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Original Article

Determinants of Anemia Status Among Reproductive Age Women During Pregnancy In Ethiopia: Cross-Sectional Study Design

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ABSTRACT

Introduction: Anemia is a major public health problem, affecting more than 56 million women worldwide. During pregnancy, hemoglobin concentrations in venous blood below 11 grams per deciliter have significant adverse effects on the health of pregnant women. The main purpose of this study was to investigate the anemia status of the participants and the factors that lead to anemia.

Methods: Data for this study were obtained from the 2016 Ethiopian Demographic Health Survey (January 18, 2016, to June 27, 2016). A total of 1053 pregnant women were included in the analysis. The risk factors for anemia status were analyzed using a partial-proportional odds model.

Results: The study included 1053 pregnant women, with 32, 214, and 395 suffering from severe, moderate, and mild anemia, respectively. Somalia had the highest proportion of severely anemic people, while Tigray had the lowest. The effect changing in different regions of the sample had various effects on the outcome variable. For example, in the Somali region, the probability of subjects with severe anemia increased by 0.027 (AMPE= 0.027, P = 0.015) percentage points when compared to their counterparts. The effect of changing iron-taking status by one percent on average across the sample decreased by 1.6% (AMPE = -0.016, P= 0.001), 3.7% (AMPE = -0.037, P = 0.001), and 3% (AMPE = -0.030, P = 0.003) points, respectively, for participants in the severe, moderate, and mild classes. The effect of changing place of residence and parity decreased for those in the non-anemic group, but it increased for the wealth index (richest household). Anemia decreased with higher education level [primary: (AMPE = 0.032, P = 0.002), secondary: (AMPE = 0.069, P = 0.025), higher: (AMPE = 0.176, P = 0.000)].

Conclusion: Finally, the authors concluded that iron intake, educational status, wealth index (richest households), place of residence, parity, and selected regions have been identified as prognostic factors for anemia status in pregnant women aged 15 to 49 years. Therefore, action on these predictors is needed to improve anemia among pregnant women in Ethiopia. Furthermore, AMPE should be used with greater motivation to interpret the logistic regression results.

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Introduction

A woman's pregnancy is one of the most important and unique times in her life. It is the most exciting time of anticipation and fulfillment; however, it is a stressful condition due to the numerous anabolic activities that occur during this time, and fetal growth occurs in conjunction with many changes in maternal body composition and metabolism.[1] Anemia is associated with poor nutrition during pregnancy.[2]

Anemia is a significant public health issue that affected 1.62 billion people worldwide, with 56 million anemia cases discovered in pregnant women.[3, 4] Anemia is estimated to affect 43% of people in developing countries and 9% of people in developed countries.[5] According to a previous study, 35% to 75% (56% on average) of pregnant women in developing countries and 18% in industrialized countries are anemic. It accounts for approximately 20% of all maternal deaths worldwide.[6] In Ethiopia, this is also a major public health issue. According to a 2012 Central Statistical Agency report, 17% of women aged 15-49 are anemic, with 13% having mild anemia, 3% having moderate anemia, and less than 1% having moderate anemia.[7]

In pregnancy, Anemia is hemoglobin concentration of less than eleven grams per deciliter in venous blood and has significant adverse health consequences, on pregnant women.[8] Anemia can be labeled by hemoglobin cut off significance adjusted to sea level altitude on the origins of gestational age and its degree of Severity were determined according to world health organization standard. Anemia status determined based on hemoglobin value both at first and third trimesters.[9, 10] Women with hemoglobin value in the range of 10 and 11 grams per deciliter at first and third trimesters and 10 g/dl ≤ Hb < 10.5 g/dl at second trimester were classified as mild anemic meanwhile pregnant of Hb value between Seven gram/decileter ≤ Hb < ten gram per decileter and Hb < Seven gram per deciliter categorized under moderate and severe consequently irrespective to their gestational age.[11]

The major causes of it at the time of pregnancy are chronic disease, Nutritional (iron, folate, and vitamin B12 deficiencies), Acute or chronic blood loss like heavy bleeding during menstruation, and parasitic infection like malaria and HIV.[12] Anemia throughout pregnancy had a negative impact on birth outcomes and increased maternal and perinatal mortality rates. Fatigue decreased work abilities, and impaired quality of life are all negative health issues for mothers.[13] Anemia in pregnant women may be linked to iron deficiency adversely affecting reasoning and motor development, causing tiredness and low productivity and, when it occurs in pregnancy, may be related to decreased birth weight and maximized the possibility of Mother and parental deaths. It greatly contributes to 20–40% of maternal deaths.[14]

Several previous studies have been conducted on anemia during pregnancy. For example, Kassa et al. conducted a systematic review and meta-analysis of the prevalence and determinants of anemia in Ethiopian pregnant women and found that the prevalence of anemia was 31.66%.[15] Correspondingly, an Indian study found that 84.9% of pregnant women were anemic, with 13.1% having severe anemia and 60.1% having moderate anemia.[4] Furthermore, the Kolar district

study found that anemia was one of the most common pregnancy-related complications (62.3%).[16] Furthermore, a study conducted in Tigray Ethiopia revealed that the overall prevalence of anemia among pregnant women was 36.1%. It was also noted that rural residence, lack of education/literacy, and lack of iron supplementation during pregnancy have been identified as significant factors.[17] Despite various studies on the determinants of anemia in pregnant women, Ethiopia lacks sufficient reliable evidence. Therefore, the current study used a cross-sectional design to determine anemia status during pregnancy in Ethiopian women of reproductive age. Furthermore, for the data, the authors used the average marginal probability effect.

Materials and Methods

Description of the study area and Data source

Ethiopia is Africa's tenth largest sovereign nation, encompassing 1,104,300 square kilometers (with one-million square kilometer land area and 104,300 square kilometer water). It is bounded on the northeast, east, south, west, and southwest by Eritrea, Djibouti, Somalia, Kenya, and Sudan. Ethiopia is divided officially into 9 Geographic States (Tigray, Afar, Amhara, Benishangul-Gumuz, Gambella, Harari, Oromia, Somalia, and the Southern Nation Nationalities and Peoples Region (SNNPR)) and administrative cities (Dire Dawa and Addis Abeba).[18] The data used in this study is secondary data, obtained from a cross-sectional study conducted to assess determinants that associated with anemia status among pregnant women enrolled in Ethiopia demographic and health survey 2016 during the census from January 18, 2016 to June 27, 2016 by central statistical agency(CSA). The data contains valuable information about demographic and health aspects that have changed over time, such as family planning behavior, child mortality, nutritional status of children, anemia, and others.[19]

Study population

The population is composed of all pregnant mothers in reproductive age, 15-49, and those dwells in Ethiopia using the 2016 EDHS data set. According to EDHS 2016, 15,683 women selected as sample. Out of these, 1,122 were pregnant. A total of 1,053 out of 1,122 pregnant women at reproductive age were effectively completed interview making response rate of 94 percent. From these, 1,053 pregnant women included in this study, 37.52 percent were with any anemic status.

Study Design

In this study, the author employed cross-sectional survey design implemented in EDHS 2016 by Central statistical association (CSA). This Design based on the total population to get representative sample.

Sampling technique

In the 2016 EDHS, two stages of stratified cluster sampling were used. Ethiopia's regions were divided into urban and rural areas, yielding a total of twenty-one strata. In each stratum, a two-stage randomly selected enumeration area was used. During first phase,

six hundred forty-five enumeration areas were chosen with a probability proportional to EA size and with independent choice for every sampling stratum. There were 202 urban areas and 443 rural areas among the enumeration areas. The second stage involved selecting a fixed number of twenty-eight households per cluster using an equal probability systematic selection from the freshly formed household listing. Then, Anemia testing was conducted based on agreeing women 15-49 whose parent agreed to the testing.

Data analysis

Data was processed, cleaned, and analyzed utilizing statistical software (SPSS version 20, R version 3.2, and STATA). The results of the study were presented using both descriptive (frequency table) and inferential (PPOM) statistics. The relationship and strength between the anemia status and predictor variables were assessed in terms of PPOM at a 95% confidence interval. The STATA user written command GOLOGIT2 with AUTOFIT option was fitted the partial proportional odds model, and the margins package was used in R-Software.

Outcome variable in the study

The response variable in this study, which is pregnant women's anemia status, can be classified into four ordinal categories. These are as follows:

$$Y_i = \begin{cases} 1, \textit{if the pregnant women severe anemic} \\ 2, \textit{if the pregnant women moderate anemic} \\ 3, \textit{if the pregnant women mild anemic} \\ 4, \textit{if the pregnant women not anemic} \end{cases}$$

Partial proportional odds model (PPOM) Approach

The PPOM is an extension of the proportional odds model proposed by Peterson and Harrel.[20] In this study, the coefficients are associated with each category of the response variable. The study employed a type of ordinal logistic regression to determine whether the parallel line test assumption was met or not.
The model has the form:

$$\lambda_i = \alpha_i + \{(\beta_1 + \gamma_{i1})X_1 + \cdots + (\beta_q + \gamma_{iq})X_q + (\beta_{q+1}X_{q+1}) + \cdots (\beta_p X_q)\}, i = 1, \ldots, k-1 \ldots. \quad (1)$$

It is reasonable to anticipate a linear relationship between each OR of the specific cut-off points and the response variable. If this is the case, a set of constraints γ_{kl} may be added to the model to clarify the linearity. The model is evolving.

$$\lambda_i = ln\left\{\frac{pr(Y=1/X)+\cdots+pr(Y=i/X)}{p(Y=i+1/X)+\cdots+pr(Y=k/X)}\right\} = ln\left\{\frac{\sum_1^i pr(Y=i/X)}{\sum_{i+1}^k pr(Y=i/X)}\right\} \ldots\ldots\ldots\ldots (2)$$

Parameter estimation Method

The maximum likelihood method of parameter estimation is used in this study, resulting in the values of the uncertain parameters that better suited the predicted and observed probability values. Therefore, it usually used a very effective and well known Fisher scoring algorithm to obtain ML estimates.[21] Therefore, using a probabilistic model for an ordinal response allows parameters to be explained in terms of marginal probability

effects. We were primarily interested in the effect of changing the explanatory variables on the likelihood of severe, moderate, mild or no anemia in this article.

Results and Discussions

The Ethiopian demography and health survey, 2016 data set used in this study was collected from pregnant women of reproductive age. This study included a total of 1053 participants. 32 (3.04%) were severely anemic, 182 (17.28%) were moderately anemic, and 181 (17.19%) were mildly anemic, while 658 (62.49%) were non-anemic (Figure 1). Somalia had the highest proportion of pregnant women of reproductive age (15-49) with severe anemia (10.98%), followed by Dire Dawa (4.08%), Afar (3.51%), and Oromia (3.40 percent). Tigray had the lowest proportion of pregnant women with severe anemia in Ethiopia, followed by Amhara, SNNPR, Gambela, and Addis Ababa (Figure 2). The proportions of pregnant women with moderate anemic status in Addis Ababa, Amhara, Tigray, Somalia, Afar, Dire Dawa, and Harari were 0.00 percent, 4.9 percent, 7.59 percent, 38.73 percent, 26.32 percent, 22.45 percent, and 20.55 percent, respectively. According to EDHS data from 2016, the Harari Region had the highest moderate anemia status among pregnant women. In comparison to other regions, Harari (26.03 percent) had the highest percentage of pregnant women with mild anemia in the age range 15-49, followed by Afar (24.56 percent) and Addis Ababa (20.00 percent). The proportion of pregnant women with non-anemic status appears to be highest in Amhara (84.31 percent), Addis Ababa (80.00 percent) (Figure 2).

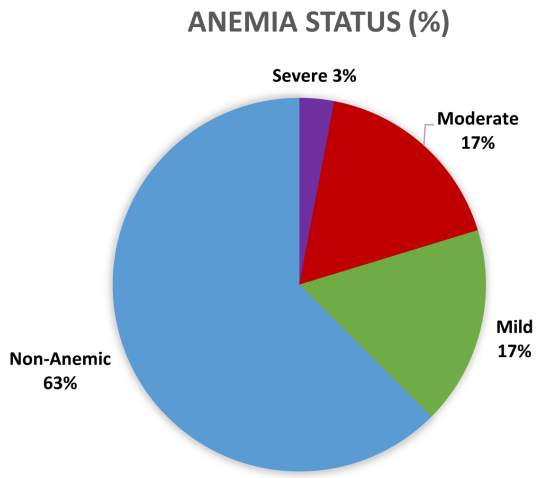

Figure 1. Anemia status of pregnant woman in Ethiopia based on EDHS, 2016

The AMPEs for each Anemia status of pregnant women are shown in Table 1. According to these results, the AMPE of pregnant women in the Somali region who are in the category of severe anemic status increased by 0.027 percentage points. Similarly, the probability of Dire Dawa and Somali pregnant women being in moderate anemia increased by 0.314 (AMPE = 0.314, P = 0.027) and 0.201 (AMPE = 0.201, P = 0.016) percentage points, respectively. Compared to pregnant women in other areas, pregnant women in these two regions were more likely to have a low probability of being anemic. The findings in the table show that the average marginal effects of iron taking status vary depending on anemia status. From this table, it is clear that there are significant status differences in iron uptake among different groups of people, and predicted that pregnant women taking iron pills were less anemic than their counter parts. For example, the effect of taking iron supplements at a severe anemic (AMPE = -0.016; P = 0.001) is much smaller than the effect of taking iron pills at a moderate anemic

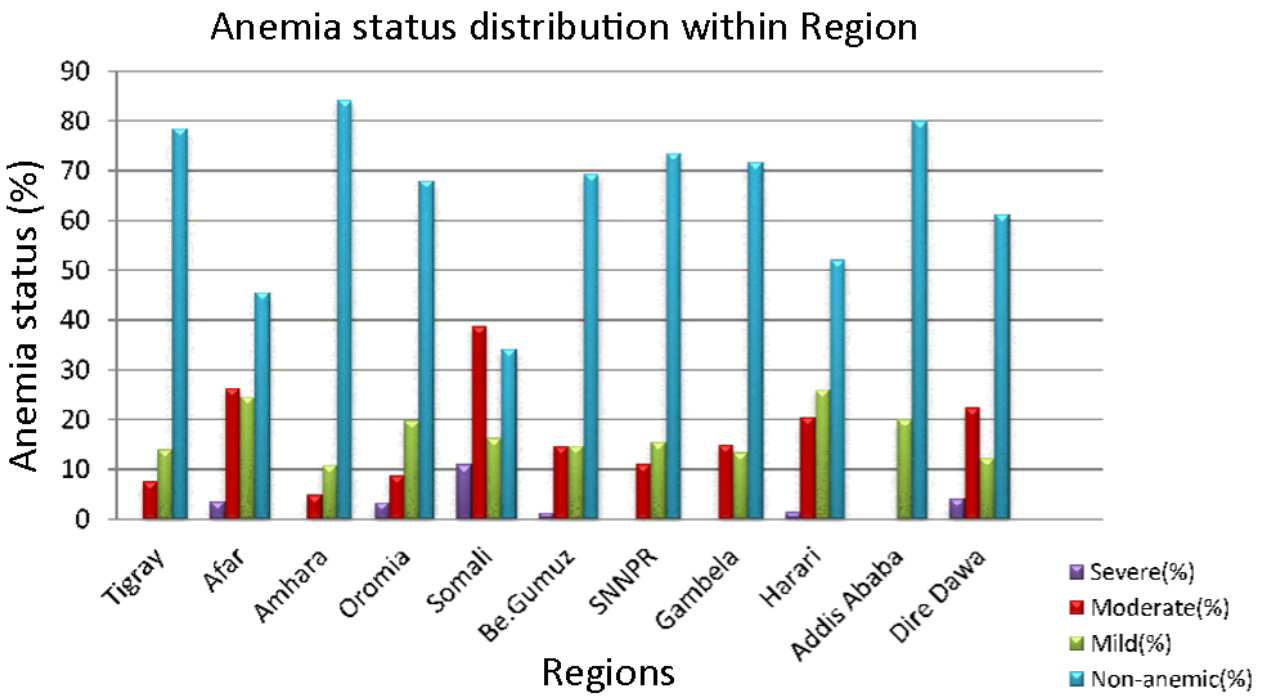

Figure 2. Anemia status distribution among pregnant women with the region of Ethiopia, EDHS 2016

(AMPE = -0.037; P = 0.001). The effect on iron pills use for pregnant women in the severe, moderate, and mild anemic category changed by 1.6%, 3.7%, and 3% respectively, if we increased the average iron pill taking by 0.01. Also, the impact of changing iron intake status by an average of 1 percent across the entire sample for those in the non-anemic class is increased by 0.093 (AMPE = 0.093, P = 0.002) (Table 1). Depending on educational status, the probability that pregnant women who completed secondary and higher levels of education would be in the moderate anemic status category was reduced by 0.209 (AMPE = -0.209, P = 0.000) and 0.200 (AMPE = -0.200, P = 0.000) percentage points for a unit increase education levels. But, the marginal probability effect of non-anemic status of pregnant mothers who completed primary, secondary, and higher education was increased by 3.2%, 6.9%, and 17.6% respectively, if we increase pregnant women education levels by one unit (Table 1). Similarly, the AMPE for pregnant women with severe and mild anemia was 4.2% (AMPE = 0.042, P = 0.003), and 7% (AMPE = 0.070, P = 0.001). This study found that for subjects in either severe or mild anemia, a one percent change in residence from rural to urban areas increased their average anemia by 0.042 and 0.07, respectively. The probability of pregnant women surviving in the richest household being in moderate anemic condition decreased by 0.036 (AMPE = -0.036, P = 0.035), and for those of non-anemic condition increased by 0.069 (AMPE = 0.069, P = 0.031). These results show that the probability of pregnant women from the richest household decreased by 3.6% to be

in the category of moderate anemic level and increased by 6.9% to be in non-anemic as compared with pregnant women from the poorest household. Similar interpretation for the rest AMPEs value (Table 1).

Table 1. Average marginal probability effect (AMPE) of anemia Status of pregnant women

Covariates (Ref)	Severe anemic		Moderate		Mild anemic		Non-anemic	
	AMPE	P-V	AMPE	P-V	AMPE	P-V	AMPE	P-V
Region (Tigray)								
Afar	0.043	0.028	0.046	0.000	0.024	0.013	-0.146	0.043
Amhara	-0.007	0.324	-0.015	0.633	-0.002	0.623	0.027	0.634
Oromia	0.023	0.066	-0.046	0.205	0.030	0.401	-0.004	0.747
Somali	0.027	0.015	0.201	0.016	0.021	0.001	-0.270	0.017
Benishangul	0.001	0.568	0.032	0.527	0.004	0.710	-0.031	0.861
SNNPE	-0.008	0.511	-0.031	0.371	-0.015	0.533	0.047	0.568
Gambela	0.016	0.396	0.038	0.521	0.008	0.392	-0.039	0.635
Harari	0.201	0.239	0.057	0.234	-0.077	0.196	-0.077	0.281
Addis Ababa	0.021	0.286	0.058	0.349	0.006	0.277	-0.058	0.350
Dire Dawa	0.026	0.029	0.314	0.027	0.015	0.012	-0.170	0.009
Educational Level (No education)								
Primary	0.007	0.685	0.021	0.564	-0.025	0.000	0.032	0.002
Secondary	-0.011	0.000	-0.209	0.000	-0.063	0.016	0.069	0.025
Higher	-0.017	0.000	-0.200	0.000	-0.017	0.031	0.176	0.000
Iron (No)								
Yes	-0.016	0.001	-0.037	0.001	-0.030	0.003	0.093	0.002
Residence								
Rural	0.042	0.003	0.037	0.069	0.070	0.001	-0.271	0.001
Parity (No children)								
1-2	0.018	0.027	0.060	0.012	0.041	0.041	-0.063	0.030
3-5	0.016	0.013	0.092	0.000	0.039	0.001	-0.386	0.000
Above 6	0.064	0.000	0.236	0.000	0.316	0.000	-0.377	0.000
Wealth Index (Poorest)								
Poorer	-0.015	0.062	0.036	0.076	-0.041	0.037	0.036	0.463
Middle	-0.007	0.371	-0.021	0.363	-0.006	0.359	0.035	0.324
Richer	-0.002	0.760	-0.017	0.791	-0.001	0.761	0.009	0.662
Richest	0.037	0.069	-0.036	0.035	-0.006	0.059	0.069	0.031

Ref, Reference; P-V, P-value

Discussions

The purpose of this study was to determine the anemia status of pregnant women, as well as to identify any associated factors. Almost thirty-seven percent of pregnant women in the study had anemia, which is similar to the results from the study done in Tigray, Ethiopia (regional level),[17] Ethiopia (national level),[15] and another country, Nepal.[22] But, this study result is slightly more than the community-based cross-sectional studies conducted in Northeast Ethiopia and Jimma. The difference may be due to the scope of the study area, cultural practices, and dietary factors that the study considered the whole of Ethiopia, while the cross-sectional study is limited to a small area. On the other hand, this result is slightly lower than the study conducted in Korea[23] and Bangladesh[24] and much lower than those in Jigjiga, Ethiopia,[23] India,[26-28] and Indonesia.[4] Compared to the 2012 Central Statistical agency report in Ethiopia,[7] the number of cases increased by more than half. The study found that about three percent of people have severe anemia, about seventeen percent have moderate anemia, and about seventeen percent have mild anemic conditions. However, only about sixty-two percent of people are not anemic. This high rate of anemia (about 37%) could be due to a lack of reliable information, as well as pregnant women who may have stopped taking treatment due to financial limitations. The data obtained are almost comparable with the results[17] but lower than the results.[4] The proportion of pregnant women who were severely anemic was highest in the Somali region and lowest in the Tigray region. The previous study found that variation in the availability of reliable information, especially about determinant factors of anemia during the pregnancy period, may be responsible for the inconsistency in results between studies.[25] This could lead to variability in anemia status among pregnant women in different regions.

The authors used a partial proportional odds model to assess factors associated with anemia status. Results of the model indicated that educational status, wealth index, parity, iron intake, region, and residence were identified as statistically significant predictors. As a result, pregnant women with illiterate, primary, and secondary education have a greater chance of developing anemia compared with pregnant women with higher education .[29, 30] The study also found that participants who were illiterate and only completed primary and secondary education were more likely to develop anemia than those who completed higher education. Likewise, iron intake was one of the most important statistical predictors of anemia status in participants aged 15 to 49 years. Women who took iron supplements were less anemic than those who did not, according to the authors' findings. This finding is consistent with other studies[12, 31] that have shown that iron pills reduce the risk of anemia in pregnant women. Another factor affecting the anemia status of Ethiopian participants was parity. According to the study's findings, subjects with a high parity are more vulnerable to anemia than pregnant women with fewer children. This finding is supported by the findings of,[32] which show that the risk of anemia is greatest in pregnant women with a high parity. Correspondingly, place of residence is a statistically significant factor. Urban participants were less likely to be anemic than rural ones.[33] The findings of

this study also show that urban women were more likely to be non-anemic than their rural counterparts. This event might be due to a lack of availability of infrastructure and information as to a sufficient balanced diet during their pregnancy. Moreover, in Ethiopia, the wealth index was also an important predictor of pregnant women's anemia status. Pregnant women from the wealthiest households have a lower risk of anemia than pregnant women from the poorest households. This finding is consistent with research findings,[34] which show an inverse relationship between anemia risk and wealth index.

Strength and limitation of the study

The study's findings were found to be generally supported by a national representative large sample size. The information was obtained using a well-known and accepted international methodology. The survey's representative nature means that the findings are representative of countries and can be generalized to pregnant women in Ethiopia. The study used AMPE to account for the complexities of logistic regression interpretation. However, the cross-sectional design of the study makes it difficult to determine causal relationships between predictor variables and anemia. This study did not use a sample size calculation because it used data that had already been collected.

Conclusions

In this article, the authors sought to use a classical partial proportional odds analysis method to identify hazards associated with anemia status of reproductive age based on EDHS 2016 data, 15-49 participants in Ethiopia. Pregnant women in the Somali region had the highest rates of severe anemia, while those in the Tigray region had the lowest.

This study also allowed us to investigate the relationship between the ordinal outcome (anemia status) and its associated predictor variables. According to the results of classical partial proportional odds model analysis, region, education level, iron intake status, wealth index, parity, and place of residence were all significantly associated with anemia status. Women in the richest quintile, the most educated, with iron-eating status, low parity, and urban living are less likely to suffer from anemia. Consequently, much attention should be paid to these significant predictor variables because they play an important role in determining pregnant women's Anemia status.

Abbreviations

AMPE, Average Marginal Probability Effect; CSA, Central Statistical Agency; EA, Enumeration Area; EDHS, Ethiopian Demographic Health Survey; Hb, Hemoglobin; HIV, Human immune virus; PPOM, Partial Proportional Odds Model; SPSS, Statistical Software for Social Science; WHO, World Health Organization.

Declarations

Availability of data

The analysis in this study is based on data available from the Ethiopian Demographic

and Health Survey.

Competing interests

The authors declare that there is no competing interest in this publication.

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