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STATISTICAL ANALYSIS OF ANEMIC STATUS AMONG PREGNANT WOMEN IN ETHIOPIA

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ABSTRACT

Background: The prevalence of anemia in pregnant women is 68% globally. In Africa its prevalence is estimated to be 66.8%. In Ethiopia, anemia is the severe public health problem affecting 62.7% of pregnant mothers and 52.3% non-pregnant women.
Objective: To fit an appropriate statistical model and identify potential factors of anemic status among pregnant women in Ethiopia
Methods**:** A cross-sectional study design carried out based on the secondary data of the Ethiopia Demographic Health Survey. Pregnant women of reproductive age (15-49) were included in the analysis. Data were mainly analyzed using R- software offered for the analysis of binary responses with correlated data (GENMOD procedure).
Results: Some of covariates for the marginal model revealed that pregnant women those lived in urban had 0.862 (p = 0.0012) times lower risk than those who lived in rural. Similarly, The odds ratio of anemic pregnant women whose age 15 to 20 had $\exp(\beta_1)= \exp(-0.1936)= 0.824$(95% CI: 0.6817 0.2945) times lower than those pregnant women whose age group (40-49), which means that the probability that the pregnant women being anemic whose age 15 to 20 is 17.6% times less likely to be anemic than those anemic pregnant women whose age group (40-49) in the same j^{th} cluster and similar interpretation can be drawn in the remaining variables.
Recommendation: Government should design strategies and policies to enhance women education to make them independent in socio-economic and cultural decision, which directly and indirectly affect women health status due to anemia. It is recommended that the remaining factors that have not been included in this study could be included in future studies.

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INTRODUCTION

Anemia is one of the most widespread public health problems, especially in developing countries. It impairs cognitive development, reduced physical work capacity and in severe cases increased risk of mortality particularly during prenatal period (World Health Organization, 2001). Anemia in pregnant women is defined hemoglobin levels less than 11g/dl (World Health Organization, 1996). It is usually caused by iron deficiency, which is the most common nutrient deficiency in the world. It has been estimated that, at any one time in developing countries, half of the population (mainly children and women of reproductive age) is affected by anemia (Hercberg, 1992). Anemia in pregnancy is also related to different socio-demographic, dietary and economic factors. Mother's age < 20 years, educational status, economic position, and antenatal care were significantly associated with anemia during pregnancy in a study conducted in India (Bechuram et al., 2006). In Ethiopia, anemia is the most frequent morbidity among pregnant women with the prevalence ranging from 23 to 66.5% (Gebremedin, 2004) . There is an urban rural difference in the prevalence of anemia. Anemia in pregnancy, (hemoglobin level <11g/dl as defined by World Health Organization is a major public health problem, especially in developing countries (De Benoist, 2008). Recent statistics indicate that anemia affects 41.8% of pregnant women globally, with the highest prevalence in Africa (WHO, 2006).

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Fifty seven percent of pregnant women in Africa are anemic, which corresponds to about 17 million affected women, with severe consequence on health, social, and economic development (Meda, 1999). Studies in Africa have shown a high prevalence of anemia in pregnancy ranging from 41 to 83% in different settings (Meda, 1999). Many studies explained the status of anemia in pregnant mothers depended on the socioeconomic level [10], illiteracy, extremes of mother's age, grand gravid, short pregnancy intervals and age of gestation .In measuring the status of anemia in the population, hemoglobin (Hb) concentration is the most reliable indicator as opposed to clinical measures.

METHODOLOGY

The 2011 Ethiopian Demographic and Health Survey, was designed to provide estimates for the health and demographic variables of interest for the following domains. The principal objective of the 2011 EDHS was to provide current and reliable data on fertility and family planning behavior, child mortality, adult and maternal mortality, children's nutritional status, use of maternal and child health services, knowledge of HIV/AIDS, and prevalence of HIV/AIDS and Anemia in general and the sample size of the population under the study was 1277 pregnant women.

Variables

For binary outcome for defining anaemia and its severity at the population level, as well as the chronology of their founding allows the identification of populations at greatest risk of anaemia and priority areas for action, especially when resources are inadequate. In view of the above, the hemoglobin level was first dichotomized based on the cut-off points as described in literature view leading to the binary response:

$$Respnse(anemic\ status) = \begin{cases} 1\ if\ Hb\ level\ < 11g/dl \\ 0\ if\ Hb\ level\ \geq 11\,g/dl \end{cases}$$

Where 1 was coded for anemic and 0 has coded as non anemic. The expected explanatory variables that would be included are explained, categorized and which were coded starting from zero to make it appropriate for further analysis using Generalized Estimate Equation Model. Independent variables:

Age:(15-26)=0,(27-38)=1,(39-50)=2),Region(0=orthox,1=catholic,2=protestant,3=muslim,4=tradation);Residence(0=rural,1= urban);occupation(0=nonemployed,1=employed);smokingstatus(0=nonsmoked,1=smoked);HIV (0=H IV-,1=HIV+); wealth index(0=poorest,1=poor,2=middle,3=riche,4=richest);Vitamin intake(0=notvitaminintake, 1=vitaminintake);maritalstatus (0=sing, 1=marr,2=llwp,3=widow,4=divorced,5=nollwp),education(0=no edu,1=primary,2=secoundary,3=higher) and where nollwp =no longer lived with partner, llwp=long lived with parner

Statistical Model

Marginal models are among the most statistical models widely used to model clustered as well as repeated data. In marginal models, the main scientific objective was to analyze the population-averaged effects of the given factors in the study on the binary response variable of interest. This means that the covariates are directly related to the marginal expectations. The marginal model fitted in this cluster data included the Generalized Estimating Equations (GEE). For clustered as well as repeated data, [Zeger, 1986] proposed GEE which require only the correct specification of the univariate marginal distributions provided one is willing to adopt "working" assumptions about the correlation structure. The "working" assumptions as proposed by Liang and Zeger included independence and exchangeable working assumptions can be used in virtually all applications, whether longitudinal, clustered, multivariate, or otherwise correlated (Molenberghs, 2005) let $Y_j = (y_{j1}, \ldots\ldots y_{jn_j})'$ be the response values of observations from j^{th} cluster, $j = 1,2,\ldots.,m$ follows a binomial distribution i.e. $Y_j{\sim}Bino(n_j,\pi_j)$ that belongs to the exponential family with the density function of the form. Then to model the relation between the response and covariates, one can use a regression model similar to the generalized linear models given by: $g = logit(\pi_j) = X'_j\beta$
Where, $g(\pi_j)$= logit link function,

X_j= (n_j x p) dimensional vector of known covariates.
β= (1 x p) dimensional vector of unknown fixed regression parameter to be estimated
$E(Y_j) = \pi_j\ is$ expected value of the response variable.

Parameter Estimation for GEE

Here GEE is not likelihood approach, rather it is quasi-likelihood based and estimates $\hat{\beta}$ by solving estimating equations which consist of the working covariance matrix V_j. The score equation used to estimate the marginal regression parameters while accounting for the correlation structure is given by: $S(\beta) = \sum_{j=1}^{m} \frac{\partial \pi_j}{\partial \beta'} \left[A_j^{1/2} R_j A_j^{1/2}\right]^{-1} (Y_j - \pi_j) = 0$ .Where R_j is working correlation matrix, and the covariance matrix of Y_j is decomposed in to $A_j^{1/2} R_j A_j^{1/2}$ with A_j the matrix with the marginal variances on the main diagonal and zeros elsewhere, Y_j multivariate vector of asymptotically normal response variables with mean vector π_j i.e $Y_j \cong N(X_j\beta, V_j)$. An advantage of the GEE approach is that it yields a consistent estimator of $\hat{\beta}$, even when the working correlation matrix R_j is misspecified. However, severe misspecification of working correlation may seriously affect the efficiency of the GEE estimator.

Table 1. Socio-demographic information of the respondents, Ethiopia, 2011

Region	Non anemic in (%)	Anemic (%)	Total
Tigray	34(24.6)	104(75.4)	138
Addis Ababa	31(29.5)	74(70.5)	105
Amhara	40(19.2)	168(80.8)	208
Oromiya	23(16.2)	119(83.8)	142
Somali	50(22.6)	80(77.4)	130
B.Gumz	25(23.4)	82(76.6)	107
SNNP	36(21.6)	131(78.4)	167
Gambela	17(21.8)	61(78.2)	78
Harar	35(21.8)	63(78.2)	98
Afar	6(4.3)	134(95.7)	140
Dire Dawa	15(11.9)	50(88.1)	65
Total	248(19.4)	1029(80.6)	1277(100%)

Table 2. Continued: Socio-demographic information of the respondents, Ethiopia, 2011

Effect/variables	Category	Non anemic in (%)	Anemic in (%)	Total
Age	15-26	154(20.5)	232(79.5)	386
	27-38	358(21.1)	345 (78.9)	703
	39-50	89(29.5)	99 (47.1)	188
	Non smoked	195 (21.8)	699(78.2)	89
Smoking status	Smoked	53(13.8)	330(86.2)	383
	Orthodox	105 (19.3)	439(80.7)	544
Religion	Catholic	4(33)	8(66.7)	12
	Protestant	42(21.5)	153((78.5)	195
	Muslim	88(17.4)	419(82.6)	507
	traditional	9(47.4)	10(52.6)	19
	Poorest	77(25.3)	227(74.7)	304
	Poor	21(12.3)	150(87.7)	171
Wealth	Middle	29(21.1)	132(82.0)	161
	Rich	29 (15.6)	157(84.4)	186
	Richest	92(20.7)	363(79.8)	455
Marital status	Single	11(7.6)	134(924)	145
	Married	188(21.6)	684(78.4)	872
	Long lwp	18(18.4)	80(81.6)	98
	wioowed	13(19.4)	54 (80.6)	67
	Divorced	13(20.3)	51(79.7)	64
	No longer lwp	5(16.1)	26(83.9)	31
	No education	78(11.4)	604(88.6)	682
	Primary	122(285)	306(71.51)	428
Edu.status	Secondary	19(27.1)	51 (72.9)	70
	Higher	29(29.9)	68(70.1)	97
	No employed	101(19.8)	410(80.2)	511
Occupation	Employed	248(19.4)	1029(80.6)	766
	HIV-	200(11.6)	1056(88.4)	1256
HIV Status	HIV+	6 (12.5)	15(87.5)	21
	Urban	100(20.9)	379(79.1)	479
Residence	Rural	88(11.8)	660(88.2)	748
	Non vi intake	94(18.3)	420(81.7)	514
	Vit intake	248 (18.6)	649(81.4)	763

As it has been shown in Table II, the basic descriptive statistics presents the information that summarizes the associations between the determinant factors and anemic status of pregnant women. The percentage of anemia of pregnant women is relatively larger which is 79.5% for age groups (15-26) as compared to other age groups. Similarly, the anemic status of pregnant women is varied with place of residence, as it can be seen in the above table I, the high percentage anemic status of pregnant women in rural is 88.2% and 79.1% is urban.

Generalized estimate Equation model (GEE model)

GEE has considered different correlation structures such as independence and exchangeable correlation structures and compared with their QIC values. Generalized estimating equations, the user may convey a correlation structure that is often called a working correlation matrix. Before selecting the correct correlation structure, consider the model building strategy (variable selection).
The full log it model for anemic status for pregnant women of i^{th} pregnant women from j^{th} cluster (π_{ij}) has been fitted as

$$logit(\pi_{ij}) = \beta_0 + \beta_1 Age_1 + \beta_2 Age_2 + \beta_3 edu.st_{Pr} + \beta_5 edu.st_{noedu+} + \beta_6 Religion_{or} + \beta_7 Religion_{pr} + \beta_8 Religion_{ca} + \beta_9 Religion_{tr} + \beta_{10} Mar.status_{single} + \beta_{11} Mar.status_{married} + \beta_{12} mar.status_{llwp} + \beta_{13} Mar.status_{widowed+} \beta_{14} Mar.status_{divorced+} + \beta_{15} Smoking_{smoked} + \beta_{16} Occupation_{employed} + \beta_{17} HIV.status_{HIV+} + \beta_{18} Vitamin_{intake} + \beta_{19} Wealth_{poorest} + \beta_{20} Wealth_{cpoor} + \beta_{21} Wealth_{middle} + \beta_{22} Wealth_{rich} + \beta_{23} Residence_{urban}$$

After fitting the model, covariates with the largest p-value of Wald test is removed and refitted the model with the rest of the covariates sequentially. Then, vitamin consumption, region and some interaction covariates were excluded from the model and the remaining covariates were included in the model. Independent and exchangeable correlation structures were considered and compared to select best correlation structure depending on the QIC value.

Table 3. Different correlation structures with its QIC for GEE

Correlation structure	QIC value
Independent	1171.735
Exchangeable	1166.0669

As it can be seen from table II, the QIC value (1166.6694) of the model with exchangeable correlation structure was less than independent correlation structure (QIC value=1171.735) and hence the model with exchangeable correlation structure would have been. The parameter estimates and their corresponding empirically corrected standard errors with the p-values from the final GEE model for parameter estimate was parsimonious and given in Table below

Table 4. Parameter estimates (empirically corrected standard errors) for GEE

Effect	category	Estimate (sd.error)	95% conf Limits	OR	P r > |Z|
	Intercept	0.9870(0.5837)	(-0.1571, 2.1311)	2.683	0. 0909
Age	15-26	-0.1936(0.2490)	(0.2945,0.6817)	0.824	0.0369
	27-38	0.0046(0.1896)	(0.3670762,0.37062)	1.005	0.005
	39-50 (ref)	--------	-----------------	----	-----
Rel	orthodox	0.4202(0.4186)	(-0.4002,1.2406)	1.522	0.3155
	catholic	-0.2240(0.8210)	(-1.8332,1.3852)	0.799	0.7850
	Protestant	0.3928(0.5330)	(-0.6519,1.4375)	1.481	0.4612
	Muslim	1.1844(0.4759)	(0.2517,2.1172)	3.269	0.0128
	traditional (ref)	--- ----------	-----------	------	------
Resid	urban	-0.1485(0.1528)	(0.1510,0.4479)	0.862	0.0012
	Rural(ref)	---------	-----	---	----
HIVstatus	HIV:H	0.1450(0.1047)	(0.0601,0.3502)	1.39	<.0001
	HIV-(ref)	-------------	----------	---	----
Smoking	Non Smoked	-1.0784(0.2595)	(-1.5871,-0.5697)	0.340	<.0001
	smoked(ref)	----------------	-------------	---	-----
Occup	Non Employed	-0.0367(0.1336)	(0.2986,0.3252)	0.964	0.0034
	Employed (ref)	------------------	-----------------	------	------

Mar. Status	Single	-0.2944(0.4288)	(-1.1348,0.5460)	0.745	0.4923
	Married	-0.9646(0.2704)	(-1.4945,-0.4346)	0.381	0.0004
	Long lwp	-0.2664(0.4484)	(-1.1453,0.6125)	0.766	0.5525
	Widowed	-0.1111(0.5160)	(-1.1224,0.9002)	0.895	0.8295
	Divorced	0.2672(0.6081)	(-0.9247,1.4591)	1.306	0.6604
	No longer lwp (ref)	---------------	---------------------	------	---- ---
Edu. status	No education	2.1161(0.4617)	(1.2112,3.0210)	8.2989	<0001
	Primary	0.6612(0.4016)	(-0.1259,1.4482)	1.937	0.0997
	Secondary	0.5420(0.3197)	(-0.0846,1.1686)	0.821	0.0900
	Higher+ (ref)	--------------	---------------	---	--------
Winx	Poorest	-0.1963(0.1931)	(-0.5749,0.1822)	0.821	0.3094
	Poor	0.7358(0.3062)	(0.1357,1.3359)	2.087	0.0162
	Middle	0.2123(0.2036)	(-0.1867,0.6114)	1.237	0.2970
	Rich	0.2768(0.2175)	(-0.1496,0.7032)	1.319	0.2033
	Richest(ref)	------------------	-------------------	-------	-------
Corr.			0.0253504575		

The parameter estimates for GEE stand for the effect of the predictors averaged across all individuals with the same predictor values. Like standard normal logistic regression, the interpretation of the parameters in the marginal (population average) model would be interpreted in terms of odd ratio. The final proposed reduced model for GEE is:

$$logit(\pi_{ij}) = \beta_0 + \beta_1 Age_1 + \beta_2 Age_2 + \beta_3 Religion_{musilum} + \beta_4 Residence_{urban} + \beta_5 smokinhg\ status_{non\ smoked} + \beta_6 Marital\ status_{married} + \beta_7 Edu.statusn_{no\ education} + \beta_8 Wealth\ poor + \beta_9 Occupation_{employed} + \beta_{10} HIV_{HIV+}$$

As it has been seen in Table III, it stands for the parameter estimates and their corresponding empirically corrected standard errors beside the p-values for GEE model. Each parameter β_j reflects the effect of factor X_j on the log odds of the probability of pregnant women being anemic, statistically controlling all the other covariates in the model. Then, the odds ratio of variables were calculated as the exponent of β_j i.e. odds ratio = exp (β_j).

The GEE analysis from table showed that, age is significantly related to anemic status of pregnant women .The odds ratio of anemic pregnant women whose age 15 to 20 had exp(β_1)= exp(-0.1936)= 0.824(95% CI: 0.6817 0.2945) times lower than those pregnant women whose age group (40-49), which means that the probability that the pregnant women being anemic whose age 15 to 20 is 17.6% times less likely to be anemic than those anemic pregnant women whose age group (40-49) in the same j^{th} cluster and similar interpretation can be drawn in the remaining variables.

DISCUSSION AND CONCLUSION

DISCUSSION

Under the model analysis ,anemia and socio-demographic variables including residence, religion(Muslim), occupation, marital status(married), income status(poor) ,and educational status(no education),smoking status and age categorized showed a statistical significant difference with anemia among pregnant women ,this finding supported on multivariate logistic regression analysis on determinants of anemia in pregnant women at bushulo health center in southern Ethiopia[13]. Educational status have strongly related to the risk of anemia among pregnant women in Ethiopia, similar results would be obtained on the study conducted on risk factors of anemia during pregnancy among pregnant women in India showed a statistical significant association between education and anemia which is consistent with the current study[14] and similarly[15] in a study reported that pregnant women with a low literacy level had significantly more from anemia compared to highly literate women. This finding indicates the need for strength ending of interventions related to education to women to create awareness of antenatal care, balanced diet during pregnancy and family planning. The present study showed poor educational, nutritional and other health indicators during pregnancy in women of lower socio-economic status as compared to those with upper socioeconomic status. In the present study significant association was found between income and Anemia. This study is supported by [16] for chi-square test of association showed that socio economic status is found to be a major explanation for the women having anemia in their study comprising of various social status groups, categorized on the basis of family income, found that the most females from low income category were more iron deficient. Present study clearly shows that unfavorable socio demographic factors are the major barriers to the efforts in place for the prevention of anemia during pregnancy.

Conclusion

Anemia has moderate public health problem in Ethiopia. Pregnant women who lived in rural areas, being from the lower economic ,educational status categories(no education) , marital status (married),religion(Muslim) , smoking status , working status and HIV status were important predisposing factors to anemia. More generally, Socio economic status, literacy of women is the major determinates that contribute to the problem of anemia. Education is the basic factor for change.

Recommendation

According to findings of this cross sectional study, place of residence, HIV status, smoking status, religion, and income level are significant factors for anemia among pregnant women. Clearly, it follows due to strong association between anemia and socio-demographic factors and economic factors. Hence, pregnant women who brought to health facilities by giving awareness about anemia since the result of this study showed that low income pregnant women, poor education level and additional factors mentioned above were high risk factor for anemia so that Government should design strategies and policies to enhance women education to make them independent in socio-economic and cultural decision, which directly and indirectly affect women health status due to anemia. Furthermore, in this analysis, we have studied how the risk of being anemic depends on age of pregnant women, type of residence, smoking status, working status, education status, marital status, and HIV and income level. However, it is worth noting that the probability of being anemic, that is, having hemoglobin (Hb) concentration below the normal level could be affected by other factors such as nutritional deficiencies, hookworm infections and inherited red blood cell disorders. Investigation of such factors could be recommended in future studies. However, challenges may stretch out on the side of resources made available and possibly means of collecting these factors.

Limitation of the study

Having hemoglobin (Hb) concentration below the normal level could be affected by other factors were not measured such as:

- Nutritional deficiencies

- Hookworm infections
- Inherited red blood cell disorders

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