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IRON DEFICIENCY ALLEVIATION IN DEVELOPING COUNTRIES

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INTRODUCTION

Iron deficiency is the most prevalent nutritional disorder worldwide, when the prevalence of anaemia is used as an indicator (ACC/SCN, 1992). Although anaemia can also be caused by other factors, such as folic acid deficiency or genetic disorders, in most cases it will be caused by iron deficiency. Table 1 shows that anaemia (as defined in the Table) is prevalent in industrialized countries, but it is especially so in developing countries where large proportions of the population are deficient. Areas with the highest prevalence are Africa and South Asia. The values in Table 1 originate partly from the early 1980s, but from more recent data it can be concluded that the situation has not much improved since that time. A report from WHO (1992) indicates that the prevalence of anaemia among pregnant women in Southeast Asia and Africa was estimated to be 74 and 52% respectively.

Iron deficiency will occur if over a prolonged period of time the amount of iron absorbed by the body is too little to compensate for the normal physiological requirements, or when iron is lost through disease or trauma. The amount of iron which can be absorbed from the food, that is its bioavailability, depends on the quantity and chemical form of iron in the diet and the presence of dietary constituents that modify its absorbability. The amount absorbed also depends on the iron status of the individual. Individuals depleted of iron have a much higher absorption rate than those who are not depleted (Hallberg *et al.* 1995).

In adult males iron requirements are determined by the basal losses, which are normally of the order of 0·7–1·0 mg (Hallberg *et al.* 1994). To be able to absorb 1 mg iron, the diet of an iron replete person should contain about 10 mg highly bioavailable iron. In women of fertile age iron lost in menstrual blood is added to the basal losses, leading to a higher daily requirement of about 1·2–1·5 mg. The requirement is especially high for pregnant

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Table 1. *Estimates of the prevalence (%) of anaemia* in adults based on reports from 1985 and 1992*

	1985 report[1]			1992 report[2]
		Females		
	Males	Pregnant	All	Pregnant females
Africa	20	63	44	52
North America	4	—	8	—
Latin America	13	30	17	40
Southeast Asia	—	—	—	74
East Asia	11	20	18	—
South Asia	32	65	8	—
Europe	2	14	12	18
Oceania	7	25	19	40

* Anaemia was defined as follows: Hb < 110 g/l for preschool children & pregnant women; Hb < 120 g/l for adolescents, non-pregnant women, school children & elderly females; Hb < 130 g/l for elderly males.
[1] DeMaeyer & Adiels-Tegman, 1985.
[2] WHO, 1992.

women, young children, and adolescents, because of rapid growth in tissue and blood volume. As a result, these population groups are most at risk of becoming iron deficient.

The physiological requirements during the second and third trimesters of pregnancy are estimated to be as high as 4–6 mg iron per day (INACG, 1981). It is difficult to acquire this through dietary intake, even though absorption increases significantly during the course of pregnancy (Whittaker *et al.* 1991). In spite of such an adaptation, part of the requirement has to be covered by iron stores. Women with sufficient iron stores can meet the high requirement. It is estimated that iron stores equivalent to a serum ferritin concentration of at least 30–40 μg/l are needed to meet the pregnancy requirement, and those with lower iron stores will become iron deficient. The majority of women from developing countries do not have such stores owing to factors such as low quantities of absorbable iron in the diet, parasitic infestations, and multiple pregnancies. Anaemia prevalence rates among pregnant women in developing countries are reported to be as high as 50–70% (ACC/SCN, 1992).

For young children iron needs are high due to rapid growth. During infancy body weight at birth should about triple, and the amount of body iron should increase by about 70% between 4 and 12 months of age. A child 6–12 months old should absorb about 0·1 mg Fe/kg body weight, which almost equals the daily requirement of an adult man (Hallberg *et al.* 1994). Especially low birth weight babies have high iron requirements during infancy since they are born with smaller iron stores, and their relative growth rate is more rapid than that of term infants (Dallman *et al.* 1980). In developing countries the low iron content and bioavailability of the diet, in combination with repeated attacks of infectious diseases and parasite infestations, increases the risk that young children become iron deficient. No systematic data are available regarding the prevalence of iron deficiency among young children, but a rate of 30–40% among preschool children in developing countries would not be exceptional, and the prevalence is expected to be higher among children 6–18 months of age (Ruz, 1994).

For adolescent girls absorbed iron needs to compensate for menstrual blood losses and for requirements due to the growth spurt. Requirements for adolescent girls are therefore higher than are those for menstruating adult women.

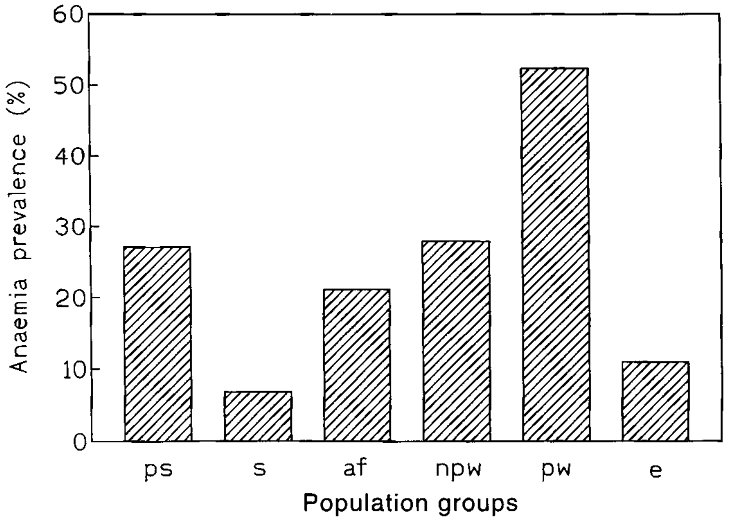

Fig. 1. Prevalence of anaemia among selected Indonesian population groups (ps, preschool children, $n = 575$; s, primary school children, $n = 123$; af, adolescent females, $n = 805$; npw, non-pregnant women, $n = 462$; pw, pregnant women, $n = 390$; e, elderly, $n = 431$).

Fig. 1 shows the results of several cross-sectional studies on anaemia among Indonesian population groups. Although the subjects investigated were not representative of the whole Indonesian population, the figure does illustrate the increased risk of iron deficiency in preschool children, adolescents, and pregnant women.

The consequences of iron deficiency are serious. During pregnancy it is associated with low birth weight babies, premature delivery, and even perinatal and fetal death (Garn *et al.* 1981; Murphy *et al.* 1986; Scholl & Hediger, 1994). During childhood, it leads to impaired cognitive performance and motor development (Soemantri *et al.* 1985; Aukett *et al.* 1986; Soewondo *et al.* 1989; Lozoff *et al.* 1991), and decreased linear growth rate (Aukett *et al.* 1986; Soewondo *et al.* 1989; Angeles *et al.* 1993; Lawless *et al.* 1994). The reduction in cognitive abilities caused by iron deficiency in early childhood may be reversible. Adults suffer from reduced ability to do physical work (Davies & van Haaren, 1973; Basta *et al.* 1979). This negative influence on physical capacity is also noticeable in work which does not require a high energy expenditure (Li *et al.* 1994). When iron deficient individuals attempt to work at the same level as those who are iron replete they need more energy, and the deficiency may therefore influence energy balance (Li *et al.* 1994). Iron deficiency also impairs the normal defence systems against infection (Joynson *et al.* 1972; Srikantia *et al.* 1976). Deficient individuals not only absorb iron more efficiently, but also other divalent metals such as lead and cadmium (Murray *et al.* 1978). In environments with a high degree of lead pollution, for example from automobile fumes in cities such as Bangkok, Jakarta, or Manila, iron deficient children would be susceptible to lead poisoning.

As opposed to other micronutrient deficiencies such as vitamin A and iodine, limited progress has been made in solving the iron deficiency problem during the past decade (ACC/SCN, 1992). This lack of success justifies a review of currently used intervention programmes and their target groups, and an investigation of possible improvements and new options. Since the situation is most serious in developing countries the contents of this presentation focus especially on these countries.

INTERVENTION OPTIONS FOR THE ALLEVIATION OF IRON DEFICIENCY

Basically there are three types of intervention to increase the iron status of populations: improvement of the diet in terms of bioavailable iron; fortification of foods; medicinal iron supplements.

In areas where iron deficiency is also enhanced by increased gastrointestinal blood loss due to hookworm infection (Layrisse & Roche, 1964) or by schistosomiasis (Prual *et al.* 1992), programmes to reduce the prevalence of these infections should be part of the effort to control iron deficiency. Parasite control will not be specifically discussed in this overview but this should certainly not be interpreted as a downgrading of the importance of these interventions, but rather as a recognition that it would require another survey.

DIETARY IMPROVEMENT

In developing countries the quantity of absorbable iron in the diet of many population groups is low, and insufficient to meet the relatively high demands for growth, menstruation, or pregnancy. This is related to the lower consumption of foods from animal sources which contain more highly bioavailable iron. The most efficient way to improve both the quantity and the bioavailability of dietary iron would be by increasing the intake of meat, containing haem iron. Another way to influence iron absorption would be by raising the intake of substances such as vitamin C which increase the absorption of non-haem iron and/or by reducing the intake of substances such as calcium, phytates, or phenolic compounds which decrease iron absorption (Hallberg, 1981; Gillooly *et al.* 1983; Hallberg *et al.* 1987). The effects of increasing the proportion of haem iron and decreasing the intake of phytate were demonstrated in a study among iron replete Swedish women (Hulten *et al.* 1995). While the total amount of iron was similar in two types of diet ($\sim$ 14 mg), daily iron absorption was 2·3 mg *v.* 1·3 mg respectively from a high *v.* a medium bioavailability diet. The high bioavailability diet contained twice as much haem iron and less than half the phytate content of the medium bioavailability diet.

However, raising haem iron consumption may be difficult for many households owing to the relatively high cost of meat. For example, a high bioavailability diet may contain 1·5 mg haem iron daily which could be provided by 50–70 g meat. The higher consumption of iron-rich animal foods will require overall economic improvements which are unlikely to occur on a short term basis. Economically, it would be more feasible to increase the amount of vitamin C in meals with poor iron availability. In iron deplete women this measure may increase absorption to levels of about 15–20 % (Hunt *et al.* 1990). Taken with a meal, 50 mg vitamin C would improve iron absorption (Hallberg *et al.* 1989; Tuntawiroon *et al.* 1990). This amount of vitamin C could be provided for example by about 100 g cauliflower, broccoli, or green leafy vegetables (Platt, 1980). This may seem feasible. However, in many areas the availability of vegetables is limited. Especially during the dry season in areas with large seasonal differences in rainfall vegetables are difficult to obtain. Furthermore, even when households have access to vegetables the consumption of many households in general, and small children in particular, is often very low.

Absorption inhibitors such as phytate also play an important role in determining the iron status of populations. Most rice varieties contain much more phytate than wheat (Tuntawiroon *et al.* 1990), and the prevalence of iron deficiency is particularly high among the rice consuming populations of Southeast Asia (DeMayer & Adiels-Tegman, 1985). It was reported that the iron bioavailability of a rice based meal increased from 7·5 to 22·1 %

when the phytate content was decreased from 175 mg to 30 mg (Tuntawiroon *et al.* 1990). The negative effect of phytate on iron absorption may be overcome by consuming more vitamin C-rich vegetables with the rice, or by improving milling techniques since the phytate content is especially high in broken rice (Tuntawiroon *et al.* 1990).

A diet that can cover the iron requirements of menstruating women (10–15 mg) should contain red meat, ascorbic acid, and not too much cereal fibre with its high phytate content. Such a diet will be difficult to achieve over a short period of time for most population groups in developing countries because they require either modified dietary habits, adaptation in food processing or preparation, increased food availability, and/or an improved economic level enabling households to purchase foods such as meat and fish.

To improve iron status by diet is particularly difficult, or perhaps even impossible, for infants 6–18 months old, whose high iron requirement needs to be provided almost entirely by food complementary to breast milk. Assuming that breast milk would provide about 400 kcal/day for an infant of 6–8 months, about 300 kcal/day would be needed from complementary food which should then also provide about 7 mg highly bioavailable iron. This is very difficult to achieve given the fact that most infant diets in developing countries are low in iron content and bioavailability unless foods are fortified.

Interventions aiming to improve iron absorption from the diet are particularly important since they would be sustainable. It should be realized, however, that they are long term strategies, and possibly difficult to apply to infants.

FOOD FORTIFICATION

Another option is the fortification of foods. For example, in the United States most infant formulas and cereals are fortified with iron (Fomon, 1987), and their use has been identified as an important factor in reducing the prevalence of anaemia among infants of low and middle income families (Dallman, 1990). Provision of foods fortified with iron has been recommended as an effective nutrition programme for high risk infants in the United States (Vazquez-Seoane *et al.* 1985). Food fortification is also an attractive option in developing countries since no modification in dietary habits is required, nor active participation of the target population.

Fortification is relatively cheap and can be sustained. However, it is a big challenge (1) to find suitable food vehicles which are easily accessible and consumed by target groups, and (2) to identify micronutrient compounds which remain stable and are of high bioavailability. Many experiments on food fortification have been conducted in developing countries. These include fortification of sugar in Guatemala (Viteri *et al.* 1995*a*), fish sauce in Thailand (Garby & Areekul, 1974), curry powder in South Africa (Ballot *et al.* 1980), and salt in India (Nadiger *et al.* 1980; Working Group on the Fortification of Salt with Iron, 1982). The experiments reported favourably in terms of acceptability by the target population as well as improving their iron status. A 32 month field trial with FeEDTA-vitamin A fortified sugar in Guatemala resulted in higher iron stores (Viteri *et al.* 1995*a*). The prevalence of anaemia among different age groups in several Indian cities decreased markedly after consumption for one year of salt fortified with iron (Working Group on the Fortification of Salt with Iron, 1982). In several developing countries fortification is already carried out on a large scale. For example in Nigeria, Chile and El Salvador flour is fortified with iron, and in Chile pasta is also fortified (Barrett & Ranum, 1985). However, in spite of these encouraging examples and research results the majority of developing countries have still not started with large scale fortification programmes. Reasons for this are: lack of commitment which may be based on insufficient understanding of iron deficiency; increased costs required for fortification; and difficulty in finding a suitable food vehicle.

Table 2. *Results of field trials on supplementation of pregnant women*

Country	n	Treatment	Initial Hb (g/l)	Treatment effect (g/l)	Reference
Thailand	($n = 42$)	120 mg Fe+fa[1], 10 wk	104	7	Charoenlarp *et al.* 1988
Thailand	($n = 47$)	240 mg Fe+fa, 10 wk	103	10	Charoenlarp *et al.* 1988
Thailand	($n = 38$)	120 mg Fe+fa, 15 wk	102	14	Charoenlarp *et al.* 1988
Thailand	($n = 41$)	240 mg Fe+fa, 15 wk	104	13	Charoenlarp *et al.* 1988
Sri Lanka	($n = 36$)	60 mg Fe+fa, ~ 18 wk	95	8	Atukorala *et al.* 1995
Sri Lanka	($n = 66$)	120 mg Fe+fa, ~ 18 wk	96	4	Atukorala *et al.* 1995
India	($n = 24$)	120 mg Fe, 11 wk	103	11	Sood *et al.* 1979

[1] fa = folic acid.

Furthermore, there may be concern about the potential risk of iron overloading. In developing countries this risk can be considered extremely small, although some specific cases have been reported (Gordeuk *et al.* 1986). In some western countries such as the United States, however, it may be necessary to monitor this (Skikne & Cook, 1987). It should be realized that food fortification can only have a wide impact if a vehicle is chosen which is purchased by a large majority of the population, including groups such as subsistence farmers. Sugar or salt seem suitable vehicles since these are consumed regularly by all socioeconomic strata, whereas staple foods such as wheat flour, rice or maize would not be purchased by subsistence farmers. Salt has been fortified with iron at a relatively high level of 1 mg iron per g salt, using ferric orthophosphate and sodium acid sulphate as an absorption promoter (Working Group on the Fortification of Salt and Iron, 1982). Salt is also promoted as a vehicle for iodine, and additional fortification with iron may not be without technological problems. Whereas salt iodization is successful in some countries (Mannar & Dunn, 1995), problems are encountered in others. For example in Indonesia many small scale producers of salt exist, which makes quality control of fortification more difficult. Similar problems would be encountered using salt as a vehicle for iron. Sugar has been fortified with FeNaEDTA at a level of 130 mg Fe/kg sugar. Although FeNaEDTA is more expensive than other iron compounds (expressed as cost per kg Fe) (INACG, 1990), an advantage of using FeNaEDTA is its relatively high bioavailability and good stability (Viteri *et al.* 1995*a*). There are probably only a few sugar producers in any country and the addition of FeEDTA to sugar is technologically uncomplicated.

Considering the favourable results of a field trial within Guatemala (Viteri *et al.* 1995*a*), sugar may also be used for fortification in other countries.

Food fortification is in principle an excellent way to increase iron intake. So far it has not been widely used and accepted owing to political and/or practical reasons. In order to remove the existing barriers it is necessary that public health nutritionists and the food industry collaborate.

SUPPLEMENTATION WITH IRON

Finally, a simple and effective way to improve iron status of a deficient individual over a short period of time is through supplementation with iron tablets. Field trials showed that providing iron supplements to target groups as a basic primary health care measure can also be an efficient way of reducing the prevalence of anaemia in larger population groups. Some examples of these field trials are shown in Table 2. The duration and the dosage vary but in none of the cases could anaemia be completely prevented.

Based on such experiences, many countries implement supplementation programmes organized through the primary health care system, and this has become the most widely accepted and used type of intervention for iron deficiency. In several countries, UNICEF supported the local government with the procurement and distribution of tablets. In 1989, UNICEF supplied yearly 1 billion iron tablets to some 47 countries at a cost of about US$1 per 1000 tablets (ACC/SCN, 1991). These tablets contain 60 mg elemental iron as ferrous sulphate and 250 μg folic acid.

The most frequently targeted population group for supplementation is pregnant women. It is expected that they will visit health centres monthly to receive antenatal care. They should also receive iron tablets from the health care staff. In areas with a high prevalence of iron deficiency WHO recommends that all pregnant women should take 120 mg iron per day throughout the second and third trimester of pregnancy (DeMayer *et al.* 1989). However, although efficacy in raising haemoglobin levels by supplementation was demonstrated in field trials, when scaled up to country level most programmes had a relatively limited impact on pregnancy anaemia. For example, the Indonesian government started an iron supplementation programme for pregnant women about 10 years ago. The prevalence of anaemia among these women was estimated at 70% in 1983 and 55–60% in 1992 (Muhilal *et al.* 1992). This situation is not unique to Indonesia, considering that in Southeast Asia the prevalence among pregnant women is estimated to be 60–70% (World Health Organization, 1992). The failure of large scale supplementation programmes may be caused by problems with the organization of the distribution of supplements, by the behaviour of target groups, or by physiological factors.

A sufficient supply of iron tablets is required. Since most developing countries have a high prevalence of iron deficiency among pregnant women, blanket coverage should be attempted throughout the second and third trimester of pregnancy requiring large numbers of tablets. In spite of assistance by UNICEF, tablet supply is a constraint experienced by many countries (ACC/SCN, 1991), arising from shortage of government funds, or absence of political awareness of the prevalence and consequences of iron deficiency leading to a lack of commitment. A sufficiency of tablets at national level does not guarantee that they are adequately distributed to provincial, district and village health centres. The distribution of supplements down to village level was also reported to be a major constraint in large scale programmes (ACC/SCN, 1991). Stock management and tablet distribution depend mainly on factors such as availability of funds, government policy, available infrastructure, and quality of health care management.

The availability of sufficient iron tablets at a health care centre again does not automatically mean that the pregnant women will get the tablets, since the coverage rate of the antenatal care programme may be inadequate. Not all women visit the governmental health centres regularly during pregnancy. In Thailand, Indonesia, Burma, India and the Caribbean 22–90% of target groups made use of the health services (ACC/SCN, 1991). However, service utilization rates depend on the stage of pregnancy of the questioned subjects. A study in rural Indonesia reported that the service utilization rate was 37·8% among women in the second trimester but 82·3% in the third trimester of pregnancy (Thorand *et al.* 1994). Women may just not be aware of the need for regular prenatal check-ups until close to delivery, or may have perceptions which are different from those of the health care staff (Gryboski, 1995). Other factors which may negatively influence the women's health seeking behaviour and consequently the coverage rate of the health service include training, motivation, and time availability of health service personnel (Gross *et al.* 1995). Finally, the local infrastructure may also negatively influence the coverage rate of health services.

After the women have received iron tablets it still remains uncertain whether they will actually take the tablets as prescribed (DeMayer *et al.* 1989). Studies from developed as well as developing countries showed that many women do not take the tablets according to prescription (Bonnar *et al.* 1969; Schultink *et al.* 1993; Thorand *et al.* 1994). It may be that only 35–70 % of the women ingest the tablets, which indicates the importance of compliance for a successful supplementation programme; this may be related to the negative side effects experienced, to insufficient motivation, and to local perceptions related to pregnancy. The side effects are influenced by the amount of iron to be ingested (Bonnar *et al.* 1969; Charoenlarp *et al.* 1988), by the type of iron supplement (Cook *et al.* 1990), and probably also by the prescribed daily intake of one, two or three tablets. Among pregnant Thai women receiving 240 mg iron per day, about 30 % complained of abdominal discomfort, nausea, vomiting, dizziness and fatigue, while about 10 % receiving 120 mg/day complained (Charoenlarp *et al.* 1985). When the daily supplement of iron during pregnancy is less than 120 mg, side effects may also be caused by the pregnancy itself (Simmons *et al.* 1993; Schultink *et al.* 1993). Local perceptions relating to pregnancy and health also play a role with respect to compliance. For example, among Indonesian women fear of having a large fetus or of loosing too much blood at delivery can be a reason for not taking iron supplements during pregnancy (Gryboski, 1995; Gross *et al.* 1995).

Possibilities of improving the efficacy of supplementation programmes for pregnant women have been discussed and include changing the distribution system by using traditional birth attendants (ACC/SCN, 1991), increasing awareness of the need for antental check-ups and iron supplements by using social marketing approaches, and using other supplements such as gastric delivery systems (Simmons *et al.* 1993).

Another factor which may be limiting any improvement in iron status, even when supplements are taken, is low vitamin status (Bloem, 1995). Studies among children (Mejía & Chew, 1988; Bloem *et al.* 1990) and pregnant women (Suharno *et al.* 1993) showed that a combined iron and vitamin A supplement was more effective than iron alone, and that even supplementing only with vitamin improved iron status. Generally, vitamin A supplementation programmes are targeted at children, whereas iron supplementation is targeted at pregnant women, and so far iron and vitamin A supplements have not been combined in the same target group in developing countries.

NEW DEVELOPMENTS ON THE FREQUENCY OF SUPPLEMENTATION

Even with the proposed or investigated alterations in iron supplementation programmes for pregnant women several of the problems mentioned will probably remain. The programme for pregnant women will continue to require large numbers of iron tablets, which has been mentioned as a constraint. The compliance of women may also be difficult to influence in spite of efforts at motivation. Both of these problems are at least partly related to the currently prescribed frequency of intake.

Studies in rats have compared the administration of iron supplements on a daily basis *v.* every third day (Wright & Southon, 1990; Viteri *et al.* 1995*b*). These studies are based on observations that human intestinal mucosal uptake of iron may be suppressed after exposure to a high dose of iron (Solomons *et al.* 1983; Fairweather-Tait & Minski, 1986; O'Neil-Cutting & Crosby, 1987). The rat studies indicated that intermittent supplementation with a smaller total dose was just as effective as daily supplementation in improving iron status. It was argued that when the administration of iron is matched with the intestinal mucosal renewal time, absorption and retention is more efficient (Viteri *et al.* 1995*b*). Based on this argument a proposal was developed for multiple studies to investigate the effect of weekly *v.* daily administration of iron in populations in developing countries (Viteri, 1994). So far, results have been published of studies among Indonesian and Chinese preshool children (Liu *et al.* 1994; Schultink *et al.* 1995), and Indonesian pregnant (Ridwan *et al.* 1996), and non-pregnant women (Gross *et al.* 1994).

A double-blind study among Indonesian preschool children with low iron status compared daily ($n = 32$) with twice weekly ($n = 33$) supplementation (Schultink *et al.* 1995). After correction for the confounding effect of initial haemoglobin, there was no statistically significant difference between groups. In a randomized trial among anaemic and non-anaemic 3–6-year-old Chinese children, daily ($n = 84$), twice-weekly ($n = 72$), and weekly ($n = 82$) supplementation was compared (Liu *et al.* 1994). It was supervised and lasted three months. The increase in haemoglobin was similar in the three treatment groups. Among Indonesian pregnant women a daily intake of 60 mg Fe ($n = 68$) was compared with a once-weekly intake of 120 mg ($n = 71$). No significant differences existed after an average supplementation period of 11 weeks (Ridwan *et al.* 1996). In anaemic non-pregnant Indonesian factory women a once weekly supplementation with 60 mg elemental iron ($n = 42$) gave similar results to a daily intake of 60 mg ($n = 38$) in terms of changes in haemoglobin concentration (Gross *et al.* 1994).

All studies among subjects from China and Indonesia indicated that weekly supplementation is as effective as daily supplementation in improving iron status. Higher absorption of iron when supplemented on a once-per-week basis was not confirmed by a laboratory based study among non-pregnant women (Cook & Reddy, 1995). These findings, however, conflicted with another study which did report a significant decrease in iron absorption from a 10 mg dose after a 50 mg dose was given 18 h previously (Fairweather-Tait & Minski, 1986).

The advantages of weekly instead of daily supplementation would be the lower costs, possibly easier distribution, and also possibly improved compliance. Furthermore, high daily intakes of iron might negatively influence the absorption of other micronutrients such as zinc (Solomons, 1986) and with weekly supplementation such a continuous negative interaction would not occur. Furthermore, with weekly supplementation the chance of iron overload would be very limited. It would be possible to supplement larger population groups who have low iron stores.

CONCLUSION AND RECOMMENDATIONS

Up to now major public health attention related to iron deficiency was paid to pregnant women. However, from the data available, it seems very likely that deficiency is widely prevalent among preschool children, particularly those who are 6–18 months old. As a result, owing to seriously focused negative health effects, intervention measures should be focused on this risk group as well.

The ideal way to improve the iron status of populations is through improvement of the diet. This approach is sustainable, and entails no risk of eventual iron overload. Therefore, efforts to improve the diet in terms of iron intake should be encouraged and strengthened. However, dietary changes require improved socioeconomic status and the understanding and willingness of consumers. It cannot therefore be expected that over a short period of time significant decreases in the prevalence of iron deficiency will or can occur through dietary changes alone. Selected foods which are affordable and consumed by target populations should be fortified with iron. Such intervention will have a relatively fast effect on iron status. In many developing countries some fortified foods are already available. These are also sold in industrialized countries, but they are not bought by a large part of

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the population in developing countries since they are either too expensive or they do not fit into local dietary practices. Local private industry should be encouraged to fortify locally accepted foods, which can be sold at lower prices. The industry may be willing to make the necessary initial investment if they get political backup. The fortification of such specific foods may be easier to achieve than the fortification of basic foods such as sugar or salt, since for this type of intervention concrete government initiatives and involvement would be needed.

The availability of fortified infant foods needs special attention. High quality foods are already being produced, but they are not available everywhere and are sold at a relatively high price since they are produced with sophisticated technologies for high income consumers. Therefore, more research is needed to develop foods of appropriate quality at a price which would make fortified infant foods affordable for larger population groups in developing countries.

The type of intervention which can be implemented quickly and targeted easily remains the distribution of iron supplements. However, the current targeting approach and the distribution mechanism need to be modified. Existing large scale programmes have a curative purpose and are mainly aimed at pregnant women. Little effort is made by the public health system in developing countries to switch from a curative to a preventive approach (Viteri, 1995). It seems more promising to intervene in a preventive way in risk groups where iron requirements are high, rather than when anaemia already exists. This approach is currently not used for such reasons as lack of funds, inadequate distribution mechanisms and probably unawareness of decision makers. Target groups for such a preventive programme would be infants and adolescent girls.

A reduction in iron deficiency among young children might be achieved by supplementing children 9–18 months old weekly during a period of 3 months or more. This age category can be reached relatively easily through mother and child health care programmes. Supplementation could also be linked with immunization campaigns. After children have reached satisfactory iron status it is likely that they may remain iron replete during a prolonged period of time (Angeles *et al.* 1995) because of decreased iron needs after the speed of growth has reduced. A suitable supplement, preferably in liquid form, should be developed and tested. Ideally, it would also contain other micronutrients such as vitamin A and zinc.

During adolescence iron deficiency not only reduces work productivity but also leads to iron deficiency during pregnancy. Therefore, targeting adolescent girls would not only have an immediate curative effect but may also have a longer term preventive effect on deficiency during pregnancy. Weekly iron supplements might also be used for this population category, who may be reached through schools or factories. The cost of weekly supplements would be low, and organizations other than Ministries of Health may be able to finance and organize the distribution.

Iron supplementation during pregnancy still remains necessary. The current recommendations on dose, frequency of ingestion and type of supplement need to be reviewed in the light of studies from different settings.

Since the socioeconomic situation and the rate and distribution of iron deficiency among the population differ strongly between countries and regions no single strategy for its alleviation can be recommended but all three types of intervention are needed simultaneously. A fairly specific mixture has to be identified for each country considering their local conditions.

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