Introduction

Chapter I

INTRODUCTION

Adolescence is a vital stage of growth and development. It is a period of life which is associated with growth spurt and attainment of puberty. Defined by WHO as individuals between the ages of 10 to 19 years, adolescents make up approximately 20% of the world's population (Unicef 2005). Although adolescence is a time of enormous physiological, cognitive, and psychological change, it is acknowledged that adolescents remain 'a neglected group'.

Ensuring Adolescent Nutrition is Important in the Women's Life Cycle

The onset of adolescence triggers a growth rate greater than in any other stage of human life except the first year of life. The adolescence period, especially early adolescence, is a very important age-group for interventions because,

- Adolescence is a period of profound growth and development. During adolescence, individuals gain about 15% of their ultimate height and 50% of their adult weight. This phase of growth and development leads to an increase in nutrient demands, which are also significantly influenced by infection and energy expenditure (Cordeiro, Lamstein, Mahmud and Levinson 2006).
- The period of early adolescence (10-15 years) is especially important from nutritional point of view as 80% adult growth occurs in this age group.
- Adolescent nutrition is the key to break the intergenerational cycle of malnutrition. Adolescence is a pivotal stage of the life cycle, and provides a unique opportunity to foster a healthy transition from childhood to adulthood and to ensure that the girl enters the reproductive phase adequately equipped with a good nutritional status (normal weight and height), absence of anemia and iron status.
- Early marriages make adolescents more vulnerable to nutritional deficiencies. Early marriages are common in India, though gradually the age of marriage is

rising. Pregnancy at a young age sharply increases the likelihood of poor pregnancy outcomes like obstructive complications and low birth weight of newborn, primarily because adolescents are still growing and may not be able to meet the demands of the growing fetus (Allan and Gillespie 2001).

- Need to combat existing nutritional deficiencies: The current scenario is dismal in India. Therefore, there is an urgent need to address the existing deficiencies of calories and other nutrients, especially the micronutrients. (Ananthakrishnam et al 2001).

Undernutrition and Micronutrient Deficiencies Co-exist

India is a developing country with a majority of the population belonging to poor socio-economic group. Lack of knowledge and ignorance of the parents and adolescent girls, regarding the need for balanced diet during this crucial period adversely affects the nutritional status of the girls and leads to undernutrition which adversely affects the growth in adolescents. Further, undernourished children are more susceptible to infections. Infections in turn lead to other health complications like loss of blood, hemoglobin, thus increasing the risk of developing micro and macronutrient deficiencies.

Literature reviewed shows a coexistence of high prevalence of anemia and undernutrition among younger and older adolescent girls, especially in developing countries. In one of the largest studies of rural school children in developing countries (Ghana, Tanzania, Indonesia, Vietnam and India), the overall prevalence of stunting and underweight was high, ranging from 48-56% for stunting and 34-62% for underweight (Partnership for Child Development 1998).

Tiwari and Seshadri (2000) reported a similar prevalence (60.3%) of anemia (Hb <12 g/dl) amongst Nepali schoolgirls (10-18 years). Almost one-third (31%) had BMI <16 Kg/m^2 and 50% had BMI between 16 and 17 Kg/m^2. In India, Verma et al (2004) reported that among adolescents the prevalence of anemia was significantly higher among those having BMI <18.5 vs. those with higher BMI.

Iron Deficiency Anemia (IDA)

Iron Deficiency Anemia (IDA) is a significant health problem the world over and throughout the life cycle especially among women and adolescent girls. Besides being a major threat to safe motherhood, anemia contributes to poor growth, lowered resistance to infections, decreased work capacity and poor cognitive development, which lead to high school dropouts and has an adverse impact on learning and adult productivity.

Iron is needed by the body in minute quantities, and yet plays a leading role in the production of enzymes, hormones and other substances, helping to regulate growth, activity, development and the functioning of the immune and reproductive systems. In IDA, physical work capacity (PWC) is reduced because the decrease in hemoglobin reduces the availability of oxygen to the tissues, which in turn affects the cardiac output (Beaton, Corey and Steel 1989). Further, in iron deficiency, changes in brain iron content and distribution, and in neurotransmitter function may affect cognition (Beard 2001). Anemia may produce scholastic under-achievement and behavioral disturbances in school children (Pollitt and Liebel 1976). Research on preschool children has shown that iron deficient children performed less well on psychomotor tests than did non-anemics (Bhatia and Seshadri 1993). Girls on marginal iron intakes may show compromised growth (Brabin and Brabin 1992). However, little is known as regards impact of anemia among children entering adolescence and those undergoing the pubertal growth spurt.

Prevalence of Anemia in Adolescent Girls

The period of pre-adolescence and early adolescence (9-14 years) is a vulnerable period for anemia. The cutoff level for public health significance is 40% prevalence of anemia according to WHO/UNICEF/UNU (1998). In India, it is above 70% in adolescent girls (IIPS 2006). The prevalence in the developing countries tends to be three to four times higher than in developed countries (Gillespie 1998).

In studies conducted in developing countries, Kruz and Johnson (1994) reported adolescent anemia as the greatest nutritional problem, which was highest (55%) in India, among all the six countries of the project. In a NNMB-MND survey (2003) in eight states of India, pooled prevalence of anemia among 12 – 14 years old was 68.7%, highest being in West Bengal (90.1%) followed by Orissa (82.1%).

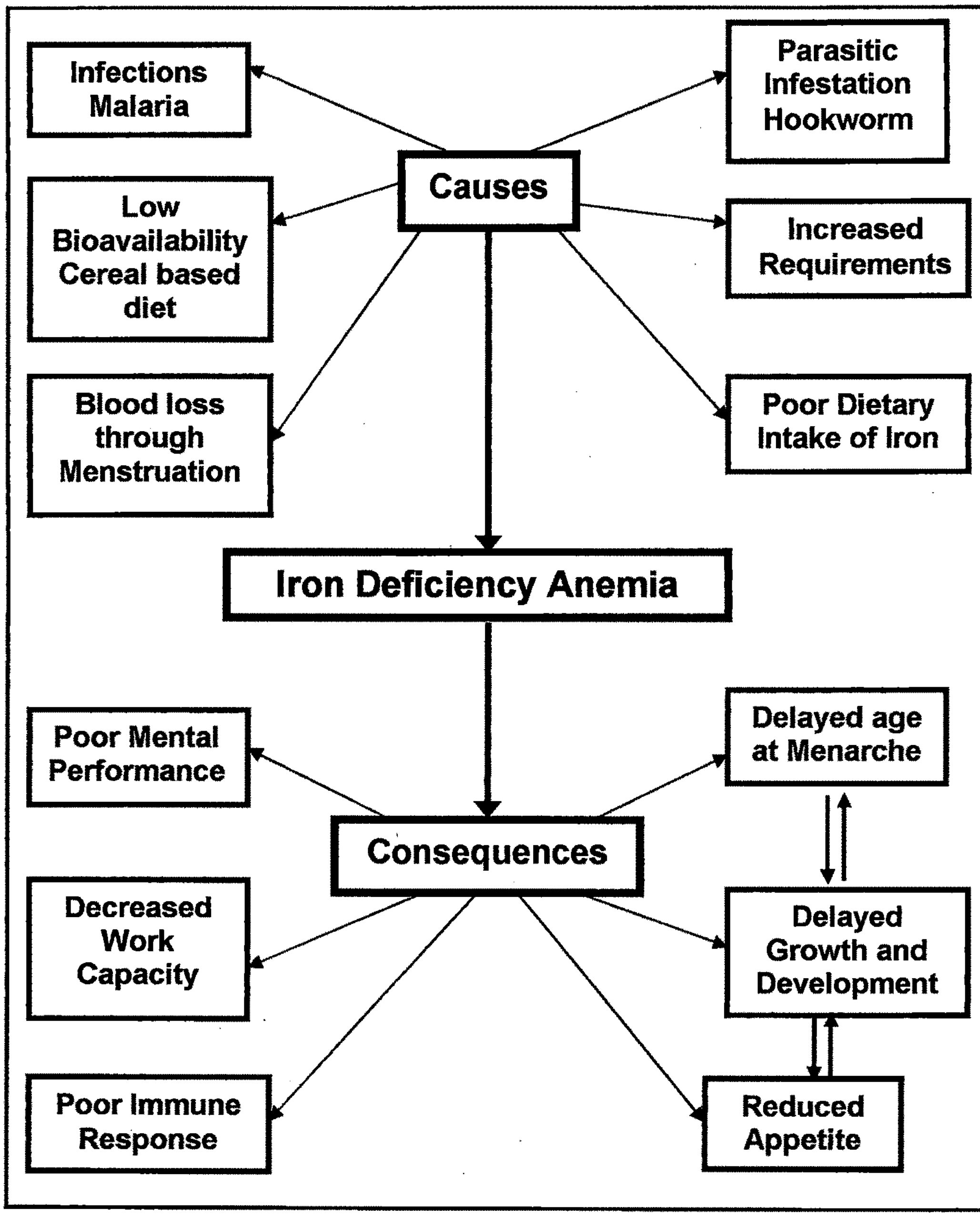
Using hemoglobin cut offs of 11 g/dl or 12 g/dl, anemia prevalence is reported to 55-75% in most studies reviewed in Gujarat. In India, Ahmedabad, 81.8% of school children (6-18 years) were reported anemic (Hb <12 g/dl) (Verma et al 2004). A study conducted in urban and rural Vadodara on secondary schoolgirls revealed that 75% of them were anemic (Hb<12g/dl) (Kotecha et al 2002). Research in the Department of Foods and Nutrition on urban school children over the past decade has also shown that over 70% are anemic (hemoglobin <12 g/dl) and a majority are growth retarded showing weight and BMI deficits. Thus, IDA is a public health problem among school age children and adolescents. It results in deleterious effects not only on hematinic status but also has serious implications on physical growth, mental development, work capacity and school performance.

Causes And Consequences of Iron Deficiency Anemia (IDA) In Adolescence

The most common cause of anemia is iron deficiency. The various factors that lead to reduced iron levels and anemia are highlighted below (**Figure 1.1**):

1. Poor Bioavailability of Iron: The bioavailability of dietary iron in our body is as important to iron nutrition as the amount of iron consumed. The average iron absorption varies considerably, ranging from 1 –5 % for plant origin foods and 10 – 25% for animal origin foods. The bioavailability of iron is low in predominantly cereal – based diets, as in India, because of presence of high content of iron inhibitors such as phytate. Tannates present in tea are also known to inhibit the absorption of iron when consumed with the meals. Among adolescent girls and pregnant women of Gujarat drinking tea with *thepla* or *bhakri* is common. Also

Figure 1.1: Etiology of Iron Deficiency Anemia



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insufficient 'iron enhancers' in the diet (foods rich in vitamin C – fruits) fail to increase the absorption of iron.

2. Increased Iron Requirements: Iron requirements are high during adolescence. Growth implies a corresponding increase in the total hemoglobin mass, and for this formation of new hemoglobin, iron is needed. The peak need for iron has shown to be more closely related to maximal growth spurt and maturation than to age (Sjolin 1981).

3. Dislike for Iron Rich Foods like green leafy vegetables especially among school children and adolescent is another reason for poor intake of iron. Poor intake may also be associated with lack of knowledge about these foods. ICMR reported that the average intake of iron is only about 50% of RDA in India (Toteja and Singh 2003).

4. Blood Loss (menstruation): The iron requirements remain high in adolescent girls after menarche to replace menstrual losses. Adolescent girls lose about 23 – 54 ml of blood per day containing approximately 15.5 mg of iron during menstruation (WHO 1995). The daily requirements for absorbed iron increase from 0.5 mg/day before puberty to 3.3 mg/day after puberty, which has to be compensated by increased intake.

5. Hookworm Infestation and Other Infections: Iron requirements are even higher in developing countries because of infectious diseases and parasitic infestation that cause iron loss. Chronic and recurrent infections can interfere with food intake and the utilization of iron.

6. Reproductive Health: Repeated pregnancies within less than 2 years interval does not give time to the women to get back to normal hemoglobin levels due to the earlier pregnancy. Further teenage pregnancy has adverse consequences on the young girls and makes them severely anemic.

Consequences of Anemia

Iron deficiency anemia results in several adverse consequences (**Figure 1.1**), as highlighted below.

1. Anorexia: Iron Deficiency Anemia leads to loss of appetite or anorexia. With loss of appetite the dietary intake of food decreases, in turn decreasing the growth and, also worsening the condition of anemia due to decreased micronutrient intake (Latham 1993).

2. Impaired Growth: IDA tends to delay growth and development in terms of weight and height gain in children, possibly because the adolescent on marginal iron intake cannot meet iron demands for growth. Sjolin (1981) reported that among adolescents, the increased requirement during puberty is in close relation to height and weight gain.

3. Compromised Cognitive Development: Iron deficiency impairs cognitive function thus compromising learning abilities. Anemic adolescent girls are at risk of compromised mental functions. Verbal learning and memory may also be impaired in iron deficient children and adolescent girls (Bruner et al 1996). This may produce scholastic under – achievement and behavioural disturbances in school children (Pollitt and Leibel 1976).

4. Poor Work Capacity and Productivity: The key role that hemoglobin plays in transporting oxygen accounts for the diminished work capacity (DeMaeyer 1989). Work output, endurance and maximal work capacity are impaired in iron deficient state. Anemia represents a major threat for tissue oxygenation; hence certain tissues and organs that require much oxygen may suffer resulting in diminished capacity to perform energy consuming tasks (Bothwell et al 1979).

5. Increased Morbidity: IDA may impair the immune system thus compromising health (Chandra 1976) and increasing risk of morbidity. Lowered resistance manifests itself in increased morbidity from diarrheal respiratory and other infections. There is a decrease in morbidity as the iron status improves (Chwang et al 1988).

6. Maternal Mortality Risk: When anemic adolescent girls become pregnant, they are exposed to additional risks. IDA during pregnancy is associated with premature delivery, low birth weight and increased prenatal mortality (Scholl et al 1992). Thus anemic adolescent girls face hazardous pregnancies.

Perception Regarding Anemia among Adolescent Girls

In most of the anthropological studies conducted using qualitative methods, it has been reported that most of the adolescent girls do not know about anemia. Further, among those who have heard about anemia, they have poor knowledge regarding its causes and consequences. Most of them consider '*Kamshakti*' i.e. anemia very common and believe that it does not need their attention (Kanani 2000).

Therefore, not only are these adolescent girls vulnerable to anemia, they are unaware of the causes and possible adverse consequences on their health.

Strategies for Prevention and Control of Anemia

To combat nutritional anemia and in order to meet the iron requirements, either the bio-availability of iron from their diets has to be improved (food based approaches) or the diets have to be supplemented with additional iron (non-food based approaches). Especially during severe anemia, usually it cannot be overcome by increasing the dietary intake alone. The strategies for control of anemia are (WHO 1998)

1. **Food Based Approaches**

- Diet Diversification: Dietary modification is primarily a strategy for improving the amount of food-iron ingested and its bioavailability. Effective nutrition education and communication can help girls to diversify their diets and meet their needs of absorbed iron.

- Food Fortification with Iron: Fortification refers to the addition to a food vehicle those nutrients that may or may not be present naturally in the food so as to improve its overall nutritional quality. Food fortification for anemia control is a long-term preventive approach.

2. Non-Food Based Approaches

- Supplementation with medicinal iron: There are various approaches of addressing the problem of IDA but the approach that has had wide support and action in developing countries is direct iron supplementation (IFA).
- Nutrition education, as an intervention, came into prominence with the realization that malnutrition to a large extent is not only due to inadequate food availability but also due to faulty food habits, some of them based on food prejudices, superstitions or taboos, and importantly, lack of awareness of the right food choices. Therefore, nutrition education is now placed at a level of priority equal to that of other interventions.
- Parasitic Disease Control: Public health measures for disease control, including helminth control, are complementary to the other approaches. They should be intensified in areas where IDA is strongly associated with high prevalence of hookworm or other parasites.

(Gillespie 1998)

In view of the focus of this study on iron-folic acid supplementation as an intervention to combat adolescent anemia, the following section deals with the issue of daily and intermittent IFA supplementation for adolescent girls.

Supplementation with Medicinal Iron

Iron folate supplementation has been considered an appropriate short-term measure to control anemia. Medicinal iron has an advantage of producing rapid improvement in the iron status and can be targeted to specific population groups (Gillespie 1998). Folic acid is also added to iron in view of the reported hazards of folate deficiency, especially increased risk of neural tube defects in the newborns. In India, to combat the pervasive problem of anemia, iron supplementation earlier in life cycle, that is, in the adolescent years, has been recommended as it is likely to improve hemoglobin levels, build iron stores and reduce morbidity (WHO/UNICEF/UNU 1998). If a woman receives IFA supplements in her adolescent years and helped to achieve normal stature and weight as well as adequate iron stores, she enters reproductive years with better chances of normal pregnancy and giving birth to healthy newborns. Besides, adolescent girls may experience other benefits like reduced anorexia, better growth and development and improved learning in school years (Kanani and Poojara 2000).

According to Gillespie (1998), the total iron requirement for girls is 1.62 mg/day and about one fifth of the total iron is required for growth. To maintain normative levels of iron storage, in addition to supporting all recognized functions of iron, the dietary iron absorbed would be about 2.5% and the adjustment factor would be 40. Therefore the diet needs to provide about 64.8 mg/day iron for adolescent girls. Studies conducted in the Department of Foods and Nutrition reveal that the iron intake of adolescents is much less than this recommended intake or even the ICMR RDA of 19 mg/day (ICMR 1991). In a study by Kanani and Ghanekar (1995), consumption of iron among 10-19 years old girls was as low as 10 mg/day.

Considering the total iron requirements, there is a wide gap between iron need and intake. This gap needs to be addressed by providing additional iron through supplementation.

Daily versus Intermittent Supplementation

Daily iron folic acid supplementation has shown positive impact on hematinic status as well as growth, cognitive abilities and physical work capacity, according to studies in India and Kenya (Kanani and Poojara 2000, Grantham-McGregor and Ani 2001, Lawless et al 1994). However, daily supplementation is believed to lead to intestinal fatigue as suggested by the Mucosal Block Theory (Viteri et al 1995). This reduces the efficacy of daily supplementation. The efficacy of daily supplementation is questioned on the basis that repeated challenges with high dose of iron daily may produce intestinal mucosal tiredness and reduce efficiency of iron absorption leading to a progressive decrease in proportion of iron absorbed. As the mucosal turnover time is one week, it is believed that the net iron absorption at the intestinal mucosa whether given weekly or daily, may be similar. Besides the biological reason, a programmatic reason favouring intermittent and not daily, IFA supplementation is the increased chances of better compliance of the beneficiaries, and low cost.

A debate has developed in the past few years regarding the desirability of intermittent iron-folate supplementation compared with daily iron-folate supplements. The primary proponents of the intermittent approach say that the compliance is low with many daily supplementation programs as the prevalence of side effect increases. Further, there is a strong need to improve the coverage of at-risk populations when resources are limited, and this is more likely when IFA is given intermittently. Thus, intermittent doses may reduce side effects, increase compliance, and reduce cost. The cost reduces to one-seventh if IFA given once weekly, and is also more feasible to administer in field settings. Program experience and operational research indicates that once weekly IFA have led to significant benefits on Hb levels among adolescent girls.

The Adolescent Anemia Reduction Program: One of the goals of Gujarat State Nutrition Policy is reduction of malnutrition of all types including micronutrient deficiency among children, adolescent girls and women in childbearing age. Thus, the Government of Gujarat is implementing a state wide *Adolescent Girls' Anemia Reduction Program* in all the secondary and higher secondary schools with UNICEF support wherein each girl is given once weekly IFA under supervision of class teacher or class monitor. Impact evaluation of the initial pilot project in Vadodara after one year of once weekly IFA supplementation showed a significant reduction in anemia by 20% from baseline levels (75% to 50%) (Kotecha et al 2002). Direct supervision was a key factor in the success of this program, and schools where teachers and principals were enthusiastic and co-operative showed better coverage and compliance.

From a review of studies in different countries, Beaton and McCabe (1999) concluded that weekly supplementation should be introduced only when there is evidence that compliance will be high (e.g. under supervised administration) as in schools. According to them, supervised distribution of once weekly iron-folate supplements to adolescent girls is reported to have similar benefits on Hb levels as daily supplements, if given under supervised conditions as in schools.

In a study done by Berger et al (1997), on 3-8 years old anemic school children in Bolivia, the increase in hemoglobin was not significantly different between the 5days/week and 1day/week supplemented groups (1.52 ± 0.69 gm/dl in weekly group and 1.86 ± 1.11 gm/dl in 5 day/week group). Though weekly supplementation has shown impact on hemoglobin levels, no significant impact was seen on growth as measured by BMI (Kanani and Mutreja 1998, Kanani and Sen 2001). The impact evaluation of the Adolescent Girls' Anemia Control Program in the Vadodara pilot study also reported that BMI benefits were not as marked as hemoglobin changes after a year of weekly IFA supplementation (Kotecha et al 2002).

Need For Addressing Anemia at A Younger Age: In Primary School Children

It is known since long that it is the earlier phase of adolescence (10-15 years), especially the pre-menarcheal phase, that shows rapid gains in weight and height, and in later adolescent years (16-18 years) growth slows down. Srikantia (1976), many years ago, in his excellent review of adolescent growth and development, stated that 80% of weight and height gain of adolescents takes place during 10-15 years.

Thus, it is worthwhile to explore if initiation of iron supplementation in early adolescence will benefit girls in early adolescence who are undergoing the pubertal growth spurt and their nutrient needs are high (including iron needs). If supplementation is started early in primary school years, when the girl is 9 or 10 years, both hematinic status and growth may be improved. Further, instead of food as an enhancer of adolescent pubertal growth, iron may be more feasible and less expensive.

Further, IFA may also improve school performance. IFA supplementation to school children in early adolescence may also improve school performance, physical work capacity and cognitive functions and thereby their quality of school life. These aspects needs further study. We also do not know whether the above functional benefits are better enhanced if IFA is given twice weekly rather than once weekly.

The school setting offers an ideal distribution system for public health interventions owing to better chances of supervision and compliance. The support from the school teachers, parents and children themselves, can be enlisted to deliver iron supplements. Thus, giving intermittent iron-folate supplements through primary schools (where girl student's enrolment is higher compared to secondary schools) is an area that merits attention and systematic research.

Therefore, the present research was undertaken with the broad objective **to study the impact of daily and intermittent (once and twice weekly) iron folic acid supplementation on hemoglobin levels, pubertal growth, food and nutrient intake, cognitive function and physical work capacity among underprivileged primary school going girls in early adolescence (9 –13 years) of Vadodara.**

The relevant literature is reviewed in the next chapter.