In-depth review of the existing literature unveiled the magnitude of the problem of low birth weights and the role of maternal nutritional status in influencing the birth weight of the neonates. The broad area of research being paediatric nutrition the primary aim was to identify high risk
foetuses and unborn neonates as influenced by the maternal nutritional parameters and help to improve the nutritional well being of the future generation by preventing/restricting the incidence of low birth weight.

As observed by Gopalan [1993] that child health is not necessarily “child health/nutrition” much less ‘maternal health’, and mere achievement of child survival without adequate steps to ensure health/nutrition of survivors and of the mothers who are primarily concerned with child rearing, this study had women in their gestation as the core of the study to achieve the prime objective.

Additionally, in order to make the developed concept to be useful to various categories of people of the society, it was even more necessary to carry out the study in a set-up which caters to pregnant women with varied socio-demographic backgrounds such as illiterate to literate and poor to rich and in different age groups.

In an urban set-up, majority of deliveries is hospital assisted. Non hospital assisted deliveries are merely an accident rather than a norm and dai assisted deliveries are
practically inconceivable now. Even in semi-urban and rural areas the shift is towards hospital assisted deliveries. Hence, it was decided to carry out the study in an hospital which meets the prerequisite conditions.

Study Area

Sri Ramachandra Medical College and Research Institute [Deemed University], [SRMC & RI, (DU)] with an attached 1540 bed state of art tertiary care referral hospital, encompassing general medical and surgical as well as super specialities, situated at the outskirts of the city of Chennai, capital of the state of Tamilnadu, India, was chosen as the study area. Strategically located, it caters to both the urban and the rural population adjoining the city. The patient population for the hospital comprises of people from all socio economic strata - below poverty line, low socio economic, middle socio economic and high socio economic group as well as with different literacy levels starting from illiterates to graduates.

Study Design

Prospective study, designed to follow up pregnant women with nutritional counselling and document its effect on
outcome which can be used in the development of predictive model.

1 Sampling Unit

Samples were selected from the outpatient admissions to the Department of Obstetrics and Gynaecology [SRMC & RI, (DU)], during the study period starting from June ‘00 - May ’01.

Sample Selection

The Obstetrics & Gynaecology department’s outpatient services registers approximately 150 pregnant women per month. The study was initiated with a proposal to have at least one fourth of the registrants, to be the representative population for the study. The study was initiated with a aim to cover approximately 450 registrants in the first three

Department of Obstetrics & Gynecology

SRMC & R[DU]

Prospective study

N = 450

Entry to study

Prenatal clinic ≤ 20 wks of
months of the study period starting from June ‘00-August ’01 and follow up the subjects till July ’01. Informed consent of each of the pregnant women willing to participate in the study was obtained by the researcher before data collection. The flow of study is presented in Fig. 3.1. The selection and exclusion criteria of subjects for the study design are delineated in Fig. 3.2.
Study Parameters

The study involved assessment of maternal, fetal and neonatal nutritional status using different parameters as depicted in Fig. 3.3.

Assessment Procedures

Maternal Non-nutritional factors

Age

Age of the study subjects was obtained from oral interviews and as entered in their medical records and were classified as adolescent/teenage pregnancies (15-19 yrs); adult pregnancies (20-35yrs) and elderly/late pregnancies (>35 yrs), as per the classification norms for pregnancy [Williams S.R 1990].

Gravidal Status (number of pregnancies):

Subjects of different gravidal status were included in this study and information on parity was obtained by reviewing medical records and oral interviews of the subjects and were classified as primigravida (women in

*Dept of obstetrics & Gynecology (OBGYN)*

\[ O \quad Out\quad Patients \]

*Prospective Longitudinal study*

\[ N = 450\]
Selection criteria

- Before & until 24 weeks of gestation
- Delivery at the university hospital
- Follow up at internals of
  - Once a month till the 1st trimester
  - Once in 15 days till the end of the 2nd trimester and
  - Once a week from the start of the 3rd trimester till delivery
  - Certain of Last Menstrual Period
  - Had an ultrasound examination before 20 weeks gestation

Exclusion Criteria

- > 24 weeks of gestation
- Not Delivering at the university hospital
- Lost during follow up at intervals of
  - Once a month till the 1st trimester
  - Once in 15 days till the end of the 2nd trimester and
  - Once a week from the start of the 3rd trimester till delivery

Fig. 3.2: Study Design, Selection and Exclusion criteria of samples for the study

Prospective Study

\[ N = 450 \]

1. Assessment of the pregnant women
   (A) Assessment of maternal non-nutritional factors
      (i) age
      (ii) parity [number of pregnancies]
   (B) Assessment of maternal socio-demographic factors
      (i) Educational achievement
      (ii) Socio economic status
   (C) Assessment of maternal nutritional factors
Fig. 3.3: Study Parameters for the prospective study
their first pregnancy) and gravida two (women in their second pregnancy)
and multigravida (women in their third/fourth pregnancies)

Maternal Socio-Demographic Factors

Educational achievement
Elicited thro’ oral interviews by the researcher and subjects were classified as illiterates inclusive of those with only primary/elementary school education or those with secondary/higher secondary school education or as those with diploma/under graduate/post graduate degree holders.

**Socio economic status**

Recorded thro’ oral interviews and on basis of their income level were categorized to be falling in one of the following groups using modified version of Kuppuswamy’s classification of socio economic status:

The categorisation of socio economic status was done using scoring system of educational status, occupation and monthly family income, [Table 3.1].

**Maternal nutritional factors**

**Anthropometric Assessment**

**Maternal Height**

Height was measured once at the first visit i.e., at <24 weeks of gestation of subjects. A standard height meter fixed firmly on the wall was used to measure the heights of the subjects. Subjects were made to stand straight with the head positioned such that the Frankfurt plane was horizontal, feet together, knees

**Table 3.1: The categorisation of Socio Economic Status**

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
A. Education
1. Professionals/Honors 07
2. Graduate/Post Graduate 06
3. Intermediate/Post High School Dip 05
4. High School Certificate 04
5. Middle School Certificate 03
6. Primary School 02
7. Illiterate 01

B. Occupation
1. Professional 10
2. Semi professional 06
3. Clerical, shop owner/farm owner 05
4. Skilled Worker 04
5. Semi-skilled worker 03
6. Unskilled worker 02
7. Unemployed 01

C. Family Income/Month (in Rs)
1. > 13,500 12
2. 6750-13,499 10
3. 5050-6749 06
4. 3375-5049 04
5. 2025-3374 03
6. 676-2-24 02
7. <675 01

<table>
<thead>
<tr>
<th>Total Score</th>
<th>Socio Economic Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>26-29</td>
<td>upper</td>
</tr>
<tr>
<td>16-25</td>
<td>upper middle</td>
</tr>
<tr>
<td>11-15</td>
<td>lower middle</td>
</tr>
<tr>
<td>5-10</td>
<td>upper lower</td>
</tr>
</tbody>
</table>

straight, heels and buttocks and shoulder blades in contact with the vertical surface of the wall, arms hanging loosely at the sides with
palms facing the thighs. For measuring the heights, subjects were asked to take deep breath and stand tall to aid the strengthening of the spine, and shoulders relaxed. The movable headboard was gently lowered until it touched the crown of the head, compressing the hair. Height was measured at maximum inspiration with the examiner’s eye level with the headboard avoiding parallax error and the reading was recorded to the nearest millimetre. In the event of the reading falling below two values, the lower reading value recorded. In the case of subjects with large amounts of adipose tissue preventing the heels, buttocks and shoulders from simultaneously touching the wall, subjects were simply asked to stand erect and the measurements made to the nearest millimetre [Plate 1].

Based on the height measurements, subjects were classified into those with <151 cms of height and those with >151 cms of height, to assess percentage deviation from the standard ICMR recommendation for height for the Indian reference women and were identified to be stunted/with normal growth.

**Maternal Weight - Prepregnancy weight**

For the subjects with <12 weeks of gestation actual measurements taken during their visit to out patient nutrition clinic was taken as the prepregnancy
weight, since the gestational weight gain during this period is either nil or negligible.

For those subjects with >12 weeks and <24 weeks of gestation, their recalled weight prior to pregnancy or recorded weight at 12 weeks of gestation was taken as the pre pregnancy weight.

Weight was measured using Seca Nera [Germany] weighing scale with a maximum capacity of 150kgs after adequate calibration using a set of known weights and checking for zero error i.e., the pointer is at the centre or returned to zero at the centre after each weighing with the set of known weights. Subjects were weighed in their light outdoor clothing between 8.00 am and 12 noon. They were made to stand unassisted and relaxed at the centre of the platform looking straightforward and the weight was recorded to the nearest 0.1kg [Plate 2]. The weighing balance was calibrated regularly throughout the study period before and at the end of each survey day.

Weights of the subjects who were coming for follow up visits at regular intervals - were also measured using the same procedure on each visit.

Based on the pre-pregnancy weight, the subjects were classified into those with <50kgs and those with >50kgs to identify the degree of their deviation
from the ICMR recommended weight for the Indian reference women, to identify wasting/overweight/obesity.

**Maternal Weight - Final Weight Gain**

Weight measured at each visit of the subjects were plotted against weight gain curves developed by WIC program for standard weight under weight and over weight women [Annexure 1] to evaluate the pattern weight gains, as well as for computing final gain weights. Mean monthly weight gain of less than one kilogram was used as a cut off point to identify pregnant women at risk [WHO 1991].

**Body Mass Index [Quetelet index]**

Body Mass Index [BMI] of the pregnant registrants was calculated using the formula:

**Weight in kilograms ÷ by height in meter squared [(wt (kgs) ÷ Ht (m²))]**

A low BMI is indicative of Chronic Energy Deficiency [CED] and therefore, the subjects were classified based on their BMI at booking using the published guidelines of National Institute of Nutrition [1983]. (Table 3.2)

2. Based on the BMI, weight gain recommendations were made as follows using weigh targets by pre gravid BMI, recommended by the National Academy of Sciences, Institute of Medicine [1990] (Table 3.3)
Table 3.2: Classification of energy deficiency states and interpretation

<table>
<thead>
<tr>
<th>BMI (Kg/m²)</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;16</td>
<td>severely under nourished</td>
</tr>
<tr>
<td>16.1-17</td>
<td>moderately undernourished</td>
</tr>
<tr>
<td>17.1-18.5</td>
<td>mildly undernourished</td>
</tr>
<tr>
<td>18.5-20</td>
<td>normal (&lt;34 yrs)</td>
</tr>
<tr>
<td>20-27</td>
<td>normal (&gt;34 yrs)</td>
</tr>
<tr>
<td>27.1-30</td>
<td>overweight</td>
</tr>
<tr>
<td>30-40</td>
<td>mild obesity</td>
</tr>
<tr>
<td>&gt;40</td>
<td>severe obesity</td>
</tr>
</tbody>
</table>

Table 3.3: Recommended Weight gains based on BMI

<table>
<thead>
<tr>
<th>BMI Category</th>
<th>Recommended Weight Gain (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underweight (BMI &lt;19.8)</td>
<td>12.5-18</td>
</tr>
<tr>
<td>Adequate weight (19.8-26)</td>
<td>11.5-16</td>
</tr>
<tr>
<td>Overweight (26-29)</td>
<td>7-11.5</td>
</tr>
</tbody>
</table>
Biochemical Assessment

Serum Haemoglobin

Maternal serum haemoglobin was assessed at the first visit of the subjects using the cyanmethaemoglobin method by the hospital laboratory personnel on request by the attending obstetrician and entered in the medical records of the study subjects was noted.

Based on the hemoglobin levels, subjects were divided into four categories – Normal (Hb >11g/dl); mildly anemic (Hb 9-10.9g/dl); moderately anemic (Hb 7-8.9g/dl); and severly anemic (<7g/dl). Since the WHO classification considers women with <11grams to be anemic, subjects were interpreted to be anaemic if the values were falling below 11g/dl, the cut-off value of hemoglobin for pregnancy. Similarly, the effect of low hemoglobin levels on the neonatal outcome, was delineated using the same cut-off values.

Energy and Protein Intake Estimation
To elicit the information on dietary intake of the pregnant subjects, a quantitative and qualitative dietary evaluation was conducted through 24-hour recall [Annexure 2], using standardised measurement tools [Plate 3] to estimate the quantity of food consumed. The food consumed was converted into their raw equivalents and the average daily intake of nutrients was calculated using food composition tables [ICMR 1996].

The calorie and protein intake of each subject was estimated using food composition tables. For analytical purposes, the calorie and protein intake estimated at the first visit, before nutritional counselling was taken as the control and the average calorie and protein intake estimated during further visits were used for evaluation of differences before and after nutritional intervention.

Implementation of Practical Nutrition Education

Based on the information obtained through 24 hour recall, dietary counselling sessions were carried out on various topics as listed below were prepared [Annexure 3].

The nutrition education module includes

- 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

The messages in the handouts were conveyed to the subjects through personalised and intensive dietary counselling through discussions, lasting for 30-45 minutes, (Plate 4) using visual aids like posters and charts 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 which totalled out to 21-25 visits during the gestational period and the handouts were given. The dietary consumption of the subjects was collected by 24 hr recall during each visit for review.

A nutrition exhibition was also conducted reinforcing the importance of nutrition during pregnancy for all the registrants. Live models of foods rich in
various nutrients that are considered to be important during pregnancy and the serving size of each of them in the form a day’s menu was displayed in the exhibition[Plate 5-13].

The researcher also developed a nutrition wheel depicting the nutritional requirements and the ways of meeting the needs during the various stages of life cycle of a woman, as a visual aid [Plate 14].

**Fetal Assessment:**

**Ultrasonography**

Accurate assessment of the fetal age is crucial for perinatal management. Over estimation can result in the delivery of a premature infant, whereas under estimation of the age of a growth restricted fetus can result in a fetal death. Ultrasonography offers the advantage of reasonably precise estimation of fetal age, measurement of the fetal head, abdominal circumference and femur length to help identify fetal growth rate and differentiate the growth-retarded fetus.

Ultrasound was performed

i. initially at the 12th week of gestation of the pregnant women to assess fetal age,

ii. between 20th and 24th weeks of gestation to assess fetal anomalies and
iii. at the 34th week for fetal weight by parameters that are accessible and reproducible.

**Fetal age, Fetal Growth and Estimated Fetal Weight**

The fetal body parts most frequently used to evaluate fetal age, fetal growth and fetal weight include:

**Biparietal Diameter** [BPD] – measured from the outer to the inner border of the echo complexes representing the anterior and posterior fetal skull bones,

**Abdominal Circumference** [AC] - the mean of the anterio-posterior and transverse diameters measured in the plane perpendicular to foetal spine at the level of intraabdominal umbilical vein from the outer to the outline of the abdominal wall

**Femur Length** [FL] - measurements between the markers at each end of the femur. The imaginary line traversing the central shaft of the femur excluding the distal femoral epiphysis.

Fetal age, fetal growth rate and estimated fetal weight as measured by the various parameters thro’ ultrasonography by the attending physician were plotted in the fetal growth assessment charts [Mediscan Growth Charts] [Annexure 4] and were compared with the percentile values for various...
growth parameters at 10th, 50th, 75th and 90th percentile ranks [Annexure 5]. 50th percentile values for each parameter was taken as the standard measurement for that particular gestational age. On basis of the assessment parameters and the percentiles, the fetuses were classified as in Fig.3.4.

**Neonatal Nutritional Assessment**

For a normal neonate, standard measurements for the assessment of nutritional status include weight, length and head circumference in addition to skin-fold thickness or mid-arm circumference of calculation of ponderal index. Neonatal parameters used to assess the neonates in this study include birth weight, length, head circumference, chest circumference and ponderal index.
Fig. 3.4: Fetal Classification

Neonate

Term (37-42 weeks of gestation) Post Term (>42 weeks of gestation)

Appropriate for Gestational Age [AGA], - birth weight between the 10\textsuperscript{th} and the 90\textsuperscript{th} percentiles of a given gestational age

Small for Gestational Age [SGA], - birth weight lesser that the 10\textsuperscript{th} percentiles of a given gestational age

Large for Gestational Age [LGA], - birth weight between greater than the 90\textsuperscript{th} percentiles of a given gestational age
The measured neonatal parameters – birth weight, length, head circumference and chest circumference were plotted against the new born growth curves, used in the neonatal block of the study area and compared with NCHS percentiles [Annexure 6]. On the basis of gestational age, birth weight, length, head and chest circumference, the neonates were divided into nine sub groups as shown in Fig 3.5.

Neonatal parameters used to assess the neonates include birth weight, length, head circumference, chest circumference and ponderal index.

**Fig.3.5: Neonatal Classification**

*Symmetric Intra Uterine Growth Retardation – length, head circumference, chest circumference and weight low for a given gestational age.*

*Asymmetric Intra Uterine Growth Retardation – normal length and head circumference, low chest circumference and weight for a given gestational age.*
Birth weight of the neonates was measured within 72 hours after birth [Plate 15]. The neonate was placed on the pan scale in such a way that the weight was distributed equally about the centre of the pan. Once the neonate was lying quietly, weight was recorded to the nearest 10g. Based on the birth weight, the neonates were classified as

- Extremely low birth weight (<1000g)
- Very low birth weight (1000-1500g)
- Low birth weight (1500-2500g) and
- Normal birth weight (>2500g).

However, for analytical purposes, all neonates weighing <2500 grams were considered as low birth weights as per WHO.

**Neonatal Length**

Recumbent length of the neonates was measured using the infantometer, by making the neonate lie on a flat surface, head positioned firmly against the fixed head board, with the eyes looking vertically, knees extended by applying firm pressure and the feet flexed at right angles to the lower legs. The upright sliding foot-piece was then moved to obtain firm contact with the heels and the length was read to the nearest 0.1 cm [Plate 16].

**Neonatal Head Circumference**
The neonates were classified as being Intra Uterine Growth Retarded (IUGR) if their birth weight was less than the 10th percentile of Lubchenco et.al., sex specific birth weight for gestational age standard and appropriate for gestational age, if their birth weight was greater than or equal to this centile.

Neonates were further classified as being type I or type II IUGR according to Lubchenco Ponderal Index for gestational standard. Neonates length measurements were defined as low (short), adequate or high (long) according to the Lubchenco et.al., length for Gestational Standard.

Subsequently, they were classified into four different subtypes of IUGR by a combination of their weight length and Ponderal Index measurements at birth. Subtype A – short length and adequate PI; subtype B – adequate length and low PI; subtype C – short length and low PI; subtype D – adequate length and adequate PI [Annexure 7]

**Development of Predictive Model**

With respect to the title objective, development of predictive model for pregnancy outcome, this study as a first step studied the correlations between maternal parameters and birth weight and used the continuous variables such as height, prepregnancy weight, gestational weight gain,
Measurements were made with a narrow, flexible, non-stretch tape, made of fibreglass about 0.6 cm wide. The neonate’s head was steadied and the greatest circumference measured, by placing the tape firmly round the frontal bones just superior to the supra-orbital ridges, covering the most prominent part of the frontal bulge and over the part of occiput which gives the maximum circumference (Weiner and Lourie, 1969) Care was taken to ensure that the tape is at the same level on each side of the head and is pulled tightly to compress the hair. Measurements were made to the nearest 0.1 cm [Plate 17].

**Neonatal Chest Circumference**

A narrow, flexible non-stretch fibreglass tape was used and measurement was made at the nipple line, in a line at right angle to the spine and the measurement was recorded in mid respiration to the nearest 0.1 cm [Plate 18].

**Ponderal Index (PI)**

It accounts for length-weight relationships calculated using the formula:

\[
\text{Weight (gms)} \div \text{by cube root of crown-heel length (cm}^3) \times 100.
\]

The ICMR reference value is 2.25-2.95. The calculated ponderal indexes of the neonate were compared with the reference value and the neonates with a ponderal index of less than the reference value were classified as growth restricted fetuses.
body mass index, hemoglobin, the pregnant subjects in the development of the predictive model.

**Analytical Procedures**

**Scientific Package for Social Sciences, version 8.0 for Windows** analysed the data statistically under three categories as explained further:

1. **Descriptive Analysis** - an analytical procedure to describe and summarise the characteristics of the subjects as in Figure 3.6.

In this study, the tools for descriptive analysis used are:

a. Frequency Distributions - the number of observations under each category arranged in the ascending order of presentation

b. Histograms - a graphic representation of observed frequencies

c. Measures of Central Tendency and Standard Deviation

Such as mean, the single value within the range of the data that is used to represent all of the values in the series and standard deviations which measures the absolute dispersion or variability of a distribution of the observed maternal and neonatal nutritional assessment strategies.

d. Mean and Standard deviations were used to describe the age of the registrants and other maternal nutritional parameters like height, pre pregnancy weight, weight gain, haemoglobin, calorie and protein intake
**Pie Diagrams**  

| Maternal Age | Height | Weight-prepregnancy weight & final weight gain | Body Mass Index | S. Hemoglobin | Total energy & Protein Intake | Neonatal Birth Weight | Neonatal Length | Head Circumference | Chest Circumference | Ponderal Index | Fetal | Medi scan graphs | Age | Growth | Weight |

**Fig.3.6: Descriptive Analysis**

e. Pie diagrams used to interpret the incidence of low birth weight in the study groups and distribution of birth weights as per classification of Pamela D, [2000]

f. Graphs (Mediscan) were used to describe the fetal growth patterns

**II. Inferential Statistics**

Tools that enable estimation and the confident inference that the phenomena observed in samples would also be observed in the
populations from which the samples were drawn i.e., they enable one to estimate how reliable the observations may be.

Tools used for inferential analysis in this study are:

a. Chi Square Test an index employed to find the significance of differences between proportions of subjects, objects, events and so forth, that fall into different categories, by comparing observed frequencies and expected frequencies.

b. Analysis of Variance [ANOVA] is used to compare the means of two or more samples and to test the significant differences between the means obtained from these samples.

c. Students ‘t’ test to find the significance of difference between the means of two groups before and after exposure to a treatment.

Fig.3.7 delineates the tools and the parameters/variables analysed.

**Inferential Analysis**

<table>
<thead>
<tr>
<th>Chi Square Test</th>
<th>ANOVA</th>
<th>Student’s ‘t’ test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth Weight Vs</td>
<td>Effect of different levels of maternal nutrition</td>
<td>To evaluate in difference in the energy and protein intake before and after nutritional intervention.</td>
</tr>
<tr>
<td>Height</td>
<td>Effect of maternal parameters on the different levels of Birth weight</td>
<td></td>
</tr>
<tr>
<td>Prepregnancy weight</td>
<td>parameters on the different levels of Birth weight</td>
<td></td>
</tr>
<tr>
<td>Gestational weight gain</td>
<td>birth weight of the neonates such as</td>
<td></td>
</tr>
</tbody>
</table>
III. Multiple Regression Analysis

This analysis represents a logical extension of two variable regression analysis. The main objective of multiple regression and correlation analysis is to derive an equation that describes the average relationship between the variables and this relationship is used to predict or control the dependent variable.
A predictive equation using multiple regression analysis was developed for birth weight using the maternal parameters, and the effectiveness of such an equation was tested using the chisquare test [Fig.3.8].

As evidenced by the literature, the extraneous effects of adolescents and elderly pregnancies on the pregnancy demands are greater and different than that of the adult women, these groups have to be treated separately. For these reasons, the adolescent and elderly pregnancies were not included in the inferential analysis, to avoid their influence of birth weight while attempting to develop a predictive model.
Predictive Model for Birth Weight using maternal Parameters:

- Height
- Prepregnancy Weight
- Gestational Weight gain
- Body Mass Index
- S. Hemoglobin

ChiSquare Analysis to test the significance of difference between the expected and observed birth.

**Fig.3.8**: Multiple Regression Analysis