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Research Article

Maternal Obstetric and Morbidity Factors in Relation to Infant Birth Weight

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Abstract: Low birth weight is an important factor that affects infant's morbidity and mortality. It is associated with infant's physiology, psychology, behavior and learning process during childhood. It is also determinant factors for future chronic health problems. The objective of this study was to investigate the association of maternal obstetric and morbidity factors with infant birth weight. In this study, a total of 343 newborns and their mothers were enrolled. The mean birth weight was 2755 ± 466 g. We found that multi-para had highest incidence of low birth weight (35.7%) and incidence of low birth weight was found higher among mothers who had started antenatal check up at 3rd trimester. Highest incidence of low birth weight (100%) was found among mothers having systolic blood pressure up to 99.9 mm Hg and lowest (16.2%) among mothers having systolic blood pressure ≥140 mm Hg. Incidence of low birth weight was 32.5% among mothers who had urinary tract infection and 24.9% who were normal. Incidence of low birth weight was highest (35.5%) when haemoglobin level was <9 g/dl and lowest (13.2%) when the level was ≥ 11. In conclusion this study we found that maternal obstetric and morbidity factors influences birth weight of newborns.
Keywords: Low birth weight (LBW), Haemoglobin (Hb), Urinary Tract Infection (UTI)

INTRODUCTION

The birth weight of newborn is probably the most important single factor that affects the future survival and quality of life [1]. It is also a significant determinant of post neonatal, infant and childhood morbidity as well as mortality. For these reasons birth weight has long been a subject of clinical and epidemiological investigations and an area for public health interest.

Baby with weight ≤ 2500g considered as Low birth weight (LBW), below this value, birth weight specific infant mortality begins to rise rapidly [2-4]. It is estimated that worldwide 15.5% of all live births per year are LBW and more than 95 percent of LBW infants are born in developing countries. 72% of LBW infants are born in Asia, although large differences exist in WHO Asia regions and its sub-regions [5]. Low birth weight babies are likely to experience greater risk of morbidity and mortality than babies with normal birth weight [6-11], also have greater mental and physiological handicaps later in life [12,13], associated with higher probabilities of infection, malnutrition and handicapping conditions during childhood, including cerebral palsy, mental deficiencies and problems related to behavior and learning during childhood [14,15]. There is also evidence that LBW or its determinant factors are associated with a predisposition to higher rates of diabetes, cardiac diseases and other future chronic health problems [16-18].

Several factors have been identified to influence newborn birth weight. Most important among them are genetic and constitutional factors, socio-demographic factors, obstetric factors, maternal nutritional status, and maternal morbidity during pregnancy, toxic exposure and antenatal care [19].

Maternal daily calorie and protein intake are important factors which affect on birth weight**.** In India, poor fetal growth has been attributed to widespread maternal under-nutrition [20]. Although energy and protein are believed to be the major macronutrients that are associated with birth size, worldwide studies of supplementation of these nutrients during pregnancy have produced variable and sometimes conflicting

results [21]. Intakes of proteins from first trimester were highly correlated with birth weight, supplement starting from the second trimester failed to show a reduction in the incidence of low birth weight [22]. Susser and Stein [23] have reported that the relationship between maternal energy intake and birth weight was not seen among non-famine Dutch women but was seen among those who experienced famine conditions.

A study which is demonstrated that manual physical activity during pregnancy is associated with small for gestation (SGA) babies [24]. Similarly, physical work during pregnancy has also been associated with increased rates of abortion and pre-term delivery [25].

Obstetric factors like parity, antenatal care, maternal morbidities e.g. urinary tract infection, maternal serum haemoglobin (Hb), blood pressure is also important determinants for infants' birth weight. There is general agreement that pregnancy outcomes are more favorable for multiparae than primiparae; grand multiparity, however is often believed to constitute a risk [26]. From vast majority of studies, it was observed that increasing parity increased the mean birth weight. Miller (1989) [27] study found that there was a very high incidence of SGA among first born: 12.6% compared to 8.5% for all other infants, a relative risk of 1.59 (95% confidence interval 1.52 to 1.65). Another study in Indonesia also had similar report, i.e. first born babies were found to be 100g lighter than babies of a higher birth order [28]. No difference was found between parity 2-7. In Bangladesh, one study revealed that among the LBW babies most of the mothers (73.2%) were primigravidae [29]. The birth weight was found to be greater in babies of women who were of higher parity [30].

Antenatal could have a beneficial impact on intrauterine growth or gestational duration either, by diagnosis and timely treatment of pregnancy complications or by eliminating or reducing modifiable risk factors [6]. From two studies in Bangladesh, it is seen that birth weight had a positive correlation with the frequency of antenatal care visits [29, 31, 32]. In the lowest socio-economic group, it was found that a greater number of mothers of infants having birth weight <3000g did not attend antenatal care, while the opposite was observed for babies weighing >3000g [33].

Urinary tract infection of mother could spread to the placenta and amniotic fluid, thereby affecting gestational duration and possibly precipitating premature labor and delivery [34]. Brumfitt (1975) [35] reported no significant difference in mean birth weight or LBW rate between 235 treated and 178 untreated patients with bacteriuria. But another study found that the relative risk for LBW associated with urinary tract infection any time during gestation was 1.40 ($P<0.001$), the risk was also significant for infection during the second or third trimester [36].

Maternal anemia, especially if severe, could impair oxygen delivery to the fetus and thus interfere with normal intrauterine growth or pregnancy duration. Iron deficiency, even without anaemia, might affect key enzymes (especially cytochromes) and thereby also lead to adverse pregnancy outcomes [37]. A study in Indonesia showed that primiparous mothers of LBW babies had a Hb level 0.3g below those having babies weighing 3.0-3.49 kg and this difference increased with increasing parity up to a difference of 0.6g at parity 5 or more [38]. In a study in Bangladesh, it was found that mothers who gave birth to low birth weight babies had lower levels of Hb [39].

It is also well established that maternal hypertension, whether it is the pregnancy specific variety developing after 20^{th} week (pre-eclampsia), or due to some pre-existing problem is associated with poor intrauterine growth and an increased perinatal mortality. In the British Perinatal Mortality Survey of 1958, severe pre-eclampsia (diastolic pressure above 110 mm Hg or above 90 with proteinuria) was associated with a reduction in mean birth weight of 225g [40]. In one study in Bangladesh, it was found that women with systolic blood pressure <90 mm Hg had low birth weight infants and there was a trend for birth weight to increase with increasing blood pressure up to a value of 140 mm Hg, above 150 mm Hg there was a tendency for birth weight to decrease [41].

METHODS AND MATERIALS

This cross sectional study was carried out among the mothers and their newborn babies at the South-west region of Bangladesh. Almost everywhere in Bangladesh, incidence of low birth weight is unacceptably high. Due to the limitations of time and resources it is not possible to conduct the study covering the whole country. Therefore, specific areas are chosen by a multistage sampling procedure.

Three districts of Khulna division from South-west region of Bangladesh our primary study area. Pregnant women attending the selected hospitals and clinics for delivery purpose and their newborn babies during the study period were regarded as the study subjects. A multistage sampling procedure was adopted in selecting the ultimate sampling unit for the present study. In the first stage, three districts of Khulna division: Jessore, Kushtia and Jhenaidah were randomly selected as primary sampling units. In the second stage, twelve upazillas out of twenty of the aforesaid districts were randomly selected as secondary sampling units. In the third stage, thirty eight Hospitals and clinics were randomly selected taking at least three from each of the upazillas. In this stage nine mothers and their newborns from each hospitals and clinics were targeted to collect

data. However in case of Jessore Sadar Hospital ten mothers and their newborns were targeted. To have a representative sample of population of the study districts, it was decided to collect data from five upazillas from Jessore, four upazillas m Kushtia and three upazillas from Jhenaidah district. Women with normal vaginal delivery and live singleton birth were included in this study. Women with multiple pregnancies, caesarian section and still birth excluded from study. The subjects were informed about the nature of the study and verbal consent was taken from them before data collection. Socio-demographic information including mother's age, education, occupation, number of living children, total family members, income, amount of daily maternal calorie and protein intake, mother's daily working hour, education and occupation of father were collected through the set questionnaires. History such as parity, antenatal care, birth to conception interval, gestational age and information's about maternal morbidities like blood pressure, urinary tract infection were collected through interview as well as from the patient file kept in the hospital. Blood pressure was recorded before delivery. Maternal Hb level was collected from the test reports.

Data analysis

Data were analyzed using standard statistical methods, which include correlation coefficient, analysis of variance, simple regressions, and sensitivity and specificity analyses using the statistical software packages, SigmaStat (version 3.1; Systat Software Inc., Point Richmond, CA, USA) and SPSS for Windows (release 17; SPSS Inc, Chicago, Illinois, USA) with P value of 0.05 considered statistically significant.

RESULTS

Generalized characteristics of the study subjects and newborns

A total of 343 mothers were enrolled in this study. The mean age of mothers was 25 ± 5 with a range from 18 to 38 years and the mean schooling years of mothers and fathers were 9 ± 4 and 12 ± 4 respectively. The average number of child of mothers was found 1 ± 1 with a minimum of no child to a maximum of three. Among 343 newborns 186 were male and 157 were female. The mean birth weight was 2755 ± 466 g. Mean values of weight for female newborns were found to be higher than those for male babies. Except weight and chest circumference, all other mean anthropometric values were found to be equal for male and female newborns.

Obstetric and morbidity factors of the study population

Relationship between birth weight and parity

The incidence of LBW weight was highest (35.7%) for mothers with parity three or more and lowest (27.2%) for mothers with parity one. We also found that incidence of LBW 29.0% for mothers with parity two, 28.9% for mothers with parity zero, respectively. Incidence of adequate birth weight was lowest (28.6%) for babies among mothers of parity three or more, while highest (34.4%) in parity one group. The highest mean birth weight was found to be 2780g for parity one group and lowest 2664.29g for parity ≥ three groups of mothers. Difference in mean birth weight between the highest mean birth weight (parity one groups) and the lowest (parity three or more than three groups) was found 115.71g, which was statistically significant (F = 5.213, P = 0.05).

Relationship between birth weight and the period of 1st starting antenatal check up

From our study it was found that the incidence of LBW was more than double (47.1%) for babies among mothers who had started antenatal check up at 3rd trimester in comparison to mothers who had at 1st trimester. Incidence of inadequate birth weight was lowest (29.4%) for babies among mothers with 3rd trimester group. In other groups incidence of inadequate birth weight was more or less similar. Incidence of adequate birth weight was 37% for mothers who had started antenatal check up at 1st trimester of pregnancy and 23.5% for mothers who had started antenatal check up at 3rd trimester. And it is statistically significant (X2 = 14.701, P = 0.05). Difference in mean birth weight between the two groups (1st trimester and 3rd trimester) was found 255.23g, this relation is also statistically significant (F = 5.213, P = 0.05).

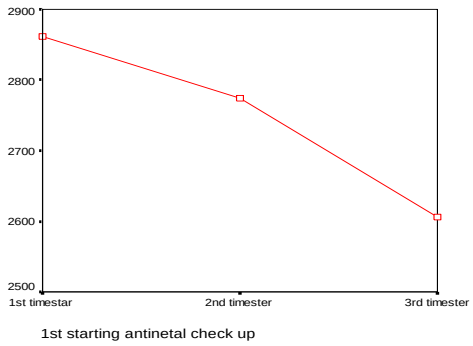

Fig. 1: Relationship between Mean Birth Weight and 1st starting period of antenatal check up

Relationship between birth weight and number of antenatal visit

Incidence of LBW was 35.3% for mothers who had no or less than three antenatal visit and 26.4% for mothers who had three or more than three antenatal visit. Incidence of inadequate birth weight 42.4% and 39.5% respectively for antenatal visit of no or less than three visit. Incidence of adequate birth weight was 34.1% for mothers who had received three or more antenatal visit and 22.4% for mothers who had less than three or no antenatal visit at all. The result is statistically significant (X2 = 4.746; P = 0.05). Difference in mean birth weight between the two

groups was found 155.76g, which is highly significant (F = 7.288, P = 0.05).

Birth weight and Maternal morbidities

Relationship between birth weight and maternal blood pressure (systolic and diastolic) before delivery

Highest incidence of LBW (100%) was found among mothers having systolic blood pressure up to 99.9 mm Hg and lowest (16.2%) among mothers having systolic blood pressure 140 mm Hg or more. There is no significant difference in mean birth weight for babies among the mothers of different blood pressure groups (F = 9.005, P = 0.5).

In different diastolic blood pressure groups, incidence of LBW was highest (52.0%) among mothers having diastolic pressure up to70 mm Hg and lowest (9.6%) among mothers having diastolic blood pressure 90 mm Hg or more. Mean birth weight difference between the highest and lowest diastolic blood pressure group of mothers was found 461.50 g and this relationship is highly significant (F = 15.218, P = 0.05).

Table 1: Relationship between Birth Weight and Maternal BP (systolic and diastolic) before delivery

Variable	Birth Weight (g)									
	<2500		2500-2999		3000+		X^2 (P)	Mean	SD	F (P)
	n	%	n	%	n	%				
Blood Pressure (systolic) mm of Hg										
Up to 99.9	1	100	0	0	0	0		2400.00	0	
100 – 140	76	35.8	83	39.2	53.0	25.0	20.713	2675.47	460.437	9.005
141 +	21	16.2	55	42.3	54.0	41.5	(0.5)	2886.92	446.066	(0.5)
Total	98	28.6	138	40.2	107	31.2		2754.81	465.568	
Blood Pressure (diastolic)										
mm of Hg										
Up to 74.9	13	52.0	11	44.0	1	4.0	34.38	2476.00	335.758	15.218
75 – 89.9	75	35.0	78	36.4	61	28.5	(0.05)	2698.60	473.076	(0.05)
90 +	10	9.6	49	47.1	45	43.3		2937.50	414.117	
Total	98	28.6	138	40.2	107	31.2		2754.81	465.568	

Relationship between birth weight and Presence of Urinary Tract Infection (UTI)

Incidence of LBW was 32.5% among mothers who had UTI and 24.9% who were normal, respectively. The percentage of inadequate birth weights was 42.4% and 38.0% for babies of mothers who had UTI and who were normal, respectively. Whereas, adequate birth weight was found 32.8% in normal group and 29.5% among UTI group of mothers. Statistically this relationship is significant (X2 = 2.471, P = 0.05). Mean birth weight was found 2719.28g for normal group and 2688.14g for mothers suffering from UTI.

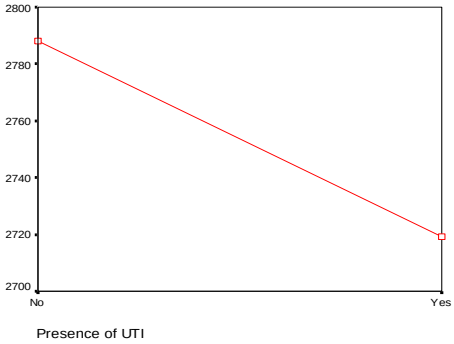

Fig. 2: Relationship between Mean Birth Weight and Presence of UTI

Relationship between birth weight and maternal Hb level

Incidence of LBW was highest (35.5%) when Hb level was <9 g/dl and lowest (13.2%) when the level was ≥ 11. The percentage of inadequate birth weight was highest (50%) when Hb level was between 10-10.9 g/dl and lowest (34.9%) when it was between 9.1-9.9 g/dl levels. Incidence of adequate birth weight was highest (58.3%) when maternal Hb level was between 11-11.9 g/dl and lowest (24%) when the level was < 9g/dl. This relationship is statistically significant (X2 = 23.721, P = 0.05). Mean birth weight was found lowest (2676g) at <9 g/dl level and highest (3328.57g) at >12 g/dl level. Difference in mean birth weight between the two groups was found 652.57g, which is also highly significant (F = 7.147, P = 0.05).

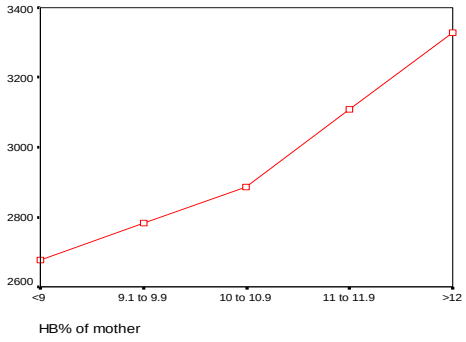

Fig. 3: Relationship between Mean Birth Weight and Maternal Hb level

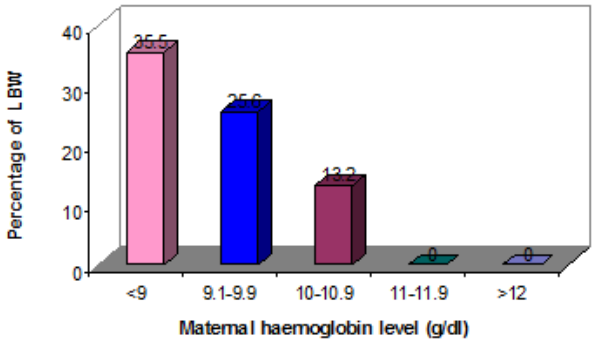

Fig. 4: Percentage incidence of LBW by maternal Hb status

Matrix of zero order co-relation coefficients between birth weight and maternal factors

Matrix of zero order correlation coefficients among different maternal variables and also with birth weight of newborns is presented in table–2. All maternal anthropometric variables show significant co-relation with each other. Highest co-relation was observed between maternal weight (before conception) and maternal height (r = 0.80).

Table 2: Matrix of zero order co-relation coefficients among different maternal factors with birth weight of newborns

	Age	Weight before conception	Maternal Height	Maternal MUAC	Hb% of mothers	Gestational age	Family income	Maternal education	Weight of newborns
Age	1.00	.024	.085	.022	.102	-.061	.173**	.055	.065
Weight before conception		1.00	.805**	.073	.146**	.064	.199**	.147**	.130*
Maternal Height			1.00	.027	.169**	.102	.189**	.150**	.140**
Maternal MUAC				1.00	.266**	.094	.114*	.128*	.286**
Hb% of mothers					1.00	.168**	.191**	.175**	.264**
Gestational age						1.00	.020	.140**	.104
Family income							1.00	.541**	.205**
Maternal education								1.00	.254**
Weight of newborns									1.00

*:Correlation is significant at the 0.01 level (2-tailed), **: Correlation is significant at the 0.05 level (2-tailed)

Simple regression equations for estimating birth weight

Table 3 presents the effects of different maternal variables on infant birth weight. From the table it is apparent that all the variables have significant (P = 0.05) effect on birth weight.

Table 3: Simple regression equations showing effect of maternal variables on infant birth weight

Variables	Regression equations	F (P)	Adjusted R square
Age	Y=2597.533 + 6.279 age	13.013 (0.05)	.001
Weight gain in pregnancy	Y=1044.822 + 178.167 wt gain	188.194 (0.05)	.354
Blood pressure (systolic)	Y=2628.904 + .911 Sys	4.065 (0.05)	.009
Blood pressure (diastolic)	Y=2017.405 + 9.090 Dias	16.892 (0.05)	.044
Gestational age	Y=1954.178 + 21.945 Gest	3.694 (0.05)	.008
Haemoglobin	Y=1663.772 + 119.772 Hb	25.527 (0.05)	.067
Working period (hr/day)	Y=2980.806 + 28.045 Work	2.665 (0.05)	.005

DISCUSSION

This cross sectional study was conducted among 343 newborns and their mothers to assess the relationship between birth weight of newborns and different maternal factors and between birth weight and other neonatal anthropometric parameters. Our study reveals that there are significant relations between certain maternal socio-economic, demographic, anthropometric factors and birth weight of newborns. The obstetric and morbidity factors and birth weight of newborns are also closely connected.

This study found a mean birth weight 2755 ± 466g. The mean birth weight in the multi-centre study was found to be 2630g, 2780g and 2840g respectively in India, Nepal and Sri Lanka. In a study in Bangladesh the mean birth weight was found to be 2860g [42]. The result of the multi-centre study and Karim and Taylor's study [42] are more or less comparable to our study. The birth weight status of newborn in our study is better than that of the previous study [43]. This difference could be due to the fact that the present study was conducted after 18 years of the previous study. In this time mothers are more conscious about their health status, antenatal care and nutrition.

From socio-demographic characteristics of mothers in our study was revealed that mean age of mothers was found to be 25 ± 5 years, where 20.6% were less than 20 years and 12.8% were in the age group of 30 or above. In another study in Bangladesh, 15.9% mothers were found to be under 20 years and 8.9% were equal or above 30 years [42]. Thus for the present study, the percentage of teenage mothers and mothers having age 30 or more were very much similar as Ahmed *et al*. [32]. But the study, conducted by Karim and Taylor [42] percentage of older mothers (30 or more than 30 years) was just half to that of our study. About 6.7% of mothers had no formal educational background, 15.45% had primary level, 64.43% had VI to SSC level, 9.62% had higher secondary and 2.9% completed graduation. There is some dissimilarity in educational status in comparison to the study conducted by Karim and Taylor [42]. Educational status of mothers was a bit higher in our study. It also shows higher educational status of mothers in comparison to another study conducted in Bangladesh.

From the parity wise distribution of birth weight it is revealed that multi-para had highest incidence of LBW (35.7%) in comparison to other parity groups of mothers. Kramer [26] in his meta analysis mentioned about one study that there was a significantly lower risk of prematurity with increasing parity [44]. Kramer also showed in his paper that of 17 relevant studies, 12 reported that increasing parity increased the mean birth weight. In this study, however highest mean birth weight (2780.00g) was found with parity one. This result doesn't show any statistical significance, which may be due to small sample size. Several other studies also showed that first born babies were lighter than babies of higher birth weight [28-30, 32].

This study has shown the positive effect of antenatal care on pregnancy outcomes. Those others who had started antenatal check up at 1st trimester and received three or more antenatal check up, gave birth to higher birth weight babies in comparison to mothers who had started at 2nd or 3rd trimester and received less than three antenatal check up or no check up at all. This study suggests that at least three antenatal visits are essential for all pregnant women to reduce the incidence of LBW in Bangladesh.

In this study, birth weight was also re-examined in relation to urinary tract infection. Incidence of LBW was found to be higher among mothers suffering from such infection. Mean birth weight was also found to be lower in comparison to mothers free from such infection. In the analysis by Sever et al. [36] from the US Collaborative perinatal project showed that the relative risk for LBW associated with UTI any time during gestation was 1.40 ($p<0.001$). In another study, no significant difference in mean birth weight or LBW rate between treated and untreated patients with bacteria was found [35]. Kramer [26] from meta analysis which suggested that the evidence is weak that maternal urinary tract infection affects either intrauterine growth or gestational duration.

Our study provided information on potential confounders of the association between maternal Hb level and birth outcome. Our findings indicate that low maternal Hb level represents an important indicator of a complication of pregnancy that can adversely affect infant's birth weight and thus the subsequent health and survival of the infants. There was gradual decrease in incidence of LBW from 35.5% to 0% for gradual increase of Hb level from <9 g/dl to 12 g/dl. This statistically significant result is an agreement with another study in Bangladesh [39]. Anaemia, especially if severe (Hb<7 g/dl), could impair oxygen delivery to the fetus and thus interfere with normal intrauterine growth or pregnancy duration, late stillbirth, preterm deliveries, and small for gestational age [45]. Although several researchers have reported an association between anemia and low birth weight (LBW), preterm birth, or both [46-48], others have not found such an association [49, 50]. Scholl et al. [51], in a US study comparing risk of adverse pregnancy outcome among women with iron deficiency anemia, anemia, or anemia from causes other than iron deficiency, found that only iron deficiency anemia during the first and second trimesters of pregnancy increased a woman's risk for preterm delivery and delivering an LBW infant. Iron deficiency even without anaemia, might affect key enzymes (cytochromes) and thereby also lead to adverse pregnancy outcomes [26].

This study also demonstrates a relation between birth weight and blood pressure. There was a tendency for systolic blood pressure to be correlated with birth weight, such that the lower the systolic pressure the lower the birth weight. Mothers with diastolic pressure between 90 and above 90 mm Hg gave birth to highest mean birth weight babies and minimum LBW babies. Higher incidence of LBW and lower mean birth weight was found among mothers with diastolic pressure less than 70 mm Hg.

In conclusion, the present study reveals that there are relations between maternal obstetric factors and birth weight. It is seen that the highest incidence of LBW and lowest mean birth weight were found among mothers who had started antenatal check up at 3rd trimester and the same result was found in case of number of antenatal visit. Both factors are significant. This study suggests that at least three antenatal visits are essential for all pregnant women to reduce the incidence of LBW in Bangladesh. This study also presents that the presence of UTI and Hb level of mothers was also significantly associated with newborn's birth weight. The prevalence of LBW babies was greater in UTI infected and whose Hb level was less than 9 g/ dl. Proper dietary advice, iron supplementation and health care for all pregnant women should be undertaken to raise the Hb level and prevent UTI, which has a direct bearing on the birth weight and which serves to improve the health status of pregnant women. Several studies have shown different results on whether socio-economic factors affect pregnancy outcomes and newborn conditions [52-54].

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REFERENCES

1. World Health Organization; Division of Family Health, Geneva, The incidence of low birth weight: a critical review of available information, World Health Stat., Q. 1980; 33:197–224
2. Chase HC; International comparison of perinatal and infant mortality, the United States and six West European Countries, Washington, Government Printing Office (Public Health Service Series 3(6), Publication No. 1000), 1967.
3. Saugstad LF; Weight of all births and infant mortality, Journal of epidemiology and community health, 1981; 35:185–191.
4. Puffer PR, Serrano CV; Patterns of mortality in childhood: report of the Inter American Investigation of mortality in childhood. Washington, D.C (Pan American Health Organization Scientific Publication No. 262), 1973.
5. Wardlaw T, Blanc A, Ahman E, LBW: country, regional and global estimate. New York, United Nations Children's Fund and World Health Organization, 2004.
6. Villar J, Smeriglio V, Maetorell R, Brown CH, Klein RE; Heterogeneous growth and mental development of intrauterine growth retarded infants during the first 3 years of life. Pediatrics, 1984; 74: 738–791.
7. Habicht JP, Lectig A, Yarborough C; Maternal nutrition, birth weight and infant mortality. In Size at birth (Ciba symposium no. 27), London, Amsterdam Oxford New York, Elsevier, 1974: 353–378.
8. Barua S, Begum R; Birth weight in relationship with the level of vitamin A and Alpha tocopherol in cord and Maternal serum. Bangladesh Journal of Nutrition, 1996; 9(1&2): 41–49.
9. Habicht JP, Yarbrough C, Lechtig A, Klein RE; Relation of birth weight, maternal nutrition and mortality. Nutr Res Int., 1973; 7(5): 533–546.
10. Bechman GJ, Vander Berg; The relationship of the rate of intrauterine growth of low birth weight infantsto later growth. Journal of Pediatr., 1975; 86(4): 504–511.
11. Mata L, Urrutia, JJ, Krommal RA, Joplin C; Survival and physical growth in infancy and early childhood. Am J Dis Child., 1975: 121(5): 561–566.
12. Shirali GS, Oelberg DG, Mehta KP; Maternal – Neonatal serum vitamin A concentration. J Pediatr., Gestroenterology and Nutrition, 1989; 9(1): 62-66.
13. Shah R, Rajalakshmi R; Vitamin A status of the newborn in relation to gestational age, body weight and maternal nutritional status. Am J Clin Nutr., 1984: 40(4): 794-800
14. Berkowitz GS, Papiernik E; Epidemiology of preterm birth. Epidemiologic Reviews, 1993; 15(2): 414–443.
15. Dunin Wasowicz D, Rowecka Trzebicka K, Milewska Bobula B, Kassur Siemienska B, Bauer A, Idzik M *et al.*; Risk factors for cerebral palsy in very low birth weight infants in the 1980s and 1990s. Journal of Child Neurology, 2000; 15(6): 417-420.
16. Barker DJP, Forsen T, Uutela A, Osmond C, Erikson JG; Size at birth and resilience to effects of poor living conditions in adult life: longitudinal study. British Medical Journal, 2001; 323: 1273–1276.
17. Barker DJP, Outcome of low birth-weight. Hormone Research, 1994; 42: 223–230.
18. Erikson JG, Forsen T, Tuomilehto J, Winter PD, Osmond C, Barker DJP; Catch-up growth in childhood and death from coronary heart disease: longitudinal study. British Medical Journal, 1999; 318(7181): 427–431.
19. United Nations Children's Fund; The state of World's Children. Oxford University Press, Oxford, UK, 1993.
20. Gopalan C; Low birth weight: Significance and implications nutrition in children. In Sachdev HPS, Chaudhury P editors; Developing Country Concerns. New Delhi, Imprint, 1994.
21. Kramer MS, Kakuma R; Energy and protein intake in pregnancy. Cochrane Database Syst Rev., 2003; (4): CD000032.

22. Doyle W, Wynn AHA, Crawford MA, Wynn SW; Nutritional counseling and supplementation in the second and third trimester of pregnancy a study in a London population. Journal of Nutrition & Medicine, 1992; 3(3-4): 249–256.
23. Susser M, Stein Z; Third variable analysis: application to causal sequences among nutrient intake, maternal weight, birth weight, placental weight and gestation. Stat Med., 1982; 1(2): 105–120.
24. Launer LJ, Villar J, Kestlr E, de Onis M; The effect of maternal work on fetal growth and duration of pregnancy: a prospective study. Br J Obstet Gynaecol., 1990: 97(1): 62–70.
25. Teitelmann AM, Welch LS, Hellenbrant KG, Bracken MB; Effect of maternal work activity on pre-term birth and low-birth-weight. Am J Epidemiol., 1990; 131(1): 104–113.
26. Kramer M; Determinants of low birth weight: Methodology assessment and meta-analysis. Bull WHO, 1987; 65(5): 663–737.
27. Miller J; Determinants of intra-uterine growth retardation: Evidence against maternal depletion. J Biosac Science, 1989; 21(2): 235–243.
28. Marsianto1, Kusin JA, De With C; With Birth weight distribution in a healthy urban population in Surabaya–Indonesia. Tropical and Geographical Medicine, 1989; 41(2):146–150.
29. Nahar N, Afroza S, Hossain M.; Incidence of LBW in three selected communities in Bangladesh, Bangladesh Medical Research Council Bull., 1998; 24(2): 49–54.
30. Brooke OG, Anderson HR, Bland JM, Peacock JL, Steward CM; Effects on birth weight of smoking, alcohol, caffeine, socio-economic factors, and psychosocial stress. BMJ, 1989; 298(6676): 795–801.
31. Das K, Ganguly R, Saha R, Ghosh BN; Inter-relationship of birth weight with certain biological and socio-economic factors. Indian J Pub Health, 1981; 25(1): 11–19.
32. Ahmed Fariduddin; The distribution of birth weight in an urban maternity centre of Bangladesh. 1992.
33. Nobrega; Anthropometry in Brazilian newborn infants: Studies of association with some maternal factors. Nestle nutrition workshop series, 1989; 18: 157–164.
34. Naeye RL; Maternal nutrition and pregnancy outcome. Dept. of pathology, M.S. Hershey Medical centre, The Pennsylvania State University College of Medicine, U.S.A., 1981: 90–111.
35. Brumfitt W; The effects of bacteriuria in pregnancy on maternal and fetal health. Kidney international, 1975; 8: 113–119.
36. Kass EH, Brumfitt W; Urinery Tract Infections during pregnancy: maternal and pediatric findings. In Infections of the urinary tract. Chicago, University of Chicago Press, 1979:19–21.
37. Kitay DZ, Haebort RA; Iron and folic acid deficiency in pregnancy. Clinics in Perinatology, 1975; 2(2): 225–273.
38. Kessel E, Sastrawinata S, Mumford SD; Correlates of fetal growth and survival. Acta Paediatric Scand., 1985; Suppl 319: 120–127.
39. Hasin A, Begum R, Khan MR, Ahmed F; Relationship between birth weight and biochemical measures of maternal nutritional status at delivery in Bangladesh urban poors. Int J Food Sci Nutr., 1996: 47(3): 273–279.
40. Bulter NR, Alberman ED; Perinatal problems, the second report of the 1958 British Perinatal Mortality survey. Edinburgh Chur-chill livingstone, 1969.
41. Canosa CA; Intrauterine growth retardation in India and Bangladesh. In Intrauterine growth retardation, Nestle Nutrition Workshop Serious. Nestle Ltd., Verey Raven Press Ltd., New York, 1989; 18: 183–204.
42. Karim E, Taylor CGN; The association between birth weight, socio-demographic variables and maternal anthropometry in an urban sample from Dhaka. Bangladesh Annals of Human Biology, 1997; 24(5): 387–401.
43. Ahmed Fariduddin *et al.*; The distribution of birth weight in an urban maternity centre of Bangladesh, 1992.
44. Nordstrom ML, Cnattingius S; Effects on birth weights of maternal education, socioeconomic status, and work-related characteristics. Scandinavian Journal of Social Medicine, 1996: 24(1): 55–61.
45. Mamun AA, Padmadas SS, Khatun M; Maternal health during preg-nancy and perinatal mortality in Bangladesh: evidence from a large-scale community-based clinical trial. Paediatr Perinat Epidemiol., 2006; 20(6): 482– 490.
46. Garn SM, Ridella SA, Petzold AS, Falkner F; Maternal hematological levels and pregnancy outcomes. Semin Perinatol., 1981; 5(2): 155–162.
47. Kim I, Hungerford DW, Yip R, Kuester SA, Zyrkowski C, Trow-bridge FL; Pregnancy nutrition surveillance system United States, 1979 –1990. MMWR CDC Surveill Summ., 1992; 41(7)S: 26-41.
48. Murphy JF, O'Riordan J, Newcombe RG, Coles EC, Pearson JF; Relation of Hb levels in first and second trimesters to outcome of pregnancy. Lancet, 1986; 1(8488): 992–995.
49. Klebanoff MA, Shiono PH, Berendes HW, Rhoads GG; Facts and artifacts about anemia and preterm delivery. JAMA, 1989; 262(4): 511–515.
50. Lu ZM, Goldenberg RL, Cliver SP, Cutter G, Blankson M; The relationship between maternal

hematocrit and pregnancy out-come. Obstet Gynecol., 1991; 77(2): 190-194.

51. Scholl TO, Hediger ML, Fischer RL, Shearer JW; Anemia versus iron deficiency: Increased risk of preterm delivery in a prospective study. Am J Clin Nutr., 1992; 55(5): 985-988.
52. Koupilova I, Rahu K, Rahu M, Karro H, Leon DA; Social determinants of birth weight and length of gestation in Estonia during the transition to democracy. International Journal of Epidemiology, 2000; 29(1): 118–124.
53. Peoples-Sheps MD, Siegel E, Suchindran CM, Origasa H, Ware A, Barakat A; Characteristics of maternal employment during pregnancy: effects on low birth weight. American Journal of Public Health, 1991; 81(8): 1007–1012
54. Kramer MS, Goulet L, Lydon J, Seguin L, McNamara H, Dassa C *et al.*; Socio-economic disparities in preterm birth : causal pathways and mechanisms. Paediatric and Perinatal Epidemiology, 2001; 15(Suppl 2): 104–123.