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Predictors of Various Levels of Anemia among Adolescent and Young Women 15 - 24 Years of Age in Ethiopia: Multilevel Ordinal Logistic Regression Modelling

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Abstract

Background: Among young women, anemia has persisted as a public health concern (15 - 24). While women's physiology and life experiences vary across reproductive ages (15 - 49), current anemia studies have concentrated on pregnant women or all women of reproductive age. Some research on young women have also been limited to the country's sub-national areas. This research therefore aims to identify factors for different levels of anemia in young women (15 - 24).

Materials and Methods: Data set from the 2016 Ethiopia Demographic Health Survey (EDHS) was used. The multilevel (three-level) ordinal logistic regression study used a total of 5839 young women who were screened for anemia.

Results: Human Immune Deficiency Virus (HIV), living with 5 or more family members, giving birth once, giving birth more than once, living in rural areas was found to be related to worse anemia. The use of pills, implants or injectables was associated with decreased odds of worse anemia. Nearly one-third (32.30%) of the anemia variability was attributed to the difference in household and community levels.

Conclusion: Anemia among young women in Ethiopia was a moderate public health concern (25.18%). Anemia was significantly associated with HIV status, contraceptive use, living with partner, number of births in the last five years, family size, place of residence, and region.

In the prevalence of anemia among households and clusters, substantial variation was observed.

For HIV-positive women, efforts to prevent and control anemia should be intensified. Interventions for broader spacing of births should also be improved.

Keywords: *Anemia; Young Women; Multilevel Ordinal Logistic Regression; Ethiopia; Demographic And Health Surveys*

Abbreviations

RBC: Red Blood Cells; WRA: Women of Reproductive Age; HIV: Human Immune Deficiency Virus; WHO: World Health Organization; EDHS: Ethiopia Demographic and Health Survey

Introduction

Anemia is characterized as a condition in which the number of red blood cells (RBCs) and their capacity to carry oxygen are not sufficient to meet the physiological needs of the body [1]. Globally anemia affected 32.8% of women of reproductive age (WRA) [2]. Children under five, pregnant women and young women are vulnerable to anemia. Adolescents or young women need higher iron intake because of the rapid growth and loss of menstruation in the body [3].

This raises the risk of anemia during adolescent years with the onset of menstruation and pregnancy [4].

In developing countries, the burden of anemia among young women ranges from 15% to over 50% percent, and in developed countries, 6%. The prevalence of anemia among adolescent females varies from 17% - 90% in South-East Asian nations. Among young women (15 - 24) of Sub-Saharan Africa (SSA) anemia is mild to severe the public health issue with a prevalence of 13.7 - 61.5% [5].

Several measures to prevent and control anemia have been undertaken by the Ethiopian government [6]. Anemia has persisted, however, as a public health issue among young women. Anemia was a moderate public health concern that affected 25.18% of young women, according to the 2016 Ethiopia Demographic and Health Survey [7].

Iron deficiency is the most common cause of anemia [8]. Additional micronutrient deficiencies (e.g. folate, vitamin B12), acute and chronic diseases, and genetic blood disorders are other common causes of anemia [9,10].

Anemia risk factors operate at various levels of the hierarchy, such as individual, household, community and higher levels (district, regional and national level) [11-14].

There is an increased risk of maternal and perinatal mortality and other poor pregnancy outcomes for young women with anemia [9,15]. Anemia also impairs cognitive and motor growth, and decreases the ability to work and productivity [16].

For the initiation of successful intervention to prevent the occurrence of anemia during their reproductive years, the identification of factors associated with anemia among young women is essential.

Although the physiology and life experiences of women differ across reproductive ages (15 - 49), recent anemia studies have concentrated on pregnant women or all women of reproductive age [17-20].

Compared to single-level logistic regression, a multilevel ordinal logistic regression technique generates more precise estimates of parameters. It also quantifies the proportion of household and population clusters from the overall variation on anemia [21].

Therefore, this research is aimed to use multilevel ordinal logistic regression to determine multilevel anemia factors among young women [15-24].

Materials and Methods

Data source

Data set from the 2016 Ethiopia Demographic Health Survey (EDHS) was used. The EDHS 2016 is the fourth nationally representative survey conducted to make use of timely and accurate health and demographic data [7]. Permission to use the data was obtained from the Inner City Fund (ICF) International.

Study design and sample size

In order to collect the 2016 EDHS data, a population-based cross-sectional survey was conducted. Enumeration Areas (EAs) and households were selected via a two-stage stratified sampling process. In the first step, 645 EAs (202 in urban and 443 in rural) were selected with probability proportional to EA size. In the second level, a systematic sampling technique was used to pick 18,008 HHs, with an average of 28 HH per EA. All WRAs in the chosen HH were eligible for testing for anemia. In this study, all young women [15-24] who had anemia status data were included. The study included a total of 5839 young women who were screened for anemia [7].

Study variables

Anemia was classified as no, mild, moderate, and severe anemia, based on Hb level. Hemoglobin analysis was conducted using the HemoCue analyzer, taking blood samples from a finger prick of freely consented women [7]. It has been adjusted for pregnancy, altitude and smoking [22]. The WHO Hb cut off points for diagnosis of anemia are given as below (Table 1) [23].

Anemia status	Hb cutoffs for Pregnant women (g/dl)	Hb cutoffs for Non-pregnant women (g/dl)
None	> 11	> 12
Mild	10.0 - 10.9	10.0 - 11.9
Moderate	7.0 - 9.9	7.0 - 9.9
Severe	< 7.0	< 7.0

Table 1: *The WHO Hb cut off points for diagnosis of anemia among women.*

Independent variables

Variables considered to be associated with anemia were retrieved from the data set after examining the literature. Due to the hierarchical nature of the 216 EDHS data, the extracted variables were classified as individual, household, and community-level variables. Characteristics of the women that were unique to each woman were individual-level variables. Household-level variables are household-level characteristics that are general and involve all females living in the same household.

Community variables are characteristics common to all women living in the same community (cluster). By aggregating individual characteristics within the cluster, variables such as community women's education, community poverty, community women's unemployment, and community mass media exposure were created. Based on the national median values of the generated variables, the generated variables were further classified as low or high.

Methods of data analysis

Multilevel ordinal logistic regression analysis

Data were analyzed using stata version 15. For describing categorical variables, frequencies with percentages were used. To summarize quantitative variables, the mean with standard deviation and median with interquartile range were used. Multilevel (three-level) ordinal logistic regression was used to identify factors associated with anemia due to the hierarchical nature of the 2016 EDHS data. To consider candidate variables for multivariate analysis, a P-value 0.25 in the bivariate analysis was used [24]. A p-value < 0.05 was used in a multivariable analysis to distinguish variables significantly associated with anemia [25]. Variance partition coefficients were used to calculate the proportion of variations in the chances of anemia between households and communities (VPC). The VPC calculates the proportion of variance in outcome (anemia) unexplained by the predictor variables that lie at each hierarchy level of the model. It calculates the relative significance of clusters, households, and individuals (women) as sources of variation for anemia status [26]. Sampling weight was incorporated in the analysis.

Model specification

Five random intercept models were fitted:

- **Model 1 (null model)**: It is the intercept only model without an independent variable.
- **Model 2:** This model was adjusted for individual-level variables.
- **Model 3:** This model was adjusted for household-level variables.
- **Model 4:** This model was adjusted for community-level variables.
- **Model 5:** Adjusted for all predictor variables that were statistically significant (p-value<0.05) in models 2 3 and 4, this is the final model. It provided variances of household and cluster random effects after controlling for the effects of individual, household, and community-level variables.

In terms of the cumulative logs, the mixed-effects ordinal logistic regression (proportional odds) model can be written as:

Log=$_{\gamma}$c_($x_{ijk}\boldsymbol{\beta}+\mathbf{u}_{ij}+u_i$)................................[25].

P_{ijkc}- Is a cumulative probability of being at the "c" category of anemia for a kth individual in the jth household and ith cluster.

$_{\gamma}$c- Is a model threshold or intercept for the C-1 level of anemia and it is a fixed parameter.

It represents the cumulative logits of being at or below the C-1 level of anemia when the covariates and random effects equal to zero. It is strictly increasing (i.e. $\boldsymbol{\gamma}1 < \gamma2 < \cdots < \gamma C-1$).

C= Number of categories of anemia which equals 4.

β- Is a coefficient (fixed effect of explanatory variable).

X_{ijk}- Is a covariate vector for the kth individual in the jth household and ith cluster.

Uij- Is level-2 (household) random effect and it is assumed to be normally distributed with variance $\sigma^2_{(v2)}$.

u_i- Is level-3 (cluster) random effect and it is assumed to be normally distributed with variance $\sigma^2_{(v3)}$.

Random effects

In terms of VPC, the variance of both household and cluster random effects was expressed.

VPC (3) is the proportion of overall anemia variance due to the random effect of clusters.

It is given as: $VPC_{(3)=}$ where $\pi^2/3$ is individual-level variance which equals 3.29.

σ2 (v3) - Is the random effect variance of a cluster (level-3).

σ2 (v2)- Is the random effect variance of the household (level-2).

VPC for level-2 and 3 clustering effects ($VPC_{(2+3)}$) is a proportion of total variation on anemia attributable to both household and cluster-level random effects. It is given as:

$VPC_{(2+3)=}$.

$VPC_{(2)}$ is a proportion of total variation on anemia attributable to household level random effect.

It is given as: $VPC_{(2)=}$ ……………………………[26].

Model selection: An Akaike information criterion (AIC) was used to select the best model for the data. The model with the lowest AIC(Model5) was considered as the best model that fits the data [27].

Proportional odds assumption

The proportional odds assumption states that the effects of all covariates are constant across categories of the outcome variable. After fitting both proportional and non-proportional odds models, the proportional odds assumption was evaluated using the likelihood ratio test (Bauer and Sterba, 2011). The likelihood ratio test supported the proportional odds assumption.

Results

Characteristics of the study participants are shown in table 2. The mean ± standard deviation (SD) age was 19.13 ± 2.79 years for the respondents. About half (49.29%) of the women attended primary school and more than a quarter (28.84%) attended secondary school and above.

A majority (93.37%) of the women were non-pregnant. More than three-fourth (85.19%) of the respondents were not current contraceptive users. The prevalence of HIV/AIDS was 0.54% [29]. More than half (53.96%) of the women had a family size greater than or equal to five. Around a quarter (24.68%) of women come from the poorest households and 64.60% live in rural areas (Table 2).

Variables	Frequency (n)	Percentage (%)
Age		
15 - 19	3,172	54.32
20 - 24	2,667	45.68
Women education		
No	1,277	21.87
Primary	2,878	49.29
Secondary and above	1,684	28.84
Marital status		
Living with husband	2,294	39.29

Not living with husband	3,545	60.71
Mass media exposure		
No	3,790	64.91
Yes	2,049	35.09
Alcohol consumption		
None	4,127	70.68
< Once/ week	1,145	19.61
At least once/week	489	8.37
>Once/week	78	1.34
Chewing khat		
No	5,562	95.26
Yes	277	4.74
Smoking		
No	5,803	99.38
Yes	36	0.62
Pregnancy		
Not-pregnant	5,452	93.37
Pregnant	387	6.63
Contraceptive use		
None	4,974	85.19
Pill/injectable/implants	810	13.87
IUD	26	0.45
Non-hormonal	29	0.50
Births in last 5 years		
No	4,089	70.03
One child	1,169	20.02
> One child	581	9.95
History of Abortion		
No	5,716	97.89
Yes	123	2.11
Use of deworming drug		
No	5,739	98.29
Yes	100	1.71
Iron supplementation		
No	4,971	85.13
Yes	868	14.87
HIV status (n = 14,465)		
Negative	5,810	99.50
Positive	29	0.50

Wealth index	`	
Poorest	1,441	24.68
Poorer	968	16.58
Middle	1,084	18.56
Rich	1,037	17.76
Richest	1,309	22.42
Family size		
<= 2	764	13.08
3 - 4	1,924	32.95
>= 5	3,151	53.96
Cooking fuel		
Solid	5,110	87.51
Clean	729	12.49
Toilet facility		
Improved	1,824	31.24
Unimproved	4,015	68.76
Place of residence		
Rural	3,772	64.60
Urban	2,067	35.40
Community-women education		
Low	2,348	40.21
High	3,491	59.79
Community mass media exposure		
Low	2,385	40.85
High	3,454	59.15
Community poverty		
High	3,152	53.98
Low	2,687	46.02
Community unemployment		
High	2,925	50.09
Low	2,914	49.91

***Table 2**: Characteristics of the young women in Ethiopia, 2020: Data from 2016 EDHS, (n = 5839).*
IUD=Intrauterine Device, other =Catholic, traditional or other religion.

Prevalence of anemia

The median hemoglobin concentration was 13g/dl (IQR: 11.80 - 14.00). The prevalence of anemia was 25.18% (1470) (Figure 1).

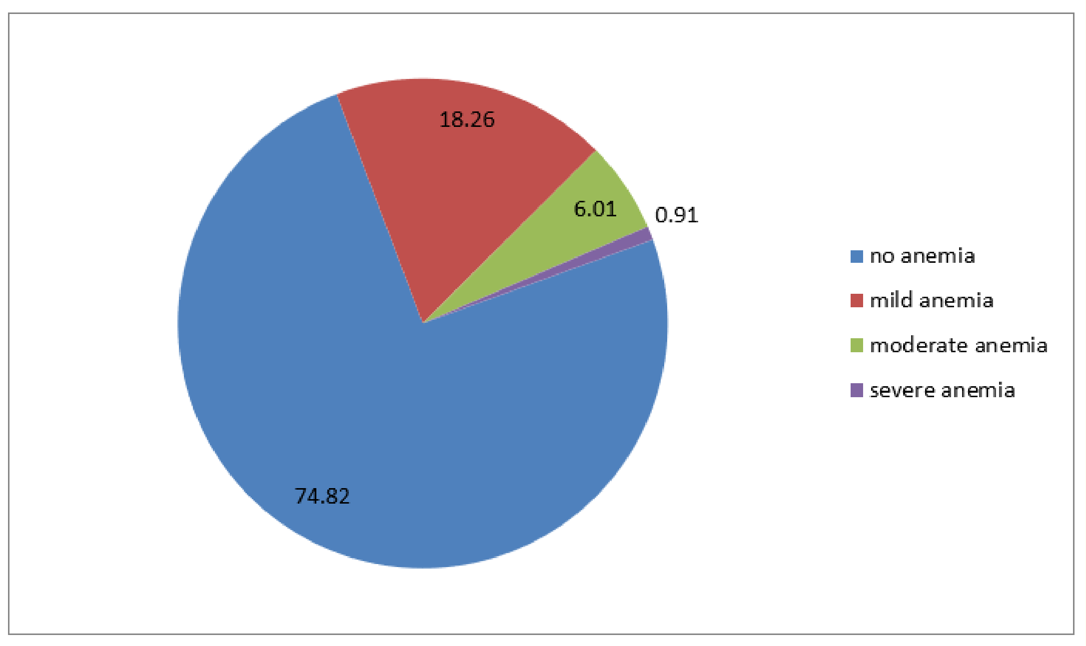

Figure 1: *Prevalence of anemia among young women (15 - 24) in Ethiopia, 2021: Data from 2016 EDHS, (n = 5839).*

Multivariable multilevel ordinal logistic regression result

Random effects

There were five random intercept models fitted with (models 1, 2, 3, 4 and 5).

Model 1 (Null model): This model showed that (32.30%) of the overall anemia variance was attributable to unnoticed influences at the level of the household and community. Around a quarter (VPC3 = 25.01%) and 7.00% (VPC2) of the difference is due to non-observed variables at the community and household level, respectively.

Model 5 (final model): Adjusted for individual, household, and community-level factors together).

This model showed that 20.14% (VPC2+3), 8.73% (VPC3) and 11.40% (VPC2) of the unexplained variance in anemia could be due to non-observed factors of the community and household level together, factors of the community level alone and factors of the household level alone, respectively (Table 3).

Random effects	Model 1	Model 5
σ2(v3)	1.23	0.36
σ2 (v2)	0.34	0.47
VPC 2+3(%)	32.30	20.14
VPC 3(%)	25.01	8.73
VPC 2 (%)	7.00	11.40

Table 3: *Random intercept variances of three-level mixed effect models.*
Note. $\sigma^2_{(v3)}$ and σ^2 ($_{v2}$) are community and household random intercept variances, respectively.
VPC $_{(3)}$ =Variance partition coefficient for a cluster, VPC $_{(2+3) =}$ Variance partition coefficient for household and cluster,
VPC $_{(2)}$ = Variance partition coefficient for a household.
Model1: the model with no independent variable; Model 5: model adjusted for individual, household, and community-level variables simultaneously.
Hint: models 2, 3, and 4 are not presented here.

Model 5 was found to be the best fit model for the data (Table 4).

Models	1	2	3	4	5
AIC	6097.554	5943.257	5939.761	5886.206	5851.785

Table 4: *Akaike information criterion (AIC) of three-level mixed effect models.*

Factors associated with anemia

Factors associated to anemia in women are presented in table 5. In contrast with non-users of contraception, women actively using pills, implants, or injectables had a 56%e lower risk of being at higher levels of anemia. Human immune deficiency virus-positive women were 30.21 times more likely than HIV-negative women to be at higher levels anemia. Women who gave birth to one and more than one child were 1.91 and 1.35 times more likely than women without birth to be at higher anemia levels, respectively. Compared to those women not living with husbands, women living with husbands were 2.2 times more likely to have higher levels of anemia. Compared to women living with two or less family members, women living with five or more family members were 1.93 times more likely to have higher levels of anemia. Rural women were 2.12 times more likely than urban women to have higher levels of anemia. Compared to women living in the Tigray region, women living in the Afar, Somali, Gambela, and Harari regions and Dire Dawa city were 2.57, 5.6, 3.95, 4.32, and 2.06 times more likely to be at higher anemia levels, respectively (Table 5).

Variables	AOR [95%CI]
Women education	
No	1
Primary	1.05 [0.65, 1.70]
Secondary and above	0.64 [0.34, 1.20]
Contraceptive use	
None	1
Pill/ injectable/implants	0.44 [0.26, 0.76]***
IUD	1.83 [0.29, 11.45]
Non-hormonal	0.27 [0.03, 2.10]
Pregnancy	
Non- pregnant	1
Pregnant	1.91 [0.93, 3.92]
Iron supplementation	
No	1
Yes	0.49 [0.26,0.93]
Khat chewing	
No	1
Yes	0.55 [0.26, 1.19]
HIV status	
Negative	1
Positive	30.21 [25.50, 34.23]*
Births in 5 years	

No	1
One child	1.91 [1.02, 3.60]*
> One child	1.35 [1.01, 3.79]*
Marital status	
Living with husband	2.20 [1.22, 3.95]*
Not living with husband	1
Family size	
<=2	1
3-4	1.58 [0.89, 2.79]
>=5	1.93 [1.12, 3.34]*
Water source	
Un-improved	1
Improved	0.85 [0.55, 1.30]
Wealth index	
Poorest	1
Poorer	0.78 [0.48, 1.26]
Middle	0.73 [0.43, 1.25]
Rich	0.64 [0.36, 1.15]
Richest	0.68 [0.38, 1.19]
Place of residence	
Rural	2.12 [1.25, 3.57]**
Urban	1
Region	
Tigray	1
Afar	2.57 [1.58, 3.17] ***
Amhara	0.47 [0.24, 0.92]*
Oromia	1.71 [0.83, 3.52]
Somalia	5.60 [4.24, 6.90]***,
Benishangul gumuz	0.83 [0.37, 1.86]
SNNP	0.87 [.45, 1.68]
Gambela	3.95 [1.34, 11.64]*
Harari	4.32 [1.55,12.03]*
Addis Ababa	1.84 [0.85, 3.97]
Dire Dawa	2. 06 [1.27, 3.33]**

Table 5: *Factors associated with anemia among women of reproductive age in Ethiopia, 2021: Data from 2016 EDHS (n=5839) - proportional odds model (model 5).*

**p-value<0.05; **p-value<0.01; ***p-value<0.001; 1= Reference category; IUD=intrauterine device; AOR=adjusted odds ratio, CI=confidence interval.*

Hint: table 5 is the result of best fit model (Model 5).

Discussion

The study found that anemia was related to variables at the levels of individual, household and community (cluster) levels. The risk of anemia across households and clusters has greatly varied. Anemia has been significantly related with the use of pills, implants, or injectables. Similar result was found in Bangladesh [13] and Ethiopia [20,28]. This may be due to the iron content of the pills and prevention of heavy menstrual bleeding among contraceptive users [29].

In the last five years before the study, women with one or more births were more likely to have higher levels of anemia relative to women with no births in the last five years. This finding is in line with the findings in India [30] and Ethiopia [31]. The observed association may be explained by the narrow birth interval that hinders the restoration of iron and other micronutrient stores between pregnancies. In addition, with the number of births, the risk of complications such as antepartum and postpartum bleeding may increase [9,18,32].

Women living with five or more members of their family were more likely to have higher anemia levels than women living with two or fewer members of their family. The findings in Ethiopia support this finding [31,33].

The insecurity of household food in a large family could compromise women's access to a balanced diet. Compared to HIV-negative women, HIV-positive women were more likely to have higher anemia levels. A consistent finding has been observed in Ethiopia [34,35]. The association observed could be explained by decreased and ineffective RBC production, and increased RBC destruction in HIV-positive women [36].

It was more likely that women living in rural areas had higher levels of anemia than urban women. This is consistent with findings in Ethiopian studies [18,19,34]. The risk of anemia could be increased by poor health-seeking behavior and low service utilization among rural women [37,38].

Compared to women living in the Tigray region, women living in the Somali, Afar, Gambela, and Harari regions and Dire Dawa city were more likely to have higher levels of anemia. This is in line with the results from studies in China [39], Tanzania [12] and Ethiopia [17]. The discrepancies observed in the odds of anemia may be explained by gaps in health care coverage between regions, differences in disease distribution and environment conditions. In Afar and Somali, the lowest use of maternal health services and chronic drought-induced food insecurity may have led to the higher prevalence of anemia in these areas [6,38].

Despite the current initiatives, anemia has persisted as a major public health concern among young women. This indicates the relevance of variables other than those covered by conventional approaches. It seems vital to devote more time and effort to determine the etiology of anemia.

In order to establish context-specific prevention and control strategies, it will be necessary to consider the causal indicators of anemia in the population-based survey. There are challenges to anemia prevention initiatives that involve inadequate attendance at antenatal clinics, or insufficient focus on behavioral aspects of taking supplements on a daily basis and eating different diets that have reduced their efficacy. Revising the existing strategies will be a significant step in presenting proof of challenges and improving performance.

Conclusion

Among young Ethiopian women, anemia was a moderate public health concern (25.18%). Anemia was significantly associated with HIV status, contraceptive use, partner living, number of births in the last five years, family size, place of residence, and region. In the likelihood of anemia among households and clusters, substantial variation was observed.

For HIV-positive women, intervention to reduce and control anemia should be strengthened. Interventions for broader spacing of births should also be enhanced.

Authors Contribution

All authors made substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; agreed to submit to the current journal; gave final approval of the version to be published; and agree to be accountable for all aspects of the work.

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Conflict of Interest

Authors have no conflict of interest.

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