Original Research Article

Determinants of low birth weight in the Lower Manya Krobo Municipality of the Eastern region of Ghana

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ABSTRACT

Background: Low birth weight refers to new borns weighting less than 2.5 kg at birth. In November 2017, the WHO reported a global prevalence of 15.5% with 96.5% of these cases happening in developing countries. Whilst this is a global canker, the risk factors differ from locality to locality. This study aims at determining which maternal factors explains low birth weight baby delivery in the Lower Manya Krobo Municipality.
Methods: The chi-square test for independence was used to test for independence. The binary logistic model is fitted for the associated factors. The receiver operating characteristic (ROC) is used to classify unbiased estimators.
Results: ANC (yes β= -2.769 sig.=0.000); Alcohol (none β=-1.479 sig.=0.000, occasionally β= −2.043 sig.=0.000); Age (<20years β=0.178 sig. =0.676, 20 to 25years β= -1.487 sig.=0.000, 26 to 30 β= -0.941 sig.=0.086); Education level (None β=2.778 sig. =0.000, primary β=3.090 sig.=0.000, JHS β=1.913 sig.=0.002, SHS/Secondary β=1.951 sig.=0.000); Exposure to Heat (Yes β=4.507 sig.=0.000). AUC education=0.67, 95% CI=0.6,0.7 and AUC Exposure to heat=0.73, 95% CI=0.68,0.77 of low birth weight.
Conclusions: Social status was not significant factor. Mothers exposed to heat had the highest risk (odds=90 times). Adolescent mothers stand high risk with odds 1.195. Mothers who attended antenatal clinics were at 94% less likelihood. Mild drinkers had lesser risk compared to no and heavy drinkers. Mothers with primary education (odds=21 times) were the riskiest compared to mothers with tertiary education. This differs from researches where no education mothers were riskiest. Only mother's exposure to heat was found to be fairly good unbiased estimators.

Keywords: ANC, JHS, Low birth weight, Lower Manya Krobo, SHS

INTRODUCTION

Low birth weight is defined by the World Health Organisation (WHO) as new-borns weighing less than 2,500 gram (2.5kg or 5.5pounds) at birth with the measurement taken within the first hour of life.[1] Low birth weight among several others is a major contributor of child deaths, as well as disabilities globally although it is largely preventable.[2-6] In November 2017, the WHO reported a global prevalence of 15.5% out of which 96.5% of these cases are in developing countries.[1,3] Inspite of the various health policies introduced to reduce child mortality, low birth rate in Ghana is still about 10.70% of births.[7-10] Low birth weight is a large contributor to child mortality but is very much avoidable with the right life style and nutrition.[2,11-14] However, a review of some studies showed that the determinants of low birth weight vary from locality to locality.

According to Michael Ofori Fosu, Iddrisu Abdul-Rahaman and Riskatu Yekeen (2013); maternal age, fetal infection, antenatal care and residence and haemoglobin level (anaemia in pregnancy), are significant risk factors associated with low birth weight.[15] Gestational age and new borns sex were not significant. Their study was in the Manhyia District Hospital in the Ashanti Region of Ghana.

Anthony Mwinilanaa Tampah-Naah, et al assessed risk factors; age, ever attended school, currently married or living with a man, wealth quintile, area, region, delivered by caesarean section, times received antenatal care, took medicine to prevent malaria and parity. Among these, the maternal factors they found to be significant were educational status and marital status.[16]

Faith Agbozo et al did a study in the Hohoe municipality on the factors parity, age and intermittent preventive treatment of malaria and sex of infant. It was only age and whether you were first born that were significant.[17]

In 2017, Afeke Innocent et al, did a study on maternal age, low birth weight and early neonatal death in Tertiary Hospital in the Volta Region of Ghana. Their results suggest that teenage mothers have a higher risk of giving birth to pre-term babies than the adult mothers. They concluded that early neonatal deaths resulting from low birth weight are still high in the Volta region of Ghana.[18]

From the above reviews it shows that risk factors differ from locality to locality. This difference has necessitated immediate district based scientific research. The Lower Manya Krobo Municipality is one district where there has not been enough of such study done.

The objective of this study is to determine whether age of mothers, mother's social status, drinking of alcohol, ANC attendance, Exposure to heat and Educational background has any influence on whether a mother will give birth to a low weight baby or not.

METHODS

Secondary categorical data was obtained for the study. The data was collected from the maternity unit of the Municipal Health Center, St. Martins Depores Hospital at Agormanya in the Lower Manya Krobo Municipality. This study uses information on all births recorded at the Hospital from January 2016 up to November 2016.

Test for association

The Pearson chi-square test was used to test for independence. Authors accept or reject the null hypothesis that the observed frequency distribution is the same as the theoretical distribution based on whether the test statistic exceeds the critical value.[19] If the test statistic exceeds the critical value then the null hypothesis (H_0=the maternal factor stated is independent of the

response, low birth weight delivery) can be rejected, and the alternative hypothesis (H_1= the response variable, delivering low birth weight is dependent on the maternal factor stated) can be accepted, both with the selected level of confidence.[19] The nature of this relationship however, is not specified or explained by the chi-square test.

The value of the test statistic is:

$$X^2 = N \sum_{i,j} p_{.i}p_{.j} \left(\frac{(O_{i,j}/N) - p_{.i}p_{.j}}{p_{.i}p_{.j}} \right)^2$$

Binary logistic regression

Since the chi-square test does not tell us of the nature of the association the response has with the determinant factor, authors perform a further test. In essence the logistic regression model predicts the logit of the binary response(Y) from the explanatory variable(X). The simplest logistic regression model is represented by:

$$\text{Logit}[\pi(x)] = \ln\left[\frac{\pi(x)}{1-\pi(x)}\right] = \alpha + \beta x.$$

This equation equates the logit link function to the linear predictor.[20] This equation predicts the probability of the occurrence Y, given X. The parameter β in the equation determines the change that is whether $\pi(x)$ is increasing or decreasing as x changes from one category level to the other. The multiple logistic regression extends the binary logit with single predictors to models with multiple explanatory variables with several categories.

The model for $\pi(x)$, at values $x_i = (x_1, x_2, x_3, \ldots \ldots \ldots x_p)$ of p predictors is:

$$\text{Logit}[\pi(x)] = \alpha + \beta_1 x_2 + \beta_2 x_2 + \cdots \ldots \ldots + \beta_p x_p$$

In this study, the alternative formula directly specifying $\pi(x)$ is used. That is:

$$\Pr(Y/X) = \pi(x)$$
$$= \frac{\exp(\alpha + \beta_1 x_1 + \beta_2 x_2 + \cdots \ldots + \beta_p x_p)}{1 + \exp(\alpha + \beta_1 x_1 + \beta_2 x_2 + \cdots \ldots + \beta_p x_p)}$$

The dependent variable is Y=Low Birth Weight=1 (yes), or 0 (no).

Independent variables are:

Maternal age = 1 (less than 20), 2 (20 to 25), 3 (26 to 30), 4 (above 30).

Educational level = 1 (none), 2 (Primary), 3 (JHS), 4 (Secondary), 5 (Tertiary).

Alcohol intake of mother = 1 (never), 2 (occasionally), 3 (heavy).

Exposure to Heat = 1 (yes), 2 (no).

Antenatal Clinic attendance = 1 (yes), 2 (no).

Social Status = 1 (lower), 2 (mild), 3 (upper).

The parameter β_1 refers to the effect of x_1 on the log odds that Y = 1, controlling the other x_j. Hence, $\exp(\beta_1)$ is the multiplicative effect on the odds of a 1 unit increase in x_1, at a fixed level of other x_j.

The odds ratio is described by Agresti as another measure of association between paired variables.[20] It occurs as a parameter in the most important type of model for categorical data. The odds of an event occurring is simply defined as the ratio of the probability that such event will occur, to the probability that the event will not occur. It is often used in logistic regression as a key indicator. Unlike other measures, the odds ratio specifically treats the two variables being compared symmetrically. It enables us to estimate the effect of another variable on the response variable. If the probability of delivering low birth weight is π, then the probability of delivering normal weight is $(1-\pi)$. Supposing the event of delivering a low birth weight or normal weight follows a data in a 2 by 2 (2×2) table, and within row one, the odds of low birth weight is represented as; $\text{odds}_1 = \frac{\pi_1}{1-\pi_1}$, and that of row two is denoted as; $\text{odds}_2 = \frac{\pi_2}{1-\pi_2}$. In general, the odds ratio $R_{S,D}$ that respectively compares the odds of event E occurring in group S and D is expressed as the ratio between the two odds. This is denoted by:

$$\text{Odds ratio } (R_{S,D}) = \frac{\text{odds}(E_S)}{\text{odds}(E_D)} = \frac{P(E_S)/(1 - P(E_S))}{P(E_D)/(1 - P(E_D))}$$

The odds ratio is a measure of the effect size. If the odds ratio is one, then the odds are the same for the event occurring in the two groups. If the estimated odds value is further away from one in a given direction mostly represent stronger association. An odds greater than one shows an increase effect in the response and otherwise if the odds is less than one.

Receiver Operating Characteristic curve (ROC and AUC)

These are useful ways of predicting the specificity and sensitivity levels of a diagnostic test. In other words, situations in which authors are using a test score typically a qualitative score to predict some kind of a dichotomous outcome. In this study the ROC is used to test whether any of the maternal factors is a biased estimator or not. The accuracy of the test depends on how well the test separates the group being tested into those with and without the characteristic in question. Accuracy under ROC is measured by the area under the curve (AUC). An area of 1 represents a perfect test; an area of 0.8 to 0.9 is a good test, an area of 0.7 to 0.8 is fair, area of 0.7 to 0.6 is a poor test, 0.6 is a fail and an area of 0.5 or less is a worthless test.[21]

The SPSS software version 16 was used for the analysis.

RESULTS

Descriptive

The descriptive statistics just talks about the general summary of the information gathered with no inferential statistics applied. It discusses the category summary within each maternal factor as against low birth weight delivery.

Table 1: Categorical summary of the response variable to the predictor variables.

		No	Yes	Total (% total)
Maternal age	Less than 20	137 (15.2%)	55 (6%)	192 (21.3)
	20 to 25	182 (20.2%)	29 (3.2%)	211 (23.5)
	26 to 30	254 (28.2%)	6 (0.7%)	260 (28.9)
	31 and above	201 (22.3%)	36 (4.0%)	237 (26.3)
Alcohol intake	No	501 (55.7%)	55 (6.1%)	556 (61.8)
	Light	144 (16%)	16 (1.8%)	160 (17.8)
	Heavy	129 (14.3%)	55 (6.1%)	184 (20.4)
Antenatal clinic attendance	No	582 (64.7%)	82 (9.1%)	664 (73.8)
	Yes	192 (21.3%)	44 (4.9%)	236 (26.2)
Social status	Lower	339 (37.7%)	60 (6.7%)	399 (44.4)
	Middle	240 (26.7%)	31 (3.4%)	271 (30.1)
	Upper	195 (25.6%)	35 (3.9%)	230 (29.5)
Educational level	None	252 (28.0%)	75 (8.3%)	327 (36.3)
	Primary	68 (7.6%)	14 (1.6%)	82 (9.2)
	JHS	180 (20.0%)	16 (1.8%)	196 (21.8)
	Secondary	126 (14%)	15 (1.7%)	141 (15.7)
	Tertiary	148 (16.4%)	6 (0.6%)	154 (17.0)
Exposure to heat and smoke	No	297 (33%)	105 (11.7%)	402 (44.7%)
	Yes	477 (53%)	21 (2.3%)	498 (55.3%)

Those who gave birth more to low weight babies were below age 20. Frequency of alcohol intake by mothers, the number of none drinkers and heavy drinkers who gave birth low birth weight are the same, 55. This is not reasonable hence a better way to determine the association for drinkers and none drinkers with low birth weight.

Test for association

To find out which individual factors are associated with low birth weight, the Pearson chi-square test for association was calculated.

Table 2: Pearson chi-square test of association.

Predictor variable	Chi-square value	df	Sig (95%)
Maternal age	58.777	3	0.000
Frequency of alcohol intake	48.512	2	0.000
Antenatal clinic attendance	5.730	1	0.017
Social status	2.116	2	0.347
Educational level	42.257	4	0.000
Exposure to heat, smoke and direct sun	88.629	1	0.000

From Table 2, authors realise that maternal age was significant on three degrees of freedom. The alcohol intake of the mother was also significant on 2 degrees of freedom. Antenatal clinic attendance was also significant on 1 degree of freedom. Educational level of the mother (sig=0.00<0.05 on 4 df) and exposure to heat and smoke (sig=0.00 on 1 df) were also significant.

Surprisingly, Social status was not significant (chi-square=2.116, sig. (95%) =0.347 on 2 df). This means that the social status of mother can be ignored in building the binary logistic model. In addition, predictor variables; Age of mother, alcohol intake by mother, antennal clinic attendance, Educational level of mother and mother's exposure to sun and heat were associated with low birth weight in the Lower Manya municipality.

Binary logistic regression model

After identifying the associated factors, we still have to study the extent of effects of such factors on the response variable. All these cannot be achieved using the chi-square discussed above. To clearly demonstrate the causal effects and understand the extent to which the levels of these categorical predictors have on the response variable, this subsection introduces readers to results and analysis of the binary logistic regression. These techniques will not only show significant association, but further give deeper insight to cause-and-effect, goodness-of-fit issues, and other easily interpretable estimates such as estimated coefficients, odds ratio and estimated confidence intervals.

Table 3: Variables in the binary logistic equation.

	B	S.E.	Wald	df	Sig.	Exp (B)	95.0% C. I. for EXP (B)	
							Lower	Upper
ANC (1)	-2.769	0.499	30.806	1	0.000	0.063	0.024	0.167
Alcohol			24.161	2	0.000			
Alcohol (1)	-1.479	0.380	15.151	1	0.000	0.228	0.108	0.480
Alcohol (2)	-2.043	0.446	21.010	1	0.000	0.130	0.054	0.311
Age			18.57	3	0.000			
Age (1)	0.178	0.427	0.174	1	0.676	1.195	0.52	2.76
Age (2)	-1.487	0.398	13.989	1	0.000	0.226	0.104	0.49
Age (3)	-0.941	0.549	2.939	1	0.086	0.390	0.133	1.14
Education level			33.402	4	0.000			
Education level (1)	2.778	0.521	28.381	1	0.000	16.083	5.788	44.687
Education level (2)	3.090	0.677	20.848	1	0.000	21.983	5.834	82.827
Education level (3)	1.913	0.610	9.839	1	0.002	6.772	2.049	22.374
Education level (4)	1.951	0.544	12.844	1	0.000	7.037	2.421	20.455
Exposure to heat (1)	4.507	0.480	82.294	1	0.000	90.659	35.38	232.25
Constant	-4.279	0.622	47.323	1	0.000	0.014	0.00	0.05

Testing for model fitness and adequacy for binary logistic

Statisticians are generally very careful with models for predictions and interpretations. This is because a misfit model may lead to inaccurate interpretations which will further mislead scientific research and consequently an inappropriate intervention for the situation studied. To avoid the unwarranted and dangerous mess, several steps are taking by analyst to ensure that every model that is fit is good and adequate in making inferences. This study is no exception. The test for model fit adequacy and goodness for this study uses the Omnibus test of model coefficients, Nagelkerke R-square, Hosmer and Lemeshow test, and the classification table.

Table 4: Test for model adequacy.

Step	Model	Value
Step 0	Classification (null model)	86.0%
Step 1	Classification (fitted)	90.8%
	Hosmer and Lemeshow	X^2=12.809, df=7, sig.=0.077
	Prediction table Omnibus test	69.3 out of 71 X^2 = 273.691, df=9, sig. 0.000
	Nagel Kerke R square	0.499558
	-2logliklihood	436.638
	Cox and Snell R square	0.277

Form Table 4, the Omnibus test statistic for model coefficients. The value for the chi-square for the significance of the coefficients in the fitted model was 273.691 on 9 degrees of freedom with significance 0.000 < (0.05). This shows a very strong model coefficient. The Nagel Kerke R-square test for the model is approximately 0.50. This means that about 50% of the variance in the dependent variable is explained by the independent variables. This means that present model explains more than a third, almost half of the variations in the response outcome.

Hosmer and Lemeshow test for model strength says that our significant value should be more than 0.05 else it is a weak model. From Table 4, the model records a significance of 0.077 >0.05. This means the model is pretty strong. The contingency table for Hosmer and Lemeshow test shows that the fitted model is able to predict correctly about 69.3 in every 71 selected cases. This means that out of every 71 randomly selected cases in the study the model is able to predict 69 whether it will be a low birth weight or not. This is more than 90% prediction accuracy hence a very strong model. From Table 4, the percentage corrected for the null (86%) is less than that of the fitted (saturated) model (90.6%). Hence, the predictors inclusion in the model.

DISCUSSION

From Table 3, among categories under maternal age, the adolescents (age group 1 i.e. below 20 years) has the highest risk of giving birth to a low birth weight baby. They have an odds of 1.2 times higher than those who are aged more than 30years (age group 4) which was the baseline for the model. The 95% confidence interval (CI) is (0.52,2.76). This therefore means that the adolescent pregnant woman has the highest risk of giving birth to a low birth weight baby compared to all age groups.

Mothers whose age are from 20 years to 25 years has the least risk (odds=0.2times) hence 20 to 25 is the safest age group. The risk can therefore be said to be decreasing as the age decreases except for adolescents who have the highest risk. Adolescent mothers have risk higher than above 30 years unlike other localities.[2,3]

In a further situation, the educational level of mothers proved to be yet another strong significant (sig.=0.000) predictive factor of the tendency to deliver low birth weight. Out of the five (5) categories of educational level of mothers, those who had attended up to primary six had the highest risk (odds=21.7) of low birth weight delivery compared to those who had tertiary education. No education was the next highest risk group(odds=16.08). They stand at risk of 16 times higher than tertiary education graduates to deliver a low birth weight baby. Then followed by those who had Secondary education level. They had an odds of 7.039 representing a risk level of seven (7) times more than the tertiary education level. Furthermore, mothers who had Secondary School had an odds of 6.77 that is a risk of more than six (6) the risk of mothers with tertiary education. All the levels were risker than the tertiary level. This means that, those with tertiary education are most likely to deliver normal weight babies. This is consistent with other studies.[22]

The next predictor that is found to be highly significant is the mothers' exposure to heat. That is those who work long hours under the direct sun or close to fire source. The binary logistic produced an estimate (β) of 4.5 at significance of 0.000. This positive more than one coefficient means that a change in the heat exposure status of a mother will have a multiplicative effect of about four times increase in the response variable, in this case the low birth weight. To examine the predictive probability of mothers' exposure to heat on the delivering of low birth weight baby, we consider the odds ratio for exposure to heat. The odds is 90.659. This represents a risk of more than 90 times for those who are exposed to heat, smoke and sun. In other words, mothers who are exposed to heat, smoke or sun have a high tendency of about 90 times delivering a low weight baby compared to mothers who are not exposed the direct sun, or heat or smoke. This risk ratio is the highest among all the predictor variables. Alcohol intake by mothers was also found to be significant (0.000). The binary logistic model reported an odds for the never/no category as 0.228.

This is interpreted as a reduction in the risk of a mother giving birth to a low birth weight baby. Those in the sometimes category also have a low risk. On the other hand, the risk of mothers who never took alcohol before were about 77.2% times less likely to record a low birth weight than their colleague mothers who had the habit of taking alcohol. Mothers who occasionally took alcohol had 87% less likelihood to give birth to low birth weight babies. This means, mothers who have been taking alcohol most of the time stands the highest risk of giving birth to low birth weight babies.[2,22]

Antenatal clinic attendance was also found to be significant (0.000). The odds for antenatal clinic attendance was found to be 0.063 with a confidence interval of (0.024, 0.167). The odds of 0.063 represents a risk of 0.063 times less for mothers who attend antenatal clinics than mothers who did not attend the antenatal clinics.

Receiver Operating Characteristic (ROC)

From the ROC curve, frequency of alcohol intake by mothers and antenatal clinic attendance are below the reference line (0.5) therefore they cannot predict whether a mother will deliver a low birth weight or not. This is further demonstrated in the area under the curve in table 4.4. Area under the curve for Educational Background is in the poor category (0.66) but we may consider it since its upper bound CI crosses into the fair category. This is similar for maternal age. The test result variable maternal

Age has at least one tie between the positive actual state group and the negative actual state group. Statistics therefore may be biased. Exposure to heat is the strongest (AUC=0.725, fair) although it is also below the good category of ≥0.8. The test significance for all the maternal factors are significant (less than 0.05 alpha level).
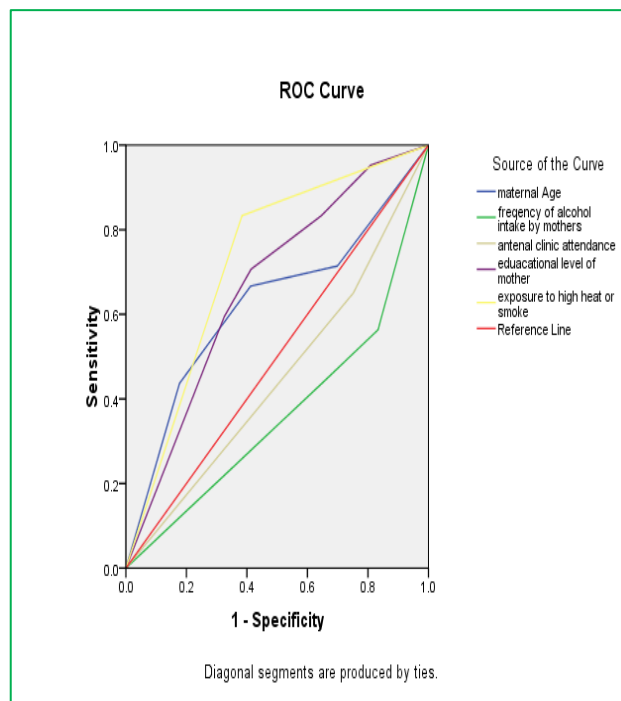

Figure 1: ROC curve.

Table 5: Area under the curve (AUC) values.

Test result variables	Area	Std. error	Asymptotic sig	Asymptotic 95%confidence interval	
				Lower bound	Upper bound
Maternal age	0.624	0.030	0.000	0.565	0.684
Frequency of alcohol intake	0.365	0.029	0.000	0.308	0.421
Antenatal clinic attendance	0.449	0.028	0.000	0.394	0.505
Educational level of mother	0.665	0.025	0.000	0.617	0.713
Exposure to heat	0.725	0.022	0.000	0.681	0.769

Table 6: Contingency table for Hosmer and Lemeshow test.

		Low birth weight = 0		Low birth weight = no		Total
		Observed	Expected	Observed	Expected	
Step 1	1	105	104.794	0	0.206	105
	2	103	103.691	1	0.309	104
	3	98	98.803	2	1.197	100
	4	122	121.617	4	4.383	126
	5	79	81.114	7	4.886	86
	6	91	82.944	1	9.056	92
	7	75	73.732	13	14.268	88
	8	62	66.696	27	22.304	89
	9	39	40.609	71	69.391	110

Table 7: Hosmer and Lemeshow test.

Step	Chi-square	df	Sig.
1	12.809	7	0.077

Table 8: Model summary.

Step	-2 Log likelihood	Cox and Snell R square	Nagelkerke R square
1	436.638[a]	0.277	0.499

[a]: Estimation terminated at iteration number 7 because parameter estimates changed by less than 0.001.

This study was targeted at assessing the determining factors of pregnant mothers who recorded low birth weight, which is babies weighing less than 2.5kg measurement taken within the first hour of birth, in the Lower Manya Krobo Municipality. It was found that out of the six maternal factors studied, only five of them were significant. The maternal factors; antenatal clinic attendance, mothers' age, alcohol intake by mother, educational level of the mother and mothers' exposure to heat. This is consistent with earlier studies discussed in the study.[22,23]

CONCLUSION

Conversely to the literature review, mothers' social status was not found to be a significant determinant of delivering a low birth weight baby in the Lower Manya Municipality. As stated earlier in the problem statement in chapter one, this study is localised it differs a little from several similar surveys conducted in other parts of the country.

Exposure to heat was found to be a fairly unbiased predictor in the receiver operating characteristic (ROC). This study has revealed that a healthy lifestyle leads to a stress-free pregnancy.

REFERENCES

1. WHO. Care of the preterm and low-birth-weight new born. Available at: www.who.int/maternal_child_adolescent/newborns/prematurity.
2. Lifespan. Available at: www.lifespan.org/conditions-treatments/disease-and-conditions/low-birthweight.
3. UNICEF (2015) The Neonatal Period Is the Most Vulnerable Time for a Child. Available at: www.data.unicef.org/Child-Survival/neonatal-mortality.
4. UN. The Millennium Development Goals Report 2014. Available at: http://www.un.org/millenniumgoals/2015_MDG_Report/pdf/MDG%202015%20rev%20%28July%201%29.pdf.
5. UN Inter-agency Group for Child Mortality Estimation. Levels and Trends in Child Mortality Report 2015. Available at: http://www.childmortality.org/files_v20/download/IGME%20report%202015%20child%20mortality%20final.pdf.
6. Wold Health Organisation (WHO). 2014. World Health Rankings. Available at: www.worldlifeexpectancy.com.
7. Ministry of Health (MOH), (2007). Under 5 Child Health Strategy: 2007-2015.
8. Ghana Statistical Services, Health of children and women in Ghana: Evidence from the Demographic and Health Surveys, December 2016.
9. Ghana Factsheets of Health Statistics 2010.
10. Ghana Statistical Service (GSS), Ghana Health Service (GHS), and ICF Macro. Ghana Demographic and Health Survey 2008. Accra, Ghana: GSS, GHS, and ICF Macro; 2009.
11. Abubakari A, Kynast-Wolf G, Jahn A. Prevalence of abnormal birth weight and related factors in Northern region, Ghana. BMC Preg Childbirth. 2015;15(1):335.
12. Heazell AE, Li M, Budd J, Thompson JM, Stacey T, Cronin RS, et al. Association between maternal sleep practices and late stillbirth–findings from a stillbirth case-control study. BJOG. 2018;125(2):254-62.
13. Afriyie J, Bedu-Addo K, Asiamah EA, Boateng ST. Low birth weight among adolescents at Cape Coast Metropolitan Hospital of Ghana. Int J Reprod Contracept Obstet Gynecol. 2016;5(12):4242-7.
14. Annan GN, Asiedu Y. Predictors of Neonatal Deaths in Ashanti Region of Ghana: A Cross-Sectional Study. Adv Public Health. 2018;2018.
15. Fosu MO, Abdul-Rahaman I, Yekeen R. Maternal risk factors for low birth weight in a District Hospital in Ashanti Region of Ghana. Res Obstet Gynecol. 2013;2(4):48-54.
16. Tampah-Naah AM, Anzagra L, Yendaw E. Factors correlated with low birth weight in Ghana. British J Med Medical Res. 2016;16(4):1-8.
17. Agbozo F, Abubakari A, Der J, Jahn A. Prevalence of low birth weight, macrosomia and stillbirth and their relationship to associated maternal risk factors in Hohoe Municipality, Ghana. Midwifery. 2016;40:200-6.
18. Afeke I, Mac-Ankrah L, Jamfaru I, Amegan-Aho KH, Mbroh HK, Lokpo SY, et al. Maternal age, low birth weight and early neonatal death in tertiary hospital in the Volta region of Ghana. Open J Pediatr. 2017;7(4):254.
19. Andy F. Discovering statistics using SPSS. For assumptions on chi square. A Bayesian formulation for exploratory data analysis and goodness-of-fit testing (PDF). International Statistical Review: 375.
20. Agresti A. An introduction to categorical data analysis. 2nd ed. University of Florida. Gainesville, Florida.

Available at: https://mathdept.iut.ac.ir/sites/mathdept.iut.ac.ir/files/AGRESTI.PDF.
21. ROC curves and area under the curve explained. Available at: www.dataschool.io.
22. O'Leary M. Low birth weight as a risk factor for under vaccination Ghana; evidence from a population-based cohort. London School of Hygiene and Tropical Medicine. 2016.
23. Owusu JT, Anderson FJ, Coleman J, Oppong S, Seffah JD, Aikins A, et al. Association of maternal sleep practices with pre-eclampsia, low birth weight, and stillbirth among Ghanaian women. Int J Gynecol Obstet. 2013;121(3):261-5.