Ethnic and racial differences in serum vitamin A levels of children aged 4–11 years[1,2]

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ABSTRACT Interpretation of differences in serum vitamin A levels observed between Hispanic and non-Hispanic children may be complicated by confounding environmental factors. Data from the Mexican-American portion of the Hispanic Health and Nutrition Examination Survey and the second National Health and Nutrition Examination Survey were used to explore these differences in 4–11-y-old Mexican Americans and non-Hispanic blacks and whites before and after accounting for vitamin-mineral supplement use and poverty status. Initial differences in mean serum vitamin A levels and prevalences < 20 μg/dL (0.70 μmol/L) or < 25 μg/dL (0.87 μmol/L) among the three ethnic or racial groups were reduced or eliminated after accounting for the two descriptive variables. These results support the hypothesis that differences in serum vitamin A levels between Mexican-American and non-Hispanic children in the United States are due more to environmental factors than to ethnicity. *Am J Clin Nutr* 1988;47:247–52.

KEY WORDS Ethnic groups, vitamin A, nutrition surveys

Introduction

Mean serum vitamin A values of Hispanic children both in underdeveloped countries and in the United States are lower than those of non-Hispanic children in the United States (1–4). The extent to which these differences are due to ethnic factors or to demographic and environmental conditions is uncertain. The present study compares serum vitamin A distributions between 4–11-y-old Mexican Americans and non-Hispanic blacks and whites in the United States before and after accounting for selected descriptive factors. Data from the Health and Nutrition Examination Surveys (HANES) (5, 6) were used to compare mean serum vitamin A levels and prevalences < 20 μg/dL (0.70 μmol/L) and < 25 μg/dL (0.87 μmol/L) among the three groups before and after excluding vitamin-mineral supplement users and categorizing by poverty status. Both the latter variables previously had been related to serum vitamin A levels (2, 7). Thus, controlling for these variables permitted a better examination of the question of ethnicity. Data from large cross-sectional surveys like HANES cannot demonstrate conclusively why serum vitamin A levels differ between Hispanic and non-Hispanic children, but they can provide important insights by permitting adjustment or control of key confounding factors.

Methods

Sample

Findings presented for non-Hispanic blacks and whites are from data collected in the second National Health and Nutrition Examination Survey (NHANES II) (5), whereas those presented for Mexican Americans are from data collected in the Mexican-American portion of the Hispanic Health and Nutrition Examination Survey (HHANES[MA]) (6). Both surveys were conducted by the National Center for Health Statistics. NHANES II, conducted from 1976–1980, was a national probability survey of the noninstitutionalized US population ages 6 mo–74 y. HHANES, conducted from 1982–1984, was a probability survey of three special population subgroups ages 6 mo–74 y in selected areas rather than a national sample. The three subgroups were Mexican Americans in selected areas of five southwestern states (Arizona, California, Colorado, New Mexico, and Texas), Cuban Americans (Dade County, Florida), and Puerto Ricans (New York City metropolitan area). Only data from the Mexican-American portion of the survey were available at the time of data analysis.

The analytic sample for this study was limited to children ages 4–11 y because serum vitamin A was not measured for persons aged > 11 y in NHANES II or for children < 4 y in HHANES(MA). In this age range 81 and 85% of the sampled children were interviewed and examined in NHANES II and HHANES(MA), respectively.

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The analytic sample from NHANES II was restricted to non-Hispanic blacks and whites by excluding children whose reported family ancestry or national origin was one of the following: Chicano, Mexicano, Mexican, Mexican American, other Spanish, countries of Central or South America, Puerto Rican, or Cuban. Because all members of a family with at least one Hispanic member were eligible to be sampled, some non-Hispanic persons were included in HHANES(MA). Thus, it was necessary to restrict the sample from HHANES(MA) to Mexican Americans by including only children whose reported family ancestry or national origin was from the first five categories listed above.

Children with missing data for serum vitamin A also were excluded from the analytic sample. Of the 3569 children ages 4–11 y in NHANES II, there were 1901 remaining in the sample after all exclusions had been made. There were 2027 4–11-y-old children in HHANES(MA); of these there were 1262 remaining in the sample after exclusions were performed. The final analytic sample consisted of 321 blacks, 1580 whites, and 1262 Mexican Americans. No apparent biases were introduced by the deletions made to form the analytic sample.

Variables

Details of venous blood sample collection, specimen storage procedures, serum vitamin A assays, and quality control procedures used in NHANES II and HHANES(MA) were published elsewhere (8, 9). Vitamin A assays were performed by the Centers for Disease Control in both surveys. In NHANES II total serum vitamin A was determined with an optimized modification (8) of the Roels and Trout (10) adaptation of the trifluoracetic acid (TFA) method of Neeld and Pearson (11) that measures both serum retinol and retinyl esters. In HHANES(MA) an isocratic modification (12) of the high-performance liquid chromatography (HPLC) method of Bieri et al (13) was used to measure serum retinol; retinyl esters were not determined. Using blood samples from 300 children in NHANES II, Driskell et al (12) conducted a study to compare results from the TFA method with those obtained with the HPLC method. Good agreement was found between the two methods. Results of a recent reevaluation of the study showed the TFA method produced serum vitamin A values that were ~1–2 μg/dL (0.03–0.07 μmol/L) higher than the HPLC method at serum levels < 35 μg/dL (1.22 μmol/L); at higher serum levels, the TFA method produced values ~4 μg/dL (0.14 μmol/L) higher than the HPLC method (2). After reviewing the comparison study, an expert panel concluded recently that the methods used in NHANES II and HHANES(MA) were reasonably comparable in the lower end of the serum vitamin A distribution, which is the range of values of greatest interest (2).

Descriptive characteristics of the respondents used in this study were age, poverty income ratio, and vitamin-mineral supplement use (5, 6). The poverty income ratio (PIR) is calculated by dividing the total household income by the poverty threshold (14) for a household of that size. Children whose family PIR was < 1.3 were considered to be poor in this study whereas those whose family PIR was ≥ 2.0 were considered nonpoor. When making comparisons between PIR categories, children with a family PIR of 1.3–1.99 were deleted.

Vitamin-mineral supplement users were defined as those who were regular or irregular users in NHANES II; children who had used supplements in the past 2 wk were considered users in HHANES(MA). Although the questions were worded in a slightly different manner in the two surveys, they were similar enough in concept for purposes of excluding supplement users from parts of the analyses. At the time of data analysis, no information was available from either survey to determine if the supplements used contained vitamin A.

Data analysis

Before data analyses were performed, the sample was divided into two age groups: 4–5 y and 6–11 y. These age groups were chosen to be consistent with previous analyses of NHANES II and HHANES(MA) serum vitamin A data (2) and to accomodate age-related changes in serum vitamin A without compromising sample size. Serum vitamin A levels did not differ significantly between sexes in the 4–11-y age range, so the data were combined for both sexes within each age and ethnic or racial group. The low ranges of serum vitamin A examined in this study (eg, < 20 μg/dL [0.70 μmol/L] and < 25 μg/dL [0.87 μmol/L]) were based on guidelines for interpretation of serum vitamin A levels from HANES published by an expert panel (2).

All statistical analyses were carried out using programs accessible through the Statistical Analysis System (15, 16). Because both surveys employed a complex survey design, sampling weights were used when calculating point estimates (eg, means and prevalences). Thus, all means and percents presented in this paper were weighted to represent the appropriate US subpopulation at the midpoint of the respective survey (March, 1978 for NHANES II and March, 1983 for HHANES[MA]). Likewise, variances were calculated by procedures that account for the complex survey design and for ratio adjustments used to produce the sample weights (17). For NHANES II this was accomplished through use of computer programs that employ a Taylor series linearization method (16). For HHANES(MA) an average design effect was used to modify the variances calculated under the assumption of simple random sampling because variance estimates calculated for subgroups by the programs mentioned above tended to be unstable (18). Average design effects for mean serum vitamin A levels and prevalences in the selected low ranges were determined previously to be 1.31 and 1.13, respectively (2).

A t test was used to compare mean levels and prevalences in the selected low ranges between ethnic and racial groups and between supplement use and poverty status categories within ethnic or racial groups. When multiple comparisons were made, the critical value for the t distribution was calculated using the Bonferroni inequality (19). To assess whether possible skewness in serum vitamin A distributions would affect results, analyses of log-transformed serum vitamin A values were compared with those based on untransformed values. Because the transformation did not change conclusions regarding significant differences between groups, only results based on untransformed data are presented.

Results

Mean serum vitamin A levels are presented in **Table 1** by age and ethnic or racial group before and after excluding supplement users. Before excluding supplement users, mean serum vitamin A levels of 4–5-y-old Mexican Americans and non-Hispanic blacks were significantly lower than that of 4–5-y-old non-Hispanic whites. The mean level of 6–11-y-old Mexican American children was also significantly lower than that of non-Hispanic white children of the same age. After supplement users were excluded, mean serum vitamin A levels differed significantly only between 6–11-y-old Mexican Americans and non-Hispanic whites. Thus, removing supplement users reduced the observed differences between mean serum

TABLE 1
Mean serum vitamin A levels of children aged 4–11 y with and without supplement users: NHANES II, 1976–80, and HHANES(MA), 1982–83

Ethnic or racial group	Supplement users included: Number of examined persons	Supplement users included: Mean	Supplement users included: SEM	Supplement users excluded: Number of examined persons	Supplement users excluded: Mean	Supplement users excluded: SEM
		μg/dL (μmol/L)			*μg/dL (μmol/L)*	
4–5 y						
Mexican Americans	234	28.7* (1.00)	0.86	138	28.2 (0.98)	0.87
Non-Hispanic blacks	142	29.8* (1.04)	0.86	91	30.3 (1.06)	1.29
Non-Hispanic whites	654	32.9 (1.15)	0.57	327	29.9 (1.04)	0.47
6–11 y						
Mexican Americans	1028	31.8* (1.11)	0.39	735	31.7* (1.11)	0.34
Non-Hispanic blacks	179	33.9 (1.18)	0.80	135	33.8 (1.18)	1.08
Non-Hispanic whites	926	34.1 (1.19)	0.35	587	33.1 (1.16)	0.37

* Comparison between ethnic or racial groups of same age within a supplement-use category; significantly lower than non-Hispanic whites, $p < 0.05$.

vitamin A levels of Mexican Americans and non-Hispanic whites but did not completely remove them. However, the difference between 6–11-y-old whites and Mexican Americans was < 2 μg/dL (0.07 μmol/L) after supplement users were excluded, which was the difference noted by Driskell et al (12) between the analytic methods used in the two surveys.

After the exclusion of supplement users, mean serum vitamin A levels were compared between Mexican Americans and non-Hispanic whites by poverty status (**Table 2**). Comparisons with non-Hispanic blacks by poverty status in either age group or with 4–5-y-old nonpoor Mexican Americans were not possible due to small sample sizes. Mean levels did not differ significantly between Mexican Americans and non-Hispanic whites of the same poverty status in the age groups tested.

Prevalences of serum vitamin A in the selected low ranges for the three ethnic or racial groups are shown by age before and after exclusion of supplement users in **Table 3**. Unlike differences observed in mean values, prevalences < 20 μg/dL (0.70 μmol/L) did not differ significantly between ethnic or racial groups even before supplement users were excluded. However, prevalences < 25 μg/dL (0.87 μmol/L) were significantly higher for Mexican Americans than non-Hispanic whites in both age categories. Excluding supplement users reduced the magnitude of the difference between these ethnic groups, but the difference remained statistically significant for the 6–11-y olds.

Table 4 contains prevalences for both low ranges by poverty status, age, and ethnic group after supplement users were excluded. Comparisons with 4–5-y-old nonpoor Mexican Americans were not possible due to the small sample size. The prevalences < 20 μg/dL (0.70 μmol/L) did not differ between ethnic groups in the age and poverty categories tested. Prevalences < 25 μg/dL (0.87 μmol/L) differed between ethnic groups only among the 6–11-y-old poor children.

TABLE 2
Mean serum vitamin A levels of children aged 4–11 y by poverty status: NHANES II, 1976–80, and HHANES(MA), 1982–83*

Ethnic or racial group	Poor: Number of examined persons	Poor: Mean	Poor: SEM	Nonpoor: Number of examined persons	Nonpoor: Mean	Nonpoor: SEM
		μg/dL (μmol/L)			*μg/dL (μmol/L)*	
4–5 y						
Mexican Americans	84	27.8 (0.97)	1.31	32	† †	†
Non-Hispanic whites	97	30.0 (1.05)	0.92	141	30.2 (1.05)	0.69
6–11 y						
Mexican Americans	405	31.3 (1.09)	0.46	195	32.5 (1.13)	0.66
Non-Hispanic whites	152	33.1 (1.16)	0.78	282	33.5 (1.17)	0.49

* Supplement users and children with PIR > 1.3 and < 2.0 excluded.
† Indicates statistic that may be unreliable due to sample size.

TABLE 3
Percent of children aged 4–11 y with serum vitamin A in selected low ranges with and without supplement users: NHANES II, 1976–80, and HHANES(MA), 1982–83

Ethnic or racial group	Supplement users included			Supplement users excluded		
	Number of examined persons	Percent	Standard error	Number of examined persons	Percent	Standard error
Percent with serum vitamin A < 20 μg/dL (0.70 μmol/L)						
4–5 y						
Mexican Americans	234	4.6	1.6	138	6.7	2.5
Non-Hispanic blacks	142	5.7	2.1	91	7.3	3.0
Non-Hispanic whites	654	2.5	0.8	327	2.6	1.2
6–11 y						
Mexican Americans	1028	2.7	0.6	735	2.4	0.6
Non-Hispanic blacks	179	2.2	2.4	135	1.9	1.5
Non-Hispanic whites	926	1.7	1.0	587	1.8	0.4
Percent with serum vitamin A < 25 μg/dL (0.87 μmol/L)						
4–5 y						
Mexican Americans	234	25.6*	3.3	138	26.4	4.4
Non-Hispanic blacks	142	22.7	4.5	91	24.4	5.7
Non-Hispanic whites	654	14.5	1.7	327	19.2	2.5
6–11 y						
Mexican Americans	1028	14.5*	1.3	735	13.6*	1.5
Non-Hispanic blacks	179	11.9	3.0	135	11.7	2.9
Non-Hispanic whites	926	8.9	0.8	587	8.9	1.1

* Comparison between ethnic or racial groups of same age within a supplement-use category; significantly higher than non-Hispanic whites, $p < 0.05$.

Discussion

Concern about the vitamin A nutriture of Mexican Americans living in the Southwest was raised by results of the Ten State Nutrition Survey showing that Spanish Americans aged < 17 y from this region had a high prevalence of deficient and low serum vitamin A values (3). More recently Chase et al (1) observed that mean serum vitamin A levels of migrant Mexican American children were lower than those of white children living in Denver. In a recent evaluation of serum vitamin A data collected in the Health and Nutrition Examination Surveys, an expert panel (2) found that prevalences of serum vitamin A below selected cutoff values were higher for Mexican Americans than for whites or blacks. They noted, however, that comparison of absolute values for prevalences across surveys was complicated by use of different serum vitamin A assays in the three surveys.

A relevant question about these observed differences in serum vitamin A levels is the extent to which they are due to ethnicity. Similar questions were raised about the differences observed in growth patterns and zinc status between Mexican Americans and whites (1, 20–24). These questions parallel those raised about differences observed in hemoglobin between blacks and whites (25–27). Unlike the black-white hemoglobin difference, however, there seems to be little published evidence to support the hypothesis that differences in growth patterns and zinc status between Mexican Americans and whites have a genetic basis (20, 22).

Similarly, results of this study support the hypothesis that differences observed in mean serum vitamin A levels between Mexican American and non-Hispanic children in the United States are due more to demographic and environmental factors than to ethnicity. Initial differences in mean serum vitamin A levels between Mexican American and non-Hispanic white children were no longer present after exclusion of supplement users and categorizing by poverty status. The pattern of differences in prevalences < 25 μg/dL (0.87 μmol/L) between ethnic groups among 6–11-y olds also provides some support.

Comparison of prevalences in the low ranges is somewhat problematic due to differences in vitamin A assays between surveys. Prevalences below a given cut-off value would be expected to be somewhat higher for the Mexican Americans because the serum retinol assay produced slightly lower values than the total serum vitamin A assay. Our decision not to adjust the prevalences to reflect this difference was based on recommendations from an expert panel who developed guidelines for interpretation of HANES serum vitamin A data (2). The panel recommended the same cut-off values for evaluation of data from NHANES II and HHANES(MA), despite differences in methodology, because interpretation of the suggested low ranges was relatively imprecise. For example, the range of values < 20 μg/dL (0.70 μmol/L) was defined

TABLE 4
Percent of children aged 4–11 y with serum vitamin A in selected low ranges by poverty status: NHANES II, 1976–80, and HHANES(MA), 1982–83*

	Poor			Nonpoor		
Ethnic or racial group	Number of examined persons	Percent	Standard error	Number of examined persons	Percent	Standard error
		Percent with serum vitamin A < 20 μg/dL (0.70 μmol/L)				
4–5 y						
Mexican Americans	84	10.3	3.8	32	†	†
Non-Hispanic whites	97	6.3	3.9	141	0.4	0.4
6–11 y						
Mexican Americans	405	2.9	0.9	195	1.4	1.0
Non-Hispanic whites	152	1.6	1.0	282	1.7	0.9
		Percent with serum vitamin A < 25 μg/dL (0.87 μmol/L)				
4–5 y						
Mexican Americans	84	30.3	5.7	32	†	†
Non-Hispanic whites	97	17.3	5.9	141	15.6	3.6
6–11 y						
Mexican Americans	405	16.4‡	2.1	195	10.2	2.6
Non-Hispanic whites	152	7.2	1.5	282	8.5	1.6

* Supplement users and children with PIR > 1.3 and < 2.0 excluded.
† Indicates statistic that may be unreliable due to sample size.
‡ Comparison between ethnic or racial groups of same age within a poverty status category; significantly higher than non-Hispanic whites, $p < 0.05$.

for 4–11-y-old children as one in which "vitamin A status is likely to improve with increased consumption of vitamin A. Some improvement may be expected among children with values of 20–24 μg/dL (0.70–0.84 μmol/L)."

Comparisons between ethnic or racial groups were also hindered by the imprecision of the prevalence estimates for some groups for whom the standard error was large relative to the size of the prevalence estimate. This was particularly evident in the 4–5-y group and likely stems from the relatively small sample of 4–5-y olds in both surveys. Because HANES surveys employ a complex design, larger sample sizes are needed to provide precise point estimates than a simple random sample would require. The low number of children with values < 20 μg/dL (0.70 μmol/L) in both age groups also contributed to the poor precision of these prevalence estimates; this may account for our inability to detect statistically significant differences between these prevalences for 6–11-y olds.

The estimates of prevalences < 25 μg/dL (0.87 μmol/L) in the 6–11-y group were more precise, so patterns of differences between ethnic groups in this age range may be more reliable. Differences in prevalences < 25 μg/dL (0.87 μmol/L) between the three groups decreased after accounting for the descriptive variables and remained significant only between 6–11-y-old poor Mexican Americans and non-Hispanic whites. Further analysis showed the 6–11-y-old poor Mexican Americans had a significantly lower mean PIR than the corresponding non-Hispanic whites, which indicates we did not completely control for this variable. Furthermore, the prevalences did not differ for 6–11-y-old nonpoor children for whom the mean PIR did not differ between ethnic groups. The lack of a significant difference between ethnic groups in the nonpoor category and the apparent relationship between severity of poverty and low serum vitamin A values in the poor category argues against a genetic basis for the observed differences in prevalences < 25 μg/dL (0.87 μmol/L).

Our results, then, suggest that differences in serum vitamin A levels between Mexican American and non-Hispanic children in the United States are related to differences in environmental factors. Our results also support the use of the same serum vitamin A reference data for evaluation of serum vitamin A levels of US white children, black children, and Mexican American children living in the Southwest. Whether the same reference data can be used to evaluate Hispanic children outside the United States remains speculative, especially if their ethnic ancestry differs from that of Mexican Americans living in the Southwest. It is also uncertain whether results from this study concerning Mexican Americans can be extrapolated to Puerto Ricans and Cuban Americans living in the United States; these comparisons will be possible at a later date when all the data from HHANES are available. Finally, our ability to determine whether the overall vitamin A status of 4–11-y-old Mexican Americans and non-Hispanic whites and blacks is equivalent after accounting for relevant descriptive factors is restricted by the lack of relationship between serum and liver vitamin A levels over a wide range of liver stores (28). Thus, serum vitamin A levels alone are not a very sensitive indicator of liver stores of vitamin A unless liver stores are depleted.

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