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Contents

Micro-nutrient Fortification of Food

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The High-level Expert Forum from FAO's 192 Member Nations will discuss, deliberate and take important decisions during the World summit scheduled in Rome around the mid November 2009, the strategies to ensure that everyone has enough to eat both today and tomorrow. During last week of October AIIMS New Delhi is organising An International Workshop on Micronutrients and Child Health to update the participants about the recent advances in the field of Micro-Nutrients and Child Health. While at the macro level food security is addressed in all sincerity at some forums, some other forums discuss the importance of micro nutrients like Iron, Iodine etc., emphasising their need for better health. It is reported that loss due to micronutrient deficiency costs India 1 percent of its GDP. This amounts to a loss of Rs. 27,720 crores per annum in terms of productivity, illness, increased health care costs and death. Anemia prevalence among children under five years is 69% and among women it is over 55% in a recently concluded national study. With the scientific reality of anemia being a late result of iron deficiency, these data reflect an almost universal iron deficiency in Indian population.

In Touch has played a vital role in periodically sharing these concerns by carrying topics by experts on Iron like "Iron Deficiency and Health Consequences", "Home Fortification: A Novel Way to Eliminate Micronutrient Deficiencies", "Micro-nutrient Deficiencies during Pregnancy and their impact" and other articles. In this issue Dr. Subadra Seshadri is concentrating on "From science to practice: improving iron nutrition of the Indian population". She states that the most vulnerable group to iron deficiency and anemia are the pregnant women, women of reproductive age and young children. The statistical data shows how appalling the picture is. Thus it should be the objective of all stake holders like public health bodies, medical fraternity and the home maker to play vital roles in correcting the situation to ensure the nutritional well-being of the emerging generation

From Science to Practice:
Improving Iron Nutrition of the Indian Population

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Micronutrient deficiencies take a major toll on the health and well being of our population. Among the several essential micronutrients that have severe damaging effects on physical, cognitive, social and economic performance, anemia particularly due to iron deficiency ranks the most prevalent. The world wide population affected by iron deficiency with or with out anemia is estimated at a staggering 2 billion people. In populations where anemia prevalence is high as in India and other developing countries, iron deficiency may be universal as anemia is only the end result of iron deficiency. Hemoglobin has been the major criterion for determining anemia, both due to all cause as well as iron deficiency. The groups that are most vulnerable to iron deficiency and anemia are the pregnant women, women of reproductive age and young children. The normal level of hemoglobin for different age and physiological groups are shown in Table 1.

Prevalence of anemia is high in all demographic groups in India as shown in Table 2. What proportion of the anemia is actually due to iron deficiency has been debated. WHO considers that approximately half of the prevalence of anemia is due to iron deficiency (3) although in countries where anemia prevalence is above 80%, iron deficiency may account for much more than half of the prevalence. Additionally an equal number may have iron deficiency (no iron stores) with out anemia. Thus it is estimated that about 2 billion people are iron deficient world wide of which one billion have IDA

TABLE: 1 HEMOGLOBIN VALUES BELOW WHICH ANEMIA IS LIKELY TO BE PRESENT IN POPULATIONS LIVING AT SEA LEVEL AS PROPOSED BY WHO IN1968 AND MODIFIED FOR 5-11Y OLD CHILDREN LATER IN 1998 (1-2)

GROUPS	HEMOGLOBIN LEVEL BELOW WHICH ANEMIA IS CONSIDERED TO BE PRESENT, G/DL
CHILDREN 6M-6Y	11.0
CHILDREN 5-11y	11.5
CHILDREN 12- 13Y	12.0
ADULT MALES	13.0
ADULT FEMALES (non regnant)	12.0
ADULT FEMALES (Pregnant)	11.0

TABLE: 2 PREVALENCE OF ALL CAUSE ANEMIA IN INDIA

GROUP	REFERENCE	PREVALENCE %
PREGNANT WOMEN	ICMR 1989 ICMR 2001 NFHS II 1988-89 NFHS III, 2006-07	87 85 50 58
EARLY CHILDHOOD - PRE SCHOOL CHILDREN (6m TO 35m)	NFHS II, 1998-99 NFHS III, 2006-7	74 79
ADOLESCENT GIRLS	SESHADRI, 1999, Rural Gujarat SESHADRI, 1999, Urban affluent ICMR, 2001, Rural India	62 22 90
ADULT WOMEN EVER MARRIED WOMEN (15-49y) EVER MARRIED WOMEN (15-49y)	 NFHS II 1998-99 NFHS III 2006-7	 52 56

SOURCE: PROC NUT SOC INDIA, 20005 (4)

Epidemiological criteria for assessing the severity and the magnitude of anemia in populations have also been proposed, which is shown in the Table 3

TABLE: 3 POPULATION PREVALENCE FOR DEFINING THE SEVERITY OF THE PROBLEM

PARAMETERS	HIGH	MAGNITUDE MODERATE	LOW
Percent of population with Hb level less than the defined cut off points	> 40	10-39	<10
Percent of population with Hb level less than 7g/dl especially women and children	>10	1-9	<1

TABLE: 4 ROLE OF IRON IN ENERGY PRODUCTION

NAME OF PROTEIN	FUNCTIONAL SITE	MAJOR FUNCTION
Hemoglobin	Red blood cell	Oxygen Transport
Myoglobin	Cytoplasm of muscle cells	Diffusion of oxygen to mitochondria
Oxidative enzymes	Mitochondrial membrane	Oxidation of substrates
Respiratory chain proteins	Mitochondrial membrane	Electron transfer

Unlike anemia, the diagnosis of iron deficiency requires a battery of laboratory tests. Iron deficiency is indicated by absence of stainable iron in the bone marrow, reduced serum ferritin level, increased transferrin receptors in the serum, elevated blood levels of free erythrocyte protoporphyrin and increase in hemoglobin levels with iron therapy, the last of which lends itself more easily for use at the community level.

Iron deficiency occurs when an insufficient amount of iron is absorbed to meet the body's requirements. It is a progressive condition that often begins with normal body iron status, which becomes depleted because of low dietary iron intake, inadequate intestinal iron absorption and increased iron losses. As this process continues, synthesis of iron containing proteins become compromised. Eventually, when hemoglobin concentration falls below a specified cut-off value as described above, anemia of iron deficiency occurs (IDA). Normal healthy individuals have a store of iron in the liver, which is mobilized under dietary deficiencies and or increased losses and rebuilt when conditions become favorable. Iron stores in the liver are kept with in safe limits through an orchestrated mechanism involving the principal hormone, hepcidin which fine controls several iron absorption regulating proteins such that iron deplete individuals absorb more iron from the same diet compared to iron replete individuals.

Iron deficiency and anemia produce a range of impairments in oxidative energy production. Hemoglobin functions in the body as the chief oxygen carrier, while other iron containing mitochondrial enzymes and respiratory chain proteins are involved in the oxidative metabolism and release of energy from substrates like carbohydrates and fats (Table 4).

In iron deficiency anemia aerobic capacity is impaired due to lowered oxygen delivery consequent to low hemoglobin levels. This reduced capacity for physical work has been shown to result in reduced productivity and income earnings of the anemic population in several countries. In addition to physical work capacity, mental functions, cognitive development, immune functions and pregnancy outcome are all affected adversely in iron deficiency anemia. Given this wide ranging adverse effects of anemia on functional capacity, it is vital to understand how the iron status of the population can be improved by bridging the gap between the science of iron nutrition and the practices for control of iron deficiency.

WHAT DO WE KNOW ABOUT THE FACTORS INVOLVED IN THE CAUSATION OF IRON DEFICIENCY AND IDA?

FORM OF IRON IN THE DIET

It is important to know that food iron exists in two forms, the heme and the non heme iron. Heme iron is found in flesh foods in an organic combination and is absorbed quite well, 15-20 %. On the other hand non heme iron is found in foods of vegetable origin, present as inorganic iron and its absorption varies widely from less than 1% to about 5% depending on the other constituents of the diet. The relative contribution of non-heme and heme iron to the total intake depends on the proportion of vegetable and flesh foods in the diet. In India, even among the non vegetarians, the frequency and quantity of consumption of meat, fish and poultry is quite low such that for practical purposes the diets are predominantly composed of vegetable foods and therefore provide primarily only non heme iron that is absorbed poorly leading to iron deficiency and anemia in the general population.

LOW IRON INTAKES

Dietary iron intakes are reported to be low among all sections of the Indian population.

The NNMB house hold surveys for the period 2000-2005 report average intakes of 15-17 mg of iron per day for an adult (CU). The average intake was less than the recommended level of 28mg/CU/day in 94% of the house holds studied and more than half of the house holds were consuming less than 50% of the RDI of iron. This would indicate that the intake of sizeable proportion of our population must be very low, which is responsible among other factors for the high prevalence of iron deficiency and anemia. This is corroborated by individual intake data reported by NNMB (5). Individual intakes reported for pregnant women 25 mg/d fall far short of the recommendation of 37.5mg/d (6). Intake data on 6m-24m old children are not widely available. Average iron intake of 1-3y old children is reported to be 8.7 mg/d whereas the recommended intake at 3% absorption is 11.5mg/d.

It must be mentioned here that these recommendations are in the process of being revised with newer data suggesting that the earlier absorption figures used in the 1990 report may have been somewhat of an under estimate. Even so the gap between requirement and intake will persist for many demographic groups.

POOR BIO AVAILABILITY (LOW LEVEL OF ABSORPTION)

Poor iron absorption from Indian dietaries is another factor that contributes to the wide prevalence of anemia. The amount of absorbable iron in the diets, also known as bio available iron is defined as the fraction of the intake that is absorbed and utilized for specific functions with in the body. A prominent feature of the vegetarian diets in India is the high content of iron absorption inhibitors such as phytic acid, tannins and poly phenols that form insoluble complexes with iron in the intestine and make it unavailable for absorption. The action of these inhibitors can be countered by ascorbic acid which is a potent enhancer of iron absorption and the most important in the Indian context.

Ascorbic acid operates in multiple ways to increase iron absorption, by forming a soluble complex at the acidic pH in the stomach that remains soluble as the pH rises in the small intestine, by reducing the ferric to more readily absorbed ferrous ions, by preventing the formation of insoluble complexes with the inhibitors and by preferentially donating its iron to the brush border receptors to increase iron uptake by mucosal cells. In vivo absorption studies have shown that 30 mg of ascorbic acid in a meal can increase the iron absorption twofold while 50-75 mg can bring about 3-5 fold increase in iron absorption. In other words with in the range of physiological intakes of ascorbic acid, iron absorption especially from typical non heme iron containing diets can be increased very significantly, a finding that needs to be translated into dietary practices much more vigorously.

Meat and flesh foods, also possess the ability to enhance non heme iron absorption in addition to containing better bio available iron. The iron absorption enhancing effect of 100g meat is considered equivalent to 100 mg of ascorbic acid. Given the economic constraints to the consumption of flesh foods, the only enhancer of significance in the predominantly vegetarian Indian dietaries is ascorbic acid. The inhibitors of iron absorption on the other hand far outnumber the enhancers. House hold processes like germination and fermentation are shown to reduce the content of inhibitors of iron absorption in the diets and can be useful as additional measures for improving iron availability. Food that contribute substantial amount of iron and ascorbic acid (vitamin C) in the Indian dietaries is shown in the Table 5.

It is evident from the Table 5 that a predominantly cereal pulse diet will provide good amount of iron but no ascorbic acid and absorption of iron will be quite low. On the other hand fresh fruits contain little or no iron but are good sources of ascorbic acid. Leafy vegetables provide both iron and ascorbic acid. A combination of all three in a meal can increase the amount of absorbable iron. Therefore it is important that every meal of staple cereal and pulse should be consumed with another food source of ascorbic acid, and this must preferably be in a fresh form if it is a fruit and cooked just right if it is a leafy or other vegetable, as prolonged cooking results in almost complete loss of vitamin C. Another requirement is that the sources of ascorbic should be a part of the meal, consumed with or immediately following it, as the concurrent presence of iron and ascorbic acid in the duodenum is necessary for the latter to increase iron absorption. If this message can be spread widely it will go a long way in alleviating iron deficiency.

INCREASED IRON LOSSES

The fourth factor concerns the increased iron losses due to infections and infestations. Especially relevant in this context is the parasitic infestations such as hook worms that result in a loss of blood and round worms that reduce absorption of nutrients. Poor personal and environmental hygiene are important causative agents in the increased susceptibility to these infestations. Periodic deworming particularly in endmic areas is shown to improve hemoglobin levels and should be used as an interim measure until such a time that personal and environmental sanitation can be substantially improved.

IRON REQUIREMENTS

INFANTS UNDER THE AGE OF 6M

Young children are particularly

TABLE 5 MAJOR FOOD SOURCES OF IRON AND ASCORBIC ACID IN INDIAN DIETARIES

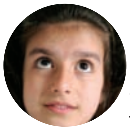
GROUP	IRON-MG/100G (raw)	ASCORBIC ACID (vitamin C) mg/100g (Raw)/(Fresh)
Cereal grains and millets: wheat, bajra, jowar and different millets	4 - 9	0
Pulses and legumes: Bengal gram, black gram, green gram, cow pea, rajmah, dry peas	4 - 7	0
Leafy vegetables, amaranthus species, bengal gram leaves, colocacia leaves, kuppemani, chekkurmani, leaves,paruppukeerai, ponnanganni, spinach, drumstick leaves	10 -30	30 -250
Other vegetables commonly consumed	Less than 2	10 -50
Drum stick, capsicum,and bitter gourd	Less than 2	88-137
ROOTS AND TUBERS: Potato, sweet potato, radish, yam	1 -1.5	17-43
FRUITS: Guavas, lime, sweet lemon, oranges, papaya, pine apple, sitaphal, korukkapalli, zizyphus	Less than one	30 -200

SOURCE: NUTRITIVE VALUE OF INDIAN FOODS, 1989

prone to iron deficiency because of their increased iron requirements. Infants from birth to 6 months are considered to receive adequate iron if they are of normal birth weight and are exclusively breastfed. The unique features of iron metabolism in the first 6 months, especially the high levels of hemoglobin in the new born, usually 18-20g/dl; the gradual decline of Hb to the normal levels of 11g/dl by 6 months; the reutilization of iron released from the excess hemoglobin for expansion of the pool of red cells in the first 6 months and the high bio availability of iron (50%) in breast milk are all important in protecting the infants from iron deficiency during this stage, for which they have to be exclusively breast fed in the first 6 months. However the NFHS 3 data show that only 46 % of children under six months of age in India were exclusively breastfed, exposing a large majority of the infants at this early age to the risk of iron deficiency. Introduction of fresh bovine milk earlier than 6m of age is reported to result in allergic gastro intestinal bleeding and loss of iron in some infants making them further vulnerable to iron deficiency.

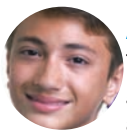
YOUNG CHILDREN 6M- 2Y

Children from 6m to 24m are placed much more precariously with respect to iron adequacy due to their rapid growth and the need to replace iron losses. Estimates of absorbable iron requirement for this group vary from 0.4-0.9 mg per day (6, 7), anywhere from half to same as that of adult requirement. Compare this with the energy requirements of young children and adults, 700 -1000 kcals/d versus 2300-2700 kcals/d and it becomes immediately apparent that the bio available iron density of the infants diet must indeed be two to three times as high as that of the adults to provide adequate amount of absorbable iron to the infants. Yet the complementary foods given to Indian infants is often the same as what the adults consume in the households, making it difficult for the infants to ingest adequate iron. This is the most difficult period in feeding young infants as mothers are generally not aware and not convinced of the variety and quantity of foods needed by these children; the need to make the food soft in texture and the need to maintain good personal and environmental hygiene. Infants on their part are very prone to infections and illnesses during this period as they become more mobile and start exploring the environment. A combination of dietary inadequacies and infections lead to high levels of IDA that can only be tackled through comprehensive integrated measures to address all of the above factors.



OLDER CHILDREN

Beyond the age of two years the ability of the child to consume solid foods becomes increasingly better as also the willingness of mothers to offer them a variety of foods. Thus we see the prevalence of anemia declining as the child gets older. The reported level of anemia in children 6-8m from the NFHS III survey is 79% which rises to 84 % in children 12-17m and declines to 74.6 in 24-35m and to 53 % at 48-59m. The requirements for absorbable iron increases from 0.4mg/d for 1-3y olds to 0.78mg/d for the 7-9 y old children.



ADOLESCENTS-10-18Y

The adolescents form a special group as their iron requirements are increased during this period. In fact during the growing years, the only time when iron requirements reach a high after infancy is during adolescence. Estimated absorbable iron requirement of adolescent males 10-18y, is 1.0-1.5 mg/day and that of adolescent females is 0.94-1.5 mg/day. Assuming a dietary iron bio availability of 5%, this translates into dietary requirement of 20-30 mg /day, and at 3% it will even be higher, 30-50mg/d. Given that typical Indian diets provide approximately 7mg of iron/1000 kcals, increasing bio availability of iron and hence the quality of the diets offers the best option for meeting the iron requirements of this group.. The spin off will be the added anti oxidants and phyto nutrients from vegetables and fruits that have many other health benefits. Iron and other micronutrient fortified foods and iron supplementation are additional measures that can effectively bridge the gap between deficits in dietary intakes and requirements. Global studies have provided evidence that supplements of iron at appropriate dose levels, given once or twice a week reduces iron deficiency and IDA in this group.

PREGNANT WOMEN

Pregnant women form another group that is most vulnerable to iron deficiency anemia. For pregnant women the estimated average requirement for absorbable iron is two to three times higher than the non pregnant non lactating women, although their energy intakes may increase only marginally and iron density of the diets remain about the same, making it almost impossible to get the required amount of iron only from the diet. There is considerable individual variation but the mean iron cost of pregnancy is around 800mg , which translates into a mean absorbable iron requirement of 3mg/d in the second trimester and 5mg/d it the third trimester .More over, pregnant women in India, hardly have any stores of iron that they can draw upon. Thus they form a special category in terms of iron needs and have to be supplemented with medicinal iron from as early in pregnancy as possible. It is well documented that iron supplements during pregnancy started early in pregnancy and continued till delivery can reduce the prevalence of anemia substantially in this group.

WHY SHOULD WE BE CONCERNED ABOUT IRON DEFICIENCY AND IRON DEFICIENCY ANEMIA?

PHYSICAL PERFORMANCE AND PRODUCTIVITY

Iron deficiency and anemia produce not only an array of changes in bio chemical measurements but also impact on several functional areas in humans. There is strong evidence of a causal relationship between iron deficiency anemia and physical performance, measured in terms of aerobic capacity and endurance, in adults. Aerobic capacity is the capacity of the respiratory and cardiovascular systems to deliver oxygen to working muscles and reflects physical fitness of an individual. Endurance is defined as the maximum length of time an individual can sustain a physical work load, usually a sub maxima load. Aerobic capacity is reduced as hemoglobin levels fall and there is almost a linear relationship between hemoglobin and aerobic capacity across the range of 6g/dl to 13g/dl. That impaired physical work capacity of IDA results in reduced productivity and reduced income earnings has also been amply demonstrated. These adverse effects are reversed with iron therapy. Our studies on pre school and school age children have shown that their ability to engage in physical activities is significantly impaired in anemia and these adverse effects are reversed when hemoglobin levels are raised with iron supplementation.

COGNITIVE DEVELOPMENT OF CHILDREN

Besides physical performance, cognitive development of children is another aspect which is adversely affected in iron deficiency anemia. Longitudinal follow up studies provide considerable evidence for poorer cognitive development of anemic children which is reversed with iron supplements in older children above the age of two years. The specific cognitive areas affected have been identified as attention, concentration, memory and concept learning. Some studies have also reported improvement in standard school achievement tests of anemic children after iron supplementation. The mental and motor development deficits noted in iron deficient anemic children below the age of 2 y are not reversed with iron therapy making it imperative to devise effective preventive measures.

ECONOMIC CONSEQUENCES OF IRON DEFICIENCY

The economic consequences of iron deficiency anemia can be quite devastating. Detailed calculations based on productivity and cognitive impairment has shown that the economic losses in India due to iron deficiency anemia may be a staggering 4200 million US dollars equivalent to 1.47% of the GDP (8). Imagine, when anemia is fully eradicated the expected increase in GDP will be enough to provide the resources for preventing the environmental warming in India, estimated to cost 1.6% of the GDP!

ADVERSE EFFECTS IN PREGNANCY

Adverse effects of iron deficiency anemia in pregnancy include pre term delivery, low birth weight and complications of child birth such as still birth and increased perinatal mortality. Anemia is an associated cause of maternal mortality in one quarter of all maternal deaths in the developing countries. Therefore it is clear that it is not only the bio chemical abnormalities but many severe damaging effects of iron deficiency and anemia that should cause grave concern and impel us to develop effective strategies for its control based on current state of knowledge.

While knowledge on iron is far more advanced than other micronutrients what hampers the translation of the science into practices is the complex interplay of dietary, environmental, social and economic factors involved in the causation of iron deficiency.

HOW DO WE TRANSLATE THE SCIENCE INTO PRACTICES: EFFECTIVE STRATEGIES FOR IMPROVING IRON NUTRITION

THE FIRST TWO YEARS ARE CRITICAL

Integrated efforts and a life cycle approach are needed to address all causative factors to see a significant improvement in iron nutrition and reduction in iron deficiency. Iron intake and bio availability both have to be improved to meet the iron requirements of infants and young children. Exclusive breast feeding of normal birth weight infants in the first 6 months will assure adequate iron status of the infant during this period. Yet only 69 percent of children under two months of age are reported to be exclusively breastfed in the NFHS III survey which dropped to 51 percent at 2-3 months of age and to 28 percent at 4-5 months of age. There is a pressing need to beam the exclusive breast feeding till 6m message (i.e. nothing other than breast milk) to the mothers in the pre natal and early post natal period and to the other house hold members who often hold views different from this to create an enabling environment for change.

However, low birth weight infants require supplements of iron from two months onwards, 2mg/kg body weight per day (3). The problem is both with identifying the LBW infants when deliveries occur in the homes and in administration of the supplements.

Children 6m to 2y are the most vulnerable to iron deficiency as the intake of high bio available iron of breast milk is reduced due to declining lactation from 6m onwards, the child's iron requirements remain quite high and complementary feeding practices are very inadequate. As the child becomes increasingly more mobile, exposure to infections increases. Thus dietary, physiological, social-cultural and environmental factors interact to make the iron status very poor. Major thrust during this period should be to convince the mothers and the care takers to adopt desirable complementary feeding practices. Production of suitable iron fortified culturally relevant complementary foods that would entail a minimum of preparation time and effort, taken up as a part of corporate social responsibility can go a long way in addressing this problem. There is little data on the impact of iron fortified complementary foods on the iron status of Indian infants and children below the age of 2y. The current emphasis is on feeding a mix of home foods with effective communication for behavior change. However, little progress has been made in improving the complementary feeding practices of young children of as seen below...

The NFHS III (9) reports that only 44 percent of children, 6m-23m, were fed at least the minimum number of times recommended i.e., thrice in a day, along with continued breast feeding. Of these only half of them consumed a variety of foods, i.e., foods from three or more food groups. Feeding practices were even poorer in children for whom breast feeding had been discontinued. Only 12 % of these children were fed frequently enough, i.e., four or more times a day using foods from four or more food groups. It is evident that these highly unsatisfactory young child feeding practices are mainly responsible for the continuing deterioration of iron status and overall nutrition during the 6m-23m age, with reported prevalence of anemia increasing from 79% at 6m to 85% at 12-17m. This age group is the most critical and if we can find successful interventions and scale them up, the magnitude of the problem at later ages will become increasingly less challenging.

We have a policy on iron supplements for young children, but this has not been translated into a program. Further we really do not have a suitable iron preparation for the 6m- 2y old children, though the policy makes a mention of liquid iron preparation for the younger age groups. Given this scenario, it should be emphasized again that fortification of suitable commonly consumed foods with iron (and other micronutrients), will need to be taken up as a priority with the involvement of industries and the private sector. Several states in India, example Rajasthan and Gujarat have described experiences of introducing fortified foods through the ICDS program but data on a large scale are not available. Attempts have also been made to develop a micronutrient mix that goes under the name of sprinkles, primarily for home fortification.

Diet diversification must be pursued concurrently, as also nutrition communication to bring about dietary behavior changes. Other measures include

continued breast feeding till one year and beyond and improved personal and environmental hygiene that must be promoted concurrently to benefit the child population fully. The last of it is once again a truly a challenging task and needs to be addressed effectively.

OLDER CHILDREN AND ADOLESCENTS

Children 2y and above can consume a wide variety of adult foods with out any difficulty and therefore, the major emphasis from this age onwards is to diversify the range of foods the house hold consumes, paying particular attention to iron bio availability. Children as they grow older get into the habit of drinking tea along with a snack or a meal which seriously inhibits iron absorption, reducing it to less than 0.5% many times. Tea drinking along with a meal or consumption of foods high in iron absorption inhibitors must be avoided, while consumption of foods containing iron absorption enhancers such as ascorbic acid along with the meals must be encouraged. Our studies of hemoglobin regeneration in anemic children and young women have shown that ascorbic acid given in the form of fruits like guavas, along with the major meals of the day improved hemoglobin levels substantially. The adoption of these practices require well designed educational programs to be beamed to the children in school and in the community and at the same time serious efforts to link food and agricultural policies for greater production, preservation and distribution of the foods. The mid day meal provides an opportunity not only to provide nutritional support to the school children but also to act as a powerful vehicle to inculcate desirable diet practices in children.

Food fortification can and must play an important role in ensuring adequate iron intakes of the older children as well. Studies on school children in India have tested double fortified salt (iron and iodine), iron fortified extruded rice and nutria candies (10-12) These were all shown to be effective in improving hemoglobin levels and reducing the prevalence of iron deficiency and IDA. As of now these are experimental studies but there is an urgent need to select and scale up the most effective of these to the larger population.

As the efforts at dietary diversification and food fortification initiatives are still in a nascent state, the former made more difficult by escalating food costs, supplements of iron (as a part of the school health/non school adolescent program) is an important measure to sustain adequate iron status of the older children. In this context the WHO has recommended that weekly iron folate supplementation is an important strategy for the prevention of iron deficiency, improvement of pre-pregnancy iron reserves and the improvement of folate status in women (13). When integrated with other efforts to control iron deficiency as mentioned above, this can prove to be effective in the long term.

PREGNANT WOMEN

The pregnant women, by virtue of the high iron cost of pregnancy and the difficulty of meeting much of this requirement through improved diets or fortification iron, are the top priority group for iron supplementation. All experimental studies have shown that the prevalence of anemia in this group can be reduced significantly through medicinal iron folate supplementation started early in pregnancy and continued till delivery. The anemia control program in India provides iron-folic acid supplements (IFA) consisting of 100 mg iron and 500 mcg folic acid daily for a minimum of 100 days to pregnant women, starting as early in pregnancy as possible and continuing for the rest of pregnancy. Improving maternal health requires that all pregnant women have access to regular antenatal check ups, consume the full course of iron folic acid tablets and have a trained and qualified person to assist in child birth. Yet , only half of all the pregnant women have had three antenatal checks, only 22% have consumed 90 or more tablets of IFA, and only 48% had births assisted by qualified personnel(9). With only one quarter of the pregnant women consuming 90 tablets or more of IFA, we can hardly expect to see any reduction in maternal anemia. Our studies on the anemia control program in Baroda have shown that if at least two thirds of the pregnant women consume 90 or more of IFA tablets, we can bring the anemia prevalence from 52% down to 39%. It is interesting that Kerala which has reported 77% full consumption of IFA by pregnant women finds anemia prevalence to be 33%, while for all India with 22% full consumption, the prevalence remains high at 58%. The key to success will be effective delivery systems for IFA supplements to pregnant women, ensuring high level of compliance through personal counseling and good remedial measures for side effects. In the current situation in India, dietary measures such as diversification

TABLE 6 INTERVENTIONS THAT SHOULD BE SCALED UP FOR CONTROL OF IRON DEFICIENCY

INFANTS/TODDLERS	1. Breast feeding promotion 2.Iron and other micronutrient fortified complementary foods 3. Improved feeding frequency, at least 4 times a day 4. Use of a variety of foods 5.Infection control
PRE-SCHOOL CHILDREN 2-6Y	1. Iron fortified foods 2.Diet diversification
SCHOOL CHILDREN/ ADOLESCENT GIRLS	1. Access to and utilization of iron fortified foods on a wider scale 2. Weekly supplements of iron and folic acid to all girls 3. Periodic deworming
OUT OF SCHOOL/ ADOLESCENT GIRLS	Same as above but through community based programs
PREGNANT WOMEN	1.Iron folic acid supplements as per the program, daily 2.Ensure regular distribution and compliance 3.General fortified foods
GENERAL POPULATION	1.Diet diversification, 2. Fortified foods

and fortification for pregnant women can only be secondary to supplementation as a measure for control. Therefore the major focus should be on making the supplementation program work well.

CONCLUDING STATEMENT

It is apparent from the above review that a comprehensive strategy for prevention and control of iron deficiency and IDA must include breast feeding promotion, food fortification- of complementary foods and other general foods, dietary diversification, supplementation, and other public health measures as shown in Table 6 (seen on page 7). Public health measures and improved personal and environmental sanitation must cover the entire population. The scientific advances related to iron in human nutrition have provided a set of solutions to prevent and control iron deficiency and IDA but how much of this can be translated into action depends entirely on the concerted action of all concerned.

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BRIDGING THE GAP OF IRON DEFICIENCY – TRANSLATING SCIENCE INTO ART OF PRACTICE.

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Iron deficiency is widely prevalent in children and women of childbearing age in India with its dire consequences of suboptimal physical work capacity and cognitive development, deficient immune functions and poor pregnancy outcome. In spite of scientific knowledge about physiology of iron absorption and utilization, there exist several factors responsible for poor iron status in Indian population. Insufficient iron intake, mainly in non-heme form, poor bioavailability of consumed iron due to presence of iron absorption inhibitors such as phytates, tannin and lack of iron absorption enhancers such as ascorbic acid in food and high prevalence of infections and worm infestations are major impediments in maintaining iron balance in Indian population.

In this volume of “In-Touch”, Dr. Seshadri with her wide experience in the field of nutrition has suggested interventions for translating science into practice to scale up control of iron deficiency in India. It is hoped that readers will seriously implement suggested ways of improving iron status of the community.