Nutrition is a critical determinant of human health and good health becomes all the more elusive in the presence of malnutrition,
which is the result of complex interplay of a number of socio-economic and cultural factors like poverty leading to lack of resources, illiteracy, ignorance and ill health.

Scrimshaw et al., (1968) described the existence of a synergistic interaction between malnutrition and infection which was also confirmed by a Latin study five years later, stating that malnutrition underlies or contributes to the death of approximately half of all deaths of children 1 to 4 years old in the countries surveyed [Puffer et.al., 1973]. In all these studies whatever the anthropometric criterion used for diagnosing suboptimal nutrition, the relationship between mortality risks and nutritional status stood out.

Childhood malnutrition is nothing new to India but what is of great concern is the fact that it is one of the issues on which large resources have been spent over a period of time with very limited results (Jonsson 1997). India ranks 49th in the world with regard to nutritional status of children under five (UNICEF 2001), despite the Integrated Child Development Scheme (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.
Since then, Child survival had gone through several revolutions. Firstly, control of some of the severe childhood illnesses did make an impact on the overall health and nutrition of children. However, there still remains a resistant core of child mortality where under nutrition is an underlying cause. Secondly, additional interventions for bringing about improvement in the nutrition of children, particularly targeting at the weaning period have been emphasized [Ebrahim 1998]. These contributions are reflected in significant achievements like decrease in the prevalence of kwashiorkor and blindness due to severe vitamin A deficiency in children and improving reproductive health care of women [Bhaskaram, 2001].

In spite of significant achievements, even today, several deficiency syndromes in women and children are prevalent and are of public health significance contributing to 3.4% of the global burden of total disease and affecting the quality of life [Bhaskaram, 2001].

According to Gopalan (1998) in the last century, the problem was one of the survival of infants and therefore reducing the Infant Mortality Rate [IMR] was a major issue of concern in many of the
developing countries, with the result that it formed an important item in the health agenda. Action to reduce infant mortality was initiated in three tiers. The proximate tier comprised the immediate biomedical conditions, which involved interactions of malnutrition and infection. Many of the interventions of Child Survival Revolution were effectively aimed at this proximate tier. The intermediate tier included childcare practices and other behaviors that exposed children to the cause of death in the proximate tier. Some of the strategies of the Child Survival Revolution, like the promotion of breastfeeding including the Baby Friendly Hospital Initiative were aimed at in this tier. Finally, the third and bottom tier comprised the broad social, economic and political process that lead to disparities in the distribution of the basic necessities of life like food, shelter, sanitation and education [Ebrahim 1998]. These three tier interventions were successful enough to bring down the Infant Mortality Rate (IMR) to 53 in 2001 (UNICEF 2002) from 144 per thousand children in 1960 (UNICEF 1998).

Gopalan (op.cit) observed that if the last century was a battle for survival there is now an increased pool of survivors, who though not showing severe signs of malnutrition such as marasmus or
kwashiorkar, nevertheless exhibited a high degree of stunting (growth retardation) which peaked during the second year of life.

About 47% of children under three years of age in India are underweight, 46% stunted and 16% wasted (NFHS 2 '98-99). Chronic energy deficiency in a nearly similar proportion (38%) of adults suggests perpetration of childhood malnutrition into adulthood (NNMB op.cit). Both policy makers and nutritionists consider this situation as a major public health problem in India.

Trends in mild to moderate malnutrition for under five children in rural India recorded as 71.3% in 1974-79, 63.9% in 88-90 and 61% in 93-94 (WHO 1997) respectively and the three tier strategies of the government to reduce infant mortality rate shows that there still exists a lacunae in the most important underlying factor of child survival - “birth weight” which predisposes to malnutrition and increases the child mortality.

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. As an adult, this growth
deficit is translated into reduced work output. 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.

Epidemiologically, in both developed and developing countries, birth weight of the child is an important determinant of childhood survival and quality of adult life. Low birth weight is considered to be significantly indicative of the infant’s distinctive immaturity, poor potential for rapid growth and high risk of mortality and morbidity and forms an important index for children’s health and development [Agarwal et al., 2002].

Based on birth weight, though the neonates (infants in the first 28 days of life) are generally categorized as Normal Birth Weight (NBW > 2500g), Low Birth Weight (LBW < 2500g), Very Low Birth Weight (VLBW < 1500g), Extremely Low Birth Weight (ELBW < 1000g) and micropremie (<750g) [Reiter et al., 2000]. The World Health Organization (WHO) on the basis of worldwide data had recommended that neonates with birth weights less than 2.5kg to be considered to fall in the low birth weight category carrying relatively greater risks of perinatal and neonatal mortality and
substandard growth/development. The validity of this definition and “cut-off point” of 2.5kgs has been occasionally challenged; but has by and large now gained general acceptance.

LBW is influenced by three major mechanisms:

* **Duration of gestation** which means the length of stay of the fetus in the womb. The normal duration of gestation is 37-42 weeks. A neonate delivered before 37 weeks of gestation is called as pre-term neonate and the one delivered after 42 weeks is referred to as Post term neonate. Based on the gestational period at the time of birth a low birth weight neonate may be classified as

1. Term low birth weights, i.e., born between 37-42 weeks of gestation, but their size may be Small for the corresponding Gestational Age (SGA)

2. Preterm low birth weights i.e., born before 37 completed weeks of gestation with appropriate size for corresponding gestational age

* **Intra Uterine Growth Restriction (IUGR)** which means inadequacy of growth in the fetal life. Low birth weight neonates of this category are classified as:
1. LBW neonates with Symmetric IUGR characterized by thinness, reduced arm and head circumference and low ponderal index

2. LBW neonates with Asymmetric IUGR characterized by normal head circumference, shortness and a low abdominal circumference

* Combination of both which means a low birth weight may be term with symmetric/asymmetric IUGR or preterm low birth weight with symmetric/asymmetric IUGR.

**Low Birth Weight in Neighboring Countries**

Almost 25 million low birth weight neonates are born each year world over and 90% of them in the developing countries [WHO 1990]. The incidence of low birth weight varies widely (Fig 1.1) between regions of the world [Blesey A.M., 1993].

**Low Birth Weight in Indian States – An overview**

The proportion of babies with low birth weights range between 13-43% in the low socio-economic strata of many countries. Our country’s record of 33% incidence of low birth weight has not
shown any decline over the previous years as evidenced by the above figure, which is also reiterated by UNICEF 2001 report. Also India had been reported to have the lowest mean birth weight ranging between 2700-2800g compared with the other countries of the world [WHO 1984]. Average birth weights in rural areas of the developing world are usually 400-1000g lower than in industrialized nations, contributing to high levels of neonatal and post neonatal mortality in such communities during the first year of life and surviving ones rank low on tests of mental development [World Health Stat Q., 1980; Puffer et al., 1987].

It is also important to note that gross regional and economic class differences exist in the prevalence of low birth weight within our country (Table 1.1), ranging from 15% in Kerala to over 45% in Gujarat and 20% in TamilNadu [ICMR, 1990; Bhaskaram, 2001].
Fig 1.1. The prevalence of low birth weight in selected countries by region

[WHO 1990]

Table 1.1 Mean Birth Weight of Infants in Different Regions of India

<table>
<thead>
<tr>
<th>Study Center</th>
<th>Birth Weight (g) Mean ± SD</th>
<th>Percentage &lt;2500</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delhi</td>
<td>2764±545</td>
<td>25.1</td>
</tr>
<tr>
<td>Varanasi (Uttar Pradesh)</td>
<td>2628±504</td>
<td>30.6</td>
</tr>
<tr>
<td>Madras (Tamil Nadu)</td>
<td>2710±536</td>
<td>23.0</td>
</tr>
<tr>
<td>Trivandrum (kerala)</td>
<td>2881±533</td>
<td>15.3</td>
</tr>
<tr>
<td>Calcutta (West Bengal)</td>
<td>2673±394</td>
<td>20.1</td>
</tr>
</tbody>
</table>
In the developed countries, the overwhelming majority of infants with low birth weight (ILB) are preterm infants; low birth weights in these countries are largely the result of shortening of the duration of gestation, attributable to obstetric factors in individual mothers. In the developing countries like India, the reverse is the case, i.e. the LBW infants are more likely to be born at term than those in the developed countries.

When the overall incidence of LBW is higher than 10%, the increase could be attributed to Intra Uterine Growth Restriction, (IUGR) i.e., weigh less than the 10th percentile for post conceptional age and are Small For Gestational Age (SGA) or Small For Dates (SFD). In India, it can be said that the LBWs in our country are predominantly born at term with IUGR or identified as small for Gestational Age babies [Villar J Belizan JM 1982].

Infants with low birth weights carry serious implications for the offspring – ‘short term’ with respect to postnatal growth and development in childhood; and possibly ‘long term’ with respect to
major degenerative diseases in adult life. Barker et al., [1993] postulate that the susceptibility of babies who start off with a low birth weight (SGA) to such degenerative diseases is the result of their being “programmed in utero” in response to an adverse environment. Though it is not clear as to how this programming occurs conferring increased vulnerability to degenerative diseases in “response to an adverse environment”, a simpler explanation could be that “the deprivation of essential nutrients to the fetus in critical phases of intrauterine growth” could result in different types of organ and tissue damage, the deleterious results of which could manifest themselves in later life.

Understanding the mechanisms by which programming of the fetus and neonate occurs may therefore lead to a new understanding of the origin of low birth weight deliveries and have implications to the approach for primary prevention [SCN news 1997].

Several studies have attempted to document and proved that maternal nutritional deprivation at relatively early stages of pregnancy, results in Symmetric IUGR characterized by thinness, reduced arm circumference and reduced head circumference and low ponderal Index, associated with more vulnerability to
Syndrome X. On the other hand, where such nutritional deprivation occurs in late pregnancy results in Asymmetric IUGR characterized by normal head circumference, shortness and a low abdominal circumference associated with increased risk of coronary heart disease in adult life – raised plasma concentrations of fibrinogen and low density lipoprotein cholesterol. It is understood from the above statements, that low birth weights in full term infants are reflection of intrauterine growth restriction largely attributable to poor maternal health during pregnancy, secondary to maternal under nutrition and infection and hence the problem of LBW with IUGR cannot be entirely reversed by an ideal environmental and nutritional inputs even in the postnatal life.

The realization therefore dawned that, in short, the problem of LBWs cannot be solved through “bypassing” the mother and focusing efforts only on the infant in the postnatal period. The problem can be solved only through focusing on the ‘mother’, as human fetal growth is not uniform and its control is complicated involving three stages - genetic, feto-placental haemostatic mechanisms and maternal environment acting on the placenta, implying that maternal nutrition plays a major role in fetal development and in determining birth weight.
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-Pregravid weight; Body Mass Index; Weight gain; Hemoglobin and Dietary Intake (Fig.1.2).

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
Fig. 1.2: Maternal Factors influencing Neonatal Birth Weight
of these factors to help in identification of low birth weight fetuses while in utero and prevention/restriction of incidence of low birth weight.

**Scope of the study**

Studies exploring the predictive model concept have been carried out in the international arena using maternal anthropometric parameters such as Quetelet’s index, waist hip ratio, head circumference and Symphysiofundal height and 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; Bolza, AG, Guimarey LM, 2001; 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* [Chadha, et.al., 1992; Sushma et.al., 1997; Sebire et.al., 2001; Sharma 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.
Therefore, this study was conceived and conducted in the self-selective hospital based population 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**

1. To identify each individual mother’s prenatal nutritional status through a comprehensive nutrition assessment process

2. 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

3. To identify, evaluate and correlate maternal factors that make predominant contribution, to fetal development and to the incidence of low birth weight
4. To use this information as a necessary base to develop a predictive model for the expected birth weight using maternal nutrition related variables.