

Intervention Strategies for Improving Iron Status of Young Children and Adolescents in India

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Despite advances in scientific knowledge regarding multiple etiology, treatment, and potential strategies for combating iron deficiency and deficiencies of other micronutrients, iron deficiency anemia, vitamin A deficiency, and iodine deficiency remain significant public health challenges for growing children and adolescents. The short-term efficient supplementation approach, although technically feasible, has not been successful due to problems with delivery and compliance. Evidence is building that preventive supplementation coupled with nutrition education may be a more effective strategy associated with better compliance and improvement in iron status. Long-term, effective approaches include fortification, dietary modification, public health and disease control measures, and income generation programs. Food fortification can be a cost-effective intervention strategy if technologically feasible, nutritionally sound, culturally acceptable and economically viable food vehicle(s) and fortificant(s) can be identified. Foods such as wheat, rice, and salt are commonly consumed in India; research is underway to evaluate various fortificants for these foods. Doubly fortified salt with iodine and iron may be particularly promising in the Indian situation as it is affordable, culturally acceptable, and may enhance iron absorption from Indian dietaries containing inhibitors of iron absorption. Feasibility studies are underway to evaluate the stability and storage issues as well as bioavailability of fortificant iron. Dietary modification involves increased iron intake, by increasing total food intake and consumption of locally available iron-rich foods, and dietary practices favoring iron absorption. Blood loss associated with worm infestation can be controlled by periodic deworming and reducing reinfestation. Coordinating these major intervention approaches by building partnerships between the community, existing nutrition and health programs, government, industry, and academic in-

stitutions is critical for success of these programs. Nutrition education must be integral to all of these strategies discussed. Primary health care system and school infrastructure and staff, along with school children and community members, can be powerful resources for addressing malnutrition in children and adolescents.

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The Department of Nutrition for Health and Development, World Health Organization, has identified and works through seven priority areas for action; three focus on addressing problems of malnutrition and the remaining four focus on programmatic approaches for preventing or managing these types of malnutrition worldwide.¹ Despite some strides in addressing nutrition deficits, protein-energy malnutrition, iodine deficiency disorders (IDD), vitamin A deficiency (VAD), iron deficiency anemia (IDA), and deficiencies of other micronutrients, such as folic acid and zinc, remain public health challenges today among young children and adolescents in India. Approaches for addressing iron deficiency in this population will be discussed in this paper.

Dietary factors are the chief causes of iron deficiency and anemia in children and adolescents. Low iron intake and poor absorption of dietary iron are insufficient to meet iron requirements for growth, menstrual blood loss, and blood volume expansion and other events related to pregnancy and delivery.^{2,3} Greater rates of intestinal worm infestations, particularly hookworm, whipworm, shistosomiasis, malaria, and other acute and chronic infections may further aggravate the dietary limitations.^{2,4}

Intervention strategies for addressing micronutrient malnutrition include the short- to medium-term approach of iron supplementation for vulnerable groups such as growing children and adolescents. Medium- to long-term effective approaches for addressing iron deficiency include food fortification, dietary modification, and public health and disease control measures, such as improved sanitation, prenatal and antenatal care, and immunization.^{4,5} Supporting income generation programs, such as the Integrated Rural Development Program in India,⁶ can increase food purchasing power and total energy and micronutrient intake.^{4,7,8}

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Iron supplementation to young growing children is part of the national nutrition policy in India. The existing supplementation programs have limitations such as poor coverage, irregular and inadequate supply of supplements, insufficient training or no training for workers, and the lack of an education component.⁹ The national iron supplementation program needs to be extended to cover all growing children and adolescents, particularly adolescent females. Supplements can be given at schools—success of this approach has been demonstrated in Malaysia¹⁰—and via the existing Integrated Child Development Services (ICDS) anganwadi infrastructure in India. Creative programs exist, such as a child-to-child trust being piloted in India and Pakistan, in which school children who receive supplements and nutrition education act as effective mediators of change, educating their families about the importance of iron and traditional, locally available iron-rich foods. They also serve as leaders for providing iron supplements to preschoolers in their family and neighborhood.

Adherence and compliance could be improved with weekly rather than daily supplementation.² Iron and folate supplementation appears prudent but more knowledge is needed regarding effective amounts for zinc supplementation. For supplementation to be effective, it must be integrated with community education activities such as child-to-child trust or focus groups with health workers and parents or teachers. For supplementation programs to be of maximum benefit, they need to include deworming efforts.^{4,5} School, village, and anganwadi health days, for example, could offer deworming, vitamin A supplementation, and immunization. Significant training and education is needed for community workers to make such programs effective. There is also a need to install systems for recording and monitoring the long-term effectiveness of iron supplementation programs.

Fortifying foods with iron compounds can be an effective strategy. The choice vehicle for fortification is a food that is inexpensive, commonly and uniformly consumed by all age groups, processed at limited centers, distributed widely throughout the country, and able to withstand prolonged storage under prevailing environmental conditions.^{3,11-13} The choice of fortificant is affected by bioavailability, stability during storage, its interaction with the vehicle during storage and preparation (organoleptic changes in cooked food), the properties of the meals containing the iron fortificant (i.e., amounts of enhancers, inhibitors), its safety in doses likely to be consumed, and the iron status of the population.^{3,11-13} Some examples of countries which have established or are establishing iron fortification programs include Mexico and Indonesia (wheat flour), Japan (rice, also fortified with vitamins A and B), Venezuela (maize, also fortified with vitamin A), and Guatemala (sugar, also fortified with vitamin A). If technically feasible,

economically viable, and nutritionally sound approaches to fortifying food with iron and other micronutrients can be developed, they would offer a low-cost, long-term effective strategy to widely control and prevent IDA.^{14,15}

In the Indian subcontinent, potential vehicles for iron fortification include wheat, rice, sugar, and salt. Although wheat, rice, and sugar are usually processed at numerous sites in the country, in rural areas, locally produced staples are often consumed instead, making these foods less suitable for fortification. Double fortified salt (DFS) with encapsulated iodine and iron may be promising.^{14,15} Salt is widely consumed, inexpensive, processed at limited sites, and is distributed throughout the country. The technology for DFS is feasible and further studies on stability and storage are being conducted by ILSI India, and the National Institute of Nutrition in Hyderabad. Thus, DFS may offer a suitable means to address IDA in the Indian subcontinent. Successful fortification would, however, require industry, government, academic institutions, and the media to work cohesively as partners to provide educational messages that encourage the consumption of fortified foods. New systems must be implemented or existing systems strengthened for quality control and enforcement of fortification policies.

Targeted fortification can offer means for reaching vulnerable populations using the existing infrastructure of schools and anganwadis (child health and development center). Recently in South Africa, a targeted fortification trial to 6-11-year-old children with cookies fortified with beta carotene, iron, and iodine, and served daily at school with a cold drink containing vitamin C, showed improvement in children's status of all three micronutrients versus a control group.¹⁶ The cookie was viewed as a snack rather than as a meal and therefore did not replace meals given at home. Cookies require no preparation, are easy to distribute, and have a long shelf life. Also, packages are easy to monitor for accounting purposes and therefore less likely to fall prey to misuse or corruption. Other existing systems, such as the ICDS ready-to-eat meals and mixes, could be fortified with vitamin-mineral premix or double fortified salt and could possibly include amylase-rich foods (ARF) such as barley malt and germinated wheat powder. Additionally, germinated wheat powder could be prepared by rural women and children and marketed to the state government for use in the ICDS program, yielding additional income for the families and empowering the community by direct participation in community intervention programs.

Dietary modification strategies to improve iron status include increasing total iron intake and encouraging dietary and lifestyle practices that favor enhanced iron absorption. Increasing total food intake has been shown to increase iron intake in studies conducted in India.^{4,7,8} Innovative ways to improve total food intake include improving self-esteem of girls, which has shown promising results in pilot studies in India, and encouraging physical activity in school to build

muscle mass, increase food intake, and prevent obesity and osteoporosis in the long term. Continued government support for income generation programs involving a nutrition component such as the Integrated Rural Development Program (particularly the buffalo program)⁶ and the germinated wheat powder cottage industry for rural women will contribute to long-term improved nutrition overall. Further, the production, conservation, and use of traditional iron-rich food plants could be increased by using participatory appraisal approaches and sustained nutrition education efforts involving the community leaders. Nutrition education at school and in the community is essential to encourage dietary practices for improving iron absorption from meals. Pilot studies show that school children, teachers, and health workers can be communicators and agents of behavior change.¹⁷ Promising results using nutrition education as a strategy to improve iron nutrition and reduce anemia have been obtained in Peru.¹⁸ In addition, bioengineered foods may offer another means for dietary modification in the near future. Genetically engineered high-iron rice, bioengineered high-phytase rice, low-phytic acid maize, and rice containing soybean ferritin gene are a few examples.^{19,20} Bioavailability studies are underway to examine the potential contribution for reducing IDA by these means. Higher cost, yield considerations, and sustainability of the genetically modified seeds in various environments may need to be considered.

It is also necessary to promote health and prevent disease by coordinating the availability of health services and improving their use by the community. Great benefits can be obtained by using the existing infrastructure and staff in health care and other governmental programs to deliver coordinated services, including deworming and preventing reinfestation; improving food hygiene and sanitation; and expanding immunization, antenatal care, and perinatal practices.^{4,5} Enhanced use of these services will depend on using empowering approaches involving active participation of the community.

In summary, for ensuring effectiveness of the strategies discussed above, it is important that these measures are coordinated and integrated into current programs, using existing infrastructure to offer a package of locally relevant intervention approaches. Strengthening partnerships among community, existing programs, industry, and government will be important in this respect. An emphasis on community involvement and participation is critical for increased use of these services, resulting in an increased likelihood of their potential long-term effectiveness.

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