INTRODUCTION
1.0 INTRODUCTION

In most of the countries - particularly those in the process of demographic transition - fertility tends to vary strongly with the level of female reproductive health, education and socio-economic status. These differentials are strongly observed in both developed and developing countries. Such extreme cases are prevalent in Africa and in most parts of Asia. India occupies an intermediate position and North America shows virtually small differentials. The degree of differentially depends on the basic health and the nutritional level of the pregnant women throughout the world.

1.1 Health and Nutritional Status of Pregnant Women – A worldwide view

Globally, there were over 138 million births during the year 1994 and the vast majority of the world’s babies (124 million) were born to mothers living in the under-developed countries (UNICEF, 1996). The WHO (1997) reported that some 200 million women became pregnant each year and most of them were from developing countries. Many of these pregnant women suffered from nutritional deficiencies and the long-term cumulative sequences of under-nutrition right from childhood onwards. Pregnancy related health and nutritional problems affects a woman’s quality of life and her new born infant well beyond delivery also that of her family and community (WHO 1997). Mc Curie and Popkin (1989) stated that the nutritional status of pregnant and lactating women in developing countries consumed only about two-thirds of the recommended daily intake of energy. Further they have observed that their average weight for height was in most cases well below the 50th percentile.
Global figures about parity and births, when considered in isolation, suggest that chronically malnourished women in the poorest countries successfully achieve a high reproductive yield. Based on this observation UNICEF (1996 a) recommended the Federal Government to provide opportunities to control fertility and to achieve their reproductive aims while maintaining their own health and happiness of their sexual relationship and the health of the offspring. However, this ideal is approached only by a small fraction of the world’s population. The remaining population is bound to several factors related to socio-economic and cultural conditions as well as to the environment they reside.

Tinker and Koblinsky (1994) revealed that more than 40% of pregnancies in developing countries resulted in complications, illness and disability of the mother or child. More than 7 million new born deaths are associated with maternal health and nutrition-related problems resulting from poorly managed pregnancies/deliveries/inadequate care of the neonates soon after birth, WHO (1997).

Malnourished women who are short, underweight and who do not gain sufficient weight during pregnancy, are more likely to have miscarriages / still births / low birth weight infants (Scholl and Hedger (1994), Adair (1987) and Lacfutig and Shrimpton (1997). These factors are linked to increased risk of prenatal and infant mortality, Chatterjee and Lambert (1989), Lettemeir et al. (1989) and Viteri (1994). In 1992 the Rio Earth Summit has declared that there is no safety womb today due to the impact of environmental degradation on women and children. The foetus developing in the womb is actually a sensory responsive living entity, perceptive of its environment, which in turn
determines its fate. The conception and nurturing of the child inside the womb is, therefore, a highly critical process.

1.2 Health Status of Pregnant Women in India

The impaired foetal development is linked to many pre-natal conditions affecting both mother and child. Churchill (1969) suggests that such impairments are caused by disturbances in the nutrition of the foetus. The WHO focuses that foetal nutrition is an important factor in the research programme on child growth and development.

The various causes of poor pregnancy outcome are complex and deep rooted in India. When pregnant women at risk do not have access to proper diet and care during the ante-natal period, at delivery or post partum, high Maternal mortality is inevitable, Gopalan (1987).

Nearly 70 percent of the Indian women of the childbearing age reside in rural area, where facilities for special care are limited. In such areas, risk-scoring systems play a vital role in the identification of high-risk pregnant women. Even an auxiliary nurse, midwife or community health worker can categorize the pregnant women into risk groups using the simple scoring schedules and judge the situation of urgency for intervention and obtain timely help from specialists. Identification, timely referral and effective care of high-risk pregnancies make tremendous improvement in the health status of the mothers and infants, Das et al. (1987).

Maternal risk levels affect the foetus and new born by way of low birth weight, inadequate stores of nutrients and slow growth during infancy. In TamilNadu, a large percentage of pregnant women are stunted and underweight Das et al. (1987). According
to UNICEF (1990) nearly 20 percent of pregnancies in India are reported as high-risk pregnancies.

1.3 Programmes of World Health Organization (WHO) on Maternal and Child Health (WHO, 1995)

The WHO pays paramount importance for Maternal and Child health and feels that female health care is a key factor in economic, cultural and social development in global as well as in regional scale, because, women in different strata of the society show different levels of health care especially in developing countries. On bearing this aspect in mind, the World Health Assembly recommended WHO to develop an action plan for maternal nutrition, child health, family planning and pregnancy related nutritional programmes, WHO (1998). They clearly defined the need to provide guidance to national health services on practical ways of assessing women’s nutritional status, particularly in relation to reproduction. Earlier investigations revealed that maternal anthropometry is a good predictor for outcomes of pregnancy. Among the anthropometric parameters maternal height, pre-pregnancy weight, gestational weight gain and mid-upper arm circumference are considered as important indicators for current / past nutritional status, which in turn directly or indirectly influence the pregnancy outcome.

The Joined Conference was organized by the support of WHO/ Pan American Health Organization / U.S. Agency for International Development/ Mother Care Conference on Maternal Anthropometry (1990), focused attention on identifying relevant anthropometric indicators for assessing the health status of adolescent women population. The conference discussed in detail the strength and weakness of single anthropometric
indicators related to the pregnancy outcome. In addition to this, the conference recommended the Body Mass Index (BMI) to be included along with earlier maternal anthropometric parameters to assess the pregnancy outcome. Cole et al. (1995) reported that infant head circumference and birth weights are influenced to a similar degree by maternal anthropometry. In contrast to the 1990 Joint Committee’s observation, Cole et al. (1995) stated that the BMI is less effective than the maternal weight for predicting infant birth weight.

1.4 Maternal Socio–Economic Status and Pregnancy Outcome

WHO (1991) stated that promoting reproductive health is achieved by a harmonious inter–relationship between humans and their environment and assessing the reproductive health of a community should include cultural, social, political, economic and health aspects. Environment represents the totality of physical, chemical, biological, behavioural and socio–economic factors. It also established a vicious circle in which poverty, poor homing and hygiene, lack of family planning, the pressure to have children together take a particular toll of woman’s reproduction.

Low Birth Weight rates vary widely with social and ethnic origin (Ventura, 1987 and Shiono and Klebanoff, 1996). Low Birth Weight differences are attributed primarily to socio–economic conditions strongly associated with different races (Institute of Medicine, 1985). It again stated that the more socio–economically disadvantaged groups are most likely to have low birth weight babies. Low socio-economic status often is associated with factors known to impair the rate of foetal growth, such as inadequate nutrition and smoking (US Department of Health and Human Services, 1986).
National Academy of Sciences (1985) focused the demographic characters such as low socio-economic status, low educational level, poor nutritional status, pregnancy induced hypertension, obstetric problems etc., are the factors responsible for low birth weight babies.

The national and regional estimates of the incidence of low birth weight babies are internationally recognized indicators of the well being of neonates and women of reproductive age. Such estimates provide specific information on the health of the pregnant women, the course of foetal development, and birth weight has been shown to be leading determinant of the chances of the survival of a new born (Mc Cormick 1985). Recently, the incidence of low birth weight was selected as one of the indicators for monitoring the health goals established by World Summit for children, i.e., to reduce the incidence of low birth weight (defined as < 2500) not more than 10%.

The Joint FAO / WHO Expert Committee on Nutrition (1967) declares that the additional nutritional requirements of the mothers should be considered on her puberty onwards, as it accelerate the growth and development of the foetus.

The population and public health studies take interest to research the association of birth rank, maternal age and birth space with pregnancy outcome. John and Albert (1984) reviewed that the ultimate number of birth (sib-ship size) has an effect on the pregnancy outcome. The joint FAO/ WHO Expert Committee (1967) reported that the birth weight depends on the parity. It also revealed that parity has a greater effect on the pregnancy outcome when compared with the maternal age in India, where the first
pregnancy is at a young age, the adolescent poor groups have the adverse pregnancy outcome.

Wyon and Gordan (1962) reported that short birth intervals have also been associated with infant birth weight in both developed and developing countries. In general, during the past decades women who bear children during their adolescent age have negative health, social and economic consequences. Rothenberg and Phyllis (1981) in their studies showed an inconsistent picture of the relationship between maternal age and infant health status. In a study of more than 13,000 births in Scotland, Douglas (1950) reported that the highest frequency of children with birth weights lower than 2500 grams occurred among women less than 20 years of age. Hardy et al. (1978) reported the mean birth weight of infants of women of 16 years old or younger to be 130 grams lower than that of children of older mothers. Chase (1983) and Lobi Weicher and Mellits (1971) also reported the positive relationships between maternal age and infant birth weight. In contrast to this, Sandler (1979) in his study found no relationship between mother's age and infant birth weight or birth length.

According to Stephen and Ventura (1989) a study in Columbia measured the educational attainment of women who become mothers at relatively older ages have a safe pregnancy outcome compared to the uneducated mothers. Demographic transition causes major shifts in the population which in turn influence fertility and female education. Africa shows the stronger educational differentials, Asia and Europe intermediate position and North America shows virtually no educational fertility differentials. When the education of the Columbian pregnant women was compared in
1970 and in 1989, in the later years the educational attainment had been increased tremendously. This knowledge made the mothers delay their first baby for their thirties and to have low birth order. The WHO (1995) stated that childbearing and making up of delayed first birth have been primarily confined to well-educated women.

Carmicheal and Abrams (2000) reported that since 1980, nearly half the women nearing their thirties having their first child were college graduates and showed better infant birth weight. The delayed first birth is due to the attainment of higher education by the womanhood.

Greater educational attainment is associated with more timely receipt of prenatal care and a better outcome in terms of birth weight. Ventura (1989) showed the studies with college graduate mothers of age 30-40 with first babies of only 5-8 percent low birth weight compared with 7-5 percent of all first births in uneducated mothers of the same age groups.

According to the WHO (1995) the prevalence of low birth weight ranges from 4% for China and USA and 28% for India (Pune). WHO recorded the highest mean birth weight in Ireland (3436 gm) and the lowest in India (Pune – 2633 gm). It also reported that Colombia, Cuba and Urban Nepal have the highest assisted deliveries of 25 percent and rural Nepal has the lowest ratio of 2.2 percent. Placek et al. (1980) found that in current obstetrical practice, over 95 percent women have at least once delivered babies by cesarean section. Launer et al. (1990) suggested that any hard physical labour during pregnancy has adverse effects on foetal growth. He also reported that pregnancy outcome is strongly associated with the characteristics of maternal employment. Mc Donald et al.
(1987) have associated the delayed foetal growth and preterm birth with the various types of maternal employment. Homer et al. (1990) found that employed mothers who are put up in psychological demands are more likely to deliver preterm low birth weight infants. They also reported that all the factors outside work experience are thought to influence pregnancy outcome.

1.5 Maternal Anthropometric Indicators and Pregnancy Outcome

WHO (1995) reported that maternal anthropometric indicators have been useful for screening women at nutritional risk, monitoring maternal nutritional status and predicting unfavourable infant outcomes related to low birth weight, prenatal, neonatal/infant mortality and poor infant growth. The above said facts are also supported by WHO, USAID, PAHO and Mother Care Organizations (WHO Bulletin, 1995)

The Maternal stature is more closely related to infant size, Cawley et al. (1954). They also reported that in some developing countries where under nutrition is widespread there are chances of low infant birth weight babies. Early pregnancies, inadequate gap between pregnancies, maternal diabetes and poorly nourished states of the upper socio-economic class mothers are being noted even in certain developed countries.

Maternal height is commonly accepted as a useful clinical indicator for the risk of obstetric complications particularly prolonged labour or delivery by operative means such as caesarean section or embryotomy. Its predictive value increases in combination with other measures such as pregnancy weight within populations where the average height of reproductive age females of low socio-economic status (SES) is around 150 cm (including India, Bangladesh, Indonesia and Colombia). Montagu (1962) has shown that
short mothers have babies of low birth weight than taller mothers, while the height of the individuals varies widely because of genetic factors. Butler and Boham (1963) reported that the height of a social group might validly be used as an index of its pre-adult social and nutritional experience. They have also reported during pregnancy maternal weight gain, weight for height and maternal arm circumferences are strongly associated with infant birth weight and its survival.

Bagchi and Bose (1962) found that well nourished mothers of higher socio-economic status delivered babies of higher birth weight when compared to the babies of the poorly nourished mothers in Calcutta. They also proposed the necessity of high pregnancy weight gain for favorable pregnancy outcome of women in the developing countries. Backstrand (1995) in his study concluded that at in all the periods of pregnancy the best predictors of birth weight was maternal weight and Body Mass Index (BMI) with the exception of upper arm circumference which showed little relationship.

Eastman and Hallman (1966) have observed that the maternal weight and height gain is related to toxemia/difficult births/maternal obesity. In contrast to this, Carmicheal and Abrams (2000) showed the existence of an association between a low rate of pregnancy weight gain and an increased risk of pre-term delivery. Later they found that excess maternal weight gain is associated with large infants i.e. macrosomia defined as greater than 4000g have a higher risk of birth injury dramatically increased.

In developing countries, large proportions of women are short and underweight and the number of low birth weight [lbwt] babies is particularly (more than 30% in South
Asia, 10-20% in other regions) with the incidence of infant birth weight being highest in low-income groups (Malvankar *et al.* 1994).

The percentage of underweight neonates in India amounts to 33% followed by Pakistan and Sri Lanka, which shows 25% underweight neonates (UNICEF, 1998). It also studied the birth weights of infants in Southern India and found that women in the small group enjoying a high income gave birth to babies with appreciable weight similar to that of developing countries.

Cole *et al.* (1995) in their study concluded that infant head circumference is significantly affected by sex, parity and maternal weight gain. They also suggested that the impact of maternal anthropometry on the infant head circumference is mediated through the birth weight. The authors have showed that infant birth weight is directly related to height and weight in late pregnancy, and also to weight gain in the third trimester. They have also reported that head circumference and birth weight are influenced to a similar degree by maternal anthropometry. They have concluded that the BMI is likely to be less effective than weight alone for predicting birth weight.

National Research Council (1981) published the guidelines to the Obstetricians and Gynecologists about the relationship of maternal weight gain to pregnancy outcome as follows:

- There is a direct relationship between maternal weight gain and mean birth weight,
- There is a direct relationship between maternal birth weight and pre-natal mobility and mortality,
• The pattern of sequential weight gain and the distribution of the weight are important clinical observations in addition to total weight gain.

During the past 50 years, recommendations for pregnancy weight gain have been highly controversial in the United States. During the first half of the century American Obstetricians restricted weight gain during pregnancy to prevent toxemia, difficult births and maternal obesity. William's Obstetrics, (Eastman and Hall man, 1966) a prestigious American textbook stated that “Excessive weight gain in pregnancy is highly undesirable for general reasons, it is essential to curtail the increment in gain to 12.5 kg. Carmichael and Abrams (2000) showed that there exists an association between a low rate of pregnancy weight gain and an increased risk of pre-term birth.

Holly et al. (1969) analyzed data from the prospective collaborative prenatal research study supported by the US National Institute of Neurological Diseases and Stroke (NINDS) and found that infants born with the birth interval of less than 12 months were of lower birth weight.

1.6 Maternal Elemental Nutrition in Developing Countries – Strategies Prospects and Challenges

Maternal nutrition is important for the health and reproductive performance of women, their health, survival and development of their children. In 1973 the WHO published a technical report (No. 532). This monograph represented the profound impact of twenty-one elements in the periodic table on human pregnancies. Widjaja et al. (1996) observed the influence of rapid economic development accompanied by modernized life styles in South East Asia which leads to the micronutrient deficiency
problems among various risk groups specially pregnant mothers similar to those of developed countries.

FAO / IAEA/WHO (1996) issued a joint publication indicating the essentialities of micronutrient requirement for the pregnant women. Following this, the International Atomic Energy Agency (IAEA) has organized a specialized group to study the problems of micronutrient deficiency in pregnant women particularly for the South East Asian Countries (Orville, 1997). The general objective of the workshop was to identify research opportunities and to develop new prophylactic and preventive strategies to reduce micronutrient deficiencies in the middle and high-income groups of South East Asian pregnant mothers. The workshop aimed to acquaint the participants with the biological background of micronutrient deficiencies in communities exposed to modern life styles. The workshop focused the attention to provide contemporary knowledge about micronutrient deficiencies in middle and high-income groups of pregnant women in Indonesia in particular and in South East Asian regions in general. It also developed recommendations for relevant future research and intervention strategies for maternal nutrition.

Swanson and King (1987) reported that the increased demand for elemental nutrition by the foetus is noted during the third trimester of pregnancy. Andrew (1996) stated that the hormone – induced – changes in certain maternal plasma proteins provide transport sites for the elements and this causes the normal physiological changes in the concentrations of existing elements within the maternal circulation. Several studies have confirmed the recommendation of the various committees on maternal elemental
requirement through individual case studies. They stated that maternal intake of essential trace elements are important for the developing foetus (Hurley and Swenerton 1966, Hambidge et al., 1975, Taper et al., 1985 and Nikolov et al., 1993). Buamah et al., (1984), Sutton et al., (1985) Speich et al., (1992) and Frel et al., (1993) have reported that the developing foetus requires substantial amount of essential elements during the later phase of pregnancy and more over premature babies have shown elemental deficiencies when compared to full term infants.

A study by Black et al. (1994) showed that micronutrient deficiencies particularly deficiencies of Fe and Vitamin B12, were frequent in women in Mexico. Jelliffe (1964), Merchant & Montorell (1988) and Jelliffe (1966) have revealed the association of closely spaced pregnancies with maternal elemental depletion. The importance of nutrition in young girls before their reproductive age and prior to pregnancy; have been insisted by Jose and Penelope (2000).

Leslie (1991) made an important distinction between being the pregnant women as targets and improving foetal growth as beneficiary. Maternal nutrition and the course of pregnancy have been insisted by the Food and Nutrition Board of the National Academy of Sciences Committee (1970). Again in 1990 the report was summarized about nutrition during pregnancy based on this report Allen (1994) published a report on nutritional status of the mother during pregnancy and lactation.

Accumulating data also suggest that micro nutrient requirements depend on the genetic characteristics and nutritional status of the women at conception (Jane & Paul, 2000) Kapu et al. (1989) reported about the developing countries with high parity and
very quick pregnancies could be the cause for the risk of elemental deficiencies in pregnant women. They have also stated that the foetus is an efficient parasite that gets its essential elements from the mother.

Cavdar et al. (1980) Chandra (1980) and Moser & Reynolds (1989) revealed that poor nutrition, high fibre and phytate contents of the diet, high exposure to infections could depress trace element status during pregnancy. They have also stated that children, pregnant and lactating women, the elderly and drug abusers are more vulnerable to such deficiencies than the population in general.

The WHO along with Food and Agricultural Organization (FAO) and Foundation of National Atomic Energy Agency (FAEA) organized an effort to update the monograph published by WHO (1973) on trace elements in human nutrition. The efforts have resulted with the issue of “Trace elements in Human Nutrition and Health” in March 1996. Widjaja et al. (1996) in their study stated the rapid economic development, accompanied by modernization of life styles in South East Asia, which leads to Micronutrient problems similar to those of developed countries. Therefore, in the coming decades, modern life-styles may in this way affect various risk groups, especially pregnant mothers.

In an International workshop on “Modern Life Styles and Micronutrient Deficiency” held in Nusa Dua, Bali on October 19-21, 1995, insisted the need to develop new prophylactic and preventive measures in middle and high-income groups in South East Asia.
In pregnant women, a low Zinc (Zn) status has been linked with spontaneous abortion (Bassiouni et al., 1979) pregnancy induced hypertension, toxemia and prematurity (Cherry et al., 1976, and Jameson 1981), anemia (Lazebnik, 1988) and enhanced infection (Antoniu et al., 1982 and Mukerjee et al., 1984). Maternal intake of essential trace elements is important for the developing foetus and severe restriction of Zn, for example provokes malformation or even death (Hurley and Swenerton 1966, Hambidge et al., 1975 Taper et al., 1985 and Nikolov et al., 1993).

Jameson (1981) studied 300 Swedish pregnant women and reported that abnormal pregnancy outcomes were associated with low plasma Zn levels in the first trimester. Sever and Emmanuel (1973) developed the hypothesis that Zn deficiency during human pregnancy is an important problem in the Middle East countries. They also proposed that endemic Zn deficiency among the poor is the cause of high rates of neural tube defects among Middle Eastern babies. Low levels of plasma and hair Zn concentrations were observed by Gibson and Huddle (1998) in the pregnant women of Nigeria, Egypt, Zeure and Malawi when compared to the pregnant women of developed countries. According to these authors Zn deficiency during pregnancy may have far-reaching consequences for maternal and foetal outcomes and subsequent child survival. It has also been proposed that the etiologic factors associated with Zn deficiency during pregnancy in less industrialized countries have not been established because of the customs and socio-economic status.

Mukerjee et al. (1984) showed the occurrence of Zn deficiency among pregnant women in the United States and described the associations between low maternal plasma
Zn levels in the second and third trimester and subsequent pregnancy complications in 394 women from Ohio. Neggers et al. (1984) and Hunt et al. (1990) showed that Zn supplementation on pregnancy outcome was less evident in a study of Mexican American women.

The concentration of urinary Zn increases during gestation, reaching a value nearly twice that of preconception. Increase in urinary Zn excretion during pregnancy is possibly because of an increase in the glomerular filtration rate (Rasmussen et al., 1997).

Maternal copper (Cu), Selenium (Se) and Zinc (Zn) dietary deficiencies have been shown to have serious deleterious effects on the growth and development of the foetus and could lead to congenital malformation and prematurity (Favier 1989). Cu and Zn intakes could be similar in developing and developed countries (Moser et al., 1988; Fergusson et al., 1989; Benemariya, 1992). Plasma Zn usually decreases during pregnancy, and plasma Cu levels increases considerably increase, owing to the elevation in ceruloplasmin and Estrogen levels (Estelle et al., 1992).

Kundu et al. (1981; Brophy et al. 1985 and Antilla et al. 1988) have reported that pregnant mothers with toxemia and pre-eclampsia are found to have hypercupremuria. Campbell (1988) found no differences in urinary Cu levels between normal and pre-eclamptic pregnant women. Supplementation trials showed beneficial effects and interactions occur among some trace elements and vitamins; a monotherapy with one of these trace elements may cause a deficiency in another (Estelle et al., 1992).

Cohen et al. (1994) and Troyer et al. (1993) suggested that lithium therapy in early pregnancy caused adverse pregnancy outcome and Li can also cross the human placenta.
(ACGIH, 1991). However, no information was found in the available literature on the sub-chronic toxicity of Li compounds to humans by the oral pathway (Dennis 1995). Trautner et al. (1955) reported that excess Li in the body can be excreted effectively through the urinary system and in turn, Li levels are maintained in a balanced state in the maternal system.

It is a well-known fact that Maternal Fe deficiency anemia increases preterm delivery and low birth weight (Scholl and Hedger 1994) and severe Zn (Masters et al., 1969; Apgar and Everett 1991) or Cu (Hall and Howell 1988) deficiencies result in embryonic death, small foetus and malformations. Foetal demand for Fe is increased in the last trimester of pregnancy as foetal absorption is increased at that time, leading to higher Fe concentrations in cord blood in comparison with that of the mother (Wleczorek et al., 1998) showed the relationship between Fe deficiency anemia and increased risk of preterm delivery. Scholl (2000) attempted to distinguish Fe deficiency anemia from the normal influences of pregnancy-associated hemodilution during gestation.

In a study of 44,000 pregnancies from Cardiff, Wales, Murphy et al. (1986) examined the prevalence of anemia in women who sought antenatal care by 24-weeks of gestation. Using data from >35,000 pregnancies followed in the Collaborative Prenatal Project (CPP), Klebanoff et al. (1989) concluded that the relationship between maternal anemia at the time of delivery and preterm delivery was an artifact of blood sample collection time. The same study revealed a weak association between anaemia early in the third trimester and preterm delivery. Andrew (1996) stated that Serum ferritin, Fe transferring or Fe binding capacity (TIBC) and hematological parameters are generally
sufficient to demonstrate Fe deficiency and low Fe with an increase in TIBC is indicative of Fe deficiency. Abel et al. (2000) stated that anaemia in pregnancy is a worldwide problem. They also reported that women in rural community should be made aware of Fe deficiency anaemia through information (regarding food habits), educational and communication (IEC). The Center for Diseases Control and Prevention (CDCP), U.S. (2001) has been working on the field to evaluate expensive methods for assessing serum Fe, TIBC (ratio) in developing and fewer developing countries.

Sean (2000) suggested that the supplementation of the Fe should be continued as early from the adolescent age onwards to have better Fe store for the pregnancy period and far pregnancy.

It has been long appreciated that the concentration of total Calcium (Ca) in maternal serum falls progressively during pregnancy, reflecting a decline in the protein bound portion of serum Ca. Ca ions are transmitted against concentration gradient through the placenta making the foetus hypercalcemic with respect to its mother in late pregnancy (Pitkin, 1975).

Much evidence has accumulated both in the form of laboratory evidence and results of clinical trials to support the relationship between Ca and blood pressure. Mc Carron et al. (1982) identified the relationship between reduced concentrations of serum ionized Ca and hypertension. To provide the increased Ca requirement of foetal bone mineralisation the maternal demand for Ca during pregnancy is elevated by as much as 300 mg /dl (Reeve, 1980). The normal increase of maternal blood volume and the pregnancy induced increase in urinary Ca excretion (Ritchie et al., 1998) occur in well-
nourished women. They also stated that additional Ca is normally provided to the maternal blood circulation by an increase in intestinal Ca absorption. Genelhu et al (1999) observed low intake of calcium might be involved in the development of gestational hypertension Frolich et al. (1992) suggested a possible beneficial effect on dietary Ca in the prevention and treatment of pregnancy induced hypertension (HT). Ritchie (2000) stated that there is an impairment in the Ca absorption and inadequate dietary Ca intake or both is unclear during pregnancy induced HT.

According to Bucher et al. (1996a) it is a well known fact that effect of Ca on blood pressure in the general population appears modest, Ca supplementation may be more relevant for certain subgroups, as in sodium-sensitive individuals, populations with inadequate Ca intake, and women with pregnancy induced HT.

Toth and Jothirujayarani (1998) in their patient information handout have explained the necessity of a pregnancy-induced hypertension to undergo a cesarean section of delivery. They have also stated that if the hypertensive severity increases, it leads to the risk of the foetus. According to their studies, the hypertension with few other symptoms quickly transforms into a more severe form termed pre-eclampsia if untreated with Ca supplementation.

Tuker (1999) states that in the severe pregnancy induced hypertension i.e., pre-eclampsia, the placental arteries are blocked with blood clots, thus reducing the amount of blood reaching the foetus. He also revealed that the above said facts are responsible for the delivery of smaller size babies by the pre-eclamptic women than the normal woman.
Sanders *et al.* (1999) stated that the serum Magnesium (Mg) concentrations are elevated in severe pre-eclamptic women when compared to women with uncomplicated pregnancy and are related to birth weight and gestational age at delivery. Lipincki (1998) in his study concluded that premature uterine contractility in women in the second trimester is accompanied by lowered serum concentrations of total Ca, inorganic phosphorus (P), Magnesium (Mg), total protein and albumin. They also reported that the Ca-P-Mg homeostasis is associated with the premature uterine contractility. Sanders *et al.* (1999) observed the Mg-induced vasodilatation to maintain adequate blood flow to the developing tissues and organs or immature parathormone function earlier in pregnancy. Pitkin (1975) reported that Mg and P are transported through the placenta making the foetus hyperphosphataemic and hypermagnesimic. Wester (1987) and Kelepouris and Agust (1998) reported that Mg-K-Ca are having synergistic effect in the human system.

Mimouni and Tsang (1991) in their review addressed the recent developments in the field of prenatal Mg metabolism. They also critically revealed the issue of possible teratogenicity of Mg deficiency, maternal hypermagnesemia and its effect on pregnancy, the foetus and the new born; the role of Mg in neonatal Ca homeostasis; and the possible relationship between Mg deficiency, prematured delivery and sudden infant death. The DASH study (Dietary Approaches to Stop Hypertension) found that greater Mg intake was significantly associated with lower risk of hypertension (Ascherio *et al.*, 1992).

The research conducted by Delemarre *et al.* (1999) revealed that International studies have yielded contradictory results on the efficiency of Sodium (Na) restricted diet
during pregnancy in preventing and curing HT of pregnancy. The authors found that no relationship exists between changes in Na restricted diet and in pregnancy. They also stated that dietary Na restriction from the third month of pregnancy onwards did not reduce the incidence of pregnancy induced HT and there is no place for dietary sodium restriction in the prevention and treatment of HT in pregnancy. Pike and Smiciklas (1972) suggested that Na restriction diet during pregnancy is unnecessary and dangerous for the mother or foetus.

Leeuw and Peters (1999) suggested that even in an early phase of pregnancy due to vascular resistance and decreased blood pressure, the kidney retains more Na and water. They also reported that in pregnancies complicated by HT and / or pre-eclampsia, body fluid volumes are low with an enhanced tendency to retain Na after a volume change. They also showed that lack of an apparent benefit of Na restriction suggest that, the practice of prescribing a low-salt diet to HT pregnant should be abandoned and there seems to be no reason in supporting a low salt diet as therapy for pre-eclampsia, since it does not affect the symptoms and might lead to hyponatremia in the newborn. Chesley (1976) and Davies (1976) revealed that restriction of Na–salt diet is associated with maternal socio–economic status, race and seasonal changes which yield conflicting results (Pike & Smiciklas 1972). Potassium (K) is found to maintain acid base balances and it works together with P and Na to maintain cellular activity and osmoregulation in the maternal system.
The belief of restricting Na salts in the pregnancy period is almost universal and the very often-prophylactic restriction in normal pregnancies was felt uncomfortable and dangerous for mother and foetus.

Tomalo (1994) experimented that the mean serum K concentration was decreasing with maternal age and parity and increased progressively with gestational age and K- Ca- Mg function synergistically and maintains normal blood pressure. Regarding the urinary excretions, Na-K goes hand in hand and stimulates the kidneys to maintain a balance during the pregnancy period. There exist slight disturbances in Na-K excretion due to hormonal induced mineral imbalance during the gestational period.

Evaluation of elemental exposure by analysis of hair is of increasing significance in certain age groups. ATSDR (2001) has convened a seven-member panel to review and discuss the current state of the science related to hair analysis, specifically its use in assessing the level of environmental exposures. On the whole, the amounts of trace metals internally deposited in hair may be used as indices of the duration and the extent of exposure and it is used as an indirect measurement of the total body elemental pool. Many heavy metals are found at relatively high concentrations in hair, because of their affinity for hair protein Hair accumulates trace metals to a greater extent than any other body tissues. Steeve (1992) stated that for nutritionally oriented practitioners, hair analysis is used for chemical diagnosis of diseases, rather than heavy metal toxicity and as an indicator of nutritional status. Mc.Kenzie (1979) and Ward (1990) have studied hair Zn content in relation to human health. Hair Cu in reproduction (Deeming and Weber 1978)
and in pregnancy (Klevey, 1970 and Vir et al., 1981) has reported that the hair Cu is a good indicator of maternal serum Cu levels.

Hair chromium (Cr) concentration (HCC) is usually considered by many researchers as a useful tool for assessing the Cr nutritional status of different groups (Hambidge 1974). Pregnancy is associated with a decrease in maternal HCC (Hambidge and Droegemueller 1974). This decrease is consistent throughout pregnancy only in women whose initial HCC is high but in women with low HCC the decrease is significant only in the third trimester (Saner 1981).

Toxic effects of heavy metals such as lead (Pb), Cadmium (Cd) and Mercury (Hg) are often found to be linked to the homeostasis of essential ions Pb, Cd, Zn, Fe and Se. RamaSasthri and Janson (1995) suggested a link between Cd content in the maternal tissues and low foetal birth weight in human pregnancies. Many heavy metals like Cr, Cd and Pb interfere with heme synthesis resulting in anaemia. Cd ions compete with Fe at the brush border membrane to decrease the intake of Fe into the intestine. This decrease may bring about the reduction of hepatic or renal Fe and cause anemia. Cd exposure for a long period, presents a possible risk for anemia (Sagawara and Sagawara 1991). In Fe deficiency, absorption of Cd is stimulated. Saner 1985, found a definite relationship between hair manganese (Mn) concentration of maternal and infant to that congenital malformations. He also theorizes that Mn deficiency may play a role as one potential factor in adverse pregnancy outcome. Mn is supplied to the foetus by a homeostatic mechanism, which depends on the Mn status of the mother. According to the same
author, prenatal Mn analysis of maternal hair may prove to be a reliable indicator for the pregnancy outcomes.

Many authors (Schramvel et al., 1988; Bralter et al., 1991 and Schumacher et al., 1996) revealed that the maternal elemental status is reflected by the trace elements in umbilical cord serum of newborns. Krachler et al. (1999) showed that a few elements are actively transported and few other elements showing block in their transport through the placenta. Aslam & Mc Ardle (1992); Waalkes et al. (1984); Page et al. (1988) and Goyer et al. (1992) showed that the elemental Zn uptake through the placenta depends on the placental uptake, utilization and release to the foetus, placental binding protein and placental metabolism. Chandra (1980) and Takada et al. (1992) have reported that the rapid growth of the foetus requires more nutrients than the adults. They also suggested that suboptimal placental transfer of elements from the mother to foetus causes growth retardation, anaemia and in turn adverse pregnancy outcome.

Carmina et al. (1997) suggested that transport proteins, affinity ligands, regulatory factors and transport mechanisms influence the elemental transfer via Umbilical cord.

From the above literature, it is understood that in the developed and developing countries, the maternal health and nutrition is affected by complex and highly interrelated biological, social, and cultural and health related factors. On the focus to overcome the challenges of maternal health and pregnancy outcome in India, it is necessary to put our scientific knowledge into action, identify biologically meaningful indicators and improve the understanding of physiological and social adaptive mechanism. Hence this present study has been undertaken to focus the following aspects as the objectives:
• To assess the elements in maternal serum, urine and hair in the high, middle and low-income pregnant women of rural urban and metropolitan sectors.

• To correlate the umbilical cord serum elements in the high middle and low-income mothers of rural, urban and metropolitan sectors.

• To analyze the correlation of maternal elements on pregnancy outcome using MLR model.

• To analyze the correlation of maternal anthropometry, socio economic status and health of the mother on pregnancy outcome using MLR model.

• To observe the correlation of infant anthropometry on pregnancy outcome using MLR model.

• To evaluate the influence of maternal socio economic status on the health of the pregnant women and the new born using logistic model, and

• To assess the impact of the maternal elements on pregnancy outcome using factor analysis.