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Nutrition and Sociomedical Correlates in Iron Deficiency Anemia of Infant and Children

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INTRODUCTION

The importance of iron to the well-being and progress of mankind was recognized long before medical practice became frimly established. At the present time, iron deficiency anemia continues to be a major health problem over the world. The prevalence rate is still high and poses a variety of problems to those working in public health.

In the past thirty years, nutritional iron deficiency has been well characterized; in spite of this information, little has been accomplished at the public health level to minimize this condition.

Iron deficiency is the most common nutritional deficiency encountered in children and in populations of all socioeconomic levels, and also nutritional anemia in the United States is due primary to a dietary deficiency in iron[1].

There are several factors to contribute to the iron deficiency anemia of infancy. The important factors responsible for this situation are the constant demand for iron in the growing child, the very low iron content of the foods which make up the bulk of the infan's diet and high incidence of "feeding problems[2]" These studies have repeatedly proven this time and time again. If nutritional iron deficiency is a particular threat to the health of our infant population, should we not attempt to eliminate it by assuring adequate iron intake through diet?

This report will present data concerning 191 infants and children with the prevalence of iron deficiency with or without anemia in particular areas and also 110 infants and children have been studied and the effects of social background and nutritional factors in iron deficiency.

SUBJECTS and METHODS

Subjects

During a twelve month period between 1979 to 1980, children who attended the outpatient department at children's Health Center of Minneapolis for a well child check or preschool examination who had FEP tests done according to the clinic protocol are reviewed and subjects with FEP greater or equal to 35 ug/dl whole blood are follow up on a second

visit to obtain further testing for iron deficiency with or without anemia.

A total of 2,150 children had one or more FEP tests performed after the well child care where 202 children were found to have FEP values greater or equal to 35 ug/dl using the hematoflurometric method and 191 of these children were able to be contacted and returned to clinic within one month which constituted the study group.

The outpatient clinic of children's hospital serves primarily the cental part of Minneapolis which is an urban center with a population of 1.5 million with most of the children coming from a family residing within a radious of two miles from the clinic and representing a middle-lower and lower social economic background which is evident by the fact that 85% of the children are covered by federal medical assistance.

Methods

Hemoglobin is analyzed with the hemoglobinometer made by Coulta Electronics which requires 0.1 mg of whole blood. Hematocrits are measured with the Coulta Counter with the standard method[3]. Serum iron and transferrin saturation are measured and calculated as described by Carter[4] with microcentrifugal analyzers made by Fisher. Serum ferritin, serum from 0.5cc of whole blood is measured by a two site radioimmunoassay based on the method of Addison[5] and modified by Miles[6] with the radioimmunoassay kit obtained from New England Nuclear. Diagnostic criteria is that hemoglobin is less than 11.0gm/100 ml. Hematocrit is below 33 percent. Iron deficiency is used both criteria (one or two), serum iron, transferrin saturation is below 16 percent, serum ferritin is below 16ug/dl.

One hundred ten infants and children among 191 were designed to determine the effects of social background and nutritional factors. The results are compared between non-iron deficiency and iron deficiency infants and children. Dietary history in iron rich food was obtained from their mothers during a clinic visit. The children were unselected. An attempt was made to include as many as possible but the number was limited by constraints on the parent's and interviewer's time. The person taking the nutrition history was unaware of the child's blood value at the time of the interview. The items included mode of feeding, intake of iron rich food, what age started, the period of intake, and frequency of intake. During a subsequant clinic visit additional demographic and other data was obtained. Statistical significance was dermined by Chi-square test.

RESULT

The study group consisted of 191 children ranging from six months to ten years of age. There were 59.8 percent of children in the age 6-24 months. They were 50.4 percent male and 49.6 percent female.

Racial distributions were 32.0 percent in white, 40.0 percent in black, 26.0 perent in American Indian and others were 2.0 percent. There were divorced mothers in 53.5 percent of the children. Mothers under 18 years of age comprised 22.1 percent of the group. In education, high school level mothers were 71.2 percent and income level was very low (See Table 1).

In the prevalence of iron deficiency with or without anemia, a total of 168 children or 88% of the of the study group (191 subjects) were found to have iron deficiency by fulfilling one or both of the diagnosis criterion.

Among the 168 iron deficient children, 106

Table 1. The descriptive characteristics of the sample

Variables	Percentage of Sample
1. Sex	
Male	50.4
Female	49.6
2. Age	
6—12	25.8
12—18	22.0
18—24	12.0
Above 24	40.2
3. Rance	
White	32.0
Black	40.0
American Indian	26.0
Others	2.0
4. Marital Status	
Married	21.0
Divorced	15.1
Never married	53.5
Others	10.4
5. Mother's Age	
Under 16	3.5
16—18	18.6
18—25	52.3
Above 25	25.6
6. Mother's Education	
Middle School	12.5
High School	71.2
College	16.3
7. Income	
$3,000—$5,000	48.0
$5,000—$7,000	24.7
$7,000—$9,000	5.4
Above $9,000	21.9

1—3 : N=191
4—7 : N=110

subjects or 63.1% have Fe/TIBC saturation below 16% and 134 subjects or 79.8% have ferritin below the diognostic criterion of 16 ug/dl where only 72 subjects or 42.9% have both criteria abnormal. Of the 191 children who screened by FEP test (35ug≧), 45 of them or 23.6% of iron deficient children fulfilled the criteria for anemia and as additional 123 children or 64.4% of iron deficient subject who do not have anemia. Normal subject was 12.0% (Table 2).

In analysis of iron deficiency with variables, there was more high pevalence in females (90.8%), in Indians (89.8%), the age range 12-24 months, and in never married mothers (89.8%). The children whose mother complained of anemia at the pregnancy were higher (86.7%) than no anemic mother(80.8%). In premature infants (<2500 gm), prevalence was also higher than normal infants and children. In the nutrition program, the families which did not receive WIC program were higher than those receiving families (See Table 3).

In mode of feeding, the more children who

Table 2. The rate of iron deficiency with or without anemia

Diagnostic enteritis	Number	Percent	
Fe/TIBC <16% only	34	20.2	N=168
Ferritin <16ug only	62	36.9	
Fe/TIBC <16% Ferritin <16ug	72	42.9	
Iron deficiency with anemia	45	23.6	N=191
Iron deficiency without anemia or microcytosis	123	64.4	
Normal	23	12.0	

Table 3. Prevalence on which group of iron deficiency and non-iron deficiency infants and children with variables

Variables	No. of Normal (%)	No. of Iron Deficiency	
Sex			
Male	18 (21.2)	67 (78.8)	
Female	8 (9.2)	79 (90.8)	P>.05
Age			
6—12	6 (17.1)	29 (82.9)	
12—24	3 (4.8)	60 (95.2)	
Above 24	18 (24.0)	57 (76.0)	P<.01
Race			
White	13 (23.2)	43 (76.8)	
Black	9 (13.2)	59 (86.8)	
Indian	5 (10.2)	44 (89.8)	
Others	1 (25.0)	3 (2.0)	P>.05
Marittl Status			
Married	3 (16.7)	15 (83.3)	
Divorced	3 (23.1)	10 (76.9)	
Never married	5 (10.9)	41 (89.1)	P>.05
Mother's Age			
14—22	3 (7.0)	40 (93.0)	
23 Above	7 (17.5)	33 (82.5)	P>.05
Mother's Education			
Middle School	2 (20.0)	8 (80.0)	
High School	4 (7.2)	51 (92.8)	
College	3 (25.0)	9 (75.0)	P>.05
Income			
<$5,000	1 (2.9)	33 (97.1)	
>$5,000	6 (16.2)	31 (83.8)	P>.05
Low Birth Weight			
<2,500 gm	1 (8.3)	11 (91.7)	
>2,500 gm	22 (14.6)	129 (85.4)	P>.05
Pregnancy Complications			
Yes	2 (11.8)	15 (88.2)	
No	7 (10.4)	60 (89.6)	P>.05
Mother's Anemia			
Yes	4 (13.3)	26 (86.7)	
No	5 (19.2)	21 (80.8)	P>.05
WIC Program			
Yes	8 (12.3)	57 (87.7)	
No	2 (7.7)	24 (92.3)	P>.05
Food Stamp			
Yes	4 (8.7)	42 (91.3)	
No	3 (9.7)	28 (90.3)	P>.05

fed formula without iron fortified were iron deficiency (88.9%) than other feeding methods. The ages at which cow's milk was earlier months (8.1 months) were iron deficiency than normal children (8.5 months). Cereal and meat were later (4.3, 6.7 months, respectively) than normal infants and children (4.0, 6.3 months, respectively) in iron deficiency. In the period of intake iron food, there were more long periods of formula with iron and meat in normal children. However, there were small amounts and short periods of cow's milk in iron deficiency infants and children (Tables 4, and 5).

Table 4. Prevalence on which group of iron deficiency and non-iron deficiency children with mode of feeding

Mode of Feeding	No. of Normals (%)	No. of Iron Deficiency (%)	
Breast Fed	0 (0.0)	6 (100.0)	
Formulas with Iron	10 (15.1)	59 (84.9)	
Formulas without Iron	1 (11.1)	8 (88.9)	
Combined (B+F)	6 (30.0)	14 (70.0)	$p > 0.05$

N=110
Mis=6

Table 5. Ages at which the children started and the period of Intake iron related food

Value	Normal (mo)	Iron Deficiency (mo)
Mean Age Started		
Cow's milk	8.5	8.1
Cereal	4.0	4.3
Meat	6.3	6.7
Mean Period		
Breast fed	6	4
Formulas with Iron	9	8
Cow's milk	8.5	8.3
Meat	20.8	13.0
Intake Cow's milk/daily	21.3cc	17.7cc

Subjects: Aged 6-24 month infant and children (66 cases)

Iron rich food was classified four items such as meat and fish, fruit, green vegetables, eggs. Intake of this food was exprssed frequency in a week. Frequency was weighted by scale 0-3 (0 : never intake, 1 : 1 time or very little, 2 : 2-3 times, 3 : 4 or more in a week). All food items except egg, iron deficiency children had low percentage of high score, on the contrary iron deficiency children had high percentage of low score (Table 6).

Table 6. Frequency of iron rich food intake between normal and iron deficiency children

Food	Score	No. of Normal (%)	No. of Iron Deficiency (%)
Meat & Fish			
	3	8 (47.0)	39 (43.9)
	2	5 (29.4)	20 (22.4)
	1	2 (11.8)	25 (28.1)
	0	1 (5.9)	1 (1.1)
	Mis	1 (5.9)	4 (4.5)
	Total	17 (100.0)	89 (100.0)
Fruit			
	3	5 (29.4)	17 (19.1)
	2	10 (58.8)	53 (59.5)
	1	1 (5.9)	12 (13.5)
	0	0 (0.0)	1 (1.1)
	Mis	1 (5.9)	6 (6.8)
	Total	17 (100.0)	89 (100.0)
Green Vegetables			
	3	5 (29.4)	13 (14.6)
	2	8 (47.0)	52 (58.4)
	1	3 (17.7)	17 (19.1)
	0	0 (0.0)	0 (0.0)
	Mis	1 (5.9)	7 (7.9)
	Total	17 (100.0)	89 (100.0)
Egg			
	3	6 (35.3)	42 (47.3)
	2	7 (41.1)	20 (22.4)
	1	1 (5.9)	19 (21.3)
	0	3 (17.7)	4 (4.5)
	Mis	0 (0.0)	4 (4.5)
	Total	17 (100.0)	89 (100.0)

N=110 Mis=4

DISCUSSION

Iron deficiency anemia has for some time been one of the most common nutritional disorders among infants and children in the United States[7] and in most countries. Filer[8] reviewed its significance as a public health problem, nothing the high prevalence of anemia[9] among infants and young children of lower socioeconomic background in large metropolitan centers. The prevalence is most prevalent among infants in the age range of 6 to 24 months.

There are many studies of the prevalence of iron deficiency anemia in all countries. The variety of standards used to decide on normal hemoglobin and hematocrit level is one of the reasons for the wide discrepancies that occur in studies of frequency of occurence of iron deficiency anemia. In the past, hemoglobin levels about 10.0 or 10.5 gm/100 ml were considered normal for children[10][11]. It became evident that there are not necessarily optimal hemoglobin levels when Sturgeon[12] gave iron therapy to a group of apparently normal infants and observed a substantial increase in hemoglobin level. Later Marner[13] and Brigety and Pearson[14] suggested that response to iron administration may be a better indication of iron deficiency than any singly laboratory value.

Recently, the Committee on Nutrition of the American Academy of Pediatrics[15] and the World Health Organization[16] recommended that normal children from six months to six years of age should have hemoglobin level 11.0gm/100ml and above and hematocrit values of 33 percent and above. A clinical investigation carried out by Hunter and Smith[17] in 1972 showed that children who had hemoglobin concentration of less than 11.0gm/100ml and hematocrit values below 33 percent had iron deficiency anemia.

Incidences in children of disadvantaged families have been reported to be as high as 68 percent in Washington, D.C. by Gutelius[18], 58 percent in the state of Washington by Hunter[19], a figure of 15 percent in the Southeastern United States was reported by Pearson et al.,[20] and 18 percent in Tennessee by Hutcheson and Hutcheson[21]. In these studies hemoglobin values below 11.0gm/100ml and hematocrit values below 33 percent were considered to be in the anemic range. In 1974 Theresa et al.,[22] found that the combination of iron deficiency with anemia and iron deficiency without anemia was 36 percent (4 months 5 years).

Our data was found 23.6% of iron deficiency with anemia and 64.4% of without anemia in these 191 subjects who have FEP 35ug/dl equal or above (total iron deficiency was 88.0%). This prevalence is not compared with our data directly because this data was primarily screened with FEP test. However, its frequency at various ages forms an interesting and definite pattern. Nathan et al.,[2] found that the highest prevalence of iron deficiency (66 percent) in from 9 to 24 months among 162 infants and children who were admitted at Christopher Hospital in 1953 Our data also found the highest prevalence was in the age range 12-24 months. This is statistically significant ($P<0.01$).

There were more children of iron deficiency in females, Indians, never married mothers, more young mothers, low income families but these were not statistically significant ($P>.0.5$). Doris et al.,[23] found that more of the children with anemia had mothers who were separated or divorced (32.0 percent versus 14.3 percent); more of the children without anemia had mothers who were

single or married. This data can be compared with our data. Calvin W.[24] concludes that the more frequant occurrence of hypochromic anemia in the male infants in his study is a reflection of their relative immaturity and increased growth rate.

Several factors concerning medical problems, mother's anemia (at pregnancy), low birth weight, these were more of the children with iron deficiency ($P>.0.5$). Calvin W.[24] found that the most common factor was prematurity or a birth-weight of less than 3,000gm, (80 percent of prematurity is less than 5gm/dl in hemoglobin level). Similar findings were recently reported by Guest and Brown[25]. Homon and Weck[26] expressed 58 percent (1-2 years) and 53 percent ($\frac{1}{2}$-1 year) of infants and children of iron deficiency in low birthweight.

Regarding the relationship between iron deficiency and the daily in take of iron food, this is not sufficiently sensitive, nor accurate for assessing dietary intake of specific nutrients in qualities and quantitative precision. But inadequate dietary intake is the most common cause of iron deficiency anemia (occasional incidence of iron deficiency resulting from blood loss, gastrointestinal disease and inadequate iron storage at birth were seen) particularly after the age of six months.

The infant needs an exogenous source of iron to maintain an adequate hemoglobin level. Morten B. et al.,[27] conclude that iron deficiency anemia can be controlled among infants in a low socioeconomic population by feeding a formula containing an adequate prophylactic quantity of elemental iron 12 mg/day. Jane H.[28] also found that of the factors investigated, the most frequantly found was an abnormal diet. In those cases in which only one cause was found, the large majority were due to abnormal dietary intake, and this was not only a common accessory cause but also it was the only one found with any frequency as the single cause in any given case.

In the study of the relationship between iron intake and hemoglobin synthesis, Beal et al.,[29] found that uspplementation of diets with iron in several forms occured in 25 percent of the group without hematologic evidence of response as compared with the group dependent on dietary iron alone. He also further studied lower intake of iron is associated with higher percentage utilization in hemoglobin synthesis and higher intake results in lower utilization. Sidney et al.,[7] also found that mean intake of iron was 7.4 mg in normal children (6-24 months) while 6.9mg in iron deficiency with hemoglobin values less than 10.0gm/100ml. However, in iron intake, there is a wide variation in the percentage of iron that is absorbed by different infants from food. The range is from about 3 percent-50 percent[30][31] These studies must be related beween the amount of intake and bioavailability.

In this presentation, the more children of iron deficiency children who fed without iron formula were found and all six children who fed breast were iron deficient. Theresa et al.,[12] found that of the children not breast fed, a greater number without anemia had been on formulas with iron. Martin et al.,[32] also found that effective prophylaxis against iron deficiency anemia can be achieved in premature infants by receiving routine iron supplementation at 12mg/quart in their milk feedings. Our data is in good agreement with that data.

The children with iron deficiency were fed less cow's milk (17.7cc) than did those of

the normal infants and children (21.3cc) and the period of intake was less than normal infants and children (8.3 versus 8.5 monlhs). Thes phenomena is reversed in contrast to other studies. Sidney et al.[33], found that the children with iron deficiency anemia were fed much more milk than did those of the normal infancy. Jane H.[28] found that the largest number gave a history of decreased intake of solids combined with increased amoulnts of milk, but a significant number maintained a normal intake of milk in the presence of diminished ingestion of solids.

In this article the age started cow's milk was earlier in iron deficiency (8.1 versus 8.5 months). Doris et al.,[23] found that the age of starting cow's milk was not a significant difference. In these studies, Samuel Gross[34] reported his finding from a study designed to determine whether the level of milk protein in feeding influences biological availability of iron from cow's milk preparations. He concludes that the higher level of protein in the formula of high protein group was responsible for inhibiting the absorption of iron from the diet of these infants and was responsible for the lower hemoglobin level. The compromised iron nutrition associated with the high protein or homogenized milk feeding could have resulted from interference with absorption of iron or occult loss of iron by gastrointestinal alterations resulting in blood loss.

In cereal intake, the age started was later months in iron deficiency infants and children (4.0 versus 4.3 months) Meat intake, the period was longer in normal infants (20.8 versus 13.0 months). In asking the frequency of iron rich food, all food items had high percentage of low score in iron deficiency except egg. The bioavailability of the iron in egg is affected by other dietary factors, which represented a significant source of iron for all the children, is variable. Formation of stabel protein-iron complex retard absorption[35].

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