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Original Article

Application of Bivariate Multiple Linear Regression on Weight of Children at Birth and Duration of Pregnancy in Ethiopia

Kindu Kebede Gebre[1*], Shimels Kebede Gebre[2], Melkamu A. Zeru[3]

[1]Department of Statistics, College of Computing and Informatics, Haramaya University, Dire Dewa, Ethiopia.
[2]Departments of Software Engineering, University of Electronic Science and Technology of China, Chengdu, China.
[3]Department of Statistics, College of Science, BahirDar University, BahirDar, Ethiopia.

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ABSTRACT

Introduction: Birth weight and gestational age are important determinants of an infant's survival and future development. Low birth weight can be caused by preterm birth or by small gestational age.
The main objective of this research was to identify the determinants of birth weight and gestational age simultaneously based on Ethiopia's demographic health survey in 2016 which implemented in a statistical package R.
Methods: Cross-sectional study design was used from Ethiopia's demographic health survey in 2016. The bi-variate linear regression model was used to identify factors of birth weight and gestational age simultaneously which had small standard errors as compared to a separate model.
Results: Bi-variate models of birth weight and gestational age determined the effect of predictors. Therefore, the model shows that the number of tetanus injections before pregnancy, educational level of a husband, desire for more children, drink alcohol, and region are statistically significant at 5% level of significance for gestational age in Ethiopia. Similarly, the size or height of a child at birth, preferred waiting time to another birth or birth interval, the number of tetanus injections before pregnancy was statistically associated with birth weight at 5% level of significance.
Conclusion: From our finding, we concluded that the number of tetanus injections before pregnancy, educational level of a husband, desire for more children, alcohol drink, size or height of a child at birth, preferred waiting time or birth interval for another birth and region were significant predictors of birth weight and gestational age simultaneously at 5% level of significance. Hence, special care should be given to the pregnant during prenatal care for minimizing the risk of low birth weight and small gestational age.

*.Corresponding Author: m7.kebede@gmail.com

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Introduction

Birth weight and gestational age are the most important and reliable indicator for neonatal and infant survival, physical growth and mental development. Birth weight and gestational age are also important determinant of an infant's survival and future development. The risk of death, illness of newborn and adulthood increase when the birth weight of child is low and growth potential decreased.

Globally, low birth weight contributes 40 to 60 percent of newborn mortality. But, low birth weight can be caused by preterm birth or by intrauterine growth restriction.[9] Birth weight is the first weight of newborn obtained after birth, preferably measured within the 1st hour of life before significant postnatal weight loss has occurred.[1, 10]

Worldwide, out of 139 million live births, about 20 million of them are low birth weight and nearly 95.6 percent of them are in developing countries. The risk of death increase on the new born early in life, and exposes to multiple health and development challenges due to low birth weight.[11]

The burden of immediate health problems on the low birth weight of newborns has been relatively widely documented in many low-income countries with national demographic surveys.[11, 6]The estimated percentage of all babies who born low birth weight found in Sub-Saharan Africa is 13% in each year.[6]

The proportion of low birth weight in health facilities has been least documented in south Ethiopia.[6] Birth occurring before 37 completed weeks of gestation comprises nearly 15 million babies each year with a survival chance varying dramatically around the world.[4, 2] South Asia and Sub-Saharan Africa account for almost two-thirds of the world's preterm babies and over three-quarters of the world's newborn deaths are due to preterm birth complications.[2]

Gestational weight gain is higher than ever before with approximately 40 percent of pregnant women gaining more weight than it recommended.[5]

Several studies have been done in this issues using binary logistic regression model separately and it should not be considering the correlation among predictor variables. The researcher was used code for fit model and the code is completely arbitrary i.e recoding the dependent variable can give very different results. Binary logistic regression jumps the gap by assuming that the dependent variable is a stochastic event, and the dependent variable describes the outcome of this stochastic event with a density function. Binary logistic regression is robust against multivariate normality and it is better suited for smaller samples than a multivariate regression model.

However under this study would have been solved those problem listed above by using bivariate regression model to predict the value of two responses variables simultaneously from a set of predictors.In addition it can also be used to estimate the linear association between the predictors and both responses variables. But it minimizes the sum of the squared distances of each observed response to its fitted value, and residuals to be equal for each level of the predicted dependent variable values. The main objective of this study was to identify the factors that affect birth weight and gestational age simultaneously based on Ethiopia's demographic health survey 2016 data.

Materials and Methods

A cross-sectional study conducted to assess factors that affect birth weight and gestational age jointly among pregnant women in enrolled Ethiopia demographic and health survey 2016.

Study Area and Population

This study was carried out in Ethiopia based on demographic and health survey 2016. The study included pregnant women who participated in this demographic and health survey of the country.

Data Collection Procedures

This research utilized Ethiopia demographic and health survey in 2016 which is the fourth comprehensive and nationally representative population and health survey.
It is an important feature of the data set that avails in-depth information on demographic and health aspects of households. The data was collected by the central statistical agency which requested by Ethiopia ministry of health. Data collection took place from January 18, 2016, to June 27, 2016.[3]

Inclusion Criteria of the Study

Mothers who are pregnant and remember her child birth weight and gestational age which record from January 18, 2016, to June 27, 2016, were included in the study.

Exclusion Criteria of the Study

Mothers who are not pregnant and not remember her child birth weight and gestational age which record from below January 18, 2016, and above June 27, 2016, were not included in the study.

Variables Included in the Study

The response variables considered in this study are birth weight and gestational age of a child. The fixed socio-demographic factors that expected to associate with birth weight and gestational age simultaneously were indicated in Table1.

Operational Definition

Gestational age is the common term used during pregnancy to describe how far along the pregnancy.
Birth Weight is the first weight of baby, taken just after he or she is born.
Size of Child at Birth is the height of child, taken just after he or she is born.
Preferred waiting time to another birth is the birth interval time between two births or the difference between birth date of child and birth date of preceding child.

Statistical Analysis

Bi-variate Multiple Linear Regression Models
Under this study, we used bi-variate multiple linear regression models. The model is multiple since we have p>1 predictors with a linear function of parameters ($\alpha_0, \alpha_1, \alpha_2, \alpha_3, ..., \alpha_p$) and the model is bi-variate because we have two response variables. The regression model with response variables (u_1 and u_2) as a function of predictor variables ($x_1, \ldots, x_p$) were assumed to follow its regression model, so that the matrix U has two response u1 and u2 with sample size "n" observation shown below.

Table 1. Description of variables in the study

Variables	Factor Categories
Sex of the child	0=Male, 1=Female
Source of Water Supply	0=Unimproved, 1=Improved
Number of antenatal visits	Count
HIV status of mother	0=No, 1=Yes
Region	1=Tigray, 2=Afar, 3=Amhara, 4= Oromo 5=Somali, 6=Benishangul, 7=SNNPR, 8=Gambela 9=Harari,10=Addis Adaba, 11=Dire Dawa
Tetanus injection before birth	0=No, 1=1-3 times, 2=4-6 times 3>7times, 4=Did not known
Tetanus injection before pregnancy	0=No, 1=1-3times, 2=4-6times 3>7times, 4=Did not known
Live birth between births	0=No, 1=Yes
Desire for more children	1=Wants within 2 years, 2=Wants after 2+ years 3=Wants, unsure timing, 4=Undecided 5=Wants no more, 6=Respondent or partner 7=Declared infecund, 8=Never had sex
Wealth index	1=Poorest, 2=Poorer, 3=Middle, 4=Richer 5=Richest
Total children ever born	Count
Size or height of Child at Birth	1= Very large, 2= Larger than average 3=Average, 4=Smaller than average 5=Very small, 8=Not known
Smokes Cigarettes	0=No, 1=Yes
Mother drink alcohol	0=No, 1=Yes
Place of residence	1=Urban , 2=Rural
Distance to health facility	0=No, 1=Yes
Age groups	1=15-19, 2=20-24, 3=25-29, 4> 30years
Preferred waiting time to another birth or birth interval	0<12 months,1=1 Year, 2=2 Year, 3=3 Year, 4= 4 Year, 5=5 Year, 6=6 Year, 7=7 Year, 8=8 Year
Timing of 1stantenatal check (months)	Continuous
Antenatal care: government hospital	0=No, 1=Yes
Antenatal care: private hospital	0=No, 1=Yes
Frequency of reading newspaper or magazine	0=No, 1=Less than once a week, 2=At least once a week, 3=Always
Frequency of listening radio	0=No, 1=Less than once a week 2=At least once a week, 3=Always
Frequency of watching television	0=No, 1=Less than once a week 2=At least once a week, 3=Always
Age at first sex	Continues

$$U = \begin{bmatrix} u11 & u12 \\ u21 & u22 \\ u31 & u32 \\ . & . \\ . & . \\ un1 & un2 \end{bmatrix}$$

$$X = \begin{bmatrix} x11 & \cdots & xp1 \\ \vdots & \ddots & \vdots \\ x1n & \cdots & xpn \end{bmatrix}$$

$$\beta = \begin{bmatrix} a01 & a02 \\ a11 & a12 \\ a21 & a22 \\ . & . \\ . & . \\ ap1 & ap2 \end{bmatrix}$$

$$\Sigma = \begin{bmatrix} \mathcal{E}11 & \mathcal{E}12 \\ \mathcal{E}21 & \mathcal{E}22 \\ \mathcal{E}31 & \mathcal{E}32 \\ . & . \\ . & . \\ \mathcal{E}n1 & \mathcal{E}n2 \end{bmatrix}$$

The error term for the first response variable has E (E_{11}) = E (En_1) = 0 and var (E_{11}) = var (En_1) $=\sigma^2$. Likewise, the error for each observation for the second response variable has E (E_{12}) = E (En_2) = 0 and var (E_{12}) = var(En_2) = σ^2 .Thus, the error terms associated with different responses on the same trial are correlated.

The bi-variate multiple regression model has unknown parameters. The parameter's value is obtained from parameter estimation. According to Nkurunziza[8] least-squares estimation is the mostly used estimation method which was used to minimize the sums of squares elements on the diagonal of the residual sum of squares and cross products matrix which has the smallest possible trace. The individual coefficients and standard errors produced by bi-variate linear regression are identical to the model produced by regress each response against the set of independent variables separately. Bivariate linear regression is used to estimate the joint estimator and it helps to estimates the between equation covariance.

There are various selection methods for linear regression modeling to specify how independent variables are entered into the analysis. A variety of regression models from the same set of variables were constructed. David J and Lilja backward elimination process were preferred because it is usually straightforward to determine which factor we should drop at each step of the process.[7] Therefore, under this study we used backward elimination. This study also used different model diagnostic frameworks for identifying, analyzing and interpreting data in a given context to identify the determinants of the response variables.

A first step of regression diagnosis is inspecting the significance regression beta coefficients as well as the coefficients of determination (R^2) that tells us how well the linear regression model fit to the data. For this study, we used plots of residuals vs fitted, normal Q-Q and scale location (spread-location).

The goodness of fitted model is used to typically summarize the discrepancy between observed values.This study was assessed by using residuals, outlier detection, a global measure of variance explained, and coefficient of determination.

Results

A cross-sectional study was conducted in this study by considering 1996 pregnant women which were collected by Ethiopia minster of health and central statistical agency. The result in Table 2, shows that the average duration of pregnancy for non-educating, primary,

Table 2. Descriptive Analysis of Explanatory Variables

Levels	Gestational Age		Birth Weight		Total
	Mean (SE)	SD	Mean (SE)	SD	Count (%)
Mother					
No education	35.98 (0.03)	0.58	3.22 (0.04)	0.90	526 (26.4)
Educational					
Primary	35.9 (0.04)	0.97	3.32 (0.03)	0.89	761 (38.1)
Level					
Secondary	35.78 (0.06)	1.18	3.24 (0.04)	0.71	403 (20.2)
Higher	35.71 (0.08)	1.38	3.30 (0.04)	0.70	306 (15.3)
Region					
Tigray	35.96 (0.03)	0.54	3.30 (0.05)	0.78	275 (13.8)
Afar	35.58 (0.29)	1.81	3.03 (0.16)	0.96	38 (1.9)
Amhara	35.86 (0.08)	0.75	3.00 (0.10)	0.87	83 (4.2)
Oromiya	35.82 (0.10)	1.20	3.35 (0.09)	1.05	132 (6.6)
Somali	35.97 (0.03)	0.33	3.31 (0.08)	0.93	145 (7.3)
Benishangul	36.03 (0.07)	0.87	3.19 (0.06)	0.75	149 (7.5)
Gambela	35.52 (0.11)	1.44	3.18 (0.06)	0.80	184 (9.2)
SNNPR	35.98 (0.07)	0.98	3.50 (0.08)	1.12	168 (8.4)
Dire Dewa	35.86 (0.07)	1.07	3.30 (0.05)	0.76	206 (10.03)
Addis Abeba	35.81 (0.06)	1.25	3.16 (0.03)	0.66	394 (19.7)
Harari	35.96 (0.04)	0.56	3.43 (0.05)	0.72	222 (11.1)
Size of Child at birth or height of child at birth					
Very large	35.9 (0.04)	0 .75	3.97 (0.04)	0.92	453 (22.7)
Average	35.93 (0.03)	0.83	3.12 (0.02)	0.57	353 (17.7)
Large than average	35.92 (0.03)	0.63	3.50 (0.03)	0.58	848 (42.5)
Smaller than average	35.87 (0.09)	1.01	2.59 (0.05)	0.61	125 (6.3)
Very small	35.41 (0.14)	2.03	2.44 (0.05)	0.66	216 (10.4)
Don’t know	36.00 (0)	0	3.10 (0)	0	1 (0.1)
Preferred waiting time for birth or birth interval					
<1 year	35.80 (0.08)	1.06	3.30 (0.06)	0.87	276 (20.9)
2 year	35.86 (0.06)	0.92	3.29 (0.06)	0.84	204 (15.5)
3 year	35.92 (0.06)	0.86	3.20 (0.05)	0.81	237 (18)
4 year	35.89 (0.08)	0.94	3.17 (0.07)	0.83	144 (10.9)
5year	35.82 (0.07)	1.06	3.28 (0.06)	0.84	224 (17.0)
>6 year	35.79 (0.12)	1.44	3.21 (0.06)	0.80	232 (17.6)
Desire for more children					
Wants within 2 years	35.88 (0.05)	0.90	3.28 (0.05)	0.88	276 (13.8)
Wants after 2 years	35.85 (0.04)	1.15	3.26 (0.03)	0.83	961 (48.1)
Wants, unsure timing	36.05 (0.11)	1.01	3.31 (0.09)	0.77	80 (4)
Undecided	35.74 (0.15)	1.34	3.19 (0.09)	0.83	78 (3.9)
Wants no more	35.90 (0.03)	0.71	3.30 (0.03)	0.84	589 (29.5)
Sterilized	34.86 (0.74)	1.95	3.29 (0.36)	0.95	7 (0.4)
Declared in fecund	36.00 (0)	0	3.10 (0.10)	0.22	5 (0.3)
Mother drink alcohol					
No	35.90 (0.03)	1.02	3.28 (0.02)	0.87	295 (14.8)
Yes	35.81 (0.04)	0.99	3.26 (0.03)	0.77	1701 (85.2)

secondary and higher educated were 35.98, 35.90, 35.78 and 35.71 weeks respectively. And also, the standard deviation of gestational age for non-educating, primary, secondary and higher educated were 0.58, 0.97, 1.18,and 1.38 weeks away from mean respectively. Moreover, the standard error of duration of pregnancy for non-educating, primary, secondary and higher educated were 0.03, 0.04, 0.06 and 0.08 respectively and concluded that sample mean is a more accurate reflection of the actual population mean.

From region point of view, the average duration of pregnancy for mother who lives SNNPR and Gambela were 35.98 and 35.52 respectively. Furthermore, the standard deviation of the duration of pregnancy mothers who live in Somali region and Afar region were 0.33 and 1.81 respectively. The standard error of duration of pregnancy for mother who lives Tigray and Somali was low which shows the sample means an accurate reflection of the actual population mean. But the standard error of duration of pregnancy for mother who lives Oromiya, Afar, and Gambela was high which show the samples mean a less accurate reflection of the actual population mean.

Mothers who lived in Ethiopia were used different birth interval or preferred waiting time to another birth of child. Therefore, the average duration of pregnancy for mothers who preferred less than 1 year and greater than 5-year waiting time for another birth or birth interval was a little over 35.80 weeks. However, the standard deviation for mother who preferred less than 1 year and greater than 5-year waiting time or birth interval to another birth was a little over 1.06 and it shows that the individual mother had on average were a little over 1.06 weeks away from mean. Furthermore, the sample mean of gestational age shows a less accurate reflection of the actual population mean when the pregnant is received greater than 7 times tetanus injections before birth.

The average birth weight for non-educating, primary, secondary and higher educated were 3.22, 3.32, 3.24 and 3.30 kg respectively. In addition, the standard deviation of birth weight for non- educating, primary, secondary and higher educated were 0.90, 0.89, 0.71, and 0.70 kg respectively. It shows that the individual mother had on average been a little over 0.7 kg away from mean. Similarly, the standard error of birth weight for non-educating, primary, secondary and higher educated were 0.04, 0.03, 0.04 and 0.04 respectively and concluded that sample mean is a more accurate reflection of the actual population mean.

The average birth weight of a child whose mother lives Amhara, afar and SNNPR were 3.00, 3.03 and 3.50 kg respectively. The standard deviation of birth weight for a child whose mothers lives Amhara, Afar and SNNPR were 0.87, 0.96 and 1.12 kg respectively. But, the standard error of birth weight for a child whose mother lives Addis Ababa was low which shows the samples mean is the accurate reflection of the actual population means. Likewise, the standard error of birth weight for a child whose mother lives Afar and Amhara were high which shows the sample means a less accurate reflection of the actual population mean.

Finally, the average birth weight for a child whose mothers preferred less than 1 year and greater than 5-year waiting time or birth interval to another birth was a little over 3.21 kg. However, the standard deviation for a child whose mother preferred less than 1 year and greater than 5-year waiting time or birth

Table 3. Summary for Comparison of Bivariate Linear Regression Models

Methods	Without interaction of Covariates		With interaction of Covariates	
	Birth Weight	Gestational Age	Birth Weight	Gestational Age
R^2	0.75	0.84	0.72	0.81
Adjusted R^2	0.74	0.83	0.70	0.80

Table 4. Parameter estimation of bi-variate multiple linear regression model

Birth Weight			Gestational Age		
Effect	Estimate	P value	Effect	Estimate	P value
Intercept			Intercept		
Size of child (very large=ref)	4.60	1.1e-09***	size of child (very large=ref)	9.59	2e-16 ***
Average size	-0.61	0.015*	Average size	0.01	0.827
Smaller than average size	-1.22	0.001**	Smaller than average size	0.018	0.654
Very small size	-0.98	0.012*	Very small size	0.024	0.708
Tetanus injection (no=ref)			Tetanus injection(no=ref)		
4-6 times	3.31	0.006**	4-6 times	-0.16	0.041*
Preferred wait time (<1year=ref)			Region (Tigry=ref)		
3 year wait	-0.79	0.034*	Oromiya	-0.56	1.7e-5 ***
4 year wait	-0.88	0.035*			
Drink alcohol (no= ref)			Drink alcohol (no= ref)		
Yes	0.06	0.47	Yes	0.11	0.029*
Husband education level (no=ref)			husband education level (no=ref)		
Higher	-0.109	0.44	Higher	0.17	0.032*
Desire more child (2years=ref)			Desire more child (2years=ref)		
Undecided	-0.033	0.895	Undecided	-0.69	0.002***
Sterilized	-0.327	0.657	Sterilized	-0.70	0.021*
R^2	0.75	0.005***		0.84	0.001***

v, Ref stands for reference category

interval to another birth was a little over 0.80 which shows that the individual mother had on average were a little over 0.80 kilogram away from mean. The sample
mean of birth weight is a less accurate reflection of the actual population mean when the pregnant who received greater than 7 times tetanus injections before birth. Children who born in Ethiopia had different size or height at birth and the average duration of pregnancy for a child who has very large, average, and smaller size or height at birth was a little over 35.9,35.93 and 35.87 weeks respectively.

Comparison of Bivariate Linear Regression Models

In order to determine the associated factors in cross-sectional data analysis, it was better to fit regression model when the outcomes variables are continuous nature. We have been considered two regression models were used such as bivariate linear regression models without interaction and bivariate linear regression models with interaction that was identify the appropriated model to the data sets. The result in Table 3 depicted that bivariate linear regression models without interaction having more explanation about the variability of birth weight and gestational age is determined by the associated factors. Bivariate linear regression models without interaction had the highest adjusted coefficient of determination and coefficient of determination as compared other candidate models which were fitted to the dataset very well. Finally, this study applied bivariate linear regression models without interaction is better model fit to made investigation of birth weight and gestational age of child.

Results of Fitting Bivariate Multiple Linear Regression Model

This study used mathematical and graphical techniques to check model assumption. Firstly, this study was used E-statistic to test multivariate normality and it showed that data is multi-variate normality with a P-value equal to 0.825.
Secondly, this study was used plots like the residual and QQ plots which are given in Figure 1. The purpose of the quantile-quantile (QQ) plot was used to check bivariate normality of birth weight and gestational age of children. The normal distribution was the base distribution and its quantiles were plotted along the x-axis as the theoretical Quantiles while the sample quantiles were plotted along the y-axis. Therefore, the QQ plot (Figure 1-B.) confirms the points match up along a straight line which shows that the quantiles match and data sets come from bivariate normal distribution. Similarly, the residual versus fitted plot were plotted along the x-axis as the residuals while the fitted or estimated of birth weight and gestational age of children were plotted along the y-axis. Moreover, the residual versus fitted plot was used to verify the assumption that the residuals are randomly distributed and have constant variance. Figure 1-A also confirms the points should fall randomly on both sides of zero, with no recognizable patterns in the points which is confirm linearity and constant variances.

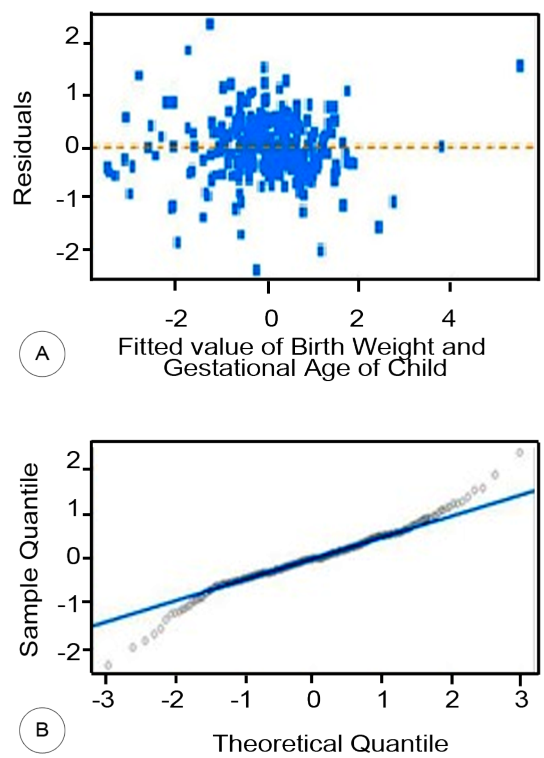

Figure 1. Residual Plot (A) and Quantile-Quantile Plot (B)

The candidate variable selection was done using uni-variable bivariate models for each covariate and evaluates it at 0.25 significance levels. Based on the uni-variable results of bivariate models size of a child or height of child at birth, number of tetanus injection before birth, number of tetanus injection before pregnancy, preferred wait time, age group, drink alcohol, husband education level, desire more a child, region, and mother educational level were associated with birth weight and gestational age of a child at 25% level of significance. Bi-variate multiple linear regression model of birth weight and gestational age well fitted to the data which has small standard error and its result shown on Table 3. The fitted bi-variate linear regression models that relating birth weight and gestational age with the explanatory variables is given as: Birth Weight = -0.61 average size – 1.22 smaller than average size – 0.98 Very small size +3.31 tetanus injection for 4 up to 6 times -0.97 preferred waiting time 3 years for other born – 0.88 preferred waiting time 4 year for other born Gestational age = 9.59 - 0.16 tetanus injection for 4 up to 6 times - 0.56 mother live Oromiaya + 0.11 drink alcohol + 0.17 higher educational level of husband-0.69 undecided desire to born more child - 0.70 sterilized desire.

From bivariate model results the size of child or height of child at birth, number of tetanus injection, preferred waiting time to another birth or birth interval, drinking alcohol status of mother, husband or father educational level, and mothers desire or plan to have more child were associated predictors for both birth weight and gestational age. Therefore, the average birth weight of a child who has average size or height at birth decreased by factor 0.61 as compared to a child who has a very large size or height at birth when the effect of other variables constant. Finally, Table 3 shows about 75% and 84% of the variation in birth weight and gestational age was explained by those significant explanatory variables respectively.

Discussion

The main objectives of this study were determining the factors that significantly affect the birth weight and gestational age simultaneously. This study focused on bivariate analysis of birth weight and gestational age based on Ethiopia's demographic health survey in 2016. Descriptive statistics and bivariate model were employed to determine the covariate effects on both birth weight and gestational age jointly in Ethiopia. There are 1996 pregnant women were included in this study. The results of the final model of bivariate model showed that the number of tetanus injections before pregnancy, educational level of husband, desire for more children, drink alcohol, size or height of a child at birth, preferred waiting time to another birth or birth interval and region were the potential determinants of birth weight and gestational age simultaneously at 5% level of significance.

Size or height of a child at birth had significantly associated with birth weight and the parameter estimation indicates that the mean birth weight of a child who has smaller height than the average size or height at birth decreased by factor 1.22 as compared to a child who has a very large size or height at birth. In addition the mean weight of a child who has average size and very small size at birth decreased by factor 0.61 as compared to a child who has a very large size at birth. This result confirmed with study done in Toronto, Canada, which was suggested that the correlation between birth weight of a child and the size of a child at birth is strong. And also, maternal body mass index and gestational age was strong.[12, 14]

Number of tetanus injections before pregnancy is another potential determinant of birth weight. The number of tetanus injections before pregnancy significantly associated with birth weight of child. Therefore, the mean birth weight of a child whose mother received injections of tetanus between 4 up to 6 times before birth increased by a factor of 3.31 as compared with mothers who have not received injections of tetanus before birth. This result lined with the previous study which was shows many vaccine-preventable diseases cause substantial morbidity and mortality in pregnant women, neonates, and infants in America, the United States. And also, another study was done in Bahirdar, Ethiopia shows that maternal nutritional advice, iron-folic acid supplementation, tetanus toxoid vaccination, maternal educational status, parity and maternal age were determinants for birth weight and gestational age of children.[15, 16]

Preferred waiting time to another birth or birth interval had significantly associated with birth weight and it indicates that the mean of birth weight whose mothers has three years birth interval for another birth of child were decreased by factor 0.79 as compared to those who has less than one year birth interval for another birth of child. Likewise, the mean of birth weight whose mothers has four years birth interval for another birth of child decreased by factor 0.88 as compared to to those who has less than one year birth interval for another birth of child. The result consistent with the study conducted in Bangladesh found that very short inter-outcome intervals were generally more detrimental when following a live birth or stillbirth than when following a preceding miscarriage or induced abortion.[13]

Similarly, number of tetanus injections before pregnancy is also potential determinant of gestational age and the parameter estimation indicates that the mean of the gestational age of the mother who received injections of tetanus between 4 up to 6 times before birth were decreased by a factor of 0.16 as compared with mothers who have not received injections of tetanus before birth. This result is linked with the previous study in America shows that the tetanus vaccination in pregnant women and women of child bearing age were highly associated.[15] In addition, the mean of gestational age for mothers who lived Oromiaya decreased by factor 0.56 as compared to those who lived Tigray. Furthermore, drinking status of mothers also the determinant of gestational age of child and it indicates that the mean of gestational age for mothers who drink alcohol were increased by factor 0.11 as compared to those who were not drinking alcohol. This result is linked with the previous study in Brazil.[18]

Finally, the mean of gestational age of child for fathers who had higher education were increased by factor 0.17 as compared to non-educated. This result is in line with the previous study in America.[17] he mean of gestational age whose mother wants of more desire of a child to be undecided for birth was decreased by factor 0.69 as compared to those wants more children within 2 years intervals. The mean of gestational age whose mother wants to be sterilized or block birth increased by factor 0.7 as compared to those wants more children within 2 years intervals.

Conclusion

This study determines the associated factors of birth weight and gestational age among pregnant women in Ethiopia simultaneously. This finding shows that preferred waiting time to another birth or birth interval, size or height of child at birth and number of tetanus injections before pregnancy are statistically significant predictors for birth weight in Ethiopia at a 5% level of significance. On the other hand, the number of tetanus injections before pregnancy, educational level of husband, desire or wants to have more children, drink alcohol, and region are statistically significant explanatory variables for gestational age in Ethiopia at a 5% level of significance. The risk of low birth weight increased when mother received less tetanus injection during pregnancy and a parent prefers more number of waiting time or birth interval to birth another child in Ethiopia. The risk of small gestational age increased when the mother received more tetanus injection during pregnancy and parent were non-educated in Ethiopia.

Abbreviation

HIV: Human immunodeficiency virus; DHS: Demographic and health survey; SNNPR: Southern Nations Nationality and peoples Region; EDHS: Ethiopia demographic and health survey; kg; kilogram.

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Availability of data and material

The raw data used in this study can be accessed from the DHS website http://www.dhsmeasures.

Authors' contributions

KK have made substantial contribution to conception, design, and interpretation of data. SK made analysis of data. MY involved in drafting the manuscript, revising it critically for important intellectual content and all have given final approval of the version to be published.
Ethics approval and consent to participate
Letter of consent was received from the measure of EDHS International Program ,which authorized the data sets. All the data that used in this study are publicly available. Confidentiality of data maintained anonymously.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Appendix

R-codes for data Analysis

```
library(MASS)
library(MVN)
MV1<-mvn(data=dataname, mvnTest="energy",
univariatePlot ="qqplot")
MV2<-mvn(data=w, mvnTest="energy",
univariatePlot ="histogram")
corlat<-cor(GA, NeBW)
w=as.matrix(dataname[,c(18,20)])
MVmodel<lm(w~as.factor(Size_child)+as.
factor(wealth_index)+as.factor(number_
befbirth)+as.factor(number_befpre)+as.
```

```
factor(Region)+as.factor(educ_l)+as.factor(alchool)+familiy_size+as.factor(husband_partner_edu_le)+as.factor(anemia_level)+as.factor(sex_child)+as.factor(Preferred)+as.factor(desire)+as.factor(live_birth))
Summary (MVmodel)
plot(fitted(MVmodel), resid(MVmodel), col = "dodgerblue",
pch = 20, cex = 1.5, xlab = "Fitted", ylab = "Residuals")
abline(h = 0, lty = 2, col = "darkorange", lwd = 2)
qqnorm(resid(MVmodel), main = "Normal Q-Q Plot", col = "darkgrey")
qqline(resid(MVmodel), col = "dodgerblue", lwd = 2)
```

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