The Prevalence and Causes of Nutritional Iron Deficiency Anemia

Patrick MacPhail and Thomas H. Bothwell

Department of Medicine, University of the Witwatersrand Medical School, Parktown, Johannesburg, South Africa

This review will be confined to a discussion of iron deficiency anemia as it affects adult populations. The problem of iron deficiency in infancy and childhood was the subject of a previous workshop in this series (1) and, together with the problem of iron balance in pregnancy and lactation, is covered in later chapters. The causes of iron deficiency have previously been extensively reviewed (2), and this review will therefore concentrate only on certain aspects, with special reference to areas of uncertainty and to the importance of nutritional factors in causation.

PREVALENCE STUDIES

Prevalence of Anemia

Anemia has long been recognized as a major medical problem affecting a considerable proportion of the world's population at all ages. In their classic study, De Maeyer and Adiels-Tegman (3) calculated that 1300 million people, or about 30% of the world's population, suffered from anemia. By assuming that adult males seldom develop iron deficiency anemia, they corrected the prevalence in each age/sex category. On this basis, they estimated that 500–600 million people suffer from iron deficiency anemia. The wide variation in the prevalence of anemia is shown in Table 1, with the highest rates occurring in the less developed regions of the world.

Prevalence of Iron Deficiency Anemia

Anemia is traditionally defined according to age- and sex-related "cut-off points" of hemoglobin values (2). Despite the fact that these WHO criteria fail to distinguish accurately between overlapping anemic and nonanemic populations, they remain the most practical and widely used method of defining anemia. However, anemia cannot be equated with iron deficiency, since there are numerous other causes, including
other nutritional anemias, genetic disorders, and chronic infections. To categorize an anemia as being due to iron deficiency, more selective measurements of iron status must be applied (4). These include the serum ferritin concentration (a measure of iron stores), the transferrin saturation (a measure of iron supply to the marrow), and red cell protoporphyrin (an indicator of iron-deficient erythropoiesis). A diagnosis of iron deficiency anemia should only be made in epidemiologic studies if the hemoglobin is below the WHO cut-off points and at least two other measurements of iron status are in the iron-deficient range (4). Unfortunately, few studies on the prevalence of iron deficiency anemia have used such stringent criteria.

Table 2 summarizes recent prevalence studies in which acceptable criteria for the diagnosis of iron deficiency anemia were used. It is apparent that the prevalence differs widely in developing and industrialized regions. In the developing regions the prevalence in women mostly exceeds 20% while that in men (about 5–6%) is similar to the prevalence seen in women in developed regions. Figures for the prevalence of iron deficiency anemia in both sexes are lower (Table 2) than the estimated figures in the WHO study (Table 1). The difference is apparent in all regions but is most striking in studies from Africa. This suggests that the stringent criteria applied in Table 2 may underestimate the true prevalence of iron deficiency anemia. Although there are many causes of anemia in these regions, it is likely that large numbers of cases of iron deficiency are complicated by other factors (such as chronic inflammation) which tend to raise the serum ferritin concentration. The problem was addressed in a recent study from Chad (10) in which 88% of pregnant women and 41% of menstruating women had a transferrin saturation and erythrocyte protoporphyrin level in the iron-deficient range. However, the serum ferritin was indicative of iron deficiency in only 20% and 10%, respectively.

---

**TABLE 1. Estimates of the prevalence (%) of anemia (circa 1980) in adults**

<table>
<thead>
<tr>
<th>Region</th>
<th>Males</th>
<th>Pregnant</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>20</td>
<td>63</td>
<td>44</td>
</tr>
<tr>
<td>North America</td>
<td>4</td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>Latin America</td>
<td>13</td>
<td>30</td>
<td>17</td>
</tr>
<tr>
<td>East Asia</td>
<td>11</td>
<td>20</td>
<td>18</td>
</tr>
<tr>
<td>South Asia</td>
<td>32</td>
<td>65</td>
<td>58</td>
</tr>
<tr>
<td>Europe</td>
<td>2</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td>Oceana</td>
<td>7</td>
<td>25</td>
<td>19</td>
</tr>
<tr>
<td>Developed regions</td>
<td>3</td>
<td>14</td>
<td>11</td>
</tr>
<tr>
<td>Developing regions</td>
<td>26</td>
<td>59</td>
<td>47</td>
</tr>
<tr>
<td>World</td>
<td>18</td>
<td>51</td>
<td>35</td>
</tr>
</tbody>
</table>

* The figures are based on the review by De Maeyer and Adiels-Tegman (3).

* Includes pregnant and nonpregnant women.
### PREVALENCE AND CAUSES OF IDA

#### TABLE 2. Prevalence (%) of iron deficiency anemia in adults living in different geographic regions

<table>
<thead>
<tr>
<th>Region</th>
<th>Country</th>
<th>Males</th>
<th>Pregnant</th>
<th>Not Pregnant</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>Algeria</td>
<td>—</td>
<td>22.5</td>
<td>20.1</td>
<td>5,6</td>
</tr>
<tr>
<td></td>
<td>Nigeria</td>
<td>6.7</td>
<td>18.9</td>
<td>—</td>
<td>7,8</td>
</tr>
<tr>
<td></td>
<td>Benin</td>
<td>5.9</td>
<td>45</td>
<td>20.6</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Chad</td>
<td>—</td>
<td>19.6</td>
<td>10.5</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>South Africa*</td>
<td>3.9</td>
<td>—</td>
<td>24.3</td>
<td>11</td>
</tr>
<tr>
<td>Americas</td>
<td>USA</td>
<td>0.2</td>
<td>—</td>
<td>2.3</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Canada*</td>
<td>5.1</td>
<td>—</td>
<td>15.7</td>
<td>13</td>
</tr>
<tr>
<td>Europe</td>
<td>Northern Ireland</td>
<td>0.5</td>
<td>—</td>
<td>6.6</td>
<td>14</td>
</tr>
<tr>
<td>Asia</td>
<td>Japan</td>
<td>—</td>
<td>—</td>
<td>8.7</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Pakistan</td>
<td>—</td>
<td>—</td>
<td>22.5</td>
<td>16</td>
</tr>
</tbody>
</table>

* Subjects of Indian origin.

### THE CAUSES OF IRON DEFICIENCY ANEMIA

#### Iron Balance

The causes of iron deficiency anemia in adults must be considered in relation to variations in daily iron requirements at different ages and in the two sexes. For iron balance to be maintained, the quantities of iron absorbed daily from the diet must be sufficient to compensate for daily iron losses. Two levels of requirements can be considered. The first is enough to prevent anemia in 95% of the population, while the second is that which is necessary to prevent any biochemical evidence of iron deficiency in 95% of the population (17). In the present context, only the first requirement will be considered. Losses incurred through menstruation vary widely. Fifty percent of women would maintain normal hemoglobin values if they absorbed 1.2 mg daily (0.8 mg basal plus 0.4 mg menstrual losses), while a figure of 2.2 mg daily would be required to cover 95% of menstruating women (17).

The capacity to absorb iron is markedly affected by the size of the body iron stores. If the iron stores are reduced, a high proportion of the available iron is absorbed and, as the stores rise, the percentage absorption falls (2). The efficient way in which the mucosa adapts to changing body needs indicates that it does not normally contribute to the development of nutritional iron deficiency except in special circumstances (e.g., tropical sprue) (2).

The balance between requirements and the amounts of iron absorbed can be disturbed by three factors working in concert or individually. These include changed physiological requirements, abnormal iron losses, and inadequate iron supply from the diet. Anemia induced by imbalance between these factors occurs more rapidly in the absence of the buffering effect of adequate iron stores.
Increased Iron Losses

As previously mentioned, iron balance in menstruating women is frequently precarious, since increased losses due to heavy menses may not be met by the diet. The choice of contraception may also affect menstrual losses: Oral contraceptives reduce them by about half, whereas intrauterine devices tend to double them. In the developed world the excessive use of anti-inflammatory drugs, particularly aspirin, is becoming an important cause of iron loss (2), and in recent years there has been increasing interest in the possible adverse effects of jogging and other strenuous physical activity on iron status. While anti-inflammatory drugs probably play a role, other mechanisms such as blood loss due to transient gut ischemia and intravascular hemolysis have been suggested. It should, however, be stressed that the changes, if any, induced by strenuous exercise are mild and not of epidemiologic significance.

An important cause of iron loss in the developing world is infestation with parasitic worms, including the hookworms *Ancylostoma duodenali* and *Necator americanus*. Layrisse and Roche (18) found blood losses of 2.4 ml for every 1000 ova/g feces in *N. americanus* infestation. While the severity of anemia was found to correlate with the worm load, the majority of victims had less than 2000 ova/g feces and were no more anemic than subjects free of hookworm (2).

Inadequate Iron Supply

In the past, major attention was directed towards the importance of excess blood loss (e.g., hookworm infestation) in the pathogenesis of iron deficiency anemia in developing countries. Since then the emphasis has changed. With an increasing awareness of the wide variations in the bioavailability of food iron, it has become apparent that it is the poor bioavailability of iron in largely cereal-based diets that is the major cause of iron deficiency anemia in most developing countries. The impact of such diets is obviously enhanced when pathologic blood loss is also present.

Food Iron Content

A diet rich in iron does not necessarily ensure adequate iron nutrition, since the amounts of iron absorbed are affected by the sources of the iron and by the interplay of inhibitory and promotive substances present in food. There are two major sources of food iron: heme iron and nonheme iron (2). Heme iron is highly bioavailable, since it is absorbed intact within the porphyrin ring and is not influenced by most inhibitory factors in the diet. In contrast, the nonheme iron in food enters an exchangeable pool which is markedly affected by promotive and inhibitory iron-binding ligands. Some forms of nonheme iron, notably ferritin and hemosiderin, only partially enter the exchangeable pool and are poorly absorbed (2). Various forms of contaminating iron (e.g., ferric oxide, ferric hydroxide, and metallic iron), which may increase daily
PREVALENCE AND CAUSES OF IDA

dietary intakes to between 15 and 30 mg, are so poorly available that they can be discounted as dietary sources of iron.

Inhibitors of Iron Absorption

It is the ubiquitous presence of inhibitors in the diets consumed in much of the developing world that plays the major role in the causation of nutritional iron deficiency anemia. Phytates, which constitute 1–2% of many cereals, nuts, and legumes, inhibit dietary iron bioavailability (19,20). A recent study showed that the addition of small amounts of sodium phytate (2, 5, and 10 mg phytate P) to phytate-free bread led to a progressive drop in the absorption ratio (0.82, 0.61, and 0.41, respectively) (19). A further reduction in the absorption ratio to 0.31 was obtained when the phytate P was increased to 50 mg.

Polyphenols represent the second major inhibitor of nonheme iron absorption (21). Polyphenols, which are plant metabolites rich in phenolic hydroxyl groups, are present in tea (tannins) and in vegetables and legumes (21). A strong negative correlation has been found between iron absorption and the polyphenol content of individual vegetables (21), with the major inhibitor being the iron-binding galloyl groups (22). The dose-dependent effect of polyphenols has also been shown by adding increasing amounts of tannic acid to white bread (20). There was a steep initial decline in nonheme iron absorption when the dose was increased from 4 mg to 55 mg per 80-g serving. Beyond this point the curve flattened out, with a near maximal inhibitory effect of about 75% being obtained with a 50-mg dose of tannic acid.

A number of plant foods with high protein contents, including soy beans and nuts, significantly inhibit nonheme iron absorption (23,24). Any negative effect on overall iron balance is, however, counterbalanced to some degree by their high iron contents. The suggestion that high-molecular-weight peptide products of digestion may be involved in the inhibition of iron absorption caused by soy protein is supported by recent studies which have shown that soy products, such as miso, in which the protein complex is broken down during processing, are associated with improved iron bioavailability (25).

Recent evidence indicates that calcium affects nonheme iron absorption in two ways (26). If calcium is added to bread dough before baking, the inhibition of iron absorption is greater than when added after baking (Fig. 1). This is because calcium, even in small doses, interferes with the degradation of phytate which normally occurs during baking. The dose-related inhibition caused by calcium is superimposed on that caused by increased phytate. The finding that calcium (165 mg) in the form of milk, cheese, or calcium chloride depresses the absorption of both heme and nonheme iron by about 50% may have important nutritional implications (26). In another study, similar findings have been reported with calcium supplements, and it has been suggested that the taking of regular calcium supplements with meals may make it more difficult for women to meet their daily iron requirements (27).
PREVALENCE AND CAUSES OF IDA

1.2—1.0—0.8—0.6—0.4—0.2—

Amount of calcium added to roll (mg)

FIG. 1. Effect of calcium on iron absorption from wheat rolls. The effect on absorption is expressed as the ratio of iron absorption from rolls with and without added calcium. Calcium was added either to baked rolls (hatched bars) or to the dough (open bars) (26).

Promoters of Iron Absorption

The effects of inhibitors in the diet can be overcome by a number of dietary constituents. The most powerful promoter is ascorbic acid (28,29), which has a dose-related enhancing effect on nonheme iron absorption. However, this effect depends on the interplay of inhibitory and other promotive factors in the diet. This is illustrated by studies using a simple white bread meal which showed that 30 mg of ascorbic acid was able to overcome maximal inhibition caused by added phytate and that more than 50 mg was needed to overcome the inhibition caused by 100 mg tannic acid (20). In another study, using infant formulas, a 40-mg rise in ascorbic acid content increased iron absorption from 3.3% to only 6.9% in a soy-based formula, compared to an increase from 10.5% to 24.2% in a milk-based formula (30). Meat has a twofold beneficial effect on iron nutrition. Not only is it an excellent source of bioavailable heme iron, but it promotes absorption of nonheme iron from the common pool (2). The effect relates specifically to meat protein and not to animal proteins in general. In quantitative terms, it has been calculated that 1 g meat has an enhancing effect on nonheme iron absorption equivalent to that of 1 mg ascorbic acid (31). Again the amount or character of inhibitory ligands in the food plays an important role (32). In an investigation in which a meal of low bioavailability was fed (maize, rice, and black beans), 75 g meat improved bioavailability to the same degree as did 50 mg of ascorbic acid (32).

Less powerful promoters of iron absorption, which include other organic acids and alcohol, may have some regional relevance. For example, lactic acid in sorghum- and maize-derived beers widely drunk in Africa (33), some spices in curry powder (34), and factors in certain oriental soy products, such as miso, enhance iron ab-
sorption (25). In addition, the high bioavailability of iron when given with citrus fruit may be explained by the additive effects of ascorbic and citric acids (35).

**Bioavailability of Iron in Different Diets**

With knowledge of the relative proportions of promoters and inhibitors of iron absorption in the diet, it is becoming possible to make rough predictions of the bioavailability of iron in different diets. For example, tea drunk with a mixed meal reduces iron bioavailability significantly, whereas orange juice increases it. On the basis of a number of iron absorption studies carried out in a variety of dietary settings, it has been possible to divide diets into ones of low, intermediate, and high iron bioavailability. These correspond to absorptions of about 5%, 10%, and 15% in subjects with depleted iron stores (17).

A diet of low bioavailability (<5%) has a high inhibitor content. It contains cereals, beans, and tubers but negligible quantities of meat, fish, or ascorbic acid and is typically consumed in many developing countries (Fig. 2). Such a diet supplies only about 0.7 mg of iron daily, which is insufficient to meet normal physiological requirements in females and in many males. A diet of intermediate bioavailability (±10%) is similar but includes limited amounts of foods which promote iron absorption (meat, fish, or ascorbic acid) and supplies enough iron (~1.5 mg) to meet the needs of more than 50% of women. The promoters in such diets may only be present during certain seasons. A diversified diet of high bioavailability (>15%) con-
tains generous quantities of meat, poultry, or fish plus vegetables and fruit with ascorbic acid in them and supplies at least 2.1 mg iron daily. It is typically eaten by many people in industrialized countries, where there is a low prevalence of iron deficiency anemia. While such diets meet the needs of most adult members of the population, they cannot match the daily amounts required in the second half of pregnancy.

REFERENCES


DISCUSSION

Dr. Hercberg: For me, as an epidemiologist, a major uncertainty concerns the epidemiological approach to assessing the prevalence of anemia, iron deficiency anemia, and iron deficiency without anemia in populations. Prevalences will depend on the laboratory tests employed and what they define, the criteria used, and the definition considered. The significance of iron markers depends on their intrinsic qualities, their sensitivity, their specificity, and their intra- and interperson variability. The problem was raised 20 years ago concerning the significance of hemoglobin determination, when it was shown that an overlap existed in anemic and nonanemic populations. But the difficulties in using hemoglobin to assess anemia also apply to other measures of iron status. No single measurement, even serum ferritin concentration, completely separates an iron-deficient from an iron-replete population, and this is particularly true where infections or even mild inflammatory syndromes are present.

Over the past few years it has been suggested that the information gathered in epidemiological studies could be improved by interpreting biochemical markers in an integrated rather than in an isolated fashion. James Cook demonstrated this concept by analyzing epidemiological data obtained in the USA, and I used the same approach using data collected in a tropical context, in Benin, West Africa. If only one parameter among erythrocyte protoporphyrin, transferrin saturation, and serum ferritin was abnormal, the prevalence of anemia increased only slightly from 8% to 11% in Cook's study and from 40% to 45% in our study. However, the combination of several indicators helps to improve the specificity of the hemoglobin measurement, especially when at least two abnormal iron indicators are used (Table 3).
TABLE 3. Percentage of anemic subjects according to the number of abnormal indicators of iron status

<table>
<thead>
<tr>
<th>Number of abnormal biochemical indicators*</th>
<th>Anemic subjectsb (%)</th>
<th>USA</th>
<th>Benin</th>
</tr>
</thead>
<tbody>
<tr>
<td>All population</td>
<td></td>
<td>8</td>
<td>40</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>11</td>
<td>45</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>28</td>
<td>71</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>63</td>
<td>86</td>
</tr>
</tbody>
</table>

* Serum ferritin, erythrocyte protoporphyrin, transferrin saturation.

b Hb values below WHO references.

This approach has been followed recently by several investigators, and various models have been proposed in the evaluation of iron deficiency and, so, independently, of anemia: Some have substituted MCV for serum ferritin, others gave a relative weighting to serum ferritin, and so on. No consensus exists to define one model as a reference permitting us to compare different epidemiological studies. It is not even certain whether the best model for developed countries is necessarily the best for tropical countries because of confounding factors such as inflammatory syndromes.

Another problem is the difficulty in defining the explicit meaning of iron deficiency. To what stage of impaired iron status do the consequences on physiological function and health correspond, before there is an effect on erythropoiesis? This problem needs to be considered at length, particularly in relation to the design of studies on the validation of iron markers.

Dr. Cook: I should like to comment on the disparities between the prevalence estimates listed in Tables 1 and 2. I agree that we simply do not know the true prevalence of iron deficiency anemia in regions where inflammation and iron deficiency coexist, that is, when the serum ferritin is not decreased but other laboratory parameters are consistent with iron deficiency anemia. The best way to resolve this problem is probably to give iron and define iron deficiency anemia as a significant hemoglobin response.

My other comment is that, while poor bioavailability of iron in cereal-based diets may be the major cause of iron deficiency anemia in developing countries, I would hesitate to say that this was true for infants or for pregnant women who develop iron deficiency. While poor bioavailability is undoubtedly a major contributing factor, there are other important causes of iron deficiency in developing countries.

Dr. Bothwell: I was hoping that either Dr. Hercberg or Dr. Cook would address the diagnostic value of serum ferritin, especially in developing countries. An arbitrary figure of 50 μg/l has been used as a cut-off point for patients suffering from a combination of iron deficiency and infection or inflammation. Is this figure based on sound data?

Dr. Cook: A serum ferritin cut-off value of 12 μg/l has been proposed, based on studies in healthy individuals. I would not use this value in a clinical setting where there may be other disease processes affecting the serum ferritin. In such cases I would use a value of 30 or even 50 μg/l. In anemic individuals, ferritin values below this level are reasonably good evidence of iron deficiency.

Dr. Hercberg: I know of only one study, performed by Fleming in Nigeria (1), where iron stores were measured directly by estimates of stainable iron in bone marrow. He found that
women and children with markedly reduced iron stores had serum ferritin values below 50 µg/l.

*Dr. Valyasevi:* What amount of vitamin C should we add to the diets of weanling infants to ensure that iron absorption is adequate?

*Dr. Bothwell:* From our studies with infant formulas and cereals we believe that the molar ratio of ascorbic acid to iron should be at least 1.5 to 1, equivalent to a weight ratio of 5 to 1.

*Dr. Hurrell:* In commercial infant cereals we add five times the weight of ascorbic acid to iron. Thus a cereal containing 20 mg of iron per 100 g would contain 100 mg of vitamin C. About the same ratio is used in infant formula.

*Dr. Anderson:* Does the benefit of ascorbic acid for iron absorption only occur when ascorbic acid is mixed in the food?

*Dr. Bothwell:* If the promoter is a drink, such as orange juice, complete mixing with the common meal pool may not occur but there is, nevertheless, a significant increase in iron absorption from the whole meal.

*Dr. Gibson:* In our studies on phytate intakes in various developing countries we have found that the level of intake depends very much on whether the staple is fermented. In Malawi the diet is based on unrefined maize, and we found preschool Malawian children to have phytate intakes of 1621–2161 mg/day. In contrast, comparable children in Ghana, with diets based on fermented maize and tubers, had intakes of 300–600 mg, a range comparable to that of omnivorous Canadian children, in whom average phytate intakes are around 350 mg/day.

*Dr. Hallberg:* In a study on iron absorption from breads, we found that sourdough fermentation of whole rye bread for 2 days caused the disappearance of all phytate and lower inositol phosphates. Iron absorption then increased to the same level as from white bread, in spite of all the remaining bran fiber components.

*Dr. Viteri:* Are there any data on the effect of multivitamin-multimineral capsules containing calcium and zinc on iron absorption in pregnancy?

*Dr. Dallman:* There is some evidence that decreasing the calcium and magnesium content of multivitamin-multimineral capsules will enhance iron absorption (2). Conversely, it is possible that high doses of iron will impair zinc absorption. It is particularly important that iron deficiency is prevented in ways that do not create other nutritional problems.

*Dr. Zlotkin:* We have recently studied a group of children receiving total parenteral nutrition. Realizing that we would have to supply these children with iron, we examined the FAO/WHO absorption estimates from various meals and concluded that absorption was likely to be about 10% on average. Based on the age of the children, the estimated RDA was about 10 mg/day, so we therefore used 1 mg of elemental iron per day in the parenteral formulation. We followed ferritin levels over a 12-month period and were surprised to find that the values rose steadily, so that after a year the mean level was close to 1000 ng/ml in 11 children so studied. Our population thus seemed to be getting too much iron. Could the estimates of iron absorption that you quote be too high?

*Dr. Bothwell:* The extrinsic tag method for measuring iron absorption has been validated as well as you can validate a biological method. However, it does have the defect that it is a measurement done at an isolated moment in time and does not necessarily reflect what happens over an extended period.

*Dr. Fomon:* Dr. Zlotkin's assumption that children absorb 10% of dietary iron is far too high. Children who are not iron-deficient absorb about 4% of the dietary iron, as do adults.
It is not surprising that long-term parenteral administration of 1 mg/day resulted in very high ferritin concentrations.

Dr. Cook: In what form was the parenteral iron given, and were the children anemic at the end of the year?

Dr. Zlotkin: The form was iron dextran and the children were not anemic. With regard to iron absorption, the FAO/WHO estimate is that in a mixed North American diet iron absorption is around 15%. Is this an appropriate value to assume in the pediatric age range?

Dr. Hallberg: The bioavailability of iron in the diet must always be related to iron stores. A 15% bioavailability in the US diet means that the availability may reach this value in borderline iron-deficient persons with no iron stores. If iron stores amount to 300 mg or so, our calculations suggest that the bioavailability is only about 7–8%. There is a close relationship between bioavailability and iron stores.

Dr. Finch: One explanation of the high ferritin levels in Dr. Zlotkin’s cases could be that by bypassing the gut, the intestinal losses of iron were reduced.

Dr. Cook: I suspect that iron dextran may affect ferritin independently of iron stores. It may be better to use serum iron or transferrin saturation as an index of iron status following iron dextran administration.

Dr. Siimes: I should like to suggest that persons with raised serum ferritin may develop iron deficiency anemia through the following mechanism. High iron stores inhibit absorption of iron, and simultaneously the body is unable to mobilize iron from the stores; otherwise the ferritin would not be raised. Thus the two sources of iron for body growth are inhibited and the individual, for example a rapidly growing infant, develops iron deficiency anemia.

Dr. Zipursky: Is anemia a health problem, and, if so, at what level does it become a problem in terms of an individual’s ability to function? To extend this further, is a low serum ferritin a health problem? Or a high iron binding capacity?

Dr. Dallman: At present there is no convincing evidence that iron deficiency without anemia has adverse consequences. On the other hand the evidence is quite strong that even mild iron deficiency anemia has harmful effects.

Dr. Fomon: As a general medical philosophy we attempt to prevent risk of illness. Iron deficiency without anemia is a risk factor for iron deficiency anemia and should therefore be prevented.

Dr. Daza: In Latin America, parasitic disease is particularly important in the pathogenesis of iron deficiency anemia, especially hookworm and giardiasis.

Dr. Dallman: Giardiasis is a very common parasitic disease that may be a more important contributor to iron deficiency than has been realized. De Vizia and coworkers (3) showed that severe iron malabsorption can be a common complication of giardiasis.

Dr. Brabin: We should be aware of the studies of Stevenson in Kenya. She and her colleagues carried out a number of controlled trials using antihelmintics for the control of schistosomiasis and hookworm and showed a significant rise in hemoglobin in treated school-children in comparison with controls (4). These infections are important and probably make a major contribution to the etiology and prevalence of iron deficiency anemia.

REFERENCES