Original Article

Development of Risk Scoring Scale Tool for Prediction of Preterm Birth

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Abstract

Background: Prediction of preterm births in the early stage during pregnancy may reduce prevalence of preterm births by appropriate interventions. **Aims/Objective:** The aim of the study is to develop an antenatal risk scoring system/scale for prediction of preterm births. **Subjects and Methods:** From a cohort of 1876 and subset of 380 pregnant women attending Krishna Hospital Karad, Maharashtra, routine antenatal and in-depth information on diet, occupation, and the rest were collected and analyzed using SPSS version 16. A scoring system was developed by multivariate analysis based on the relative risk (RR) and tested on separate set of 251 mothers. **Statistical Analysis Used:** Bivariate analysis by Chi-square test, backward multivariate regression model, receiver operating characteristic curve (ROC) curve analysis, and calculation of RR for identified risk factors. Sensitivity and specificity of newly developed risk scoring scale. **Results:** Out of six risk factors from whole cohort (n = 1876) and three risk factors from subsample (n = 380) identified by bivariate analysis. Further four and three risk factors were retained after multivariate analysis from whole and part of cohort, respectively, and risk scores of "7" and "9" were assigned based on RR cutoff levels of three and five were identified separately for whole and part data by ROC curve analyses together making it "8" with 75.5% sensitivity and 85.5% specificity when tested on 251 independent patients. Based on the prevalence of preterm births, low-, moderate-, and high-risk grading was done by identifying as second cutoff value. **Conclusions:** Identification of low-, moderate-, and high-risk of preterm births was possible at <8, 8, and 9 and equal to ≥10 with high sensitivity at lower cutoff and high specificity at upper cutoff.

Keywords: Antenatal risk scores, attributable risk, population attributable risk, preterm births, relative risk

Introduction

Preterm birth is, worldwide, the most challenging problem in obstetrics, but the prevention of preterm births has been difficult because of its multifactorial nature and partly due to still unknown etiology.[1,2]

The WHO defines preterm birth as birth before 37 completed weeks. Each year, 15 million preterm babies are born.[3] India is the biggest contributor to the world's prematurity burden. According to the WHO fact sheet 2013, India has 35,19,100 preterm births. It is around 23.6% of the total 15 million world preterm births.

If a scoring system is developed based on the risk factors associated with the preterm births to identify "At risk" mothers early during pregnancy, action can be taken to avert the risk of the preterm births. This primary prevention of preterm births would improve the health and survival of the babies during neonatal period. A hospital-based study was therefore planned to identify the risk factors and develop a scoring system to detect the "At risk" pregnant mothers more likely to give birth to preterm babies.

Subjects and Methods

A consecutive sample of 1876 mothers and their singleton babies were included in the study. The enrollment was started from November 1, 2013, till desired sample size was reached, and continued for 10% more enrollments in view of outcome of 71 still births, 33 multiple pregnancies, and 48 though planned to deliver at Krishna Hospital, delivered outside; hence, 152

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women were excluded [Flow Chart 1]. Thus, the cohort of 1876 was analyzed for the study. In-depth study was done about occupation, hours of rest during day and hours of sleep at night, and the diet consumed by the mother during antenatal period from randomly selected 380 mothers from original cohort.

Results

The risk factors related to the sociodemographic, anthropometric, and clinical aspects of pregnant mothers were subjected to bivariate analysis. Six risk factors, namely, education (literate), type of family (Nuclear), weight gain <10 kg, number of antenatal care (ANC) visits <4, weight at first trimester <40 kg, and anemia in the first trimester (hemoglobin <11 g%) from the main cohort of 1876 pregnant women were identified. They were subjected to backward multivariate regression model. Out of these six factors, all were retained as significant indicators of preterm births except two, that is, antenatal morbidity and anemia in the first trimester. Three variables were found significantly associated with preterm births by bivariate analysis of subsample of 380 pregnant women, namely, type of work (hard work), number of meals (<4), and hours of rest during day (<2 h); they were subjected to backward multivariate regression model. All the three risk factors were retained as significant indicators of the preterm births. Relative risk (RR) and confidence interval for all risk factors related to preterm births were found to be highly significant. They were arranged in order of magnitude [Table 1].

Highest RR, attributed risk for preterm births was observed for hard work (RR = 3.880), followed by number of meals of <4 per day (RR = 3.258) and hours of rest during day <2 h (RR = 2.222). It was followed by education (RR = 1.670), weight gain <10 kg during pregnancy (RR = 1.579), number of ANC visits of < 4 (RR = 1.530), and nuclear type of family (RR = 1.330) [Table 1].

For effective and easy identification of "At risk" mothers for preterm delivery, the scores were given on the basis of RR. Total score of first three variables (type of work, number of meals per day, and rest during day time) from the subsample (n = 380) was "9." Receiver operating characteristic curve (ROC) analysis revealed cutoff score of "3," for these three risk factors. Similarly, total scores of four variables available from the whole data (n = 1876) (education, weight gain, number of ANC visits, and type of family) were "7," which was considered to determine the cutoff score for identification of "At risk" pregnant women. ROC curve analysis revealed cutoff value of "5." Adding these cutoff values (3 + 5), 8 was identified as final cutoff value for the scoring system of seven risk factors with total score of 16 (9 + 7). The score ≥8 indicated higher probability of preterm delivery and <8 indicated higher probability of nonpreterm delivery. This newly developed scoring system for identification of "At risk" women giving birth to preterm babies was applied to a set of 251 pregnant women who were not included in the study cohort for computing the scoring system. At cutoff score of ≥8, correct classification of preterm births could be done for 83.2% pregnant women. The predictive value for preterm birth was 57.3% and sensitivity of 75.5% and specificity of 85.4% [Table 2].

The frequency distribution of maternal scores of "At risk" mothers is given in Table 3. There was a sharp increase in the prevalence of preterm birth from 50% to 91.6% when the score increased from 9 to 10. Hence, the 2nd cutoff value was identified at ≥10 risk score. The correct classification was possible for 84.4%, with sensitivity of 30.7%, specificity of 98.4%, and positive predictive value of 84.2%. With identification of this 2nd cutoff value, the risk could be graded as low at <8 score, moderate risk at score 8 and 9, and high risk above the score of 10 or more with high sensitivity at first cutoff value of "8" and higher specificity at second cutoff value of "10."

There were 183 (72.9%) women who could be classified as low risk who delivered 13 (7.1%) preterm babies, 49 women (19.5%) could be classified as having moderate risk who delivered 23 (46.9%) preterm babies, and 19 (7.5%) women could be classified as high risk who delivered 16 (84.2%) preterm babies.

Discussion

Scoring systems for identifying the risk of preterm birth in antenatal period were developed by many workers from 2001 to 2014: Talsania and Lala in New Civil Hospital, Ahmadabad, India (2001),[4] Okunade *et al*. at Lagos Tertiary Hospital in

Table 1: Relative risk, attributed risk, and population-attributed risk of significant risk factors for preterm births

Risk factor	*n* (%)	RR of 95% CI	AR	PAR (%)	Scoring
Preterm births: From in-depth subsamples study (*n*=380) (total score-9)					
Hard work	23 (6.1)	3.880 (2.239-6.726)	74.2	14.9	4
Number of meals/day <4	150 (39.4)	3.258 (1.866-5.691)	69.3	74.7	3
Hours of rest during day <2 h	267 (70.3)	2.222 (1.078-4.581)	55.0	46.1	2
Preterm births: From whole cohort study (*n*=1876) (total score-7)					
Literate	1751 (93.3)	1.670 (1.030-2.710)	40.1	36.8	2
Weight gain <10 kg	1295 (69.0)	1.579 (1.258-1.980)	36.7	28.5	2
Number of ANC visits <4	665 (34.9)	1.530 (1.275-1.837)	34.6	15.6	2
Nuclear family	716 (38.1)	1.330 (1.107-1.598)	24.8	11.2	1

RR: Relative risk, AR: Attributed risk, PAR: Population-attributed risk, CI: Confidence interval, ANC: Antenatal care

Nigeria (2014),[5] Samiya and Samina at[6] Maternity Hospital of Kashmir (LalaDed Hospital) attached to the Government Medical College, Srinagar (2005), Marete *et al*.[7] Kasr El Aini Hospital, (2014). In their studies, they have identified the risk factors based on bivariate analysis and multivariate analysis. The common risk factors have been maternal malnutrition, higher pregnancy order, older maternal age at delivery, prior preterm births, history of fetal loss, preeclampsia (hypertension and proteinuria developing >20 weeks' gestation), fetal distress, intrauterine growth retardation, abruptio placentae, and fetal death. The sensitivity varied from 50% to 95.77%, specificity from 19.69% to 75%, and predictive values from 11.93% to 73.8% for antenatal prediction of preterm births.

The risk factors identified in our study were hard work, <4 meals a day, hours of rest during day <2, literacy, weight gain <10 kg, number of ANC visits <4, and nuclear family in decreasing order of magnitude. The predictive value for preterm birth was 57.3% and sensitivity of 75.5% and specificity of 85.4% at the cutoff value of ≥8 scores. These values are in the range of the values observed by other researchers. Grading was done by Beck *et al*.[8] grading was done as low risk (<8 score), moderate (8 and 9 score) and high (≥10 score), respectively. Preterm birth is of multifactorial origin as it occurs as a result of play of many risk factors simultaneously present. RR indicates the probability of preterm birth if there is the presence of given risk factor. It is therefore an important measure of risk, and risk scores based on RR are likely to predict preterm births better than the arbitrary scoring system. The scoring system in the present study is based on sound prospective research design with cutoffs determined using advanced statistical tools of multivariate analysis, RR, and ROC curve analysis, and frequency distribution of risk scores, which resulted in good sensitivity at lower cutoff level score of ≥8 of 75.5% and specificity of 98.4% at higher cutoff score of ≥10 more. Therefore, the use of low-risk, moderate-risk, and high-risk scale for prediction of preterm birth would be better than using only one cutoff value at lower or higher level.

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

Gestational age score category	Gestational age category		Total (%)
	Preterm, *n* (%)	Not preterm, *n* (%)	
Preterm (score ≥8)	39 (75.0)	29 (14.6)	68 (27.1)
Nonpreterm (score <8)	13 (25.0)	170 (85.4)	183 (72.9)
Total	52	199	251

Table 3: Frequency distribution of preterm births according to Gestational age score from 0 to 16 (*n*=251)

Score	Frequency (%)	Preterm (%)	Preterm prevalence (%)
<8	183 (72.9)	13 (25.0)	7.1
8	19 (7.6)	8 (15.4)	42.1
9	30 (12.0)	15 (28.8)	50.0
10	12 (4.8)	11 (21.2)	91.6
11	5 (2.0)	4 (7.7)	80.0
12	2 (0.8)	1 (1.9)	50.0
Total	251 (100.0)	52 (100.0)	20.7

It has been noted that prolonged standing at work of ≥7 h/day, working in hot environments, commuting, walking, carrying and lifting heavy weight, and night work have all been seen to be associated with pregnancy loss and preterm birth, especially in women whose nutritional status is compromised.[9-13]

In a study done by TH Kim *et al*.[14] in Korea, researchers have noted that occupation during pregnancy of laborer had 20% increased risk of preterm delivery as compared to legislators and managers. Peasants are associated with increased risk of preterm delivery probably due to hard working in the farms which trigger early labor and hence lead to preterm birth.

The study conducted by Temu[15] in Northern-eastern Tanzania (2016), Zhang *et al*.[16] in Beijing (2016), Steer,[17] and Räisänen *et al*.[18] have noted that women who were involved in hard physical work during pregnancy had more than three-fold increased odds of preterm delivery even after adjusting for the confounders. The high risk of preterm delivery may be explained by increased stress which triggers premature labor, which leads to preterm delivery.

Simpson[19] and Keith and Luke[20] have speculated that strenuous occupations increased uterine contractions and therefore increased the risk of premature birth. Heavy weight lifting increases intra-abdominal pressure, and this may provoke uterine contractions. Heat stress causes dehydration resulting in the release of the antidiuretic hormone and oxytocin, which stimulates the uterus to contract.

The study conducted by Siega-Riz *et al*.[21] in University of North Carolina, USA (1998) noted that women who consumed meals/snacks less frequently had a higher risk of delivering preterm births (adjusted odds ratio = 1.30, 95% confidence interval: 0.96, 1.76), which supports previous animal model work of an association between decreased frequency of eating and preterm delivery. This could be due to malnutrition due to inadequate food intake and fluctuations in the blood glucose levels.

Tellapragada *et al*.[22] in South India (2014) Udupi district have observed higher rates of preterm births with higher educational levels of mothers. We have also observed significantly higher rates of preterm births among babies born to literate women.

Maternal poor ANC attendance (ANC visits <4) was associated with increased risk of preterm delivery in our study. Similar findings were noted by Temu[15] in Northeastern Tanzania (2014), Zhang *et al*.,[16] and Mahande.[23] Diseases or obstetrical complications are more likely to be detected during ANC and treated preventing preterm delivery. Studies from several developing countries have found that "no ANC visit" is a significant risk factor for preterm birth, ranging from 1.3 to 7 times higher risk than for women having any ANC visit.[24-27]

Studies conducted in Northern India by Saini *et al*.[28] and Rashmi *et al*.[29] Mysuru, Karnataka, India, have found that type of family

affects the pregnancy outcome. Nuclear family had positive impact by having good socioeconomic status and more leisure.

In the present study, the pregnant women doing hard work like road buildings were 6.1% with higher RR of 3.88 with a prevalence of preterm births of 26.1%. Providing less strenuous work during pregnancy and ensuring adequate nutrition by minimum of 4 meals a day and supplementary feeding under Integrated Child Development Scheme (ICDS) are of paramount importance. Rest in the afternoon for 2 h, ANC visits for minimum four times during pregnancy can be achieved by counseling. The risk factors identified in this study have a strong scientific basis as they are based on RR. Population-attributable risk percentage is determined jointly by the magnitude of RR and the prevalence of the risk factor in the community. The community strategies suggested appear to be feasible, acceptable to the community, and will be a leap forward toward achieving MDG4, and 50% reduction in preterm births by 2015,[30] the announcement by global experts on world prematurity day 2012.

Limitations 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 the study

Identification of 'At Risk' pregnant women is possible during pregnancy with good sensitivity and specificity using the scoring system which can be easily done by preparing a stamp of the same. There is also possibility of primary prevention by modifying the identified risk factors like reducing hard work, increasing frequency of meals to four, taking afternoon rest 2 hours, availing ANC visit at least for four occasions, and monitoring weight gain during pregnancy.

Stamp

Significant risk factors by bivariate analysis from subsample of 380 patients were (Total 3) and from whole cohort, data of 1876 patients were (Total 4). Hence, grand total of all is (7) variables

Risk factors risk scores:

1. Type of work (Hard work)	(4)
2. Number of meals per day (<4)	(3)
3. Hours of day rest (<2 h)	(2)
4. Education (Literacy)	(2)
5. Weight gain (<10 g)	(2)
6. Number of ANC visits (<4)	(2)
7. Type of family (Nuclear)	(1)

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.

↓

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

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Data collection period- from November 1, 2013, to 31st December 2015 and followed till delivery

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Exclusion criteria - All stillbirths and multiple pregnancies and deliveries at places other than Krishna Hospital were excluded.

↓

Data collection method- Information was collected by interview method. The weight was taken on a standard electronic weighing machine, and gestational period was determined from the LMP.

↓

Variables under study - maternal age, education, parity, weight at registration, hemoglobin g %, and number of ANC visits, antenatal morbidity and weight gain during pregnancy, type of work, a detailed nutritional history (by 24 h recall method), rest during day and sleep at night.

↓

Ethical consideration - Approval of Institutional Ethics Committee was obtained, and informed consent was taken from eligible pregnant women before the commencement of the study.

↓

Data analysis-The data were analyzed using SPSS version 16. Multivariate regression analysis was used for the identification of significant risk factors for preterm births. RR was calculated, and a scoring system based on it was prepared for the prediction of preterm births. ROC curve analysis was used to identify cutoff level for identifying "At risk" women; this scoring system was tested on 251 women who were not included in the study cohort and outcome was noted. Frequency distribution of the preterm births and the maternal risk score were computed. Sensitivity, specificity, and positive predictive value for preterm birth were calculated using appropriate formulae.

Flow Chart 1: Showing Research participant

Total Risk Score	(16)

Instruction: Please encircle/Tick mark appropriately:

Low risk	(<8)
Moderate risk	(8 to 10)
High risk	(≥10)

The results are applied to the local population. It can be applied through trained ANM and ASHA workers in the rural areas and semi-urban areas. In urban areas, municipal hospitals, government hospitals, and urban health centers can use this scoring system routinely in ANC clinics.

Conclusions

Community-based studies to test the feasibility and acceptability of risk/predictors of preterm births by developing and testing scoring system/tool are required. Once the effective, feasible, and acceptable scoring system is developed, it can be incorporated in the routine ANC services for detection and management of high-risk women for primary prevention of preterm births in routine health-care delivery system. Identification of women at high risk for delivering preterm babies would be improved using this tool developed in this study.

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Conflicts of interest

There are no conflicts of interest.

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