Forging Effective Strategies to Combat Iron Deficiency

Experiences and Challenges in Industrialized Countries: Control of Iron Deficiency in Industrialized Countries

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ABSTRACT This paper provides a synopsis of the experience in combating iron deficiency in industrialized countries and identifies the reasons for the considerable success and future challenges. Significant progress has been made over the last century in reducing and even eliminating iron deficiency in many industrialized countries. Current estimates are that the prevalence of iron deficiency has declined to <20% in many of these countries, even among women and young children, compared with 30 to 70% in many developing countries. The reasons for this success cannot be attributed solely to a single approach but rather to a range of factors that have occurred over time as a result of both economic development and the implementation of specific policies. Several factors have contributed to improving both iron intakes and reducing iron losses; these include fortification, supplementation, dietary diversification and public health measures. For example, the decline in anemia in infants can be attributed to the introduction of iron-fortified formula and complementary foods in the 1960s to 1970s. Similarly, the enrichment and fortification of cereals with iron that began during World War II in North America and Europe is a result of effective public-private partnerships. Despite these successes, iron deficiency remains a public health concern in industrialized countries for selected subgroups such as women of reproductive age with excess menstrual losses and pregnant women who cannot meet increased requirements from the diet alone. Constant vigilance and innovative approaches for screening and combating this problem are thus still required even in developed countries. J. Nutr. 132: 820S–824S, 2002.

KEY WORDS: • iron deficiency • iron fortification • control and prevention interventions

Historical trends in iron deficiency

Young children and women of reproductive age especially during pregnancy have increased requirements for iron, placing them at increased risk of deficiency and related adverse consequences (1,2). In contrast to many developing countries in which iron deficiency affects a large proportion of the population (30–70%), the prevalence of iron deficiency is <20% in the industrialized countries of Europe and North America (3–5). These lower rates are the result of the significant progress that has been made in last century. This paper examines the various factors that account for this decline with lessons that can be learned for strategies in developing countries.

Historical records show that iron deficiency and anemia were very common among women of reproductive age in many developed countries even during the late 18th and 19th centuries. Among the earliest documented references to iron deficiency are those from the 15th to 16th centuries when the term “chlorosis” was used to describe “green sickness” as a hysterical condition associated with weak blood and particularly affecting young women and adolescent girls (6). Chlorosis was quite common in many developed countries and there were even concerns about the increase in incidence during the 19th century. At the same time, however, significant advances were made in hematology and this led to iron salts being recommended as a treatment for chlorosis. Without a doubt, these scientific advances combined with the improvements in environment and diets of women in the early 20th century most likely contributed to the disappearance of “chlorosis” in developed countries by the mid-20th century. A standard definition of anemia became available only in the 1960s (it was created by the WHO) after which estimates of the prevalence of this nutritional disorder were generated (7). Although limited data exist on trends in the prevalence of anemia and iron deficiency using nationally representative data, there is evidence to support declines in the prevalence of iron deficiency and anemia among women and young children.
in many developed countries in North America and Western Europe. For example, the prevalence of anemia declined from 25% in 1963 to 1964 to 7% in 1974 to 1975 among women of reproductive age living in Goteborg, Sweden (8). Estimates from nationally representative data based on the National Health and Nutrition Examination Surveys (NHANES) in the United States also show that iron deficiency declined from 21 to 13%, and from 10 to 6% among young children aged 1 to 2 y and 3 to 4 y, respectively, between 1974 to 1975 and 1989 to 1994 (9). The reasons for these declines cannot be attributed solely to a single approach but rather to a range of factors that have occurred over time as a result of both economic development (direct and indirect) and the implementation of specific policies (for example, routine iron supplementation for pregnant women).

**Determinants of iron status**

Iron deficiency usually results from a combination of factors that affect both intakes and losses as shown in Figure 1. In terms of iron intake, fortified products and pharmaceutical supplements are important sources of iron, in addition to the usual diet in many developed countries; the actual amount of iron absorbed depends on iron requirements (e.g., increased during pregnancy) and the presence of inhibitors (e.g., phytates) and enhancers (e.g., ascorbic acid, animal foods) of iron absorption in the diet. On the other hand, iron is lost in sweat and during menstruation, both of which can vary significantly among individuals. Iron requirements are also increased during periods of rapid growth, such as during pregnancy, early childhood and adolescence, and significant amounts of iron can also be lost due to parasitic infections such as malaria, hookworm and schistosomiasis (1).

**Iron intakes**

Adequate intakes of iron have been attained in many industrialized countries as a result of the following: 1) improved food intakes; 2) transition from cereal-based diets that are rich in inhibitors of iron absorption to more mixed diets that have better bioavailability (e.g., increased intakes of animal products that are rich sources of highly bioavailable heme iron); 3) increased reliance on industrially processed foods that are fortified with iron (e.g., fortified ready-to-eat cereals and infant foods); and 4) consumption of iron-containing supplements. For example, data from NHANES III show that iron intake for women of reproductive age in the United States is 13 mg/d, with 2.1 mg from heme iron (10). The current recommended daily allowance for iron is 18 and 27 mg/d for nonpregnant and pregnant women of reproductive age in the United States, respectively (11). Food consumption data indicate high intakes of meat (168 g/d in 1994–1995) and citrus fruits (52 g/d) in American women, both of which can enhance iron absorption. It is noteworthy that the consumption of total grain, one of the commonly fortified foods, has increased dramatically from 177 g/d in 1977 to 207 g/d in 1994. In contrast, beef consumption has declined from 47 g/d in 1974 to 1975 to 19 g/d in 1994 to 1995 in American women (12). Data from Europe also indicate adequate iron intakes from diverse sources (13).

**Role of fortification**

Fortification has played a key role in the reduction of iron deficiency in developed countries during the latter half of the 20th century (14–16). The effect of two World Wars, which created an urgent requirement to meet nutritional needs effectively, combined with advances in food technology, nutritional sciences and rapid expansion of the commercialization of food processing set the stage for enrichment and fortification in many industrialized countries. Enrichment of flour with essential nutrients, namely, vitamins and minerals such as iron to compensate for losses during processing, began as early as the 1930s in many developing countries (17). During World War II, the U.S. Food and Drug Administration (FDA) set enrichment standards for all cereals (rice, cornmeal) as well as pasta and bread, whereas Canada permitted it only for wheat flour in 1952 [(18), Johnson, J., IDRC, personal communication, 2001]. Elemental iron powder has been used as the fortificant especially for cereal-based products, with levels of enrichment ranging from 18 to 30 µg/g. The increased awareness of the problem of iron deficiency anemia in the 1960 to 1970s led to increases in the level of enrichment in cereals, an action supported by the United States milling industry. Similarly, many countries in Europe, especially in Scandinavia (Sweden, Denmark, Finland), also recommended increasing the amount of iron added to flour from ~30 to 60 µg/g in the 1960s (19,20).

The recommendations for enrichment and/or fortification differ among countries and have also evolved over time. For example, iron fortification has been mandatory for white flours, enriched pastas, enriched precooked rice and certain substitute foods in Canada since 1976, whereas it is voluntary at the national level and mandatory at the state level for nearly two thirds of the United States (16). In contrast, fears of iron overload have led to the removal of fortification in Finland and Denmark (21,22). The key to success in fortification, however, does not rely solely on the regulatory framework but rather on successful private-public partnerships as shown in Figure 2. For example, key private sector players in the U.S. experience include commercial food processors (millers, breakfast foods, infant food) and the pharmaceutical industry. Also involved are public health agencies such as the Centers for Disease Control and Prevention and the medical community, both private and public (universities, National

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5 Abbreviations used: FDA, United States Food and Drug Administration; NHANES, National Health and Nutrition Examination Surveys; SES, socioeconomic status; WIC, Women, Infant and Children’s Program.

6 Mandatory addition of iron to other food products such as simulated meat products, enriched rice and enriched pasta began in 1975, 1986 and 1994, respectively, in Canada.
Institutes for Health) and regulatory groups such as the FDA, USDA and the Department of Health and Human Services at the federal level and other state and regional bodies. Of note are the strong linkages that have existed between the research community and public health agencies, strong support for research and development in the private sector and interaction between legislators and private industry. Similar structures are in place in other industrialized countries such as Canada, United Kingdom and parts of Europe but are often lacking in developing countries due to limited resources and structural inadequacies.

Major constraints on the present analyses include the limited documentation of trends, the paucity of nationally representative data in many settings and the lack of formal evaluation of intervention strategies. In a review of the iron status and intakes in Europe, Hallberg and Hulthen (13) estimated from national food consumption data that fortified cereal contributed ~10 to 20% of total iron intakes in Denmark, Finland and Sweden where iron fortification was mandated (13). The contribution of different dietary sources of iron in selected countries in Europe is shown in Figure 3. In their analysis of the reasons for the decline in iron deficiency among Swedish women, Hallberg and Hulthen identified increased intakes due to the consumption of fortified flour combined with reduced losses due to increased usage of oral contraceptives as the main factors (8). As the demand and supply of processed food products have increased during the 1980s and 1990s, several vitamins and minerals such as iron have been added to an increasing array of food products especially ready-to-eat cereals. For example, a recent study shows the steady increase in the contribution of fortified foods to iron intakes of German children aged 2 to 13 y from 60% in 1987 to 78% in 1995 (23). Nationally representative data from the United States show that in women of reproductive age, fortified ready-to-eat cereals contributed ~40% of total iron intakes among consumers of these foods (24).

The most convincing evidence for the contribution of fortification is the “infant story.” Nationally representative survey data (NHANES) and surveillance data (Pediatric Nutrition Surveillance System) have shown a clear reduction in anemia and iron deficiency among infants and young children in the United States after the introduction of guidelines to fortify infant formula and foods with iron in the late 1960s and establishment of targeted nutrition programs such as the national Women’s, Infants and Children (WIC) Program in the 1970s (25,26). The prevalence of anemia declined steadily from 7.8% in 1975 to 2.9% in 1984 among low income children enrolled in the WIC Program as shown in Figure 4. Furthermore, data from Tennessee show that although socioeconomic status (SES) remained relatively stable during the same period, the prevalence of anemia declined significantly within each SES group, indicating the effect of improvements in iron nutrition. Similar reductions were also found among middle-class children during the same period based on data from pediatric clinics throughout the United States (27).

**Iron losses**

At the same time at which iron intakes improved, iron losses also were minimized in many industrialized countries, most of which was due to improved sanitation and overall economic development. Specifically, factors that may have contributed to improved iron status by limiting losses are the following: 1) eradication of helminthic and other infectious diseases as a result of improvements in living conditions especially access to safe water and hygienic practices and good health care, for example, helminthic infections were not uncommon in many parts of the southern United States as late as the 1960s (28); and 2) improvements in women’s status that has lead to delayed childbearing and fewer pregnancies. Total fertility rates have declined from about 4 during the latter half of the 19th century to about 1.8 in 2000 in North America and parts of Europe (29). Age at first pregnancy has also increased over time along with coverage of maternal health services (prenatal and postpartum care), which is now almost universal (>90%) in most developed countries. Both mean age at first pregnancy (16–19 y) and coverage of maternal health services are much lower (30–65%) in many developing countries in which iron deficiency is common (30). These factors are important because health services in most devel-
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veloped countries continue to recommend routine iron supplementation during pregnancy, a practice that began in the 1960s. Moreover, compliance with supplementation is higher than in many developing countries in which problems of supply and lack of knowledge are common (31,32). For example, nationally representative data from the United States show that prenatal supplement use ranged from 60 to 85% during the 1980s (33). It is interesting to note that 18 to 30% of women also reported preconceptional use of iron-containing supplements. Data from NHANES III also show that, overall, 25% of women of reproductive age consume iron-containing supplements, although this varies by age, race-ethnicity and SES (24). Other factors such as the reduction of low birth weight may also contribute to the reduction of iron deficiency in infancy because iron stores of the newborn may be related to that of the mother (34). Undoubtedly, increased intakes and reduced losses of iron have helped improve iron stores in many industrialized countries. It is also important to note that although some of these changes have occurred rapidly, others have taken more time. Thus, improvements in iron status have occurred during various stages of the life cycle for recent generations living in developed countries, which in turn have contributed to the declines in the prevalence of iron deficiency.

Challenges

Despite the success accomplished to date, iron deficiency remains a public health concern in industrialized countries in certain subpopulations. For example, although overall prevalence of iron deficiency has decreased significantly in the past 30 to 40 y, recent data indicate increased risk and/or lack of progress in certain subgroups such as low income populations and migrants. Data from NHANES III conducted in 1989 to 1994 showed that the prevalence of iron deficiency has not changed among women of reproductive age in the United States since the previous NHANES II in 1974 to 1975 and that Hispanic women are 2 to 3 times more likely to be iron deficient compared with non-Hispanic Whites (4). Similarly, surveillance data from the Pregnancy Nutritional Surveillance System indicate that during the 1990s, the prevalence of anemia has remained around 20% and may even have increased slightly among low income pregnant women in the United States, indicating the need for constant monitoring and development of new approaches (9). Other studies have also shown high rates of anemia among children in Alaska and Native American populations in Canada, where nearly one fourth (24%) of infants aged 9 mo are iron deficient (35,36).

Although historical data lead us to infer that fortified foods have increased iron intakes over time, current patterns of intake of fortified foods and/or supplements do not necessarily explain the increased risk of iron deficiency in selected subgroups. For example, data from NHANES III indicate that only 13% of women of reproductive age consume iron fortified ready-to-eat cereals and, more importantly, that the risk of iron deficiency anemia is not associated with the consumption of these foods (24). Similarly, dietary intakes (both in terms of actual intakes and bioavailability) do not explain the differences in the prevalence of iron deficiency in Hispanic women compared with non-Hispanic Whites (10). These findings demonstrate the need for more information about patterns of consumption of iron-containing foods as well as a better understanding of factors that may influence iron losses so that interventions can be targeted appropriately. For example, survey data indicate that consumption of iron-containing supplements in the United States is low among groups at greatest risk of iron deficiency (24), suggesting that increased provision of iron supplements could be an appropriate intervention in these groups.

Another major challenge is that intakes may decline in some developed countries as a result of recent policies, i.e., the removal of legislation that had required fortification of flour with iron and a shift from universal to selective supplementation during pregnancy, motivated by concerns about possible adverse effects of increased iron stores. For example, fortification of flour with iron was stopped in Denmark in 1987 to 1988 and other Scandinavian countries have followed suit (22). Although recent data from Denmark have not shown any adverse effects,7 these actions may lead to an increased risk of iron deficiency among subgroups such as young children and women of reproductive age over time and therefore require constant monitoring and evaluation (22). The resurgence of iodine deficiency disorders due to reduced production and distribution of iodized salt following the break-up of the former Soviet Union serves as another example of the need for ongoing monitoring of nutritional status (37). Also, as the prevalence of iron deficiency declines, another concern for industrialized countries is the need for more effective and sensitive iron status screening methods. As prevalence declines, traditional indicators, such as hemoglobin, will no longer work as effectively. Finally, improved methods for identification of women with increased iron losses is another area of need because excess iron loss is becoming a more likely cause of deficiency than inadequate iron intake.

In conclusion, significant progress has been made and the experience gained is valuable in our efforts to combat iron deficiency in developing countries in which the problem of iron deficiency and challenges to prevent it are far greater. Although few challenges remain for industrialized countries, constant vigilance and innovative approaches to combat this problem for subgroups that are at increased risk for iron deficiency even in developed countries are indeed warranted.

LITERATURE CITED


7 Although mean serum ferritin values declined slightly, they remain high (>100 μg/L) among adult men and postmenopausal women and adequate (32 μg/L) among premenopausal women in 1994–1995.