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Declining Prevalence of Anemia in Childhood in a Middle-Class Setting: A Pediatric Success Story?

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ABSTRACT. To study trends of anemia among middle-class children, we collected 6,162 hematocrit measurements from the medical records of 2,432 children, ages 9 months through 6 years, as seen at a private pediatric clinic during the past 18 years. A decline in prevalence of anemia was observed during that period. The overall age-adjusted rate of anemia decreased from 6.2% in 1969 to 1973, 5.8% in 1974 to 1977, 3.8% in 1978 to 1981, and 2.7% in 1982 to 1986. The decline was also observed when trends were determined for three age groups using a single hematocrit measurement per child.The 1982 to 1986 prevalences of anemia for various age groups among this middle-class pediatric population were relatively low: 2.8% among 9- to 23-month-old children, 2.4% among 24- to 47-month-old children, and 2.7% among 48- to 83-month-old children. Most of these recent cases of anemia were mild—most were only slightly less than the hematocrit values used to define anemia—and most did not show strong evidence of iron deficiency based on elevated levels of erythrocyte protoporphyrin. We conclude that iron deficiency is now mild and uncommon in these middle-class children. This improved nutritional status with regard to iron is probably related to increased intake of iron among infants and young children during the past two decades. These findings suggest that the recommended screening schedule for iron deficiency with hemoglobin or hematocrit measurements may need to be reassessed for well-defined populations of low-risk children. *Pediatrics* 1987;80:330–334; *iron deficiency anemia, erythrocyte protoporphyrin.*

Two recently published studies have indicated an improvement in nutritional status with regard to iron among low-income children. These studies have shown a decline in the prevalence of anemia in the past 15 years among infants and preschool children from low-income families enrolled in two different public health clinics.[1,2] The authors of both studies suggested that the Special Supplemental Food Program for Women, Infants, and Children (WIC) was the main factor responsible for the observed decline in rates of anemia.

Data collected from selected states that have consistently participated in the Pediatric Nutrition Surveillance System of the Centers for Disease Control[3], between 1975 and 1985, also have demonstrated a continued and statistically significant decline in prevalence of anemia among infants and preschool children enrolled in WIC programs.[4] In addition, the Pediatric Nutrition Surveillance System data have shown a significantly lower prevalence of anemia for children with more than one WIC visit compared with children of the same ages seen at preenrollment screening visits. This is consistent with a possible beneficial impact of WIC. However, the prevalence of anemia among those children seen at WIC preenrollment has also declined significantly in the past 10 years. Thus, factors other than the WIC program may have contributed to the improvement in nutritional status related to iron, among infants and children of high-risk background. If this were the case, one might expect these same factors to have positively influenced the nutritional status related to iron among low-risk children as well. To test this hypothesis, we conducted a 17-year retrospective chart review of hematocrit measurements of middle-class children seen in a private pediatric practice in Minneapolis.

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SUBJECTS AND METHODS

Study Population

The population used in our study consisted of all children seen for well-child care between the ages of 9 and 83 months (6 years) at a private pediatric clinic in Minneapolis from September 1969 through May 1986. The patient population is and has been primarily white and middle class. To ensure that we were studying a low-risk group of children, we restricted our sample to children from households that had never received public assistance while attending the clinic and that included at least one employed parent. We further excluded children from households headed by never-married women. To eliminate the possibility of genetic or other nonnutritional factors that may influence the prevalence of anemia, black children and children with histories of chronic disease were also excluded.

Most of the hematocrit data we abstracted were collected from healthy children during office visits for well-child care. However, some hematocrit data were also collected from children with mild illness. There were two hematocrit sources for the ill children. One was from children seen at well-child visits but reported to have recent or ongoing illness. The other source was from children seen specifically for an illness for which complete blood cell counts were performed. These illnesses usually consisted of mild childhood infections such as upper respiratory tract infections, gastroenteritis, and otitis media.

A total of 6,162 hematocrit values were collected from the charts of 2,432 children; of these, 5,593 (91%) were obtained from 2,363 healthy children at the time of well-child visits. From 526 ill children, 561 measurements of hematocrit were obtained.

In 1981, erythrocyte protoporphyrin measurements were initiated as part of routine screening for iron deficiency. A total of 1,846 values of erythrocyte protoporphyrin were collected in addition to hematocrit values. Of this total, 1,683 measurements of erythrocyte protoporphyrin were obtained from healthy children.

Study Design and Data Collection

Data were collected by retrospective review of all active and inactive records containing hematocrit values since 1969. For each child meeting the eligibility criteria, the following information was collected: date of birth, dates of examinations during which a hematocrit measurement was performed, recorded values for hematocrit, values for erythrocyte protoporphyrin (when available), and whether the child was ill or well at the time of visit.

All values of hematocrit were determined at the clinic via measurements of centrifuged capillary blood samples using standard technique (Readacrit, Clay-Adams, Parsippany, NJ). Measurements of erythrocyte protoporphyrin using capillary blood samples were determined by a hematofluorometer (ZEP Hematofluorometer, AVIV Biomedical, Lakewood, NJ).[5] Quality control of the erythrocyte protoporphyrin measurement was done by participation in the monthly Centers for Disease Control erythrocyte protoporphyrin proficiency-testing program. Values for both hematocrit and erythrocyte protoporphyrin values were recorded in the medical record to the nearest integer.

Data Analysis

For purposes of this study, the following age-specific values for hematocrit were used to define anemia: hematocrit <33% in children <2 years of age; hematocrit <34% for children 2 to 5 years old; and hematocrit <35% for children 6 to 7 years of age.[6] Values for erythrocyte protoporphyrin ≥35 μg/dL of whole blood were considered to be elevated and were used as evidence of iron deficiency.[7] To ensure adequate numbers for meaningful comparisons, data were grouped into four time periods according to the year of examination: 1969 to 1973, 1974 to 1977, 1978 to 1981, and 1981 to 1986. Because acute infection is known to be associated with anemia, values for hematocrit and erythrocyte protoporphyrin obtained from healthy children and those obtained from ill children were analyzed separately.

Prevalences of anemia were determined for three different age groups: 9 to 23 months, 24 to 47 months, and 48 to 83 months. In each age group, if a child had more than one hematocrit value determined, only the first was used to ensure independence of data in the trend analysis for anemia. Approximately 20% of the values for hematocrit were eliminated in this manner. A composite prevalence of anemia for all children within each time period was based on the recalculated sum of three age-specific prevalences of anemia after adjustment for the distribution of age.

We used the angular χ^2 test to determine the significance of the anemia trend for each age group.[8] Statistical significance of differences in prevalence of anemia between healthy and ill children was tested using a two-tailed test for the difference between two proportions.[9]

RESULTS

Prevalence of Anemia Among Healthy Children

Among the healthy children seen at well-child visits, a consistent and statistically significant decline in the prevalence of anemia for three age-specific groups during the four time periods was observed as shown in Fig 1 (ages 9 to 23 months, $P = .002$; ages 24 to 47 months, $P = .001$; ages 48 to 83 months, $P = .06$; angular χ^2 test). After adjustment for age, the overall (ages 9 to 83 months) prevalences of anemia for each time period were as follow: 6.2% for 1969 to 1973, 5.8% for 1974 to 1977, 3.8% for 1978 to 1981, and 2.7% for 1982 to 1986.

Relationship Between Anemia and Iron Deficiency, 1982 to 1986

The prevalence of anemia in the most recent time period (1982 to 1986) among this healthy, middle-class pediatric population appears to be low, ranging from 2.4% to 2.9% for the different age groups. Furthermore, 70% of these anemic children had hematocrit values only one percentage point of hematocrit below the values of definition for anemia, suggesting that most of the anemic children in this study had borderline cases.

Since 1981, 85% of the healthy children seen in this practice had measurements of erythrocyte protoporphyrin performed at the same time of measurement of hematocrit (N = 1,683). Fifty-four children with simultaneously obtained values of hematocrit and erythrocyte protoporphyrin had anemia, but only 7.4% of those children with anemia also had elevated erythrocyte protoporphyrin values (n = 4). Thus, only a small percentage of the children with anemia we observed had biochemical evidence of iron deficiency. Conversely, of the 51 children who had elevated values for erythrocyte protoporphyrin, only 7.8% were found to have anemia (n = 4), suggesting that most cases of iron deficiency were mild.

Prevalence of Anemia Among Acutely Ill Children

A total of 561 measurements of hematocrit were collected from children suffering mild childhood infections. Comparison of the ill children's prevalence of anemia adjusted for age distribution with the similarly adjusted prevalence of anemia among healthy children revealed a significantly higher prevalence of anemia among the ill children for all four examination periods ($P < .001$ at each time point, test of proportions, Fig 2). There was also a significant decline in the prevalence of anemia throughout time among the ill children ($P = .006$, angular χ^2 test), which closely paralleled the trend observed for healthy children.

DISCUSSION

In this study, we observed a continuous decline in prevalence of anemia among middle-class children during the past 17 years that is both statistically and clinically significant. The decline was present for all age groups studied. These findings are consistent with the Centers for Disease Control's Pediatric Nutrition Surveillance System data

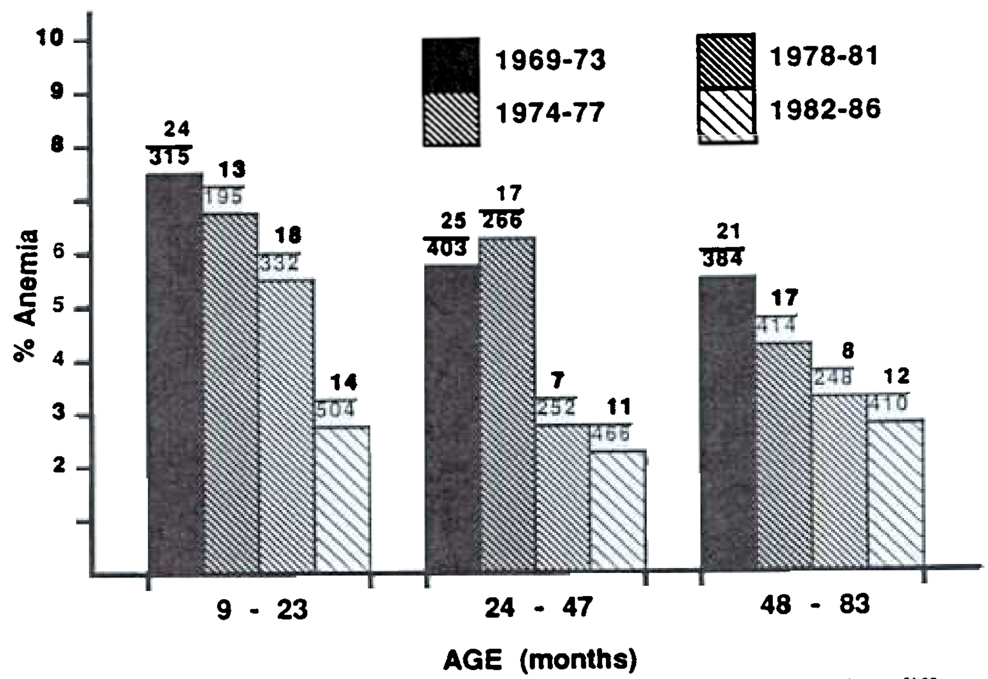

Fig 1. Prevalence of anemia for three age-specific groups of children at four different time periods. Numbers on each bar represent numbers of subjects with anemia as numerator and all children having measurements of hematocrit as denominator.

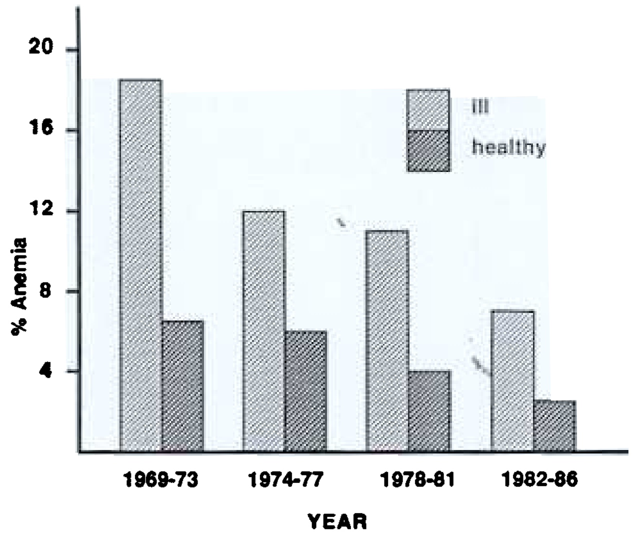

Fig 2. Comparison of prevalence of anemia between healthy children and children with mild infection (age 9 to 83 months) at four time periods. At each time period, prevalence of anemia of ill children is significantly higher than prevalence of anemia of well children ($P < .001$). Declining trend of anemia of ill children is also statistically significant ($P < .001$).

showing a decline in prevalence of anemia during the past decade among higher risk children who were assessed before their enrollment in the WIC program.[4]

By excluding black children and children with a history of chronic disease, and by separately analyzing values of hematocrit obtained from acutely ill *v* healthy children, we can better attribute the observed decline in prevalence of anemia to nutritional rather than nonnutritional factors. Improvements in nutritional status related to iron among preschool children may be the result of proven changes in feeding practices for infants and children in the United States during the past 20 years: the substitution of iron-fortified formulas for unfortified formulas and cow's milk, a trend toward a more prolonged use of fortified formulas during the first year of life, a greater frequency and duration of breast-feeding; and the increased use of iron-fortified infant cereals.[10-12] In addition, the recently completed 1985 National Food Consumption Survey reported higher daily intake of iron among children 1 to 5 years of age compared with the 1977 survey.[13] The improved pattern of infant feeding and nutritional status related to iron can probably be attributed to the concerted effort in nutritional education of the pediatric community, which resulted in heightened parental awareness of nutritional issues related to iron and improved feeding practices for infants.[14,15] In this respect, one may consider this improved nutritional status of iron in childhood a pediatric success story.

The prevalence of anemia was significantly higher among children suffering from or recovering from acute infectious illness than among healthy children, although the prevalence of anemia among ill children declined in parallel with the decrease among well children during the four study intervals. The higher prevalence of anemia among ill children is consistent with the recent observations of Reeves et al,[16] who have suggested that mild infection is a major contributing factor to anemia in childhood. The improved nutritional status with regard to iron throughout time may have made ill children less likely to have hematocrit values of less than the definition for anemia during infectious episodes. In light of this evidence, clinicians may need to consider any history or physical signs of recent infection when interpreting the screening results for anemia. The findings also point out the importance of separating ill children from healthy children, when assessing the prevalence of anemia related to nutrition.

The low prevalence of anemia we observed during 1982 to 1986 among healthy children in all age groups suggests that screening preschool children from low-risk backgrounds for anemia will uncover few iron-deficient children. Nearly three fourths of the children found to have anemia in our study had hematocrit values in the borderline range of 32% or 33%. Some of these values could have been related to the random variations in capillary sampling or technique.[17,18] Furthermore, based on the general principle of developing normal laboratory values using the 95% central range of a healthy reference sample, one would expect 2% to 3% hematologically normal children to have hematocrit values less than the reference range of hematocrit.[19] Thus, some of the borderline values of hematocrit may represent part of the expected outliers of a normal distribution. This is especially true when the prevalence of anemia is low, as in this study. The fact that only 7% of the anemic children also had biochemical evidence of iron deficiency, based on elevated values of erythrocyte protoporphyrin, suggests that few cases of anemia in recent years are the result of nutritional iron deficiency. Taking these findings together, we believe that iron deficiency has become relatively uncommon and mild in this study population.

If the findings of this study can be confirmed by similar investigations, we believe that screening for anemia to detect iron deficiency using hemoglobin or hematocrit measurements may be considered an optional practice in well-defined low-risk populations of healthy preschool children. Hopefully, with further public health and nutrition education efforts directed in particular toward the children at higher risk, childhood iron deficiency in the United States will become a disorder of the past.

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MODERN ABERRATIONS WITHIN THE HUMAN AND MORAL RECORD

Except in egregious situations, parents should be presumed to have the primary responsibility to make decisions for their children in life-threatening situations; biologic life alone (fetus and neonate) does not represent a person, a bearer of rights and duties; the capacity for self-determination is the criterion on which personhood depends; contemporary efforts to confer on newborn life, and fetal life as well, an absolute value appear to be aberrations within the human and moral record.

Submitted by Student

From Shelp EE: *Born to Die? Deciding the Fate of Critically Ill Newborns*, reviewed in *N Engl J Med* 1986;315:524.