

RESEARCH PAPER

Low Birth Weight Baby and Its Associated Factors among Rural Women in Bangladesh: A Decision Curve Analysis

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Abstract

Background: Low birth weight is considered to be one of the main risk factors for infant mortality and morbidity. It is associated with a range of both short- and long-term consequences.

Objectives: The study examined the factors contributing to low birth weight of the baby in Bangladesh. This study also attempted with the objective of ensuring a prediction of low birth weight.

Methods: The study was a case-control quantitative survey. A three-stage cluster sample design was used to conduct the survey. A total of 674 (337 cases and 337 control) mothers/care givers of under 1 year children were selected from 2 districts of Bangladesh. Binary logistic regression and decision curve analysis were used to investigate the factors which attribute to low birth weight baby born.

Results: The findings of the study revealed that mean birth weight was 2.1±0.4 kg among low birth weight children whereas it was 3.0±0.5 kg for normal birth weight children. The mean age of sampled mothers was 25.2±5.4 years. Every 2 in 3 mages got married before 18 years. The prevalence of low birth weight baby among the women with secondary or higher education was lower (47.4%) compared to the women no formal education (65.4%). Analysis revealed that several socio-demographic factors like parental education level, maternal age at first marriage, working status were significantly associated with low birth weight of the baby ($p < 0.05$). Some biological and medical factors like multiple births, maturity of the birth, prenatal care and taking iron and folic acid during pregnancy were also significantly associated with low birth weight baby born. Finally, decision curve analysis technique predicted a net benefit of 0.3907 for the profitable model with highest number of factors. This result implies that the fitted model can predict 39% low birth weight based on independent factors.

Conclusion: Prediction model indicates that parental and biological factors are caused for low birth weight baby born in rural areas. Maternal and child health program should focus behavioural change regarding create awareness of disadvantage of early marriage, intake IFA supplementation, at least 4 ANC visit to reduce low birth weight baby born.

Keywords: Decision curve analysis, Low birth weight, Prediction model, Rural area

Introduction

Low birth weight is a public health problem globally and is associated with a range of both short- and long-term consequences. According to the estimates of World Health Organization (WHO), 15-20% of all births worldwide are Low Birth Weight (LBW), representing more than 20 million births a year and 5 million of them die globally. The goal is to achieve a 30% reduction of the number of infants born with a weight lower than 2500 gm. by the year 2025.¹⁻² There is considerable variation in the prevalence of low birth weight across regions and within countries; however,

the great majority of low birth weight births occur in low and middle-income countries and especially in the most vulnerable populations.³⁻⁴

LBW is a major health problem in under-resourced settings, where it increases the risk of child morbidity, mortality and disability, and represents significant costs for families, communities and health systems.⁵⁻⁷ LBW and prematurity are the second driving reason for newborn child mortality after congenital anomalies but contribute disproportionately to the infant mortality rate. Infant with an LBW are 40 times more likely to die than newborn children with normal birth weight (NBW).⁸ Low birth weight leads to inhibited growth and cognitive development⁹ and is also associated with chronic diseases later in life. Newborn children with LBW are at a much higher danger of being conceived with cerebral paralysis, mental hindrance,

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and other tangible and intellectual disabilities, contrasted with infants of NBW.¹⁰

There is a strong relationship between the mother's social status and having a LBW baby.¹¹⁻¹² Although there is no definitive evidence on the causal pathways between specific social disadvantages and giving birth to a LBW baby, chronic malnutrition, poor health-seeking behaviours, unhealthy life styles, increased risk of infection and stress are believed to be important determinants of LBW. The impact of malnutrition during woman's pregnancy is critical child's lifetime. LBW early in life can cause irreversible damage to a child's brain development, immune system and physical growth.¹³ The damage done by malnutrition translates into a huge economic burden for countries, costing billions of dollars in lost productivity and avoidable health care costs.

There are numerous factors contributing to LBW, both maternal and foetal. The maternal risk factors are biologically and socially interrelated.¹⁴ The mortality due to low birth weight can be reduced easily, as most of the maternal risk factors can be modified if detected early and managed by simple techniques. Socioeconomic status, parity, maternal height, pregnancy weight gain, tobacco exposure and anemia are associated with LBW.¹⁵ Rates of morbidity and mortality among pregnant women, mothers and newborns remain high in Bangladesh, particularly among poorer groups. Access to skilled and timely care is the key to reduce the toll of maternal and neonatal deaths. Adolescent mothers (<19 years) had a higher risk of delivering LBW babies compared to older mothers after adjusting for potential confounders. Mother's education which had a lower social, prima parity, previous miscarriage or abortion, antenatal care visit during last pregnancy, anemia and postpartum weight are significantly associated with risk of having an LBW infant.¹⁶⁻¹⁷

According to the 2011 population census about 72% of the populations live in rural areas in Bangladesh.¹⁸ Overall, 10.5% of the population is under five children. Infant mortality for the rural poor population is high than the urban population. Under nutrition is still high with about 42% of the under five children suffer from malnutrition.¹⁹ Traditionally, rural women in Bangladesh have played an important role in a wide range of income-generating activities. The women are primary care givers and domestic workers within the household, and this responsibility of care-giving is

expanded to serve the needs of the community too. Strenuous working activities during pregnancy may have negative reproductive outcome among rural women. Government of Bangladesh has given the highest priority to achieve the Sustainable Development Goal (SDG) 3 and pursuing a series of programme and policies to ensure safe delivery and reduce under five children mortality.²⁰

Prediction models are utilised to assess the probability of the presence a specific disease (diagnosis) or to assess the probability of developing a specific result in the future (prognosis). New method based on decision curve analysis (DCA) has recently been introduced.²¹ DCA joins the mathematical simplicity of accuracy measures, such as sensitivity and specificity, with the clinical applicability of decision analytic approaches.²² Most critically, DCA can be applied straightforwardly to a data set and could identify the range of threshold probabilities, in which a model was of value, the magnitude of advantage, and which of several models was ideal.²³ The empirical findings helped policy makers understand possibilities of intervention to improve the lives of the rural poor. This study assessed the socio-demographic factors, quality of life, and health conditions related to LBW during pregnancy among rural women. It is also attempted with the objective to ensure a prediction scale for LBW.

Materials and Methods

A retrospective type unmatched case-control study preceded by a cross-sectional survey was carried out. Data were collected from women and who delivered their babies one year preceding the survey in 2 upazilas of 2 districts (Munshiganj and Gazipur) of Bangladesh. The cases included births <2500 gm. and control included births e"2500 gm. in the rural community. Data about women's conditions were obtained by interview from women after delivery.

Three stage sampling procedure was adopted for the study. At first, from 2 districts 2 upazila were selected using simple random sampling method and thereafter from each district 4 unions were selected randomly. List of women child birth was collected from union health and family welfare centre (UH&FWC) (available in family welfare assistant register or from available client records in community clinic) in the selected union and case (LBW: <2500 gm.) and control (normal birth weight: births e"2500 gm.) were identified from the list. Finally, on an average 84 children (0-11 months) were selected where 42 children were LBW and 42

children were normal birth weight (NBW) from each UH&FWC. The respondents for the survey were the mother/care giver who had birth within one year preceding the survey. A total of 674 women aged 15-49 years were identified as given birth in last one year preceding the survey from two sampled districts of which 50% sample were taken from each district respectively. Total sample cases are estimated statistically sound technique with $\alpha=0.05$, $b=0.80$, $p=0.10$ power and odd ratio=2. The estimated sample size was 283 for the case-control study.²⁴⁻²⁵ Finally, the study was conducted among 337 LBW and 337 NBW children. Structured questionnaire was used to interview mothers for identifying the factors associated LBW. Data on socio-economic, demographic, anthropometric, psychological, physical activities were collected for both case and control. Height and weight were measured to nearest 0.5 cm and 100 gram respectively.

Statistical analysis: Univariate analysis was done to describe central tendency and dispersion, creating frequency distribution as well as percentage distribution for all variables. The comparisons of various characteristics between LBW group and NBW group were done by bivariate analysis. In the bivariate analysis, cross tabulation and the chi-square test were applied to examine the association between each of the independent variables and birth weight of the newborns. Logistic regression model was used to predict a dichotomous dependent variable on the basis of continuous or categorical independents.

Decision curve analysis: Decision curve analysis is a method for evaluating models and diagnostic tests that was introduced by Vickers and Elkin in 2006.²³ Model validation is the task of confirming that the outputs of a statistical model have enough fidelity to the output of the data-generating process that the objectives of the investigation can be achieved. It can be based on either data that was used in the construction of the model or data that was not used in the construction. Validation based on the first type usually involves analyzing the goodness of fit of the model or analyzing whether the residuals seem to be random (i.e. residual diagnostics). Validation based on the second type usually involves analyzing whether the model's predictive performance deteriorates non-negligibly when applied to pertinent new data.

A decision curve is obtained by plotting the net benefit against threshold probability. Where, threshold probability of a disease or event is informative of how patient weighs the relative harms of a false positive and false negative prediction.^{22-23, 26}

Results

Of all sampled children 368 (55.0%) were boys and 306 (45.0%) were girls. The mean birth weight of children was 2.6 ± 0.4 Kg. Mean age of the respondent mothers was 25 years (SD 5.4). The age- distribution of the women in the study area is presented in Table I. About two-third of the women (68.0%) are between 20-30 years of old. Marriage occurs early for women in Bangladesh. Among women age, 45 percent married by age 18. Nearly 75.0% of women attended secondary level of education and 4% women had no formal education. Three-fourth (75%) of the women gave birth 2 or less children. The mean birth weight of the sampled children was 2.6 ± 0.4 Kg.

Table-I: Socio-demographic characteristics of sampled mothers

Characteristics	n	Percent
Mother's age (in Year)		
<20	117	17.3
20-30	457	67.7
≥ 30	100	15.0
(Mean \pm SD) year	(25.1 \pm 5.4)	
Mother's working status		
Working	397	59.0
Not working	277	41.0
Mother's age at marriage		
<18 year	300	44.4
≥ 18 year	374	55.6
Mother's Level of education		
No education	26	3.9
Primary	143	21.2
Secondary and higher	506	75.0
Mother's number of gravida		
≤ 2	507	75.1
>2	167	24.9
Sex of the child		
Male	368	54.6
Female	306	45.4
Birth weight in kg. (Mean \pm SD)	(2.6 \pm 0.4)	
Total	674	100.0

Socio-demographic factors and low birth weight: Socio-demographic factors that were considered to have empirical relationship with birth weight of the baby are education, age, working status, religion, area of residence, family income etc. Woman's age at birth

was not significantly associated with the low birth weight of the baby (table II). But the age of the women at first marriage was significantly ($p<0.05$) associated with birth weight of the baby.

The average age at first marriage was higher among mothers with normal birth weight than mothers with low birth weight (17.4 ± 2.5 vs 16.9 ± 2.6). Mean birth weight was significantly ($p<0.001$) higher among normal birth children (3.0 ± 0.5 kg.) than LBW children (2.1 ± 0.4 kg.).

Level of parental education was significantly ($p<0.05$) associated with low birth weight of the baby (table III).

The rate of low birth weight was decreasing with increasing the level of education. Percentage of low birth weight was higher among no educated mother (65.0%) compared to secondary and above educated mother (47.0%). Mother's working status was also associated for low birth weight baby. Mothers who work for cash earnings were less likely to give low birth weight baby than the mother who were not ($p=0.03$). Mother who received iron and folic acid (IFA) supplementation had lower percentage of low birth weight baby ($p<0.01$).

There is no good direct measure of degree of maturity of newborns. Gestational age is used as a proxy measure of a degree of maturity.

Table-II: Comparisons of Mother's Characteristics between two groups (Mean \pm SD)

Variables	LBW (n=337)	NBW (n=337)	p-value
Mother's age at birth (in Year)	24.9 \pm 5.6	25.2 \pm 5.3	0.50
Age at first marriage (in Year)	16.9 \pm 2.6	17.4 \pm 2.5	0.01
Maternal Gravidity	2.1 \pm 1.1	2.0 \pm 1.0	0.09
Number of living children	1.9 \pm 1.0	1.8 \pm 0.9	0.25
Duration of preceding birth interval (in Month)	65.7 \pm 36.8	62.8 \pm 37.6	0.56
Number of Abortion	0.3 \pm 1.2	0.2 \pm 1.2	0.54
Distance between home and maternity	4.1 \pm 3.5	4.4 \pm 3.6	0.35
Birth weight (in Kg.)	2.1 \pm 0.4	3.0 \pm 0.5	0.00

Table-III: Comparisons of maternal Characteristics of two groups

Variables	LBW (n=337)		NBW (n=337)		p-value
	n	%	n	%	
Sex of Child					
Male	172	51.0	196	58.2	0.03
Female	165	49.0	141	41.8	
Father's educational level					
No Education	46	68.7	21	31.3	0.00
Primary	105	54.4	88	45.6	
Secondary and above	185	44.8	228	55.2	
Mother's Educational level					
No Education	17	65.4	9	34.6	0.04
Primary	81	56.6	62	43.4	
Secondary and above	240	47.4	266	52.6	
Mother Work for cash earnings	185	46.5	213	53.5	0.03
IFA supplementation	255	47.4	285	52.6	0.00
Diabetes	4	1.2	8	2.4	0.36
Hypertension	33	9.8	25	7.4	0.28
Multi-vitamin	279	82.5	290	86.1	0.21
Haemorrhage	15	12.9	16	13.9	0.83
Eclampsia	28	24.1	23	20	0.45
Obstructed/prolonged labour	4	3.4	3	2.6	0.71
Total	337	100.0	337	100.0	

Maturity is highly significantly ($p < 0.001$) associated with birth weight of the baby (table IV). Prevalence of low birth weight is higher among the cases involving immature birth than the cases involving mature birth. Multiple pregnancy is significantly ($p < 0.05$) associated with low birth weight of the baby. The percentage of low birth weight is higher among twin mother than the single birth. Table IV also shows that antenatal care visit has a significant ($p < 0.05$) association with low birth weight of the baby, prevalence of lbw is the highest among the women involving no antenatal care visit and lowest among the women involving two antenatal care visit. Prevalence of low birth weight baby is higher among the women who had not medical checkup during pregnancy compared to the women who had medical checkup during pregnancy ($p < 0.05$). Women with blood test have lower prevalence of low birth weight baby than the women without blood test ($p < 0.05$).

Logistic Regression analysis: Education level of father has significant effect on the low birth weight of the baby. It shows that, father with no formal education are 2.01 times more likely to have a low birth weight baby than the father with secondary and higher education. Working status of the women is also an

important factor for the low birth weight of the baby. Women who are working for cash are 38% less likely to give birth to a low birth weight baby than the women who are not working (table V).

Table-IV: Association between low birth weight and medical and obstetric factors of the women.

Background Characteristics	LBW (n=337) (%)	NBW (n=337) (%)	p value
Preterm Birth	61.9	38.1	0.00
Multiple pregnancy	73.9	26.1	0.02
Antenatal care visit			
No visit	84.6	15.4	0.03
1	59.1	40.9	
2-3	46.5	53.5	
4 and above	48.3	51.7	
Medical check-up during pregnancy	48.7	51.3	0.01
Blood test	46.4	53.6	0.00
BP measure	47.9	52.1	0.05
Urine test	46.2	53.8	0.00

Table-V: Effect of different factors on low birth weight determined by binary logistic regression model

Variables	Odd Ratio	95%CI	P-value
Father's education level			
Secondary or above(ref.)	1.00		
Primary	1.39	0.94-2.07	0.10
No education	2.01	1.09-3.70	0.02
Working status of the women			
No working (ref.)	1.00		
Working for cash earning	0.62	0.37-1.00	0.05
Age at first marriage			
≤18 years (ref.)	1.00		
<18	1.11	0.79-1.57	0.54
Multiple birth			
No (ref.)	1.00		
Yes	4.07	1.46-11.38	0.01
Resting during pregnancy			
Yes (ref.)	1.00		
No	0.66	0.39-1.09	0.10
Medical check- up during pregnancy			
Yes (ref.)	1.00		
No	1.44	1.12-2.34	0.04
IFA supplementation			
Yes(ref.)	1.00		
No	1.69	1.09-2.64	0.02
Maturity of the infants			
Term (ref.)	1.00		
Preterm	3.47	2.35-5.12	0.00

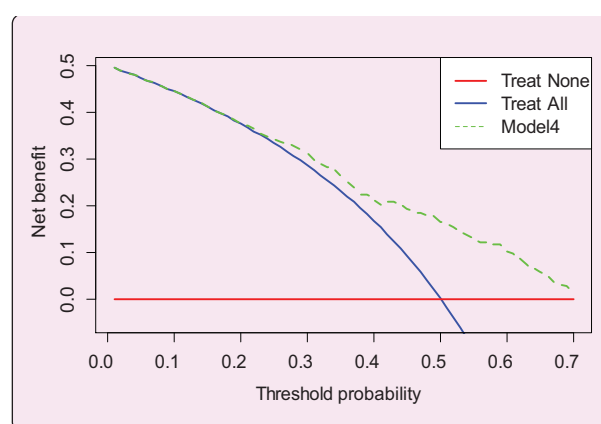
Table-VI: Confusion matrix for model and net benefit calculation

Prediction model threshold probability		Observation			
		n = 674	LBW	NBW	
P≤0.18129		Yes	334	332	
		No	3	15	
Case if risk>0.18129	Negative	True positive	False positive	Net benefit calculation	Net benefit
	18	335	322	335-322 (0.18129-8.81)	0.3907
				674	
All	0	338	337	337-336 (0.18129-0.81)	0.3902
				674	

Maternal age at first marriage had effect on the birth weight of the baby. Maturity of the newborns had a significant effect on the low birth weight of the baby. Babies born as immature were 3.5 times more likely to be low birth weight baby than those of born as mature. Multiple pregnancies have significant effect on the low birth weight of a baby. Babies born as twin are 4.0 times more likely to be low birth weight than those of born as a single (table V).

Medical check-up has effect on low birth weight of the baby. Women who had not medical check-up during pregnancy are 1.44 times more likely to give birth to a low weigh baby than those who had medical check-up during pregnancy. Testing blood and urine has also effect on low birth weight of the baby. Women who had blood test during pregnancy are 1.36 times more likely to give birth to low weight baby than those who had had blood test. Similarly, Women who had urine test during pregnancy are 1.37 times more likely to give birth to low weight baby than those who had not urine test. Though these effect are not significant. Supplementation of iron and folic acid has a significant effect on low birth weight of the baby. Women without iron and folic acid supplementation are 1.69 times more likely to give birth to low weight baby than those with iron and folic acid supplementation.

Here, we fitted four binary logistic regression models to detect the most influential factors affecting low birth weight of the newborns. A decision curve for the model is drawn (figure 1) by using net benefit across all possible threshold probabilities (0-1). The curve of the model was also compared with two theoretical scenarios.

**Figure 1:** Decision Curve for Model

One, in which, every cases have low birth weight (with 100% sensitivity and 0% specificity) and another, where no cases have low birth weight. The full model expresses the association between true low birth weight status and result of prediction model with a positivity criterion of 0.18129 predicted probability of low birth weight. Table VI shows that, the net benefit is 0.3907, which indicates that based on the factors used in model, we can predict 39.0% low birth weight infants with no unrealistic reported cases.

Discussion

The main aim of this study was to examine the effects of socio-demographic, maternal biosocial and medical factors on low birth weight of the baby. In bivariate analysis confirmed that different socio-demographic factors like education level of parents, maternal working status, and age at first marriage are found to be significantly associated with LBW. In this paper husband's level of education has a significant effect on women's low birth weight of the baby. Partners with lower level of education are more likely to

experience women's low birth weight baby than those partners with primary and secondary or higher level of education. This finding is not consistent with other studies.^{16, 26-27} This usually occurs because of the educated men are considered to be more careful about antenatal and other cares for their wife. That is why their wives may experience lower amount of LBW babies compared to the wives of uneducated men.

Bivariate analysis indicates that education level of the women has a great impact on the low birth weight of the baby though this finding is not significant in multivariate analysis. The similar result obtained earlier papers.^{16, 28} Woman's working for cash earnings also affects the birth weight of the newborns. Not working women are more likely to give birth to a low weight baby than those of women working for earnings. Similar finding was derived by Koiral and Bhatta in their study of low birth weight babies among hospital deliveries in Nepal.²⁸

Different maternal biosocial factors like maternal age at first marriage, multiple pregnancy and maturity of the infants were found to have significantly associated with low birth weight of the baby in the bivariate analysis. Though, in the final binary logistic regression model most of them had an insignificant effect on the low birth weight of the baby. Multiple births have a significant effect on low birth weight of the baby. Twin or multiple babies are found to be more likely to be low birth weight baby than the singleton babies. This result is consistent with the study of Rajbaran and others.³⁰ In the present study, maturity of the infants also found to have significant effect on the low birth weight of the baby. Babies with preterm delivery are more likely to be low birth weight baby than those with term delivery.^{17, 31}

In bivariate analysis different medical factors and obstetric history of the women like medical check-up, blood testing, urine testing, taking iron and folic acid supplementation were found to be significantly associated with low birth weight of the baby. However, in the final stage most of these variables were not found to have significant effect on the low birth weight of the baby. Iron and folic acid supplementation during pregnancy was found to have significant effect on the low birth weight of the baby. This study had found that, women without supplementation of iron and folic acid are more likely to give birth to a low weight baby than those with supplementation of iron and folic acid.¹⁷

After examining the effect of different factors at the final stage of the study we used decision curve analysis to determine maternal parameters concerning their capacity to anticipate LBW delivery and formulate a prediction model or scale to anticipate LBW with

education level of the women, husband's level of education, working status of the women, ownership of the residence of the women, age of the women at first marriage, place of delivery, multiple birth, medical check-up, blood testing, urine testing, maturity of the infants, antenatal care and iron and folic acid supplementation that used DCA with 0.3902 net benefit. We also compared the net benefit of the final model with the other model and showed how net benefit increased with the increased number of factors. Net benefit has a simple clinical interpretation; and the final model with net benefit of 0.3902 at threshold of 0.18129 were profitable among other and utilizing this model is what as well might be called that based on the factors used in the model we can predict 39.02 LBW per 100 cases with no unnecessary detect. Similar results also found in other studies.³¹

Conclusion

Women age first marriage is implicated with the low birth weight of the baby. According to this study, 55.6% women got married under age 18. Factors like maternal education, working status, antenatal care, medical check-up during pregnancy and taking IFA supplementation are important. Increasing parental education increases the age at marriage, which in turn, has a great effect on the birth weight. Regular check-up during pregnancy is important to know about the current physical status of the fetus that may also keep the fetus safe from various diseases. Therefore, maternal and child health program programs should focus on behavioural change regarding create awareness of the marriage law and disadvantage of early marriage, intake IFA supplementation, at least 4 ANC visit to reduce low birth weight. Taking necessary supplementation by mother also may ensure the useful nutrients for the fetus.

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