Forging Effective Strategies to Combat Iron Deficiency

Experiences and Challenges in Developing Countries\textsuperscript{1,2}

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ABSTRACT Compared with the industrialized nations, the challenges of combating iron (Fe) deficiency in developing countries include the far greater magnitude of the problem, the more limited resources and the more complex nature of the setting. The two groups most affected by Fe deficiency are young children and women of reproductive age. Infant diets in developing countries are low in iron, due to less use of industry prepared foods and much lower consumption of food from animal sources. Successful experiences in countries such as Chile and the United States have shown that it is feasible to reduce anemia levels in young children through the use of fortified infant food products and low cost weaning foods. In settings in which people are already using processed foods, the cost of improving the nutritional value of these foods is marginal compared with the significant benefits. However, costs and accessibility by the poorest are important concerns, and other options such as supplementation and efforts to improve complementary feeding also require attention. The high prevalence of iron and other micronutrient deficiencies due to poor diets and/or infections among women before and during pregnancy calls for strategies such as fortification and periodic supplementation. Experience to date suggests that fortification of staples (e.g., wheat flour) is a cost-effective and feasible strategy, but regulatory monitoring is required to demonstrate effectiveness and ensure quality. Supplementation is still required for all pregnant women, however, and challenges remain in finding ways to improve coverage and compliance. In summary, effectively combining and balancing the needs of program implementation, research and community involvement will help combat Fe deficiency.


KEY WORDS: iron deficiency • iron fortification • interventions • developing countries

This paper focuses on the challenges faced and the experience gained in the developing world in combating iron deficiency. It will also compare and contrast that experience with lessons learned in more industrialized countries.

Compared with the industrialized nations, the challenges of working in developing countries include the far greater magnitude of the problem, the more limited resources and the more complex nature of the setting. Part of that complexity is the broad spectrum of conditions in developing countries. For example, Latin America has less anemia but higher incomes and better diets compared with South Asia. Similarly, large countries such as India, China and Brazil have areas that are highly developed and others that are very poor. These differences, combined with the challenge of limited human and financial resources, add to the complexity of combating iron deficiency in developing countries. Therefore, to make progress, it is crucial to review the full spectrum of experiences from developed and developing countries to identify which approaches work best, and then to apply that knowledge as broadly as possible.

Assessment of iron deficiency

The choice of indicators with which to assess the magnitude of iron deficiency and monitor progress is an important concern. The most commonly used indicator of iron deficiency is hemoglobin. However, the uncritical use of this indicator raises concerns stemming primarily from the understanding that not all anemia is due to iron deficiency and not all iron deficiency will be reflected in anemia. Hemoglobin may not always be the most appropriate indicator because the nature of the problem can differ considerably in different settings. For example, iron deficiency is generally mild and anemia prevalence is relatively low in developed countries, whereas the opposite is true in many developing countries. The etiology of anemia may also differ, thus affecting the assessment tools we use. Typically, most of the anemia in developed countries results from iron deficiency, whereas this is not the case in many parts of Asia and Africa. Without doubt, the prevalence of anemia and iron deficiency is much greater in these less developed regions, but many other factors such as infections...
and other nutritional deficiencies also contribute to the greater prevalence and severity of anemia (1).

The utility of hemoglobin as an indicator of iron status is significantly affected by the different relationships between iron deficiency and anemia in developed vs. developing country settings. These differences are illustrated in Figures 1 and 2 (2). In Figure 1, the dotted line represents the hemoglobin distribution of a subset of U.S. children from a national sample survey with distinct evidence of iron deficiency based on two or three biochemical tests. The key observation is that the hemoglobin distribution for iron deficient children substantially overlaps the distribution of children who are not iron deficient. This substantial overlap demonstrates the limitation of using anemia to identify iron deficient individuals in a population in which the prevalence of iron deficiency is low. In such populations, other indicators of iron status, such as transferrin saturation, free erythrocyte protoporphyrin (FEP), serum ferritin and most recently, transferrin receptor, can be used to define iron status at both the individual and the population level (3).

In contrast to the overlapping hemoglobin distribution curves in Figure 1, the distributions in Figure 2 are distinctly different, with relatively little overlap. In this figure, the dotted line illustrates the hemoglobin distribution curve of a sample of Palestinian refugee children drawn from a population in which iron deficiency is highly prevalent. It is obvious that the hemoglobin distribution of the Palestinian children is lower than that of the sample of U.S. children, and even lower than that of the iron deficient U.S. children in Figure 1. These observations suggest that in many developing country settings in which iron deficiency is highly prevalent, hemoglobin levels will serve quite adequately as a simple and inexpensive indicator of iron status, and that additional test of iron status, such as those mentioned above, may not be required. In fact, these tests may not work well in developing country settings because the test results can be affected by the high prevalence of infections (3) and the cost to set up a quality laboratory to measure these sophisticated biochemical tests may not be justified in a resource-limited setting.

Experiences and challenges in reducing iron deficiency

The two groups most affected by iron deficiency are young children and women of reproductive age. However, it is important to examine experiences with these groups separately because solutions for children may not apply to adults, and vice versa.

![Figure 1](https://example.com/figure1.png)

**FIGURE 1** Hemoglobin distributions of a subset of iron deficient U.S. children (dotted line) and children who are not iron deficient (solid line). The key observation is the substantial overlap.

![Figure 2](https://example.com/figure2.png)

**FIGURE 2** Hemoglobin distributions of Palestinian refugee children (dotted line) and U.S. children (solid line). The key observation is the relatively small overlap.

Young children

The most critical period at which iron deficiency anemia develops is between 6 and 18 mo of age because iron requirements are the highest during this period, i.e., almost 10 times higher by body weight compared with an adult man (4). Further, the diet of infants differs from that of the regular family and, in the absence of special interventions such as fortification, is often poor in bioavailable iron. For example, even in a country such as Argentina, a country in which adult iron intakes are very high because of high meat intakes, almost a third of young infants and children were anemic 20 years ago because their diets differed from the regular adult diet (5).

The daily diet of infants and young children in most developed countries is quite adequate in iron content, due primarily to the better dietary quality (higher consumption of animal foods, especially meat which is rich in several micronutrients) and inclusion of fortified foods such as infant formula and processed complementary foods. In contrast, infant diets in developing countries are low in iron, due to less use of industry-prepared foods and much lower consumption of food from animal sources. Infants in developing countries also rely to a greater extent on iron from breast milk. Although iron is more bioavailable in breast milk, it may not be adequate to supply the iron needs of older infants, even in more industrialized countries. For example, data from several studies in Chile since the 1970s show that among infants whose main food since birth was breast milk, almost 40% developed iron deficiency by 9 mo of age (6).

Fortification strategies

In contrast to results for primarily breast-fed infants, studies in Chile found very little iron deficiency among infants who received milk powder that was fortified with iron. Based on these results, fortification has now become part of a successful national program in Chile (4). Similarly, data from the CDC pediatric nutrition surveillance system show that the prevalence of anemia among low income children in the U.S. has declined gradually since the 1970s and is continuing to fall (7). These trends have coincided with improvements in the quality and quantity of the iron in commonly consumed fortified infant foods, whether they are infant formula or cereals. These results indicate the nutritional value of iron-fortified infant foods as well as the usefulness of routine monitoring to demonstrate program effectiveness. It is important to note that this type of monitoring is often lacking in developing coun-
tries. In the absence of a credible monitoring system, it is not possible to demonstrate whether interventions such as fortification have been effective.

The successful experiences in countries such as Chile and the United States have shown that it is feasible to reduce anemia levels in young children through the use of fortified infant food products and low cost weaning foods. Although concerns have been raised that “all good complementary foods should be home-grown or homemade,” if people are already using processed foods, the cost of improving the nutritional value of these foods is marginal compared with the significant benefits. Provision of fortified processed foods is obviously not a feasible solution in many populations in the developing world, but for those places in which it is feasible, it should be considered.

An important issue in regard to fortification is the cost and accessibility of fortified food products by the poorest and most vulnerable populations. If fortified foods are too costly or inaccessible by needy populations, should these foods be provided for free and distributed by a government as some countries have done? Or, should private industry play a role by providing these foods at low cost, as a sort of service with basic cost recovery? Even when these options are feasible, efforts to improve complementary feeding through better selection and early introduction of iron-rich foods are recommended.

Supplementation strategies

The combination of high iron requirements in childhood and the poor dietary quality of typical infant diets in many parts of the developing world, raises the question of whether supplementation strategies should also be considered. There are, however, several important challenges in this regard. In addition to the cost of supplements, another issue is how to effectively deliver the supplements to the infants and children who most need them. Also, because the overall diet is poor, should we not consider supplementation of other nutrients besides iron? Little is known, however, about the effectiveness of different combinations of supplements. This issue must be addressed by researchers so that they can provide appropriate recommendations to those who are directing programs in the field.

Women of reproductive age

The risk of developing iron deficiency is greatest during pregnancy when requirements are the greatest. However, prepregnancy iron status is also important because having inadequate iron stores at the outset of pregnancy definitely increases the risk of developing iron deficiency as the pregnancy progresses. The principal causes of iron deficiency may differ for women in developed vs. developing world settings. In most industrialized areas, iron deficiency among women of reproductive age is more likely to be due to increased blood loss than to poor diet. Based on the best evidence from Europe, there appears to be a subset of women who have higher than average menstrual blood loss such that even a normal diet cannot keep up with their iron requirements (8).

Without doubt, iron deficits due to menstrual blood loss affect women even more in developing countries, in which diets are relatively low in both iron content and bioavailability. For this reason, in developing countries, dietary factors are likely to make a greater contribution to iron deficiency than is the case in more developed countries. Also, although the small proportion of women who do become anemic in developed countries typically have only iron deficiency, women in developing countries may suffer from multiple micronutrient deficiencies. Their diets are low in nutrients such as zinc, copper, calcium and vitamin A, due to poor overall dietary quality and a low intake of foods from animal sources (9). In addition, women living in tropical areas in which infections such as hookworm and malaria are prevalent may have significant additional blood loss, especially when the intensity of the infection is severe (10).

The iron requirement of pregnant women is at least twice as much, if not more, than that of nonpregnant women, and is much higher than that of men in relation to energy intake (Fig. 3) (4). Current data suggest that in developed world settings, ~50% of women do not have adequate iron storage to meet pregnancy requirements, which means they are likely to become anemic or iron deficient to some degree (11). The high iron requirements of pregnancy are the basis for the iron supplementation policies in developing countries and even in developed countries such as the United States. The majority of the women in the developing world do not meet iron requirement even before pregnancy, let alone during pregnancy.

The policy of iron and folate supplementation makes very good sense for developed parts of the world because those are the only micronutrients that are likely to be deficient. However, this policy may not be adequate or optimal for developing countries in which multiple deficiencies that existed before pregnancy are encountered. In developing countries, it is important to look at additional strategies to improve iron and other micronutrient intakes both before and during pregnancy. Fortification is probably the most efficient method to improve iron status even though it is not specific for women; men and children will also benefit. Another emerging concept is that of periodic supplementation with iron tablets in a supervised setting such as a worksite or school (12).

There is considerable experience in the area of fortification in the past decade, but several issues remain to be addressed and overcome. The first issue is the lack of good data that demonstrate effectiveness of fortification. This issue points to the need for good monitoring systems. For example, in Venezuela, data from a monitoring system of school children have demonstrated the effect of wheat and corn flour fortification that began in 1992 (13). Other demonstrations of the effectiveness of fortification must be carried out in other settings.

Another issue relating to fortification is the concern that people in the target population may not consume enough of the fortified food, such as iron-fortified wheat flour. However, even a low consumption of fortified wheat flour is likely to provide a significant increase in iron intake. For example, 20 kg/y of wheat consumption is regarded as very low. In India and China, the average annual wheat availability per person is 56 and 80 kg/y, respectively (14). Using the low figure of 20

![Figure 3](https://academic.oup.com/jn/article-abstract/132/4/827S/4687251)

**FIGURE 3** Iron requirements in relation to energy intake for infants, men, women and pregnant women. Adapted from (4).
kg/y of wheat fortified at 60 μg/g, the total amount of iron consumed will be 1.2 g or 1200 mg/year, which is equivalent to 3 mg/d or 25% of the recommended daily allowance. This amount is equivalent to consuming iron supplements containing 40 mg/d for almost 40 d which has been shown to be a very efficacious dosage to correct iron deficiency anemia in non-pregnant women in supplementation trials (15).

Another major issue is the cost of fortification and who will pay for it. Recent data indicate that it costs only US$ 1.30 to fortify 1 ton (907.2 kg) of flour with a premix that contains six micronutrients, including iron (16). Therefore, for those who consume 20 kg of flour annually, the cost will be only $0.025/(person·y). Experience from existing fortification efforts in >50 countries indicated that fortification is financially feasible as long as the cost is shouldered by the consumers. Finally, regulatory monitoring is essential to provide quality assurance and to ensure a level playing field in which all products meet the same standards.

Another strategy to address iron deficiency that deserves serious consideration is the promise of plant breeding to improve the micronutrient content of food staples such as rice and wheat (17). The original green revolution was successful in eliminating food insecurity in many parts of the world as a result of significant increases in the yield of cereal grains in the 1960s. This success calls for us to pursue the potential of plant breeding and biotechnology as a viable option at the turn of the 21st century.

Finally there is no doubt that supplementation is required for pregnant women. However the challenge remains to improve the effectiveness of supplementation strategies in many developing countries. Several efforts are underway to improve coverage and compliance, but much can still be learned from experience in dealing with other health problems, such as the 6-mo drug therapy strategies developed to treat tuberculosis.

In conclusion, we can overcome the challenges of eliminating iron deficiency in many developing countries if we effectively combine and balance the needs for program implementation, research and community involvement. This calls for all of us to work together, consider all options that are appropriate for a particular setting, and, most importantly, not forget the people whom we are serving.

LITERATURE CITED