Biology and Medicine

OPEN ACCESS Freely available online

Research Article

Application of Partial Proportional Odds Model in Determining Anaemia Status and Its Associated Risk Factors among Pregnant Women in Ethiopia

Meskerem Abebe, Alemayehu Legesse*

Department of Statistics, Madda Walabu University, Bale Robe, Ethiopia

ABSTRACT

Anaemia is a significant public health problem that affects more than fifty six million women globally. In pregnancy, it is haemoglobin concentration of less than eleven gram per decilitre in venous blood and has significant adverse health consequences, on pregnant women. The major objective of this study is to investigate Anaemia status and its associated factors among pregnant women in Ethiopia. The data source for this study was 2016 Ethiopia demographic health survey data. A total of 1053 pregnant women were considered in this study. Partial Proportional odds model use in the analysis of determinant of risk factors of Anaemia status among pregnant women in Ethiopia. Among the total, 1053 pregnant women involved in this study 32 were severe anaemic, 214 were moderate anaemic and 395 were mild anaemic whereas 658 were non-anaemic. The highest proportions of severe anaemic among pregnant women were observed in the region of Somali (10.98%) whereas the smallest were in Tigray region. According to the results of Partial Proportional odds Model; region, wealth index, educational level, iron taking status, parity and residence were found to be significantly associated with Anaemia status of pregnant women in Ethiopia. Finally, the author conclude that Education status, iron take, wealth index, residence, parity and region identified as prognostic factors of Anaemia status among pregnant women age 15-49.Therefore, action targeting on these predictors variables are necessary to improve the Anaemia status of pregnant women in Ethiopia.

Keywords: Anaemia; Ethiopia; Partial Proportional odds model; Pregnant women

INTRODUCTION

Anaemia is a significant public health problem that affects more than fifty six million women globally. In pregnancy, it is haemoglobin concentration of less than eleven gram per decilitre in venous blood and has significant adverse health consequences, on pregnant women. 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 that of heavy bleeding during menstruation and parasitic infection like malaria and HIV [1]. Anaemia during pregnancy resulted in negative maternal and child health effect and increase maternal and prenatal mortalities as a whole. The negative health effects for the mother include fatigue, poor work capacity and impaired immune function [2].

Anaemia in pregnant women may due to iron shortage adversely affects reasoning and motor development, causes tiredness and low productivity and, when it occurs in pregnancy, may be related with low birth weight and maximized the risk of maternal and parental mortality. It greatly contributes in 20–40% of maternal deaths [3].

Anaemia can be labelled by haemoglobin cut off significance adjusted to sea level altitude on the origins of gestational age and it's degree of Severity were determined according to world health organization standard. Anaemia status determined based on haemoglobin value both at first and third trimesters. Women with haemoglobin value in the range of 10 and 11 gram per decilitre at first and third trimesters and10 g/dl≤ Hb< 10.5 g/dl at second trimester were considered as mild anaemic whereas those pregnant women with haemoglobin value between 7 g/dl ≤ Hb<10g/dl and Hb<7gram per decilitre categorized under moderate and severe consequently irrespective to their gestational age [4].

MATERIAL AND METHODS

Description of the study area and Data source

Ethiopia is one of the tenth independent largest country in

***Corresponding to**: Alemayehu Legesse, Department of Statistics, Madda Walabu University, Bale Robe, Ethiopia, Tel: +251 904458143; E-mail: alexleg26@gmail.com

Received: November 04, 2021; **Accepted:** November 18, 2021; **Published:** November 25, 2021

Citation: Abebe M, Legesse A (2021). Application of Partial Proportional Odds Model in Determining Anaemia Status and Its Associated Risk Factors among Pregnant Women in Ethiopia. Bio Med 13: 456. doi: 10.35248/0974-8369.21.13.456

Africa, covering 1,104,300 square kilometres (with one-million square kilometre land area and 104,300 square kilometre water).It bordered by Eritrea, Djibouti, Somalia, Kenya, Sudan on the northeast, east, south, west and southwest respectively. Administratively, Ethiopia is divided into nine Regional States (Tigray, Afar, Amhara, Benishangul-Gumuz, Gambella, Harari, Oromia, Somali, and Southern Nation Nationalities and Peoples Region (SNNPR)) and two administrative cities(Dire Dawa and Addis Ababa) [5]. The data employed in this study is secondary data, which obtained from Ethiopia Demographic and Health Survey (EDHS) 2016 that implemented by Central Statistical Agency (CSA).The data consists of valuable information regarding to demographic and health aspects over time, like family planning behaviour, child mortality, nutritional status of children, Anaemia and others.

Study population

The study populations are all pregnant women 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 anaemic 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

Two stage stratified cluster sampling was employed in 2016 EDHS. All regions of Ethiopia stratified into urban and rural that result in 21 strata. Two stage randomly selected enumeration area were applied in each stratum. In the first stage, a total of 645-enumeration areas were selected with probability proportional to the EA size and with independent selection in each sampling stratum. Among these enumeration area, 202 were urban areas whereas 443 rural areas. In the second stage, a fixed number of 28 households per cluster were selected with an equal probability systematic selection from the newly created household listing. Then, Anaemia testing was conducted based on agreeing women 15-49 whose parent agreed to the testing.

Data analysis

The collected data entered, cleaned and analysed by using statistical package for social sciences (SPSS) version 20, R version 3.2 and STATA Software. The results of the study were presented using both descriptive (frequency table) and inferential (PPOM) statistics. The relation and strength between the Anaemia status and predictors variables assessed in terms of PPOM at 95% confidence interval.

Outcome variable in the study

In this study the response variable, which Anaemia status of pregnant women can be categorized in to four ordinals categories. These are:-

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

Partial proportional odds model (PPOM) Approach

This model is the type of ordinal logistic regression that used both in case of parallel line test assumption is fulfilled or not [7]. The PPOM allows for some the explanatory variables to be modelled with the parallel line assumption, and for the other variables in which this assumption is violated specific parameters are included in the model that vary with different category comparisons which is the effect associated with each i^{th}cumulative logit, adjusted by the other covariables. The PPOM is an extension of the proportional odds model as suggested by Peterson and Harrel [7]. In this study, the coefficients are associated with each category of the response variable.

The model has the form:

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

It is normally expected that there is a type of linear trend between each OR of the specific cut-off points and the response variable. If there is then a set of restrictions γ_{kl} may be included in the model to clarify this linearity. When these restrictions are included this model is called the restricted partial proportional odds model. The $\tau_i$parameters are fixed scale parameters which take the form of restrictions allocated to the parameters. In this case for a given covariableX_m, $\alpha_m$does not depend on the cut-off points, but is multiplied by $\tau_i$for each ithlogit. The model becomes (Peterson and Harrell, 1990).

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

Parameter estimation Method

In this study Maximum likelihood method of parameter estimation is employed which result in the values of the unknown parameters that best fit the predicted and observed probability values. Therefore, it usually used a very effective and well known Fisher scoring algorithm to obtain ML estimates [7].

RESULTS AND DISCUSSIONS

The data set considered in this study is EDHS 2016 data collected from pregnant women at reproductive age. A total of 1053pregnant women were included in this study. From those 32 (3.04%) were severe anaemic, 214(20.32%) were moderate anaemic and 395 (37.51%) were mild anaemic whereas 658(62.49%) were non-anaemic (Table 1).

The highest proportions of severe Anaemia among pregnant

Table 1: Anemia status of pregnant women in Ethiopia based on EDHS, 2016.

Anemia status	Frequency	Percent	Com. Percent
Severe	32	3.04	3.04
Moderate	182	17.28	20.32
Mild	181	17.19	37.51
Non anemic	658	62.49	100

women at reproductive age (15-49) were observed in the region of Somali (10.98%) followed by Dire Dawa (4.08%), Afar (3.51%) and Oromia (3.40%) Whereas the smallest proportion of severe Anaemia status among pregnant women in Ethiopia were occurred in Tigray followed by Amhara, SNNPR, Gambela and Addis Ababa (Table 2). The proportions of moderate anaemic status of pregnant women in Addis Ababa, Amhara, Tigray, Somali, Afar, Dire Dawa and Harari were 0.00%, 4.9%, 7.59%, 38.73%, 26.32%, 22.45%, 20.55%) respectively. According to EDHS, 2016 data the highest moderate anaemic status among pregnant women were identified in Harari region. The highest percentages of mild anaemic status for pregnant women in Ethiopia in the age interval 15-49 were observed in Harari (26.03%) followed by Afar (24.56%) and Addis Ababa (20.00%) in relative to other regions. The proportion of non-anaemic status of pregnant women were seems the highest in Amhara (84.31%), Addis Ababa (80.00%) and Tigray (78.48%) among the rest region of Ethiopia (Table 2).

The average Marginal probability effects for each Anaemia status of pregnant women were displayed in Table 3. According to these results, AMPE of pregnant women to be Severe Anemic is the highest in Somali region (AMPE1 = 0.0366, P ≤ 0.05). This indicates that Somali region pregnant women were 3.66% more likely to get severe anaemic in relative to Tigray region pregnant women. Dire Dawa and Somali Pregnant women were with high moderate anaemic (AMPE2 = 0.314, P ≤ 0.05) and (AMPE2 = 0.201%, P ≤ 0.05) respectively. This shows that Dire Dawa and Somali pregnant women were 31.4% and 20.1% more likely to get moderate anaemic consequently as compared with pregnant women from Tigray. In Similar manner pregnant women in this two regions (Somali (AMPE4 = -0.270, P ≤ 0.05) and Dire Dawa (AMPE4 = -0.170, P ≤ 0.05)) were with high chance of being non-anaemic. This indicate that Pregnant women in Somali and Dire Dawa regions were 27% and 17% less likely to experience non-anaemic when compared with pregnant Women in reproductive age,15-49, of Tigray region.

Regarding to iron pills taking status, the estimated probability of pregnant women being severe, moderate and mild anaemic approximately decreased by 1.6%(AMPE1 = -0.016, P ≤ 0.05), 3.7%(AMPE2 = -0.037, P ≤ 0.05), and 3%(AMPE3 = -0.030, P ≤ 0.05) respectively as compared with pregnant women those didn't take iron. Pregnant women who took iron had 0.093 estimated probability being non-anaemic (AMPE4 = 0.093, P ≤ 0.05). This reveals that the chance of pregnant women to be non-anaemic increased by 9.3 percent in relative to pregnant women who didn't take iron pills Table 3.

Based on education status, Pregnant Women those completed secondary and higher education were 2.09 percent (AMPE2 = -0.209, P ≤ 0.05) and 2 percent (AMPE2 = -0.200, P ≤ 0.05) less likely to have moderate anaemic respectively in comparison to non-educated pregnant women. The analyzed marginal probability effect of non-anaemic status pregnant women who completed primary, secondary and higher education were subsequently 3.2% (AMPE4 = 0.032, P ≤ 0.05), 6.9% (AMPE4 = 0.069, P ≤ 0.05) and 17.6% (AMPE4 = 0.176, P ≤ 0.05), indicating that pregnant women in respective education status were 3.2%, 6.9% and 17.6% more likely to be non-anaemic as compared to non-educated pregnant women Table 3.

Similarly, the average marginal probability of rural pregnant women with severe and mild anaemic were 4.2%(AMPE1 = 0.042, P ≤ 0.05), 7%(AMPE2 = 0.070, P ≤ 0.05). This finding shows that pregnant women from rural area were 4.2 and 7 percent more likely to be severe and mild anaemic respectively and 27.1 %(AMPE4 = -0.271, P ≤ 0.05) less likely to be non-anaemic in relative to pregnant women from urban area Table 3.

The estimated probability of pregnant women survive in richest household being moderate anaemic was 3.6 percent (AMPE2 = -0.036, P ≤ 0.05) and for those of non- anaemic was 6.9 percent (AMPE4 = 0.069, P ≤ 0.05). This results show that pregnant women from the richest household were 3.6 % less likely to be moderate anaemic and 6.9 more likely to be non-anaemic as compared with pregnant women from poorest household. Similar interpretation for the rest AMPEs value (Table 3).

Table 2: Anemia status of pregnant women distribution among the region of Ethiopia.

Variable	Anemia status of pregnant women in Ethiopia (EDHS,2016)			
Region	Severe (%)	Moderate (%)	Mild (%)	Non-anemic (%)
Tigray	0.00	7.59	13.92	78.48
Afar	3.51	26.32	24.56	45.61
Amhara	0.00	4.90	10.78	84.31
Oromia	3.40	8.84	19.73	68.03
Somali	10.98	38.73	16.18	34.10
Be.Gumuz	1.33	14.67	14.67	69.33
SNNPR	0.00	11.03	15.44	73.53
Gambela	0.00	15.00	13.33	71.67
Harari	1.37	20.55	26.03	52.05
Addis Ababa	0.00	0.00	20.00	80
Dire Dawa	4.08	22.45	12.24	61.22

Key: Be. Gumuz=BenishangulGumuz

DISCUSSIONS

The major objective of this study is to investigate Anaemia status and its associated factors among pregnant women in Ethiopia using EDHS 2016 data. Partial proportional odds model was employed in this study. The results of this model revealed that education status, wealth index, Parity, iron take, region and residence were identified as statistically significant predictors of Anaemia status of pregnant women in reproductive age in Ethiopia.

Illiterate, primary and secondary educated pregnant women had more chance to develop Anaemia than higher educated pregnant women [8]. The results of this study also show that pregnant women who are illiterate, attained primary and secondary education are highly vulnerable to Anaemia than those pregnant women who attained higher education.

Iron taking status is one of the most important statistical predictors of Anaemia status among pregnant women in age interval 15-49. According to Authors findings, women who took iron were more non-anaemic than those pregnant women not take iron. This finding is agree with other studies [9, 10] revealing that Anaemia risk decrease as pregnant women take iron pills.

Parity is another factor that affects Anaemia status of pregnant women in Ethiopia. The results of this study show that pregnant women with high parity are more vulnerable to Anaemia than those pregnant women with less number of children. This finding

Table 3: Average marginal probability effect (AMPE) of anemia Status of pregnant women.

Explanatory variables		Severe anemic		Moderate		Mild anemic		Non-anemic	
		MPE1	P-V	MPE2	P-V	MPE3	P-V	MPE4	P-V
Region(**Tigray = Ref**)	Afar	0.043	P ≤0.05	0.046	P ≤0.05	0.024	P ≤0.05	-0.146	P ≤ 0.05
	Amhara	-0.007	P >0.05	-0.015	P >0.05	-0.002	P >0.05	0.027	P >0.05
	Oromia	0.023	P >0.05	-0.046	P >0.05	0.030	P >0.05	-0.004	P >0.05
	Somali	0.027	P ≤0.05	0.201	P ≤0.05	0.021	P ≤0.05	-0.270	P ≤ 0.05
	Benishangul	0.001	P >0.05	0.032	P >0.05	0.004	P >0.05	-0.031	P >0.05
	SNNPE	-0.008	P >0.05	-0.031	P >0.05	-0.015	P >0.05	0.047	P >0.05
	Gambela	0.016	P >0.05	0.038	P >0.05	0.008	P >0.05	-0.039	P >0.05
	Harari	0.201	P >0.05	0.057	P >0.05	-0.077	P >0.05	-0.077	P >0.05
	AddisAbaba	0.021	P >0.05	0.058	P >0.05	0.006	P >0.05	-0.058	P >0.05
	Dire Dawa	0.026	P ≤0.05	0.314	P≤0.05	0.015	P ≤0.05	-0.170	P ≤ 0.05
Educational Level(**No educ.= Ref**)	Primary	0.007	P >0.05	0.021	P >0.05	-0.025	P ≤0.05	0.032	P ≤ 0.05
	Secondary	-0.011	P ≤0.05	-0.209	P ≤0.05	-0.063	P ≤0.05	0.069	P ≤ 0.05
	Higher	-0.017	P ≤0.05	-0.200	P ≤0.05	-0.017	P ≤0.05	0.176	P ≤ 0.05
Iron (**No = Ref**)	Yes	-0.016	P ≤0.05	-0.037	P ≤0.05	-0.030	P ≤0.05	0.093	P ≤ 0.05
Residence	Rural	0.042	P ≤0.05	0.037	P >0.05	0.070	P ≤0.05	-0.271	P ≤ 0.05
Parity(**No children = Ref**)	1-2	0.018	P ≤0.05	0.060	P ≤0.05	0.041	P ≤0.05	-0.063	P ≤ 0.05
	3-5	0.016	P ≤0.05	0.092	P ≤0.05	0.039	P ≤0.05	-0.386	P ≤ 0.05
	Above 6	0.064	P ≤0.05	0.236	P ≤0.05	0.316	P ≤0.05	-0.377	P ≤ 0.05
Wealth Index (**Poorest = Ref**)	Poorer	-0.015	P >0.05	0.036	P >0.05	-0.041	P ≤0.05	0.036	P >0.05
	Middle	-0.007	P >0.05	-0.021	P >0.05	-0.006	P >0.05	0.035	P >0.05
	Richer	-0.0015	P >0.05	-0.017	P >0.05	-0.001	P >0.05	0.009	P >0.05
	Richest	0.0370	P >0.05	-0.036	P ≤0.05	-0.006	P >0.05	0.069	P ≤ 0.05

Key: Ref = Reference, P-V = P – value

is supported by the study result of [11], revealing that the risk of Anaemia is highest in pregnant women with high parity.

Similarly, Place of residence is statistically significant factors of Anaemia status of pregnant women in Ethiopia. Urban pregnant women were less likely to be anaemic than rural pregnant women [12,13]. The results of this study also indicate that urban pregnant women were more likely to be non-anaemic than rural pregnant women in reproductive age. This might be due to lack of availability of infrastructures and losing information regarding to sufficient balanced diet during pregnancy.

Wealth index was also important predictors of Anaemia status of pregnant women in Ethiopia. Pregnant women from richest household are found to be at lower risk of Anaemia than pregnant women from poorest household. This finding is consistent with studies [8] indicating that Anaemia risk and wealth index has inverse relation.

CONCLUSIONS

In this study, author tried to assess the risk factors that are associated with Anaemia status among pregnant women of reproductive age, 15-49 in Ethiopia based on EDHS 2016 data using classical Partial proportional odds analysis approach. The highest proportions of severe anaemic were observed among pregnant women who belong to Somali region (10.98%) whereas the smallest severe anaemic status was in Tigray region.

This study has also provided the chance to explore relationship between ordinal outcomes (Anaemia status) and its associated predictor variables. The results of classical partial proportional odds model analysis showed that region, educational level, iron taking status, wealth index, parity and residence were found to be significantly associated with Anaemia status of pregnant women. Pregnant women who belong to household with richest wealth quintiles, highest education status, iron take status, low parity and reside in urban area were less likely to get Anaemia. Therefore, considerable attention should provide to these significant predictors variables since they play great role in determining Anaemia status related factors.

DECLARATIONS

- **Availability of data**

Not applicable in this publication manuscript

- **Competing interests**

The author declares that there is no competing interest in this publication.

- **Funding**

Not applicable in this publication manuscript

ACKNOWLEDGEMENTS

The authors would like to acknowledge Central statistical Agency for collecting these data used in this study. Support of my best

wife meskerem abebe Abera on this manuscript preparation is appreciated.

ABBREVIATIONS

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

REFERENCES

1. Benoist B. D, Mclean E, Egll I, Cogswell M. Worldwide prevalence of anaemia 1993-2005: WHO global database on anaemia. Worldwide prevalence of anaemia 1993-2005. Public Health Nutr. 2009 Apr; 12(4):444-54.
2. Stephen G, Mgongo M, Hussein Hashim T, Katanga J, Stray-Pedersen B, Msuya S. E. Anaemia in pregnancy: Prevalence, risk factors, and adverse perinatal outcomes in Northern Tanzania. Anemia 2018:1846280.
3. Shulman C, Graham W. J, Jilo H, Lowe B, New L, Obiero J, Snow R. W, Marsh K. Malaria is an important cause of anaemia in primigravidae: evidence from a district hospital in coastal Kenya. Trans R Soc Trop Med Hyg.1996; 90(5):535-9.
4. WHO 2011. The global prevalence of anaemia. World Health Organisation.
5. MOH 2010. Ministry of health: Health sector development Programme IV, 2010/11- 2014/15 final Draft, Version. 2010; 8(19): 4.
6. Peterson B, Harrell JR F. E. Partial proportional odds models for ordinal response variables. Appl Statist. 1990; 39(2): 205-217.
7. Mccullagh P. Regression models for ordinal data. J R Statist. Soc. B. 1980; 42(2):109-142.
8. Bisoi S, Haldar D, Majumdar T, Bhattacharya N, Sarkar G, Ray S. Correlates of anemia among pregnant women in a rural area of West Bengal. J Fam Welfare. 2011; 57(1):72-8.
9. Worku Takele, W, Tariku, A, Wagnew Shiferaw, F, Demsie, A, Alemu, W. G. & Zelalem ANLAY, D. 2018. Anemia among Women Attending Antenatal Care at the University of Gondar Comprehensive Specialized Referral Hospital, Northwest Ethiopia, 2017. Anemia. 2018; 8(9):7618959.
10. Abiselvi A, Gopalakrishnan S, Umadevi R, Rama R. Socio-demographic and obstetric risk factors of anaemia among pregnant women in rural Tamil Nadu. Int J Community Med Public Health. 2018; 5(2):721.
11. Noronha J. A, AL Khasawneh E, Seshan V, Ramasubramaniam S, Raman S. Anemia in pregnancy-consequences and challenges: a review of literature. J South Asian Feder Obs Gynae. 2012; 4 (1):64-70.
12. Getahun W, Belachew T, Wolide A. D. Burden and associated factors of anemia among pregnant women attending antenatal care in southern Ethiopia: cross sectional study. BMC Res Notes. 2017 Jul 14; 10(1):276.
13. EDHS 2016. Ethiopia Demographic and Health Survey 2016 Key Indicators Report, CSA, Addis Ababa-Ethiopia. 2016.