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Iron Fortification: Prevention of Iron Deficiency Anemia For Developing Countries

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Prevalence of Iron Deficiency

Iron deficiency is the most prevalent nutritional disorder in the developing world and the only remaining micronutrient deficiency still of public health importance in developed countries. Using anemia as an indicator, almost half of all infants and pregnant women in developing countries suffer from iron deficiency. About 20-25% of non-pregnant women are also iron deficient.

It is worth noting that anemia represents the more severe end of the spectrum of iron deficiency. In its milder form, individuals have depleted iron stores yet are not considered anemic as they have adequate iron for normal physiological function. In general, for every case of iron deficiency anemia detected in a given population, there is another one or two cases of the milder form of iron deficiency. In other words, using anemia to estimate the burden of iron deficiency underestimates the actual problem of iron deficiency.

Differential Iron Requirements Determine High Risk Groups

Women and children are clearly more vulnerable to iron deficiency anemia. This is because different groups have different daily iron requirements. These requirements vary among different population groups and stages of the life cycle. For example, men need 1 mg of iron per day while an average woman who is smaller in size needs 50% more iron, or 1.5 mg a day. This higher requirement for women is mainly because of menstrual blood loss. Pregnant women require 4.5 mg day. This is more than four times the iron required by an adult man and three times the requirement for non-pregnant women.

A reasonably good diet only provides 1.5-2 mg of absorbable iron per day, about half of this requirement. Based on this gap of intake and requirement, routine supplementation is suggested for pregnant women. However, in most developing countries, because of poor dietary quality or low intake of food from animal sources (a better source of iron), many women can not meet their iron requirement even when not pregnant. Under these circumstances, efforts to improve baseline iron status are needed. Fortification appears to be the most effective strategy to do so.

Table 1

Segment	Absorbed Iron Requirement (in mg per day)	Dietary Iron Needed at 8% Absorption to Satisfy Absorbed Iron Requirement
Adult Men	*1*	*12.5*
Adult Women	*1.5*	*18.75*
Pregnant Women	*4.5*	*56.25*
Infants	*0.8*	*10*

Infants require only .8 mg of absorbed iron a day—less than men do. However, children consume far less then men, and often the quality of the iron is inferior. Assuming an iron absorption rate of 8%, 1800 kcal of iron with average bioavailability must be consumed by young children to meet the requirement. However, the average infant diet in the developing world is only 800 calories and contains less iron than the typical adult diet. Generally, the infant diet in developing countries provides only one-half the absorbed iron requirement. For this reason, without a special provision to assure greater iron content of infant diet, most will develop some degree of iron deficiency.

Determinants of Iron Deficiency

Iron deficiency is caused by an intake of iron that does not meet the iron requirement and/or by blood loss. Inadequate intake is caused by a variety of factors. A diet may lack sufficient iron content (quantity) or bioavailability (quality). From a nutritional point of view, not all iron in foods are created equal. Some are more available or better absorbed than are others.

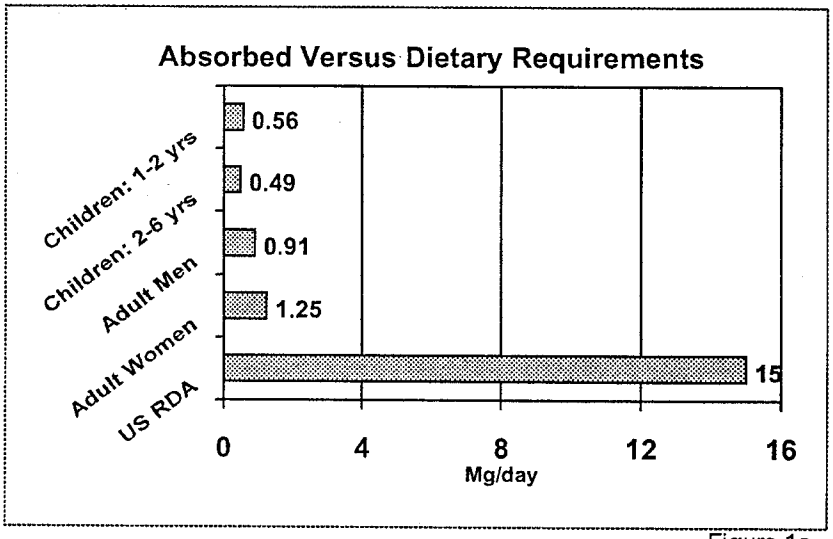


Figure 1a

The quality component of the equation is loss. Certain persons require more iron than do others. Women require more iron mainly because of menstrual blood loss. A body that is growing rapidly has higher iron requirements. Therefore, infants and young children or pregnant women carrying a growing fetus require more iron. In developing countries there is also iron deficiency due to pathological losses. A large part of the

population often suffers from a hookworm infection, which causes blood loss in the gut and significantly increases the requirement for iron.
Four dietary factors largely determine iron nutrition. The first is quantity or simply how many milligrams of iron per gram of food are consumed. Second, the nature or bioavailability of the iron compound in food is critical. Some forms of iron are much more available to the body than others. Third, there are promoters of iron absorption such as vitamin C or protein from animal products. Finally, there are substances that can inhibit iron absorption in the intestine such as phytates from grain products or tannic acids from tea. From a dietary perspective, iron status is determined by all these factors, not just the iron intake quantity.

Animal sources are the better iron sources because so-called heme iron, which comes from animal tissue, is much more easily absorbed than non heme-iron, which comes from vegetable or fortificant sources. On average, 15-20% of this heme iron can be absorbed in a meal. By contrast, non-heme iron is absorbed at a rate of only 2-5%. One of the principle reasons for the high prevalence of iron deficiency in the developing world is lower consumption of food from animal sources. This is the major contributory factor to iron deficiency anemia (IDA) in poor countries.

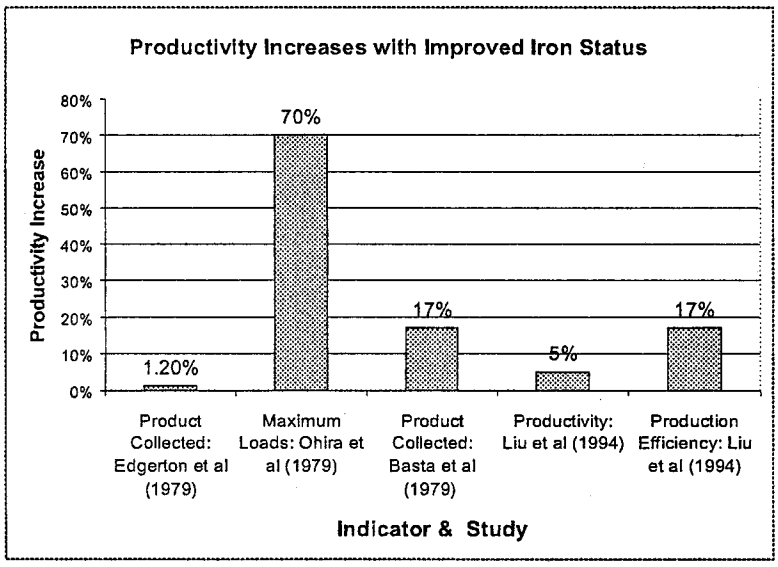
Populations that cannot afford iron rich foods because of economic constraints and who thus have a low intake of food from animal sources, are usually deficient in other major nutrients such as zinc, calcium and vitamin A. Effective interventions to reduce iron deficiency in developing countries need to consider iron deficiency not as a single nutritional deficiency but as part of multiple nutrient deficiencies. In contrast, in the U.S., where populations with very high requirements still suffer iron deficiency, the overall diet is usually adequate and there are no other deficiencies.

The Consequences of Iron Deficiency Anemia

When anemia is severe, sufficient oxygen cannot be carried to body tissues. This can lead to death. In South Asia and Africa, severe anemia can be fatal for pregnant women and children with serious infections or high fevers. Although in many parts of the world anemia is not solely caused by iron deficiency, iron deficiency usually plays a major role.

Specific consequences for young children are well established. These include a reduction of growth, development, and learning capacity. In essence, iron deficiency affects the brain to a degree similar to that of lead poisoning—reducing IQ or developmental quotient by an average of 5-7 points. Deficiency in iron can also cause the body to increase absorption of heavy metals such as lead. Therefore, it is a contributing factor in many cases of lead poisoning. There is also increasing evidence that suggests IDA reduces resistance to disease. In developing countries this can contribute to a range of severe consequences related to infection.

Among pregnant women, who have the highest requirements for iron, consequences of iron deficiency include increased probability of death during childbirth as well as pre-term delivery—babies born too early and too small. Furthermore, there is a direct association between babies born to iron deficient mothers and babies becoming iron deficient themselves.



From some perspectives, the population most significantly impacted by IDA in developing countries is average men and women. Iron deficiency in adults causes reduced muscular function and endurance. As a result, average men and women can not work as hard or as long. This directly lowers income and productivity. Economic output can drop an estimated 10-15% among iron deficient adults. Particularly in developing countries where physical labor represents a large segment of the overall workforce, this means a significant impact at the community and population level. One can conservatively estimate a 2-3% drop in total economic output. For a large country such as China or Indonesia, that equates to billions of dollars lost annually. (See Figure 1b).

Strategies to Control Iron Deficiency Anemia

There are two general strategies to control iron deficiency anemia. One is to improve iron intake by dietary means. The other is to work through the primary health care system to provide supplements, education and deworming.

Figure 1b

There are two major dietary approaches. The first focuses on proper education: teaching people how to select food items and to consume more iron rich foods. Second, through iron fortification or some other process—reducing inhibitors, increasing enhancers or fermentation, for example—the bioavailability of the iron in the diet can be improved. These strategies have distinct limitations and difficulties. In fact, we are far from the achievement of international goals, such as the World Summit for Children's goal of reducing iron deficiency anemia by one-third.

Nutrition education approaches are limited because iron-rich food from animal sources is often unaffordable to those at greatest risk. Meat products are usually

among the most expensive classes of food in any culture or society. There is evidence to indicate that most poor families will consume more meat products if their marginal income increases. It appears that the major role for nutrition education to play is helping the family identify inexpensive plant sources that are relatively rich in iron and enhance iron absorption. However, even with the knowledge of iron bioavailability from laboratory studies, there have been no small-scale trials or programs demonstrating that this approach is indeed effective. In the absence of evidence of efficacy or effectiveness, it would be difficult for a program- oriented agency such as UNICEF to recommend the use of a nutrition education-based approach as the sole intervention to improve iron nutrition.

Iron supplementation programs focus on the highest risk group, mainly pregnant women. This approach is limited by a number of factors. It does not address other sectors of the population that are also impacted, such as young children. Moreover, in many developing countries, iron deficiency is so severe prior to pregnancy that even proper supplementation during pregnancy may not be adequate—a case of too little, too late. In small-scale research trials, iron supplementation consistently reduced maternal anemia and hence demonstrated efficacy. However, in large-scale program settings, a number of evaluations failed to prove a significant reduction in maternal anemia—the prevalence remained high. It appears that there are a number of operational factors, such as supply, distribution, and the role of health workers, that must be properly addressed if iron supplementation systems are to work.

Feasibility of Iron Fortification

Fortification is a feasible approach to prevent iron deficiency on a population-wide scale for a number of reasons. First, technical feasibility has been well established. For example in North America, flour has been fortified with iron and other vitamins and minerals for over 50 years. Second, the cost of fortification is relatively low. Third, there is evidence from several parts of the world that iron fortification is effective. Fourth, once established, iron fortification does not require any special investment in pro-

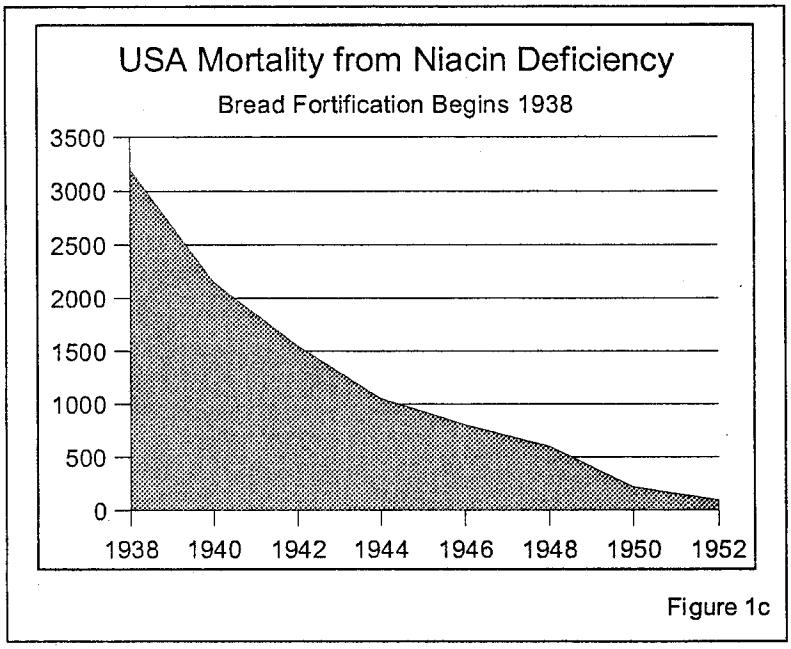


Figure 1c

motion or education. People do not need to know about fortification to benefit from it. Finally, since iron deficiency in the developing world usually coexists with a complex of nutrition deficiencies, flour fortification is attractive because it can deliver other vitamins and minerals, including zinc, vitamin A.

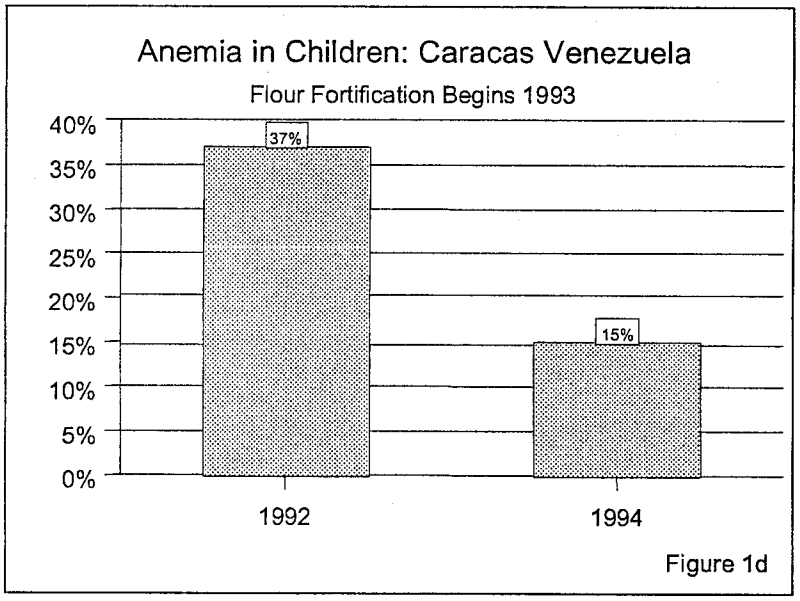
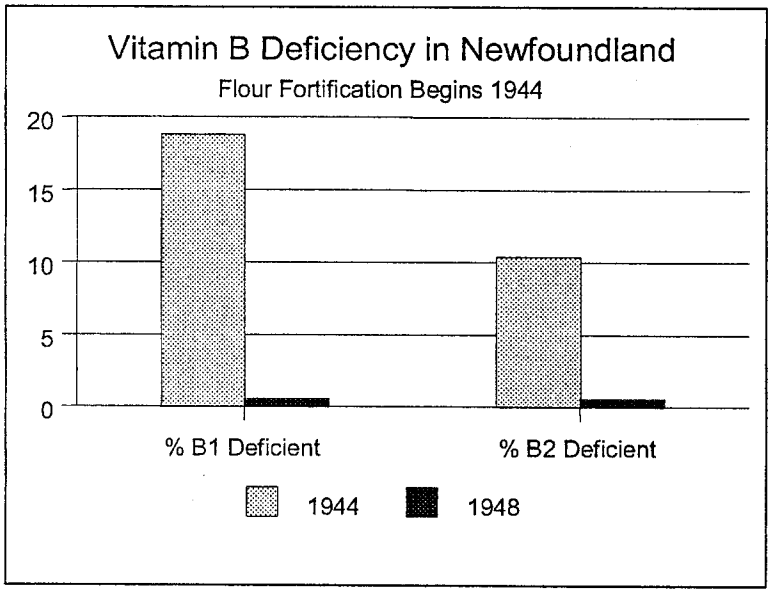


Figure 1d

There are numerous examples of fortification dramatically reducing rates of iron deficiency and anemia. Over 20 years ago in Chile, after receiving iron fortified milk powder, iron deficiency among low income children dropped from 38% to 9% and anemia from 23% to 4%. At one point, only 10% of infant formula was fortified with iron in the United States. After fortification became widespread, iron deficiency among infants dropped from 30% to less than 5%---the same prevalence found in older children and adults. More recently, in 1993, Venezuela made the decision to fortify all wheat and corn flour. Within one year, a survey of school aged children in Caracas slums showed a dramatic decline in iron deficiency from nearly 37% to less than 15%. Anemia prevalence dropped from about 16% to about 9%. (See Figure 1d).



Significant barriers and limitations accompany opportunities for iron fortification programs. An iron fortification program requires multiple partners, many of them beyond the traditional health and nutritional sector. For example, food producers—the private sector—are not usually involved with nutritional deficiencies. Defining who pays for fortification during start-up often presents a major barrier. Even though the cost of fortification is relatively low, it still exists and someone must pay for it. (If at all possible, the small additional cost should be borne by consumers to assure sustainability of the fortification program). In cases where a single food vehicle cannot reach all sectors of the population, some will argue that any fortification program should be deferred until a universal vehicle is identified. However, it is better to reach a substantial portion of the population than to not reach any at all. These obstacles often keep fortification from moving forward. Nevertheless, many countries overcome these obstacles and implement successful iron fortification programs.

Development of Iron Fortification of Wheat Flour in Indonesia

Indonesia is aiming for full national fortification of wheat flour by the end of 1998. In reviewing the development of this program, we can identify strategies to persuade governments and the private sector to take action.

The initial situation was not very encouraging. In Indonesia, average flour consumption is only about 15 kg per person per year while the consumption of rice is more than 110 kg per person per year. Because of the relatively low consumption, many insisted that flour fortification could not have a widespread impact and argued that efforts should be focused on rice. However, for a number of technical reasons, it is not feasible to fortify rice. A major obstacle to rice fortification in Indonesia is the decentralized nature of the industry. On the other hand, 5 large mills process all of Indonesia's wheat flour. One mill refines 85% of the wheat flour for the entire country. Moreover, consumption of noodles, a wheat product, is becoming increasingly widespread and penetrating even the most poor and rural areas. In light of this industry environment and the market situation, the government was convinced that flour fortification was feasible and could impact less advantaged and at-risk groups.

A fortification profile was developed with recommended levels of 6 mg/100g of iron, 3 mg/100g zinc, 400pg/100g riboflavin, 250pg/100g ppm thiamin and 200 pg/100g folic acid. The iron level is higher than the 48 ppm for flour in the United States. At this level, one packet of instant noodles, which is the most common unit of consumption and contains about 75 grams of wheat, can supply between one-quarter and one-third of the RDA for all these nutrients. Since fortification is a dietary approach, the goal is not to supply 100% of RDA with one pack of noodles. People consume other foods containing iron and sometimes more than one packet of noodles a day. However, just one meal of fortified noodles a day can make a big difference in meeting iron requirements.

The small incremental cost was a most difficult barrier to overcome in Indonesia. Adding 150 grams of recommended premix to one metric ton of flour adds US $1.30 to the cost of each ton of flour. This represents less than one-half of one percent of the cost of a ton of flour. Nevertheless, on a large scale, the cost can be daunting. Fortifying all the flour in Indonesia will cost about $4.6 million per year.

In Indonesia, a number of calculations were made that put a positive perspective on the cost of fortification. When advocating an increase in the cost of a staple food, no matter how small, one has to consider the additional expense or burden on the consumer. Fortification was calculated to add about 0.13 cents or 10 rupiah to the cost of a kilogram of flour. Since the smallest coin in Indonesia is 25 rupiah, 10 rupiah became a powerful figure illustrating the low cost. In retrospect, the 10 rupiah figure was crucial in convincing the Indonesian government to support the program.

Incremental costs can be framed in a number of ways to emphasize the low cost to consumers. For an average consumption of 15 kg per year, the annual increase was projected at about 1.5 cents or 150 rupiah per year. This adds 0.8 rupiah to the cost of a single packet of instant noodles, bringing the total cost to 400 rupiah. Such cost calculations made the added cost mentally easier to accept. Everyone can agree that is a reasonable burden to impose, especially considering the nutritional benefit.

Calculations were also made to project the potential impact on productivity. Assuming the average intake of 15kg fortified flour per person per year, the recommended 60 mg per kg of flour translates into an additional annual intake of 900 mg per year. This is equivalent to providing 30 mg iron tablets every day for 1-2 months. This dosage has been shown to correct iron deficiency among women and children. So even though some people argue that Indonesia may not have high flour consumption, on average, current consumption can deliver a significant amount of iron.

It was projected that halving iron deficiency among women, from 25% to 12%, would result in an average increase in work productivity of 10% for those women who were no longer anemic. This productivity gain among the 12-13% of women whose deficiency was corrected through fortification translates into an annual gain of 15,000 rupiah—or a 0.5% rise in Indonesia's per capita GDP of 3 million rupiah. Since the average annual cost increase for fortified flour is 150 rupiah, the cost-benefit ratio of flour fortification is 1:100 for Indonesia. That is another very attractive figure.

Advocacy for flour fortification in Indonesia involved answering questions about safety. There is always concern about excess iron in the diet. Fortunately, iron absorption is a well-regulated process. Iron deficient individuals absorb more iron while those without deficiency absorb far less. There is no question that people who do not need iron will absorb a bit more iron from fortification. However, the body also has a remarkable capacity to store extra iron, making it unlikely the additional iron will reach a harmful level. The main exception is the potential harm to the few people per thousand who suffer clinical conditions that would cause high iron ab-