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MATERNAL ANTHROPOMETRY AND BIRTH OUTCOME AMONG BENGALIS IN KOLKATA

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Samiran Bisai[1]

INTRODUCTION[2]

The last half-century has witnessed many changes in the reproductive habits of population, the technologies and management of childbirth. Throughout this period birth weight has been, and continues to be, a central focus of professional and social interest. The essential source of concern lies in the implications of birth weight, and particularly of low birth weight (LBW) i.e. birth weight less than 2500 g (1).

Birth weight is an important parameter, which could be indicative of the immediate viability of the neonate and the state of maternal health and nutrition during pregnancy (2). The survival of infants and their postnatal growth and development largely depend on birth weight (1,3,4,5). WHO in 1995 estimated that 142 million babies were born in the world in 1990; out of them 25 million were of low birth weight and 19 million of these LBW babies were born in the developing countries (6). The present proportion of LBW babies in India is estimated to be 30 percent (7) as compared to 4-5 percent found in economically developed countries (7, 8). In India, over half of perinatal and two-thirds of all infant deaths are due to low birth weight (9).

LBW is a consequence of either preterm (<37 weeks of gestation) delivery or intrauterine growth retardation (IUGR) or of both (1). In addition to short-term consequences, such as high infant morbidity, mortality and childhood growth failure among survivors (10), growth retardation is a major public health problem worldwide. Fetuses which suffer from growth retardation have higher perinatal morbidity and mortality (11, 12, 13), and are at an increased risk of sudden infant death syndrome (14). During childhood they are more likely to have poor cognitive

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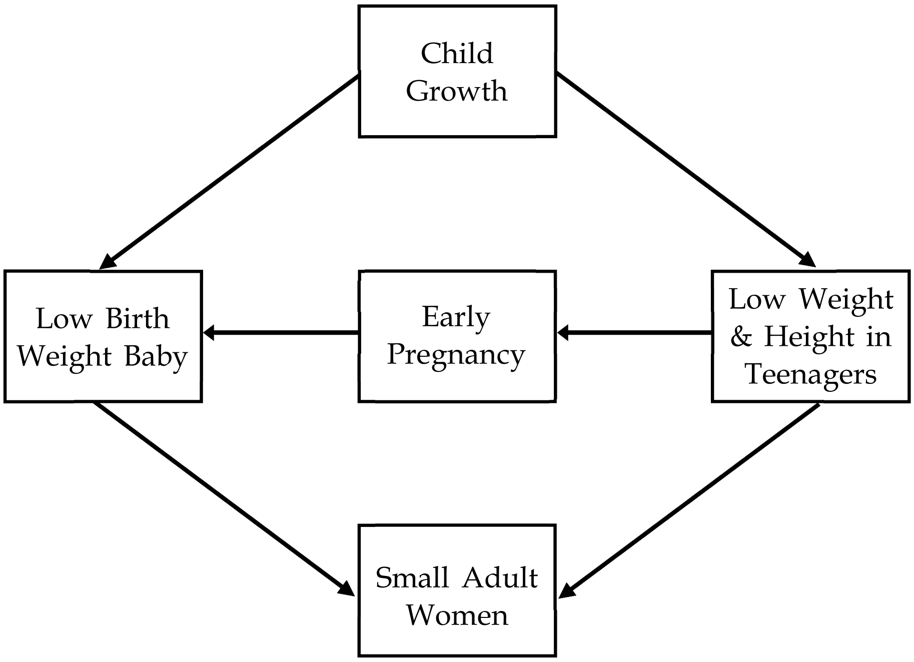
2 The numbers within brackets in the text refer to the particular sources with the appropriate numbers in the list of references at the end.

development (15, 16) and neurological impairment (17, 18, 19). Moreover, IUGR contributes to the intergenerational cycle of poverty, disease and malnutrition as sketched by United Nations Administrative Committee on Co-ordination / Sub-Committee on Nutrition (ACC/SCN).

The cycle of poor nutrition continues across generations. Young girls who grow poorly become stunted women, and are more likely to give birth to low birth weight infants. If those infants are girls, they are likely to continue the cycle by being stunted in adulthood, and so on, if some thing is not done to break the cycle. Adolescent pregnancy heightens the risk of low birth weight and the difficulty of breaking the cycle. Support is needed for good nutrition at all these stages – infancy, childhood, adolescence and adulthood- especially for girls and women.

Intergenerational cycle of growth failure



Source*:* Sub-Committee on Nutrition / United Nations Administrative Committee on Co-ordination (SCN/ACC), *2nd Report on the World Nutrition Situation, vol. 1, Global & RegionalResults*, ACC/SCN, Geneva, 1992 (20).

The causes of low birth weight are multi-factorial (8, 21), associated with environmental, demographic, social and cultural characteristics. Medical complications in pregnancy, adverse maternal practices, genetic factors and nutritional variables and especially maternal anthropometry also cause low birth weight.

Malnourished women are more prone to deliver low birth weight babies (21) and to have pregnancy complications (22). Perinatal mortality and prematurity rates were found to be high among short-stature women (23). Women among developing countries like India are undernourished (24), and their dietary energy intake is not adequate to compensate their heavy physical workload. In these countries most women were found to weigh below the 55 kg norm used by WHO. For instance, several studies in Asian and African countries reported the average weight of nonpregnant nonlactating young women to be in the range of 40-50 kg (25). Several cut-offs have been used to screen mothers at risk of having pregnancy complication; most studies from India and other developing countries have used <145 cm for height and 45 kg for weight as cut-off for screening high-risk mothers (26)

In the course of pregnancy, anthropometric measures such as maternal weight, weight gain, weight for height or BMI, height or arm circumference have been shown to be good predictors of birth weight and survival (21, 27). Camilleri et al (28) found direct association between maternal height and weight and the size of the fetus. Birth weight variation of 750 g was noted between infants born to mothers 170cm in height, 75 kg weight and mothers 150 cm height, 40 kg weight (29). Similarly birth weight variation of 667 g between infants born to mothers with low (36.3 kg) and heavy (72.6 kg) weight, and 216 g variation of tall (>162 cm) and short (<143 cm) mothers (30) were noted. A study of 8870 women showed that height was significantly positively associated with infant birth weight for White, Black and Asian women, but this relation was not statistically significant for Hispanic women (31). Bhatia et al (32) found birth weight increasing as maternal height increased.

Earlier studies in India reported that mothers who are less than 140 cm in height were more prone to have LBW babies (33, 34); these studies also found association of anemia, low socio-economic status and inadequate pregnancy weight gain with low birth weight (34, 35, 36, 37). Short women gain on average approximately 1kg less during pregnancy than taller women (38). On the other hand, older women with higher parity levels were more likely to weigh less during the third trimester and have lower summed skinfolds. Lower weight was associated with poorer outcome, but lower skinfolds were associated with better pregnancy outcome (39). But, Piperata et al (40) found significant increases in the suprailiac skinfold thickness (between 2^{nd} and 3^{rd} trimester during pregnancy) of women who had normal birth weight infants. Lawrence et al (41) found that women who experienced decrease in fat stores were more likely to give birth to larger babies, implying that mobilization of fat stores enhances fetal growth (42).

In an earlier study in Bangladesh, Karim et al (43) documented the best cut-off for predicting LBW and normal birth weight (NBW) infants as maternal weight

50 kg, body mass index of 20.5 and maternal arm circumference of 23 cm at term. Krasovek (44) also found that arm circumference and changes in arm circumference during pregnancy were very useful predictors, and suggested arm circumference cut-off values of 20.5 to 21.5cm. Akhtar and her colleagues collected maternal anthropometric data just prior to birth and data shows that weight was a better predictor of LBW than arm circumference (45).

A Multi-Centre Study (27) has provided cut-off values of maternal anthropometry as a risk for poor infant outcome; these are maternal height less than 148 cm and pre-pregnancy weight less than 45 kg. For IUGR, cut off for maternal height was less than 150 cm and pre-pregnancy weight below 40 kg. Similarly the incidence of pre-term deliveries is higher in the group of mothers who are above 50 kg of pre-pregnancy weight and 150 cm height. At a cut-off point of 145 cm for maternal height, the association with full-term low birth weight becomes stronger. In an earlier study in India, Raman et al (27) suggested that maternal pre-pregnancy weight below 41 kg or less than first quartile and Body Mass Index below 18.5 were associated with a higher incidence of low birth weight.

RESEARCH OBJECTIVES

(a) To test to what degree anthropometric measurements are useful and efficient in predicting birth outcome of pregnancy;

(b) To determine the quantitative associations of anthropometric indicators and combinations of indicators with the risk of low birth weight.

Sample group

A sample of 200 mothers who were delivered at a Government General Hospital in South Kolkata was studied. Of the two hundred newborn babies born to their mothers, the difference in birth weight between mothers with a height of –1SD of the mean and +1SD of the mean was 200g. At 80% power and 95% confidence, the estimated sample size is 88 (each height group) babies for detecting a difference in birth weight of 200g. The characteristics of 176 mothers were scrutinised for answering the research questions.

METHODOLOGY

A team of research workers (Society for Applied Studies) was given a short training and orientation using pre-tested questionnaire and measuring equipment before initiation of study. A pretested data form was developed and tested for maternal anthropometry, obstetric and socio-demographic history including mother's age, parity, gravida, education, family members, family income, additional food intake during pregnancy, multivitamin and iron folic acid consumption, antenatal care, occupation and addiction. A separate data form was developed for newborn anthropometry.

Subjects were enrolled by screening mothers with babies lying on the bed after delivery in obstetric ward of M. R. Bangur Hospital, South Kolkata. Following screening, three criteria were used for recruiting the study sample. The women (a) not suffering from any significant medical and surgical disorder even before pregnancy and at the time of enrollment, (b) with Bengali mother tongue and (c) willing to participate in the study were enrolled. After screening, study procedures were explained to the guardian /pregnant women and written consent was obtained for history and examination. Information was collected by face-to-face interview following a structured schedule and the secondary information including maternal age, parity, living children, gravida, and abortion history were obtained from the antenatal case sheet, as recorded earlier by the health worker.

I used the direct method, namely, anthropometry, for assessing the nutritional status of currently delivered pregnant women and the neonate, along with partial dietary assessment by recall methods shown in the following sketch.

Methods of anthropometric measurement

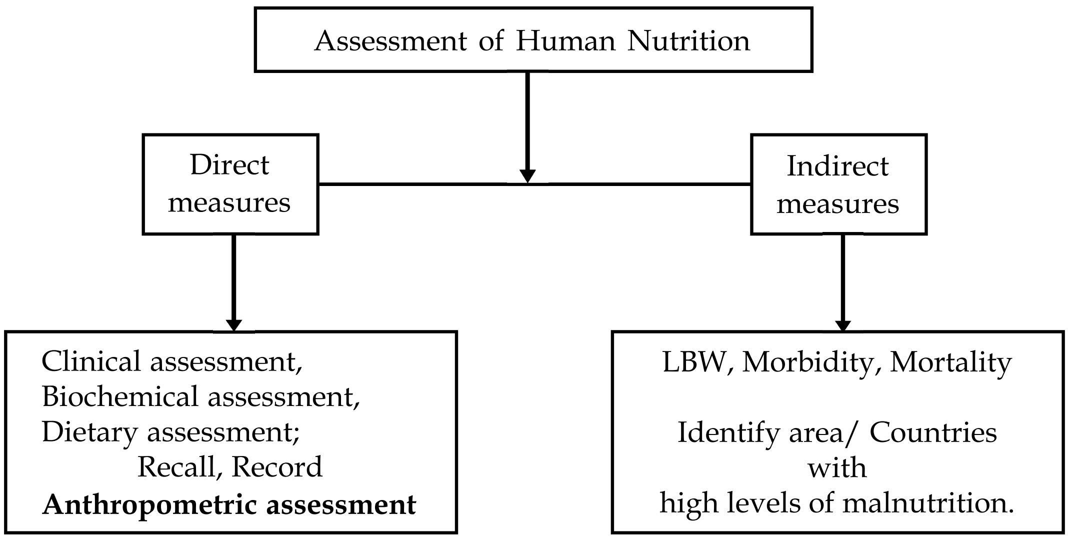
Maternal anthropometry : Maternal anthropometric measurements such as post-pregnancy weight, height, mid-arm circumference and triceps skin fold thickness were recorded at the time of enrolment following stabilization (within 24 hours of delivery) at hospital using standard techniques (46). Maternal mid-arm circumference was measured using non-stretchable fibre tape. Mother's triceps skin fold thickness was measured using Lange skin fold caliper and body mass index was calculated using the formula, weight in kg divided by the square of height in meters.

Height : Maternal height was measured using wall-mounted wooden height measuring board. After removing the shoes, the subject should stand on a flat surface with feet parallel and with heels, buttocks shoulder and back of head touching the upright board. The head should be held comfortably erect, with the lower border of the orbit of the eye in the same horizontal plane on the external canal of the ear. The arms should be hanging loosely at the side. The moving piece of the measuring device, which can be a wooden headboard, is gently lowered, crushing the hair and making contact with the top of the head. The presence of unusually thick hair requires to be taken into account. The measuring board should be 185 cm high and capable of measuring to an accuracy of 0.1cm.

Weight : A Salter digital weighing balance was placed on a hard flat surface and checked for zero balance before each measurement. Subjects stood unassisted in the center of the platform of the balance and asked to look straight ahead standing relaxed but still, with minimal clothes and bladder emptied. The body weight was recorded to the nearest 100 g as soon as the indicator on the scale was stabilized. The balance was calibrated with a set of standard weights regularly.

Mid-arm circumference : MAC measurement was made using a flexible, nonstretch tape. The subject stood erect and sideways to the measurer with the head in the Frank-furt plane, arms relaxed and legs apart. The measurement was taken at the midpoint of the upper left arm between the acromion process and the tip of the olecranon. After locating the midpoint the left arm was relaxed so that it was hanging loosely by the side, with the palms facing inwards. The tape was wrapped gently but firmly around the arm at the mid point. Measurement was taken to the nearest 0.1 cm.

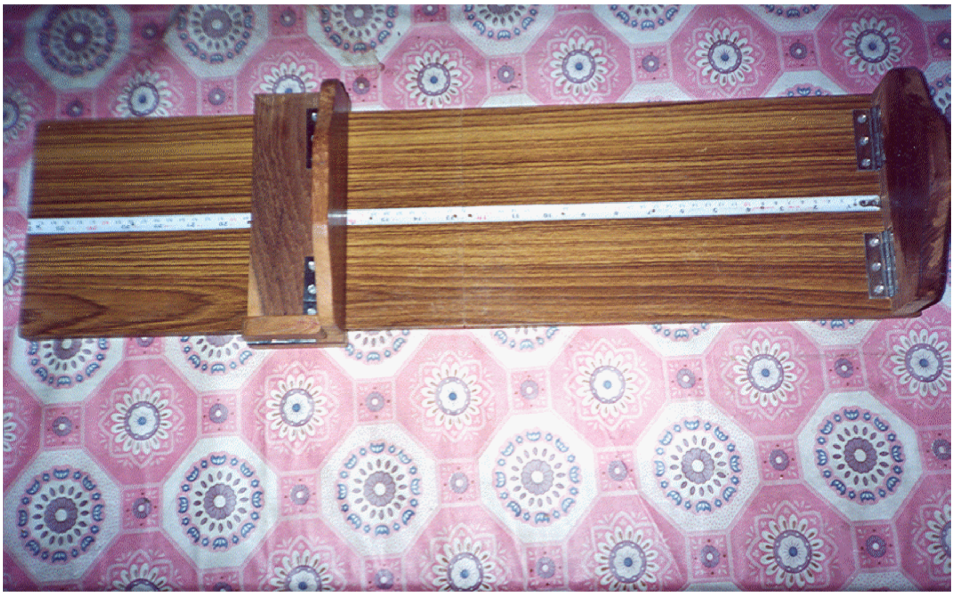
Triceps skinfold thickness : The measurement of the triceps skinfold was performed at the midpoint of the upper left arm, between the acromion process and the tip of the olecranon, with the arm hanging relaxed. To mark the midpoint, the left arm was bent 90° at the elbow, and the forearm was placed palm down across the body. Then the tip of the acromion process of the shoulder blade at the outermost edge of the shoulder and the tip of the olecranon process of the ulna were located and marked. The distance between the two points was measured using a nonstretchable tape and midpoint was marked with a marker pen, directly in line with the point of the elbow and acromium process. The left arm was then extended so that it was hanging loosely by the side. A vertical fold of skin plus the underlying fat was grasped, 1 cm above the marked midpoint, in line with the tip of the olecranon process, using the thumb and forefinger. The skinfold was gently pulled away from the muscle tissue and then the caliper jaws applied at the right angles, exactly at the marked midpoint. The caliper reading generally diminished for 2 to 3 seconds.



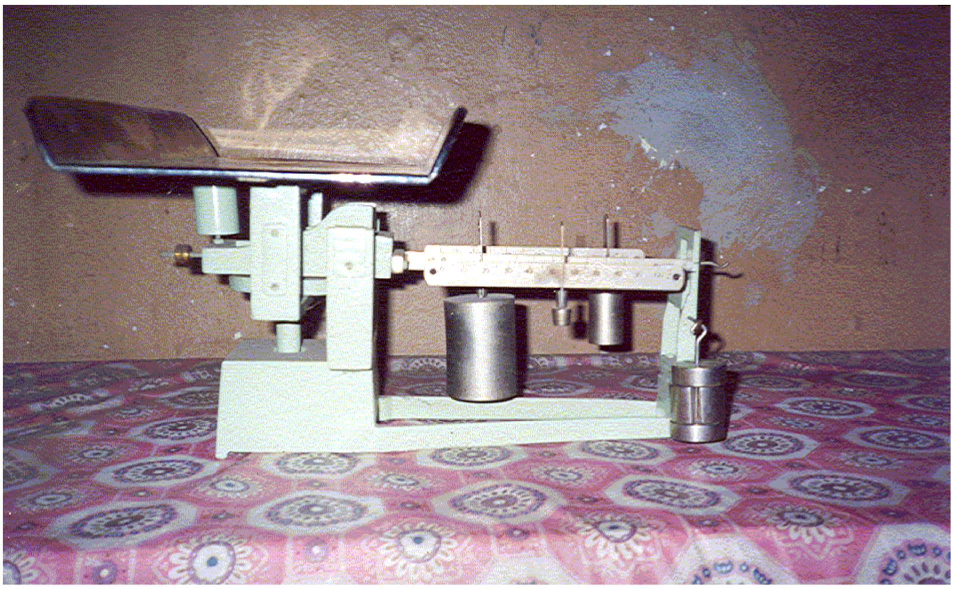
(a) Adult weighing scale

(b) Wall mounted height measuring scale

(c) Baby weigh scale



(d) Neonatometer



Newborn anthropometry: Newborn anthropometric (birth weight, length at birth, foot length and circumference: mid arm, chest, head) measurements were made and recorded within 24 hours of birth at obstetric ward of the same hospital and gestational age assessed by Ballard's (47) physical and neurological maturity scoring method of newborn and then matched with gestational age as calculated from history of maternal last menstrual period (LMP). In case of unavailability of LMP, the gestational age by Ballard's score was used for classification of maturity and weight-for-gestational age. All newborn anthropometry was measured by standard techniques.

Birth weight: Birth weight is taken in a triple beam balance without clothing under radiant warmer. The baby is placed on the pan, so that the weight is distributed equally about the centre of the pan. The infant should be lying quietly and easily. Weight is recorded to the nearest 1 g.

Length at birth: Newborn length was measured by neonatometer with accuracy to 0.1 cm. The infant is laid on the board on its back, which is itself on a flat surface. The head is positioned firmly against the fixed head board, with the eyes directed vertically up. The knees are extended, usually by firm pressure applied by an assistant. The upright sliding piece is moved to obtain contact with the heels and the length read to the nearest 0.1cm.

Foot length: Foot length is measured by the setsquare triangle with markings in millimeter by holding one foot of the neonate vertically on a hard surface and measuring the length to great toe from the heel with the longer side of the instrument.

Circumference: Head, chest and mid arm circumferences were measured by a non stretchable fiber tape with markings in millimeter division .The accuracy of the measurement was 0.l cm. While taking the measurements, the tape was held in contact with the surface neither too tight nor too loose.

Head circumference: Head circumference is measured with the tape touching the most prominent part of occiput at back and just above the supraorbital ridge infront of the head, thus circumscribing the head.

Chest circumference: Chest circumference is measured at the level of nipple with the tape touching the skin around chest without any gap at intra axillary hollows.

Mid-arm circumference: In supine position the arm is held extended; the midpoint of the arm is marked on the line joining the acromion and olecranon processes and the circumference is measured at that level. **Statistical method:** Statistical analysis was conducted by grouping the independent variables into four equal groups in a distribution, using three values such as the 25th percentile, 50th

percentile and 75th percentile of the distribution. The process divides the values into first, second, third and fourth quartiles of such distribution. Except for mother's age, all (weight, height, BMI, MAC) anthropometric and economic variables were grouped by quartile cut-off points for equal division. The family income first quartile was considered as low SE class and second and third quartile as middle class, whereas the fourth quartile was considered as the high socio-economic class. We used the classification of body mass index as described by James et al (48). Mother's age was grouped by five-year intervals. Adolescent and older mothers were grouped by mother's age <20 years and ≤30 years, respectively.

The data handling was simplified by the use of computer packages. Both EPI-INFO 6.0 (49) and STATA 7.0 (50) packages were used to enter data and perform analysis with standard statistical methods. ANOVA was used to study differences between groups for continuous variables. Odds ratio and relative risk were calculated to measure the risk between the groups. Chi-square test was used to study the significance of difference between proportions. Correlation coefficient (r) was calculated to find out the relationship between maternal anthropometry and birth weight. Sensitivity and specificity was used for screening disease by efficient cut-off point of maternal anthropometry. ROC [?] curve was plotted for predicting most efficient cutoff point to detect low birth weight.

For predicting anthropometric cutoff point for birth outcomes of pregnancy, an indicator is required. In this context, WHO (27) has proposed that an indicator should fulfill the following criteria :

1. A simple single measurement (acceptable, low cost);
2. Strong predictability or effect (high odds ratio ORs);
3. Reliable (narrow confidence interval for ORs);
4. Timely (permitting effective intervention, including referral);
5. Sensitive and specific for screening;
6. Efficient in performance (low number of false classification).

ANALYSIS AND RESULTS

Subjects were enrolled from 18th March to 21st July' 04 at the obstetric ward of M.R.Bangur Hospital. This is a baby friendly hospital of South Kolkata that served the needs of people belonging to lower socio economic category. Their average family income was Rs. 3367 per month and average per capita income was Rs. 26 per day. The average educational status of women and husband was class five and six respectively. Their average family size was 5 persons. Most of them (58 %) were engaged in daily wages/ labour followed by 25 % in business and 17 % in service. The mean (SD) age of mothers was 22.1 (3.5) years and the mean parity was 1.6. The mean (SD) gestational age (n=150) was 38.2 (3.3) weeks, based on last normal menstrual period and 38.5 (2.2) weeks (n=176) by Ballard's physical and neurological maturity-scoring methods. The difference in gestational ages by two methods was not statistically significant. The maturity of newborn babies was evaluated by using both gestational ages.

Antenatal care and the results of laboratory investigation during pregnancy are important factors for birth outcome. In the present study 98 % women attended antenatal clinic for antenatal check up and 97 % women received tetanus toxied injection during pregnancy. Among them 8 % and 92 % women received single and double doses of tetanus toxied injection. More than 76 percent women had tests for post prandial blood sugar, total blood hemoglobin, ABO blood group including rh factors and VDRL test during pregnancy.

Maternal anthropometry and family income

Table: 1. Mean & standard deviation for the total and 25^{th}, 75^{th} percentile values of maternal anthropometry and family income

Variable :	Mean, SD	25^{th} centile	75^{th} centile
Mother height (cm)	149.3 ± 5.5	145.7	152.4
Mother weight (kg)	47.2 ± 6.7	42.5	51.6
Body mass index (kg/ m^2)	21.1 ± 2.6	19.4	22.5
Midarm circumference (cm)	23.0 ± 2.3	21.4	24.6
Triceps skinfold (mm)	08.6 ± 3.7	06.0	11.0
Family income (monthly)	3367 ± 2632	1700	4000

The mean (SD) and quartile values of maternal anthropometry and family income are given in Table-1. Of the 176 mothers, 41 percent had weight of less than 45 kg, 19.3 percent had height of less than 145 cm and 13.1 percent had BMI of less than 18.5 kg/m^2.

Gender and birth outcome

I have summarized the birth outcomes and compared them by gender in Table-2. As expected, anthropometric indicators favoured boys. Nearly 14 percent of all neonates are small for date (SFD). Of all low birth weight neonates 33.3 percent SFD, whereas the prevalence of low birth weight (<2.5 kg and all gestational age) was 41 percent.

Table 2 Birth outcome by Gender differences

Variable :	All Cases (n=176)	Male (n=98)	Female (n=78)	ANOVA* /χ^2 P-value
Birth Weight (g)	2575 ± 381	2639 ± 375	2494 ± 375	0.0119
Birth length (cm)	47.69 ± 1.9	48.14 ± 1.9	47.14 ± 1.8	0.0006
Head circumference (cm)	32.79 ± 1.3	33.14 ± 1.2	32.34 ± 1.3	0.0001
Chest circumference (cm)	30.01 ± 1.7	30.26 ± 1.7	29.70 ± 1.6	0.0311
Arm circumference (cm)	9.76 ± 1.1	9.87 ± 1.0	9.62 ± 1.1	0.1259
Foot length (cm)	7.61 ± .5	7.70 ± .5	7.48 ± .4	0.0078
Gestational age (week)	38.5 ± 2.2	38.8 ± 2.1	38.2 ± 2.3	0.0907
LBW (%)	72 (40.9)	34 (34.7)	38 (48.7)	0.1594
Preterm Birth (%)	37 (21.0)	18 (18.4)	19 (24.4)	0.2987
IUGR babies (%)	24 (13.6)	11 (12.2)	13 (16.7)	0.3162

* Analysis of variances (sex difference)

Out of 176 all singleton live born babies, 98 (56 %) were boys and 78 (44 %) were girls. The mean and (SD) birth weight was 2575 g (381), 2639 g (375) for boys with 47 per cent incidence of low birth weight and 2494 (375) g for girls with 53 percent incidence of low birth weight. Twenty one per cent of all neonates were preterm (<37 weeks of gestation) and nearly 77 percent were term (37-41 weeks gestational age) and 2.3 percent were post term (>41 weeks of gestation) baby. Similarly, 60 percent of all low birth weight neonates were term (IUGR-LBW) and nearly 39 per cent were preterm and 1.4 percent were post-term infants.

An earlier study documented that boys are significantly (120 g) heavier than girls at birth (43). In our study boys are 145 g heavier than the girls. The difference in birth weight is statistically significant (p<0.011). The present study also observed the significant difference of crown heel length, head circumference, chest circumference and foot length between male and female babies. Female babies are lighter at birth and the incidence of low birth weight was higher compared to male babies. These results support previous findings (51), (52). Similarly, the incidence of intrauterine growth retardation and preterm birth are higher among girls than boys.

Maternal factor and low birth weight

Table - 3 shows that the mothers age less than 20 years, blood group phenotype 'O' and cooking fuel type was significantly associated with low birth weight. Others only show a trend – this may be due to small sample size and / or low incidence rate.

Table: 3. Maternal risk factor associated with low birth weight

Maternal Characteristics	No. with low birth weight (%)	Risk ratio 95% CI
Adolescent mothers (<20 years): Mothers age ≥ 20 years:	23 (54.8) 49 (36.6)	1.50 1.05-2.13
Blood group phenotypes 'O': Phenotypes A,B & AB:	28 (56.0) 44 (34.9)	1.60 1.14-2.26
Cooking fuel type: Coal, wood, cow dung: Electric, Gas and Kerosene:	39 (46.4) 33 (35.9)	1.46 1.02-2.10
Parity: Primipara: Multipara:	39 (45.9) 33 (36.3	1.27 0.89-1.81
Place of residence in rural area: Urban area:	23 (46.9) 49 (38.6)	1.22 0.84-1.76
Temporary latrine/ open field: Sanitary:	10 (50.0) 62 (39.7)	1.26 0.78-2.03
Occupation: daily wages/ labour: Business and service:	47 (46.1) 25 (33.8)	1.36 0.93-2.00
Family smoking history present: Smoking history absent:	50 (44.2) 22 (34.9)	1.27 0.85-1.88
Mother Education: Illiterate: Literate	23 (44.2) 49 (39.5)	1.12 0.77-1.63
Husband Education: Illiterate: Literate:	20 (44.4) 52 (39.7)	1.12 0.76-1.65
Abortion history present: Abortion history absent:	13 (50.0) 59 (39.3)	1.27 0.82-1.96
Iron folic acid not taken: Iron folic acid taken:	40 (43.5) 32 (38.1)	1.14 0.80-1.63
Antenatal checkup<4 times: Antenatal checkup ≥4 times:	43 (44.3) 29 (36.7)	1.21 0.84-1.74

Maternal anthropometry, family income and low birth weight

Table - 4 shows that the mean height, weight, BMI and arm circumference of low birth weight mothers was lower than those who have normal birth weight baby. Of these, the difference in mother's weight ($p<0.005$), height ($p<0.03$) and BMI ($p<0.048$) was statistically significant. The mean triceps skin fold was similar in two groups of mothers ($P=0.57$). Mean weight of mothers with low birth weight baby was 45.5 kg. Just 500g higher than the cut-off point of under weight mothers. The difference in mean weight, height and BMI in two groups of mothers was nearly 3 kg, 2 cm and 1 kg/m², respectively. Similarly, the difference of mean family income was nearly Rs. 400 between the two groups of mothers.

Table: 4. Mean and standard deviation of maternal anthropometry in birth weight category

Maternal anthropometric Variable	LBW (n=72) Mean	SD	NBW (n=104) Mean	SD	ANOVA P-value*
Weight (kg)	45.5	6.4	48.4	6.7	0.005
Height (cm)	148.2	5.5	150.1	5.4	0.030
Body Mass Index (kg/m²)	20.7	2.5	21.5	2.7	0.048
Mid Arm Circumference (cm)	22.8	2.2	23.1	2.4	0.414
Triceps skin fold (mm)	08.6	3.1	08.6	4.0	0.569
Family income/month (Rs.)	3131	2262	3530	2859	0.313

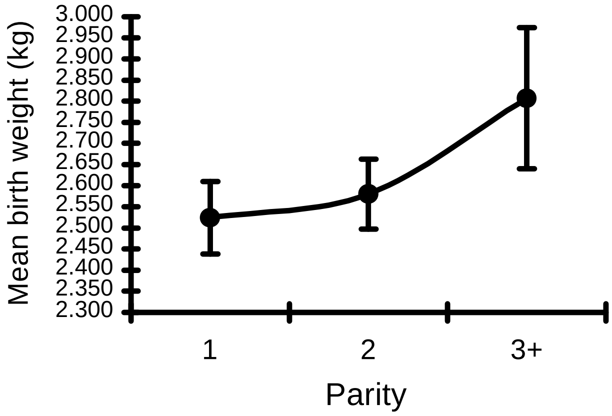
Socio-economic variable and birth weight

Table – 5 shows that the relationship of maternal socio-economic variables and newborn birth weight by category is continuous. The parity was significantly associated with birth weight.

Parity and birth weight

The risk of LBW was seen to decrease with increasing parity. Similar results have been seen in other studies (52). Mothers with parity one had higher incidence of low birth weight. Dougherty (53) and Roosmallen (54) reported the mean birth weight of neonates born to primipara mothers were less than that for multipara mothers by 104 g and 100 g, respectively. In the present study the difference of mean birth weight was 98 g between primipara and multipara mothers. The mean birth weight by parity is shown in figure - 1.

Figure : 1. Relationship of mother's parity with birth weight ± 2 Standard Error



ANOVA (P=0.019)

Table : 5. Relationship of mean birth weight with maternal socio-economic variable

	Birth weight (g)							
	<2500		≥2500		x^2	Continuous		
Variable/category	**n**	**%**	**n**	**%**	**p**	**Mean**	**SD**	**Anova (p)**
Age of mothers (years) :								
<20	23	54.8	19	45.2	7.57	2476	395	0.185
20-24	35	37.2	59	62.8	n.s	2596	385	
25-29	9	28.1	23	71.9		2664	352	
≥30	5	62.5	3	37.5		2.483	287	
Parity:								
1	39	45.9	46	55.1	3.08	2524	395	0.019
2	29	39.2	45	60.8	n.s	2580	356	
≥3	4	23.5	13	76.5		2807	833	
Husband's occupation:								
Daily wages /labour	47	46.1	55	53.9	3.74	2.534	403	0.123
Business	17	38.7	27	61.3	n.s	2590	297	
Service	8	26.7	22	73.3		2693	396	
Family income (Rs.):								
Low (≤1700)	21	47.7	23	52.3	1.56	2504	404	0.657
Middle (1701-4000)	38	40.4	56	59.6	n.s	2591	372	
High (>4000)	13	34.2	25	65.8		2663	367	
Mother's Education:								
Illiterate	23	44.2	29	55.8	1.66	2568	373	0.586
1-5	19	42.2	26	57.8	n.s	2526	373	
6-9	24	41.4	34	58.6		2586	378	
≥10	6	28.6	15	71.4		2664	427	

Parent's education and birth weight

The present study found 30 percent female and 26 percent male were illiterate. The study found 96 g birth weight difference between no schooling and ≥10 years of schooling women. Similarly, Karim et al (43) found the difference in mean birth weight of 229 g between no schooling and ten years and above schooling of women. The figure – 2 & 3 show the relationship of parent's education and birth weight.

Figure: 2. Relationship of women's education and birth weight ± 2 Standard Error

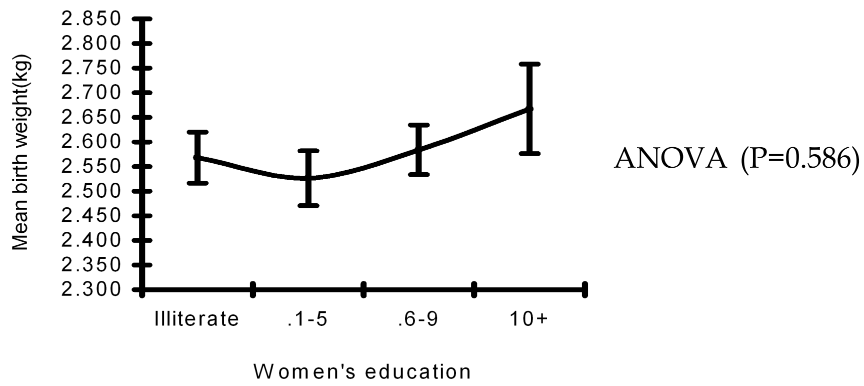
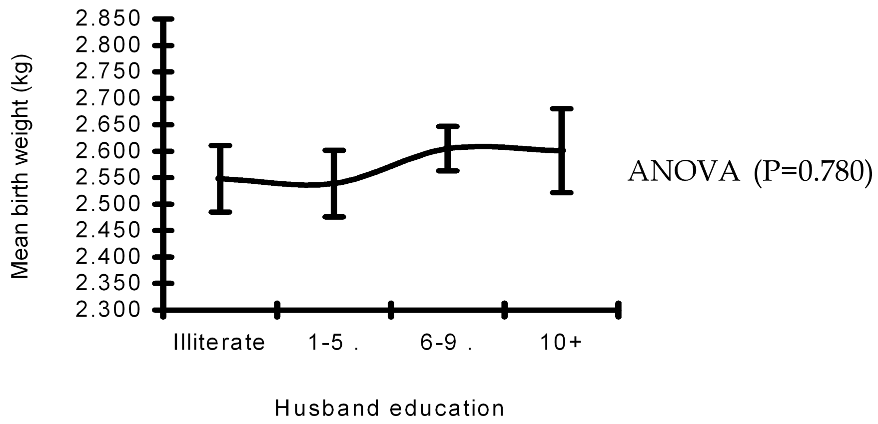


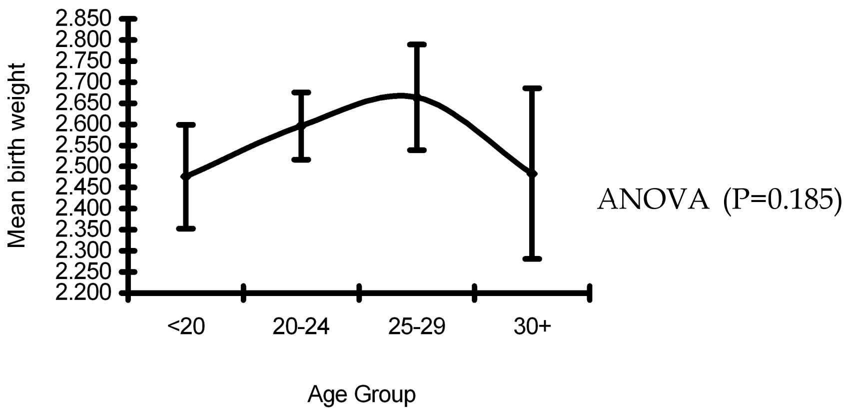
Figure: 3. Relationship of husband education with birth weight ± 2 Standard Error



Mother's age and birth weight

Maternal age is an important factor on the incidence of low birth weight. In the present study, the higher incidence of low birth weights was observed in older mothers. In contrast, Pakrasi et al (51) and Chakraborty et al (56) reported that the young (<20 years) mothers had higher incidence of LBW than older (≥30 years) mothers. Teenage (15-19 years) pregnancies are a common phenomenon in India, inspite of legal constraints, legal age of marriage for women being 18 years as per amendment of 1978. The government of India also recommended that the first childbirth should be after 20 years of maternal age (57). In the present study nearly 24 percent mothers delivered their baby before they attained age of 20 years; among them 55 percent mothers gave birth to low birth weight neonates. The LBW baby of adolescent mothers was 13.1 per cent of the total. Similarly, our previous study found 13 per cent of LBW babies were born to adolescent mothers among 331 women (unpublished). Pakrasi et al (51) documented 7.7 per cent LBW babies among adolescent mothers out of 5117 women. Mondal (58) documented 6.2 per cent LBW babies among adolescent mothers among 390 women and Karim et al (43) documented 5.2 per cent of LBW babies among adolescent mothers out of 268 samples. All the above studies were conducted among Bengali population in different geographical regions. On the basis of these work we note that LBW babies of adolescent mothers comprised 5 to 13 percent low birth weight babies. Preventing pregnancy in teenaged mothers should be an important intervention to prevent low birth weight. In an earlier study from the same hospital Verma et al (59) found that 35 percent neonates are of low birth weight among teenage mothers compared to 23 percent in older mothers (20-29 years).

Figure: 4. Relationship of maternal age group with birth weight ± 2 Standard Error



Maternal anthropometric and bio-social variables and birth outcome by family income and husband's occupational status

The occupational status and income of household reflects their poverty levels. The relationship between income group and maternal parameter including birth outcomes is given in Table-6. In Table-7 the same variables are shown by husband's occupational category.

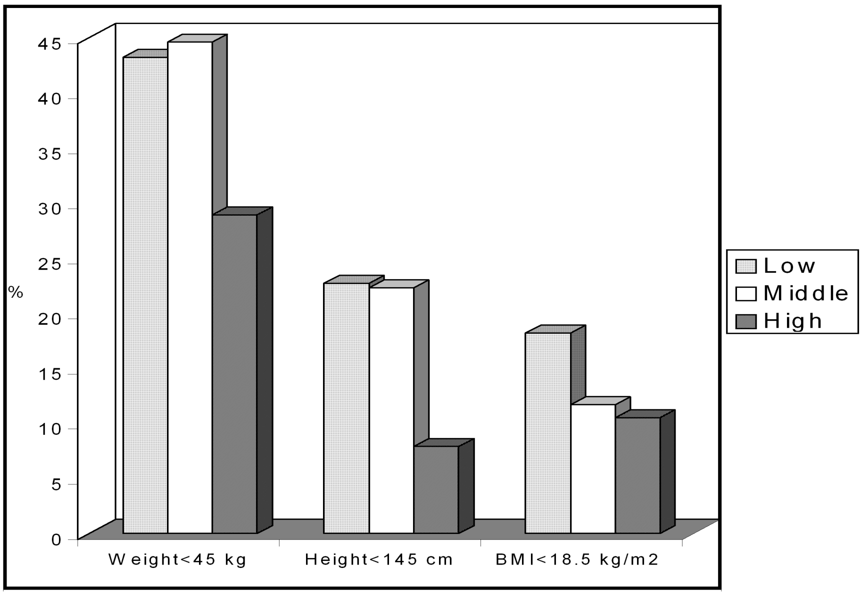
Table : 6. Maternal characteristics and birth outcome by family income

Variable **n=176**	**Low Income** **n=44**	**Middle Income** **n=94**	**High Income** **n=38**	**p-value**
Maternal anthropometry :				
Height (cm)	149.4	148.6	150.9	0.095
Weight (kg)	46.5	46.7	49.3	0.094
Mid Arm Circumference (cm)	22.8	22.9	23.4	0.427
Body Mass Index (kg/m²)	20.7	21.1	21.7	0.342
Triceps Skinfold Thickness (mm)	08.1	08.6	09.3	0.339
Underweight (wt<45 kg), %	43.2	44.6	28.9	0.234*
Stunting (height<145 cm), %	22.7	22.3	07.9	0.131*
Malnutrition (BMI<18.5), %	18.2	11.7	10.5	0.501*
Maternal socio-economic variable :				
Percapita income /day (mean Rs.)	15.0	25.0	40.0	0.001
Mother age (mean years),	22.0	22.0	21.0	0.134
Gravida (mean)	02.0	01.7	01.6	0.032
Women Education (mean)	02.8	05.1	06.8	0.001
Husband Education (mean)	03.5	05.9	06.8	0.001
Antenatal visit (mean)	03.1	03.4	03.9	0.086
Additional quantity food taken (%)	75.0	75.5	86.8	0.319*
Abortion history (%)	18.2	10.6	21.1	0.237*
Birth outcome:				
Birth weight (g)	2504	2572	2663	0.165
Length (cm)	47.3	47.7	48.3	0.059
Head circumference (cm)	32.6	32.8	33.0	0.333
Chest circumference (cm)	29.7	30.0	30.5	0.064
Mid arm circumference (cm)	09.5	09.7	10.2	0.016
Foot length (cm)	07.4	07.6	07.7	0.072
Low birth weight (%)	47.7	40.4	34.2	0.458*
Preterm birth (%)	22.7	25.5	07.9	0.075*
Intrauterine growth retardation (%)	20.5	11.7	10.5	0.309*

* Chi-square

Table-6 shows that the low income groups had lower mean value of all parameters of mothers than middle and high-income groups. In contrast, percentage of all parameters (except premature baby) had higher values than middle and high-income groups. The prevalence of premature birth was higher in middle-income groups. In middle-income groups the height of mother had comparatively lower mean value than low and high-income group.

Figure: 5. Maternal nutritional status by family income



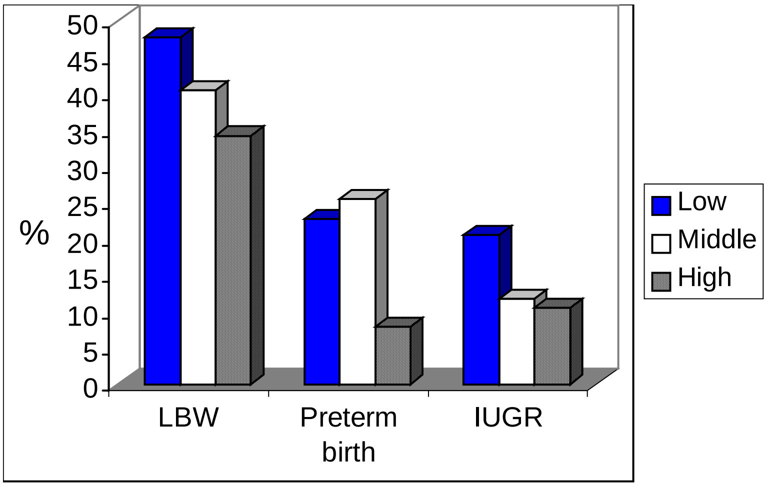
The women of low-income group made on average 3.1 antenatal visits, whereas middle and high income groups made on average 3.4 and 4.9 visits during pregnancy. There was trend for a difference in antenatal visits by income group (p=0.086), but occupational status (Table-7) was significantly associated with the number of antenatal visits (p=0.02). Eighty seven per cent women in high income group consumed additional quantity of food during pregnancy compared to 75 percent in low and 76 percent in middle income group (p=0.32). Similarly, 87 percent women in service group consumed additional quantity of food during pregnancy compared to 75 percent daily wages/labor group and 80 percent in business group (p=0.35). Rate of abortion history was high in both high and low income groups compared to middle income group. Among occupational groups rates of abortion history was highest in the service, intermediate in business group and least in daily wages group. The difference in the rates of abortion history by income group was not significant but husband's occupational groups show a significant difference for previous abortion (p=0.022). The difference in educational status (both husband and women) by income and occupational groups was statistically significant (p<0.001). The lower mean years of education were observed in low income and daily wages / labour groups. The mean years of education increase with the rising economic condition.

Table: 7. Maternal socioeconomic characteristics and birth outcome by husband's occupation

Variable n=176	Daily wages n=102	Business n=44	Service n=30	P value
Maternal anthropometry :				
Height (cm)	148.7	150.1	150.1	0.291
Weight (kg)	45.9	48.1	50.3	0.015
Mid Arm Circumference (cm)	22.7	22.8	24.2	0.015
Body Mass Index (kg/m^2)	20.7	21.3	22.4	0.011
Triceps Skinfold Thickness (mm)	08.2	09.1	09.5	0.163
Underweight (wt<45 kg), %	46.1	34.1	33.3	0.261*
Stunting (height<145 cm), %	23.5	13.6	13.3	0.251*
Malnutrition (BMI<18.5), %	12.7	11.4	16.7	0.793*
Socio-economic characteristic:				
Mother age (mean)	22.2	21.4	22.9	0.196
Gravida (mean)	01.8	01.5	01.9	0.069
Women education (mean class)	03.8	06.0	07.1	0.001
Husband education (mean class)	04.6	06.3	07.5	0.001
Family member (mean)	04.5	04.5	05.5	0.208
Percapita income /day (mean Rs.)	21.0	33.0	30.0	0.001
Antenatal visit (mean)	03.2	04.1	03.6	0.021
Additional quantity food taken (%)	74.5	79.5	86.6	0.352*
Abortion history (%)	09.8	15.9	30.0	0.022*
Birth outcome:				
Birth weight (g)	2534	2590	2693	0.123
Length (cm)	47.5	47.8	48.3	0.131
Head circumference (cm)	32.7	32.8	33.1	0.228
Chest circumference (cm)	29.8	30.3	30.5	0.078
Mid arm circumference (cm)	09.6	09.8	10.2	0.016
Foot length (cm)	07.5	07.7	07.8	0.116
Low birth weight (%)	46.1	38.6	26.7	0.154*
Preterm birth (%)	26.5	13.6	13.3	0.114*
Intrauterine growth retardation (%)	18.6	11.4	–	0.029*

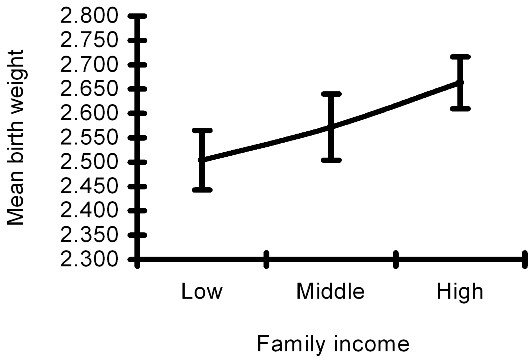
* Chi-square

Figure: 6. Selected birth outcome by family income



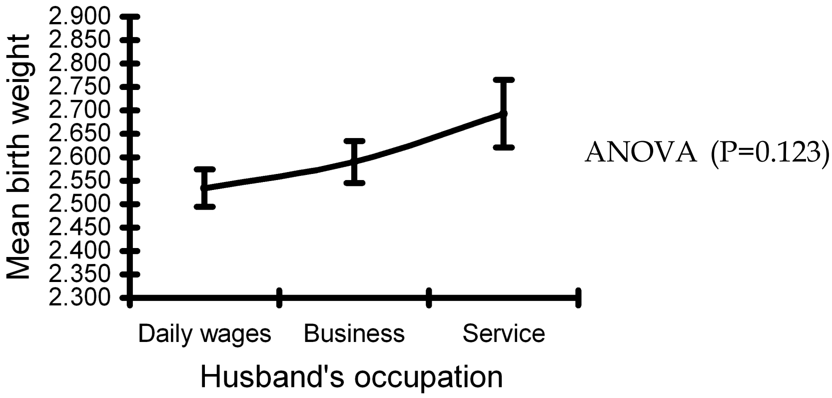
The present study found that the preterm birth rate was three times higher in low and middle-income groups than in high income group. Similarly, the percentage of IUGR baby was two times higher in low-income group than high-income group. The differences of birth weight and length of baby between daily wages /labour and service group and between low and high-income groups was 159 g and 1 cm, respectively. The difference in mean birth weight between daily wages/labour and service group and between low and high-income groups have shown a trend for increasing mean birth weight with the rising economic condition. In an earlier study Karim et al (43) found the birth weight difference of 226 g between low and high-income group. Similarly, WHO multicenter study found on average 200 g birth weight difference in India, Bangladesh and Sri Lanka between low and high income groups.

Figure: 7. Relationship of Family Income with birth weight ± 2 Standard Error



ANOVA (P=0.657)

Figure: 8. Relationship of Husband's Occupation with birth weight ± 2 Standard Error



Nearly 29 percent women in high income group was under weight. They were as high as 43 and 45 percent in low and middle income groups respectively. The short stature (<145 cm) women were three times more in low and middle-income groups than in high-income group. Similarly, the percentage of malnourished women was higher in low income groups. The percentage decreases with increasing economic condition. The short stature women were 10 percent more in daily wages / labour group than service and business groups. Similarly, more than 33 percent women in service and business groups were underweight (<45 kg). The rate of underweight women increases to 46 percent in daily wages/ labour group, whereas the rate of malnourished women was comparatively low in business group.

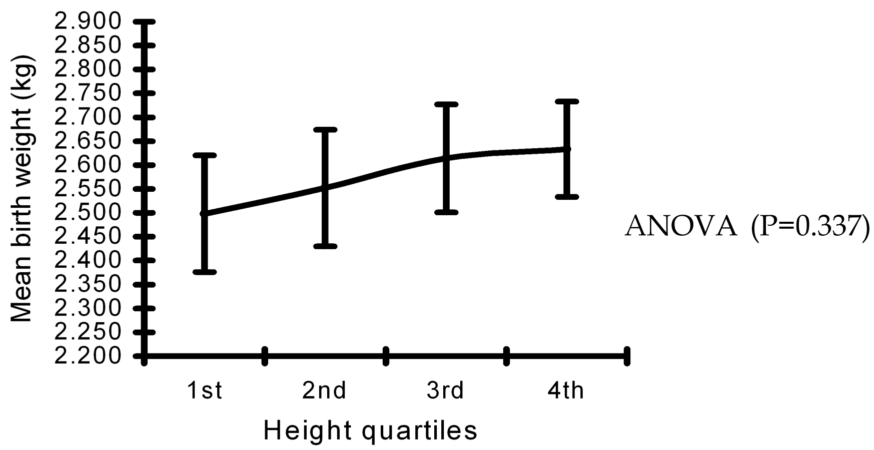
Nearly 48 percent and 46 percent babies in low income and daily wages groups were LBW. The lower rate of LBW babies was observed in service and high income groups. The difference in the rate of LBW babies by family income (p=0.458) and occupational status (p=0.154) was not significant. However the difference in preterm birth by family income (p=0.08) and occupational status (p=0.11) shows a trend. And the difference in the rate of IUGR babies by husband's occupational status was statistically significant (p=0.03); family income did not have a significant effect (p=0.31).

The first quartile (≤1700) monthly family income is considered as low-income group in the present study. Forty three percent women in low income group were under weight (45 kg). Among them 58 percent mothers delivered low birth weight babies. In the present study I observed that the maternal post delivery weight of <45 kg in low income group was associated with more than 2 fold risk for delivering low birth weight neonates. Similarly, of the mothers with short stature (<145 cm) more than 29 percent belong to low income group. Among them 60 percent mothers delivered low birth weight babies. The short statured mothers were at 1.36 (95% CI: 0.72-2.56) times risk for delivering low birth weight. The high percentage (34.8) of malnourished mothers belonged to low income group and majority (63 %) of them delivered low birth weight babies. The mean difference in birth weight of 112 g in low (<45 kg) and normal (≥45 kg) weight mothers was noted (p>0.37); 145 g birth weight variation was noted in low (≥145 cm) and normal (³145 cm) stature mothers among low income group (p>0.323). The incidence of IUGR babies was higher among low weight (<45 kg) mothers than premature babies, whereas the incidence of preterm birth (<37 week of gestation age) was higher than IUGR babies in short statured (<145cm) women. An earlier study from India reported 21 % pretern birth among short statured mothers compared to 15 percent among control (³145) (60). Nearly 38 percent malnourished (BMI<18.5) women delivered intra uterine growth restricted (IUGR) babies.

Maternal anthropometry and birth outcome

The mean height of Bengalee women in the present study was 149.3 cm. It was 7 mm lower than the WHO collaborative study conducted in Pune and Hyderabad, India. The National Family Health Survey -2 (61) observed that the mean height of Indian women was 151 cm. and mean height of women in West Bengal was 150 cm. Thirteen percent and 19 per cent women were less than 145 cm in height in India and West Bengal respectively. The present results are similar to the findings from West Bengal (NFHS-2). The short (<145 cm) mothers delivered 121 g lighter babies than normal (≥145 cm) mothers (p=0.095).

Figure: 9. Relationship of maternal height with birth weight ± 2 Standard Error



The present study found that the increase in several maternal anthropometric indicators from first to fourth quartile is associated with a decrease in low birth weight rate. Except mothers triceps skin fold thickness the first quartile of all (weight, height, MAC, BMI) anthropomatric variables showed (Table-8) higher incidence of low birth weight and the percentage decrease with increasing quartiles. Similarly, the higher mean birth weight was observed in the fourth quartile and lower mean birth weight in first quartile. The figure 7, 8, 9,10 and 11 show the quartile differences in mean birth weight in relation to maternal anthropometry. Mother's weight has a linear trend for a decreasing rate of low birth weight ($p<0.05$) with increasing weight quartile.

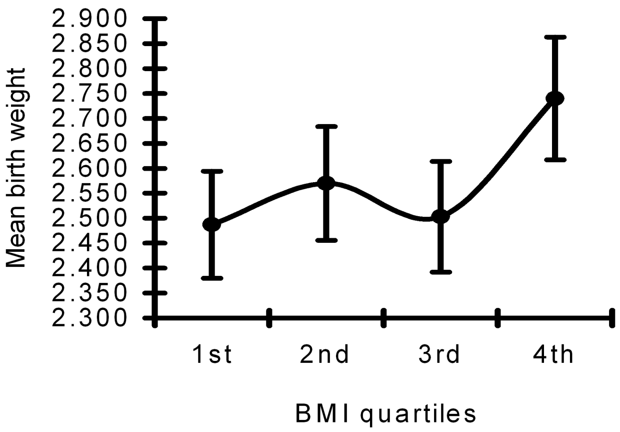
Table: 8. Relationship of birth weight by maternal anthropometric variable

	Birth weight (g)							
	<2500		≥2500			Continuous		
Variable/category	n	%	n	%	x^2 p	Mean	SD	Anova (p)
Weight (kg):								
<42.5	25	56.8	19	43.2	8.91	2453	377	0.009
42.5-46.5	20	45.5	24	54.5	<0.05	2529	330	
46.6-51.5	14	32.6	29	67.4		2604	367	
≥51.6	13	28.9	32	71.1		2711	407	
Height (cm):								
<145.7	22	52.4	20	47.6	5.14	2498	396	0.337
145.7-149.1	20	43.5	26	56.5	n.s	2552	414	
149.2-152.3	17	39.5	26	60.5		2614	371	
≥152.4	13	28.9	32	71.1		2633	335	
Body Mass Index (kg/m²):								
<19.4	23	51.1	22	48.9	9.07	2487	328	0.005
19.4-20.7	18	40.9	26	59.1	<0.05	2570	377	
20.8-22.4	21	48.8	22	51.2		2503	363	
≥22.5	10	22.7	34	77.3		2740	408	
Mid Arm Circumference (cm):								
<21.4	20	45.5	24	54.5	3.31	2527	349	0.402
21.4-22.6	17	40.5	25	59.5	n.s	2589	342	
22.7-24.5	21	47.7	23	52.3		2533	394	
≥24.6	14	30.4	32	69.6		2647	428	
Triceps Skinfold Thickness (cm):								
<6.0	14	35.0	26	65.0	0.89	2597	333	0.897
6.0-7.9	17	40.5	25	59.5	n.s	2590	430	
8.0-10.9	20	44.4	25	55.6		2539	426	
≥11	21	42.9	28	57.1		2577	334	

Maternal Socio-economic variable and birth outcome by Body Mass Index Status

Body mass index is a measure of protein energy malnutrition of an individual. Generally it measures fat store in the body. BMI <18.5 is used as a cutoff point for malnutrition of an individual as well as of a population. In the present study only 13 percent mother BMI was <18.5; it is very low from the state and national values.

Figure: 10. Relationship of maternal BMI with birth weight ± 2 Standard Error



ANOVA (P=0.005)

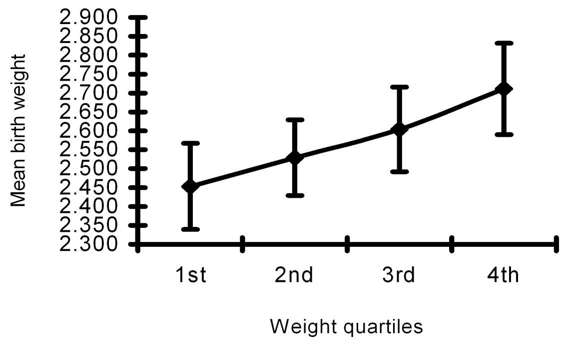
However, there was no universal validation of a cut-off point in relation to birth outcome and post pregnancy body mass index. Recently, IOM subcommittee recommended that BMI<19.8 be considered as under weight. In the present sample 28 percent mothers fall in this group. If we considered the cut-off point less than first quartile i. e., body mass index< 19.4 kg/m^2, only 26 percent mothers were malnourished. NFHS-2 observed the mean BMI for women in India to be 20.3 kg/m^2. More than one third (36 %) women in India and 44 percent women in West Bengal have a BMI below 18.5. The mean post pregnancy BMI of present sample is 21.1 kg/m^2. In an earlier study, Bhadra et al (62) found the mean BMI to be 23.1 kg/m^2 among young (18-22 years) Bengalee adult women of Kolkata. They also documented the mean weight, mid arm circumference and Triceps skin fold thickness of their population. They were 54. 6 kg., 24.8 cm and 22.2 mm respectively. Results of the present study were substantially lower than their study. The possible explanation of this disparity may be socio-economic condition.

Table : 9. Maternal anthropometric, socio-economic characteristic and birth weight by BMI

Maternal Characteristics	Body Mass Index Status				Total
	<18.5	18.5-20.0	20.0-25.0	≥25.0	
Sample size (n)	23	40	98	15	176
Percentage	13.1	22.7	55.7	8.5	100.0
Mother age (years)	21.7	22.0	21.8	24.7	22.1
Gravida	01.7	01.9	01.6	01.9	01.8
Percapita income/day (Rs)	22.7	25.2	26.2	27.4	25.6
Height (cm)	150.9	147.7	149.7	148.8	149.3
Weight (kg)	39.7	42.4	48.9	60.0	47.2
Mid arm circumference (cm)	20.3	21.5	23.6	27.2	23.0
Triceps skinfold thickness (mm)	05.9	06.7	09.9	13.2	08.6
Birth weight (g)	2530.0	2458.0	2622.0	2650.0	2575.0
Low birth weight (%)	43.5	57.5	34.7	33.3	40.9
Preterm birth (%)	21.7	27.5	20.4	6.7	21.0
IUGR baby (%)	21.7	17.5	10.2	13.3	13.6

Table-9 compares different maternal characteristics such as age, gravida, income and anthropometric status and birth weight and percentages of LBW, IUGR and premature birth by BMI status. Except mother's height all anthropometric parameters increased with increasing BMI status. Lower mean height was observed between BMI of 18.5-20.0 group with high rate of LBW. The rate of preterm babies was comparatively high in this group. For this reason the mean birth weight was lower than in the group with BMI of <18.5, but the mean birth weight further increased with increasing BMI from 18.5-20.0. The percentage of IUGR babies was high in malnourished (BMI<18.5) mothers and the rate of IUGR decreased with increasing BMI status.

Figure: 11. Relationship of maternal weight with birth weight ± 2 Standard Error



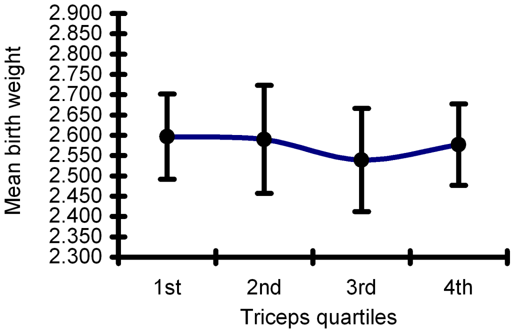
ANOVA (P=0.009)

Several studies from developed and developing countries found that the weight is an important parameter for foetal outcome. Our study found that the mean post pregnancy weight was 47.2 kg and 41 percent mothers had less than 45 kg of weight. So, the present data show that mothers in this population are underweight as compared to developed countries (63). Walravan GEL (64) documented that maternal post delivery weight of less than 45 kg had an odds ratio of 2.03 for low birth weight. The present study found that odds ratio for low birth weight was greater than 2.5 in mothers with post pregnancy weight <45 kg (OR: 2.54, 95% CI: 1.30-5.00). Similarly, under weight (<45 kg) mothers delivered significantly lighter babies by 174g (p=0.01).

Correlation between maternal anthropometry, family income and birth weight by Gender

The weight of mother and birth weight of babies (irrespective of sex) shows (Table – 10) the best correlation followed by body mass index, family income, height of mother, mid arm circumference and triceps skin fold thickness in that order. Similarly, Gueri et al (65) documented the best correlation between birth weight and maternal weight followed by weight for height. All the above mentioned anthropometric measurements are positively correlated with birth weight. Similarly, weight of mothers and sons showed best correlation followed by BMI, family income, height and mid arm circumference.

Figure: 12. Relationship of maternal triceps skin fold with birth weight ± Standard Error



ANOVA (P=0.897)

Only mother's triceps skin fold thickness does not show any correlation with birth weight, whereas all anthropometric variables of mothers show positive correlation with their newborn daughter's birth weight. The weight of mothers and newborn daughter's birth weight showed better correlation than weight of mother's and son's birth weight. Similarly, Das et al (66) documented the best significant positive correlation between mother's weight and daughter's birth weight. The body mass index of mothers shows good correlation with weight of the babies (irrespective of sex), sons and daughters beside mother's weight. The family income and daughter's birth weight shows best significant correlation than family income and all babies birth weight and son's birth weight.

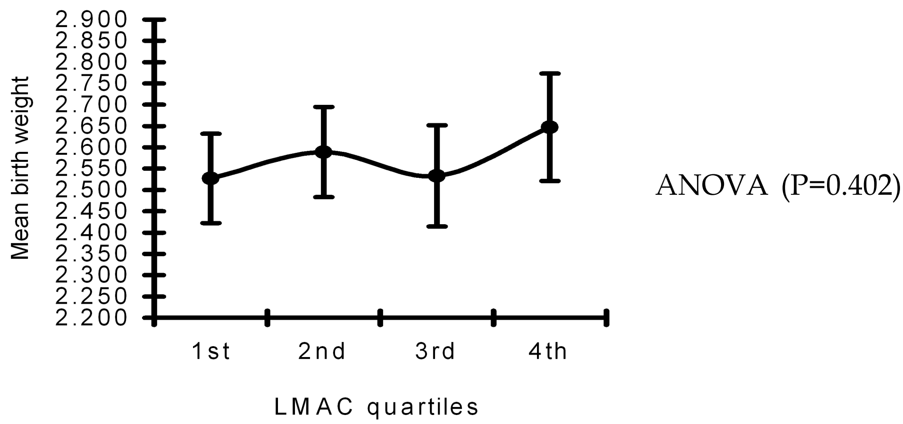
Table: 10. Correlation between maternal anthropometry and newborn birth weight

Maternal anthropometric Variable	All baby + (n=176)	Son + (n=98)	Daughter + (n=78)
Weight (kg)	0.25****	0.20*	0.29***
Body Mass Index (kg/m^2)	0.20***	0.16	0.26**
Height (cm)	0.14	0.12	0.13
Mid Arm Circumference (cm)	0.08	0.08	0.08
Triceps skin fold (mm)	0.01	-0.02	0.07
Family Income (Rs)	0.16*	0.14	0.25*

* $p<0.05$, **$p<0.02$, ***$p<0.01$, ****$p<0.001$. + Values are Pearson correlation coefficients

The regression equation for maternal weight, height, mid arm circumference and body mass index predicts 14g, 10g, 14g and 30g increase in birth weight for each unit increase in the above mentioned maternal anthropometry. The post pregnancy body mass index predicts the highest increment, while weight and mid arm circumference showed an equal increment in birth weight for a unitary change. Often mid arm circumference is used as proxy measurement for weight.

Figure: 13. Relationship of maternal MAC with birth weight ± 2 Standard Error



Maternal Mid Arm Circumference and Weight

Table-11 shows a comparison between two previous WHO collaborative studies from India on the relation of mid arm circumference with mother's weight.

Mother's weight and body mass index have good correlation; if weight increases by 2.25 kg, body mass index increases by one unit for the same height. Body mass index is a derived variable and is a product of weight divided by the square of height in meters. So, weight is the only nutritional parameter which is gaining rapidly during pregnancy due to pregnancy and nutrition but not the height. The study from India (Anderson MA. Relationship between maternal nutrition and child growth in rural India, Doctoral thesis, Tufts University 1989, p 159. Unpublished) documented that the women in this country gain an average weight of 6 kg during pregnancy. Socio economic status has a close impact on height (67), without ignoring ethnicity and genetic factors. In a study in West Bengal only 62 percent and 21 percent women were measured for weight and height during pregnancy (NFHS-2). In India non-institutional delivery is 80 percent. So, specific cut-off point is essential for monitoring high-risk women in the community. The TBAs and health workers can easily assess women to refer to higher centers for better management using MAC as a complementary to weight and BMI. For example, in Burkina Faso, West Africa, short statured women had nearly five times risk for LSCS than taller women (68). In this context, the researcher suggested that the TBAs in Burkina Faso should refer all short statured women to higher centers.

Table: 11. Relationship between maternal mean post delivery weight with MAC

Mid arm circumference (cm)	Pre-pregnancy weight		Post-delivery weight
	Pune	Hyderabad	Present study
15	29.5	29.6	–
16	31.3	31.7	–
17	33.0	33.7	–
18	34.8	35.8	–
19	36.5	38.0	38.3
20	38.2	40.1	39.9
21	39.9	42.2	41.9
22	41.5	44.4	43.1
23	43.2	46.5	46.0
24	44.8	48.7	48.8
25	46.4	50.9	49.5
26	48.0	53.1	52.2
27	49.6	55.4	54.2

Pearson Correlation Coefficient (r) between post delivery weight with MAC=0.80, $p<0.001$

Prediction of cutoff point

(Values at the point of intersection)

Figure: 14. Sensitivity and Specificity for low birth weight by maternal weight

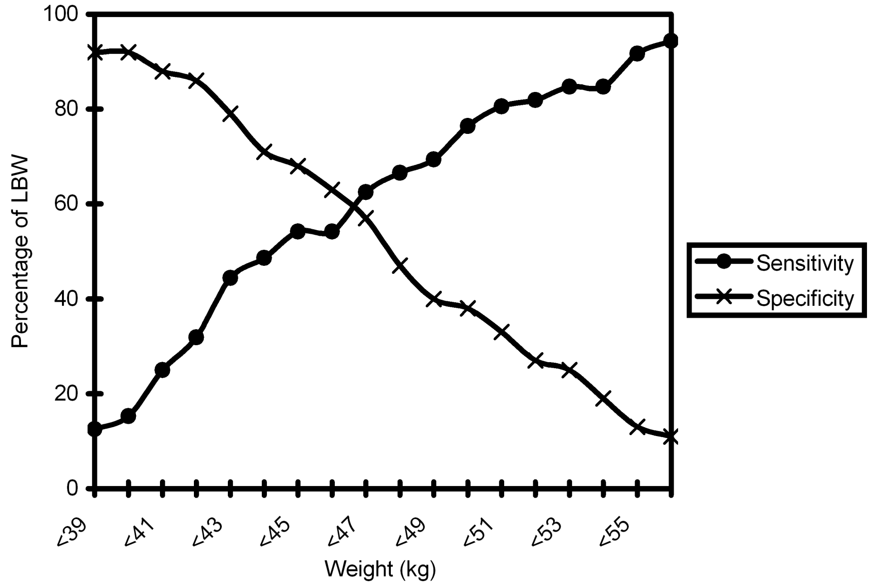


Figure: 15. Sensitivity and Specificity for low birth weight by maternal height

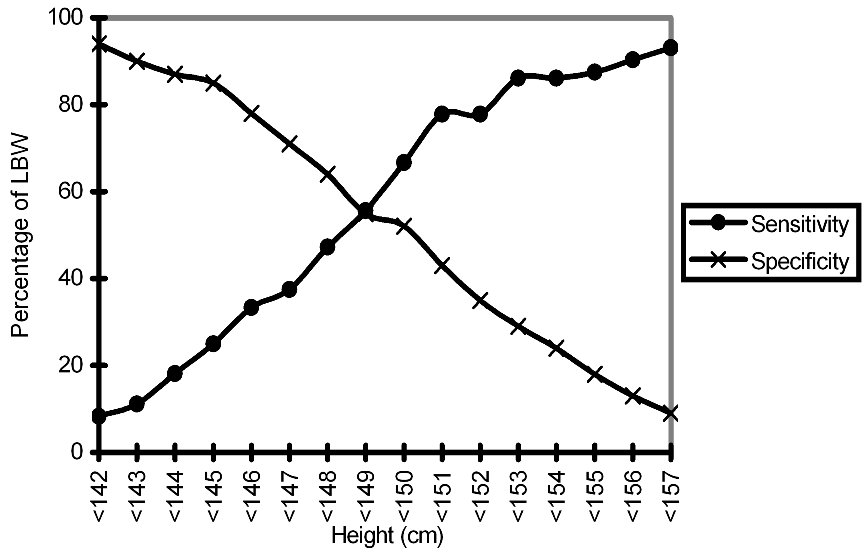


Figure: 16. Sensitivity and Specificity for low birth weight by Maternal BMI

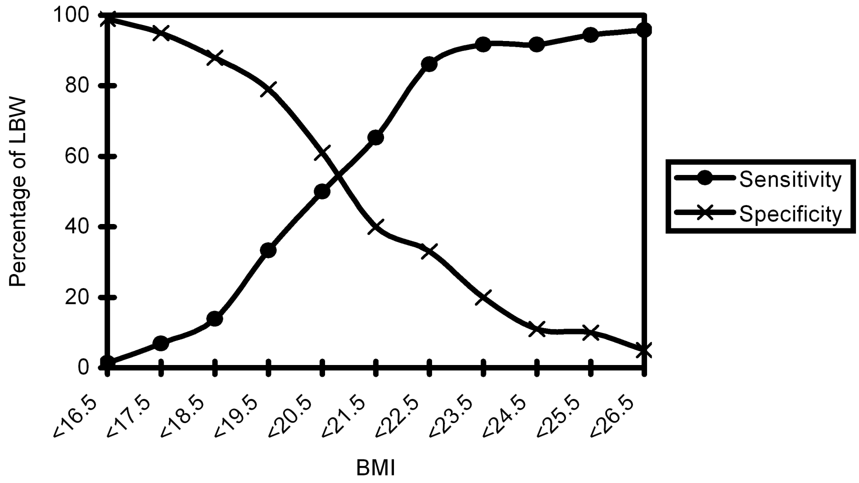


Figure: 17. Sensitivity and Specificity for low birth weight by Maternal MAC

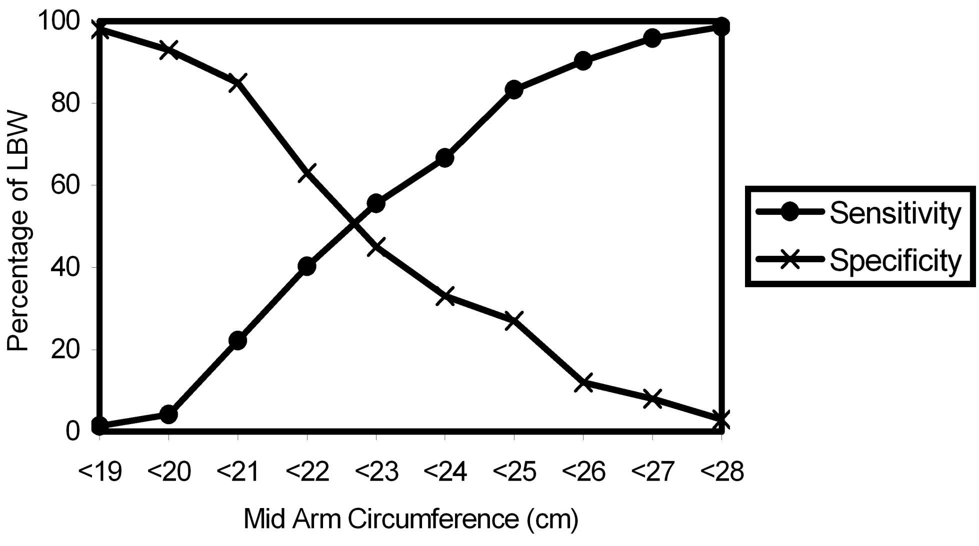
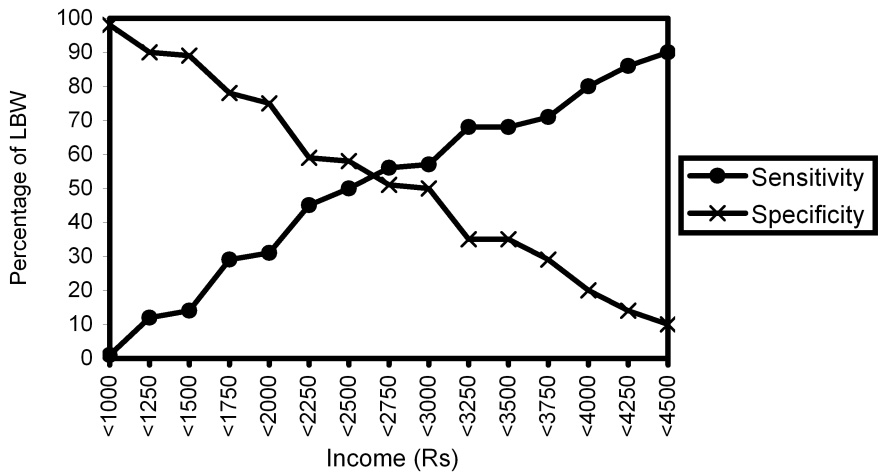


Figure: 18. Sensitivity and Specificity for low birth weight by family income



Figures 19, 20, 21, 22, 23 show the risk ratio (RR) for low birth weight by family income, maternal post delivery weight, height, BMI and mid arm circumference (MAC). Risk decreases with increasing family income, maternal post delivery weight, height, BMI and mid arm circumference (MAC).

Figure: 19. Risk ratio (RR) for low birth weight by family income

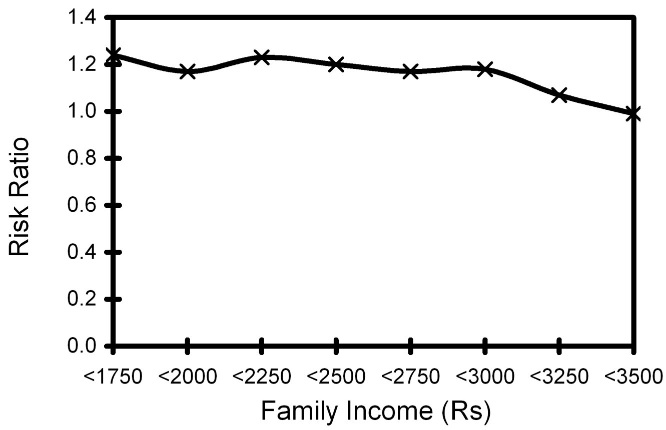


Figure: 20. Risk ratio (RR) for low birth weight by maternal weight

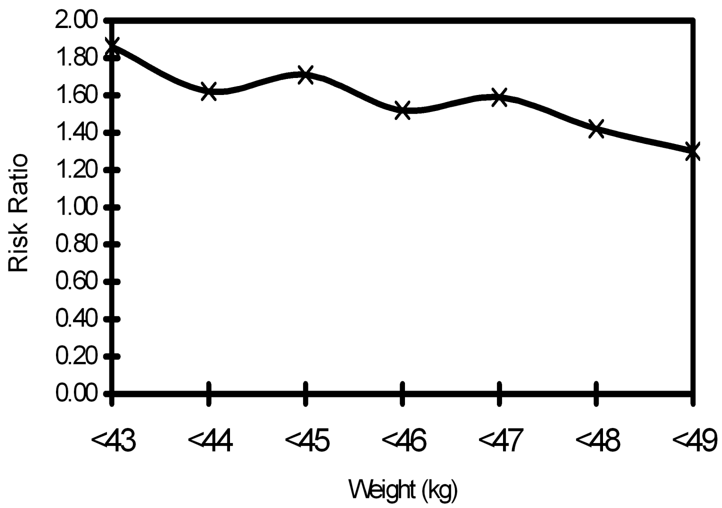


Figure: 21. Risk ratio (RR) for low birth weight by maternal height

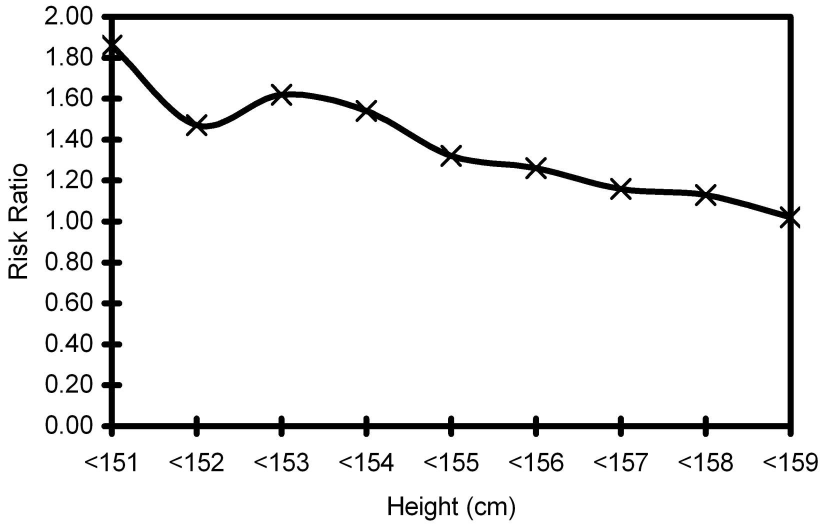


Figure: 22. Risk ratio (RR) for low birth weight by maternal BMI

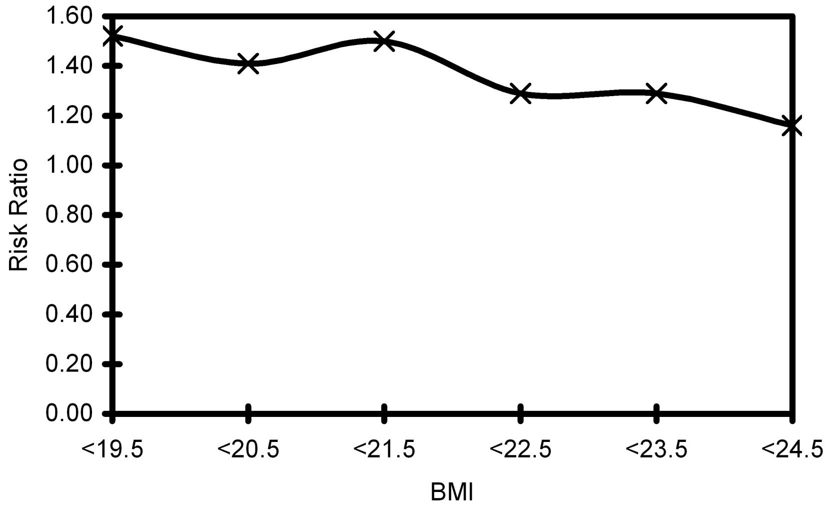


Figure: 23. Risk ratio (RR) for low birth weight by maternal MAC

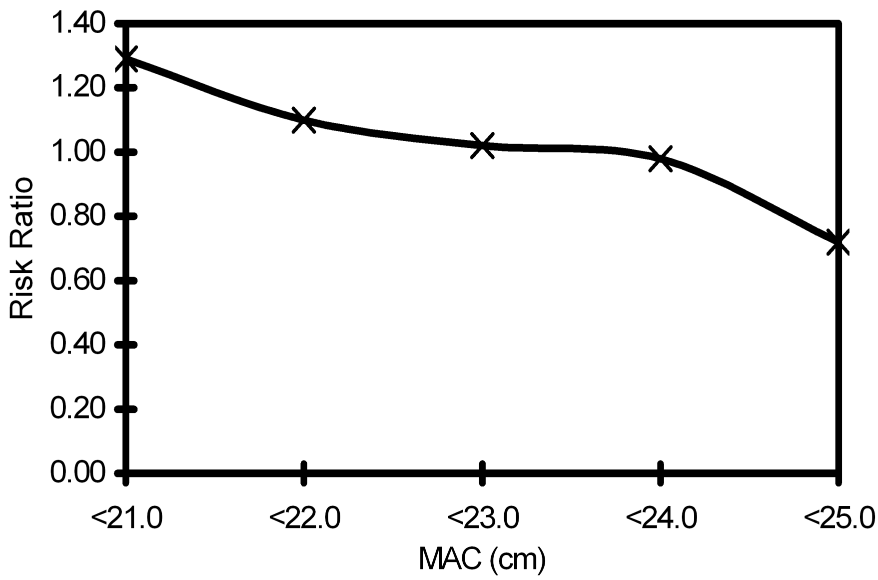


Table: 12. Sensitivity, Specificity, Positive predictive value, Negative predictive value for low birth weight by maternal anthropometry

Anthropometry	Sensitivity	Specificity	PPV	NPV	Risk Ratio	95 % CI
Maternal weight (kg):						
43.0	44.4	79.8	60.4	67.5	1.86	1.33-2.60
46.5	62.5	59.6	51.7	69.7	1.70	1.17-2.48
Maternal Height (cm):						
149.0	55.6	55.8	46.5	55.8	1.31	0.77-2.85
151.0	77.7	43.3	48.7	73.8	1.86	1.17-2.94
Body Mass Index (kg/m^2):						
21.0	59.7	50.9	45.7	64.6	1.29	0.90-1.87
22.5	86.1	32.7	46.9	77.3	2.07	1.16-3.67
Mid Arm Circumference (cm):						
21.0	22.2	84.6	50.0	61.1	1.26	0.86-1.92
22.5	47.2	54.8	41.9	60.0	1.05	0.74-1.50
Family Income (Rs):						
1750	50.0	58.7	45.6	62.9	1.24	0.74-2.74
2750	55.6	51.6	44.0	62.4	1.17	0.82-1.67

The prediction of low birth weight using cut-off point for maternal anthropometry is difficult due to small sample size. However, the present data shows maternal body mass index of 22.5 cm had highest sensitivity (86.1 %) followed by height of 151 cm (77.7 %), maternal weight of 46.5 kg (50 %) and Mid arm circumference of 22.5 (47.2 %) and family income of 2750 (55.6 %). The risk ratios of these variables are 2.07, 1.86, 1.70, 1.05 and 1.17 respectively. From the risk ratio calculation, mother's BMI with a cut-off of 22.5 (RR 2.07), weight <43 kg and height <151 cm have shown an equal value (RR: 1.86); MAC with cut-off of 21.0 cm (RR 1.26) and family income <1750 rupees (RR 1.24) are less useful to detect low birth weight. Maternal weight<46.5 kg, height <149.0cm, body mass index <21.0, mid arm circumference of <22.5 cm and family income less than Rs. 2750 were predicted by plotting ROC curve using the value of sensitivity versus 1-specificity. However, mother's BMI had high sensitivity, more negative predictive power and higher risk ratio to detect low birth weight. So, BMI is the most efficient screening tool for high-risk mothers during early second trimester of pregnancy. Similarly Moller et al (69) recommend that the weight within 48 hours of delivery can be taken as a proxy measure for weight at 14 weeks of gestation.

BIRTH WEIGHT AT A GLANCE AMONG BENGALI POPULATION

"The last half-century has witnessed many changes in the reproductive habits of population, the technologies and management of childbirth. But, during the last three decades there were no changes of birth weight and also the rate of low birth weight among Bengalis of Eastern India. In an earlier study Chakraborty et al (56) reported that mean birth weight was 2572 gram. Pakrasi et al (51) documented that the mean birth weight was 2587 g from the same population and the prevalence of low birth weight was more than 46 percent using the weight criterion of 2.5 kg or less. In an earlier study, Mondal (58) reported from North East India in a Bengali population, the mean birth weight of 2677 g and the incidence of low birth weight 32 percent, whereas the incidence of low birth weight (26 %) was comparatively low among tribal population (Khasi) in the same geographical region. The percentage of low birth weight among Khasi people was lower than the national average (30 %) and the present study (41 %)".

KEY MESSAGES FOR REDUCING LOW BIRTH

- **Special care need for women of Low SE status, first pregnancy, older age group and malnourished.**
- **Preventing pregnancy in teenaged mothers should be an important intervention to avert LBW.**

SUMMARY

Most of the relevant literatures in our country are on mixed population. The population-based studies are very scanty, especially in eastern India in the field of maternal anthropometry and birth outcome. The aim of this study was to find out risk factors, singly or in combination that affect the outcome of birth. Health care delivery system can identify vulnerable mothers in need of special attention. Risk strategy facilitates more efficient use of scarce resources to provide better attention to those who need it the most. Maternal nutritional parameters such as weight and body mass index have been found useful for the prediction of birth outcome. The present study was conducted to find an association between maternal anthropometry and birth outcome. One hundred and seventy six women were included in this study. Mother's weight<46.5 kg, height <149.0 cm, BMI<21.0, mid arm circumference<22.5 cm and family income<2750 rupees were identified as cut–off points for low birth weight. The following important observations were made:

1. Of the 176 mothers, 40.9 percent had weight less than 45 kg, 19.3 percent had height less than 145 cm and 13.1 percent had BMI<18.5 kg/m^2.
2. Forty three percent women among those in the low-income group had weight below 45 kg compared to 28.9 percent in the high-income group.
3. Twenty two percent women in the low-income group had height below 145cm.The percentage decreased to 8 in high income group. 18 percent women in low income group were malnourished (BMI<18.5). The percentage decreased to 12 and 11 in middle and high income groups respectively.
4. The percentage of low birth weight in low-income group was 47.3 percent. This percentage decreased to 40.4 in middle and 34.2 in high-income group.
5. Similarly, the low (10.5 %) incidence of intrauterine growth retardation has been observed among high income group. It is twice as high among low income group.
6. The preterm birth was three times higher among low and middle income groups compared to high income group.
7. Short statured mothers had 1.8 times more risk of delivery of low birth weight babies.
8. Babies born to mothers <45 kg weight had significant risk of being LBW (P=0.01).
9. Adolescent (<20 years) mothers had a significantly higher risk of low birth weight (RR: 1.50, CI: 1.05-2.13) compared to mothers aged 20-29 years; older **(≥30 years) mothers had 1.79 times higher risk for low birth weight. The**

results of the present study show that both age groups of mothers delivered babies with lower birth weight than 20-24 and 25-29 years age groups.

10. Birth weight significantly increases with increasing parity (p=0.019). The highest mean difference of birth weight (283 g) has been observed between first and third parity.
11. Cooking fuel type and blood group phenotype 'O' had 1.46 (CI: 1.02-2.10) times risk for low birth weight.
12. Mean birth weight of female babies was significantly lower (by 145 g) and had 1.4 (RR: 1.40 CI: 0.99-2.00) times the risk for low birth weight (<2.5 kg).
13. Maternal weight (p=0.009) and body mass index (p=0.005) were significantly associated with birth weight. Both these nutritional parameters were also significantly (p<0.05) associated with the incidence of low birth weight (quartile differences).
14. The birth weight difference between low and high-income group was 159 g and 13.5 per cent difference in low birth weight rate.
15. Birth weight differences between daily wages / labour and service group was 159 g and had 19.4 percent difference in low birth weight rate.
16. The maternal weight in the first and fourth quartile was associated with a difference in birth weight of 258 g followed by BMI of 253 g., height of 135 g, MAC of 120 g. and triceps skinfold thickness of 20 g.
17. Nearly 38 percent malnourished women in low income group delivered IUGR babies.
18. A unit increase of maternal weight and mid arm circumference was associated with a birth weight increase of 14 gram while a unit increase of body mass index was associated with 30 g increase in birth weight.
19. The difference in mean birth weight was 174 g between underweight (<45 kg) and normal (≥45 kg) mothers (P=0.01).
20. Similarly, 121g birth weight variation was observed between short (145 cm) and normal statured (≥145 cm) mothers (P=0.095).

CONCLUSION

The following conclusions can be made from the study:

1. Women with low socio economic status and malnutrition are at risk of having babies with intrauterine growth retardation.
2. Women with low socio economic status and short stature are also at risk of preterm birth.
3. Women of low socio-economic status were more prone to have low weight

and height at their childbearing age. They did not consume adequate food during pregnancy probably due to their inadequate economic status. So, special nutritional support is needed for those women whose economic condition is poor. Adequate nutrition is needed not only for women of childbearing age but also for all through the life cycle-infancy, childhood, adolescence and adulthood— especially for girls and women.

4. TBAs and field workers can use weight and body mass index as useful indicators for identification of high-risk pregnancy.
5. Mid arm circumference is a proxy measurement for weight. TBAs and field workers can use cut-off point for MAC instead of mother's weight in the community. They should refer all high-risk women to treatment centers for better management.

The prepregnancy weight was not available due to the short duration of study. In our country, the pregnant women come to health institution for seeking antenatal care between 12^{th} to 16^{th} weeks of gestation. The weight within 48 hours of delivery can be taken as proxy for weight at 14 weeks of gestation, as significant weight gain occurs in second and third trimester only. So, antenatal care giver of health institution and community health worker can easily use cut off values for monitoring pregnant women and they might be given advice for better birth outcome based on efficient cut-off point. However, study in a larger population would be more confirmative to identify more precise the cut-off points for body mass index and weight as indices for referral category.

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APPENDIX

ABBREVIATION

AFD	–	Appropriate for Date
BMI	–	Body Mass Index
CDC	–	Center for Disease Control
CI	–	Confidence Interval
CPD	–	Cephalo-Pelvic Disproportion
ELBW	–	Extremely Low Birth Weight
IMR	–	Infant Mortality Rate
IOM	–	Institute of Medicine
IUGR	–	Intrauterine Growth Retardation
LBW	–	Low Birth Weight
LFD	–	Large for Date
LSCS	–	Lower Segment Cesarean Section.
MAC	–	Mid Arm Circumference
MCH	–	Maternal and Child Health
NMR	–	Neonatal Mortality Rate
NND	–	Neonatal Death
NPV	–	Negative Predictive Value
OR	–	Odds Ratio
PNMR	–	Perinatal Mortality Rate
PPV	–	Positive Predictive Value
RR	–	Relative Risk
SB	–	Still Birth
SES	–	Socio Economic Status
SFD	–	Small for Date
TBAs	–	Traditional Birth Attendants
VLBW	–	Very Low Birth Weight
WHO	–	World Health Organization
ACC/SCN	–	United Nations Administrative Committee on Co-ordination / Sub-Committee on Nutrition

SOME WORKING DEFINITIONS

Anthropometry : The science dealing with measurement of the size, weight and proportion of the human body

Abortion : Abortion is termination of pregnancy before the fetus becomes viable, i.e., at 28 weeks (when it weighs approximately 1 kg.)

Percentile : A number that corresponds to one of 100 equal divisions in a range of values; a measure of relative location. For example, the 10th percentile means that 10 % of values in the data set are less than or equal to it and (100-10) 90 % are greater than or equal to it

Appropriate for Date (AFD) babies : Babies with a birth weight between 10th – 90th percentile for the period of their gestation

Large for Date (LFD) babies : babies with a birth weight of more than 90th percentile for the period of their gestational age

IUGR (SFD) : The weights at birth of a baby less than 10th percentile for their gestational age are designated as SFD babies

Body mass index : An index that uses the variables weight and height to measure body fat stores (weight in kg divided by the square of height in meters)

Child: Male and female below 15 years of age

Gestational age : Gestational age is calculated from the first of the last normal menstrual period till the date of birth and is expressed in completed weeks

Neonate : A baby of 0 to 4 weeks of age

Infant : A child below the age of one year

Low birth weight (LBW) : Baby's weight at birth less than 2.5 kg is considered as low birth weight.

Term : Babies with a gestational age between 37 and 41 weeks are called term babies (259-293 days)

Pre-term : Preterm is defined as a baby with a gestation of less than 37 completed weeks (less than 259days)

Post-term : Babies with a gestational age of 42 weeks or more are classified as post term babies (294 days or more)

Perinatal period : It extends from the 28th week of gestation (or more than 1 kg) to the 7th day of life (early neonate)

Stillborn : It is synonymous with late fetal death, i.e., twenty-eight completed weeks of gestation

Sensitivity (Sens) : Proportion of all diseased who have positive test (?)

Specificity (Spec) : Proportion of all nondiseased who have a negative test (?)

Positive predictive value (PPV) : Proportion of all those with positive tests who truly have disease

Negative predictive value (NPV) : Proportion of all those with negative tests who truly do not have disease

Rate ratio (RR) : Ratio of incidence of disease among people with risk factor to incidence of disease among people without risk factor

Odds ratio (OR) : Ratio of odds of having risk factor in people with disease to odds of having risk factor in people without disease