

Logistic Regression Modeling for Maternal Determinants of Low Birth Weight

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ABSTRACT

Low birth weight is a major public health issue in India. Low birth weight leads to an impaired growth of the infant resulting in a higher mortality rate and increased morbidity. In India, nearly 20% of new borns have Low birth weight. Males have less frequency of Low birth weight than females. This study emphasizes the need for improving maternal health, weight gain during pregnancies, prevention and proper management of risk factors along with improving socioeconomic and educational status of mothers. Logistic regression is a statistical model for analyzing a dataset in which one or more independent variables that determine an outcome. The main objective of this paper is to identify the predictors of low birth weight through simple logistic regression model.

Keywords : Logistic regression, Low birth weight, Wald Test, Omnibus Test and Case control study.

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I. INTRODUCTION

Indian has made progress in economic, social, demographic and health fields has been defined by WHO as weight at birth of less than 2.5 kg. By international agreement, Low birth weight (LBW) has been defined as a birth weight of less than 2500 grams, with the measurement being taken preferably within the first hour of life, before significant postnatal weight loss has occurred. It contributes substantially to neonatal, infant, and childhood mortality and morbidity. Across the world, neonatal mortality is 20 times more likely for LBW babies compared to NBW babies (>2.5 kg). It is now a well-recognized fact that birth weight is not Only a critical determinant of child survival, growth, and development, but also a

valuable indicator of maternal health, nutrition, and quality of life. The main objective of this study to assess the maternal and socio demographic factors associated with LBW babies in rural area of Madurai. Low birth weight has costs to the individual and family but also to society. In the short-run, low birth weight babies faced increased mortality risks and larger health costs.

Biswas et al., (2008) have discussed the community based epidemiological study on birth weight of newborns in the rural domain of a backward district of West Bengal. Dharmalingam et al., (2010): have examined mother's nutritional status and socio-biological aspects in determining the birth weight. And the mothers' BMI impacts were more pervasive

across India than the impact of other factors on birth weight. Choudhary et al., (2013) have conducted community based cohort study on birth weight of newborns among pregnant women of an urban slum in Bhupal, India. They concluded that mother occupation, daily calorie intake and duration of day-time rest taken by pregnant women were found in significant association.

Chaman et al., (2013) have used univariate and multivariate logistic regression methods to evaluate the LBW risk factors in LBWs compared to normal weight infants. They found prematurity and high risk pregnancy were the most important risk factors for LBW. Ravi Kumar Bhaskar et al., (2015) have suggested interventions such as delay age at first pregnancy, improving maternal education and nutrition, and iron and calcium supplementation can prevent LBW. Shashikantha et al., (2017) have found that the prevalence of low birth weight was 18% aged below 19 years married females. Ahankari et al., (2017) have discussed the preterm delivery and low birth weight in India and they found that preterm

delivery and LBW were much higher in mothers less than 22 years of age in this rural Indian population.

II. METHODS AND MATERIAL

This is hospital based case control study, 139 comprised of histologically control 139 data were collected from Tirunelveli Government Hospital, Tamilnadu in October 2018 to June 2019. The data were analyzed with logistic regression by use of the Survival package in R software.

2.1 Logistic Regression

Logistic regression is to find the best fitting model to describe the relationship between the dichotomous characteristic of interest and a set of predictor variables. Logistic regression generates the coefficients of a formula to predict a logit transformation of the probability of presence of the characteristic of interest.

$$\text{Logit}(p) = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + \dots + b_k X_k \quad (1)$$

where p is the probability of presence of the characteristic of interest. The logit transformation is defined as the logged odds.

$$\text{Odds} = \frac{p}{1-p} = \frac{\text{probability of presence of characteristic}}{\text{probability of absence of characteristic}} \quad (2)$$

and

$$\text{logit}(p) = \ln\left(\frac{p}{1-p}\right) \quad (3)$$

Rather than choosing parameters that minimize the sum of squared errors (like in ordinary regression). Estimation is logistic regression chooses parameters that maximize the likelihood of observing the sample values. Logistic model describes the expected value of Y ($E(y)$) in terms of the following logistic formula

$$E(y) = \frac{1}{1 + \exp\left[-\left(\beta_0 + \sum_{j=1}^k \beta_j X_j\right)\right]} \quad (4)$$

For (0, 1) random variables such as y , it follows from basic statistical principles about expected values that $E(y)$ is equal to the probability $\Pr(y = 1)$; so the formula for the logistic model can be written in a form that describes the probability of occurrence of one of two possible outcomes of y , as follows

$$\Pr(y = 1) = \frac{1}{1 + \exp\left[-\left(\beta_0 + \sum_{j=1}^k \beta_j X_j\right)\right]} \quad (5)$$

The logistic model is useful in many important practical situations where the response variables can take one of two possible values. For example, a study of the development of a particular disease in some human population could employ a logistic model to describe in the study group will ($y = 1$) or will not ($y = 0$) develop the disease in question during a follow up period of interest. The first step in logistic regression analysis is to postulate (based on knowledge about, and experience with the process under study) a mathematical model describing the mean of y as a function of the X_j and the β_j values.

The model is then fitted to the data by maximum likelihood, and eventually appropriate statistical inferences are made after the model's adequacy of fit is verified, including consideration of relevant regression diagnostic indices. It is used to investigate the factors affecting incidence of LBW, Associations between independent variables and low birth weight were analyzed using simple logistic regression and odds ratios and 95% confidence intervals were calculated.

Wald and Omnibus Test

In logistic regression, the Wald test is the common t-test for testing the significance of a particular regression coefficient. The formula for the Wald statistic is

$$Z_j = \frac{b_j}{S_{b_j}}$$

where S_{b_j} is an estimate of the standard error of b provided by the square root of b_j the corresponding diagonal element of the covariance matrix, $V(\hat{\beta})$.

With large sample sizes, the distribution of Z_j is closely approximated by the normal distribution. With small and moderate sample sizes, the normal approximation is described as 'adequate.' The Wald test is used to test the statistical significance of individual regression coefficients. And omnibus tests are used to test whether the explained variance in a set of data is significantly greater than the overall unexplained variance through Omnibus test.

III. RESULT AND DISCUSSIONS

The problem of low birth weight is multidimensional and integrated approach is necessary which includes medical, social, economic and educational measures.

Table 1: Omnibus Tests of Model Coefficients

| | | Chi-Square | Df | Sig. Value |
|-----------|-------|------------|----|------------|
| Step 1 | Step | 124.834 | 7 | 0.000 |
| | Block | 124.834 | 7 | 0.000 |
| | Model | 124.834 | 7 | 0.000 |

Table 1 show that omnibus tests of model coefficients results which are used to verify that the new model is an improvement over the baseline model. The chi-square values are the same for step, block and model. The chi-square test is used to check if there is a significant difference between the Log likelihoods of the baseline model and the new model. Since the chi-square value is highly significant (chi square=124.834, df = 7, p < 0.000) so our fitted model is significantly better.

Table 2: Model Summary

| Step | -2 Log Likelihood | Cox & Snell R Square | Nagelkerke R Square |
|------|-------------------|-------------------------|------------------------|
| 1 | 67.861 | 0.593 | 0.790 |

Table 2 shows that the R² values tell us approximately how much variation in the outcome is explained by the regression model. We prefer to use the Nagelkerke's R² which suggests that the model explains roughly 80% of the variation in the outcome.

Table 3: Classification Table

| Observed | Predicted | | |
|----------------|----------------|-------------|--------------------|
| | Low Birth Baby | Normal Baby | Percentage Correct |
| Low Birth Baby | 2 | 12 | 14.3 |
| Normal Baby | 1 | 124 | 99.2 |

Table 4: Logistic regression values of Low Birth Weight

| Step 1 | β | S. E | Wald | df | Sig. Value | Exp (β) | 95% C.I. for Exp(β) | |
|--------------------------------|---------|-------|-------|----|---------------|--------------------|--------------------------------|--------|
| | | | | | | | Lower | Upper |
| Sex | 0.076 | 0.666 | 0.013 | 1 | 0.909 | 1.079 | 0.292 | 3.982 |
| Mother Qualification | 2.732 | 0.900 | 9.208 | 1 | 0.002 | 15.367 | 2.631 | 89.748 |
| Father qualification | -0.865 | 0.706 | 1.502 | 1 | 0.220 | 0.421 | 0.106 | 1.679 |
| Mother age at marriage | -0.098 | 0.107 | 0.831 | 1 | 0.013 | 0.907 | 0.735 | 1.119 |
| Mother age at time of delivery | -0.074 | 0.098 | 0.568 | 1 | 0.451 | 0.928 | 0.766 | 1.126 |
| Order of Child | 1.126 | 0.873 | 1.662 | 1 | 0.197 | 3.083 | 0.557 | 17.082 |
| Pregnancy period on weeks days | 0.143 | 0.060 | 5.652 | 1 | 0.017 | 1.153 | 1.025 | 1.298 |

Table 4 provides the regression coefficient (β), the Wald statistic and the Odds Ratio (Exp (β)) for each variable. From the results mother qualification highly significant from the overall effect (Wald = 9.208, df = 1, $p < 0.002$). Mother age at marriage, pregnancy period on week's days also associated between low birth weights.

The fitted logistic regression model for LBW expressed in terms of the variables used in below equation

$$\text{Log}(p/1-p) = +2.732 * \text{Mother qualification} + 0.098 * \text{Mother age at marriage} + 0.143 * \text{Pregnancy period on weeks days}$$

IV. CONCLUSION

This study suggests that the low birth weight was found to be higher with the maternal factors associated with LBW, it has concluded LBW was found to be affected by rural place of residence. Preference nutritionally poor food items and miss timing of nutritious foods during pregnancy and child birth was prominent accentuating the occurrence of low birth weight. The mother's age at time of delivery, parent's education and occupations are major factors associated with low birth weight in new borns. Thus, the findings of this study emphasize the need for improving maternal health, weight gain during pregnancies, prevention and proper management of risk factors along with improving socioeconomic and educational status of mothers.

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