PREVENTION OF IRON-DEFICIENCY ANEMIA IN INFANTS AND CHILDREN OF PRESCHOOL AGE

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Iron deficiency is almost certainly the most prevalent nutritional disorder among children in the United States (Stare, 1962; Goldsmith, 1965). Etiology is known, prevention is feasible, and the group primarily affected can be readily identified as those between 6 and 24 months of age. The question is not whether prevention of iron-deficiency anemia is possible but, rather, selection of the most practical approaches to prevention.

Definition of Anemia

Anemia in infants and preschool children is arbitrarily defined as a state in which the concentration of hemoglobin is less than 10 gm./100 ml. This definition has the advantage of simplicity and agrees reasonably well with the apparent consensus among authors reporting hemoglobin concentrations of infants and small children. Thus, more reports provide data on incidence of hemoglobin concentrations below 10 gm./100 ml. than on incidence of concentrations below any other arbitrarily assigned value.

Although there may be an advantage in maintaining hemoglobin concentrations of all infants above 12 gm./100 ml. rather than above 10 gm./100 ml., the advantage cannot be clearly documented at present. From the practical point of view, a great advance in health care would be achieved if hemoglobin concentrations of most children could be maintained at or above 10 gm./100 ml.

If the anemia is hypochromic and microcytic, the assumption that it is caused by iron deficiency seems reasonable. Determination of serum or plasma iron concentration and iron-binding capacity can be employed to confirm the diagnosis.

Incidence of Anemia

Anemia, as defined above, is frequently encountered among infants and young children of low socioeconomic status but may be seen infrequently among infants of similar age cared for by private practitioners in certain geographic areas.

Random sampling of children from the three busiest child health stations in New York City demonstrated that 19 (41 percent) of 46 infants less than 1 year of age and 31 (23 percent) of 137 children 1 to 3 years of age had concentrations of hemoglobin less than 10.0 gm./100 ml. (Haughton, 1963). Andelman and Sered (1966) have reported that 76 percent of 337 infants followed in the Child Welfare Stations of the Eighth Health District of Chicago became anemic, usually before age 1 year. Iron-deficiency anemia as defined above has been reported to be present in about 30 percent of infants admitted to various hospitals in larger cities in the United States (Lahey, 1957; Woodruff, 1958; Holowach and Thurston, 1963). Schulman (1961) found that 44 percent of infants between 6 and 24 months of age admitted to Children's Memorial Hospital in Chicago had hemoglobin concentrations less than 10.5 gm./100 ml. Shaw and Robertson (1964) reported that 24.7 percent of 775 infants aged 6 to 24 months entering the Columbus Children's Hospital in 1960 had hemoglobin concentrations less than 10.0 gm./100 ml. During the same period not a single case of scurvy or of vitamin D deficiency rickets was identified at that hospital.

Although few reports are available to indicate the frequency of iron-deficiency anemia among infants from socioeconomically more privileged communities, verbal reports from many private practitioners suggest that the incidence is often quite low. Beal et al. (1962) reported that among 60 12-month-old infants cared for by pediatricians in private practice in Denver only 2 had concentrations of hemoglobin less than 10.0 gm./100 ml. No surveys have been reported of the incidence of iron-deficiency anemia among infants from rural areas or among socioeconomically and educationally favored urban populations of the United States.

Possible Reasons for Widespread Iron-Deficiency Anemia

1. An erroneous belief exists that iron is not absorbed before 2 or 3 months of age and that therefore it is useless to give iron during the first months of life. In fact, iron is absorbed efficiently by young infants (Garby and Sjölin, 1959; Gorten et al., 1963) and subsequently (by 3 to 4 months of age) is utilized in formation of hemoglobin.

2. There is a lack of knowledge among professional workers as well as parents about the inadequacy of unfortified foods as sources of iron (Table 1).

3. Infant feeding practices are such that iron-fortified formulas or iron-fortified cereal are usually not given after 6 months of age (Fomon, 1967).

4. Experience in several parts of the country indicates that many parents are unlikely to carry out a program of daily administration of medicinal iron.

5. Some families cannot afford to purchase iron-fortified formulas or even the very modestly priced iron-fortified cereals.

Laboratory Methods

As discussed in "Suggested Guidelines for Evaluation of Nutritional Status of Preschool Children" (1966), it is recommended that the concentration of hemoglobin be determined by the cyanmethemoglobin method (ICNND, 1963), and that the hematocrit also be determined (O'Brien and Ibbott, 1962). A volume of packed RBC's of less than 30 percent is assumed to indicate anemia. A mean corpuscular hemoglobin concentration of less than 30 gm./100 ml. of packed RBC's indicates hypochromia.

Determinations of iron concentration and iron-binding capacity in serum or plasma are also useful and can be done by micro methods. Plasma or serum iron may be determined by complexing iron with 2, 2'-dipyridyl (Woodruff, 1959) or by the method of O'Brien and Ibbott (1962) except that tripyridyl-s-triazine rather than dipyridyl should be used. Concentrations of iron in plasma or serum less than 45 µg./100 ml. suggest iron deficiency (Hagberg, 1953).

A relatively minor modification of the method of Ressler and Zak (1958) permits microdetermination of plasma or serum iron-binding capacity. Total iron-binding capacity greater than 600 µg./100 ml. or saturation of iron-binding capacity of less than 12 percent suggests iron deficiency.

Approaches to the Problem

Although certain infants can be identified as peculiarly likely to develop iron-deficiency anemia, it is by no means possible to identify all such infants. Therefore, efforts at prevention require a two-fold approach: special measures directed at infants who can be identified as likely to develop iron-deficiency anemia, and measures directed at all other infants.

Infants identified as likely to develop iron-deficiency anemia: Infants of low birth weight (less than 2.5 kg.), those of multiple births (twins, triplets, etc.) and possibly those born to mothers with several recent pregnancies, 1/ are notably prone to develop iron-deficiency anemia and require more intensive preventive measures than will be feasible for the entire population. Such infants are likely to require larger daily intakes of iron than those recommended for the infant population in general and cannot be adequately managed without regular determinations of hemoglobin and/or hematocrit.

All other infants: Relatively little information is available to serve as a basis for estimating the least intake of iron that will regularly prevent development of iron-deficiency anemia (i.e., hemoglobin concentration less than 10 gm./100 ml.) in infants. A daily intake of 5 to 6 mg. of elemental iron beginning no later than 1 month of age and continued until at least 18 months of age has been suggested (Fomon, 1967). Because it is unlikely that infants will receive this quantity of iron from natural foods (Table I), prevention of iron-deficiency anemia requires regular administration of medicinal iron or of iron-fortified foods. For practical purposes, iron-fortified foods for infants are limited to certain commercially prepared formulas and cereals.

1/The importance of maternal iron deficiency in the production of iron-deficiency anemia in the infant remains a matter of controversy (Oski and Naiman, 1966). It seems unlikely that iron deficiency in the infant can be prevented by measures aimed at preventing anemia in the mother.

Recommendations

1. A massive educational effort should be undertaken to reach all levels of professional and auxiliary workers who counsel parents, as well as parents themselves.

2. For all infants iron-fortified foods should be introduced during the first few months of infancy (usually by age 6 weeks) and be continued at least through age 18 months. Except for "high risk" infants desirable intakes of iron are considered to be 6 mg./day (the amount provided by 700 to 1,000 ml. of iron-fortified infant formulas or by about 3 oz. of prepared iron-fortified cereal 2/).

3. For infants identified as likely to develop iron-deficiency anemia, more intensive preventive measures are required. Daily intakes of iron of 10 to 15 mg./day may be needed, the level of intake being adjusted on the basis of regular determinations of hemoglobin and/or hematocrit. Use of medicinal iron preparations may be desirable to achieve the required intakes.

4. When recommending a source of iron, consideration should be given to such practical aspects as cost, ease of administration, and acceptability of product to parent and child. Per unit of iron provided, iron-fortified cereals are inexpensive (Table II) and have the advantage that during the child's second year, parents are much more likely to feed iron-fortified cereals than iron-fortified formulas.

Application to MCH Programs

1. The major effort in the prevention of iron-deficiency anemia in infants and young children should be an intensive educational campaign which includes both professional workers and parents. The need of the infant and child of preschool age for iron should be stated repeatedly and in different ways. The role of iron-fortified cereal in the prevention of iron-deficiency anemia needs to be emphasized.

2/Assumes 40 to 50 mg. elemental iron per 100 gm. of powdered cereal and dilution of 1 part cereal to 6 parts milk.

2. In the case of infants of needy families who are at special risk of developing iron-deficiency anemia, the provision or distribution of iron-fortified formulas, iron-fortified cereal or medicinal iron should be considered. In this respect, iron-fortified cereals are particularly useful.

3. In order to adequately evaluate a program, baseline data about the incidence of iron-deficiency anemia should be collected even before educational or other activities are initiated. Data on concentrations of hemoglobin of infants and small children should be collected through well-child clinics, pediatric clinics, crippled children clinics, children and youth projects, maternity and infant care projects, clinical mental retardation programs and other special projects. In addition, incidence of anemia among infants and children admitted to hospitals in various geographic areas should be determined. After instituting the proposed program of prevention, subsequent determinations of hemoglobin concentrations will permit assessment of its effectiveness.

4. Information about the infant feeding practices among low-income families with high incidence of iron deficiency should be collected.

TABLE I

IRON CONTENT OF IRON-FORTIFIED CEREAL AND OF COMMERCIALLY PREPARED STRAINED AND JUNIOR FOODS FOR INFANTS

	Iron Content*
Iron-fortified cereals**	7-12
Meats	
Liver and a few others	3-4
Egg yolks	3-4
Most meats	< 3
Most "meat dinners"	< 2
Vegetables	
Peas, green beans, spinach	1-2
Most vegetables	< 1
Fruits	
Plums, prunes	> 1
Most fruits	< 1

*Milligrams of elemental iron per 100 gm. (about 6-7 tablespoons) of food

**Assumes 1 part by weight of dry cereal mixed with 6 parts milk.

TABLE II

SOURCES OF IRON: AMOUNTS AND COST TO SUPPLY SIX MILLIGRAMS OF IRON

Product*	Amount to Provide 6 Milligrams of Iron	Cost of Amount to Provide 6 Milligrams of Iron	Comments
Iron-fortified baby cereal (precooked)	5-6 tablespoons, dry	$.01	Cereals <u>not fortified with iron</u> provide less than 1 milligram in 6-8 tablespoons (dry).
Quick Cream of Wheat (enriched - to provide 160% of MDR for iron)	6-8 tablespoons, cooked	$.01	Cereals <u>not fortified with iron</u> provide less than 1 milligram in 6-8 tablespoons (dry).
Medicinal iron (several preparations)	Varies with preparation	$.01 - .013	Ferrous salts of sulfate, lactate, fumarate or gluconate

*Iron fortified infant formulas are not included because presumably these are purchased as complete foods for infants rather than because they supply iron. Commercially prepared formulas fortified with iron are generally the same cost as commercially prepared formulas not fortified with iron. Most iron-fortified formulas provide 8-12 mg. of iron per quart as fed and thus 16-24 ounces would supply 6 mg. of iron at a cost of $0.20 to 0.28.

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