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WEIGHT - A LONGITUDINAL STUDY

# CORRELATES OF ANTENATAL BODY MASS INDEX (BMI) AS A DETERMINANT OF BIRTH WEIGHT – A LONGITUDINAL STUDY

## Correlação entre Índice de massa Corporal (IMC) pré-natal e peso ao nascer – um estudo longitudinal

### ABSTRACT

*Objectives:* To study the correlation between Body Mass Index (BMI) in antenatal period and birth weight of child, along with the socio-demographic determinants of birth weight. *Methods*: A longitudinal study of one-year duration, from June 2010 to May 2011, was conducted in an urban slum of Mumbai, India. Universal sampling method was employed, including as subjects all pregnant women with minimum two Antenatal Care (ANC) visits - and at least one in the third trimester - registered at an urban health centre from June to August 2010. Subjects with any pre-existing co-morbid illness or with past history of giving birth to twins or to any congenitally malformed child, or else, with outcome of still births or home delivery, were excluded. These women were followed up for the next months until delivery. Maternal weight was recorded at each visit and BMI was calculated, or the average BMI, in case of more than one visit in any trimester. Birth weight was recorded using hospital or maternity home records. *Results*: Prevalence of low birth weight was 26.7%. Correlation between maternal BMI of third trimester and neonatal birth weight was moderately positive. 60.8% of variability in birth weight can be predicted by maternal BMI in third trimester. *Conclusions*: Third trimester BMI can be used as a predictor of neonatal birth weight. Information, Education and Counseling (IEC) activities regarding utilization of Antenatal Care (ANC) services can help reducing the incidence of Low Birth Weight (LBW).

*Descriptors*: Low Birth Weight; Body Mass Index; Anemia; Infant, Premature; Pregnancy.

### RESUMO

**Objetivos:** Estudar a correlação entre Índice de Massa Corporal (IMC) no período pré-natal e o peso de nascimento da criança, bem como, os determinantes sócio-demográficos de peso ao nascer. **Métodos:** Um estudo longitudinal de um ano de duração, de junho 2010 a maio de 2011, foi realizado em uma favela urbana de Mumbai, Índia. O método de amostragem universal foi aplicado, incluindo como sujeitos todas as mulheres grávidas que realizaram pré-natal com, no mínimo, duas visitas, incluindo pelo menos uma no terceiro trimestre, registradas no centro urbano de saúde, de junho a agosto de 2010. Mulheres com qualquer estado mórbido pré-existente ou com histórico de gestações com nascimento de gêmeos ou de criança com qualquer má-formação congênita, ou inda, com ocorrência de natimorto ou parto em casa, foram excluídas do estudo. Estas mulheres foram acompanhadas durante os próximos meses até o parto. O peso materno foi medido em cada visita e calculado o IMC, ou o IMC médio, no caso de mais de uma visita em qualquer trimestre. O peso ao nascer foi registrado a partir de dados do hospital ou maternidade. **Resultados:** A prevalência de Baixo Peso ao Nascer (BPN) foi de 26,7%. Correlação entre o IMC materno do terceiro trimestre e o peso ao nascer foi moderadamente positiva. 60,8% da variabilidade no peso ao nascer podem ser preditos pelo IMC materno no terceiro trimestre. **Conclusão:** O IMC materno no terceiro trimestre pode ser usado como um preditor de peso ao nascimento neonatal. Informação, Educação e Aconselhamento (IEC) sobre a utilização do pré-natal podem ajudar na redução da incidência de Baixo Peso ao Nascer (BPN).

**Descritores:** Baixo Peso ao Nascer; Índice de Massa Corporal; Anemia; Prematuro; Gravidez.

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## INTRODUCTION

*"How much did he/she weigh?"* is often the first question proud parents are asked after they have announced the sex of their newly delivered progeny. Having a low birth weight (LBW) baby can cause emotional, social and financial stress for the family. In one mother's words: *"It is difficult to portray in writing the stress and fear felt as a parent when your child comes into this world not as expected"*.

Birth weight is a reliable index of intra-uterine growth retardation (IUGR) and it is a good indicator, not only of mother's health and nutritional status, but also of the newborns' chances for survival, growth, long term health and psychosocial development[1,2]. Low birth weight has a significant impact on the financial status of the family[3].

Low Birth Weight (LBW) is any newborn with a birth weight less than 2.5 kg (including and up to 2,499 g), regardless of its gestational age, and it includes two kinds of infants – preterm babies and small for gestational age or small for date babies[4]. *Preterm babies* are those born before the end of 37 weeks of gestation (less than 259 days). Nineteen million newborns weigh less than 2,500 grams in the developing world, more than half in South Asia. India alone has more than 7 million low birth weight babies[5].

In countries where the population of low birth weight infants is less, short gestational period is the major cause. In countries where this proportion is high (e.g., India), the majority of cases can be attributed to fetal growth retardation[5].

Although *Small for Gestation Age* (SGA*)* has no generally accepted standard definition, the following ones are commonly used: birth weight less than 10th percentile for gestational age; birth weight less than 2,500g and gestational age greater than or equal to 37 weeks and birth weight less than two standard deviations below the mean value for gestational age[6].

Birth weight, like growth, is determined by complex interplay of genetic and environmental factors. The proportional contribution of these influences is unclear. However, birth weight varies within genetically similar populations, suggesting that environmental factors play a significant role[7,8]. Studies in India and worldwide have shown that the etiology of low birth weight is multi-factorial[9,10]. Studies have been done across the world to assess the association between maternal Body Mass Index (BMI) and obstetric and neonatal outcomes[11,12,13]. Other factors that contribute to LBW are chronic health problems and infections in mothers, alcohol, smoking and babies with birth defects[14].

Many studies have been carried out using BMI as a predictor of complications like neonatal macrosomia, but there are only a few studies which can determine the correlation between BMI and neonatal weight. This study has been carried out to determine the correlation between Antenatal BMI and neonatal birth weight. This may lead to identification of an appropriate tool for assessment of predicted birth weight and may support health care providers to plan interventions during the antenatal, intra-natal and postnatal periods, thereby preventing undue maternal and child health morbidities.

## METHODS

A longitudinal study of one year, from June 2010 to May 2011, was conducted in an urban slum of Mumbai, India.

The Universal sampling method was employed and every antenatal women registered at the urban health centre from June 2010 to Aug 2010 were included as the study subjects. Inclusion criteria were: subjects with the minimum of two antenatal care (ANC) visits including at least one visit in the third trimester. Exclusion criteria were: subjects with any pre-existing co-morbid illness, such as diabetes mellitus, hypertension, HIV, bronchial asthma, heart disease, cancer etc., with past history of any congenital malformed child, twins or with outcome in the form of still births or home delivery.

On pilot basis, 10 women were interviewed to test validity and response. The questionnaire was then suitably modified and used as the tool for data collection.

With the help of the medical social worker, rapport was established with study subjects at the time of their registration and, after obtaining their informed consent, information on age, religion, education and occupation of women, and information on family income per month, menstrual and obstetrical history was recorded. Information pertaining to personal habits, such as tobacco use and smoking among women and their husband, was also noted down.

These registered women were then followed up for nine months (Sep 2010 to May 2011), at each of their antenatal visit till delivery, for monitoring the maternal weight gain and finally, the birth weight of the newborn, which was recorded with the help of discharge cards or the hospital register of the maternity hospital / private hospitals.

Maternal weight was recorded at each visit and BMI was calculated. Average BMI was calculated in case of more than one visit in any trimester. Thus, BMI was calculated for each trimester. The expected date of delivery was calculated based on the history of last menstrual period of each woman or with the help of abdomen ultrasound report, whichever was available.

Among 204 registered pregnant women, 21 were excluded from the analysis, as 5 had home delivery, 3 pregnancies terminated into still birth, 3 had spontaneous abortion and the outcome of 10 pregnancies could not be recorded, as they could not be contacted (lost to follow up). Thus, for final analysis, sample size was 183.

Kuppuswamy's method of socioeconomic status was used to determine social class to which women belonged[15].

Height of women was measured with women wearing no footwear. They were made to stand against a wall with heels and head touching the wall. The point was marked after holding a hard card on woman's head. Height was measured from the floor till the mark with the help of standard measuring tape. Weight was measured with the help of a portable standard size circular weighing machine without any footwear. Weight was measured at each of their visit, preferably at three points: 12 ± 2 weeks, 24 ± 2 weeks, 36 ± 2 weeks of gestation. To minimize observer's bias, measurement was done twice - one by the investigator and other by a trained person - and the average of the two was taken.

Blood pressure was checked with mercury column sphygmomanometer with women sitting comfortably. Hemoglobin estimation was done by Sahli's method at the time of ANC registration and WHO classification was used to classify anaemia in pregnancy[16].

Body mass index was classified using the International Classification of adult weight[17]. Bad obstetric history was operationally defined as previous unfavorable fetal outcome in terms of two or more consecutive spontaneous abortions, early neonatal deaths, stillbirths, intrauterine fetal deaths, intrauterine growth retardation and congenital anomalies.

Prior approval was taken from the Institutional Ethics Committee – Committee for Academic Research Ethics, Number 998/10, before conducting the study. Informed consent was obtained from all the study participants. Special care was taken to maintain privacy and confidentiality.

Statistical analysis was done with SPSS software 17 version. Chi square test was used to estimate the association between socio-demographic parameters and neonatal birth weight. Linear Regression analysis was used to assess the prediction of neonatal birth weight (dependent variable) by the maternal BMI (independent variable).

## RESULTS

Table I shows that 112 subjects were in the age group of 18 – 25 years. Mean age was 23.8 years old. Prevalence of low birth weight was 26.7%. No significant association was observed among birth weight and religion, occupation, socio-economic class and type of family. Only 9(16.7%) subjects with secondary and higher education level had low birth weight while 11(45.7%) illiterate subjects had low birth weight babies. Thus, as the level of education improved, the neonatal birth weight also improved. Fourteen (46.7%) subjects with addiction (either tobacco or alcohol) had low birth weight babies while, among those without addiction, 118(77.1%) had newborn with normal weight. No association was found between birth order and neonatal birth weight. Significant association was observed between maternal BMI and birth weight. Among underweight and normal weight subjects, 27(35.5%) and 20(22%) subjects had low birth weight babies, respectively. Among 73 subjects having anaemia, 26(35.6%) had newborns with low birth weight. Percentage of low birth weight was found to be significantly associated with previous bad obstetric history. Weight gain during pregnancy was also significantly associated with neonatal birth weight. Twenty six (41.9%) of the women with less than 6 kg weight gain during pregnancy had low birth weight babies, while women with more than 10 kg weight gain had only 6(17.1%) low birth weight babies. No statistical association was found between neonatal birth weight and time of ANC registration, number of ANC visits and inter-pregnancy interval.

Table II shows that 49(67.1%) underweight subjects were anaemic. Significant association was observed between being underweight and having anaemia. Prevalence of neonatal/ obstetric complications was higher (44.2%) among underweight subjects as compared to 34.9% among normal weighing subjects and 21% among overweight subjects. No association was found between maternal BMI and caesarean delivery.

Table III shows that the correlation between BMI of the third trimester and the neonatal birth weight was moderately positive. 60.8% of the variability in neonatal birth weight may be accounted for (or predicted) by maternal BMI in the third trimester.

On applying linear regression:

$Y = a + bx$

where y = birth weight

a = intercept

b = slope

x = BMI

Birth weight = 2.373+ 0.011 X BMI.

(95.0% Confidence Interval for a=1.866 to 2.880)

Table I - Socio-demographic parameters and birth weight. Mumbai - India, 2010.

| Socio-demographic parameters | | Birth weight | | p value |
|---|---|---|---|---|
| | | Normal | Low | |
| Age group (years) | 15 – 18 | 17(65.4%) | 9(34.6%) | >0.05 |
| | 18 – 25 | 89(79.5%) | 23(20.5%) | |
| | 25 – 35 | 28(62.2%) | 17(37.8%) | |
| Religion | Hindu | 53(74.6%) | 18(25.4%) | >0.05 |
| | Muslim | 81(72.3%) | 31(27.7%) | |
| Education | Illiterate | 13(54.2%) | 11(45.7%) | *<0.05* |
| | Primary | 76(72.4%) | 29(27.6%) | |
| | Secondary & above | 45(83.3%) | 9(16.7%) | |
| Occupation | Unemployed / housewife | 101(74.3%) | 35(26.7%) | >0.05 |
| | Employed | 33(70.2%) | 14(29.8%) | |
| Socio-economic class | Lower | 26(61.9%) | 16(38.1%) | >0.05 |
| | Middle | 92(71.7%) | 28(28.3%) | |
| | Upper | 16(76.2%) | 5(23.8%) | |
| Type of family | Nuclear | 72(72.7%) | 27(27.3%) | >0.05 |
| | Joint | 62(73.8%) | 22(26.2%) | |
| Addiction in subject | Yes | 16(53.3%) | 14(46.7%) | *<0.05* |
| | No | 118(77.1%) | 35(22.9%) | |
| Addiction in husband | Yes | 95(72%) | 37(28%) | >0.05 |
| | No | 39(76.5%) | 12(23.5%) | |
| Birth order | 1st & 4th | 73(74.5%) | 25(25.5%) | >0.05 |
| | 2nd & 3rd | 61(71.8%) | 24(28.2%) | |
| Maternal Body mass index | Underweight | 49(64.5%) | 27(35.5%) | *<0.05* |
| | Normal | 71(78%) | 20(22%) | |
| | Overweight | 14(87.5%) | 2(12.5%) | |
| Anaemia | Yes | 47(64.4%) | 26(35.6%) | *<0.05* |
| | No | 87(79.1%) | 23(20.9%) | |
| Bad obstetric history | Yes | 32(59.3%) | 22(40.7%) | *<0.05* |
| | No | 102(79.1%) | 27(20.9%) | |
| Weight gain during pregnancy | <6kg | 36(58.1%) | 26(41.9%) | *<0.05* |
| | 6 – 10kg | 69(80.2%) | 17(19.8%) | |
| | >10kg | 29(82.9%) | 6(17.1%) | |
| Trimester of registration | First | 31(70.5%) | 13(29.5%) | >0.05 |
| | Second | 103(74.1%) | 36(25.9%) | |
| Number of ANC visits | <3 | 37(71.2%) | 15(28.8%) | >0.05 |
| | >3 | 97(74%) | 34(26%) | |
| Interpregnancy interval (n = 125) | <3 years | 29(61.7%) | 18(38.3%) | >0.05 |
| | >3 years | 58(74.4%) | 20(25.6%) | |

ANC - Antenatal Care.

Table II - Distribution of obstetric and neonatal complications according to Body Mass Index (BMI). Mumbai, India, 2010.

| Complications | BMI classification | | | Total | p value |
|---|---|---|---|---|---|
| | Underweight | Normal | Overweight | | |
| **Caesarean section** | 12(36.3%) | 15(45.5%) | 6(18.2%) | 33(100%) | >0.05 |
| **Any obstetric/neonatal complications** | 19(44.2%) | 15(34.9%) | 9(21%) | 43(100%) | <0.05 |
| **Anaemia** | 49(67.1%) | 22(30.1%) | 2(2.8%) | 73(100%) | <0.01 |

Table III - Correlation between Body Mass Index (BMI) and birth weight. Mumbai, India, 2010.

| Body mass index | Pearson`s Co-efficient (r) | Co-efficient of determination ($r^2$) |
|---|---|---|
| 1st trimester (n = 44) | 0.46 | 0.2116 |
| 2nd trimester (n = 183) | 0.54 | 0.2916 |
| 3rd trimester (n = 183) | 0.78 | **0.6084** |

## DISCUSSION

The majority of the subjects in our study, 112 women (61.2%), were in the age group of 18 – 25 years. Mean age was found to be 23.8. Proportion of low birth weight was found to be 26.7% in the present study. There is significant variation in low birth weight incidence across the main geographic regions, ranging from 6% to 18%. The highest incidence of low birth weight occurs in the sub-region of South-Central Asia, where 27% of infants are low birth weight[18]. In a longitudinal study done in urban slums of Mumbai involving 290 pregnant women, the incidence of low birth weight was found to be 32.5%. Range of LBW was 2.23 kg ± 0.22 kg and that of NBW 2.83 kg ± 0.3 kg[19]. A cross sectional survey done in Kerala reported LBW incidence of 17.9 %[20].

In the current study, as the level of education improved, the neonatal birth weight also improved, while no significant association was observed among birth weight and religion, occupation, socio-economic class and type of family. Significant association was observed between neonatal birth weight and maternal BMI, weight gain during pregnancy, maternal anaemia and previous bad obstetric history, but no statistical association was found between neonatal birth weight and birth order, time of ANC registration, number of ANC visits and inter-pregnancy interval. In a study done in Dehradun, it was observed that, among the various epidemiological factors, the maternal factors like antenatal care, parity, inter-pregnancy interval and bad obstetric history are found to influence birth weight[21].

Prevalence of neonatal/ obstetric complications in the present study was higher (44.2%) among underweight subjects, as compared to 34.9% among normal weighing subjects and 21% among overweight subjects and no association was found between maternal BMI and normal delivery or caesarean delivery, while in a study done in the United Kingdom, it was observed that the caesarean section rate rose from 18.2% in women of normal BMI to 40.6% in the morbidly obese women (RR 2.2 - CI 1.7-2.8)[22]. It could probably be because there were fewer number of subjects in our study who belonged to overweight category, mainly because of lower socio-economic status.

In a study to assess the correlation of BMI to pregnancy outcomes in Thai women, it was observed that underweight BMI resulted in significant risk of preterm, very preterm, low birth weight (LBW) infant with [OR (95% CI)] 1.79 (1.48-2.16), 1.69 (1.15-2.47), 1.61 (1.27-2.03)[23]. Another study, done in the north of China, concluded that the increased maternal BMI is associated with many adverse pregnancy outcomes and its risk increases with the degree of obesity. Maternal underweight has a protective effect, although it increases the risk of having small-for-gestational age baby and anemia[24]. In similar studies done in Ghana, California, Australia and Korea, it was concluded that Overweight and Obesity are associated with significantly increased incidence of adverse maternal and neonatal outcomes[25-28].

It was observed that 26(41.9%) of the women participant of this study, whose weight gain during pregnancy was less than 6 kg, had low birth weight babies, while women with

more than 10 kg weight gain had only 6(17.1%) low birth weight babies. Similar findings were observed in a study done in Vietnam, which concluded that having a low BMI puts women at risk of delivering an infant too small for gestational age, especially when total maternal gestational weight gain is under 10 kg[29].

In the present study, BMI of third trimester and neonatal birth weight were found to have moderately positive correlation. Also, it was observed that 60.8% of the variability in neonatal birth weight can be accounted for (or predicted) by maternal BMI in the third trimester. Similar findings were obtained in a study done in Norway, which concluded that linear regression analyses, adjusted for potential confounders, showed that offspring birth weight increased with increasing maternal pre-pregnant BMI[30]. A study done in New York also concluded that increasing pre-pregnancy BMI reduced the risk of SGA and increased birth weight[31]. Even in studies done in India, maternal BMI was found to be significantly associated with LBW[32,33]. In contrast to the above findings, another study, based on analysis by areas under the receiver-operating characteristic (AUC) curves concluded that maternal body mass index is a poor diagnostic test for detection of abnormal fetal growths[34].

Low birth weight thus continues to be a significant public health problem and, as multiple factors are associated with it, it requires a more holistic and multipronged approach for its reduction. Concept of High risk approach needs to be implemented, which means better health care services to all antenatal subjects, with special attention to those who are found to be at high risk.

## CONCLUSION

Early registration of pregnancy should be promoted to detect the presence of any high risk factors from the very beginning. Importance of regular ANC visits should be explained to each of the high risk women, so that any untoward consequences can be averted.

Serial monitoring of weight gain must be done in each ANC visit, so that subjects identified as underweight can be given attention throughout antenatal period and delivery. The involvement of the community level workers should be encouraged in the management and follow up of high risk cases at regular intervals.

Newer initiatives, in the form of Husband Craft Clinics, should be taken, so that husbands can also be involved throughout the pregnancy. This will also give an opportunity to the health care providers for promoting the adoption of family planning service and the maintenance of a spacing interval between two pregnancies.

Consumption of tobacco in any form should be discouraged among mothers, as well as their husbands. Provision of ANC identity card should be started, so that weight gain can be monitored. This will also help in the proper and specialized care to the low birth weight babies.

Involvement of the private practitioners should be encouraged in the provision of maternal and newborn care services. Education of subject has a significant impact on neonatal birth weight and thus, education of girl should be emphasized. Awareness about the importance of female education among community members, including religious leaders, male members of the family and other influential people, should be promoted.

Strengthening Information, Education and Counseling (IEC) activities at the health centre and in the community would help to a great extent. Such education must address hazardous effect of tobacco use, harms of early marriage and teenage pregnancy and need for special diet during pregnancy, with the help of Community Health Volunteers.

## ACKNOWLEDGEMENTS

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