PREVENTING AND CONTROLLING IRON DEFICIENCY ANAEMIA THROUGH PRIMARY HEALTH CARE

A GUIDE FOR HEALTH ADMINISTRATORS AND PROGRAMME MANAGERS

E.M. DeMaeyer
with the collaboration of
**P. Dallman, J.M. Gurney, L. Hallberg,
S.K. Sood & S.G. Srikantia**

WORLD HEALTH ORGANIZATION
GENEVA

PREVENTING AND CONTROLLING IRON DEFICIENCY ANAEMIA THROUGH PRIMARY HEALTH CARE

A guide for health administrators and programme managers

E.M. DeMaeyer
Formerly Medical Officer, Nutrition,
World Health Organization,
Geneva, Switzerland

with the collaboration of
P. Dallman, J.M. Gurney, L. Hallberg,
S.K. Sood & S.G. Srikantia

World Health Organization
Geneva
1989

ISBN 92 4 154249 7

The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of the Secretariat of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

The mention of specific companies or of certain manufacturers' products does not imply that they are endorsed or recommended by the World Health Organization in preference to others of a similar nature that are not mentioned. Errors and omissions excepted, the names of proprietary products are distinguished by initial capital letters.

PRINTED IN SWITZERLAND
88/7815 — Phototypesetting — 5000

Contents

Preface

Both the understanding of the epidemiology of iron deficiency anaemia and the technical means for preventing and controlling it have expanded greatly in recent years. There are as yet relatively few examples of the application of this knowledge to the development and implementation of comprehensive control strategies. On the other hand, a considerable body of evidence is accumulating, based on national experience in a diversity of settings, indicating that primary health care may well offer the most practical means for translating this new knowledge and understanding into lower prevalence rates of anaemia.

The Joint WHO/UNICEF Nutrition Support Programme (JNSP) is active in 18 countries in improving the nutritional status of children and their mothers through primary health care. JNSP has generated a body of knowledge concerning the practical aspects of integrating primary care at various levels of organization to achieve nutritional goals. It is in this context that JNSP has sponsored this publication, written to help health administrators and programme managers develop suitable strategies for preventing and controlling iron deficiency anaemia through primary health care.

Grateful thanks are expressed, through its Government, to the people of Italy, who made possible the publication of this book and the Joint Nutrition Support Programme itself.

The collaborators of the author were all participants in the May 1987 meeting of the International Nutritional Anemia Consultative Group (INACG) in Quito, Ecuador. Their help is gratefully acknowledged, as is that of INACG. By providing an international framework within which scientists can communicate with each other and share the findings of their research on anaemia, INACG has contributed to the expansion of knowledge about this threat to the well-being and productivity of millions of people the world over.

The principal author, Dr Edouard M. DeMaeyer, served the World Health Organization for 18 years as Medical Officer in its Nutrition unit at WHO headquarters in Geneva. After his retirement in December 1981, he continued to make his expertise in nutrition available to the Organization. Convinced that recent public health trends and advances in the understanding of iron deficiency anaemia were improving the prospects for controlling this scourge, he wrote this book at the invitation of WHO. Sadly, he died shortly before it appeared in print.

1. Introduction

Iron deficiency anaemia is a problem of serious public health significance, given its impact on psychological and physical development, behaviour, and work performance. It is the most prevalent nutritional problem in the world today, affecting more than 700 million persons (*1*). Simply stated, an iron deficiency occurs when an insufficient amount of iron is absorbed to meet the body's requirements. This insufficiency may be due to inadequate iron intake, to reduced bioavailability of dietary iron, to increased needs for iron, or to chronic blood loss. When prolonged, iron deficiency leads to iron deficiency anaemia.

Iron deficiency is by far the commonest nutritional cause of anaemia; it may be associated with a folate deficiency, especially during pregnancy. Other nutrient deficiencies such as vitamin B_{12}, pyridoxine and copper are of little public health significance because of their infrequency. Infants, preschool children, adolescents and women of childbearing age, particularly pregnant women, are at greatest risk of developing iron deficiency anaemia. However, adult males may also be at risk, especially where there is inadequate food intake or frequent parasitic infestation.

The treatment of iron deficiency anaemia is technically quite simple, requiring only the administration of medicinal iron, although for a variety of reasons millions of sufferers are currently left untreated. Prevention is somewhat more complex. Fortunately, there are a number of simple control measures available that can be applied through primary health care, and these are the main subject of this book.

2. Assessment, prevalence and consequences of iron deficiency anaemia

Anaemia may be diagnosed with confidence when the haemoglobin concentration is lower than the level considered normal for the person's age/sex group. When the anaemia is due to iron deficiency, increasing the person's intake of absorbable iron will raise the haemoglobin concentration (*2*). However, many individuals with seemingly normal haem levels likewise respond to iron administration with a rise in haemoglobin, which implies that they were actually deficient in iron (*3,4*). Assessing the frequency of iron deficiency anaemia in a population by means of haemoglobin measurements thus tends to underestimate the true prevalence.

The distribution of normal haemoglobin values is generally similar the world over, making allowance for factors such as age, sex, pregnancy and altitude (*5*).

On the basis of information from published and unpublished sources, and the haemoglobin cut-off points recommended by a WHO Scientific Group (*5*), it is estimated (*1*) that about 30% of the world's population of 5000 million people are anaemic.

Young children and pregnant women are the most affected, with an estimated global prevalence of 43% and 51% respectively. Anaemia prevalence among school-age children is 37%, non-pregnant women 35%, and adult males 18% (see Table 1). There are few data concerning anaemia in adolescents and in elderly people, which precludes any precise estimates for these two groups, but it is thought that the prevalence rate for adolescents is close to that for adult females and the rate for the elderly is slightly higher than that for adult males.

Iron deficiency anaemia is considerably more prevalent in the developing than in the industrialized world (36%—or about 1400 million persons—out of an estimated population of 3800 million in developing countries, versus 8%—or just under 100 million persons—out of an estimated population of 1200 million in developed countries). Africa and South Asia have the highest overall regional prevalence rates. Except for adult males, the estimated prevalence of anaemia in all groups is more than 40% in both regions and is as high as 65% in pregnant women in South Asia. In Latin America the prevalence of anaemia is lower, ranging from 13% in adult males to 30% in pregnant women. In East Asia, prevalence ranges from an estimated 11% in adult males to 22% in children of school age.

Table 1. ESTIMATED PREVALENCE OF ANAEMIA BY REGION, AGE AND SEX IN 1980

Region	Percentage of anaemic individuals				
	Children 0–4 years	Children 5–12 years	Men	Women 15–49 years	
				pregnant	all
Developed regions	12	7	3	14	11
Developing regions	51	46	26	59	47
World	43	37	18	51	35

Anaemia may be caused not only by a deficiency of iron (or, less often, of other nutrients) but by other conditions. Malaria, hookworm disease (whether ancylostomiasis or necatoriasis), schistosomiasis and other infections play an important role in tropical climates. Congenital haemolytic diseases such as sickle-cell anaemia and thalassaemia are also found in certain populations, particularly in Africa, Asia, and some Pacific islands, although they rarely constitute a significant public health problem. In some Asian countries, however, such as Burma, Lao People's Democratic Republic, Thailand and Viet Nam, the high prevalence of thalassaemia should be taken into account when iron supplementation programmes are envisaged.

If all these factors are taken into consideration, it is estimated that some 700–800 million people worldwide are affected by iron deficiency anaemia. This is a very conservative estimate, however; the real figure is probably higher. Likewise, since iron deficiency anaemia is the end-stage of a relatively long process of deterioration in haemoglobin levels, many more persons are suffering from iron deficiency, with its adverse effects on health and physical stamina, than are frankly anaemic.

The consequences of iron deficiency, and especially iron deficiency anaemia, are many. They include the following:

In infants and children (6-9):
- impaired motor development and coordination;
- impaired language development and scholastic achievement;
- psychological and behavioural effects (inattention, fatigue, insecurity, etc.);
- decreased physical activity.

In adults of both sexes (10,11):
— decreased physical work and earning capacity;
— decreased resistance to fatigue.

In pregnant women (12-15):
— increased maternal morbidity and mortality;
— increased fetal morbidity and mortality;
— increased risk of low birth weight.

The key role that haemoglobin plays in transporting oxygen to tissues accounts for the diminished work capacity and physical performance of persons with a diminished concentration of haemoglobin. The biochemical basis of the impaired development and altered behaviour is unclear, although it may be related to certain functional changes at cellular level, e.g., alterations in certain iron-containing enzymes.

As for the health risks, controversy surrounds their origin. There is a growing body of evidence, based on animal studies, that iron deficiency as such, even before the stage of frank anaemia is reached, adversely affects the immune system. Defects in cell-mediated immunity and in the killing of bacteria have been well demonstrated. However, the clinical implications of these findings are not clear (*16*). Early studies of the effects of iron deficiency anaemia on the frequency of infection in anaemic children (*17,18*) suggested that children who received iron as a medication or as a food fortificant had lower rates of respiratory and gastrointestinal disease than untreated children. In contrast, a more recent study showed little protective effect from the correction of anaemia (*19*), although associated protein-energy malnutrition and unfavourable environmental sanitation may have contributed to this finding.

In recent years, it has even been proposed that iron administration itself might predispose a person to infection. There is some experimental evidence to suggest that iron-binding proteins protect animals from infection by withholding iron from the invading organisms that require it for growth (*20*). This phenomenon would explain why the administration of large doses of iron by injection could be harmful. However, increased susceptibility to infection has been demonstrated primarily when serum transferrin is nearly saturated with iron (see page 27). Under ordinary circumstances, transferrin is less than 35% saturated and only minimal changes occur in this percentage with iron consumption. Although iron deficiency may in fact protect the host against certain specific organisms under laboratory conditions, there is no evidence that such protection outweighs the many more tangible and persistent handicaps imposed by iron deficiency itself.

3. Etiology and epidemiology of iron deficiency anaemia

A thorough understanding of iron requirements, intake and bioavailability is needed to explain why some individuals—for example, women in their reproductive years (particularly pregnant women), infants and young children—are at greater risk of developing iron deficiency anaemia than others.

Iron requirements

A dietary intake of iron is needed to replace iron lost in the stools and urine and through the skin. These basal losses represent approximately 14 μg per kg of body weight per day, or approximately 0.9 mg of iron for an adult male and 0.8 mg for an adult female (*21*). The iron lost in menstrual blood must be taken into consideration for women of reproductive age (see Table 2).

Table 2. IRON REQUIREMENTS OF 97.5% OF INDIVIDUALS (MEAN + 2 S.D.) IN TERMS OF ABSORBED IRON,[a] BY AGE GROUP AND SEX[b]

Age/sex	in μg/kg/day	in mg/day[c]
4–12 months	120	0.96
13–24 months	56	0.61
2–5 years	44	0.70
6–11 years	40	1.17
12–16 years (girls)	40	2.02
12–16 years (boys)	34	1.82
Adult males	18	1.14
Pregnant women[d]		
Lactating women	24	1.31
Menstruating women	43	2.38
Post-menopausal women	18	0.96

[a] Absorbed iron is the fraction that passes from the gastrointestinal tract into the body for further use.

[b] See reference *29*.

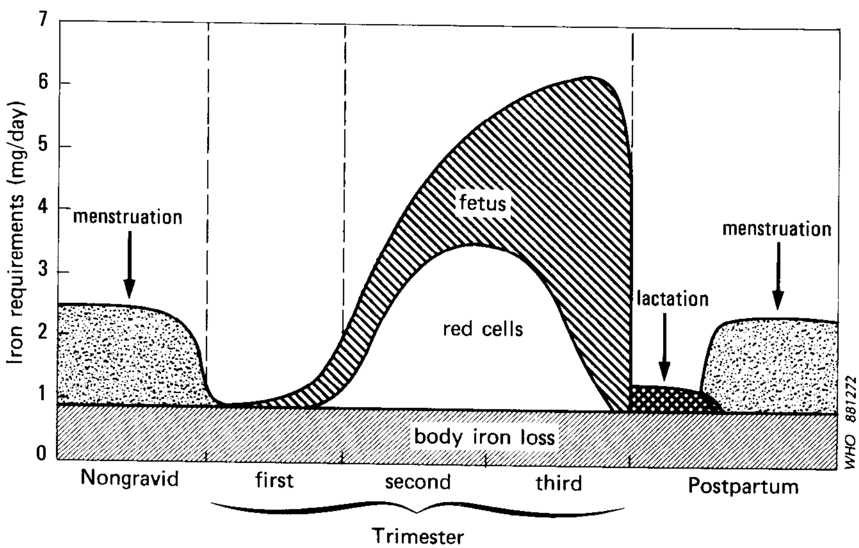
[c] Calculated on the basis of median weight for age.

[d] Requirements during pregnancy depend on the woman's iron status prior to pregnancy. See text for further explanation.

While the volume of menstrual blood lost is relatively constant for a given woman from month to month, it varies greatly between women. Several studies have shown that the median blood loss during menstruation ranges between 25 and 30 ml per month. This represents an iron loss of 12.5–15 mg per month, or 0.4–0.5 mg per day over 28 days. When basal losses are added, the total iron loss for menstruating women is about 1.25 mg per day. This means that the iron requirements of 50% of all women are in excess of 1.25 mg per day. Taking into account the skew of the frequency distribution of menstrual blood loss, one can calculate that only 2.5% of women have iron requirements in excess of 2.4 mg per day.

Although menstruation-related iron losses are reduced to nil during pregnancy, additional iron is nevertheless required for the fetus, the placenta and the increased maternal blood volume. This amounts to approximately 1000 mg of iron over the entire pregnancy (*22*). Requirements during the first trimester are relatively small, 0.8 mg per day, but rise considerably during the second and third trimesters to a high of 6.3 mg per day (see Fig. 1). Part of this increased requirement can be met from iron stores and by an adaptive increase in the percentage of iron absorbed. However, when iron stores are low or non-existent and dietary iron is poorly absorbed, as is often the case in developing countries, iron supplementation is essential. During lactation

FIG. 1. DAILY REQUIREMENTS FOR ABSORBED IRON IN 97.5% OF WOMEN (MEAN ± 2 S.D.) BEFORE, DURING AND AFTER PREGNANCY[a]



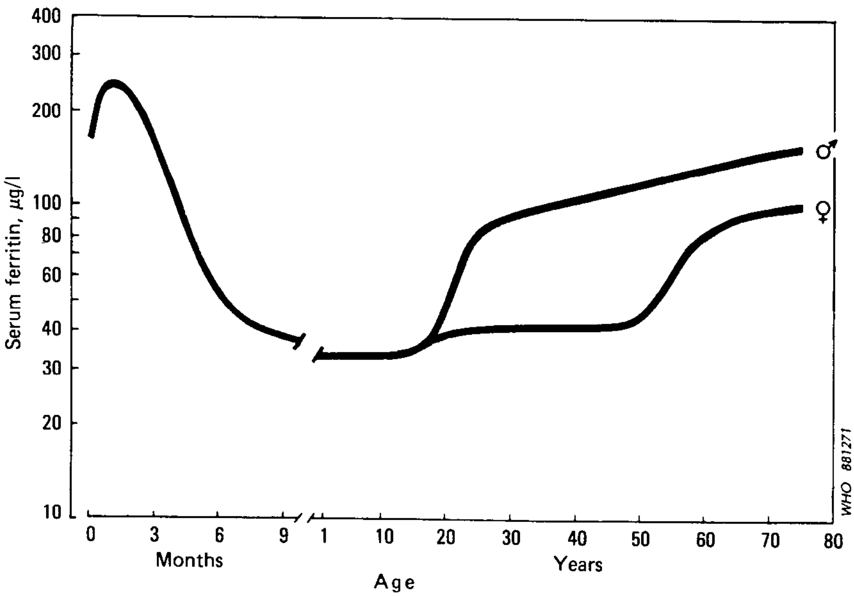
[a] The horizontal axis is not a true scale. Lactation, for example, usually continues for at least nine months.

the absence of menstrual blood loss is partially offset by the secretion of about 0.3 mg of iron per day in breast milk, in addition to basal losses. A woman's mean requirement during the first 6 months of lactation is estimated to be about 1.3 mg of iron per day (see Table 2).

Infants, children and adolescents require iron for their expanding red cell mass and growing body tissue. A normal infant at birth has about 75 mg of iron per kg of body weight, two-thirds of which is present in red blood cells. During the first 2 months of life there is a marked decrease in haemoglobin concentration with a consequent increase in iron stores. These stores are subsequently mobilized to supply iron for growth needs and to replace losses; hence, during this period there is a minimal requirement for dietary iron. By 4–6 months, however, iron stores have decreased significantly and the infant needs a generous dietary intake of iron. During the first year of life, a child triples its body weight and doubles its iron stores. Changes in the concentration of serum ferritin with age parallel the changes in iron stores (see Fig. 2).

Overall, as shown in Table 2, iron requirements per kg of body weight are substantially higher in infants and children than in adults. Since they have lower total energy requirements than adults, they eat less and

FIG. 2. CHANGES IN CONCENTRATION OF SERUM FERRITIN WITH AGE[a]



[a] Mean values (geometric means) in healthy populations are shown. At all ages, a serum ferritin concentration below 10 or 12 µg per litre is considered indicative of depleted iron stores (*25-28*).

are thus at greater risk of developing iron deficiency, especially if the iron in their diets is of low bioavailability.

Iron requirements increase in cases of chronic bleeding caused by such parasites as hookworm (*Ancylostoma* and *Necator*), *Schistosoma* and possibly *Trichuris trichiura*; these cause frequent infections in countries with hot, humid climates and poor sanitation. In the case of hookworm disease, blood loss varies from 2 to 100 ml per day according to the severity of the infestation (*23*). Some of the iron in the blood shed by the worm in the intestine will be reabsorbed further down the gastrointestinal tract, but the remainder will be lost via the stools. It is estimated that iron loss per thousand eggs per gram of faeces is 0.8 mg per day in the case of *Necator americanus* and 1.2 mg per day with *Ancylostoma duodenale (24)*.

Infections interfere with food intake and the absorption, storage and use of many nutrients, iron among them. In many rural communities and urban slums where environmental sanitation is poor, morbidity from viral and bacterial infections is high. It is in these same communities that diets are most often energy deficient. Where the iron balance is precarious, repeated episodes of infection may result in the development of anaemia, particularly in young children whose morbidity burden is much higher than that of adults. This explains in part the high prevalence of anaemia among infants and preschool children. By implication, the control of infection may be the intervention with the greatest impact on the problem of anaemia and iron deficiency in these age groups.

Types of dietary iron

There are two distinct types of dietary iron—haem and non-haem iron. Haem iron is a constituent of haemoglobin and myoglobin and therefore is present in meat, fish and poultry, as well as in blood products. Haem iron accounts for a relatively small fraction of total iron intake—usually less than 1–2 mg of iron per day, or approximately 10–15% of the dietary iron consumed in industrialized countries. In many developing countries, haem iron intake is lower or even negligible. The second type of dietary iron, non-haem iron, is a more important source; it is found to varying degrees in all foods of plant origin.

Besides the iron derived from food, the diet may also contain exogenous iron originating from the soil, dust, water or cooking vessels. This is more frequently the case in developing countries, where the amount of such contamination iron in a meal may be several times greater than the amount of food iron. The cooking of foods in iron pots may increase the iron content of a meal several fold. This is especially true for soups containing vegetables of low pH which are simmered for a long time. Frying in iron pans does not usually increase the food's iron content. Any iron released during cooking is integrated into the non-haem iron pool and is available for absorption. Another form of exogenous iron is that present in foods such as flour, sugar and salt which are deliberately fortified with iron or iron salts.

Table 3. SOURCES OF DIETARY IRON

Chemical form and type of iron	Source
Haem iron	Meat, fish, poultry and blood products. Accounts for 10–15% of iron intake in industrialized countries. Usually represents less than 10% of total intake (often negligible amounts) in developing countries. Bioavailability high: absorption 20–30%.
Non-haem iron — food iron	Mainly found in cereals, tubers, vegetables and pulses. Bioavailability determined by the presence of enhancing and inhibiting factors consumed in the same meal (see text).
— contamination iron	Soil, dust, water, iron pots, etc. Potential bioavailability usually low. May be present in large quantities, in which case its contribution to total iron intake is not insignificant.
— fortification iron[a]	Various iron compounds used, of varying potential bioavailability. Bioavailability of soluble fraction determined by composition of meal.

[a] Fortification is the process whereby one or more nutrients are added to a food to maintain or improve the quality of the diet of a group, a community or a population (*30*).

Overall, in any given diet the quantity of iron habitually ingested is relatively constant and difficult to modify, but some types of diet are inherently denser in iron than others. Iron density (the amount of iron ingested per unit of energy consumed) is actually higher in the diets of the developing world than in those typical of industrialized countries. All too often, however, this advantage is offset by the inadequacy of developing country diets in terms of total energy consumed. Where this is the case, the most straightforward way of increasing the amount of iron ingested is to increase total energy intake.

Even where people generally have enough to eat, children and women are a special case. Because of their lower energy needs they tend to consume less food than other groups, which makes it more difficult for them to meet their iron needs. Like all individuals subsisting on a low-energy diet, children and women are at risk of developing iron deficiency.

A factor just as important as the total iron content of the diet is the bioavailability of the iron ingested, i.e., its absorbability. How much iron is effectively absorbed by the body varies considerably depending on a number of factors, as explained below. Increasing total energy intake and enhancing the bioavailability of the non-haem iron ingested are thus the main dietary strategies for helping people to meet their iron requirements.

Absorption of dietary iron

The absorption of dietary iron is influenced by the amount and chemical form of the iron, the consumption during the same meal of factors enhancing and/or inhibiting iron absorption, and the health and iron status of the individual (see Tables 3 and 4).

Table 4. MAJOR DETERMINANTS OF IRON ABSORPTION

DIETARY FACTORS:

(1) factors that enhance non-haem iron absorption:

- ascorbic acid (vitamin C)
- meat, poultry, fish and other seafood
- low pH (e.g., lactic acid)

(2) factors that inhibit non-haem iron absorption:

- phytates
- polyphenols, including tannins

HOST FACTORS:

(1) iron status

(2) health status (infections, malabsorption)

Contamination iron usually has a very low bioavailability. One exception is the iron derived from cooking pots.

Iron compounds that are used for food fortification vary considerably in bioavailability. Easily soluble compounds, for example, ferrous