HISTORICAL

In 1967 the 90th Congress of the United States attached an amendment to the Partnership for Health Act requiring the Secretary of the Department of Health, Education, and Welfare to undertake a survey of "the incidence and location of serious hunger and malnutrition— in the United States." In response to the legislative mandate the Ten-State Nutrition Survey was conducted during the years 1968 through 1970. The sample was selected from urban and rural families living in the following ten states: New York, Massachusetts, Michigan, California, Washington, Kentucky, West Virginia, Louisiana, Texas, and South Carolina.

The families selected were those living in some of the census enumeration districts that made up the lowest economic quartiles of their respective states at the time of the 1960 census. During the eight years after the 1960 census the social and economic characteristics found in some of the individual enumeration districts had changed, so that there was a significant number of families in the surveys with incomes well above the lowest income quartile. Thus, it was possible in analyzing results to make some comparisons on an economic basis.

Thirty thousand families were identified in the selection process; 23,846 of these participated in the survey. Data regarding more than 80,000 individuals were obtained through interviews and 40,847 of these individuals were examined.

The survey included the following: extensive demographic information on each of the participating families; information regarding food utilization of the family; a 24-hour dietary recall for infants up to 36 months of age, children 10 to 16 years of age, pregnant and lactating women, and individuals over 60 years of age. In addition, physical examinations, dental examinations, and biochemical and anthropometric evaluations were performed on most of the individuals selected for examination.

During the formative portion of the Ten-State Nutrition Survey, the Committee on Nutrition of the Academy of Pediatrics assisted in program design and selection of biochemical standards. For the past two years another committee of the Academy has been reviewing the voluminous data accumulated during the survey. The summary analysis which follows has been prepared by this committee and concerns those portions of the data which pertain to 22,000 children less than 17 years of age. Detailed review of the findings of the survey will form the basis of additional reports to be published in the future.

INTERPRETATION

The goal of the survey was to ascertain the extent of malnutrition in a sample population, and this was done. The nature of the sample, however, precludes estimating the nutritional status of any other population segment in the United States. Comparisons of various populations within the sample defined by ethnic, geographical educational, and economic variables permitted the identification of certain groups of children which were at particular risk to vary-
ing hazards of malnutrition. Although this massive survey revealed much about the nutritional status of Americans, it also made clear that considerable research is needed in the development of useful methods and standards for evaluation of the nutritional status of children.

**DIETARY INTAKE**

The survey data demonstrated that the diets during early childhood and adolescence varied with geographic locale, economic status and race or ethnicity. The energy (caloric) value of the diets and the intakes of all nutrients studied were lowest for blacks and Mexican-Americans living in the southern states. The nutritional quality of the diets, as calculated from dietary recall data and expressed as the amount of nutrients per 1,000 kilocalories, showed surprisingly little variation in relation to family income or race, except as noted below for vitamin A. Variations in vitamin A intakes reflected the influence of both locale and ethnicity on diets apart from total energy intakes. Although the diets of individuals living in low-income families did not differ in the concentration of essential nutrients from those of middle-income groups, the availability of calories, i.e., the amount of food available, was directly related to family income. The total food intake of children in low-income families was limited and this was reflected in growth performance.

Of particular interest to the pediatrician was the dietary intake data for subjects less than 36 months of age and for children 10 to 16 years of age. In all age groups iron was the one nutrient for which mean intakes were uniformly below accepted dietary standards. These data were compatible with the prevalence of iron deficiency found in the population studied. As suggested previously, average dietary intakes of iron per 1,000 kcal were essentially the same regardless of economic status. Thus, the diets of persons in very low-income families contained on the average as much iron per 1,000 kcal as did those of individuals in higher income families. The high prevalence of iron deficiency in adolescent boys from low-income families in contrast to the very low prevalence for adolescent boys of higher income families appeared to result from restricted food consumption and not from a diet of poor quality.

It was of considerable interest to find that the mean energy intake and the mean dietary iron intake of adolescent girls varied little in relation to family income. This was in striking contrast to the findings for boys 13 to 16 years of age, whose energy and iron intakes increased directly with family income.

There were distinct differences in the nutrient intakes of pregnant women which were related to family income level. For example, the mean energy and protein intakes (1,506 kcal and 60 gm/day, respectively) of low income black pregnant women were about 30% below those of pregnant white women of higher income (2,127 kcal and 89 gm of protein per day). On the average, pregnant women in all economic and ethnic groups had insufficient dietary iron.

**PLASMA VITAMIN A LEVELS**

There was a general increase in plasma vitamin A concentrations with increasing age. In those states with the highest income levels (California, Massachusetts, Michigan, New York, and Washington), mean values showed a progressive increase from about 35 pgm/100 ml at 1 year of age to about 60 pgm/100 ml for persons 45 to 59 years of age. In the remaining five states representing the lowest economic level of the sample, the mean vitamin A levels for all age groups were generally lower. However, the change with age was present and followed a pattern similar to that noted for persons of higher income. Thus, it appeared that slightly higher levels of plasma vitamin A were associated with higher family incomes.

A second major finding was that Mexican-Americans living in several southern states had lower levels of plasma vitamin A than did the black or white populations. The
mean values at all ages were lower, approximating 20μg/100 ml until adolescence, then rising to 30 to 35μg/100 ml at age 45 and above. The slight increase in mean vitamin A values with increasing income seen in all groups was more pronounced in this population of Mexican-Americans.

From the age of 1 year through adolescence 50% of the Mexican-American children living in the southern states had plasma vitamin A values below 20μg/100 ml. This was in marked contrast to the Spanish-American population living in New York and California in which less than 10% of the children had plasma vitamin A levels below 20μg/100 ml.

SERUM ASCORBATE LEVELS

The vast majority of children studied in this survey had serum levels of vitamin C (ascorbate) above 0.2 mg/100 ml. In those five states with higher mean family incomes less than 2% of the children had values below 0.2 mg/100 ml. In the other states in which mean family incomes of the sample population were distinctly lower, the percent of children with values below 0.2 mg/100 ml approached 10. It was not possible to identify ethnic or economic factors associated with the observed differences in mean serum ascorbate levels. Of interest was the finding that females tended to have higher levels than males. There was an apparent relation between vitamin C levels in serum and reported dietary intakes of the vitamin, a relation unique for this nutrient in that it alone was independent of energy intake.

HEMOGLOBIN AND IRON DEFICIENCY

Iron nutriture of children was evaluated in the Ten-State Nutrition Survey by determining hemoglobin levels. In those individuals found to have hemoglobin concentrations below selected values, determinations of serum iron and iron-binding capacity were performed to document the extent of iron deficiency. The available evidence suggested that essentially all anemia found in the survey was due to having iron deficiency.

Of particular importance was the demonstration of a high prevalence of iron deficiency in boys and girls of all ages, including infancy, childhood, and adolescence. For example, 70% of black preschool children living in the South and 30% of white preschool children in the North had hemoglobin concentrations below 12.0 gm/100 ml. There were distinct ethnic differences in the distribution of hemoglobin values for pediatric subjects of both sexes and of all ages. Black children had the highest percentage of low hemoglobin values. There was less risk of iron deficiency in the Mexican-American children living in southern and western states than in Spanish-American children living in northern states.

The influence of family economic level on the extent of iron deficiency in adolescence was of particular interest. A limited segment of the data was analyzed in considerable detail and demonstrated this influence. The prevalence of iron deficiency in adolescent males in this sample was inversely related to family income. Adolescent males from low-income families had a higher prevalence of iron deficiency than did adolescent females of similar economic status. Adolescent males in higher income families had a low frequency of iron deficiency. In striking contrast, the extent of iron deficiency among adolescent females bore no relation to family income. These findings were consistent with the iron intake mentioned previously.

GROWTH AND ECONOMIC STATUS

As might be expected, a greater per capita income was associated with greater stature, greater body weight, a greater thickness of subcutaneous fat, advanced skeletal development, advanced dental development, earlier maturation, and earlier attainment of maximum stature. The data showed that these differences were in large part established by the first year of life and were consistent thereafter. The data from the Ten-State Nutrition Survey provided a
clear indication of the magnitude of the economic impact on dimensional, skeletal, dental, and sexual development.

**GROWTH AND ETHNICITY**

Both on an absolute basis, and when corrected for income level, black boys and girls in comparison to white and Spanish-American children, tended to have skeletal advancement (ossification), dental advancement (age at permanent teeth eruption), and earlier maturation and had some tendency toward greater body size, notwithstanding lesser body fat through adolescence. Black boys and girls evidenced a greater skeletal mass, both on a group basis and on an income-corrected basis. Therefore, genetic factors outweighed economic factors in explaining differences in skeletal and dental development. These findings suggest the need for different standards for black and white children when assessing nutritional status during growth.

**FATNESS AND OBESITY**

From infancy through adolescence the median thickness of subcutaneous fat increased directly with income. The proportion of children defined as obese showed the same trend and this was particularly apparent in adolescent boys. During adolescence median fatfold thickness continued to be proportional to income level in males. However, for females the relation reversed during adolescence so that those of lower incomes were the fattest and became increasingly so in adulthood. At all ages black males were leanest, and after adolescence, black females were fattest. At least part of this (adult) black-white difference in fatness was related to income. The poorer the adult black, the more likely the male was to be thin and the female to be fat.

**DENTAL FINDINGS**

With approximately 19,000 children examined, this was by far the largest survey ever conducted in this country. The criteria used to assess dental health, namely the DMF index in older children and adults and the df index in younger children (where D and d stand for decayed, M for missing, and F and f for filled) are primarily measures of caries prevalence.

Using the DMF index, white males and females from high-income states tended to have slightly higher DMF values as compared with blacks or Spanish-Americans, a trend repeated in low-income states. The racial difference is also seen in df indices for the primary teeth in low- and high-income states, comparing white with black children.

The caries index could not be related to plasma vitamin A or serum vitamin C levels, or to serum albumin concentrations. The one significant factor was the between-meal consumption of refined carbohydrate: in adolescent children of all races the caries index progressively rose as this dietary component increased. For example, in children 10 to 16 years of age the effect of increasing the between meal carbohydrate intake from negligible amounts to 150 gm or more per day was to increase the DMF index from 30% to 60% in different ethnic groups. It is thus apparent that this effect must be considered in any attempt to assess the influence of other factors on the caries index.

When only those adolescents who consumed no refined carbohydrate between meals were considered, Spanish-Americans living in higher income areas had the lowest caries index, and whites and blacks in low-income areas the highest. Considering all racial groups together family income was not related to the prevalence of caries.

**IS THERE MALNUTRITION AMONG THE CHILDHOOD POPULATION IN THE UNITED STATES?**

Accepting a definition of malnutrition as faulty or inadequate nutrition (Webster), the data from the Ten-State Nutrition Survey were unambiguous; substantial numbers of the children examined in this large survey were indeed malnourished.

In answer to the question of whether or not there is malnutrition among American
children, one might begin by evaluating the findings for these variables which can be measured with most precision and for which experience allows the most confident interpretation. At the risk of being unduly simplistic in analyzing the mass of data now available, a mere look at measures of growth and prevalence of anemia will provide partial but confident answers to the question.

Evidence of retarded growth was apparent in children from low-income families. Relative to what would be expected for a well-nourished population, two times as many black and three times as many white children in families living in poverty were below the 15th percentile for accepted American standards of height. There was a progressive decrease in the prevalence of undergrown children with increasing family income. Children in certain age groups from higher income families were advanced in their height by as much as a year over children from lower income families.

The widespread prevalence of iron deficiency anemia throughout infancy, childhood, and adolescence was previously noted in this summary. That this may be an indicator of a broader spectrum of nutritional inadequacies in American children is suggested by the following observation. Boys 7 through 12 years of age with high (normal) hemoglobin levels averaged 3 to 4 cm taller than those with low hemoglobin values.

Obesity in children and adolescents is a common nutrition-related health problem. The almost complete failure of programs to correct obesity once it is present in childhood and the potentially serious behavioral and health consequences of persisting severe obesity demand of the pediatric community a new level of concern for prevention of this condition and a recognition that obesity has in part a cultural base.

Some degree of malnutrition does indeed exist in a substantial number of the American children studied in the survey. To a significant degree malnutrition in children appears to be a consequence of both the quality of life and the economic status of the family. Present information should prompt the pediatrician and other physicians caring for children to become increasingly aware, informed, and concerned about nutritional problems in a population of growing individuals. While it is incumbent upon the physician to treat malnutrition in his patients, it must be noted that the limited approach entailed in assuming that the physician plays the only role in relieving malnutrition is not likely to succeed. Where malnutrition emerges as a consequence of improcunity, society as a whole must be involved in amelioration.

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