Antenatal Risk Scoring Scale for Predication of Low Birth Weight and Its Validity

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Abstract

Background: Prediction of low birth weight (LBW) early during pregnancy may prevent LBW by appropriate interventions. **Aims/Objective:** The aim of the study is to develop an antenatal risk scoring scale for prediction of LBW. **Subject and Methods:** Routine and in-depth information on diet, occupation, and rest was collected from November 1, 2013, to November 13, 2015. A cohort of 1876 and subset of 380 pregnant women attending Krishna Hospital Karad, Maharashtra, India. **Statistical Analysis:** Multivariate analysis and relative risks (RRs) were found out by SPSS version 16 and tested on a separate set of 251 mothers. **Results:** The frequency of meals of <4, hard work <6 h of sleep and illiteracy, antenatal morbidity, <10 kg weight gain, <40 kg maternal weight, and anemia during the first trimester were the risk factors identified from subset and cohort, respectively. Based on their RRs, a new scoring system with a total score of 24 and cutoff "12" was identified by using receiver operating characteristics (ROC) curve analysis with 98.6% sensitivity and 41.1% specificity as tested on 251-independent individuals. The second cutoff of "15" score was identified based on the prevalence of LBW in babies of these 251 mothers. **Conclusions:** The identification of low-, moderate-, and high-risk of LBW was possible at <12, between 12 and 15, and >15 scores, respectively, with good sensitivity and specificity.

Keywords: Antenatal risk scores, attributable risk, low birth weight, population attributable risk, relative risk

Introduction

About 40% of all low-birth weight (LBW) babies in the developing world are born in India.[1] The prevalence of LBW babies is about 28% in India as compared to 4.5% in the industrially developed countries.[2] LBW remains a challenge in most of the Indian states.[3] The problem of LBW, therefore, is a matter of public health concern worldwide and more serious in India. If the objective estimation of risk of birth of LBW baby is based on the presence of locally relevant socioeconomic, anthropometric, and clinical- and laboratory-related risk factors during pregnancy, then undertaking suitable interventions may be possible for primary prevention of birth of LBW baby and high morbidity and mortality associated with it. A hospital-based prospective study was therefore planned to develop a risk scoring system to find out high-risk mothers most likely to give birth to LBW babies.

Subjects and Methods

Enrollment of a cohort of 2028 apparently healthy consecutive pregnant women planning their delivery at Krishna Hospital Karad, Maharashtra, India, was done from November 1, 2013, to November 13, 2015, and followed till delivery and the outcome was noted. Women giving birth to stillbirths (152), twins and triplets (33), and delivery outside of Krishna Hospital (48) were excluded from the study [Flow Chart 1].[4] The weight of the baby was taken on standard electronic weighing machine, and the gestational period was determined from the Last menstrual period (LMP). Routinely available information was systematically collected from a cohort of 1876 mothers using structured interview schedule, which included maternal age, education, parity, weight at registration,

Access this article online	
Quick Response Code:	**Website:** www.ijcm.org.in
	DOI: 10.4103/ijcm.IJCM_263_18

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How to cite this article: Salunkhe AH, Pratinidhi AK, Salunkhe JA, Kakade SV, Mohite VR, Patange RP. Antenatal risk scoring scale for predication of low birth weight and its validity. Indian J Community Med 2019;44:97-101.

Received: 22-08-18, **Accepted:** 14-03-19

Approach- comparative, exploratory
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Design -prospective cohort study
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Setting- Krishna Hospital attached to Krishna Institute of Medical Sciences Karad, Maharashtra, India
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Population-All apparently healthy consecutive pregnant women planning their delivery at Krishna Hospital
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Sample and sample technique- 1876 pregnant women planning their delivery at Krishna Hospital were enrolled
↓
Data collection period- from November 1, 2013, to December 2015 and followed till delivery
↓
Exclusion criteria-All stillbirths and multiple pregnancies and deliveries at places other than Krishna Hospital were excluded

Flow Chart 1: Showing Research Participants

hemoglobin (Hb) g %, number of antenatal care (ANC) visits, antenatal morbidity, and weight gain during pregnancy. From the subset of randomly selected 380 mothers, additional information related to diet, type of work, rest during day time, and night sleep were collected. The data related to dietary intake were collected by 24-h recall method. Meal-wise food consumed during the day was recorded in household measures and converted into calories, proteins, calcium, and iron content by conversion tables prepared by the Indian Council of Medical Research (ICMR)[4] and Agharkar Research Institute, Pune, India.[5] If the food intake was different due to many reasons such as fast, feast, and festival, the woman was excluded and the next consecutive eligible woman was included. Approval of Institutional Ethics Committee was obtained, and informed consent was taken from pregnant women before the commencement of the study.

Sample size calculation

A rounded off 25% prevalence (p) of 20.37% and 24.6% LBW as estimated by[6,7] at 95% CL (Z = 2) with relative precision of 25% (e) a sample size of 1874 was computed using formula:

$$n = \frac{Z^2 (1-p)}{E^2 p}$$

The minimum sample size for LBW was 1536 adding 22% for attrition it came to 1874. SPSS 16.0 is a comprehensive system for analyzing data (SPSS Inc., Chicago, IL). Multivariate regression analysis was used for the identification of significant risk factors for LBW. Relative risk (RR) was calculated and the value of RR was converted into nearest whole number and was taken as the score for given risk factor when it was present and “0” score was given if it was absent, for example, for RR of 11.8, score of 12, and for RR of 3.4, score of 3 was given. A scoring system based on identified eight factors was prepared for the prediction of LBW. Receiver operating characteristics (ROC) curve analysis was used to identify cutoff level for identifying at-risk women. Risk scores were determined for a separate set of 251 women who were not included in the study cohort. Frequency distribution of the LBW and the maternal risk scores was computed. Sensitivity, specificity, and positive predictive value for LBW were calculated using appropriate formulae.

Results

The mean age of the mothers was 24.05 years with an SD of 3.3 years. There were 42 (2.2%) teenage pregnancies, 1330 (70.9%) were in the age group of 20–25 years and only 6 (0.32%) were above 35 years. There were 125 (6.7%) women illiterate and 226 (12%) graduates and postgraduates, and 1525 (81.3%) were educated up to primary or secondary school level. The ratio of rural to urban residence was 2.4:1. Joint family system was seen among 61.0% and 14 (0.7%) were extended families. 1717 (91.5%) of pregnant women were Hindus, 139 (7.4%) Muslims, and 20 (1.1%) either Buddha or Christians. Majority, that is, 262 (68.9%) families had a monthly income of Rs. 5000 or more per month and the rest 118 (31.1%) had <Rs. 5000. About 90% of the women consumed a mixed type of diet, i.e., mixed vegetarian and nonvegetarian food, and only 10% were vegetarians. Only 1.8% of husbands were illiterate and 98.2% were educated. The sociodemographic, anthropometric, and clinical variables of the mothers were subjected to bivariate analysis for the presence of risk factors and the outcome of birth weight of the baby. Seven variables were found significantly associated with LBW by bivariate analysis of the study population of 1876 pregnant women, and their live born babies, namely illiteracy, height of mother (<145 cm), number of ANC visits (<4), weight at first trimester (<40 kg), weight gain (<10 kg) during pregnancy, and presence of anemia (Hb < 11 gm%) at first trimester, and antenatal morbidity in the current pregnancy. They were subjected to backward multivariate regression model. Of these seven risk factors, all were retained as significant except two, namely height of mother and number of ANC visits. Similarly, four variables were found significantly associated with LBW by bivariate analysis of subset of 380 pregnant women, namely hard work, number of meals < 4, sleep at night < 6 h, and hours of rest during the day of < 2 h. These four risk factors were subjected to backward multivariate regression model. Of these four risk factors, all were retained as significant except one, namely, hours of rest during the day of < 2 h. The weight of RR was given to the five risk factors from the whole cohort and three from the subset and arranged in order of magnitude of the RR. The attributable risk was 91.6%, 70.8%, and 42.1% for subset and 36.1%, 23.5%, 22.5%, 22.5%, and 19.5% for whole cohort, respectively [Table 1].

A scoring system was developed on the basis of RR from the subsample (*n* = 380) and the whole cohort (*n* = 1876). The combined maximum score was 24 [Table 1 and Figure 1].[8]

ROC curve analysis revealed a cutoff score of “10” and “2” for the data of subsample and the whole cohort, respectively, that is, a combined score of “12.”

The cutoff point of 12 had a sensitivity of 98.6% which was good and specificity of 46.1%, which was unsatisfactory [Table 2].

Table 1: Relative risk, attributed risk, and population attributed risk of low-birth weight babies on parameter significant by logistic regression

Risk factor	*n* (%)	RR of 95.5 CI	AR	PAR (%)	Scoring
LBW				***n*=380, total score 18**	
<4 - meals/day	150 (39.4)	11.883 (6.754-20.909)	91.6	81.1	12
Hard work	23 (6.0)	3.429 (2.637-4.460)	70.8	12.9	3
<6 h night sleep	27 (7.0)	2.705 (1.958-3.737)	42.1	6.5	3
LBW				***n*=1876, total score 6**	
Illiteracy	125 (6.0)	1.57 (1.306-1.887)	36.3	3.7	2
Antenatal morbidity (present)	504 (26.8)	1.307 (1.147-1.490)	23.5	18.3	1
Weight gain <10 kg	1295 (69.0)	1.291 (1.399-1.936)	22.5	16.7	1
Weight <40 kg at 1st trimester	131 (7.0)	1.291 (1.047-1.591)	22.5	2.0	1
Anemia in 1st trimester (Hb<11 g %)	1178 (62.7)	1.243 (1.083-1.426)	19.5	13.24	1
Total score					24

RR: Relative risk, CI: Confidence interval, AR: Attributed risk, PAR: Population attributed risk, Hb: Hemoglobin, LBW: Low birth weight

Table 2: Classification ability of the cutoff score for low birth weight (*n*=251)

Birth weight score category	Birth weight category		Total (%)
	LBW (%)	NBW (%)	
LBW (score ≥12)	70 (98.6)	97 (53.9)	167 (66.5)
NBW (score <12)	1 (1.4)	83 (46.1)	84 (33.5)
Total	71	180	251

LBW: Low birth weight, NBW: Normal birth weight

To improve the specificity of the scale, one more cutoff point at higher level was identified using frequency distribution according to the risk score of the 251 mothers [Table 3].

It was observed that at the score of 15 there was a sharp increase in the proportion of LBW to 96.3% which was identified as a higher cutoff point. Thus, the risk scale was refined as <12 indicating low risk, between 12 and 14 as moderate risk, and ≥15 as high risk [Table 4]. This higher cutoff value of ≥15 had a sensitivity of 74.6% and specificity of 99.4% and positive predictive value of LBW of 98.1%.

The distribution of women on LBW scale for prediction of LBW indicated that 33.5% women with score of <12 were low risk and gave birth to only 1 (1.2%) LBW baby. The moderate-risk category between 12 and <15 was 45% and had prevalence of LBW of 15%. There were 21.5% of women who had score above 15 and prevalence of LBW among babies born to them was 98.2%.

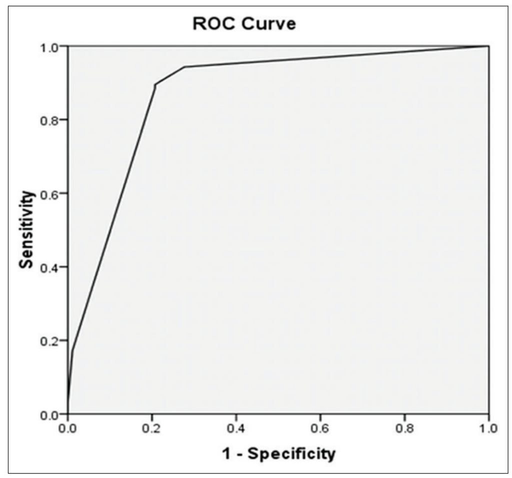

Figure 1: ROC curve for subsample (*n* = 380). Area under curve = 0.871

Discussion

Scoring systems for identification of risk of LBW in the antenatal period were developed by many workers from 2005 to 2014. Metgud *et al*.[8] in rural Karnataka (2012), Prasad, in Belgavi (2014),[3] Samiya and Samina[9] at Srinagar, Kashmir (2005), and Marete *et al*.[10] Kasr El Aini Hospital, (2013–2014). These researchers have identified risk factors based on bivariate analysis and multivariate analysis. The number of risk factors has varied from 5 to 14 and risk scores from 6 to 16. The common risk factors have been illiteracy, primary education, exposure to passive smoking, age ≥ 25 in first pregnancy, birth interval < 2, previous history of LBW baby, weight gain ≤ 4 kg during pregnancy, maternal weight ≤ 45 kg at the last week of gestation, pregnancy-induced hypertension, antenatal registration at third trimester and high-risk pregnancy, parental height, type of conception, gravidity, gestational age, lack of folic acid and calcium intake, irregular intake of iron and folic acid, and inadequate rest during pregnancy. The sensitivity varied from 84.4% to 93.4%, specificity from 54.4% to 79.7%, and predicative values ranged from 20.6% to 77.7%.

The risk factors identified in our study were <4-meals per day, hard work, night sleep of <6 h. illiteracy, weight at first trimester <40 kg, anemia in first trimester (Hb < 11 g%), weight gain of <10 kg during pregnancy and antenatal morbidity, the sensitivity and specificity observed by us for the cutoff value of 12 was 98.6% and 46.1%, respectively. These values are similar to the values observed by other researchers.[8-10]

LBW is of multifactorial origin as a result of play of many risk factors simultaneously present. RR indicates the probability of

Table 3: Distribution of Low Birth Weight babies of low birth weight babies according to birth weight risk score - from 0 to 24 (*n*=251)

Birth weight score	Frequency (%)	LBW babies (%)	LBW prevalence (%)
<12	84 (33.5)	1 (1.4)	1.19
12	84 (33.5)	9 (12.7)	10.71
13	29 (11.6)	8 (11.3)	27.59
15	27 (10.8)	26 (36.6)	96.30
16	20 (8.0)	20 (28.2)	100.0
17	1 (0.4)	1 (1.4)	100.0
18	1 (0.4)	1 (1.4)	100.0
20	4 (1.6)	4 (5.6)	100.0
21	1 (0.4)	1 (1.4)	100.0
Total	251 (100.0)	71 (100.0)	28.28

LBW: Low birth weight

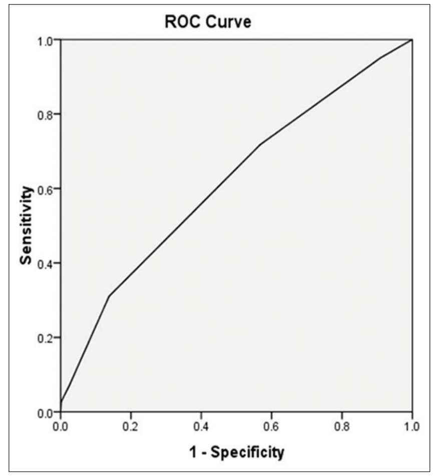

Figure 2: ROC curve for whole sample (*n* = 1876). Area under curve = 0.617

Table 4: Low-, medium-, and high-risk categorization according to frequency of low birth weight (*n*=251)

Risk score	*n* (%)	LBW (%)	Prevalence of LBW (%)
<12 (low)	84 (33.5)	1 (01.0)	1.2
12-14 (moderate)	113 (45.0)	17 (24.0)	15.0
≥15 (high)	54 (21.5)	53 (75.0)	98.2
Total	251 (100.0)	71 (100.0)	

LBW: Low birth weight

an event in the presence of a given risk factor. It is, therefore, an important measure of risk and risk scores based on RR is likely to be better than arbitrary scoring system. The scoring system in the present study is based on the sound prospective research design with cutoffs determined using advanced statistical tools of multivariate analysis, RR and ROC curve analysis which resulted in good sensitivity of 98.6% at lower cutoff level of score of ≥ 12 and with grading of risk with identification of higher cutoff score of≥ 15, and the specificity has improved to 99.4%. The use of low-risk, moderate-risk and high-risk scale for prediction of the birth of LBW baby would be better than using only lower or higher cutoff value [Figure 2].[11]

In a study conducted by Kadam *et al*.[11] It was observed that consumption of breakfast and evening snacks were significantly related to higher mean birth weight. It was also observed in that study that hard work or working in a standing position by women during pregnancy was negatively associated with the weight of the baby. Joshi *et al*.,[12] Kiran and Garg,[13] and Mavalankar *et al*.[6] have noted that the proportion of LBW was maximum (43.94%) in the babies of mothers who were laborers by occupation. Coelho Nde *et al*.[14] have noted that the multiple snacks dietary pattern was positively associated with birth weight (β =56.64; *P* = 0.04) in pregnant adolescents.

These findings are similar to our study where the frequency of meals of <4 was found to have a strong association with the birth of LBW of the baby. With the increasing number of meals up to four, the nutrient intake also significantly increased and so also the birth weight.

The proportion of pregnant women consuming <4-meals a day was 39.4%. Indian women consume staple food of cereals and pulses which has low-caloric density and hence becomes bulky to fulfill the nutritional requirement. The sustained optimal level of glucose is conducive to weight gain during pregnancy and growth of baby which is achieved by having four meals a day separated by an equal time interval in the form of breakfast, lunch, evening snacks, and dinner. Increase in meal frequency to four is possible by health education of pregnant women, her husband and mothers-in-law as a routine part of ANC.

Hard work requires more consumption of calories per day. It was observed that mean caloric intake of 23 women putting in hard work was 2031.4 ± 401.0 in this study which was significantly lesser than the mean caloric intake of sedentary workers of 2239.2 ± 385.1, and the recommended daily allowance by ICMR of 3200 calories for hard-working pregnant women.[4] It is therefore not surprising that in a situation of hard work during pregnancy where energy expenditure is very high and energy intake is very low resulting in a big caloric gap, which is associated with very high proportion of LBW of 82.8%, and RR of 3.4, attributable risk of 70.8%, and population attributable risk of 12.9%. Ensuring the intake of calories as per the recommendation of ICMR for this group, providing a lighter job to women during pregnancy may reduce the caloric gap of these hard-working pregnant women.

Limitation of the study

Study is limited to mothers delivered at the hospital only. Women not having ANC, referred cases and only coming for delivery are not included in the study.

Implications of study

The implications of the study were as follows:

1. The scoring system is easy to use routinely in the ANC clinic by preparing stamp of scoring system
2. Good sensitivity and specificity with the use of two cutoff

points at the scores of 12 and 15 indicating low-, medium-, and high-risk statuses can be achieved during pregnancy
3. There is the possibility of primary prevention by modifying most of the risk factors such as reducing hard work, increasing frequency of meals to four, taking 6 h sleep, availing ANC at least on four occasions, and monitoring weight gain during pregnancy
4. Ensuring hospital delivery so that better newborn care can be ensured
5. Reduction in newborn morbidity and mortality due to LBW babies may be possible if scoring system is used routinely in ANC clinics through trained ANMs and ASHA workers in the rural areas and semi-urban areas. In urban areas also municipal hospitals, government hospitals, and urban health centers can use this scoring system routinely in ANC clinics.

Conclusions

A tool of scoring system was developed for predicating the birth of LBW baby. The developed tool is tested for predictability of birth of LBW and normal BW babies. Thus, ≥12 could be identified as lower cutoff value and ≥15 at higher cutoff value, demarcating <12 as low-risk category, between 12 and 14 as moderate-risk category, and ≥15 as high-risk category. This scoring system is evidence based, with high sensitivity and specificity, easy to understand and use for health-care workers. It is possible to incorporate this tool in routine ANC and give specific timely intervention.

Acknowledgment

This work is a part of PhD work of the first author and sponsored by the self.

The research work was carried out in the Department of Obstetrics and Gynecology, and the researchers are thankful to Honorable Dr. Suresh Bhosale Chairman and Managing Trustee, Krishna Institute of Medical Sciences Deemed to be University, Dr. R. P Patange; Professor and HOD and all the staff of Obstetrics and Gynecology Department Krishna Hospital Karad for extending all the cooperation during research work. We also acknowledge the efforts of the participant pregnant women and contribution made by them.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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