Review Of Literature

MALNUTRITION

Malnutrition at its fundamental biological level is inadequate supply of nutrients to the cell. On a biological level, nutritional deficiency disorder may be classified as primary or secondary, according to the availability of the nutrient. A primary deficiency disease is a disease that results directly from dietary lack of specific essential nutrients. A secondary deficiency disease is a disease that results from the inability of the body to use a specific nutrient properly. Such inability may result from either two general type of failure

1. Failure to absorb the nutrients from the alimentary tract into the blood
2. Failure to metabolize the nutrients normally after it has been absorbed

Undernutrition is considered to be the underlying cause of more than 50% of all childhood deaths in the world. Undernutrition diminishes the ability of all systems of the body to perform properly, with particularly grave consequences in young children. The relationship between underweight status and ill health, however, is complex because ill health often results in Undernutrition and Undernutrition increases susceptibility to disease, particularly severe disease. Numerous studies have demonstrated associations between Undernutrition and growth retardation, impaired mental development, and increased susceptibility to infectious diseases.

MALNUTRITION WORLD WIDE

More than one-half of the 9.7 million child deaths worldwide are linked to under nutrition. Malnutrition alone not only kills, but also exacerbates the burden of infectious diseases (USAID 2009). World Health Organization in 2002 estimated that more than 3.7 million deaths could be attributed to underweight. Since deaths from under nutrition occur among young children, the loss of healthy life years is even more substantial.

In developing regions, children in rural areas are more likely to be underweight than children living in cities. In part of Asia and in Latin America the relative disparity actually increased between 1990 and 2008. In eastern Asia, there was a striking increase in the rural/urban ratio from 2.1 to 4.8, indicating that in 2008 children in rural area were almost five times as likely to be underweight as children in urban areas.

All the same time, south eastern Asia, sub Saharan Africa and northern Africa have succeeded in reducing child malnutrition more rapidly in rural area and in narrowing the gap with the urban population, demonstrating that more equitable progress is indeed possible.

Across the developing world, children from the poorest household are twice as likely to be underweight as children from the richest household. The disparity is more dramatic in regions with a high prevalence of underweight children. This is the situation in southern Asia, where as many as 60 % of the children in the poorest families are underweight, compared to about 25 % in the richest households (Millennium Development Goal 2010).

MALNUTRITION IN INDIA

India ranks first with 39% of global share for underweight children with 47% of prevalence (UNICEF 2006). According to Krishnaswami 2000 and Measham and Chatterjee 1999, half of the world's undernourished population lives in India. According to World Development Indicators 2007, with 47% of low weight for age; India ranks 3rd amongst the countries with highest level of child malnutrition next to Nepal and Bangladesh.

The prevalence of under nutrition tended to increase from about 63% among 6-9 year age group to 78% in 10-13 years and then decreased to 66% in 14-17 year age group of children. Though no significant sex differences in the prevalence of under nutrition were observed in 6-9 and 10-13 year age groups, a relatively higher proportion of boys (73%) in 14-17 year age group were found to be undernourished as compared to girls (60.4%) (NNMB 2001).

A study conducted by NIN on rural adolescents revealed that 39% of the adolescents were stunted (<Median -2 S.D. of NCHS height for age) irrespective of sex. The prevalence of under nutrition (<median -2 S.D of NCHS weight for age) was higher (53.1%) in boys than in girls (39.5%). The extent of stunting was higher (42.7%) among adolescents belonging to the scheduled caste community. In the case of girls, the extent of underweight was considerably less in each age group than boys (Venkiah et al 2000). **Table 2.1** gives an overview of the prevalence of under nutrition in various parts of India. As can be seen, various studies substantiate the magnitude of the problem of undernutrition among school age group children.

Studies have shown that the rural children are more likely to be underweight than the urban children. Further, poor children are twice more likely to be underweight than the rich. However, little difference is seen in underweight prevalence of boys and girls (MICS & DHS surveys 2003-2008).

MALNUTRITION IN SCHOOL GOING CHILDREN

School age group (5-18 y) spans the period between preschool years and adult life. The number of school age children continues to rise. The total number of children out of school is decreasing from 106 million in 1990 to 69 million in 2008. The gender gap in the out of school population has also narrowed. The share of girls in this group decreased from 57 % to 53 % globally between 1999 to 2008.

Table 2.1: Prevalence of Undernutrition in various parts of India

REFERENCE	PLACE	AGE (y)	PREVALENCE (%)
Bose et al 2008	West Bengal (rural)	6-14	Underweight: 16.9 Stunting: 17.2 Thinness: 23.1
Pandaya et al 2000	Ludhiana	5-16	Wasting:52.2 Stunting:26.3
Deshmukh et al 2006	Wardha	6-14	Underweight: 53.8
Kapoor & Aneja 1992	Delhi	10-18	Stunting Girls: 35.5
Patil & Wasnik et al 2009	Maharashtra (rural)	5-12	Underweight:19 Stunting:30.3 Thinness:16.8
Anand et al 1999	Haryana (rural)	12-15	Thinness (M):43.8 (F):30.1 Stunting (M):41 (F):37.2
Chaturvedi 1996	Rajasthan (rural)	10-18	Underweight Girls: 79
Jude et al 1991	Vellore	13-18	Underweight Girls:48.8
Das & Bisai 2008	West Bengal	13-18	Undernutrition: 28.60 (M): 37.59 (F): 19.43
Rao et al 2003	Madhya Pradesh	11-19	Undernutrition: 61.7 Stunting: 51.7 Wasting: 32.8
Mukhopadhyay et al 2005	West Bengal	11-14	Undernutrtion: 36.49% (M): 41.08: (F): 30.61
Iyer et al 2005	Baroda	10-18	Underweight: 41.2

M – Male, F - Female

In 2008, there were 96 girls for every 100 boys enrolled in primary school. Poverty puts girls at a distinct disadvantage in terms of education. Girls of primary school age from the poorest 60 % of household are 3 times more likely to be out of school as those from the wealthiest household (The MGD report 2010).

India's education system is the second largest in the world after China. About 21.8% of the country's population comprises of school going children and there are still about 21 million children who are unable to attend school (IES 2007). According to NFHS-3, 90.1% of the 6-10 & 74.2% of 11-14 y old children attended primary school in 2005-06. Though the number of children of primary age group who were out of school has dropped by 33 million since 1999, still 72 million children worldwide were denied the right to education in 2007 (MDG Report 2009).

In India, according to UNICEF (2008), the prevalence of malnutrition in school going children varied across states, with Madhya Pradesh recording the highest rate (55 %) and Kerala showing the lowest prevalence of 27%.

IMPORTANCE OF NUTRITION IN THIS AGE

School going children are the future generation of any country and their nutritional needs are critical for the well being of society. In SEAR, a large number of children suffer from chronic malnutrition and anaemia, which adversely impacts their health and development (WHO 2006). The complex myriad of physiological as well as psychological changes, accompanied by rapid growth and increase in physical activity, creates special nutritional needs that are higher during adolescence than at any other time in life. Failure to consume adequate diet at this time can potentially retard physical growth, intellectual capacity and delay sexual maturation (WHO 1999). Addressing the nutrition needs of school going children could be an important step towards breaking the vicious cycle of intergenerational malnutrition, chronic diseases and poverty. Epidemiological evidence from both the developed and developing countries indicates that there is a link between foetal under-nutrition and increased risk of various chronic diseases during adulthood (ACC/SCN 2000).

School going period is considered as a nutritionally critical period of life for several reasons:

- Firstly, the dramatic increase in physical growth and development puts greater pressure on the need for nutrients. During this period, children will experience a weight gain equivalent to 65% of their weight at the beginning of the period or 40% of their final weight, and a height gain equivalent to 15% of their adult height (Brasel 1982).

- Secondly, there may be socio-cultural factors or change of lifestyle and food habits of children that can affect both nutrient intake and needs (Spear 1996).

- Thirdly, growing children have increased nutrient requirements (Scholl et al 1994, Story et al 1999).

- Fourthly, school age can be the second opportunity to catch up growth if environmental conditions, especially in terms of nutrient intake are favorable (Gopalan 1989).

- Finally, psychological changes and development of their own personality can impact on their dietary habits during a phase when they are very influence-able (WHO 2006).

School going children have typically been considered a low risk group for poor health, and often receive few healthcare resources and scant attention. However, this approach ignores the fact that many health problems later in life can be improved or avoided by adopting healthy lifestyle habits in adolescence (World Bank 2003).

Good nutrition during school age is critical to cover the deficits suffered during childhood. Dietary intake with respect to adequate availability of food in terms of quantity and quality (particularly, the mean caloric intake), ability to digest, absorb and utilize food and the social discriminations against girls can greatly affect the adequate nutrition of these children (WHO 2006).

Studies in India and Bangladesh have shown deficiencies in the intake of all nutrients, particularly iron, calcium, vitamin A and vitamin C. The reported reasons are mainly the low educational level of parents and low family income. The nutritional deprivation affects almost all growth parameters and final adult body size resulting in thinness and stunting. However, nutritional status of both boys and girls improved with age, showing that the effect of malnutrition is more pronounced at the time of peak growth. The prevalence of protein energy malnutrition (PEM) is high in most countries of the SEA region (FAO 2005)

IMPORTANCE OF NUTRITIONAL ASSESSMENT

The best global indicator of children's well being is growth. The assessment of growth not only serves as a means of evaluating the health and nutritional status of children but also provide an excellent measure to decide future action. Growth is the fundamental physiological process that characterizes childhood. Secular trends in growth show the level of health of the population group. Growth monitoring is a screening tool to diagnose nutritional chronic systemic and endocrine diseases at an early stage.

Growth monitoring has the potential for significant impact on mortality even in absence of nutrition supplementation or education. Growth trends are an essential tool in pediatric practice. Their value resides in helping to determine the degree to which physiological needs for growth and development are being met during important childhood period (Mercedes De 2009).

Nutrition monitoring helps to assess nutritional problems prevalent in the community, in terms of their nature, magnitude and distribution among the population groups as well as geographical areas. Such monitoring over a period of time gives us an opportunity to study the changes occurring over a period of time. This information is necessary to evolve policies, to formulate appropriate programs and implement the same for the prevention and effective control of nutritional deficiency disorders. It highlights the need to evaluate the ongoing nutrition programs, identify bottlenecks if any and to initiate corrective steps, wherever necessary (Brahmam 2005).

Secular changes in growth and development can be considered as the changing pattern of nutritional status of children. The best way to measure nutritional change of children is taking the anthropometric measurements of children.

Anthropometric indices

Measurements by themselves are incomplete unless they are associated with other measurement. Thus anthropometric indices are derived from combination of raw measurement (WHO 1995; Gibson 2005). Examples of anthropometric indices are weight for age, height for age, weight for height, BMI for age etc. These indices are essential for the interpretation of measurements as it is evident that a value of body weight alone has no meaning unless it is related to an individual's age or height. These indices are expressed as Z scores, percentiles or percentage of the median. Further, these indices are used to compare an individual or a group with a reference population.

1. Weight for age

Weight for age reflects the body mass relative to chronological age. The advantage of this index is that it reflects both past (chronic) and present (acute) Undernutrition. Because of its simplicity and the availability of scales in most health centers in low income countries, weight for age index is commonly used to assess the nutritional status of children. It is commonly used for monitoring growth and to assess changes in the magnitude of malnutrition over a period of time. A major limitation of using weight for age is that it reflects both weight for height and height for age. It fails to distinguish tall, thin children from those who are short with adequate weight/more weight.

Nutritional terms for weight for age

- Low weight for age: Underweight

The term "underweight" is commonly used to refer to the underlying pathological processes of low weight for age (WHO 1995). It is described as gaining insufficient weight relative to age or losing weight and is obtained as weight < 2 SD of sex specific references data relative to age.

International references/standards which provide weight for age

Many countries have collected anthropometric data and developed their local growth references for different age group. The growth references/standards are developed and reported as Z score and percentiles. The commonly used and recognized international growth standards for assessing underweight in children using weight for age as an index are:

- NCHS/WHO 1977 growth standards
- Center for Diseases control and prevention (CDC) 2000 growth charts
- WHO 2007 growth references (5-9) years
- WHO child growth standards 2006(0-71 months)

The NCHS/WHO 1977 and CDC 2000 provides age and sex specific weight for age data for children from birth to 18 years and birth to 20 years respectively

(Hamill et al 1977; WHO 1983, 1995; Kuczmarski et al 2000 2002). WHO 2007 provides weight for age index for children between 5-10 years of age (de onis et al 2007; WHO 2007).

2. <u>Height for age</u>

Height for age reflects the achieved linear growth and its deficits indicate long term cumulative inadequacy of human health and nutrition. It cannot measure short term changes in malnutrition. Height for age is primarily used as a population indicator rather than for individual growth monitoring.

Nutritional condition identified for height for age

- Low height for age: Stunting or shortness

The term "stunting" is commonly used to refer to the underlying pathological processes for low height for age (WHO 1995). It is described as gaining insufficient height relative to age and is obtained as height<-2SD of the sex specific references data relative to age.

3. <u>Weight for height</u>

Weight for height measures the body weight relative to height and helps to identify current or acute Undernutrition. It is normally used as an indicator of current nutritional status and can be useful for screening children at risk and for measuring short term effects such as nutritional stress brought by illness. It is important to note that weight for height is not a substitute for weight for age or height for age, since each index reflects a different combination of biological processes.

Nutritional condition identified from weight for height

- Low weight for height: wasting

The term "wasting" is commonly used to refer to the underlying pathological processes of low weight for height (WHO 1995). It is described as gaining insufficient weight relative to height. It indicates current or acute malnutrition resulting from failure to gain weight or actual weight loss. Causes for wasting includes inadequate food intake, infections etc. Wasting in individual children and population group can change rapidly and shows marked seasonal patterns associated with changes in food availability or diseases prevalence, to which it is very sensitive.

4. <u>BMI for age</u>

Body mass index (BMI) is calculated from a person's weight and height and is obtained as the individual's body weight (in Kgs) divided by the square of his or her height (in meters). It is the only indicator that includes all the three measurements of weight, height and age. In recent years, it has become the most widely used diagnostic tool for screening and identifying underweight, overweight and obesity in population for both adults and children.

BMI for age overcomes the complication of weight for age index:

Weight for age, when used alone, makes the interpretation of the nutritional status assessment complicated. For example, a high weight for age may be simply because the child is overweight or it may be owing to the child being tall. Similarly, a low weight for age may be because the child is actually underweight or it may be that he is misclassified as underweight owing to his short height though he may have an appropriate weight for that short height. Therefore, weight for age alone, without taking height of the child into account, provides incomplete information regarding his/her nutritional status.

The NCHS/WHO 1977 and CDC 2000 growth references report the weight for height index, which compares the child's weight to the average weight of children of the same height. The weight for height index thus ignores the age of the child and allows the nutritional status assessment in situations when age is not known. However, this index is based on a major assumption that, on an average, children of a given height, weight the same whatever is their age. However, this assumption is not true as the weight and height relation depends on age, especially so during infancy and adolescence (Cole 1985).

International references/ standards which provide BMI for age index

The commonly used and recognized international growth reference/ standards for assessing BMI for age in children and adolescents are:

- WHO BMI for age 1995 reference (9-24) years (Must et al 1991)
- Center for diseases control and prevention (CDC) growth charts
- WHO 2007 growth reference (5-19years)
- IOTF cut off points (cole et al 2000) and thinness cut offs (cole et al 2007)
- WHO child growth standards 2006 (MGRS)

WHO BMI age reference (1995) reported BMI for age percentile for male and female adolescents 9-24 years of age (Must et al 1991; WHO 1995). The CDC 2000 references provide age and sex specific BMI for age data for children between 2-20 years (Kuczmarski et al 2000, 2002). WHO 2007 provides BMI for age data for children between 5-19 years (De onis et al 2007; WHO 2007).

Anthropometric references and standards

A growth standard defines a recommended pattern of growth that has been associated empirically with specified health outcomes and the mineralization of long term risk of diseases. The growth standard is developed using the reference data from populations that have stabilized in terms of secular increment in anthropometry and that have not been subjected to discernible external constraints on growth (dietary deficiencies, infections etc) (Butte et al 2000).

Strengths of NCHS/WHO 1977 growth standard

The NCHS/WHO 1977 growth standard was based on three national US data sets which were samples collected from non obese populations with expected heights. During this period of data collection, the US population did not show high prevalence of overweight or obesity. Therefore the data which was collected is not considered to be skewed towards high rates of overweight and obesity, which was observed in subsequent (NHANESIII) national survey of USA.

Drawbacks of NCHS/WHO 1977 growth reference

- In the current scenario, where the prevalence of overweight and obesity is rising globally, the BMI for age is recommended to be used as an index of assessing the prevalence of thinness, overweight and obesity. However, the old NCHS/WHO 1977 growth references did not report the data in terms of BMI for age index.
- Though the NCHS/WHO 1977 growth reference reported the weight for height index, but it was done so only for prepubescent children with limited heights (90-145 cm for boys and 90-137 cm for girls)
- The percentile were not developed using any sophisticated statistic method, which resulted in wiggly percentiles

Strengths of CDC 2000 growth chart

- The CDC 2000 charts were extended till the age of 20 years
- A major feature revision to the CDC 2000 growth charts was the inclusion of the BMI for age index
- The BMI for age index helped in replacing the weight for stature index which was only for prepubescent children with limited height
- The CDC 2000 growth chart used more sophisticated smoothening procedures of the LMS method for developing the percentiles. Therefore, the percentiles in the CDC 2000 were smoother non wiggly percentiles
- The NCHS/WHO 1977 growth reference suffered from a disjoint in the length for age and height for age of children between 2-3 years of age. The CDC 2000 corrected this disjunction

Drawbacks of CDC 2000 growth charts

The CDC 2000 growth charts suffer from one major limitation. The data set included two additional US national survey of NHANES II (1976-80) and III (1988-

94). The data from these two surveys is skewed towards overweight and obesity. Though children > 6 years from NHANESIII have been excluded, it is still based on right skewed US population, and data was collected at a time when transition towards obesity was ongoing in US. In contrast, the NCHS/WHO 1977 growth standards were based on non obese US population with expected heights.

WHO 2007 growth reference (5-19 years)

Strengths of WHO 2007 over NCHS/WHO 1977

- In this new WHO 2007 reference the BMI for age index has been made available for school children and adolescents (5-19 years)
- This new BMI for age has replaced the weight for stature index, which suffered with prepubescent and height restriction
- State of art sophistication smoothening procedures have been used for developing the percentiles, giving smoother non wiggly percentiles
- Provides a smooth transition from WHO 2006 child growth standards (0-5 yrs) and current WHO 2007 growth reference (5-19 yrs)
- Provides a uniformly merged international reference for 0-19 years
- No disjunction between length and stature from 2-3 years seen in NCHS/WHO 1977

Strengths over CDC 2000

- As compared to the CDC, the WHO 2007 provides a wider range of percentiles

Drawbacks of the WHO 2007 growth reference

- Unlike height and BMI for age, the WHO 2007 growth reference reports weight for age index for age 5-10 years instead of 5-19 years. In developing countries, where the height measurements and BMI calculations are still in the process of gaining importance, weight measurements alone may be used for nutritional status assessment, owing to their ease in measurement. Therefore, the need for the weight for age index for 11-19 years may be deeply felt in such situations.

Comparison of different international references available

A concise Table (**Table 2.2**) comparing the international references of NCHS/WHO 1977, CDC 2000 and WHO 2007 are shown. The detailed comparison revealed that for school aged children; the WHO 2007 growth standards may be the preferred option to be used as an international reference.

MICRONUTRIENT MALNUTRITION

Micronutrient malnutrition i.e. insufficient dietary intake of nutrients such as vitamin A, iron and iodine- affects the health and survival of more than 2 billion people worldwide. Deficiency of these three micronutrients is closely linked with childhood illness and mortality (OMNI 1996). Micronutrient deficiencies are the reason for both death and disability among the South East Asian Region (SEAR) children. According to the WHO, 1 out of 3 people in developing countries are affected by vitamin and mineral deficiencies. The most important in terms of health consequences for poor people in developing countries are:

VITAMIN A: Vitamin A Deficiency (VAD) can cause night blindness and reduce the body's resistance to disease. In children VAD can also cause growth retardation. Between 100 and 140 million children are vitamin A deficient. An estimated 250,000 to 500,000 VAD children become blind every year; half of them are dying within 12 months of losing their sight (WHO 2010).

The estimated prevalence of VAD is 23.4%, suggesting that there are ~83 million VAD school-aged children in the region, of whom 10.9% (9 million, at an overall prevalence of 2.6%) have mild xerophthalmia (night blindness or Bitot's spot). Potentially blinding corneal xerophthalmia appears to be negligible at this age (Singh & West 2004).

Table 2.2 Comparison of all the growth standards

	NCHS/WHO 1977	CDC 2000	WHO 2007
Year of release	**1977-1978**	**December 2000**	**September 2007**
Data sets included	NHES II NHES III NHANES I	NHES II NHES III NHANES I NHANES II NHANES III	NHES II NHES III NHANES I WHO growth standards
Period of survey	1963-1965 1966-1970 1971-1974	1963-1965 1966-1970 1971-1974 1976-1980 1988-1994	1963-1965 1966-1970 1971-1974 1997-2003
Age group used from survey to develop standard	6-11 years 12-17 years 1-18 years	6-11 years 12-17 years 2-20 years 2-<6 years	6-11 years 12-17 years 1-24 years 18-71 months
Population on which it was based	Civilian non institutionalized US population	Civilian non institutionalized US population	NHES & NHANES based on US population WHO MGRS based on 6 country population
Indices and age range for which standard is provided	Weight for age (2-18 yrs) Stature for age (2-18 yrs) Weight for stature	Weight for age (2-20 yrs) Stature for age (2-20 yrs) BMI for age (2-20 yrs)	Weight for age (5-10 yrs) Stature for age (5-19 yrs) BMI for age (5-19 yrs)

Statistical methods used	Smoothed by cubic spinning	Modified LMS estimation procedure (using BOX COX transformation)	LMS model (using BOX COX power exponential method)(BCPE)
Format in which data is available	Percentiles and Z scores	Percentiles with LMS Parameters & Z scores	Percentiles with LMS parameter

In Ethiopia a study on children aged 6-9 years, reported the prevalence of xerophthalmia as 5.8%. The serum retinol levels below 0.35 mmol/l and between 0.35 and 0.70 mmol/l was 8.4% and 51.1% of the children respectively. The liver vitamin A reserve (modified relative dose response ratio $\geq$ 0.06) was low in 41.0% of the children (Tarik et al 2001).

Major supplement programs are in place to raise vitamin A status in the region; but in South Asia, only one child in four actually receives them (Asian Development Bank 2010).

Iron: Iron deficiency is a principal cause of anemia. Two billion people i.e. over 30 % of the world's population are anemic, mainly due to iron deficiency & in developing countries this is frequently exacerbated by malaria and worm infections. The health consequences include premature birth, low birth weight, infections, and elevated risk of death. Later, physical and cognitive development is impaired, resulting in lowered school performance (WHO 2001).

Nutritional anemia due to iron and folic acid deficiency is widely prevalent among young children and adolescents. About 67.5% children under five years and 69% of adolescent girls suffer from anemia (NNMB 2001). Percentage prevalence of anemia in school age children (6-14 years) as per studies conducted during 1981 to 1996 ranges from 14% to 96% and is given in **Table 2.3**. Thus, Iron Deficiency Anemia is a public health problem among school children and is seen across the various cities of India.

Iodine: IDD affects over 740 million people, 13 percent of the world's population. Fifty million people have some degree of mental impairment caused by IDD (WHO 2009). Iodine deficiency disorders (IDD) jeopardize children's mental health and often their very lives. Serious iodine deficiency during pregnancy may result in stillbirths, abortions and congenital abnormalities such as cretinism which is a grave, irreversible form of mental

Table 2.3: Percentage of Anemic children in different parts of India

Location	% anemic children
Baroda	91
Kolkata	96
Hyderabad	60
Chennai	14
New Delhi	67
Varanasi	68

Source: Task Force Report on Micronutrients, 1996, DWCD, GOI.

retardation that affects people living in iodine-deficient areas of Africa and Asia. IDD also causes mental impairment that lowers intellectual prowess at home, at school, and at work.

Although, on an average, prevalence of total Goiter among 6-12 year old children is about 4%, it is 12.2% in Maharashtra and 9% in West Bengal which is much above the WHO cut off level of 5.0%. No State in the country is free from IDD. Around 260 districts out of 321 districts surveyed had more than 10% prevalence of IDD (Task Force Report on Micronutrients 1996)

Urinary iodine levels in children (6-12 years) indicated that 56.6% of urban children and 51.1% of rural children were biochemically iodine replete and had urinary iodine excretion (UIE) levels ≥10μg/ dl. Urban children (29.4%) and rural children (37.1%) were found to have goiter (Sen et al 2005).

Thus to summarize, high levels of malnutrition particularly among growing children are directly and indirectly associated with high morbidity and mortality. Iron deficiency in school-going children affects their learning ability and concentration power. Even mild deficiencies of micronutrients (vitamin A, iron, folic acid, zinc etc.) affect their growth, development and immunity. Malnourished children tend to have lower I.Q. and impaired cognitive ability which affects their school performance and productivity in later life.

ANEMIA

Iron status can be considered as a continuum from iron deficiency with anaemia, to iron deficiency with no anaemia, to normal iron status with varying amounts of stored iron, and finally to iron overload - which can cause organ damage when severe. Iron deficiency is the result of long-term negative iron balance. Iron stores in the form of haemosiderin and ferritin are progressively diminished and no longer meet the needs of normal iron turnover. From this critical point onward, the supply of iron to the transport protein apotransferrin is compromised. This condition results in a decrease in transferrin saturation and an increase in transferrin receptors in the circulation and on the surface of cells, including the erythron. All tissues express their need for iron in exactly the same way, i.e. by the same type of transferrin receptors on cell surfaces in proportion to actual iron need. Accordingly, a compromised supply of iron to the erythron is associated with a similarly insufficient supply of iron to all other tissues.

Functionally, the lack of mobilizable iron stores will eventually cause a detectable change in classical laboratory tests, including measurement of haemoglobin, mean corpuscular haemoglobin concentration, mean corpuscular volume, total iron-binding capacity, transferrin saturation, and zinc-erythrocyte protoporphyrin. Iron deficiency is defined as a condition in which there are no mobilizable iron stores and in which signs of a compromised supply of iron to tissues, including the erythron, are noted. The more severe stages of iron deficiency are associated with anaemia. When iron-deficient erythropoiesis occurs, haemoglobin concentrations are reduced to below-optimal levels.

Nutritional anaemia is not a disease but may be considered a syndrome caused by malnutrition in its widest sense. It is a condition in which the haemoglobin content of the blood is lower than the normal due to deficiency of either a single or more essential nutrients regardless the cause of such deficiency (WHO 1995). IDA is an important public health problem in most developing countries (Soekarjo et al 2006).

Iron deficiency is impairing the mental development of 40-60 percent children in developing countries. Worldwide, $50 billion in GDP is lost annually in low-Estimates of Economic Losses from Iron Deficiency Anemia (Cognitive & Productive) as % of GDP income countries due to IDA's effect on productivity (World Bank 2009). Anemia may produce scholastic under-achievement and behavioral disturbances in school children (Pollitt et al 1976). A departmental study showed that anemia is likely to adversely affect physical work capacity and cognition in young adolescent girls undergoing pubertal development (Sen & Kanani 2006).

Adolescence is a time of increased iron requirement because of the expansion of blood volume and increase in muscle mass. During adolescence, requirement for growing boys also jumps up significantly due to muscle mass development. The deficiency gets further aggravated due to faulty food habits, lack of awareness, inadequacy of foods and poverty (Mittal 2007).

Prevalence of anemia among adolescents

Iron deficiency anemia is the most common type of nutritional anemia in the world, affecting more than two billion people globally (Stoltzfus; International Nutritional Anemia Consultative Group USA 1997).

In studies conducted by the International Center for Research on Women, country findings on adolescent anemia among both males and females anemia was found to be the widespread nutritional problem and its prevalence ranged from 32- 55% (Kurz and Johnson-Welch 1996). Also high rates of anemia have been found among children and adolescents in other developing countries, such as Indonesia, Brazil, Egypt and India varying within the range of 24%-60% (WHO 2003, Anjali 2000, Verster et al 1998, Mashauri et al 1998, Sichieri et al 1996).

Shatha et al in 2003 collected data on adolescents comprising 46% from high socio-economic area (HSEA) and 54% from low socio-economic area (LSEA) in Baghdad, Iraq. The prevalence of anemia among adolescents in HSEA was 12.9% compared to 17.6% in LSEA. Hemoglobin concentration in males was significantly correlated with age and dietary iron intake while in females it was correlated significantly with years of education of father and mother, number of pads and age at menarche.

Mine et al 2002 estimated the prevalence of IDA among a total of 1633 students (11-18 y) from different socioeconomic status in Turkey. Prevalence of IDA was 4.2 % among the urban school and 13.8 % among the shanty town school and students with low family income had a 1.75 times greater risk of IDA than those with high family income.

An assessment of nutritional status of adolescents in India revealed that almost half of the adolescents including both sexes consume inadequate iron and protein in their daily diet and the prevalence if IDA is also high (**Table 2.4**). A multi-center study carried out by ICMR in 16 districts of 10 states in year 2001 showed that the overall prevalence of anemia was 90.1%.Tiwari and Seshadri (2000) reported a similar prevalence (60.3 %) of anemia amongst Nepali School girls. In Ahmedabad, 81.8 % of school children of 6-18 years were reported to be anemic (Verma et al, 2004). A study conducted in urban and rural Vadodara on secondary school girls revealed that 75 % of them were anemic (Kotecha et al, 2002). Thus IDA is a public health problem among school age children and adolescents. It affects in deleterious effects not only on hematinic status but also had serious implications on physical growth, mental development, work capacity and school performances.

Causes of anemia

Adolescents are considered to be a nutritionally vulnerable segment of the population. A rapid growth rate combined with a marginal nutrient intake increases the risk of nutritional deficiencies in this population (World Bank Report 1993).

Adolescents are more vulnerable to develop anemia. It results from inadequate iron intake, reduced bioavailability of dietary iron, increased need for iron, chronic blood loss and parasitic infections. Iron deficiency is a major cause of anemia in all developing countries, where consumption of iron is limited because dietary sources of iron are not affordable by most families (World Bank report 2003).

TABLE 2.4 Prevalence of Anemia in India

RESEARCHER	PLACE	PREVALENCE
Agrawal et al 2003	Delhi	45%
Basu et al 2003	Chandigarh	25.4%
SWACH Foundation 2001	Haryana	82.9%
Rajaratnam et al 2000	Tamilnadu	45.2%
Anand et al 1999	Delhi	48%
Sharda et al 1999	Amritsar	70.5%
Rawat et al 1998	Meerut	35.4%
Mehta et al, 1998	Bombay	63.8%
Chaturvedi et al 1997	Rajasthan	73.7%

In spite of increased iron needs due to growth spurt, many adolescents, especially females, do not get enough iron from their diets. About 75% teenaged girls, did not meet their dietary requirements for iron, compared to only 17% of teenaged boys (CDC 1998). Dislike for certain 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 (Kanani et al 1994). Excessive red blood cell loss due to helminthes infections (mainly hookworm and schistosomiasis and in some cases trichuriasis) also leads to iron deficiency.

Differences in test performance equivalent to a six- month delay in development can typically be attributed to heavier infections of the sort experienced by around 60 million school age children (Partnership for Child Development Report 2002). Anemia can also be exacerbated or caused by malaria infection that in turn can be increased by energy, vitamin A and zinc deficiencies. Excessive red blood cell destruction due to malaria displaces hemoglobin and prevents the transport of oxygen to the tissues (World Bank Report 2003).

The iron requirement remains higher in 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 increases from 0.5 mg/day before puberty in girls to 3.3 mg/day after puberty which has to be compensated by increased intake.

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 extremely, ranging from 1-5 % for plant origin foods and 10-25 % for animal origin foods (Monsen 1998). The bioavailability of iron is low in predominantly cereal- based diets, as in India, because of their high phytate and phosphates content. Tannates present in tea are also known to inhibit the absorption of when consumed with meals (Seshadri et al 1997).

Consequences of anemia

Studies have shown that adolescents with anemia have decreased verbal learning and memory, as well as lower standardized math scores. There is evidence, though, that correcting the iron deficiency may improve learning. A study of adolescent girls with iron deficiency showed that their test scores improved after receiving iron supplements (Alton 2005).

Anemia can have a profound negative impact on psychological and physical development, behavior and learning capacity, working performance and reproductive health (De Maeyer et al WHO 1989). Low iron stores throughout childhood may contribute to a delayed age of menarche and anemia in adolescents may impair immune response (Brabin 1992). In addition, anemia in adolescence may also impair the immune response thus making them more prone to infections (Dallman 1989).

IDA also leads to loss of appetite or anorexia. With loss of appetite the dietary intake of food decreases. A study conducted on 10-18 years old adolescent girls living in three slums of Vadodara indicated that anorexia was more frequently reported among anemic girls than the non-anemic as assessed by lower appetite scores (Kanani and Poojara 2000).

Biochemical Basis of causation of signs & symptoms in Iron deficiency

1. ***Oxygen transport and cellular respiration***

   Iron is a component of several respiratory proteins and respiratory enzymes. Hence deficiency of iron in these molecules causes defective electron transport and cellular respiration. Several mitochondrial proteins within the cell including cytochromes contain iron. Several of the citric acid cycle enzymes like aconitase, succinate dehydrogenase, isocitrate dehydrogenase requires iron as the essential cofactor for the enzyme activity (Maguire J et al 1982).

2. ***Bactericidal activity and oxidant damage***

Several enzymes which are involved in bactericidal action and those involved in production and breakdown of H_2o_2 are iron containing enzymes. Catalase is such an enzyme, Myeloperoxidase in neutrophils also require iron for its optimum bactericidal activity (Tallar, Miyamoto 1948).

3. ***Porphyrin Metabolism***

Certain porphyrin metabolizing enzymes are also under the feedback control of iron. Heamsynthetase, uroporphyrinogen decarboxylases are the two examples. Thus it is clearly seen that in absence of iron even if hemoglobin levels are maintained artificially, cellular respiration in each and every cell is affected and the cells are metabolically compromised.

4. ***Pigment Metabolism***

Iron is intimately concerned with melanin metabolism. The enzymes phenylalanine hydroxylase, homogentisic oxidase requires iron for formation of homogentisic acid and melanin quinines. Hence iron deficiency can affect the formation of melanin pigments. Phenylalanine metabolism is also intimately concerned with catecholamine and thyroxine generation in the respective tissues (Mackler et al 1979).

5. ***DNA and RNA synthesis***

DNA synthesis is an extremely important step before the cell division. Infact most of these syntheses takes place during the "S" (synthesis) phase of cell division. One of the most important enzymes involved in DNA synthesis is ribonucleotide reductase. It is responsible for converting ribonucleotides to deoxy ribonucleotides. This enzyme requires iron for its optimum functioning. In the absence of iron this reaction cannot proceed satisfactorily. Xanthine oxidase, which is involved in oxidation on purines also require iron as one of the cofactors (Brittenham et al 2000).

6. ***Monoamine Metabolism***

Catecholamine is one of the most important monoamines involved in adrenergic neurotransmission and is the glandular secretion of adrenal medulla with potent action on blood pressure, cardiac rhythm, carbohydrate and lipid metabolism. In the central and peripheral nervous system it is the harmonious function and interaction of cholinergic and adrenergic nervous system that controls our innumerable viscero vegetative functions, e.g. sleep, wakefulness, moods and so on. Iron has also been found to be an important component of neuronal monoamino oxidase. Tryptophan hydroxylase, another enzyme involved in production of serotonin also uses iron as an essential cofactor. Dopamine receptors are down regulated during iron deficiency and there is an altered Gama Amino Butyric Acid (GABA) metabolism in this condition (Beard 2001).

7. ***Cytochrome P-450 and drug metabolizing enzyme***

There are a large number of drug metabolizing enzymes of this class which contains haeme iron as essential component of the enzyme. These enzymes are involved in phase I reaction in biotransformation of drugs and other xenobiotics. These enzymes are present in ample quantities in liver. Hence it is expected that iron deficiency may alter metabolism of some of the drugs. The clinical consequence of this is uncertain (Pinero et al 2000).

8. ***Myelinogenesis***

Oligodendroglia in central nervous system contains large amount of iron. Studies have shown increased transferrin receptors in vascular endothelium of choroid plexuses in the brain. Knowing the essential role of oligodendroglia in myelinogenesis, it is but natural to explore the possibility that iron deficiency in experimental animals may cause abnormal myelination during immediate postpartum development phase corresponding to 4-20 month age of human infants. Biochemically oligodendroglia contains a protohaem oxygenase, which is involved in cholesterol biosynthesis and may influence myelination through this process (Taneja et al 1986).

9. ***Clinical presentation of iron deficiency gastrointestinal tract***

Angular stomatitis, Glossitis, Koilonychia, sideropenic dysphagia with postcricoid oesophageal web in iron deficiency can easily be explained by the necessity of iron for cellular proliferation and differentiation. Whether iron deficiency can cause atrophic gastritis and mal absorption syndrome is a question, which is more difficult to answer. Weight of evidences seems to indicate that iron deficiency can be caused by these pathologies rather than they themselves are caused by iron deficiency except under rare circumstances. Several studies from India have shown that iron deficiency anemia which is resistant to iron therapy is caused by symptomatic celiac disease which was considered to be rare in India. One of the clinical presentations of iron deficiency with or without anemia is abnormal eating behavior or pica which can be in the form of eating clay (geophagia), ice (pagophagia) and similar things (Khosla 1984).

10. ***Skin and its appendages***

Premature loss of hair, alopecia areata, greying of hair, folliculitis, acne and reduced growth of nails have been reported with iron deficiency with or without anemia. Koilonychia is one of the best known clinical features of iron deficiency (Mehta 1987).

11. ***Cardiovascular physiology***

Several non invasive studies like systolic time intervals have shown myocardial dysfunction during iron deficiency without anemia as evidenced by reduced PEP / LVET ratio. This ratio was normalized within days of iron replacement before hemoglobin started to rise significantly. Similarly abnormal ST segment depression on treadmill test has been demonstrated in IDA and this test reversed on parenteral iron therapy (Mehta 1987).

12. *Effect on cerebral function*

Poor cortical arousal, diminished attention span, reduced scholastic performance in school has been reported in iron deficiency anemia and these abnormalities partly reverse on iron replacement. Depression, disturbances of sleep rhythm and reduced mental alertness also occur in this condition. It is believed that in infants with iron deficiency not all parameters of cognitive development can be totally reversed; neither the various domains of higher cerebral function show recovery at the same rate. Hence the degree of reversal often depends on time of measurement of these parameters. It has been demonstrated that iron is concentrated in different parts of central nervous system like globus pallidus, substantia niagra, nucleus accumbens in an adult but the pattern changes in different age groups. However, most of these areas are associated with dopaminergic and GABA minergic pathways and several receptors of dopamine D1 & D2 are down regulated in IDA. Peripheral nerve conduction velocity also improves in a study following iron replacement (Burner 1996).

13. *Renal function and drug metabolism*

The important role of P-450 cytochrome oxidase group of enzymes in drug metabolism is very well known. Thus it is but natural that some of the drug metabolism may be altered in iron deficiency. However in iron deficiency with anemia there could be several reasons for altered drug handling by the body in addition to its effect on metabolism. The absorption of drug from gastro intestinal tract may be delayed or may be incomplete. Increased cardiac output and redistribution of blood flow to various organs particularly to liver may alter the drug available to biotransformation site and may alter the volume of distribution of the drug as evidenced by prolonged half life and its correction by iron therapy on antipyrene half life. Finally the abnormal creatinine clearance due to iron deficiency may also alter the drug excretion. Hence there are theoretical reasons that every phase of drug handling i.e. absorption, distribution metabolism and excretion is likely to be altered by iron deficiency but in practice no adverse reaction or interaction due to drug administration specially caused by iron deficiency has been reported (Mehta 1984).

14. *Musculoskeletal function*

Easy fatigability and decreased work performance in iron deficiency and its improvement following iron therapy have been reported in various case control studies. This finding has enormous consequences in national economy. Studies show that anemia due to iron deficiency tends to affect fast acting muscle function (sprint function) whereas cellular deficiency of iron tends to affect endurance exercise (Dallman PR.1982).

PHYSICAL WORK CAPACITY

The key role that hemoglobin plays in transporting oxygen accounts for the diminished work capacity (DeMaeyer 1989). Workoutput, 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).

Iron has a key function in oxygen transport, either as part of hemoglobin or as myoglobin. In IDA the decrease in hemoglobin reduces the availability of oxygen to the tissues, which in turn affects the cardiac output (Beaton, Corey and steel 1989). The movement of oxygen from the environment to terminal oxidases is one of the key functions of iron. Dioxygen binds to porphyrin ring iron containing molecules either as part of the prosthetic group of hemoglobin within the red blood cells or as the facilitator of oxygen diffusion in tissue myoglobin (Beard, Dawson and Pinero 1996). The very significant decrease in myoglobin and other iron containing proteins in the skeleton muscle seen in iron deficiency anemia contributes significantly to the decline in muscle aerobic capacity (Dallman 1986).

Pyruvate and malate oxidase were reduced to 35 % of normal iron deficient muscle and improved to 85 % of normal in 10 days of treatment (Beard, Dawson and Pinero 1996).

The different mechanisms through which iron deficiency and anemia affects work capacity are reduced tissue oxidative capacity and reduced oxygen carrying capacity. Tissue oxidative capacity is affected across all levels of iron deficiency, whereas the oxygen carrying capacity is affected only at the most severe stages of deficiency when hemoglobin concentration is reduced. In turn these two impairments affect different aspects of physical performance. Reductions in oxygen carrying impair aerobic capacity, whereas reductions in tissue oxidative capacity impair endurance and energetic efficiency (Davies et al, 1984).

Iron deficiency anemia is found throughout the world and especially in developing countries where productivity is of prime importance. It is also known that physical work capacity in anemia subjects may be improved after iron supplementation, with a concomitant increase in circulating Hemoglobin. It has been shown that work performance can be improved almost immediately when the oxygen carrying capacity of the blood is simply increased (Gardner et al, 1977).

Oxygen saturation (SO_2) is the blood oxygen binding by hemoglobin oxygenation (HbO_2). The functional oxygen saturation for the concentration of HbO_2 concentration, HbO_2: Hb ratio, which is different from the percentage of oxyhemoglobin. Therefore, monitoring of arterial oxygen saturation (SPO_2) on pulmonary oxygenation and hemoglobin oxygen carrying capacity is estimated.

Optical method is an electrochemical method to overcome the shortcomings of the new optical measurement method. It is a continuous non-invasive oxygen measurement method which can be used in emergency wards, operating room, and recovery room and sleep studies. The principle of pulse oximeter is that detection of blood volume changes in light absorption, measurement of oxyhemoglobin (HbO_2) of total hemoglobin (Hb) the percentage obtained directly SO2. The advantages of this method can be done on the human body for non-destructive measurement, and instrumentation is simple and convenient to use, it has been a growing attention. The disadvantage is that it measures less accurately than the low electrochemical method, the extraordinary value in the low oxygen generated by the larger error. The latest pulse oximeter measurement errors can be controlled at less than 1 percent to the requirements of clinical use. Although they are not satisfactory in some respects, but its clinical benefits have been widely recognized

Hemoglobin in the blood is a major role in the delivery of oxygen, the majority of oxygen in the blood is hemoglobin (Hb) combined. 1g of hemoglobin can be combined with 1.34 ~ 1.36ml of oxygen. Healthy adults is hemoglobin 15g/100ml, 100ml of blood oxygen can combine a maximum of 20ml, 100ml of blood hemoglobin oxygen can be combined with the largest capacity of the volume of oxygen is called hemoglobin, 100ml of blood hemoglobin oxygen level in the actual combination of oxygen is called hemoglobin. Oxygen content of hemoglobin in blood oxygen capacity accounted for the percentage of hemoglobin called hemoglobin oxygen saturation. Is often said that the oxygen saturation, blood in the existence of other means (eg, dissolved) oxygen content in small, can be neglected. Blood in the vast majority of oxygen molecules in hemoglobin and red blood cell (Hb) for the reversible combination of hemoglobin molecules in each of up to 4 molecules of oxygen combine with the combination of Hb after that oxyhemoglobin (HbO2), HbO2 total blood capacity in the percentage of hemoglobin that "oxygen saturation."

For instance, if one hemoglobin molecule is carrying three oxygen molecules, the hemoglobin is carrying only 75 percent of its total capacity. In a larger blood sample, 1,000 hemoglobin molecules could carry up to 4,000 oxygen molecules. If only 3,920 oxygen molecules are transported, that equals 98 percent of total capacity. That means the blood's oxygen saturation level is 98 percent.

An accurate, easy way to measure oxygen saturation levels is through pulse oximetry. A pulse oximeter is a small clip that attaches to a patient's finger. The oximeter shines two bright lights, one red and one infrared, through the finger to measure the blood oxygen levels. It does this by analyzing the color of the arterial blood. Oxygen-rich blood is bright red. In order to tell the arterial blood apart from the surrounding tissue, the oximeter measures the change in the overall color in coordination with the beating pulse.

Oxygen saturation is an indicator of the percentage of hemoglobin saturated with oxygen at the time of the measurement. The reading, obtained through pulse oximetry, uses a light sensor containing two sources of light (red and infrared) that are absorbed by hemoglobin and transmitted through tissues to a photodetector. The amount of light transmitted through the tissue is then converted to a digital value representing the percentage of hemoglobin saturated with oxygen.

Oxygen saturation values obtained from pulse oximetry (SpO_2) are one part of a complete assessment of the patient's oxygenation status and are not a substitute for measurement of arterial partial pressure of oxygen (PaO_2,) or of ventilation (Grap 1996).

WAYS TO COMBAT ANEMIA

The three major causes of anemia (iron deficiency, malaria and helminths infections) can be addressed during contacts with vulnerable groups using a combination of key interventions, as needed. Five Key Interventions recommended are:

- Iron supplements targeted to at-risk groups

- Fortification of staple foods with iron and other micronutrients that cause anemia for the general population and iron-fortified foods targeted to at-risk groups
- Prevent and treat malaria
- Use of insecticide-treated materials and bednets
- Deworming (anthelminthics) in at-risk groups

IMPORTANCE OF INTERVENTION AT THIS PHASE

It has been known that malnutrition undermines economic growth and perpetuates poverty. Thus the three reasons for intervening to reduce malnutrition are:

- High economic returns; high impact on economic growth and poverty reduction
- The alarming shape and scale of the malnutrition problem
- The markets are failing to tackle malnutrition

The causes of malnutrition are predictable and preventable and can be addressed through affordable means. Practical measures that address the immediate causes of child under nutrition include a health, hygiene, nutrition education and promotion, fortification, micronutrient supplementation, parasite control measures (de-worming in particular); and situation-specific household food security interventions (Stephenson et al 1993).

These interventions, enacted in tandem with measures to increase the economic viability of families and communities and their capacity to access the food and basic services they need and use them effectively can lead to accelerated and sustained progress in improving child nutrition. Numerous interventions are essential if child under nutrition is to be addressed effectively and sustainably.

The Initiative will directly promote interventions that are known to have immediate impact for children, can be scaled up and are currently under-championed.

The promotion of a focused set of interventions will fully and directly complement other, ongoing efforts to take the measures essential to tackle child malnutrition in the short term and to address its underlying causes (Nokes et al 1993).

There is now unequivocal evidence that workable solutions to child under nutrition exist and that they are excellent economic investments.

Purpose of Biological assessments

- Determine the magnitude, severity and distribution of iron deficiency and anemia and preferably its main causes. This information can serve as a basis for planning policies and intervention, and as a baseline against which to assess their impact
- Identify population more affected or at greater risk. This information enables national authorities to select priority area for action, especially if resources are limited
- Monitor trends in prevalence and regulate the impact of interventions. Other program indicators are also needed for monitoring program implementation
- Measure progress towards achieving the goals adopted by the international community
- Provide the basis for advocacy program for iron deficiency and anemia prevention in affected vulnerable population.

IRON FOLIC ACID SUPPLEMENTATION

Iron supplementation is the most common strategy currently used to control iron deficiency in developing countries. This is likely to remain the case until either significant improvements are made in diets for entire population or universal food fortification is achieved.

Supplementation is most often used to treat existing IDA. It should also be considered as a preventive public health measure to control iron deficiency in population at high risk of iron deficiency. Various delivery systems and modalities, under conditions of varied efficiency, reach a wide range of target groups. Small controlled studies of supplementation have been shown to be particularly successful and a few large scale supplementation programs clearly demonstrate positive biological impact. Only then will information be sufficient to introduce effective and efficient solution, if traditional approaches and practices are to continue.

It is important to differentiate between supplementation that aims at preventing anaemia by correcting iron deficiency before IDA is manifested, and therapeutic supplementation, aims at correcting established iron deficiency anaemia. Therapeutic supplementation should be part of health care delivery system. Supplementation to prevent iron deficiency without anaemia may be a community based initiative which needs innovative approaches in order to deliver timely preventive supplementation.

Several trials utilizing supplementations on a weekly or daily basis are in progress. However, the demonstrated effectiveness of weekly programs, based on self administered iron supplements under program condition is awaited before being recommended as public health measure (Ridwan et al 1996).

Supplementation is also preventive strategy to treat existing anaemia. It is the most common strategy used in developing countries to combat anaemia and is likely to be the case until the diets of the entire population change significantly or there is food fortification (UNICEF/UNU/WHO, 2001). Iron supplementation has shown positive results and, thus, remains the strategy of choice. Numerous studies have been done to observe the beneficial impact of iron supplementation as well as to come up with best possible supplementation schedule (Chwang et al1988; Brunken et al 2004; Hall et al 2002; Tee et al 1996; Berger et al 1997; Sungthong 2002 and Zavaleta et al 2000).

The iron absorption can occur at any level of the gastro intestinal tract from the stomach. However, absorption is greatest in the duodenum and progressively less in a descending gradient. Divalent ferrous iron is absorbed better than trivalent form (Moore et al 1939). Uptake of iron by intestinal mucosal cell is unidirectional and there is practically no excretion of iron into the gut. Under normal condition the body's iron content remains constant at level of 4 to 5 gms and absorption balances excretion of 0.5 to 1.5 mg per day.

The essence of mucosal block theory is that ferrous ions entering the mucosal cell stimulate the production of an acceptor protein, apoferritin. After entry into the cell the divalent ions are oxidised to the ferric state by the redox potential at the luminal border and the trivalent iron combines with apoferritin to form ferritin (Stewart 1950). At the vascular border of cell the ferritin is reduced by a different redox environment with consequent release of ferrous ions which will emerge from cell into the blood stream and after reoxidation are bound to transferring, the iron transport globulin of plasma. Thus when the needs of the body are met, further absorption of iron is curtailed by accumulation of mucosal ferritin. High dose of iron would load the mucosa with iron and block the subsequent dose from absorption. By reducing the dose frequency to once a week, matching the mucosal turnover of humans, iron from the tablet is absorbed (Brown 1963).

Chwang et al (1988) showed a significant reduction in morbidity and increased growth in children aged 8.2 – 13.5 years with supplementation of 10 mg of ferrous sulphate per kg body weight per day over 12 weeks. A mean increase of 3.5 g/dl of haemoglobin was observed in the anaemic group which was statistically significant compared to control group. Another study (Brunken et al, 2004) found a reduction of 25% in the prevalence of anaemia. Six milligram per kg body weight of iron was provided on weekly basis in six child-care centres in

Brazil. The subjects were children below three years of age. Four months of supplementation were followed by five months of nutritional guidance for the maintenance of adequate iron levels and led to an average improvement of 0.1 g/l after each dose of iron sulphate in haemoglobin.

Hall et al (2002) demonstrated the effectiveness of iron supplementation channelled through school. Weekly dose of 65 mg of iron along with 0.25 mg of folic acid were administered by teachers for 10 weeks in thirty schools, covering almost 1100 students in the age group of 6 – 19 years. Haemoglobin levels rose by an average of 1.8 g/l and prevalence of anaemia fell by 8.2% both significant at P < 0.001. Young children (< 12 years) and girls benefitted more.

A Malaysian study (Tee et al, 1996) also yielded similar positive result with weekly iron supplementation of 60 mg or 120 mg and folic acid of 3.5 mg, for 22 weeks. Increase in haemoglobin levels was considerably higher in first 12 weeks than in the next 10 weeks regardless of dose. The mean haemoglobin increase was 2 times greater in the anemic girls during the first 12 weeks in both iron supplemented groups. Ferritin levels also increased in the group which had consumed iron tablet and folate. Thus 60 mg of iron along with 3.5 mg of folate was recommended since it had low frequency of side effects but produced similar result as that of 120 mg iron.

In Thailand study (Sungthong et al, 2002), average increase in haemoglobin in daily group (6.5 ± 6.0 g/l) was similar to weekly group (5.7 ± 6.3 g/l). However, the average increase in serum ferritin was greater in daily group compared to weekly group. Weekly group was found to have greater impact on height gain then daily group. These means that daily schedule was better in improving iron status than weekly one. The results of these studies are more or less similar to the once obtained from a research done in Peru (Zavaleta et al, 2000).

Tiwari (2000) conducted on 420 adolescent girls 10-18 year and compared the supplementation (daily vs weekly) over a period of 6 months. Deworming was also a part of study. Both daily as well as weekly schedule were effective in increasing the haemoglobin level. However none could decrease the prevalence of anemia.

There are several small iron supplementation studies that have examined its impact on growth, haemoglobin and morbidity in young children. The studies become clearer when they are classified by baseline prevalence of anemia. The studies where prevalence of anemia is greater than 80 % showed significant benefit in linear growth following the supplementation (median effect size 0.6 SD unit). An Indian study reported a negative effect in anemic children too (Bhatia & Seshadari 1992).

Similarly, none of the studies in anaemic iron replete children reported a beneficial impact of iron supplementation. On the contrary there is some suggestion that growth might be adversely affected under these circumstances (Indjradinata et al, 1994). Non significant negative effects were reported for length (-0.21 SD units) in a study by Chwang et al, 1988. The summary of few of the studies is given in the Table 2.5, Table 2.6.

Iron deficiency affects many age groups but school age is the least identified group. These groups suffer ignorance of policy makers in terms of preventive strategies to control iron deficiency anemia.

Since the target group is adolescent or to be more specific school age population schools becomes an obvious medium for such preventive strategy. It becomes important to come with feasible supplementation schedule which are not burden on teachers. Otherwise it is bound to fail eventually. Therefore weekly supplementation with elemental iron along with 0.5 mg folic acid seems to be a good strategy.

Table 2.5: Summary of IFA intervention studies in World

Researcher	Location	Age	Sample Size	Iron Supplementation	Positive Effect
Atukarala, 2001	Srilanka	5 -10 years	364	Oral 60mg/day, 2 months	URTI, diarrhoea
Gebresellassie, 1996	Ethiopia	5 -14 years	500	Oral 60 mg/day, 3 months	Malaria
Lawless,1994	Kenya	6-11 years	86	Oral150 mg/day, 3 months	Diarrhoea, cough, malaria
Harvey, 1989	Guinea	8-12 years	312	Oral 130 mg/day, 6 months	Malaria
Tee et al	Malaysia	5-11 years	266 girls+ 358 girls	60 & 120 mg weekly, 22 weeks	Hb and Ferritin concentration
Sen et al, 2009	India	9-13 years	161	100 mg elemental iron + 0.5 mg folic acid, one year	Digital span, maze test and visual memory
Kanani et al, 2007	India	10-18 years	210	Oral 60mg/day, 3 months	Height & Weight and hunger perception
Chwang et al, 1988	Indonesia	8 – 13 years	119	10mg/day, 12 weeks	Growth and morbidity
Latham et al, 1994	Kenya	8 years	55	80 mg/day (15 & 32 weeks)	Growth
Aguayo, 2000	Bdivia	6-12 years	64	3mg/kg body wt/week, 18 week	Hb & growth
Bhatia, 1992	India	8-13 years	165	2 mg/kg body wt for 12 weeks/day	Growth

Table 2.6: Summary of IFA intervention studies in the Department

Author / Place	Age Group	Intervention	Impact Hemoglobin Change (g/dl) and Growth
Seshadri and Gopaldas 1989, India	5-8 yrs (n=94)	20mg elem Fe + 0.1 FA for 60 days	Significant improvement in Hb 1.1 vs 0.15
	8-15 yrs (n=48)	60 mg elem Fe for 60 days	Significant improvement in Hb 2.4 vs 0.5 in control
Tiwari and Seshadri 2000, Nepal	School going adolescent girls (10-18 y) (n=1500)	Single dose 500mg mebendazole + 60mg elem iron given • Deworming+daily for 3 months • Deworming+weekly for 6 months • Only deworming or only placebo	Weekly IFA (0.33g/dl)as effective as daily (0.3 g/dl) group with regard to Hb increments, however, there was no significant reduction in prevalence of anemia
Seshadri et al 1998, Bharuch, India	Adolescent girls (10=19y) (n=1513)	Unsupervised supplementation of 100mg elem Fe+ 0.5mg Folic Acid Tablets • Daily for 100 days • Weekly for 6 months Placebo once weekly for 6 months + brochure on anemia	Weekly supplementation was not as effective as daily in terms of rise in Hb levels Weekly : 0.5 g/dl Daily : 0.3 g/dl
Kanani and Poojara 2000, India	Adolescent girls (n=203)	60 mg elem Fe+ 0.5mg folic acid for daily 3 months	Experimental group+1.73 vs. -0.08 g/dl control Increase in Hb was higher in anemic girls Significant improvement in BMI in supplemented girls compared to controls (0.0 vs -0.35 kg/m^2)

Kanani et al 1998, Vadodara, India	School girls (10-15y) (n=729)	100mg elem Fe + 0.5mg Folic Acid for 6 months	No significant impact on Hb levels after weekly supplementation (1.2 vs. 1.0g/dl in control) No difference in BMI gain between supplemented (0.68 Kg/m^2) and control group (0.49 Kg/m^2) after the intervention.
Kanani and Singh 1999, Vadodara	9-12y (n=296)	60 mg elem Fe+0.5 mg Folic acid for 3months	Significant improvement in weight (3.33 Kg vs. 1.56 Kg) and BMI as compared to controls.
Kuruvilla & Mulchandani 2010	10-19 y (n=131 boys)	100mg elem Fe 0.5mg Folic Acid and weekly for 3months	The increment seen in Hb was 0.3 g/dl
Kuruvilla & Bhatt 2010	10-19 y (n=133)	100mg elem Fe 0.5mg Folic Acid and weekly for 3months	The increment in Hb was 0.2 g/dl
Kuruvilla & Malhotra 2011	10-19 y (n=135)	100mg elem Fe, 0.5mg Folic Acid, twice weekly for 5months	A highly significant improvement was seen in Hb levels(0.4 g/dl in girls & 0.34 g/dl in boys)
Kuruvilla & Thappar 2011	10-19 y (n=96)	100mg elem Fe 0.5mg Folic Acid, twice weekly for 4months	A significant improvement was seen in Hb levels was 0.5 g/dl

DEWORMING TABLETS

Worms infect more than one third of the world's population, with the most intense infections in children and the poor. In the poorest countries, the infection is long-term and chronic, and can negatively affect all aspects of a child's development: health, nutrition, cognitive development, learning and educational access and achievement (World Bank report 2003).

Hookworm infection load can include IDA, especially in women of reproductive age and children, whose dietary iron intake is low and whose body iron stores are exhausted due to increased demand of iron for growth. Even normal levels of dietary iron intake may not be sufficient to protect from anaemia in the situation of high hookworm load (Powlawski et al 1991).

A high prevalence of intestinal parasitic infections is closely correlated with poverty and poor environmental hygiene, namely: a) lack of safe water supply, b) contamination of the environment by human excreta, c) lack of shoes, and d) poor environmental or personal hygiene. In the long run, worm infections increase susceptibility to other infections and diminish learning ability and growth in children.

Intestinal parasitic infections negatively affect the health status of a high proportion of school-age children in developing countries, giving rise to general discomfort and acute symptoms such as abdominal pain, nausea and coughing. More than two billion children globally are infected by intestinal helminthes, with 155,000 deaths reported annually. The burden of diseases caused by intestinal helminthes infection (39 million disability associated life years (DALYs) is higher than that caused by measles (34 million DALYs) or malaria (36 million DALYs). Intestinal helminthes infection affects the nutritional status of children through intestinal bleeding, malabsorption, competition for nutrients, loss of appetite and diarrhea. All of these effects are reversible after treatment. Another benefit of treatment is better digestion of the sometimes limited food available.

These symptoms are closely correlated with the "intensity of intestinal parasitic infections" (commonly called "worm burden"): the greater the worm burden, the more severe are the symptoms. In addition, hookworm infections give rise to blood loss, as the worms suck blood from the intestinal wall. This may cause iron deficiency anaemia and a decrease in work capacity and fitness.

High parasitic infestation rate (30-80%) could be one of the major cause of anaemia (Tiwari, 2000). Hook worm infestation load can induce the IDA, especially in children and adolescents, whose dietary iron is low and whose body iron stores are exhausted due to increased demand of iron for growth. Even normal levels of dietary iron intake may not be sufficient to protect from anaemia in the situation of high hook worm load (SCN News, 2007).

School-age children harbor the most intense infections with roundworm (Ascarislumbricoides), hookworm (Ancylostoma duodenale and Necator americanus) and Whipworm (Trichuris trichiuria). Therefore, treatment of this age group - which is easily accessible through the school system - achieves optimal improvements in health status and educational performance.

In Zanzibar, heavily infected school children living in high transmission areas were treated with mebendazole three times a year. The study found that a quarter of a litre of blood can be saved per child per year for as little as 1 US cents per child per year (i.e. 5 US cents per treatment including the cost of the tablet of about 3 US cents, and drug delivery, which amounts to about 2 US cents). Deworming of children can result in remarkable growth spurts. In one of the trial in Kenya, treated school-age children gained one centimeter more in height in the four months following treatment than did children who received a placebo.

In 1998, Curtale et al and in 2008, Koukounari et al reviewed the relation between parasitc infection and anaemia among Egyptian school going children

(6-12 years) and Kenyan School children (aged 10-21 years) respectively. Both the studies reported that children heavily infected with parasite were also more likely to be anaemic (more than 90% in both cases) compared to uninfected children. Similarly other study was carried out by Uddin and Khanum (2008) in two different districts (Kutumbopur and Gazirchat) of Bangladesh and reported that parasitic infestation was observed among 33.82% adolescent where as in the other district the prevalence was 84.21%. Parasitic infestation was observed much higher in Gazirchat than Kutumbopur. The prevalence of anaemia was high in Kutumbopur (94.83%) than Gazirchat (41.2%) but the correlation between anaemia and parasitic infestation was statistically insignificant.

Recent studies suggest that intestinal parasitic infections negatively affect school children's cognitive functions. A study in Jamaica showed significant improvements in the auditory short-term memory of heavily infected children after nine weeks of treatment. Single oral dose treatment with mebendazole (500 mg) or albendazole (400 mg) is very effective, safe and inexpensive. The direct benefit of chemotherapy is that the worm burden is removed, which immediately alleviates symptoms and may reduce the rate of transmission. Furthermore, WHO recommends improved sanitation and safe water supply as well as health education on the prevention of intestinal parasitic infections as important strategy.

School-age children typically have the highest intensity of worm infection of any age group. In addition, the most cost-effective way to deliver deworming pills regularly to children is through schools because schools offer a readily available, extensive and sustained infrastructure with a skilled workforce that is in close contact with the community.

Regular deworming contributes to good health and nutrition for children of school age, which in turn leads to increased enrolment and attendance, reduced class repetition, and increased educational attainment. The most disadvantaged children - such as girls and the poor - often suffer most from ill health and malnutrition, and gain the most benefit from deworming (World Bank Report 2003).

Drugs for deworming treatment are highly effective, widely available, inexpensive, easy to administer during school or general population drug campaigns and without serious side effects. One caveat is that treatment must be repeated every 6-12 months because of re-infection.

Among the interventions found to be most effective in reducing malnutrition in children micronutrient supplementation and water and sanitation interventions, deworming has been found to be particularly effective intervention for children of school age. Thus giving high priority to several of these interventions in order to attack malnutrition was emphasized by the Copenhagen Consensus panel in 2004, 2006 and again in 2008 and 2010.

MID DAY MEAL

National Programme of Nutritional Support to Primary Education, popularly known as the Mid-Day Meal Scheme involves provision of lunch free of cost to school-children on all working days. More than 12 crore (120 million) children are covered under the Mid-day Meal Scheme, which is the largest school lunch programme in the world. Allocation for this programme has been enhanced from Rs 3010 crore to Rs 4813 crore in 2008-2009. The MDM allocation has increased by 6 crore in the year 2011-2012. Last year, Rs 10,380 crore was allocated for the scheme.

A healthy MDM can help to protect children from hunger, and to provide supplementary nutrition. MDM is not enough to guarantee the right to food, but they are an important step towards it. Similarly, cooked midday meals contribute to the right to education by facilitating regular school attendance and enhancing children's learning abilities.

Objectives of MDMP are:

- To improve the nutritional and health standard of the growing children.
- To reduce drop-out rate and to increase attendance and to attract poorer children to come to the school.
- To create supplementary employment opportunities at the village level.
- To achieve social and national integration.
- To supplement state efforts towards removal of poverty.

STRENGTHS, WEAKNESS AND MILESTONES

Strengths: Merits of MDMP (NFI, 2003*)*

- Combating classroom hunger
- Promoting better learning,
- Inculcate in the pupils good dietary habits
- Promote personal hygiene
- Awareness of the importance of environmental sanitation
- Valuable means of imparting health and nutrition education to children, their parents and the community,
- Create employment opportunities,
- Improving school enrolment and attendance especially enrolment of girls and SC/ST children,
- Foster sound social behavior,
- Trigger all round development of the entire school system.

A study conducted by Amartya Sen in Birbhum West Bengal revealed that MDM has a positive role in eliminating classroom hunger to a substantial level (Pratichi Research Team 2005)

According to National Council of Educational Research & Training's latest report (2005) children covered under MDM have higher achievement level than those who were not covered under it. Situational analysis of MDMP in Rajasthan showed MDM to be contributing to gender equity and women employment. CORD study in Delhi reported that the impact of attendence was more likely on girls, who often came to school without breakfast. A study on rural area of Karnataka revealed reduced absenteeism in 64% of the schools (Naik 2005). In Madhya Pradesh 15% increase in enrollment was seen which was more marked in the case of SC and ST children (43%) (Samaj Pragati Sahyog 2005)

Weaknesses: Despite the success of the program, child hunger as a problem persists in India. According to current statistics, 42.5% of the children under 5 are underweight. "India is home to the world's largest food insecure population, with more than 200 million people who are hungry," India State Hunger Index (ISHI). Adding to that the country's poor performance is driven by its high levels of child under-nutrition and poor calorie count. A report released as part of the 2008 Global Hunger Index ranks India at 66 out of 88 countries. It says that India has more people suffering hunger - a figure above 200 million - than any other country in the world, it says. The report also stated that improving child nutrition is of utmost urgency in most Indian states (WFP, 2006).

The major problem which comes in effective implementation of MDMP is the poor enrollment and absenteeism. Although these two are major objectives of MDMP they still remain unachieved.

In Gujarat only 71% of children aged 6-17 years attend school. School attendance is somewhat higher in urban areas (74%) than in rural areas (69%). About 90% of the primary school children (6-10 years) attend school (92% of urban and 89% in rural areas). The percentage fall in children attending school drops to 74% for children age 11-14 years and 32% for 15-17 years. Gender disparity in education is quite evident in school age population 66% girls of the 6-17 years of population attend school to 75% of the boys of similar age group(NFHS-3 2005-2006).

Recent field survey of MDM initiated by the Centre for Equity Studies, New Delhi suggests that mid-day meals have made a promising start around the country. In each of the three sample areas (three districts each in Chhattisgarh, Rajasthan, and north Karnataka; mid-day meals were being served regularly in all primary schools. However, achievements of mid-day meals have been seriously compromised, if not defeated, by inadequate quality and low budgets.

There is an urgent need for better infrastructure (e.g. cooking sheds in all the schools), improved facilities (e.g. safe drinking water everywhere), closer monitoring (e.g. regular inspections), and other quality safeguards (Dreze & Goyal 2009).

An evaluation report on 112 schools of Delhi revealed that only 47% of schools were found to have distributed MDM in their school for a period of over 150 days. Teachers felt that continuation of the same item gradually make students develop dislike towards it.

An assessment of program implementation and impact reported provision of meals was sometimes interrupted because of inadequate delivery of wheat and funding. None of the schools had permanent kitchen. If MDMP is implemented in close convergence with several other development program it will ensure that all requirements of the Program are fully met in the shortest possible time frame.

Inspite of the educational development realized through Mid-day Meals program, several socio-cultural, administrative, managerial, and financial factors affected the scheme's effectiveness in Orrisa and Tamil Nadu. However, downsizing the program through appropriate organizational and operational measures is being considered (Mishra & Behera 2004).

Some other loopholes reported by Right to food review in UP in 2007 were:

- The nutritional value of the meal is far below the prescribed standard

- Meal is often not served in adequate quantity.

Most states, however, reported severe resource constraints, inadequate cooking arrangements and resentment among teachers. In recent years, the scheme has suffered from disruption in supply of foodgrains due to paucity of funds and non-reconciliation of lifting figures between states and FCI with the latter, in response, often resorting to the suspension of supply of foodgrains (Saxena 2002)

ACHIEVEMENTS AND MILESTONES

Achievements: A study conducted by National Institute of Rural Development in 2006 involved 7,200 school going children (9-12 y) at three different areas - urban, rural and slum of two representative districts- Lakhimpur Kheri and Sitapur (Uttar Pradesh) and Bharatpur and Jodhpur (Rajasthan) to assess the impact of MDM supplementation on the nutritional status of school going children (Seetharaman 2002). The findings revealed that

- Children of the three areas in all the four districts spread across two States greatly varied both in respect of calorie intake and their background variables. However, within group differences were marginal and non significant in all cases except Bharatpur.
- The MDM did not make any appreciable and significant impact on improving the nutritional status of the children. One important impact was that there was a reduced dropout among the girls. The performance of Lakhimpur Kheri in reducing the dropouts among girls was significant followed by Jodhpur, Sitapur and Bharatpur.
- Educational achievement of the children was very much influenced by their nutrition, parental as well as home environmental conditions. This was clearly evident in Lakhimpur - Kheri followed by Sitapur, Jodhpur and Bharatpur.

Another similar study on impact of MDMP on educational and nutritional status of school children in Karnataka on 2,694 children (MDM: 1361; Non-MDM: 1333) from 60 schools indicated better enrolment ($p < 0.05$) and attendance ($p < 0.001$), higher retention rate with reduced dropout rate ($p < 0.001$), a marginally higher scholastic performance and marginally higher growth performance of MDM children (Laxmaiah 1999)

Milestone: For eradicating malnutrition by MDMP, one centralized model will not be either effective or efficient given the diversity and plurality in socio-economic and cultural aspects. A decentralized approach involving state and local governments would work better. This would also address greater accountability and transparency at every level of the program (Deshpande et al 2008)

Other major problems are that after the meal, 25% of the children tend to leave the schools thereby diluting the impact of the MDM in improving school attendance. Also the quality of wheat and rice grain being supplied under the MDM is not of good quality. Around 24% wastage of grains was reported mainly because of the poor quality.

There are many shortcomings in the delivery mechanism. It is true that the problems of reducing anemia and malnutrition have not been greatly impacted and the drastic mitigation of the problem observed. There are problems with Mid Day Meals as an incentive to prevent school dropouts. Despite these shortcomings all such schemes need to be expanded and intensified rather than curtailed.

GROWTH MONITORING

Growth monitoring has been defined as the regular measurement, recording and interpretation of child's growth change. The advantages of growth monitoring and promotion are:

- It allows for the early identification of children at high risk of malnutrition.
- It enhances the transfer of nutritional information by providing the educator with data concerning children's growth patterns that can be used in tailoring advice
- It assists in focusing scarce resources such as supplementary food commodities and recipients who most need them
- When combined with nutrition surveillance, it assists in evaluating the impact of other health and development activities and in identifying groups in need of special health attention

Growth monitoring is widely regarded as an essential element of primary health care. The potential of growth monitoring lies in its use as a diagnostic tool for identifying a child with nutritional or health problem, thus enabling action to be taken before the child's nutritional status is seriously jeopardized (Deheeger M, 2004).

In 1961 the use of growth charts was recommended by a joint committee of the Food and agriculture organization and WHO (WHO 1962). In 1990, Samir Basta, then Director of the UNICEF evaluation office, initiated evaluation of UNICEF supported growth monitoring activities in seven countries. This revealed low coverage, poor understanding of the causes of malnutrition and very few growth promoting actions (Pearson 1995). The survey reported that growth monitoring activities were ineffective (Shrimpton et al 2003).

In growth monitoring, height velocity remains a useful tool. However, in the assessment of height velocity, the need of accurate measurement is even more important. In the assessment of height velocity two measurements are required separately by time, ideally 1 year (Vass et al 1990). In assessing growth, accuracy is a key consideration. Longitudinal growth charts allow assessment of growth of individual children, which is a key influence on growth assessment. (Hilary et al 2005.)

The main anticipated benefits in developing countries are:

- Early intervention when growth faltering is more easily remedied
- Improved knowledge about the effect of diet and illness on growth
- Families motivated and enabled to take effective action
- Greater self reliance and self esteem
- Fewer referrals for curative care; cost saving and communities mobilized to address underlying socio economic causes of poor health

Individual measurement at a single point in time detect absolute short or tall stature but two or more measurement over a period of time are needed to detect a change in growth rate, irrespective of the starting height, hence the term is growth monitoring and not screening.

Measuring height is subject to error as a result of poor techniques, variations between instrument and observer, diurnal variation and plotting mistakes. A degree of imprecision is inevitable, because over 90 % of the variation between height measurements is the result of the fact that children are not rigid object and do not have an exact or correct height. School entry offers a good opportunity to screen the whole population. The theoretical advantages are low marginal cost when combined with other school entry screening procedure, potentially high coverage and detection of problematic causes. (Hall 1982)

Further research is needed to determine health utility gains and costs. There is a need for controlled studies to evaluate the exact role of height screening programs in improving child health and appropriate measurement strategies to adopt.

Monitoring child growth and development is a routine part of child health care in many countries. In a typical scenario, the health care worker plots heights and weights on a reference diagram, and assesses whether the growth pattern of child deviates from that of the reference population. If so, closer examination of child might be needed. An important goal is to identify diseases and condition that manifest themselves through abnormal growth (Van Buren et al, 2004).

A study done by Lipman et al shows that many children were measured with inaccurate equipment and techniques which results in inaccurate measurements. The study showed that incorrect techniques used when obtaining linear measurement is a major factor contributing to inaccuracy. In the study 70 % of the students were weighed incorrectly (Lipman et al 2004).

The oxford district growth screening program was a community based survey of heights of children at 3 and 4.5 years of age. Over the 3 years period 20338 children were screened for growth monitoring. The mean SD score for boys and girls were 0.33 and 0.35 respectively at age 3 and 0.20 and 0.26 at 4.5 years. The mean growth velocity of 2742 children measured at 3 and 4.5 years of age was similar to that of the national standards, 7.14 cm/year in boys and 7.12 cm/ year in girls (Ahmed et al 1993).

A growth dynamics and weight transition study in India done by Raj et al in Ernakulam District showed the weight and height measurement taken at two point of time. A population of 25228 children was selected from schools. The paired data of 12129 children aged 5-6 years were analysed for the study. The mean interval between two survey was 2.02 ± 0.32 years. The percentage of underweight, normal weight, overweight and obese children in the first year was 38.4 %, 56.6 %, 3.7%, and 1.3 % respectively. The corresponding figures in next year were 29.9 %, 63.6 %, 4.8 % and 1.7% respectively. The study highlights that there was significant difference in trends between socio demographic groups regarding conversion of underweight status to normal weight as well as normal weight status to overweight (Raj et al, 2009).

The school age period has been called the latent period of growth. The rate of growth slows down and the body changes occur very gradually. Resources however are being laid down for the growth needs to come in the adolescent period and it is some time a lull before the storm. The body type is established. Growth rates vary widely within this period. Girls usually outdistance boys by the latter part of the period.

SUMMARY

Thus from the review we can come to the conclusion that prevalence of malnutrition among children is very high in India, especially in rural areas. We also know that school going children are the neglected group. School children are hardly thought of as at risk population. But consequences of malnutrition increases manifold in this age. Thus to reduce the prevalence of malnutrition along with iron deficiency anemia is very important. Growth monitoring is one of the most useful tool for eliciting the data on prevalence and tracking of malnutrition in rural areas.

Iron deficiency affects many age groups but school age is the least identified group. There are very few studies carried out in India for weekly IFA supplementation in school setup. Majority of the studies are done on younger children. The combined effect of IFA supplementation and deworming on growth, hemoglobin status and physical work capacity is also not studied in rural area where the chances of worm infestation are very high due to unhygienic conditions.

This group suffers ignorance at the hands of policy makers in terms of preventive strategies to control iron deficiency anemia. As made clear in the preceding paragraphs, iron deficiency has short term as well as long lasting effects which can be easily prevented by adopting supplementation as the strategy. Since the target group is school children, school becomes an obvious medium for such preventive strategy. It becomes important to come up with feasible supplementation schedule which are not burden on teachers. Therefore weekly supplementation along with deworming was tried in the study.