Summary
and
Conclusion

Significance/Justification of the study
Nutrition is a critical determinant of human health and good health becomes all the more elusive in the presence of malnutrition. Childhood malnutrition is nothing new to India and it ranks 49th in the world with respect to nutritional status of children under five (UNICEF 2001), despite the ICDS having started as far back as 1975 to specifically address the health, nutritional and educational needs of children from the ante-natal period to six years after birth.

However, there still remains a resistant core of child mortality where undernutrition is an underlying cause (Ebrahim 1998). Several deficiency syndromes in women and children are still prevalent and are of public health significance contributing to 3.4% of the global burden of total diseases and affecting the quality of life (Bhaskaram 2001). Chronic Energy Deficiency in a nearly similar proportion (38%) of adults suggest perpetuation of childhood malnutrition into adults.

Epidemiologically, birth weight of a child is an important determinant of childhood survival and quality of adult life. Low birth weight for gestation is an important cause of increased perinatal morbidity and mortality too especially in developing countries [Mhaskar, et.al.,2001]. Children born with low birth weight are at increased risk of being malnourished at one year of age. By the age of four or five years, such a child suffering a cycle of infection and malnutrition will be seriously stunted and will carry its growth
deficiency and often its impaired learning ability, into adult life. Clinical and experimental evidence indicates that there may be a causal link between fetal and infant growth and diabetes mellitus, cardiovascular diseases and possibly obesity in later life [Hoet, JJ 1997]. Thus, the identification of factors that underlie the incidence of low birth weight deliveries and the institution of appropriate measures to combat them is the need of the hour to improve the quality of life of the survivors.

Low Birth Weight is influenced by three major mechanisms-duration of gestation, Intra Uterine Growth Restriction [IUGR], Combination of both. It is understood from the above statements, that low birth weights are largely attributable to poor maternal health during pregnancy secondary to maternal under nutrition and infection. Therefore, the problem of low birth weights cannot be solved through “bypassing” the mother and focusing efforts only on the infant.

The specific maternal factors that may be expected to contribute to low birth weight has been identified as Non Nutritional Factors-age at conception; Gravidal status (number of pregnancies) Socio Demographic Factors-socio-economic status; educational achievement. Nutritional Factors-stature; pre gravid weight; body mass index; gestational weight gain; hemoglobin and dietary intake.
This array of complicated factors and its established effect on birth weight gave rise to the increasingly felt need to explore the feasibility of evolving an appropriate predictive model for neonatal birth weight, using as many of these factors to help the health care team in identification of low birth weight fetuses while in utero and prevention/restriction of incidence of low birth weight.

Therefore, the conduct of the study in the self-selective hospital based population was to understand

(i) the frequency of LBW in the given population
(ii) the risk factors for LBW
(iii) the role of prenatal care in its prevention as well as
(iv) to use information regarding physiological determinants of birth weight to predict individual intrinsic birth weight potential

Objectives of the Study

To identify each individual mother’s prenatal nutritional status through a comprehensive nutrition assessment process
To develop and implement a practical Nutrition Education plan and to test whether nutrition related messages incorporated into the antenatal check up visits can be transmitted to the group of women

To identify, evaluate and correlate maternal factors that make predominant contribution to fetal development and to the incidence of low birth weight

To use this information as a necessary base to develop a predictive model for the expected birth weight using maternal nutrition-related variables.

**Scope of the Study**

Studies exploring the predictive model concept have been carried in the international arena using maternal anthropometric parameters such as Quetelet’s index, waist hip ratio, head circumference and Symphysiofundal height had suggested that these can be successfully used as a predictor of low birth weight while the fetus is in utero [Wandja K et. al. 1995; Brown et al., 1996; Ngare DK, Newmann C 1998; Mhaskar, et.al., 2001]
Several investigators in India have studied the individual effect of maternal anthropometrics, biochemical and food intake on the pregnancy outcome per se [Sebi re et.al., 2001; Yegammai, et.al., 2002]. Though in India studies have been carried out on assessing the efficacy of nutrition education on pregnancy outcome, none had attempted to incorporate this component in the development of predictive model for the expected birth weight.

**Limitations of the Study**

- The data is based on the self-selective population—the pregnant women coming to hospital for delivery and hence may not be directly applicable to the community.

- The study had not attempted to develop the predicted model for those mothers admitted with pregnancy related nutritional complications, which may be, explored in future researches.

**Materials and Methods**

With the view to develop the predictive model, a prospective longitudinal study was designed with subjects drawn from pregnant women registering
in the Department of Obstetrics and Gynaecology at Sri Ramachandra Medical College & Research Institute [Deemed University], during the period starting from June '00 – July '01.

The study was initiated with the aim to cover at least one fourth of the registrants to the outpatient department of obstetrics and gynecology, which registers approximately 150 pregnant women per month. Therefore the initial aim was to cover at least 450 pregnant subjects during the study period in the first three months i.e., from June '00-August '00 and follow up till July '01.

Methods

Objective 1 – “Identification of each individual mother’s prenatal nutritional status through a comprehensive nutrition assessment process

Assessment Procedures

1. Assessment of Pregnant subjects [Annexure I]

Maternal Non Nutritional Factors

Age

Gravidal Status (number of pregnancies)

Maternal Socio Demographic Factors

Educational Achievement

Socio-Economic Status (Kuppusamy modified version of socio-economic status scale)
Maternal Nutritional Factors

Anthropometric Measurement

Maternal Height

Maternal Weight-Prepregnancy Weight & gestational Weight Gain

Body Mass Index

Biochemical Assessment

Serum Hemoglobin*

Nutritional Intake Assessment

Energy and Protein Intake Assessment

Detailed assessment of energy and protein intake was done using 24 hr recall at the time of registration [Annexure I]

2. Fetal Assessment

Ultrasonography* to estimate

Fetal age, Fetal Growth and Fetal Weight

Estimation of Fetal age, Fetal Growth and Estimated Fetal Weight was done using Biparietal Diameter [BPD], Abdominal Circumference [AC], Femur Length [FL] at the 12th week, between 20th and 24th week and 34th week of gestation respectively of the pregnant registrant.
These data were obtained from the medical records of the subjects as entered by the hospital laboratory and the attending physician as a part of the routine antenatal check up.

3. Neonatal Nutritional Assessment

Neonatal
Weight
Length
Head Circumference
Chest Circumference
Ponderal Index

Objective 2 “Development and implementation of practical nutrition education plan and evaluating the efficacy of the nutrition related messages”

Based on the information obtained through 24 hour recall dietary counseling modules were prepared on various topics as listed below:

- introduction to nutrition
- significance of birth weight
- ill effects of low birth weight
- role of nutrition in pregnancy and birth weight
- importance of weight gain during pregnancy
nutritional requirement during pregnancy
introduction to foods and nutrients
meeting the special nutrition needs during pregnancy
balanced diet – important nutrients during pregnancy, food groups providing these nutrients, number of servings per food group to provide an adequate nutrition and to satisfy the RDA for particular nutrients increased during pregnancy

Objective 3 “Identification, evaluation and correlation of maternal factors making a predominant contribution to birth weight”

Correlation of maternal factors with fetal outcome with respect to birth weight was analysed using Chisquare test and ANOVA:

Maternal Height Vs birth weight
Prepregnancy weight vs birth weight
Body Mass Index vs birth weight
Final weight vs birth weight
hemoglobin vs birth weight
total calorie intake vs birth weight
total protein intake vs birth weight
Objective 4 “the development of a predictive equation for expected birth weight using maternal nutritional related variables,”

With respect to the title objective – development of predictive model was done using the maternal parameters such as height, prepregnancy weight, gestational weight gain, body mass index, hemoglobin, total calorie intake and total protein intake.

Analytical Procedures
Scientific Package for Social Sciences, version 8.0 for Windows was used for analysing the data under the three categories as follows:

I. Descriptive Analysis – to describe and summarize the characteristics of the subjects

II. Inferential Statistics – to estimate and infer about the phenomena observed in samples using Chi Square and ANOVA

III. Multiple Regression Analysis – to develop a predictive equation for birth weight using the maternal parameters, and the effectiveness of such an equation was tested using chi square test,
Highlights of the Results

Results of the study are presented in four sections.

Section 1 Deals with results of the first objective of the study: “Identification of each individual mother’s prenatal nutritional status through a comprehensive nutrition assessment process done through descriptive analysis.

Composition profile of the subjects

The study recorded 400 subjects corresponding to 89% of the initial plan. A total of 300 dyads, [mothers and their newborns] which is statistically approved, were available for statistical analysis and development of predictive model.

Subjects excluded as per the exclusion criteria are

- pregnant subjects who registered in the out patient clinics, but did not deliver at the university hospital
- pregnant subjects who developed non nutritional complications during gestation
- pregnant subjects who delivered pre term babies and babies with congenital malformations
Maternal Age Profile

Adolescent pregnancies were registered to be 18 numbers, i.e., six percent of the study population, with a mean age of 18.66±0.49 years with their age ranging between 18-19 years. Pregnant subjects in the normal, safe and recommended age for pregnancy were 281 numbers, i.e., 93% of the study population with a mean age of 24.87±3.61 years with their age ranging between 20-35 years. The other high-risk category, the elderly pregnancies contributed to only one percent with only one registrant of 36 years of age.

Maternal Gravidal Status Profile

83% of the eighteen-adolescent pregnancies were primis with only 17% in gravida two. Similarly, 44% of the 281 pregnancies among the adult subjects were primis followed by 34% of gravida two and 22% of multi gravidas. Therefore, this study had a majority of its population in the 20-35 years of age with predominance of primigravidas.

Maternal Socio-Demographic Factors

Educational Achievement
The overall percentage of illiteracy was 12.6% while that of literacy was 87% predominated by those with higher secondary and secondary school of education.

Socio-Economic Status
Forty six percent of the subjects were from the lower middle-income group. The next high percentage was found to be at the upper lower income group level (34%) and there was a lesser representation (four percent) of lower income group and nil representation of higher income group.

Maternal Nutritional Factors
Anthropometric Assessment
Maternal Height Profile

The adolescent subjects were having a mean height of 143.05±2.91 cms, The mean heights of subjects in the 20-35 years of age is 155.05±4.63 and the one subject in the >35 years of age was found to be taller with a height 170.00±0.00. Analysis of the stature of adult study subjects based on ICMR criterion of 151 cms, for Indian reference women, revealed only 20% of subjects to be short statured, and 80% to be normal.
Maternal Weight

Pre pregnancy Weight Profile

The mean pre pregnancy weight of adolescent subjects was 13% lesser than the NCHS reference standards for pre pregnancy weight for adolescent girls.

Forty nine percent of the adult subjects were in the “at risk” category (<45kgs) according to WHO standards for weight during pregnancy. The mean pre pregnancy weight of these subjects was 43.66 ±4.04kgs.

Maternal gestational weight gain

The average gestational weight gain was 10.6±1.05kgs in the subjects ranging from ½ kg per week to 3kgs/month

Maternal Body Mass Index Profile

Adolescent subjects showed BMI value of 23.94±2.04kg/m². The BMI of the adult pregnancies falls in the normal range of 19-25 kg/m² for people <34 years with a mean BMI of 20.78±3.16 kg/m². BMI of the elderly pregnant women was 19.03±0.00 kg/m².
Among the adult pregnancies, third degree chronic energy deficiency (BMI <16kg/m²) was prevalent only among 5% of subjects. 66% of subjects were found to be having a satisfactory nutritional status with a mean BMI of 19.18±0.46kg/m² and 22.32±1.29kg/m² respectively. The incidence of overweight was only 10% with mean BMI of 26.53±1.04kg/m² and there were no subjects who could be categorized to be obese based on BMI.

Biochemical Assessment
Serum Hemoglobin

Lower value were observed among the adolescent subjects with a mean of 10.37±1.79, indicating prevalence of moderate anemia in this group. Comparison of mean hemoglobin levels among the adolescent and adult subjects reveal a higher mean hemoglobin value among subjects between 20-35yrs. However, the mean hemoglobin levels of adult and elderly pregnant subjects were not deviating significantly from the WHO recommendation of 11g/dl. Among the adult subjects as per WHO Categorization (<11g/dl) around 44% were anemic. Among these about 31% were mildly anemic (Hb10-10.9g/dl) with a mean of 10.33±0.32g/dl and 12 % were moderately
anemic (Hb 7-9.9g/dl) with a mean of 9.1±0.67g/dl. The prevalence of severe anemia (Hb<7g/dl) was negligible with only one percent of subjects, with a mean of 6.40±0.34g/dl.

Comparison of serum hemoglobin level as per the criteria of WHO (<11g/dl), among the three age groups of subjects indicated a higher incidence of anemia in the adolescents compared to the adult and elderly subjects.

Nutritional Intake Assessment
Energy and Protein Intake
Data from 24hr dietary recall showed that the average energy and protein intake among the adolescent and adult pregnancies were almost similar with 1770.00±1.29 kcals, 1798.39±236.83kcals and 64.00±4.30g, 64.94±7.89g respectively. The percentage of protein deficit (76%) was high when compared to the energy deficit (25%) among the subjects.

Fetal Assessment
Fetal age, Fetal Growth and Estimated Fetal Weight
Fetal assessment done at the
- 12th week of gestation of the pregnant registrants did not show deviations from the expected age for gestation.
- Between 20th and 24th week of gestation showed no gross anomalies.
- 34th week of gestation showed that the rate of growth of the fetuses were on an average as per the recommended ranges.

**Neonatal Nutritional Assessment**

**Neonatal Birth Weight Patterns**

The total number of neonates was 281 with their gestational ranging between 37-42 weeks and birth weight ranging from 2400-4000gms. Overall mean birth weight of the neonates was $2944.55\pm371.00$gms. Of the 281 neonates, 19 born with low birth weight, thereby giving an incidence of 7%. The mean birth weight of LBW neonates was $2442.11\pm26.57$gms. The average birth weight of the LBW neonates was only 2.3 percent lower than the WHO standards for lbw, i.e., <2500g. The mean birth weight of normal birth weight neonates was $2980.99\pm357.96$. Male neonates were heavier than female neonates by 23.52g.

The mean birth weight of neonates delivered by the adolescents was $2180.00\pm0.00$gms and that of elderly pregnancies was $4300.00\pm0.00$. 
The mean birth weight of neonate delivered by pregnant subjects between 20-35 yrs of age was 2944.55±371.29. There was totally 28 low birth weight deliveries, corresponding to 100% (n=18) in adolescent group and 7% (n=19) in adult pregnancies. Young mothers (<20 years) were found to deliver more number of low birth weight babies. All the low birth weight deliveries in the adult group have been term low birth weights.

In this study, the nutrition intervention program has been successful in reducing the percentage incidence of low birth weights and improved mean birth weights.

Section 2 Presents the results of the second objective “development and implementation of practical nutrition education plan and evaluating the efficacy of the nutrition related messages”

The nutrition counseling modules developed based on the nutritional intake assessment was conveyed through personalized and intensive dietary counseling through discussions lasting for 30-45 minutes, at the time of their visit to the antenatal nutrition clinics at intervals of

- once a month till the first trimester (3 visits @ 1 visit/month),
- once in a fortnight beginning from the second trimester (6 visits) till the third trimester and
once in a week beginning from the third trimester (12-16 visits) till delivery, totaling up to 21-25 visits during the gestational period.

A nutrition exhibition was convened and conducted in the Obstetrics and Gynecology department in March '01 based on the nutrition counseling modules using live models, pictures and charts. A nutrition wheel was developed depicting the significance of nutrition, nutritional requirements and ways of meeting the requirements throughout the various stages of life cycle of a woman as part of the exhibition. The messages conveyed and the models were well appreciated by the professionals and the public and the researcher was awarded a prize for the same.

Section 3 Deals with the results in relation to the third objective “Identification, evaluation and correlation of maternal factors making a predominant contribution to fetal development and low birth weight ” presented as inference drawn through inferential analysis-Chi square and ANOVA.

Correlation revealed between maternal parameters and neonatal birth weight:

• Maternal Height significantly positively correlated

  (t-8.647) p<0.001
• Maternal Body Mass Index significantly negatively correlated (-2.274) p <0.05

• No significant correlation found between maternal pre pregnancy weight, gestational weight gain, serum hemoglobin levels, total calorie and protein intake.

Section 4 Deals with the fourth and the title objective of the study, “The development of a predictive equation for expected birth weight using maternal nutritional related variables,” developed through multiple regression analysis.

In the pursuit of developing the predictive model, the correlation coefficients were performed only for the adult pregnancies excluding the adolescent pregnancies, since the influence of adolescent nutritional status on the outcome are multi faceted and therefore needs to be treated separately.

The final model obtained included the variables maternal height, maternal pre pregnancy weight, body mass index, gestational weight gain and hemoglobin.

Multiple Regression (R) =0.975; R² = 0.943; F=917.785
Dependant variable: Birth Weight
Independent Variable: maternal height, pre pregnancy weight, weight gain, hemoglobin and body mass index.

The prediction equation developed by this analysis is:

\[
\text{Birth Weight} = -9680.391 + 81.020 \text{ (Height)} - 8.116 \text{ (Pre-pregnancy weight)} + 3.098 \text{ (Weight gain)} + 12.558 \text{ (Body Mass Index)} + 2.131 \text{ (Hb)}
\]

Birth weights were estimated by substituting the actual maternal values in the equation and were compared with the observed birth weights. The mean actual weight was 2944.56±371.29 and the mean predicted weight was 2944.62±360.65. There was a high correlation between the actual birth weight and the estimated weight (chi square=2.54, p<0.01).

The hierarchical order of efficiency of the maternal parameters in predicting the birth weight along with the overall R square values is highlighted in Figure illustrated below:
Conclusion

In the Indian scenario, where low birth weight is continuing to be a problem with a persisting higher incidence of 33% and threatening the future generation with its associated comorbid disease conditions in later life. The continued nutritional counseling rendered to the pregnant registrants intertwined with periodic monitoring of their nutritional intake and gestational weight gain had contributed significantly to the positive results.

The cost to society of caring for people with diseases such as diabetes mellitus, cardiovascular diseases and obesity in developing countries are high and the costs of preventing theses disease by adequate nutrition in utero during pregnancy would be considerably less.

The predicative equation developed in this study after a continued nutritional intervention has been successful in predicting the expected birth weight and therefore can be used by the health care team in the hospital to improve quality of service and pregnancy outcome by identifying the pregnant woman at risk of delivering low birth weight and take appropriate nutritional measures in addition to medical care towards the prevention of incidence of low birth weight.