilevel logistic regression model.

2.4.1. Binary Logistic Regression

Logistic regression is a popular modeling approach when the dependent variable is dichotomous, ordinal or multinomial, from a set of predictor variables that may be continuous, discrete, dichotomous, or a mixture of any of these .This study used logistic regression model which is the most important model for categorical response data. Since logistic regression calculates the probability of success over the probability of failure, the results of the analysis is in the form of an odds ratio. There are two main reasons for choosing the logistic distribution function. The first, from a mathematical point of view, it is an extremely flexible and easily used function, and the second; it lends itself to a clinically meaningful interpretation [9]. The odds of success are the ratio of probability of success (the probability of anemic women) to probability of failure (in our case the probability of not anemic) is given by:-

$$odds = \frac{p(xi)}{1-p(xi)} = \frac{\pi}{1-\pi} \qquad [1]$$

In logistic regression analysis, the response variable and the predictors do not have a linear relationship. However, study used the log transformation called logit which is a suitable link function that has linear relationship. For a binary response variable Y and an explanatory variable X, let P(Y=1/X=x) =1-P(Y=0/X=x). The logistic regression model is

$$\pi(x) = \frac{e^{\beta_0+\beta x}}{1+e^{\beta_0+\beta x}} \qquad [2]$$

Equivalently, the log odds, called the logit, has the linear relationship

$$\log it(\pi(x)) = \log(\frac{\pi(x)}{1-\pi(x)}) = \beta_0 + \beta^{'} x \qquad [3]$$

Equation [3], shows that the odds are an exponential function of x. This provides a basic interpretation for the magnitude of β, the odds increase multiplicatively by e^{β} for every 1-unit increase in x. In other words, e^{β} is an odds ratio, the odds at X=x+1 divided by the odds at X=x. The most commonly used method for estimating the parameters of a logistic regression model is maximum likelihood estimation. The method of maximum likelihood estimation yields to estimate values for the unknown parameters which maximize the probability of obtaining the observed set of data. This study used person's X^2 statistic, wald test and the likelihood-ratio test for test the goodness of fit.

However, the structure of data in this study is hierarchical, and a sample from such a population can be viewed as a multistage sample. Therefore, multilevel regression model is appropriate that assumes a hierarchical data set with one single dependent variable is measured at the lowest level and explanatory variables at all existing levels.

2.4.2. Multilevel Logistic Regression

In a particular analysis, multilevel modeling provides a convenient framework for studying how covariates at various levels of a hierarchical structure affect the outcome variable. It used to correct the biases in parameter estimates as well as biases in their standard errors resulting from clustering. Multilevel model used estimates of the variances and covariance of random effects at various levels enable investigators to decompose the total variance in the outcome variable into portions associated with each level.

A multilevel logistic regression model used to account for lack of independence across levels of nested data (e.g., women nested within regions). In this study, multilevel binary logistic regression model would be adopted to the variations of anemia status of women with in regional states of Ethiopia. In this study the basic data structure of the two-level logistic regression is a collection of N groups (regions) and within-group j (j=1,2,….,N), a random sample of level-one units (Women).

Random Intercept Logistic Regression Model: In the random intercept logistic regression model, the intercept is the only random effect meaning that the groups differ with respect to the average value of the response variable. Random intercept is used to model unobserved heterogeneity between groups in the overall response. This allows knowing how the variability of the over all probability of anemia status seems across regions. Random intercept models have many applications, for instance estimating the regional effects on anemia status, adjusting for individual women level factors, and within the model, evaluate and compare the performance of the regions in anemia status. This can be done by obtaining the odds ratio for each region. This regional effect is a measure of the situation of anemia status due to the region relative to the average of all regions. If the odd of anemia status for regional effects is sufficiently larger than one, the region is considered to have performed worse than the average; if it is significantly smaller than one, the region is considered to have better performance than the expected.

Random Coefficient Logistic Regression Model: Random coefficients model explain unobserved heterogeneity in the effects of explanatory variables on the response variable. In logistic regression analysis, linear models are constructed for the log-odds. The multilevel analogue, random coefficient logistic regression, is based on linear models for the log-odds that include random effects for the groups or other higher-level units.

Consider explanatory variables which are potential explanations for the observed outcome denote these variables by X_1, X2… X_k and its value x_h (h=1,2,..,k) are indicated in the usual way by x_{hij}. Since some or all of these variables could be level-one variables, the success probability is not necessarily the same for all individuals in a given group. Therefore, the success probability depends on the individual as well as the group that denoted by πij. The model with group-specific regressions of logit of the success probability logit (πij) on a single level one explanatory variable X written as follows:-

$$\operatorname{logit}(\pi_{ij}) = \log\left(\frac{\pi_{ij}}{1-\pi_{ij}}\right) = \beta_{0j} + \beta_{1j}x_{1ij} \qquad [4]$$

The intercepts β_{0j} as well as the regression coefficients or slopes β_{1j} are group (region) dependent. These group dependent coefficients can be split into an average coefficient and the group dependent deviation written as:-

$$\begin{aligned} \beta_{0j} &= \beta_0 + U_{0j} \\ \beta_{1j} &= \beta_1 + U_{1j} \end{aligned} \qquad [5]$$

Thus, substitution into equation [4]

$$\operatorname{logit}(\pi_{ij}) = \log\left(\frac{\pi_{ij}}{1-\pi_{ij}}\right) = \beta_0 + \beta_{1j}x_{1ij} + U_{0j} + U_{1j}x_{1ij} \qquad [6]$$

The first part of equation [6] , $\beta_0 + \beta_{1j}x_{1ij}$ is called the fixed part of the model whereas the second part, $U_{0j} + U_{1j}x_{1ij}$ is called the random part of the model.

Intra-Class Correlation Coefficient (ICC): The other fundamental reason of using multilevel analysis is the existence of intra-class (intra-regional) correlation arising from similarity of anemic women in the same region compared to those of different regions. The intra-class correlation coefficient (ICC) measures the proportion of variance in the outcome explained by the grouping structure that can be calculated using an intercept-only model. The ICC is then calculated based on the following formula:-

$$ICC = \frac{\sigma_0^2}{\sigma_0^2 + \sigma_e^2} \qquad [7]$$

Where, σ_e^2 is a variance individual (lower) level unit and σ_0^2 is variation due to regional levels. In multilevel logit model level one residual variance σ_e^2 is approximately equal to 3.29 [12].

Parameter estimation for multilevel logistic model is not straightforward like the methods for simple logistic regression models. The most common methods for estimating multilevel logistic regression models are marginal quasi likelihood. The Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC) will also be used for model comparison.

3. Results

3.1. Characteristics and Distribution of Determinants on Anemia status of women in the reproductive age

Among a total of 14489 women who were interviewed for Anemia status in Ethiopia demographic and health survey of 2016, about 3929(27.1%) had anemia whereas 10560(72.9%) non-anemic from nine regional states and two administrative cities of Ethiopia in this study. More of the anemic women were found in the Age group of 35 and above years that had the proportion percentages of 1073(7.40%) and seems like equal number of women with anemia were in the age 15-19 and 25-29 with proportion of 5.20% (**Table 2**). The first and the second, maximum percentage of anemic women who lived in Somalia 737(5.0 %) and in Oromia 482(3.3%) whereas the two administrative region who had minimum percentage of women with anemia were Benishangul-Gumuz 202(1.4%) and Harari 204(1.5%) respectively. This regional variation is very realistic and expected based on living conditions of people within and between regions. Among the total women who had experienced anemia, 2998 (20.7%) of them were from rural areas, and 931 (6.5%) were from urban areas of Ethiopia. The result of regional variation among women with anemia also observed in educational level of woman that depicted more of them experienced anemia who had no education access 2244(15.5%) and the status of having anemia decreases as the education level increases from primary to higher (1141(7.9%) for primary, 388(2.8%) for seconder and 156(1.1%) for higher respectively).

Regarding the source of water for women who experienced anemia, from the total about 2417(16.7%) were used improved source of water whereas only 1512(10.5%) were used unimproved source of water. Furthermore, the distribution of determinants in (**Table** 2) indicates most (2066(14.3%)) of the women with anemic were from poorest wealth index family whereas about 484(3.4%) and 1379(9.6%) of the women with anemia were from the rich and middle income families respectively.

Table 2: Summary of socio-demographic covariates that associated to Anemia status of women.

Variables	Levels	Anemia status of Women					
		Anemic		Normal		Total	
		Count	%	Count	%	Count	%
Age group of mother	15-19	755	5.2	2417	16.7	3172	21.9
	20-24	715	4.9	1952	13.5	2667	18.4
	25-29	761	5.2	1891	13.1	2652	18.3
	30-34	625	4.3	1466	10.1	2091	14.4

	>=35	1073	7.4	2834	19.6	3907	27.0
Region	Tigray	331	2.3	1268	8.8	1599	11.0
	Afar	477	3.2	562	3.9	1039	7.2
	Amhara	297	2.0	1391	9.6	1688	11.7
	Oromia	482	3.3	1320	9.1	1802	12.4
	Somali	737	5.0	525	3.6	1262	8.7
	Benishangul-G.	202	1.4	836	5.8	1038	7.2
	SNNPR	379	2.6	1381	9.5	1760	12.1
	Gambela	276	1.9	709	4.9	985	6.8
	Harari	204	1.5	546	3.8	750	5.2
	Addis Ababa	256	1.8	1357	9.4	1613	11.1
	Dire Dawa	288	2.0	665	4.6	953	6.6
Residence	Urban	931	6.5	3778	26.1	4709	32.5
	Rural	2998	20.7	6782	46.8	9780	67.5
Educational level	No education	2244	15.5	4352	30.0	6596	45.5
	Primary	1141	7.9	3721	25.7	4862	33.6
	Secondary	388	2.8	1615	11.1	2003	13.8
	Higher	156	1.1	872	6.0	1028	7.1
Source of water	Unimproved	1512	10.5	3113	21.5	4625	31.9
	Improved	2417	16.7	7447	51.4	9864	68.1
Wealth index	Poor	2066	14.3	3540	24.4	5606	38.7
	Middle	484	3.4	1419	9.8	1903	13.1

	Rich	1379	9.6	5601	38.7	6980	48.2

3.2.Reproductive related risk factors associated for women with Anemia in Ethiopia

Likewise, regarding the Age women at 1st birth characteristics of women with anemia were highest for women whose age at 1st birth was in 15-19 years 1668(11.4%) as compared to women in the 20-24 years 828(5.7%), 25-29 years 185(1.4%), 30-34 years 35(0.3%) and the second highest 1213(8.4%) for the women with experienced anemia to give their 1st birth at the age of 35 and above years. Based on the women weather she have seen menstruated cycle or not for women with anemia, most of them 2131(14.6%) had menstrual cycle in the last six weeks at the time of survey conducted whereas slightly less 1798(12.4%) were not experienced menstrual cycle in the last six weeks (**Table** 3). Most of the 1039(7.2%) woman who have no children caught by anemia in Ethiopia which is seems similar with those women who had children more than or equal to five 1054(7.2%). The health service for woman was not enough to give information for all women, this resulted more of women 1117(17.7) didn't have told family planning at health facility for those anemic women whereas 507(8.0%) have information regarding family planning at health facility. In addition, the characteristics for place of delivery and Births in the last five years among women in the reproductive age (15-49) years were presented as detail in Table 3.

Table 3: Reproductive related factors for Women with Anemia in the study area

Variables	Levels	Anemia status of Women		
		Anemic=n(%)	Normal=n(%)	Total=n(%)
Age of respondent at 1st birth	15-19	1668(11.4)	3727(25.7)	5395(37.2)
	20-24	828(5.7)	1914(13.2)	2742(18.9)

	25-29	185(1.4)	461(3.2)	646(4.5)
	30-34	35(0.3)	120(0.8)	155(1.1)
	>=35	1213(8.4)	4338(29.9)	5551(38.3)
Menstruated in last six weeks	No	1798(12.4)	4227(29.2)	6025(41.6)
	Yes	2131(14.7)	6333(43.7)	8464(58.4)
Number of living children	No child	1039(7.2)	3903(26.9)	4942(34.1)
	1-2 children	991(6.9)	2714(18.7)	3705(25.6)
	3-4 children	845(5.9)	1929(13.3)	2774(19.1)
	>=5 children	1054(7.2)	2014(13.9)	3068(21.2)
At health facility, Told of family planning	No	1117(17.7)	3059(48.4)	4176(66.1)
	Yes	507(8.0)	1631(25.8)	2138(33.9)
Place of delivery	Home	1550(10.6)	2629(18.1)	4179(28.8)
	Government HC	613(4.2)	1705(11.8)	2318(16.0)
	Private HC	1766(12.2)	6226(43.0)	7992(55.2)
Births in the last five years	No child	1682(11.6)	5992(41.4)	7674(53.0)
	1-2 children	2031(14.0)	4324(29.8)	6355(43.9)
	>=3 children	216(1.5)	244(1.7)	460(3.2)

3.3. Distributions of continuous variables associated with anemic women in the reproductive age

In this study the mean for household members were 5 with standard deviation 2 approximately in which the household had minimum of one member and maximum of twenty members. The succeeding birth interval measured in months for women in the reproductive age was 41.73 ±

25.328 months on average having minimum of eight months and maximum of 208 months. As indicated in Table 4, number of tetanus injection before birth for women with anemic was 1.41 ± 1.681 on average and they have maximum of eight injections before births.

Table 4: Descriptive Statistics for continues covariates that included in this Study

Variables	Minimum	Maximum	Mean	Std.
Number of household members	1	20	5.44	2.428
Succeeding birth interval (months)	8	208	41.73	25.328
Duration of current pregnancy	1	10	5.57	2.230
Number of tetanus injections before birth	0	8	1.41	1.681
Number of antenatal visits during pregnancy	0	98	2.88	5.510

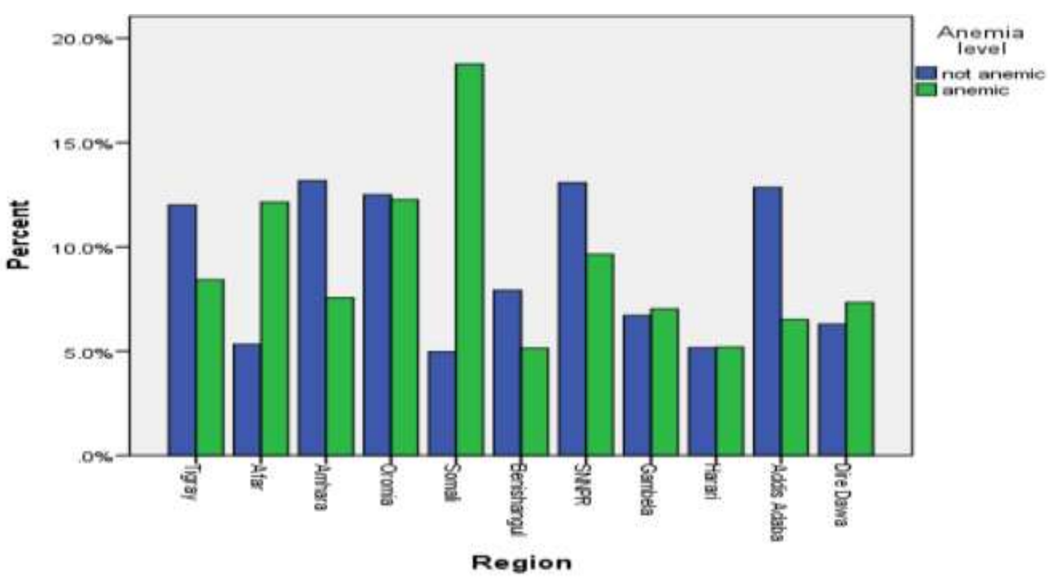

Figure 1:- Bar graph for Anemia status of women with in Region

Based on bar graph (Figure1) women who lived in Somali region was more anemic whereas lived Benishangul and Harari was less anemic.

3.4. Univariate analysis of Logistic regression for factors associated with women of anemic

Binary logistic regression was used to examine the effects of each predictor on anemia status of women in the reproductive age in this study. We employed uni-variable binary logistic regression model which is an appropriate procedure that used to screen out potentially important variables before directly included in multilevel logistic regression model. Log-likelihood chi-square statistic for screen out potentially important variables was applied. The relationship between each covariates and anemia level for women are presented in **Table 5**. The result showed that age of women, region, residence, educational level, source of drinking water, number of household members, wealth index, succeeding birth interval, births in last five years, age of respondent at 1st birth, duration of current pregnancy, menstruated in last six weeks, number of living children, health facility told about family planning, number of tetanus injections before birth, number of antenatal visits during pregnancy and place of delivery were significantly related to anemia level of women at 10 % level of significance and candidate predictors that were included in multilevel binary logistic regression model.

Table 5: Univariate Binary Logistic Regression Model result to screen out potential factors.

Variables	Log likelihood(χ^2)	DF	Prob > chi2
Age group	-8452.7834	4	0.0001***
Region	-7961.9739	10	0.0001***
Residence	-8368.8323	1	0.0001***
Education level	-8300.5552	3	0.0001***
Source of water	-8415.275	1	0.0001***
Number of household members	-8436.2883	1	0.0001***

Wealth index	-8237.9093	2	0.0001***
Succeeding birth interval	-4730.4915	1	0.0001***
Births in last five years	-8335.3165	2	0.0001***
Age of respondent at 1st birth	-8400.1147	4	0.0001***
Duration of current pregnancy	-690.22665	1	0.0003***
Menstruated in last six weeks	-8448.3855	1	0.0001***
Number of living children	-8372.2212	3	0.0001***
health facility told about family planning	-3596.2645	1	0.0087***
number of tetanus injections before birth	-4310.8095	1	0.0001***
number of antenatal visits during pregnancy	-4304.6734	1	0.0001***
place of delivery	-8315.6444	2	0.0001***

3.5. Result of Multilevel Binary Logistic Regression analysis

The candidate variables that were significant in the univariate analysis of binary logistic regression can be employed into multilevel logistic regression analysis for the improvement of unobservable heterogeneity due to women nested under regions. Before joining final model, the first logical step was chi-square test of heterogeneity among anemic women between regions. As a result the chi-square statistic was found to be 1088.22 with p-value ($p < 0.0001$) providing evidence for heterogeneity among regions and intra-class correlation (ICC) is also equal to 0.1023 which is different from zero with p-value ($p < 0.0001$).

This implies that multilevel binary logistic regression was an appropriate model to handle the heterogeneity of women among regions.

3.5.1. Comparison Among Multilevel Logistic Regression Models

Three multilevel logistic regression models were used such as empty model with random intercept, random intercept with fixed effects model and random coefficient with random intercept model have been considered and identify the appropriated model to this data. The result in Table 6 depicted that multilevel logistic regression model having fixed slope with random intercept had the smallest Akaike information criteria (AIC = 385.0685) and Bayesian information criteria (BIC= 491.2944) as compared other candidate models and fitted the dataset well. Finally, this study applied random intercept with fixed effect model is better model fit to made investigation of anemic women in Ethiopia.

Table 6: Summary for Comparison of Multilevel Logistic Regression Model

Methods	Random Intercept only Model	Random Intercept With fixed effect model	Random coefficient model
Log Likelihood	-7993.6479	-163.53426	-2749.775
AIC	15991.3	385.0685	5503.551
BIC	16006.46	491.2944	5516.561

3.6. Results Of Final Model Of Random Intercept With Fixed Effect In Multilevel Analysis

After fitting the multilevel logistic regression, goodness of fit of model to test the significance of individual predictors using Wald test of overall goodness of fit gives chi-square value equal to 25.95 having degree of freedom 27 with p value 0.016 which suggest that adding explanatory variables is important to predict the effect of anemia patients. The result of **Table 7** result showed that inclusion of level one covariates decreased regional variations from 0 .573 (level-two variance without covariates) to 0.375 that implies there is a significant variation between regions in anemia of women in Ethiopia. The reduction of the random effects of the intercept variance is due to the inclusion of fixed explanatory variables that taking into account the fixed independent variables can provide extra predictive value on anemia status of women in each region. This also indicates that there is significant variation between regions in the anemia status of women.

Based on the multilevel logistic regression result source of drinking water, wealth index of women, age of women at first birth, number of living children and place of delivery for women had significant effect on anemia status when regional heterogeneity was included at 5% level of significance whereas age group of mother, residence, education level, number of household members, succeeding birth intervals, births in the last five years, duration of current pregnancy, Menstruated in the last six weeks, told of family planning at health facility, number of tetanus injections before birth and number of antenatal visits during pregnancy were non-significant. As a result in **Table 7** women who use improved water source were 1.98 times more likely to be anemic as compared to those who use unimproved water source controlling for other variables in the model. Odds of Women who live in middle and rich households were about 0.25 and 0.42 times less likely to be anemic than that of women who live in poor households respectively. Age of women at 1^{st} birth is highly associated with anemic status at alpha equal to 5% level of significant. Women whose age at 1^{st} birth was 20-24 years old had odds 0.24 times less likely to be anemic as compared to women whose age at 1^{st} birth 15-19 years old.

The number of living children is another determinant of anemia level of women in Ethiopia at 5% level of significance. Besides, risk ratio of women who had 1-2 and 3-4 living children were

3.68 and 3.03 times more likely to exposed for anemic as compared to their counterparts respectively. Place of delivery is important predictor to determine anemia level of women in Ethiopia and the associated odds for women who use government health center service for delivery was 0.382 times less likely to have anemic as compared to women who use home place of delivery.

Table 7: Socio-demographic and health related factors result of Random Intercept with Fixed Slope Multilevel Model analysis

Variables(Ref)		Odds ratio(OR)	SE	Statistic	p-value	95% CI for OR
Age of women(15-19)	20-24	1.22	1.89	0.13	0.898	0.059, 25.332
	25-29	2.12	3.35	0.48	0.632	0.10,46.6
	30-34	2.77	4.54	0.6	0.535	0.111 ,68.8
	>=35	6.18	10.60	1.06	0.287	0.2 ,177.5
Residence (Urban)	Rural	0.68	0.38	-0.7	0.489	0.22,2 .1
Educational level(no)	Primary	0.83	0.30	-0.5	0.599	0.412, 1.7
	Seconder	1.12	0.88	0.14	0.888	0.238, 5.2
	Higher	0.26	0.26	-1.3	0.184	0.035,1.91
Source of water(unimproved)	improved	1.98	0.64	2.10	0.035	1.048 ,3.722
Number of household members		1.01	0.09	0.01	0.996	0.836, 1.2
Wealth index(poor)	Middle	0.25	0.12	-2.9	0.003	0.098 ,0.6
	Rich	0.42	0.17	-2.1	0.035	0.187, 0.9
Succeeding birth interval (months)		0.98	0.01	-1.6	0.102	0.965,1.00

Births in last five years(no birth) 1-2	3.15	2.16	-1.7	0.094	0.822,12.1
>=3	1.10	0.98	-1.8	0.198	0.981,1.987
Age of women at 1st birth(15-19) 20-24	0.24	0.097	-3.5	0.000	0.107,0.528
25-29	0.92	0.70	-0.1	0.922	0.211,4.09
30-34	0.001	0.0004	-0.2	0.99	0
>=35	1.25	0.72	0.4	0.699	0.402, 3.9
Duration of current pregnancy	1.14	0.08	1.88	0.061	0.99,1.31
Menstruated in last six weeks(no) yes	0.36	0.51	-0.7	0.470	0.22, 5.81
Number of living children(no child) 1-2	3.68	0.012	2.13	0.033	3.48,4.98
3-4	3.03	0.06	2.42	0.015	2.48 ,4.05
>=5	2.98	0.21	1.97	0.19	2.01,3.12
At health facility, told of family planning(no) yes	0.63	0.21	-1.4	0.170	0.33,1.22
Number of tetanus injections before birth	0.92	0.08	-0.9	0.368	0.78,1.096
Number of antenatal visits during pregnancy	0.99	0.03	-0.5	0.636	0.928 ,1.05
Place of delivery(home) Government HC	2.62	0.99	2.6	0.011	1.25,5.5
Private HC	1.27	1.29	0.24	0.812	0.17 ,9.3
Parameter estimates	Coefficient	SE	Z	P-vale	Odds ratio
Fixed effect intercept(β_o)	-0.4533	1.968	-0.2	0.018	0.6355
Random effect var(U_j)	0.3750	0.291			
Intercept only model var(region)	0 .573	0.831			

4. Discussion

This current study was assess demographic, socio economic and health service factors affecting anemia status and determines the variation of anemia status between regions in Ethiopia. The women with anemic have differences across geographical regions in Ethiopia as a result of healthcare facility, clean water, age at first birth and terms of economic in the regions. This study is consistent with study done in Ethiopia [22-26]. The prevalence rate of anemia status for women under reproductive age 27.1%, which responsible to exposure of woman at individual and regional levels in Ethiopia. To examine the regional variation of anemic women multilevel logistic regression was employed while adjusting for all covariates in the model, the risk of having anemia was higher for poor women, having number of children 1-2 and 3-4, using home for delivery, giving first birth in the younger age and didn't have access to improved water.

The overall prevalence in this study for the women with anemia was 27.1%. This result is slightly more than the community based cross sectional study conducted in Northeast Ethiopia which is 24.2% [7] and in Jimma 16%[27]. The difference may occur due to the scope of the study area, cultural practice and dietary factors in which our study considered whole Ethiopia whereas cross sectional study is limited to small area. Another studies confirmed with our results had prevalence 28% in East Africa[4], 49.5%-69% in India[5-7], 37.6% in Nepal[8] ,41.3% in Bangladesh[9], 36-40% in some parts of Ethiopia[1], [10]and 40% in Korea[11].

Based on the result of this study, age of woman at 1st birth was found to be a determinant factor of anemia status of women. The likelihood of woman in the age at 1st birth 20- 24 years old were 0.24 times less likely to be anemic as compared to women who had age at 1st birth in younger (15-19) years old. It suggested adolescent females were under higher risk of anemic in Ethiopia.

More study indicated that anemia focused on the adolescents and high fertility age of women under childbearing. The result confirmed with study [2], [28], [29], [30]and [31]. Another important factors associated with anemic women was source of drinking water which have significant effect on women to develop anemia. Women who use improved water source were 1.98 times more likely to develop anemic as compared to those who use unimproved water source. This finding is consistent with the study by[12].

More proportion of anemia cases were observed among women with poorest wealth index. As a result the women who were in the middle and rich were about 25% and 42% times less likely to develop anemia than that of women who were in the poorest wealth quintile respectively. This implies women in the poorest wealth index were 75% and 58% more likely to experienced anemia as compared to women categorized under middle and richest wealth index respectively. This result is linked with the previous study[16] and another studies confirmed were [32-35].

Another important determinant associated with prevalence of anemia in developing country like Ethiopia for women among reproductive age was number of living children. The univariate logistic and multilevel logistic regression analysis of this study showed that number of living children have significant effect to develop anemia for women under reproductive age at 5% level of significance. The odds of women who had 1-2 and 3-4 living children were 3.68 and 3.03 times more likely to develop anemic as compared to women who had no living children respectively. Several studies supported our results in different countries such as study conducted in India which reported that repeated child bearing of women have significant effect to develop anemia for women and having anemic was found to be increased for women with multiple pregnancy [32]. Having more children increased the family size and decreased the birth interval for women in the reproductive age which implies this family share basic resources needs such as food, house and money which in turn exposed to anemia for women under reproductive age. Another's study in-lined with this result were [14] and [36-39].

Place of delivery is important predictor to determine anemia level of women among reproductive age in Ethiopia at 5% level of significance. The odds of multilevel analysis considering regional heterogeneity for women who use government health facility to delivery was 2.62 times more likely to become anemic as compared to women who use home place of delivery. This result is linked with the previous study[14].

5. Conclusions

In the current study wealth index, age of women at 1st birth, number of living children, source of drinking water and place of delivery were associated with prevalence of anemia for women in Ethiopia. Anemia status of women in the reproductive age varies between regions significantly and the inclusion of level of one covariate decreased the regional variations. As a result the decrement of poorest women, having small number of children, Delivered at home and using unimproved water were found to be protective toward prevalence of Anemia which is public health problem. Therefore, it is better to design appropriate interventional strategies and use family planning to reduce reproductive-aged women anemia by considering the geographical characteristics and distribution of women. Health extension and volunteers should give attention to survive adolescents which cover more number of women in reproductive age.

Abbreviation

DHS: Demographic and health survey; SNNPR: Southern Nations Nationality and peoples Region; EDHS: Ethiopia demographic and health survey, CSA; Central Statistical Agency ,EAs;

enumeration areas, O_R; Odd Ratio,X^2;Chisquare,ICC; Intra Class Correlation coefficients, CI; Confidence Interval, AIC; Akaike Information Criteria and BIC; Bayesian Information Criteria

Appendix

STATA 14-codes for data Analysis

tabulate var1 var2 var3 varn

-logit anemia i.var1

-melogit anemia i.var1 var6 i.var3 i.var4 i.var5 i.var7 i.var9 var10 i.var13 i.var14 var16 i.var17 i.var18 i.var22 var23 var24 var26 i.var27 i.var31 || var2:,

-melogit anemia i.var1 i.var3 i.var4 i.var5 var6 i.var7 i.var11 i.var13 i.var14 i.var16 i.var17 i.var18 i.var22 var23 var24 var26 i.var27 || var2: var1 var7 var14

-melogit anemia, || var2:,

-estimates stats

-melogit anemia i.var1 i.var3 i.var4 i.var5 var6 i.var7 var11 i.var13 i.var14 var16 i.var17 i.var18 i.var22 var23 var24 var26 i.var27 || var2:

-melogit anemia,or

Declarations

Ethics approval

All processes performed in this study were in accordance with the ethical standards of the Ethics Committee of the Ethiopia Demography Health Survey.

All the data that used in this study are publicly available. The raw data used in this study can be accessed from the DHS website. Reference number: http://www.dhsmeasures.

Consent to participate

Letter of consent was received from the measure of EDHS International Program ,which authorized the data sets. Informed consent was obtained from all participants included in the study. Reference number: http://www.dhsmeasures.

Consent for publication

Not applicable.

Availability of data and material

The raw data used in this study can be accessed from the DHS website

http://www.dhsmeasures.

Competing interests

The authors declare that they have no competing interests.

Funding

None.

Authors' contributions

All Authors have read and approved the manuscript.

Acknowledgments

Authors are thankful to the measure of DHS and the permission to use this data.

Reference

1. Gebre, A. and A. Mulugeta, *Prevalence of anemia and associated factors among pregnant women in North Western zone of Tigray, Northern Ethiopia: a cross-sectional study.* Journal of nutrition and metabolism, 2015. **2015**.
2. Milman, N., *Anemia—still a major health problem in many parts of the world!* Annals of hematology, 2011. **90**(4): p. 369-377.
3. Organization, W.H., *The global prevalence of anaemia in 2011*. 2015, World Health Organization.
4. Stevens, G.A., et al., *Global, regional, and national trends in haemoglobin concentration and prevalence of total and severe anaemia in children and pregnant and non-pregnant women for 1995–2011: a systematic analysis of population-representative data.* The Lancet Global Health, 2013. **1**(1): p. e16-e25.
5. Lilare, R.R. and D.P. Sahoo, *Prevalence of anemia and its epidemiological correlates among women of reproductive age group in an urban slum of Mumbai.* Int J Community Med Public Health, 2017. **4**: p. 2841-2846.
6. Subhathra, N. and M. Merlin, *A study to assess the prevalence of anemia among women in a selected urban area in Coimbatore district.* Journal of Scientific and Innovative Research, 2017. **6**(1): p. 11-15.
7. Woldu, B., et al., *Prevalence and Associated Factors of Anemia among Reproductive-Aged Women in Sayint Adjibar Town, Northeast Ethiopia: Community-Based Cross-Sectional Study.* Anemia, 2020. **2020**.

8. Karki, K.B., et al., *Anemia and its Determinants among Women of Reproductive Age in Mid-Western Tarai of Nepal 2015*. 2016, Nepal Health Research Council.

9. Kamruzzaman, M., et al., *Differentials in the prevalence of anemia among non-pregnant, ever-married women in Bangladesh: multilevel logistic regression analysis of data from the 2011 Bangladesh Demographic and Health Survey.* BMC women's health, 2015. **15**(1): p. 54.

10. Mihiretie, H., et al., *Magnitude of anemia and associated factors among pregnant women attending antenatal care in Nekemte health center, Nekemte, Ethiopia.* Journal of Medical Microbiology & Diagnosis, 2015. **4**(3): p. 1.

11. Gautam, S., et al., *Determining factors for the prevalence of anemia in women of reproductive age in Nepal: Evidence from recent national survey data.* PloS one, 2019. **14**(6): p. e0218288.

12. Gautam, S., et al., *Determining factors for the prevalence of anemia in women of reproductive age in Nepal: Evidence from recent national survey data.* PloS one, 2019. **14**(6).

13. Guyatt, H.L. and R.W. Snow, *The epidemiology and burden of Plasmodium falciparum-related anemia among pregnant women in sub-Saharan Africa.* The American journal of tropical medicine and hygiene, 2001. **64**(1_suppl): p. 36-44.

14. Akhtar, M. and I. Hassan, *Severe anaemia during late pregnancy.* Case reports in obstetrics and gynecology, 2012. **2012**.

15. Antelman, G., et al., *Nutritional factors and infectious disease contribute to anemia among pregnant women with human immunodeficiency virus in Tanzania.* The Journal of nutrition, 2000. **130**(8): p. 1950-1957.

16. Addis Alene, K. and A. Mohamed Dohe, *Prevalence of anemia and associated factors among pregnant women in an urban area of Eastern Ethiopia.* Anemia, 2014. **2014**.

17. Torabi, H. and N.H. Montazeri, *The logistic-uniform distribution and its applications.* Communications in Statistics-Simulation and Computation, 2014. **43**(10): p. 2551-2569.

18. CSA, I., *Ethiopia demographic and health survey 2011.* Addis Ababa, Ethiopia and Calverton, Maryland, USA: Central Statistical Agency and ICF International, 2012. **430**.

19. Agresti, A., *Categorical data analysis*. Vol. 482. 2003: John Wiley & Sons.

20. Hox, J.J., M. Moerbeek, and R. Van de Schoot, *Multilevel analysis: Techniques and applications*. 2017: Routledge.

21. Snijders, T.A. and R.J. Bosker, *Multilevel analysis: An introduction to basic and advanced multilevel modeling*. 2011: Sage.

22. Hailemariam, A., S. Alayu, and C. Teller, *The National Population Policy (NPP) of Ethiopia: achievements, challenges and lessons learned, 1993–2010*, in *The Demographic Transition and Development in Africa*. 2011, Springer. p. 303-321.

23. Institute, E.P.H., *Ethiopia national food consumption survey*. 2013, Ethiopian Public Health Institute (EPHI) Addis Ababa (Ethiopia).

24. Berhane, G., et al., *Foodgrain consumption and calorie intake patterns in Ethiopia.* IFPRI Ethiopia Strategy Support Program II (ESSP II) Working Paper, 2011. **23**.

25. Assefa, Y., et al., *Rapid scale-up of antiretroviral treatment in Ethiopia: successes and system-wide effects.* PLoS Med, 2009. **6**(4): p. e1000056.

26. Chaya, N., *Poor access to health Services: Ways Ethiopia is overcoming it.* Res Comment, 2007. **2**(2): p. 1-6.

27. Ababa, A., *Central Statistical Agency*. 2011.

28. Sinha, A., G. Singh, and K. Karki Karna, *Prevalence of anemia amongst adolescents in Biratnagar, Morang Dist. Nepal.* International Journal of Pharmaceutical & Biological Archives, 2012. **3**(5): p. 1077-1081.

29. Baral, K. and S. Onta, *Prevalence of anemia amongst adolescents in Nepal: a community based study in rural and urban areas of Morang District.* Nepal Med Coll J, 2009. **11**(3): p. 179-182.

30. Singh, P., et al., *Anemia amongst adolescent girls and boys attending outpatients and inpatient facilities in far western part of Nepal.* Ibnosina Journal of Medicine and Biomedical Sciences, 2013. **5**(6): p. 330-4.

31. Chalise, B., et al., *Prevalence and correlates of anemia among adolescents in Nepal: Findings from a nationally representative cross-sectional survey.* PloS one, 2018. **13**(12): p. e0208878.

32. Balarajan, Y.S., W.W. Fawzi, and S. Subramanian, *Changing patterns of social inequalities in anaemia among women in India: cross-sectional study using nationally representative data.* BMJ open, 2013. **3**(3).

33. Alaofè, H., et al., *Prevalence of anaemia, deficiencies of iron and vitamin A and their determinants in rural women and young children: a cross-sectional study in Kalalé district of northern Benin.* Public health nutrition, 2017. **20**(7): p. 1203-1213.

34. Balarajan, Y., et al., *Anaemia in low-income and middle-income countries.* The lancet, 2011. **378**(9809): p. 2123-2135.

35. Rammohan, A., N. Awofeso, and M.-C. Robitaille, *Addressing female iron-deficiency anaemia in india: is vegetarianism the major obstacle?* ISRN Public Health, 2012. **2012**.

36. Bekele, A., M. Tilahun, and A. Mekuria, *Prevalence of anemia and Its associated factors among pregnant women attending antenatal care in health institutions of Arba Minch town, Gamo Gofa Zone, Ethiopia: A Cross-sectional study.* Anemia, 2016. **2016**.

37. Obse, N., A. Mossie, and T. Gobena, *Magnitude of anemia and associated risk factors among pregnant women attending antenatal care in Shalla Woreda, West Arsi Zone, Oromia Region, Ethiopia.* Ethiopian journal of health sciences, 2013. **23**(2): p. 165-173.

38. Abay, A., et al., *Determinants of prenatal anemia in Ethiopia.* Archives of Public Health, 2017. **75**(1): p. 1-10.

39. Getahun, W., T. Belachew, and A.D. Wolide, *Burden and associated factors of anemia among pregnant women attending antenatal care in southern Ethiopia: cross sectional study.* BMC research notes, 2017. **10**(1): p. 276.

Figures

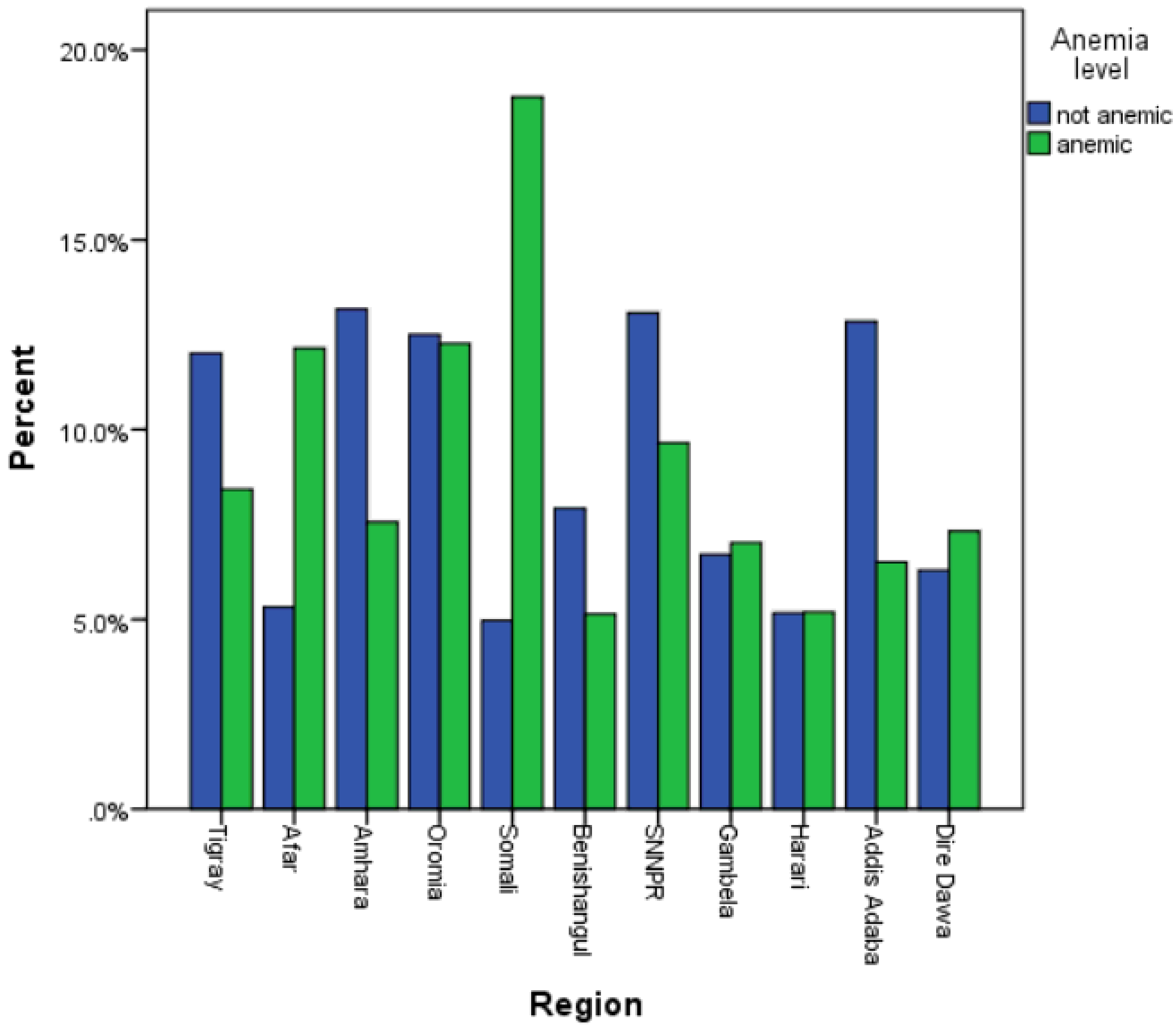

Figure 1

Bar graph for Anemia status of women with in Region