

## Association of Maternal Age, Pregnancy Order and Seasonal Variations in Low Birth Weight (LBW) in West Bengal, India

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**ABSTRACT** Birth weight of newborns is a common proxy measure of intrauterine growth, which is influenced by nutrition, environment, socio-economic status and lifestyle factors during the gestation period. The objectives of the present investigation were to understand the influences of maternal age, pregnancy order and seasonal variation in newborn low birth weight (LBW). Data of 13,423 newborn birth weight during the period from July 2007 to June 2010 were recorded from the Siliguri District Hospital of Darjeeling, West Bengal India. The information collected comprised of birth weight, type of pregnancy, maternal age, pregnancy order, month (season) of delivery and residential addresses. The overall mean ( $\pm$ SD) and prevalence of LBW were  $2.71 \pm 0.41$  kg and 19.19 percent ( $n=2576$ ), respectively. The binary logistic regression analysis showed higher odds values ( $p < 0.01$ ) of LBW with mother's age  $< 20$  years (Odds: 1.416) and 1<sup>st</sup> pregnancy order (Odds: 1.636). However, births during spring season exhibited lower odds of LBW (Odds: 0.798) ( $p < 0.01$ ). The maternal age  $\leq 20$  years and  $\leq 1$ <sup>st</sup> pregnancy order was associated with LBW ( $p < 0.05$ ). The ROC-AUC analysis showed that pregnancy order (AUC=0.553) was better surrogate associate measure than maternal age (AUC=0.544) for determination of LBW ( $p < 0.05$ ). Early detection in newborns can attain appropriate weight gain and this can be achieved through regular checkup effective implementation of ongoing intervention programmes and appropriate healthcare facilities to prevent intrauterine growth retardation.

### INTRODUCTION

Birth weight of newborns is considered being a common proxy measure of intrauterine growth, influenced by socio-economic status, nutrition, environment, lifestyle factors and maternal health services during the gestation period (Christian 2009; Ludwig and Currie 2010; Sen et al. 2010; Yigwan et al. 2012; Amose and Degan 2014; Demelash et al. 2015; Kananura et al. 2017; Mahumud et al. 2017). Low birth weight (LBW) has been defined by the World Health Organization (WHO) as weight at birth of less than 2,500 gm. The LBW is the single most underlying risk factor leading to neonatal mortality

and morbidity all over the world (WHO 2003). It has been estimated that 18 million LBW newborns are born worldwide with half of them being in South-Asia and a 20 times higher risk of death than heavier infants (UNICEF 2004). Studies have observed strong associations between LBW and an increased risk of mortality during the periods of neonatal, infancy and later adulthood. In fact, LBW is considered being a risk factor causing developmental retardation during childhood (UNICEF 2004; Mahumud et al. 2017). The prevalence of LBW is positively associated with different short and long-term adverse consequences apparent with fetal development and neonatal mortality and morbidity, inhibiting several significant physical growth and congenital development risk and causing chronic diseases in later life (UNICEF 2004; Sen et al. 2010; Adane et al. 2014; Demelash et al. 2015; Dahlui et al. 2016; Mahumud et al. 2017). The LBW is considered being public health issues in many of the developing countries including India (Bisai et al. 2007; Badshah et al. 2008; Bisai

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2010; Sen et al. 2010; Bharati et al. 2011; Yilgwan et al. 2012; Adane et al. 2014; Bhaskar et al. 2015; Demelash et al. 2015; Dahlui et al. 2016; Saini et al. 2016; Kananura et al. 2017; Mahumud et al. 2017; Sudha et al. 2017; Kavle and Landry 2018).

Children have only a single chance to develop and protection of that one chance demands the commitment that will not be superseded by any other priorities. Many factors observed to have profound effects during the period of gestation are related to maternal, physical and socio-economic environments. They have important roles in determining newborns birth weight and determining future health. Several studies have reported that LBW is affected by maternal nutrition or weight gain during pregnancy (Sen et al. 2010; Ludwig and Currie 2010; Yilgwan et al. 2012; Bhaskar et al. 2015; Demelash et al. 2015; Dahlui et al. 2016; Mahumud et al. 2017; Soltani et al. 2017; Kavle and Landry 2018), socio-economic status (Sen et al. 2010; Demelash et al. 2015; Mahumud et al. 2017; Budree et al. 2017; Sudha et al. 2017) and physical factors, maternal environment, physical activity and healthcare services (Li and Chang 2005; Elshibly and Schmalisch 2008; Demelash et al. 2015; Budree et al. 2017; Kananura et al. 2017; Wang et al. 2017). Maternal factors such as maternal age and pregnancy order are important determinants of birth weight. Significant number of studies have reported effects of maternal age and pregnancy order with newborn birth weight (Badshah et al. 2008; Elshibly and Schmalisch 2008; Christian 2009; Bisai 2010; Sen et al. 2010; Adane et al. 2014; Demelash et al. 2015; Mahumud et al. 2017; Wang et al. 2017). It has also been reported that a wide range of LBW-related morbidity/mortality is influenced by the external environment such as temperature, humidity and rainfall throughout the seasons (Murray et al. 2000; Lawlor et al. 2005; Onyiriuka 2006; Chodick et al. 2007; Strand et al. 2012; Hughes et al. 2014; Lei et al. 2016; Zhang et al. 2017). Infants born during late spring and summer are lighter than those born in winter, which might result from exposure to low winter temperatures during mid-gestation (Murray et al. 2000). Exposure to the low outdoor ambient temperature in the mid-trimester is also associated with LBW (Strand et al. 2012). Understanding the effects of maternal age, pregnancy order and environmental factors associated with birth outcomes, especially LBW will provide useful information to develop strategies for healthcare,

appropriated surveillance, and preparedness to reduce related consequences necessary among populations. Identification of the suggested causal environmental factors may have public health implications in the development of primary prevention programs for LBWs in the developing countries such as India.

## Objectives

The objectives of the present investigation were to determine the prevalence and understand associations of maternal age, pregnancy order and seasonal variation on LBW in West Bengal, India.

## METHODOLOGY

The present study was a cross-sectional study carried out based on the data registered in the hospital records at Siliguri District Hospital located in the sub-divisional town of Siliguri (Latitude: 26° 22", Longitude: 88° 41") in the district of Darjeeling, West Bengal India. The area chosen for the present study is located in the Darjeeling district of this region. A number of ethnic communities of Lepcha, Rabha, Meche, Oraon, Santal and Munda, Rajbanshi, Dhimal, Bengali Caste and Bengali Muslim, several linguistic and heterogeneous caste groups reside in this area. The minimum number of subjects required for reliably estimating the prevalence was calculated following a standard sample size estimation method (Lwanga and Lemeshow 1991). In this method, the anticipated population proportion of fifty percent, absolute precision of one percent and confidence interval of ninety-five percent are taken into consideration. Thus, the minimum sample size estimated for the present study was 9558. A total of 15,479 newborn birth weight data along with their maternal characteristics were recorded from the hospital records of the period from July 2007 to June 2010. However, to avoid necessary sample bias, a total of birth records of 2056 (13.29%) infants were excluded from the final sample as these mothers had the history of stillbirths, multiple births and pre-term delivery. Hence, the final sample consisted of 13,423 birth records of normal or completed gestational period including both cesarean and vaginal deliveries. The prevalence of any macrosomic baby (>4000 gm) was absent and/or not considered in the analyzed samples. The data

consisted of birth weight, type of pregnancy, maternal age, pregnancy order, delivery month, seasons and residential addresses were obtained from office record. The newborns were defined as LBW and normal birth weight (NBW) as the weight at birth <2500 gm and >2500 gm, respectively (WHO 2003). The meteorological data of the region was obtained from the regional Meteorological Centre of Kolkata which is under the Meteorological Departments, Government of India. Data on daily maximum and minimum temperature ( $^{\circ}\text{C}$ ) were obtained for the period 2007-2010. In order to determine the seasonal effect, the birth weight data were separately categorized in terms of the following four seasons: Winter (December-February), Spring (March-May), Summer (June-August) and Autumn (September- November). Permissions for the study were obtained from the Siliguri District Hospital and the University of North Bengal. The data of the present study were recorded over a seven months period from June 2013 to January 2014.

### Statistical Analysis

All statistical analysis was performed by utilizing using SPSS (version 17.0). A p-value <0.05 and <0.01 were considered being statistically significant. One-way analysis of variance (ANOVA) using Scheffe procedure was performed to determine the mean differences in between and within the variables between (NBW) and LBW mothers. Chi-square analysis ( $\chi^2$ ) was done to assess differences in the prevalence of the variables between (NBW) and LBW. Binary logistic regression analysis was performed to fit into estimate the odds or risk being the LBW vs NBW, which allows controlling the different independent variables. To create the dependency (LBW vs. NBW) newborn birth weight of <2.50 kg were coded as '0' and birth weight >2.50 kg and above were coded as '1'. The maternal variables were entered into the binary logistic regression model as a set of dummy variables and results were obtained by comparing with reference categories. The predictor variables used in the regression model analysis were mothers' age, pregnancy order and seasonal variation. The reference categories that were selected from the above-mentioned variables comprised of 'mother's age 21-24 years', '2<sup>nd</sup> pregnancy order' and 'winter season', respectively.

Receiver Operating Characters (ROC) curve analysis was used to evaluate the accuracy of mothers' age and pregnancy order to predict LBW. The ROC curve determines the efficacy of the screening measures for correctly identifying subjects on the basis of their classification of a reference test. It is a plot of the true positive rate (sensitivity) against the false positive rate (1-specificity). Sensitivity is the proportion of the reference test positive subjects who test positive with the screening test. Specificity is the proportion of reference test negative subjects who test negative with the screening test. In ROC curve analysis, one important index is reflecting the accuracy of the diagnostic test derived from the ROC analysis is an area under curve (AUC). The ninety-five percent of the confidence interval (95% CI) of the AUC curve (AUC-ROC) was also calculated to ascertain the best surrogate fitted variables for LBW. The values of the each AUC curve can be between '0' and '1'. A value of '0' indicates that the screening measure does not perform well, whereas the value of '1' denotes perfect performance. The AUC was found to be 0.50 which means that the diagnostic test is no better than chance, hence, values >0.50 are thus more desirable. The optimum cut-off limit point was defined by the highest specificity-sensitivity product to consider a newborn with LBW.

### RESULTS

Results of the present study showed that the overall mean and standard deviation ( $\pm\text{SD}$ ) of birth weight was  $2.71\pm 0.41$  kg. The prevalence of LBW was 19.19 percent (n=2576). The frequency and means  $\pm\text{SD}$  of birth weight, maternal factors and seasonal variation as categorized according to birth categories is shown in Table 1. The descriptive statistics of the newborn birth weight was observed to be significantly higher in NBW as compared with LBW categories (p<0.05). The mean birth weight of the newborns gradually increased with maternal age and pregnancy order. Higher mean values were observed in >25 years ( $2.74\pm 0.42$  kg) and 3<sup>rd</sup> pregnancy order ( $2.77\pm 0.44$  kg), respectively. The difference was observed to be statistically significant within the categories of maternal age (F= 85.72; p<0.01), pregnancy order (F= 155.97; p<0.05) and the seasonal variation (F=27.62; p<0.01). The season wise mean values were observed to be higher in

**Table 1: Categorized frequency and descriptive statistics (mean  $\pm$ SD) of birth weight of the newborns**

| Variables            | Birth weight (N=13423) |               |                 | LBW (N=2576) |                 |  | NBW (N=10847) |                 |  | F value | p     |
|----------------------|------------------------|---------------|-----------------|--------------|-----------------|--|---------------|-----------------|--|---------|-------|
|                      | Frequency              | Mean $\pm$ SD |                 | Frequency    | Mean $\pm$ SD   |  | Frequency     | Mean $\pm$ SD   |  |         |       |
| Mother's Age (years) | <20                    | 4786 (35.66)  | 2.64 $\pm$ 0.39 | 1092 (42.39) | 2.14 $\pm$ 0.23 |  | 3694 (34.05)  | 2.79 $\pm$ 0.30 |  | 4590.04 | 0.000 |
|                      | 21 - 24                | 4112 (30.63)  | 2.73 $\pm$ 0.40 | 710 (27.56)  | 2.16 $\pm$ 0.23 |  | 3402 (31.36)  | 2.85 $\pm$ 0.32 |  | 2956.41 | 0.000 |
|                      | >25                    | 4525 (33.71)  | 2.74 $\pm$ 0.42 | 774 (30.04)  | 2.15 $\pm$ 0.23 |  | 3751 (34.58)  | 2.87 $\pm$ 0.33 |  | 3308.06 | 0.000 |
| Pregnancy Order      | 1                      | 5557 (41.40)  | 2.63 $\pm$ 0.38 | 1301 (50.50) | 2.15 $\pm$ 0.23 |  | 4256 (39.24)  | 2.78 $\pm$ 0.29 |  | 5355.88 | 0.000 |
|                      | 2                      | 4892 (36.44)  | 2.75 $\pm$ 0.40 | 770 (29.89)  | 2.15 $\pm$ 0.22 |  | 4112 (37.90)  | 2.86 $\pm$ 0.32 |  | 3445.53 | 0.000 |
|                      | 3>                     | 2974 (22.16)  | 2.77 $\pm$ 0.44 | 505 (19.60)  | 2.14 $\pm$ 0.24 |  | 2469 (22.76)  | 2.90 $\pm$ 0.35 |  | 2163.82 | 0.000 |
| Seasonal Variation   | Dec - Feb              | 3455 (25.74)  | 2.70 $\pm$ 0.40 | 657 (25.50)  | 2.14 $\pm$ 0.23 |  | 2798 (25.80)  | 2.83 $\pm$ 0.31 |  | 2807.77 | 0.000 |
|                      | Mar - May              | 2819 (21.00)  | 2.77 $\pm$ 0.41 | 445 (17.28)  | 2.16 $\pm$ 0.22 |  | 2374 (21.89)  | 2.88 $\pm$ 0.33 |  | 1918.78 | 0.000 |
|                      | Jun - Aug              | 3270 (24.36)  | 2.69 $\pm$ 0.41 | 668 (25.93)  | 2.15 $\pm$ 0.22 |  | 2602 (23.99)  | 2.83 $\pm$ 0.32 |  | 2745.68 | 0.000 |
|                      | Sep - Nov              | 3879 (28.90)  | 2.68 $\pm$ 0.41 | 806 (31.29)  | 2.14 $\pm$ 0.23 |  | 3073 (28.33)  | 2.82 $\pm$ 0.31 |  | 3329.96 | 0.000 |

summer ( $2.77 \pm 0.41$  kg) and lower in autumn ( $2.68 \pm 0.41$  kg). There were statistically significant differences between the categories of NBW and LBW using ANOVA ( $p < 0.01$ ) (Table 1).

### Association of Maternal Age, Pregnancy Order and Seasonal Variation with LBW

The profiles based on the mother's age, pregnancy order and seasonal variation with newborn birth weight are shown in Table 1. The frequency of newborn LBW was highest in the maternal age group of <20 years (42.39%) followed by >25 years (30.04%) and finally 21-24 years (27.56%). Pregnancy order showed that half of the LBW newborns were observed to be in 1<sup>st</sup> order births (50.50%), while lowest prevalence was observed in >3<sup>rd</sup> pregnancy order (19.40%). When seasonal variations were taken into consideration, highest and lowest prevalence of LBW was found in autumn (31.29%) and summer (17.28%), respectively. The  $\chi^2$ -analyses indicated the statistically significant ( $p < 0.01$ ) differences in the prevalence of LBW with different sub-categories of maternal age ( $\chi^2 = 42.22$ ), pregnancy order ( $\chi^2 = 74.51$ ), sex of newborn ( $\chi^2 = 15.05$ ) and the seasonal variation ( $\chi^2 = 21.14$ ).

### Binary Logistic Regression Analysis of Maternal Age, Parity and Seasonal Variation on LBW

Results of the binary logistic regression analysis indicate that all the variables exhibited significant influences on LBW (Table 2). The odds value of a newborn being LBW with mother's age were higher in < 20 years (Odds: 1.416,  $p < 0.01$ ). However, mother's age of >25 years had a slightly lower association (Odds: 0.989) than the reference. The 1<sup>st</sup> pregnancy order showed a significantly ( $p < 0.01$ ) higher association of being LBW (Odds: 1.636). When seasonal variations were taken into consideration, a higher association was observed in autumn (Odds: 1.117), followed by the summer (Odds: 1.093). However, spring exhibited lower odds values (Odds: 0.798) as compared to the reference category ( $p < 0.01$ ).

### ROC-AUC Analysis of Maternal Age and Pregnancy Order of LBW

The ROC-AUC curve analysis was performed on maternal age and pregnancy order as predic-

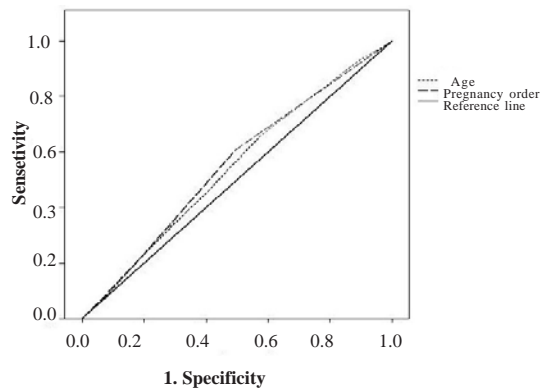
**Table 2: Binary logistic regression analysis and association mother's age, pregnancy order and seasonal variations with LBW**

| Variables            |                              | Binary logistic Regression analysis for LBW newborn |       |         |               |
|----------------------|------------------------------|-----------------------------------------------------|-------|---------|---------------|
|                      |                              | B                                                   | SE    | Odds    | 95% CI        |
| Mother's Age (years) | <20                          | 0.348                                               | 0.054 | 1.416** | 1.275 - 1.574 |
|                      | 21 - 24 <sup>®</sup>         | -                                                   | -     | -       | -             |
|                      | 25>                          | -0.011                                              | 0.057 | 0.989   | 0.884 - 1.106 |
| Pregnancy Order      | 1 <sup>st</sup>              | 0.493                                               | 0.050 | 1.636** | 1.482 - 1.806 |
|                      | 2 <sup>nd</sup> <sup>®</sup> | -                                                   | -     | -       | -             |
|                      | 3 <sup>rd</sup> >            | 0.091                                               | 0.063 | 1.095   | 0.968 - 1.238 |
| Seasonal Variation   | Dec-Feb <sup>®</sup>         | -                                                   | -     | -       | -             |
|                      | Mar-May                      | -0.225                                              | 0.067 | 0.798** | 0.699 - 0.911 |
|                      | Jun-Aug                      | 0.089                                               | 0.061 | 1.093   | 0.970 - 1.233 |
|                      | Sep-Nov                      | 0.111                                               | 0.059 | 1.117   | 0.996 - 1.253 |

Note: Values in parentheses indicates percentages, <sup>®</sup>Reference category, \*p<0.01

tor variables to determine the optimal cut-offs along with the sensitivity, specificity values, positive predictive value and negative predictive value of the derived cut-offs associated with newborn LBW are shown in Table 3. The results indicate that maternal age <20 years and <1<sup>st</sup> pregnancy order was associated with newborn LBW

(p<0.05). The ROC-AUC analysis showed that pregnancy order (AUC=0.553) was the better surrogate associate measure than maternal age (AUC=0.544) for determination of LBW (p<0.05). The comparative evaluation of maternal age over pregnancy order for screening measures of LBW using AUV-ROC analysis was plotted in Figure 1.



**Fig. 1. ROC analysis showing comparative evaluation of maternal age and pregnancy order for screening measures of LBW**

## DISCUSSION

Birth weight or LBW is the single most significant reproductive outcome or determinant of infant mortality and the chances of a newborn to experience healthy development or survival. The prevalence of LBW appears to be a major public health issue in India and reported to be the highest among South-Asian countries. The LBW appears to be related to higher risks of several important chronic conditions (Christian 2009; Demelash et al. 2015; Kananura et al. 2017; Mahumud et al. 2017). Thus, the determining factors that influence intrauterine growth and birth weight may have a serious effect on health outcomes many years later in life. The result of the present study indicates that a total of 19.19

**Table 3: ROC-AUC curve analysis of mother's age and pregnancy order for estimation of risk factors to being newborn LBW**

| Variable           | Optimal cut-offs | Sensitivity % (95% CI) | Specificity % (95% CI) | +PV  | -PV  | AUC (95% CI)        |
|--------------------|------------------|------------------------|------------------------|------|------|---------------------|
| Mother age (years) | <20              | 42.39 (40.5-44.3)      | 65.94 (65.0-66.8)      | 22.8 | 82.8 | 0.544** (0.54-0.55) |
| Pregnancy order    | <1 <sup>st</sup> | 50.50 (48.6-52.5)      | 60.76 (59.8-61.7)      | 23.4 | 83.8 | 0.553** (0.54-0.56) |

Note: \*p>0.05, \*\*p<0.05, AUC = Area under the ROC curve  
+ PV = Positive predictive value, - PV = Negative predictive value

percent outcomes had LBW. The comparative evaluation of the LBW prevalence was observed being similar to those reported from other studies conducted in India from Darjeeling (17.30%) (Sen et al. 2010), Pune (29%) (Hirve and Ganatra 1994), Kolkata (34%) (Bisai et al. 2007), Mumbai (45.20%) (Velankar 2009), Haryana (28.8%) (Bharati et al. 2011), India (20%) (Saini et al. 2016) and Andhra Pradesh (34.1%) (Sudha et al. 2017). Maternal physical characteristics and environmental factors have long been known to influence the reproductive outcomes in newborns (Sen et al. 2010; Amosu and Degun 2014; Demelash et al. 2015; Wang et al. 2017). Related factors such as maternal age, pregnancy order, sex of newborn and seasonal variation were observed to be significantly associated with an increased risk of being a newborn LBW. It was reported that maternal age exhibited a significant effect on the LBW (Bisai 2010; Badshah et al. 2008; Sen et al. 2010; Demelash et al. 2015; Mahumud et al. 2017; Wang et al. 2017). The result of the present study indicates that higher prevalence of LBW was observed to be in <20 years followed by >25 years of mothers' age group. Several studies have reported that the prevalence of LBW increases with the extremes of mothers' reproductive life between 15-19 years (Velankar 2009; Badshah et al. 2008; Bisai 2010; Demelash et al. 2015). It is attributed to the teenage mothers have significantly higher risk of adverse pregnancy outcomes. The findings of the present study are in accordance with the higher prevalence of LBW newborn being significantly associated with mothers age <20 years (Hirve and Ganatra 1994; Badshah et al. 2008; Velankar 2009; Bisai 2010; Demelash et al. 2015). The higher prevalence of LBW in the lower age mother suggests that younger mothers tend to have relatively greater risk of smaller and lighter newborns than their older and biologically more mature counterparts (Kirchengast and Hartmann 2006; Badshah et al. 2008; Bisai 2010; Sen et al. 2010; Demelash et al. 2015). The results of ROC-AUC curve analysis showed that maternal age <20 years is the relatively best fitted surrogate cut-off for assessing LBW (Table 3).

The results of binary logistic regression analysis showed that the mothers' <20 years of age exhibited 1.416 times significantly higher odds for newborn LBW ( $p < 0.01$ ). Similar studies have reported that maternal age <20 years had significantly ( $p < 0.05$ ) higher odds for LBW in India

(Odds: 1.27) (Hirve and Ganatra 1994), Bangladesh (Odds: 2.20) (Hosain et al. 2005), Pakistan (Odds: 6.10) (Badshah et al. 2008) and Ethiopia (Odds: 3.00) (Demelash et al. 2015). The binary logistic regression analysis showed that the odds value for >25 year's maternal age was lower (Odds: 0.989) for LBW. It was reported that maternal age at first childbirth >25 years was an independent risk factor for LBW (Beydoun et al. 2004). Maternal age also acted as a determinant factor for LBW where the prevalence was more common in <20 years ages and the older mothers (>30 years) (Li and Chang 2015). The pregnancy order considered being the very major and significant maternal parameter which influences birth weight and risk of LBW (Elshibly and Schmalisch 2008; Sen et al. 2010; Demelash et al. 2015). The risk factor of LBW was documented to be decreased significantly with increasing pregnancy order. The result of the present study is agreement with other similar studies (Hirve and Ganatra 1994; Sen et al. 2010; Dahlui et al. 2016). The mean birth weight values increased with the increase of pregnancy orders in mothers. Studies have reported that birth weight of the newborns increased with higher pregnancy order (McGrath et al. 2005; Sen et al. 2010; Demelash et al. 2015). The odds value (1.636 times) in the present study was distinctly higher in 1<sup>st</sup> order pregnancy outcomes for LBW newborns ( $p < 0.05$ ). Similar study has reported that 1<sup>st</sup> order pregnancy outcomes had 2.08 times ( $p < 0.05$ ) and 2.10 times ( $p < 0.05$ ) significantly greater odds among Nigerian (Dahlui et al. 2016) and Indian women (Pawar and Kumar 2017), respectively. Several studies have reported that 1<sup>st</sup> pregnancy order showed significantly ( $p < 0.05$ ) risk factors for LBW outcomes in India (Hirve and Ganatra 1994), Sudan (Elshibly and Schmalisch 2015) and Nigeria (Dahlui et al. 2016).

The analysis of seasonal variations in birth weights may enable researchers to suggest specific factors that influence the measure of LBW (McGrath et al. 2005; Chodick et al. 2007; Hughes et al. 2014; Lei et al. 2016; Zhang et al. 2017). Maternal exposure to the lower outdoor ambient temperature in mid-trimesters can also lead to an increase in LBW (Strand et al. 2012). Lawlor et al. (2005) reported that the birth weight was seasonally patterned in Aberdeen, Scotland, with LBWs among those born in the winter months and highest birth weights among those

born in the autumn months. A similar study has reported that newborn born in the fall had a significantly lower birth weight than those born in the winter (Onyiriuka 2006; Chodick et al. 2007; Strand et al. 2012; Hughes et al. 2014; Zhang et al. 2017), indices that the extremes of temperature may be an important determinant of LBW. Onyiriuka (2006) has reported that the mean birth weights significantly differed between wet and dry seasons in newborns born in Nigeria ( $p < 0.01$ ). Similarly, the mean birth weight was observed to be lower during the dry period (March-May) in the present study (Table 3). The month specific birth outcomes associated with the higher risk for adverse outcomes includes neonatal mortality, LBW, preterm, and small for gestational age, even when controlling for maternal characteristics (Hughes et al. 2014). A significant ( $p < 0.01$ ) seasonal pattern in birth weights was observed, with a peak in July and a trough in January (Chodick et al. 2007). Similarly, the odds of LBW were found being greater for the period of September-December in the present study ( $p > 0.05$ ).

The present study has reported the degree of specificity and sensitivity of maternal age and pregnancy order as an indicator as surrogate measures for screening LBW using the ROC-AUC analysis. The results tend to show maternal age  $< 20$  years and  $< 1^{\text{st}}$  pregnancy order are derived cut-offs for screening LBW. The comparison of results indicates that the suggested cut-offs for screening LBW were  $< 27$  years and  $< 23$  years from Sudan (Elshibly and Schmalisch 2008) and India (Sen et al. 2010), respectively. The comparison of ROC-AUC analysis showed that maternal age is a relatively better surrogate indicator over pregnancy order of LBW (Fig.1). Furthermore, results of AUC analysis showed a higher association in maternal age (AUC-0.544) with LBW than reported studies of Elshibly and Schmalisch (2008) (AUC-0.536) and Sen et al. (2010) (AUC-0.512). However, ROC-AUC curve analysis suggested the pregnancy order (AUC=0.553) is considered being better surrogate measures than maternal age in the present study.

### CONCLUSION

The results of the present investigation showed that the mother's age  $< 20$  years and  $1^{\text{st}}$  pregnancy orders exhibited significant effects to being a newborn LBW. Similarly, the finding also supports the fact that seasonal variations

also have significant effect on the LBW. A longitudinal assessment and a more robust assessment of disease and socio-economic and demographic determinants could help definitively to ascertain the true effects/associations on the prevalence among newborn for being LBW. In-depth studies are necessary for identifying the factors responsible for the intrauterine growth retardation in newborns. Moreover, the findings may be attributed to the efficacy of ongoing health and nutritional intervention programme in the populations.

### RECOMMENDATIONS

Prevention of intrauterine growth retardation through early detection and correction of nutritional status (that is, undernutrition) so that newborns can attain appropriate weight gain for their height/length are essential to promote linear growth. However, the appropriate intrauterine growth attainment can be achieved through effective implementation of ongoing intervention programmes utilizing the available infrastructure and healthcare facilities. There is a need of frequent health checkup camps for the young mothers ( $< 20$  years) and/or  $1^{\text{st}}$  pregnancy should be conducted during pregnancy period by governmental organizations to monitor or evaluate the weight gain, health conditions and nutritional status to reduce the manifestation of intrauterine growth retardation in population. Dissemination of proper knowledge and awareness programmes on LBW or intrauterine growth retardation of newborns birth weight in women/pregnant mothers by the health workers at the community level could be helpful to reduce the overall health burden in population.

### LIMITATIONS

The study was confined to a large set of secondary records available from the hospital register, so as to ascertain their effects on LBW. Data was also subject to measurement errors and as the presence of a current condition was not validated by the researchers, misclassifications of birth outcomes could have been present. Furthermore, lack of information related to household income, poverty, nutritional status, population/ethnic backgrounds, socio-economic and demographic information and also of supportive environments are other disadvantages of the investigation.

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