
Cross-regional Variation of Complex Pregnancy Problems in Ethiopia

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To cite this article:

Endale Alemayehu, Tsigereda Tilahun. Cross-regional Variation of Complex Pregnancy Problems in Ethiopia. *American Journal of Health Research*. Vol. 9, No. 2, 2021, pp. 57-63. doi: 10.11648/j.ajhr.20210902.15

Received: February 24, 2021; **Accepted:** April 27, 2021; **Published:** May 14, 2021

Abstract: Adverse pregnancy outcome is a complex outcome of pregnancy other than the normal live birth. It lead to serious health consequences to the mother or the baby. It also can be still major public health and socioeconomic status problems in developing countries where most pregnancies are unplanned, complications. There is disparity of adverse pregnancy outcomes rate from region to region in Ethiopia. Objectives: The main objectives of the study were to identify the important determinant of adverse pregnancy outcomes in Ethiopia. With this study the multilevel logistic regression models were used to explore the major risk factors and regional variations. Different stages of multilevel models like intercept model and slope model were employed to attain the goal of the study. The results indicated that out of 15683 reproductive age of women, 8412 (86.8%) not experiencing adverse pregnancy outcome while 1282 (13.2%) of women have experienced adverse pregnancy outcome at the time of the survey. From multilevel logistic regression, it was found that the random intercept model provided the best fit for the data under consideration. All the fitted models gave the same conclusion that, Age of mother, place of residence, antenatal care visit and delivery place, Parity, Education of mother, Marital status, Anemia level were found to be statistically significant. Conclusion: The random intercept multilevel model provided the best fit for the data under consideration. Furthermore, it is found that not having Antenatal care, residing in rural area, working occupational status, being anemic, increased educational level, never married, divorced, or separated marital status, being in age group of 15-24 or >35 years are associated with increased risk of adverse pregnancy outcome among reproductive age group women in Ethiopia.

Keywords: Adverse Pregnancy Outcome, Abortion, Multilevel Logistic Regression Model

1. Introduction

Abortions and stillbirths are common adverse pregnancy outcomes that contribute substantially to poor maternal health. The World Health Organization (WHO) has defined stillbirth as fetal death late in pregnancy deferring the gestational age (GA) when a miscarriage (abortion) becomes a stillbirth to country policy [1, 2].

Worldwide in 2015, 18.4 stillbirths per 1000 total births occurred, compared with 24.7 stillbirths in 2000. Although stillbirth rates have decreased slightly, the average annual rate of reduction of stillbirths (2.0%) has been far slower than that for either maternal (3.0%) or post-neonatal mortality of children younger than 5 years (4.5%) [3, 4]. Similarly other study showed, the number of third trimester stillbirths worldwide has declined by only 1.1% per year, from 3

million per year in 1995 to 2.6 million in 2009.

Induced abortion is an ancient practice, experienced by women of all backgrounds in every part of the world. Abortion is the termination of a pregnancy after, accompanied by resulting in, or closely followed by the death of the embryo or fetus or a spontaneous or induced expulsion of a human fetus during the first 12 weeks of gestation [5].

Other study in Ethiopia reported, about 620,300 cases of induced abortions were performed in 2014 and the annual abortion rate was 28 per 1,000 women aged 15–49. Between 2008 and 2014, the proportion of abortions occurring in facilities rose from 27% to 53%, and the number of such abortions increased substantially nonetheless, an estimated 294,100 abortions occurred outside of health facilities in 2014 [6, 7]. Adverse pregnancy outcome is associated with poor maternal health and heavy burden of psychosocial and

economic cost on families and nations. For instance, abortion accounts for about 8% of maternal mortality worldwide [8] and unsafe abortions account for up to 20% of maternal deaths in East Africa in addition to other serious complications and disability in women [9]. Adverse pregnancy outcomes (abortion, stillbirth and miscarriage) represent significant problems in both developing and developed countries. It accounts for a large proportion of prenatal losses and the victims suffer from lifelong physical, nervous, or educational ill health, often at great cost to families and societies. More than any other region, sub-Saharan Africa is home to the highest number adverse pregnancy outcome. In Ethiopia, adverse outcome of pregnancy are still major public health difficulties.

Different studies were conducted although they weren't accounted for adverse pregnancy outcome at country level and didn't explore if there is heterogeneity (variation) between regions of Ethiopia. Hence, this study has attempted to investigate and identify factors associated with adverse pregnancy outcome in Ethiopia by incorporating these variables.

2. Methodology

2.1. Source of Data

For the analysis, the data has been obtained from the Demographic and Health Survey conducted in Ethiopia in 2016. The 2016 (EDHS) is the fourth Demographic and Health Survey conducted in Ethiopia. It was implemented by the (CSA) at the request of the (FMoH). The 2016 EDHS used three questionnaires: the Household Questionnaire, the Woman's Questionnaire, and the Man's Questionnaire. The Woman's Questionnaire was used to collect information from all women age 15-49 from the selected households. The primary purpose of the EDHS is to furnish policymakers and planners with detailed information on fertility, sexual activity, family planning, breast feeding practices, nutrition, child hood, maternal mortality, maternal and child health, nutrition and knowledge of HIV/AIDS and other sexually transmitted infections. A nationally representative sample of 15,683 women aged 15-49 and 12,688 men age 15-59 in 16,650 selected households were interviewed.

2.2. Study Variables

2.2.1. Response Variable

The 2016 EDHS asked women to report any pregnancy loss that occurred in the five years preceding the survey. The response was binary: presence or absence. The response (dependent) variable for the i^{th} mother (15-49) is represented by a random variable Y_i with two possible values coded as 1 and 0. So, the response variable of the i^{th} mother Y_i was measured as a dichotomous variable with possible values $Y_i=1$, if i^{th} mother have experienced adverse pregnancy outcome and $Y_i=0$ otherwise.

$$Y_i = \begin{cases} 1, & \text{if the } i^{th} \text{ experienced adverse pregnancy outcome} \\ 0, & \text{otherwise} \end{cases}$$

2.2.2. Independent Variables

Many explanatory variables are used as predictors of adverse pregnancy outcome. Since based on the reviewed literatures, some of the common predictors that are expected to influence on determinants of adverse pregnancy outcome in Ethiopia were recorded as given below for the purpose of the analysis. These include education level of mother, place of residence, region, marital status, Antenatal care utilization, Place of Delivery, Body mass index (BMI), Smokes cigarettes, Anemia level, Occupation of mother, Maternal age, Wealth Index, Parity.

2.3. Methodology

2.3.1. Statistical Methodology

In this study Descriptive statistics, logistic regression, multilevel logistic regressions and General estimating equation were employed to identify determinant risk factors of adverse pregnancy outcome in Ethiopia. The response variable of the study is experiencing adverse pregnancy outcome prior to the survey. Using multilevel logistic regression model by assuming the occurrence of adverse pregnancy outcome and assessed the effect of determinant factors and regional difference on prevalence of adverse pregnancy outcome.

2.3.2. Multilevel Logistic Regression Model

Multilevel modeling is applied to logistic regression and other generalized linear models in the same way as with linear regression. Multilevel models can be fitted for dependent variables that are categorical outcomes as well as allowing the relationship between the explanatory and dependent variables to be estimated, having taken into account the population structure. Linear and logistic regressions, generalized linear models can be fit to multilevel structures by including coefficients for group indicators and then adding group-level models.

A multilevel logistic regression model also referred to in the literature as a hierarchical model, can account for lack of independence across levels of nested data (i.e, women nested within regions). Standard logistic regression assumes that all experimental units (in this case, women) are independent in the sense that any variables affecting the dependent variable have the same effect in all regions

Multilevel model selection criteria

There are several methods of model selection. Two most commonly used model selection criteria is Information Criterion (AIC) and Bayesian information criteria (BIC). The model with the smallest AIC and BIC value is considered a better fit. When fitting several models to the same data set, it can be helpful to compare those using summary measures of fit.

$$AIC = -2 \times \ln(\text{likelihood}) + 2k$$

$$BIC = -2 \times \ln(\text{likelihood}) + (N) k$$

3. Results and Discussions

The purpose of this chapter is to analyze different factors that determine adverse pregnancy outcome in Ethiopia using data from 2016 Ethiopian Demographic and Health Survey (EDHS). The results of the analysis are divided into the

following sections: descriptive analysis results, binary logistic regression result, results of multilevel analysis and GEE estimation. These results and their discussions are presented in the following sections.

3.1. Descriptive Analysis

The initial population consisted of 15683 women of

reproductive age. Out of this 9694 (61.8%) of women with complete information were selected and studied in the analysis. From the sampled women, the proportion of experiencing adverse pregnancy outcome was about 1282 (13.2%) and 8412 (86.8%) not experiencing adverse pregnancy outcome.

The Random Coefficient Model

Table 1. Result of Parameter Estimate of Random Coefficient Multilevel Model for Anemia and Antenatal care level of women.

Covariates	Estimate	Std. Err.	P> Z	OR	[95% Conf. Interval OR]
Intercept	-5.039	0.315	.00001		
Anemia					
Not anemic (ref)					
Anemic	0.5241	0.0685	.00001	1.6889	1.4767 1.9316
Smoking					
No (ref)					
Yes	-0.5593	0.2961	0.059	0.5715	0.3199 1.0213
Residence					
Rural (ref)					
Urban	-0.3556	0.0798	.00001	0.7007	0.5992 0.8194
Education of mother					
No education (ref)					
Primary	0.4003	0.0727	.00001	1.4922	1.2938 1.7209
Secondary	0.4542	0.1076	.00001	1.5750	1.2754 1.9448
Higher	-0.2266	0.1326	0.087	0.7971	0.6146 1.0338
Marital status					
Married (ref)					
Never in union	1.1498	0.1856	.00001	3.1576	2.1945 4.5433
Living with partner	1.3183	0.3151	.00001	3.7373	2.0151 6.9311
Widowed	1.0333	0.2581	.00001	2.8103	1.6943 4.6616
Divorced	1.3064	0.2185	.00001	3.6929	2.4063 2.4063
Separated	1.5444	0.2752	.00001	4.6854	2.7319 8.0355
Age of mother					
25-34 (ref)					
15-24	0.8246	0.0999	.00001	2.2810	1.8750 2.7749
35 above	1.5333	0.1038	.00001	4.6338	3.7802 5.6803
Body mass index					
Normal (ref)					
Underweight	0.1068	0.0777	0.169	1.1127	0.9554 1.2958
Over weight	0.1816	0.1166	0.116	1.1448	0.956 1.5037
Obesity	0.2165	0.2078	0.297	1.2417	0.8262 1.8661
Occupation of mother					
Not working (ref)					
Working	0.4142	0.0648	.00001	1.513	1.3324 1.7183
Parity					
Multi parity (ref)					
Nulliparous	0.6489	0.2244	0.004	1.9135	1.2325 2.9709
Single para	0.1303	0.2207	0.555	1.1392	0.7391 1.7558
Delivery place					
Home (ref)					
Health facility	0.1057	0.0690	0.125	1.1115	0.9709 1.2725
Antenatal care					
Visit at least once (re)					
No antenatal visit	0.3077	0.0927	0.001	1.3603	1.1343 1.6313

Random-effects Parameters				
	Estimate	Std. Err.	[95% Conf. Interval]	Region: Unstructured
var (Anim)	0.0049	0.0989	0.00011	0.2431
var (ANC)	0.0404	0.0350	0.00739	0.2213
var (_cons)	0.1739	0.0880	0.06447	0.4693
cov (Anim,ANC)	0.0131	0.0168	-0.02004	0.0461
cov (Anim,_cons)	-0.0277	0.0319	-0.09037	0.0348
cov (ANC,_cons)	-0.0616	0.0467	-0.15337	0.030

The value $var(U_{oj})$, $var(U_{ANC})$ and $var(U_{Anim})$ are the estimated variance of intercept and slope of Antenatal care and Anemia respectively. These estimated variances are significant suggesting that intercept and slope of Antenatal care and anemia vary significantly in Ethiopia.

The random coefficient logistic regression model is a multilevel model which has random intercept, like the random intercept model, and random coefficient of predictors, unlike the random intercept model. In random intercept model we allowed the intercept only to vary across regions by fixing explanatory covariates, but the relation between explanatory and dependent variables can differ between groups (regions in our case). Example, in experiencing adverse pregnancy outcome (nesting structure: women within regions) it is possible that the effect of Antenatal care of a woman and anemia level of women on experiencing adverse pregnancy outcome is stronger in some regions than in others.

The effect of Antenatal care of women and anemia level (allowing it to randomly vary between regions) with other fixed effects (by setting the variance of other coefficients zero) on experienced adverse pregnancy outcome. The variance components model which we have just specified and estimated in the preceding section assumes that the only variation between regions is in their intercepts. We should allow for the possibility that the regions have different slopes. This implies that the coefficients of the explanatory variables are random at level two. All variables included in the random intercept model are included in the random coefficient model. Estimates of this model showed that the variance of random slopes of all included variables are zero except for Anemia level and Antenatal care of mother.

The effect of the intercept on region j is estimated to be $-5.039 (0.315) + U_{0j}$ and their variance 0.17396 (Standard error 0.0850926). The intercept variance of 0.17396 (Standard error 0.0850926) is interpreted as the variance between regions when all other variables are held constant (i.e. equal to zero). Their mean is -5.039 (standard error 0.315) and their variance is 0.17396 (Standard error 0.0850926). The between-region variance of slope of Antenatal care is estimated to be 0.040451 (standard error 0.0350804). The individual region slopes of Antenatal care vary about with a variance 0.04045 (standard error 0.03508) and the between-region variance of slope of anemia level is estimated to be 0.004991 (standard error 0.09894). The individual region slopes of anemia level vary

about with a variance 0.004991 (standard error 0.09894). Both the covariance between the random intercept and the random slope for Antenatal care show a negative sign, estimated as -0.0616838 , suggesting that there is an inverse relation between the random intercept and the corresponding random slope. Similarly, covariance between the random intercept and the random slope for anemia level show a negative sign, estimated as -0.0277896 , suggesting that there is an inverse relation between the random intercept and the corresponding random slope (See table 1).

Generally, interpretation of significant covariance terms can be easily made in terms of the correlation coefficients between random intercept and random slopes. Positive covariance/correlation between intercept and slopes implies that regions with higher intercepts tend to have on average higher slopes on the corresponding predictors. The intercept slope correlation, for example intercept and slope of Antenatal care, is estimated as:

$$\rho_{\sigma^2 ANC} = \frac{-5.039}{\sqrt{0.174 * 0.0405}} = -0.581 \text{ (calculated from the results found in table 1)}$$

The negative sign for the correlation between intercepts and slopes implies that regions with higher intercepts tend to have on average lower slopes on the corresponding predictors. This value indicates that women who live in those regions with high of Antenatal care of mother are less likely to be experienced adverse pregnancy outcome than women who live in regions without any of Antenatal care of mother.

$$\rho_{\sigma^2 Anim} = \frac{-0.0277896}{\sqrt{0.00499 * 0.17396}} = -0.943 \text{ (calculated from the results found in table 1)}$$

This value indicates that women who live in those regions with high Anemia level of mother are less likely to be experienced adverse pregnancy outcome than women who live in regions without any experienced adverse pregnancy outcome.

Table 2. The model which has small AIC is best model for the data set of adverse pregnancy outcome in Ethiopia.

	AIC	BIC	Loglik	Deviance
Only random intercept	7502.49	7516.848	-3749.245	7498.49
Random intercept and fixed slope	6896.597	7083.258	-3422.298	6844.6
Random coefficient (Anemia level and Antenatal care)	6900.875	7123.432	-3419.437	6838.87

The random intercept and fixed slope model with small AIC=6896.597 was an improved fit as compared to the rest models for any combination of variables in the data set. The result of parameters of observed variables can be interpreted much the same way as those from the standard logit model.

According to the result of the random intercept model, the fixed part showed that place of residence, educational status, Parity, Occupation status, Anemia level, antenatal care, Marital status and Age of mother were found to be significant variation in the adverse pregnancy outcome among regions (see table 2).

Goodness of Fit Test

An overall evaluation of the multilevel logistic model was assessed using the deviance. The test is done by comparing the deviance of two models by subtracting the smaller deviance from the larger deviance. The difference is a chi-square with the number of degrees of freedom equal to the Number of different parameters in the two models. The significance of this chi square indicates that the model is a good fit. Similarly, it was also assessed by using AIC and BIC. The random intercept and fixed slope model have a significant deviance chi-square and the value of AIC and BIC are less than from the random coefficient model and Random Intercept only model. So, we conclude that the random

intercept and fixed slope model is a good fit.

3.2. Discussions

The study has intended to identify the influential factors for the complicated pregnancy in Ethiopia. Accordingly, different models are fitted.

In order to include the cluster variability, the important working correlation has been considered. If the working correlation $R(\alpha)$ is correctly specified, then the naive variance is consistently equal to robust variance. since $cov(y_i)$ is the true covariance rather than assumed covariance; however if working correlation $R(\alpha)$ is not correctly specified, then only robust variance provides the correct variance for clusters [10]. An appropriate choice of the working correlation matrix (structure) can result in large efficiency gains and bias reduction or elimination. Therefore, it is important to try and choose a working correlation matrix that is close to the true correlation matrix.

The purpose of multilevel model was to evaluate within and between regional variations of adverse pregnancy outcome of mothers in Ethiopia. In the multilevel analysis, women are considering as nested within the various regions in Ethiopia. Multilevel model was step wise, on the first step the intercept only or the empty model was fitted to check whether multilevel effects or heterogeneity exists among the hierarchies [11].

The experiencing adverse pregnancy outcome in Amara, Gambela, SNNPR and Dire Dawa were not significantly differing from that in Addis Ababa. However, women who live in Afar, Somali and Benishangul Gumuz, Harar, Tigray and Oromia regions were significantly more likely to experience adverse pregnancy outcome than those women living in Addis Ababa. This difference might be due socio cultural variations and difference in accessibility of reproductive health services between these regions and this study is consistent with the previous studies [11, 12].

The study also revealed that odds of experiencing adverse pregnancy outcome were significantly associated with the women's age. Women whose age range between 15-24 years were 6.1% more likely to experiencing adverse pregnancy outcome than women whose age range between 25-34 years. On the same way, women whose age range 35 above years were 22.7% more likely to experiencing adverse pregnancy outcome than women whose age range between 15-24 years. Women in higher age group, especially those above 35 years, are more likely to experience adverse pregnancy outcome than those at 24-34 age group. These might be both age extremity are risky for adverse pregnancy of out due to it associated with higher rate maternal complications. This finding is consistent with pervious study [14]. Similarly the similar previous study [13] suggested that risk of adverse pregnancy outcome is increased with age of mother.

This study finding shows the significant association between Antenatal care (ANC) of mother and adverse pregnancy outcome. The odd of adverse pregnancy outcome of women no antenatal visit had 1.373 times more likely than women visit at least once. Visiting antenatal care for at least

once is found to decrease the probability of experiencing adverse pregnancy outcome. Similarly, the finding is correspondence with previous study [15]. Study done in Wollo showed that, Mothers who didn't attend ANC were more than 3 times to have adverse pregnancy outcome, than mothers who attended ANC follow up, OR=3.4. [16]

Another important risk factor for adverse pregnancy outcome in this study is marital status of mothers. Women's who had Never in union, Living with partner, Divorced, Widowed, separated were more likely to experienced adverse pregnancy outcome than married women. These findings agree with the findings of a study which revealed out that with respect to pregnancy, marital status seems to be the significant factor [17, 18]. This is similar to findings from other studies in Ghana [19] which reported that the risk of abortion were higher among unmarried (never married, divorced, or separated).

There was also a significant association between adverse pregnancy outcome and anemia level of mother. According to this study, anemia level of mother increased the risk of having adverse pregnancy outcome of reproductive age of women. This finding is similar with the previous studies [17, 20]. They indicated that suggested that anemia in pregnancy is associated with an increased risk of adverse pregnancy outcomes, such as abortion, still birth, and miscarriage.

In addition, this study revealed that, place of delivery or place of termination of pregnancy is not significantly associated adverse pregnancy outcome. However previous study was documented that those pregnancies delivered at health facilities were less likely to end with adverse pregnancy outcome than those delivered at home [17]. This inconsistency between researches might be due to difference in sample size, data analysis and population across studies.

4. Conclusions

The study is mainly aimed to assess socio-economic, demographic, and medical factors associated with experiencing adverse pregnancy outcome and to estimate within regional and between-regional level of difference of the experiencing adverse pregnancy outcome in Ethiopia. Thus, after a procedural identification of the appropriate model, different possible influential predictors were identified.

From the results of multilevel logistic regression analysis among all the three models, the random intercept and fixed slope multilevel model provided the best fit for the data under consideration for the analysis of within and between regional variations for adverse pregnancy outcome of mothers in Ethiopia. It was concluded that there is heterogeneity of experiencing of adverse pregnancy outcome between and within regions. Additionally, in empty with random intercept model and random intercept and fixed coefficient models the overall variance of the constant term was found to be significant, which reflects the existence of differences in the experienced adverse pregnancy outcome

across region.

In the final model (the random intercept and fixed slope multilevel model), it is found that not having Antenatal care, residing in rural area, working occupational status, being anemic, increased educational level, never married, divorced, or separated marital status, being in age group of 15-24 or >35 years are associated with increased risk of adverse pregnancy outcome among reproductive age group women in Ethiopia. However, in this study, place of delivery, Body mass index, Wealth index and Smoking cigarette were not significantly associated with adverse pregnancy outcome.

Abbreviations

ANC: Antenatal care; APOs: Adverse pregnancy outcomes; AIC: Akaike Information Criterion; BIC: Bayesian information criteria; CSA: Central Statistical Agency; EDHS: Ethiopian Demographic Health Survey; FMOH: Federal Ministry of Health; HLM: Hierarchical linear model; GA: Gestational age; OR: Odd Ratio; PM: Prenatal Mortality; SBR: Still Birth Rate; WHO: World Health Organization.

Declarations

Ethics Approval and Consent to Participate

The data were obtained via online registration to measure the DHS program and downloaded after the purpose of the analysis was communicated and approved.

Availability of Data and Material

The dataset was demanded and retrieved from the DHS website <https://dhsprogram.com> after formal online registration and submission of the project title and detail project description.

Competing Interests

The authors declare that they have no competing interest.

Authors' Contributions

This study was designed and compiled by Mr. Endale Alemayehu (MSc in Biostatistics) as the principal investigator. The development of the basic research questions, identifying the problems and selecting appropriate statistical models have been done by him. Edition of the overall progress of the work and compiling the R-command was supported by Ms. Tsigereda Tilahun

Acknowledgements

We thank EDHS to provide the data to be easily accessible online.

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