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Declining Prevalence of Anemia Among Low-Income Children in the United States

Ray Yip, MD, MPH; Nancy J. Binkin, MD, MPH;
Lee Fleshood, PhD, MPA; Frederick L. Trowbridge, MD, MSC

To determine the anemia trends among low-income US children, hematologic measurements obtained from children aged 6 to 60 months who were enrolled in public health programs in six states that were consistently monitored by the Centers for Disease Control Pediatric Nutrition Surveillance System were studied. Overall, the prevalence of anemia has declined steadily from 7.8% in 1975 to 2.9% in 1985. The prevalence of anemia declined significantly among children seen at preenrollment screening visits, as well as those seen at follow-up visits, suggesting a generalized improvement in childhood iron nutritional status in the United States, as well as a positive impact of public health programs. To ensure that the declining trend of anemia was not a function of a change in the population of children enrolled in the surveillance system, Tennessee nutrition surveillance records were further analyzed; these records were linked with birth records to obtain detailed socioeconomic status (SES) information. Even though the SES composition remained stable from 1975 to 1984, the prevalence of anemia has declined significantly within each SES group. These findings indicate a true decline in the prevalence of anemia among low-income children that is likely the result of improvements in childhood iron nutrition.

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TWO RECENT studies have documented a decline in the prevalence of anemia among infants and preschool children 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 reason for the observed decline in the prevalence of anemia among these two low-income clinic populations. Data collected by the Centers for Disease Control (CDC) Pediatric Nutrition Surveillance System (PNSS), between 1974 and 1985, on low-income children who participated in the public nutrition and health programs from multiple states also have demonstrated a continued decline in the prevalence of anemia among infants and preschoolers.[3-7] However, this nutrition surveillance system has expanded from the initial five states at its inception in 1974 to 35 states in 1985, and changes in the number of states and composition of participating clinics may have affected the observed trend.

For editorial comment see p 1645.

To determine the magnitude and extent of the decline in the prevalence of anemia, we examined hematologic data from the six states that consistently participated in the CDC PNSS from 1975 to 1985. To ensure that changes in the prevalence of anemia were not a function of secular changes in socioeconomic status (SES) among participants enrolled in public nutrition and health programs, we used linked birth and nutrition records to study trends among children enrolled in the Tennessee WIC program while we controlled for the family SES of these children.

SUBJECTS AND METHODS

Data Sources

CDC PNSS (1975 to 1985).—The CDC PNSS assists multiple states in collecting pediatric growth and hematologic data from low-income children enrolled in various public health programs, including WIC; the Early Periodic Screening, Diagnosis, and Treatment program; Head Start; and maternal and child health clinics.[3-6] For this analysis, nutrition surveillance data collected from Arizona, Kentucky, Louisiana, Montana, Oregon, and Tennessee, from 1975 to 1985, were used. These six states were among the first to join the system and have been consistent participants. With the exception of Louisiana, where most of the reported data was from the Early Periodic Screening, Diagnosis, and Treatment program, most data from other states were from WIC programs. Because WIC enrollment is limited to children younger than 5 years of age, we limited the anemia trend analysis to children

From the Division of Nutrition, Center for Health Promotion and Education, Centers for Disease Control, Public Health Service, US Department of Health and Human Services, Atlanta (Drs Yip, Binkin, and Trowbridge), and the Nutrition and Supplemental Food Programs, Tennessee Department of Health and Environment, Nashville (Dr Fleshood).

Reprint requests to Division of Nutrition, Bldg 3, Centers for Disease Control, Atlanta, GA 30333 (Dr Yip).

between the ages of 6 and 60 months.

A total of 1 680 740 hemoglobin (Hgb) or hematocrit (Hct) measurements were collected from 499 759 children. Hence, most children had serial measurements obtained at different ages. Overall, 83% of the measurements used were Hct, and 17% were Hgb. For 10.4% of visits, both Hgb and Hct measurements were reported, but in this situation, only the Hct values were used. Essentially, all Hct measurements were based on the standard microhematocrit centrifuge method. The Hgb measurements were performed in the earlier years of the study and used a variety of outpatient laboratory methods. At the end of the study period, virtually all clinics were using only Hct measurements.

Tennessee-Linked Pediatric WIC and Birth Records.—Detailed analyses of anemia trends for the Tennessee pediatric WIC participants were performed with the use of WIC records from the CDC PNSS linked to birth certificate records from 1975 to 1984. This linked data file contained sociodemographic data, including parental age, education, and marital status from the birth records. The data linkage was performed by matching the last name, first initial, and date of birth from WIC records with birth records. Overall, 87% of the WIC records were successfully linked to birth records. Approximately 0.8% of the matched WIC records had more than one birth record match and were eliminated from the analysis. Based on reported race and birth weight on WIC records, the unmatched WIC records had comparable race composition and birth-weight distribution to those matched with birth records. A total of 326 266 WIC records of children aged 6 to 60 months were linked to 74 864 individual birth records during the ten-year study period.

Definition of Anemia

For the anemia trend analysis of both the six-state CDC PNSS data and the Tennessee-linked WIC-birth data, we used age-specific Hgb and Hct cutoff values to define anemia. The Hgb cutoff value was 103 g/L (10.3 g/dL) for children aged 6 to 23 months and 106 g/L (10.6 g/dL) for children aged 24 to 60 months. The Hct cutoff values were 0.31 (31%) for children aged 6 to 23 months and 0.32 (32%) for children aged 24 to 60 months. These age-specific cutoff values are 6 g/L (0.6 g/dL) lower for Hgb or 0.02 (2%) lower for Hct than the commonly used anemia cutoff values recommended by the American Academy of Pediatrics.[8] Lower cutoff values were chosen, in part, to select only the definite cases of anemia for trend analysis and, in part, to avoid the inclusion of children with hematologic values near the common cutoff values used by the WIC program for certification purposes (eg, Hct, <0.34 [<34%]). This decision was based on the observation of an overreporting of Hct values just below the WIC program cutoff values. However, analysis of Hgb and Hct distributions indicated that hematologic values not adjacent to the WIC program cutoff values were not affected (R.Y., unpublished data, October 1986).

Anemia Trend Analysis

CDC PNSS (1975 to 1985).—Annual prevalences of anemia by year of visit, as well as by birth year cohort, were calculated for children seen at preenrollment screening visits, follow-up visits, and both types of visits combined. Additionally, the annual anemia prevalences were determined by six-month age groupings and by race. All age-specific anemia trends compared in this study were based on birth-year cohort to maximize comparability. Each data point in the trend analysis for preenrollment visits and for the various age groups represents a true prevalence estimate because each child is represented only once in each time period and age interval. For the race-specific anemia trend, Hispanic children were grouped with white children because most of the states did not distinguish Hispanic from non-Hispanic white children in race reporting.

Tennessee-Linked Pediatric WIC and Birth Records.—Anemia trends, from 1975 to 1984, were determined for children from different SES groups enrolled in the Tennessee WIC program. Family SES for these children was based on three sociodemographic risk factors from the birth records: (1) mother's age of 17 years or younger at child's birth; (2) mother's education less than the 12th grade; and (3) mother unmarried. We defined low SES as those whose families had two or three risk factors, intermediate SES as those whose families had only one of the risk factors, and higher SES as those whose families had none of the risk factors. We further divided the higher SES group into two subgroups based on whether or not at least one of the parents had more than a high school education. This procedure of defining SES background resulted in four SES groups that ranged from high SES (group 1) to low SES (group 4).

Anemia trends by birth-year cohort were analyzed based on preenrollment screening records and on all visit records for the total group, as well as for each of the four SES groups. The rela tive proportions of children in each SE group during the study period wer compared to determine any significan changes in SES composition of the WI(population. In addition, an adjuste prevalence of anemia for each birth-yea cohort was determined after controllin for age, SES, and type of visit (initial v follow-up) for each birth-year cohort and a first-order linear regressio model was fitted over the adjuste trend.

Statistical Analysis

The significance of trend for all ag specific anemia trends, as well as trend based on initial visits, were based o angular χ^2 tests, which assess the diffe ences among proportions (prevalence anemia), as well as the direction o change among proportions (increase o decrease).[9] For those trends that may have contained more than one measure ment per child, a first-order derivati linear regression model was used to the slope of anemia prevalence over study years. The R^2 values were used assess the fit and significance of trend of the linear model.[10]

RESULTS

Anemia Prevalence in CDC PNSS (1975 to 1985)

General Characteristics of St Population.—Among the 499 759 ch dren 6 to 60 months of age who w seen at public health clinics from th selected states, a total of 294 955 H and 1 385 785 Hct measurements w used for the anemia trend analy Each state contributed the follow percentages of the total measureme Arizona, 18.2%; Kentucky, 29.4%; L siana, 8.8%; Montana, 4.8%; Ore 11.3%; and Tennessee, 32.4%. The eral characteristics of the children summarized in the Table. The ra distributions remained relatively st during the study years; for example proportion of black children was 2 from 1975 to 1977 and 19.2% from 19 1985. The age distribution shifted slightly younger composition during study period; the proportion of chil 6 to 23 months of age increased 47.4% from 1975 to 1977 to 55.8% 1983 to 1985. During the study pe the proportion of measurement tained from initial or preenroll screening visits declined from during the period from 1975 to 19 23.0% during the period from 19 1985.

Anemia Trends.—The overall p lence of anemia based on all hemat measurements by year of visit de from 7.8% in 1975 to 2.9% in 1

Anemia

General Characteristics of Children in CDC Pediatric Nutrition Surveillance System (1975 to 1985)*

Major Characteristics	%
Type of public health program	
WIC	82.3
EPSDT	9.8
Other	7.9
Race	
White and Hispanic	71.8
Black	20.0
American Indian	7.5
Asian	0.7
Age range, mo	
6-11	21.8
12-23	30.2
24-35	21.0
36-47	16.1
48-60	10.9

*Data collected from the six selected states participating consistently in the system. CDC indicates Centers for Disease Control; WIC, Women, Infants, and Children; and EPSDT, Early Periodic Screening, Diagnosis, and Treatment.

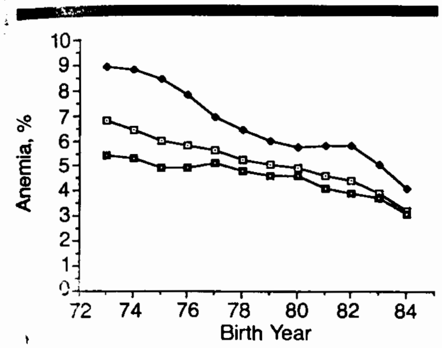

Fig 1.—Prevalence of anemia for each birth-year cohort, six selected states in Centers for Disease Control Pediatric Nutrition Surveillance System. Top line represents prevalence for children seen at initial visit only; bottom line, prevalence for children seen at follow-up visits; and middle line, all visits combined.

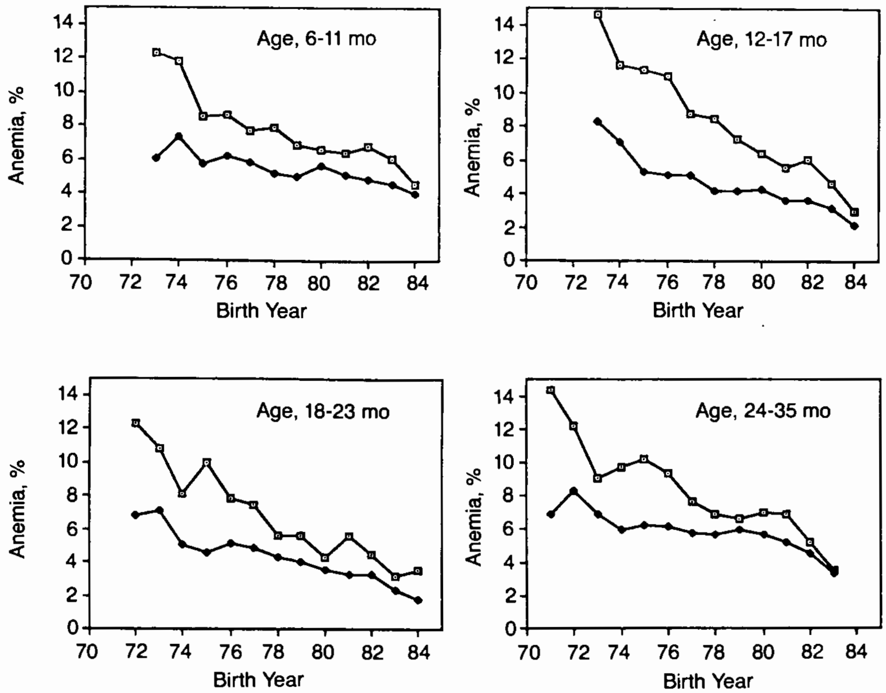

Fig 2.—Prevalence of anemia for children seen at initial (top lines) or preenrollment screening visits vs those seen at follow-up (bottom lines) visits for four specific age groups, six selected states in Centers for Disease Control Pediatric Nutrition Surveillance System. Prevalence of anemia at follow-up visits is consistently lower than those at initial visits for each age group ($P<.001$).

similar decline was noted in trends of the prevalence of anemia based on birth-year cohort, from 6.8% in the 1973 cohort to 3.1% in the 1984 cohort (Fig 1). In Fig 1, significant declines in anemia are demonstrated for the following types of visits: (1) children seen at the initial or preenrollment screening visit; (2) children seen at follow-up clinic visits after enrollment in the programs; and (3) children seen for all visits combined. In each case, the rate of anemia declined more than 50% during the study period ($P<.001$, based on R^2 of linear regression trends). There was little difference in the pattern of decline based on Hgb measurements compared with that based on Hct measurements. For the 10.4% of children who had both Hgb and Hct values measured, use of either Hgb or Hct to determine anemia resulted in similar prevalences of anemia.

The prevalence of anemia based on either the year of visit or birth-year cohort was consistently higher for those children seen at initial visits compared with those seen at follow-up visits. To ensure that the higher rate of anemia for children at initial visits was not a function of the younger ages of the initial visit group, age-specific anemia trends using birth-year cohorts were determined (Fig 2). Again, the prevalence of anemia declined significantly for all age groups ($P<.001$, angular χ^2 test).

Race-specific prevalences of anemia by birth-year cohort for white, black, and American Indian children, based on measurements from all visits, are shown in Fig 3. For all races, the prevalence of anemia declined significantly ($P<.001$, based on R^2 of linear regression trends). In the earlier years, black children had a higher prevalence of anemia, but the difference between black and white children narrowed as the rate of anemia declined. For each year, American Indian children in this study had a significantly lower rate of anemia than either black or white children ($P<.001$, χ^2 test). Most of those American Indian children came from the WIC program of Arizona.

Anemia Trends Based on Tennessee-Linked Pediatric WIC and Birth Records

General Characteristics of Study Population.—The Tennessee-linked data, from 1975 to 1984, contained a total of 319114 Hct measurements from a total of 72983 children aged 6 to 60 months. The overall racial composition was 76.6% white and 23.1% black; this composition changed little over the study period. Between 1975 and 1984, the relative proportion of children in each SES group did not change substantially. Twenty percent of children in 1975 and 22% in 1984 were in the lowest SES group (group 4), and 8% in 1975 and 9% in 1984 were in the highest (group 1). This evidence of stability in SES composition over time indicates that any decline in anemia is not related to a changing SES composition among WIC-enrolled children.

Anemia Trends.—From 1975 to 1984, the overall prevalence of anemia declined from 8.0% to 3.2%. For children seen at initial screening visits, the rate declined from 10.3% to 3.8%. The decline of age- and race-specific anemia rates was similar to the trend noted for the six-state CDC PNSS shown earlier.

The trends in anemia for the four SES groups based on birth year cohort are shown in Fig 4. The anemia rate for each SES group declined significantly ($P<.001$, angular χ^2 test), with children belonging to the lowest SES group (group 4) showing the greatest decline over the ten years. It is also important to note that there are significant differences in the prevalence of anemia among the four SES groups over the study period ($P<.001$, χ^2 test), and that the