ORIGINAL CONTRIBUTION

Ethnic Variation in Cardiovascular Disease Risk Factors Among Children and Young Adults

Findings From the Third National Health and Nutrition Examination Survey, 1988-1994

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Context Knowledge about ethnic differences in cardiovascular disease (CVD) risk factors among children and young adults from national samples is limited.

Objective To evaluate ethnic differences in CVD risk factors, the age at which differences were first apparent, and whether differences remained after accounting for socioeconomic status (SES).

Design Third National Health and Nutrition Examination Survey, 1988-1994.

Setting Eighty-nine mobile examination centers.

Participants A total of 2769 black, 2854 Mexican American, and 2063 white (non-Hispanic) children and young adults aged 6 to 24 years.

Main Outcome Measures Ethnicity and household level of education (SES) in relation to body mass index (BMI), percentage of energy from dietary fat, cigarette smoking, systolic blood pressure, glycosylated hemoglobin (HbA_{1c}), and non–high-density lipoprotein cholesterol (non–HDL-C [the difference between total cholesterol and HDL-C]).

Results The BMI levels were significantly higher for black and Mexican American girls than for white girls, with ethnic differences evident by the age of 6 to 9 years (a difference of approximately 0.5 BMI units) and widening thereafter (a difference of >2 BMI units among 18- to 24-year-olds). Percentages of energy from dietary fat paralleled these findings and were also significantly higher for black than for white boys. Blood pressure levels were higher for black girls than for white girls in every age group, and glycosylated hemoglobin levels were highest for black and Mexican American girls and boys in every age group. In contrast, smoking prevalence was highest for white girls and boys, especially for those from low-SES homes (77% of young men and 61% of young women, aged 18-24 years, from low-SES homes were current smokers). All ethnic differences remained significant after accounting for SES and age.

Conclusion These findings show strong ethnic differences in CVD risk factors among youths of comparable age and SES from a large national sample. The differences highlight the need for heart disease prevention programs to begin early in childhood and continue throughout young adulthood to reduce the risk of atherosclerosis.

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Although cardiovascular disease (CVD) does not manifest until adulthood, CVD risk factors, such as elevated blood pressure, excess weight, and abnormalities in plasma lipoprotein levels, are present in childhood[1] and persist into adulthood.[2] Furthermore, CVD risk factors are associated with the presence of atherosclerosis in children and young adults.[3-5]

Ethnic differences in CVD risk factors in children are of special importance because of the premature mortality from CVD and high levels of CVD risk factors experienced by adult ethnic minority populations, most notably African American and Mexican American populations, which constitute the 2 largest minority groups in the United States. For example, CVD mortality rates for African American and white women 45 to 64 years old were 274 and 107 per 100 000, respectively, in 1992. For African American and white men, rates were 511 and 299 per 100 000, respectively.[6] In addition to higher CVD mortality rates, African American adults have higher prevalences of excess weight, physical inactivity, diabetes, and hypertension than do white adults.[7-9] Studies of CVD mortality among Mexican Americans are much less conclusive[10]; however, Mexican American adults are more likely to be overweight and physically inactive, to have diabetes, and to have higher levels of untreated and uncontrolled hypertension than are white adults.[9,11-13]

Past studies of ethnic differences in CVD risk factors among children have most commonly focused on school-

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aged children ranging from 5 to 18 years of age. These studies suggest that African American and Mexican American children have higher levels of body mass index (BMI [weight in kilograms divided by the square of height in meters]), physical inactivity, lipoproteins, insulin, glucose, and blood pressure than white children, and that these differences may occur as early as middle childhood.[1,14-22] While these studies have made substantial contributions, most are limited by restricted geographic regions of study, limited power from small sample sizes, and nongeneralizable samples. Furthermore, few have controlled for potential confounding from socioeconomic status (SES), a powerful predictor of CVD.[23,24]

Although there is some evidence that childhood SES can affect CVD in adulthood,[25] to our knowledge, there are no national studies of children that have evaluated the impact of both ethnicity and SES on multiple CVD risk factors. However, several recent national studies of adults have found that ethnic differences in CVD risk factors remained after accounting for individual as well as family-level indicators of SES.[9,26] While adjusting for SES does not fully account for all of the attributes of socioeconomic position, these studies suggest that biological, behavioral, cultural, medical, and societal factors may contribute to ethnic variations in CVD risk factors independently of SES.

In this article we used data from a large national probability sample of black, Mexican American, and white (non-Hispanic) children and young adults. We examined ethnic differences in CVD risk factors, the ages at which ethnic differences were first apparent, and whether ethnic differences remained after accounting for 2 different measures of SES.

METHODS

The Third National Health and Nutrition Examination Survey (NHANES III), conducted by the National Center for Health Statistics, was designed to assess the health and nutritional status of the US noninstitutionalized civilian population.[27] It oversampled black and Mexican American populations and included a total sample of 33 994 persons, aged 2 months and older.[28] The survey was conducted at 89 locations in two 3-year phases: phase I, 1988 to 1991, and phase II, 1991 to 1994. The survey used a stratified, multistage probability cluster sampling, similar to that used by previous NHANE surveys. Weights indicating the probability of being sampled were assigned to each respondent, enabling results to represent the entire US population.

The NHANES III staff conducted surveys in households, administering questionnaires to families, adults, and children. The survey included demographic, SES, dietary, and health history questions. All survey instruments were available in both English and Spanish. Following the survey, standardized medical examinations were conducted by physicians and health technicians in NHANES III mobile examination centers.

Our analysis sample includes 7686 black, Mexican American, and white children and young adults, 6 to 24 years of age. We excluded younger children because of substantial missing data. We also excluded data for young women who were pregnant (n = 164) and individuals who were not from black, Mexican American, or white ethnic groups (n = 385), whose surveys were coded as unreliable (n = 6) or who completed the home but not the medical examination (n = 485). The 485 individuals who completed only the home questionnaire were similar to the 7686 individuals who completed both the home questionnaire and medical examination for most sociodemographic characteristics, including age (14.9 vs 14.0 mean years, respectively), education of the head of the household (11.6 vs 10.9 mean years, respectively), and country of birth (88% vs 87% born in the United States, respectively).

Measures

Age was calculated in years from the subject's reported birthdate. Race or ethnicity was based on asking respondents to identify themselves as follows: black; Mexican or Mexican American; white, non-Hispanic; Asian or Pacific Islander; Aleut, Eskimo, or American Indian; or other Latin American or other Spanish. Respondents who chose 1 of the first 3 categories are included in our analyses. The NHANES III collected data on several indicators of SES. We used educational attainment of the head of the household as our primary indicator of SES because, unlike income and occupation, education had little missing data, is available regardless of employment outside the home, and is unlikely to be influenced by CVD-related morbidity.[29] We used poverty-income ratio as our secondary indicator of SES. The poverty-income ratio is the ratio of 2 components: the numerator is the family income and the denominator is an assessment of the income level that is minimally adequate for a family of that size for that calendar year. Education of the head of the household and poverty-income ratio were moderately correlated ($r = 0.42$, $P < .001$), a finding consistent with previous research.[29]

Indicators of CVD Risk

Indicators of CVD risk were as follows:

- Body mass index, a preferred measure of body fatness for children and adolescents.[30]
- Percentage of energy from dietary fat, estimated on the basis of a single 24-hour dietary recall, administered by a trained dietary interviewer with a proxy, if necessary, for children 6 to 11 years of age.
- Current cigarette smoking status, defined as smoking at least 100 cigarettes during one's lifetime and currently smoking cigarettes, based on self-report and not assessed for children younger than 8 years of age. Serum cotinine levels (>74 nmol/L [>13 ng/mL]),[31] available for phase I participants, were used to validate smoking status.
- Systolic blood pressure, measured in millimeters of mercury. The mean of the second and third of 3 readings, measured on the right arm using a mercury sphygmomanometer while the participant was seated during the medical examination, is reported. Diastolic blood pressure is not reported because of substantially more missing data (12% missing diastolic vs 4% missing systolic).

Table 1. Sample Sizes and Sociodemographic Characteristics for Black, Mexican American, and White Youths Aged 6-24 Years, Third National Health and Nutrition Examination Survey (NHANES III), 1988-1994

Characteristic	Black	Mexican American	White
US population, aged 6-24 y, in millions*	10.2	5.9	45.5
Analytic sample, No.†	2769	2854	2063
Sociodemographic characteristic‡			
Age, mean, y	14.7	14.9	14.9
Girls, %	50.4	47.2	48.1
Living in urban area, %	53.8	58.3	42.3
No. of persons in family, mean	4.3	5.2	3.9
Education of head of household, mean, y	11.8	9.3	12.8
Below poverty level, %§	42.5	45.7	15.3
Having no health insurance, %	24.1	52.8	20.7
Born in United States, %	96.0	68.0	97.5
Speaking English at home, %	99.9	54.0	99.8
Region of residence			
Northeast/Midwest, %	35.7	12.0	48.9
South, %	55.7	24.3	34.2
West/Southwest, %	8.6	63.8	16.9

*Projected estimates based on weighted percentages from NHANES III for defined sample.
†Number who participated in both the home questionnaire and physical examination, unweighted.
‡Means and percentages were calculated with normalized sample weights.
§Calculated from family income and family size. The cutpoint for poverty level is based on annual tables from the US Bureau of the Census.

• Glycosylated hemoglobin (HbA_{1c}), a percentage of total hemoglobin, analyzed from whole blood in 1 laboratory (DIAMAT HPLC/Bio-Rad Laboratories, Columbia, Mo)[27] and used as a marker for the blood glucose concentration during the previous 2 to 3 months.[32] Glycosylated hemoglobin, the only indicator of diabetic status available for children in NHANES III, has been related to atherosclerosis in youth and may indicate a preclinical stage of diabetes.[33]

• Non–high-density lipoprotein cholesterol (non–HDL-C), measured in millimoles per liter and calculated as the difference between total cholesterol and HDL cholesterol.[34] Measurements were taken from serum specimens and analyzed by standardized protocols. Non–high-density lipoprotein cholesterol, which may be a better indicator of atherogenic lipoprotein particles than indirectly estimated low-density lipoprotein cholesterol,[34] does not require fasting

Table 2. Regression Coefficients (β) and *P* Values From Linear Models for Cardiovascular Risk Factors in Black, Mexican American, and White Youths Aged 6-24 Years, Third National Health and Nutrition Examination Survey (NHANES III), 1988-1994*

	Body Mass Index, kg/m²		Energy From Fat, %		Current Cigarette Smoker†		Systolic Blood Pressure, mm Hg		HbA_{1c} Level, %		Non-HDL Cholesterol, mmol/L	
	β (SE)	*P*	β (SE)	*P*	β (SE)	*P*	β (SE)	*P*	β (SE)	*P*	β (SE)	*P*
Girls												
Main effects												
Ethnicity												
Black‡	1.20 (.26)	<.001	2.20 (.43)	<.001	−2.89 (.47)	<.001	1.19 (.52)	.03	.21 (.03)	<.001	−.06 (.05)	.20
Mexican American‡	.85 (.33)	.01	1.29 (.50)	.01	−1.67 (.33)	<.001	−.67 (.53)	.21	.08 (.03)	<.01	−.08 (.05)	.16
SES§	−.23 (.06)	<.001	−.04 (.15)	.78	−.22 (.06)	<.001	−.14 (.14)	.30	−.01 (.01)	.20	−.02 (.01)	.11
Age	.46 (.04)	<.001	−.03 (.07)	.62	.36 (.03)	<.001	.70 (.06)	<.001	.00 (.00)	.55	.00 (.00)	.65
Significant interactions‖												
Mexican American × SES	. . .	. . .	. . .	. . .	.48 (.09)	<.001	. . .	. . .	. . .	. . .	. . .	. . .
Black × age	.13 (.05)	<.01	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Boys												
Main effects												
Ethnicity												
Black‡	−.10 (.21)	.66	1.22 (.50)	.02	−1.29 (.21)	<.001	−.60 (.67)	.38	.20 (.03)	<.001	.01 (.04)	.98
Mexican American‡	.48 (.25)	.06	.24 (.67)	.72	−.29 (.30)	.34	−.57 (.73)	.44	.06 (.02)	<.01	.04 (.04)	.38
SES§	−.13 (.09)	.15	−.25 (.14)	.07	−.29 (.06)	<.001	−.33 (.19)	.10	−.02 (.01)	<.001	.01 (.01)	.41
Age	.44 (.04)	<.001	−.04 (.07)	.58	.43 (.04)	<.001	1.33 (.11)	<.001	.00 (.00)	.03	.02 (.00)	.002
Significant interactions‖												
Black × SES	. . .	. . .	. . .	. . .	.26 (.11)	<.01	. . .	. . .	. . .	. . .	. . .	. . .
Mexican American × SES	. . .	. . .	.48 (.17)	<.01	.48 (.08)	<.001	. . .	. . .	. . .	. . .	. . .	. . .
Black × age	.15 (.04)	<.001	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .

*Linear models incorporated sampling weights. Independent variables were age, ethnicity, years of education of head of household, and all first-order interactions between independent variables. Regression coefficients are unstandardized. HbA_{1c} indicates glycosylated hemoglobin; HDL, high-density lipoprotein; and SES, socioeconomic status.
†Coefficients for this binary outcome are based on multiple logistic models. To calculate an odds ratio, exponentiate the β coefficient.
‡White youths coded as the reference group for both black and Mexican American groups.
§Measured by years of education of head of household.
‖Significant interactions with ethnicity at $P<.01$. Ellipses indicate that the interaction with ethnicity was not statistically significant.

blood samples, and therefore was available for the entire NHANES III sample. Total cholesterol is reported as a secondary measure.

Missing data ranged from 1% to 5% for BMI, percentage of energy from fat, smoking, and blood pressure, to 10% to 12% for glycosylated hemoglobin and non–HDL-C levels.

Data Analysis

The data were analyzed using SUDAAN, version 7.11 (Research Triangle Institute, Research Triangle Park, NC), a software program that adjusts for the complex NHANES III sample design. All analyses incorporated sampling weights that adjusted for unequal sampling probabilities. SUDAAN was used to calculate weighted means, percentages, and SEs; SAS, version 6.12 (SAS Institute Inc, Cary, NC) was used to calculate weighted SDs.

We used multiple linear regression models for continuous outcomes and logistic regression models for binary outcomes. The dependent variables in our models were the 6 CVD risk factors described above. The independent variables were age (in years, centered at the sample mean to aid in the interpretation of the regression coefficients); ethnicity (black and Mexican American youth compared separately with white youth; each comparison used white youth as the reference group); and years of education of the head of the household (continuous and centered at 12 years). We included all first-order interactions between independent variables (age and ethnicity, age and education, ethnicity and education). All *P* values are 2-tailed.

In 2 ancillary analyses, we used the poverty-income ratio rather than educational attainment, and total cholesterol level rather than non–HDL-C level in the linear models to examine whether these measures would produce similar findings.

RESULTS

There were 2769 black, 2854 Mexican American, and 2063 white children and young adults for whom data were complete for the home questionnaire and the medical examination (**TABLE 1**). There were substantial numbers in groups at the extremes of educational attainment that are commonly underrepresented in studies of ethnic differences in CVD. For example, there were large numbers of white youths from homes with lower levels of education (n = 212 from homes with ≤9 years of education; n = 257 from homes with 10-11 years of education) and Mexican American youths from homes with higher levels of education (n = 401 from homes with ≥13 years of education). White youths were the least likely to live in urban areas, were from homes having the highest levels of education, and were the least likely to live in poverty. More than 40% of black and Mexican American youths lived below the poverty level.

TABLE 2 presents the multivariate results for the 6 CVD risk factors. The coefficients are presented for the black-white comparisons, the Mexican American-white comparisons, for SES, and for age. All interactions with ethnicity that were statistically significant at $P<.01$ are also presented. After accounting for SES and age, BMI levels were sig-

Table 3. Cardiovascular Risk Factors by Age and Ethnicity for Black, Mexican American, and White Girls Aged 6-24 Years, Third National Health and Nutrition Examination Survey (NHANES III), 1988-1994*

Age and Ethnicity	Sample Size, No.	Body Mass Index, Mean (SD), kg/m²	Energy From Fat, %	Current Cigarette Smoker, %	Systolic Blood Pressure, Mean (SD), mm Hg	HbA_{1c} Level, % Mean (SD)	Non-HDL Cholesterol, Mean (SD), mmol/L [mg/dL]†
6-9 y							
Black	352	17.7 (3.8)	35.1	0.0	96.4 (9.8)	5.2 (0.4)	3.0 (0.8) [116 (31)]
Mexican American	377	17.5 (3.1)	34.1	0.0	94.7 (8.2)	5.0 (0.4)	3.0 (0.8) [116 (31)]
White	286	17.1 (3.5)	33.3	0.0	95.4 (9.5)	4.9 (0.6)	3.1 (0.7) [119 (27)]
10-13 y							
Black	352	20.9 (4.7)	35.5	0.2	103.2 (9.4)	5.2 (0.5)	2.9 (0.7) [112 (27)]
Mexican American	351	20.9 (4.6)	35.1	0.3	102.0 (9.4)	5.0 (0.4)	2.9 (0.7) [112 (27)]
White	241	19.8 (4.2)	33.4	0.7	102.2 (9.7)	5.0 (0.4)	3.0 (0.7) [116 (27)]
14-17 y							
Black	278	23.9 (5.8)	36.8	1.9	105.5 (9.8)	5.1 (0.5)	2.9 (0.8) [112 (31)]
Mexican American	256	23.6 (4.9)	34.2	3.8	104.6 (10.0)	5.0 (0.5)	2.9 (0.8) [112 (31)]
White	236	22.2 (4.3)	33.8	16.7	104.2 (9.2)	4.9 (0.7)	2.9 (0.9) [112 (34)]
18-24 y							
Black	412	25.6 (6.2)	35.4	17.8	107.0 (9.6)	5.1 (0.6)	3.1 (0.9) [119 (34)]
Mexican American	405	25.3 (5.2)	33.3	14.4	105.2 (9.7)	5.0 (0.4)	3.2 (0.9) [123 (34)]
White	308	23.1 (5.0)	32.7	38.3	105.6 (8.9)	4.9 (0.5)	3.1 (0.8) [119 (31)]
25-34 y‡							
Black	580	27.8 (7.2)	35.1	35.3	110.9 (13.4)	5.3 (0.9)	3.3 (0.9) [127 (34)]
Mexican American	525	27.3 (6.3)	33.3	14.7	106.9 (10.4)	5.2 (0.6)	3.5 (0.9) [135 (34)]
White	531	24.6 (5.8)	33.5	41.2	106.9 (10.7)	4.9 (0.4)	3.4 (0.9) [131 (34)]

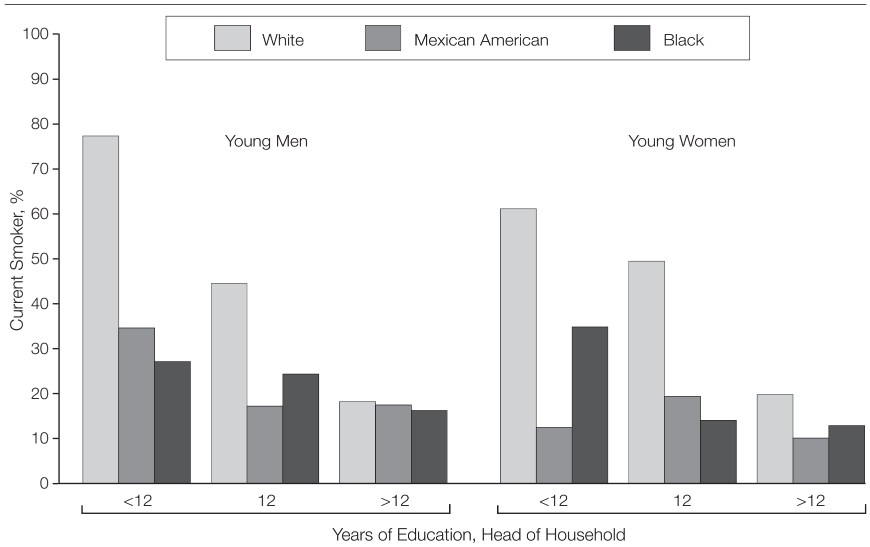
*Means, SDs, and percentages were calculated with normalized sample weights. HbA_{1c} indicates glycosylated hemoglobin; HDL, high-density lipoprotein.
†Non-HDL cholesterol values were highly correlated with NHANES III low-density lipoprotein cholesterol values (r = 0.95) and were, on average, 0.65 mmol/L (25 mg/dL) higher than low-density lipoprotein cholesterol.
‡Data for women, aged 25-34 years, are presented for reference.

Table 4. Cardiovascular Risk Factors by Age and Ethnicity for Black, Mexican American, and White Boys Aged 6-24 Years, Third National Health and Nutrition Examination Survey (NHANES III), 1988-1994*

Age and Ethnicity	Sample Size, No.	Body Mass Index, Mean (SD), kg/m^2	Energy From Fat, %	Current Cigarette Smoker, %	Systolic Blood Pressure, Mean (SD), mm Hg	HbA_{1c} Level, % Mean (SD)	Non-HDL Cholesterol, Mean (SD), mmol/L [mg/dL]†
6-9 y							
Black	365	16.9 (3.0)	34.5	0.0	95.5 (9.0)	5.2 (0.4)	2.9 (0.7) [112 (27)]
Mexican American	356	17.7 (3.2)	34.7	0.0	97.0 (9.3)	5.0 (0.3)	2.9 (0.6) [112 (23)]
White	295	17.0 (3.0)	33.8	0.0	95.7 (9.4)	4.9 (0.4)	3.0 (0.7) [116 (27)]
10-13 y							
Black	336	19.8 (4.6)	34.8	0.0	104.0 (10.1)	5.1 (0.5)	3.0 (0.9) [116 (34)]
Mexican American	339	20.8 (4.6)	33.3	0.4	104.1 (9.2)	5.1 (0.4)	2.9 (0.8) [112 (31)]
White	238	19.5 (3.5)	33.6	0.4	103.1 (10.4)	5.0 (0.3)	2.9 (0.7) [112 (27)]
14-17 y							
Black	277	22.4 (4.6)	36.1	3.2	112.9 (9.2)	5.1 (0.5)	2.8 (0.7) [108 (27)]
Mexican American	258	22.7 (4.3)	34.3	13.3	111.2 (9.8)	5.1 (0.4)	2.9 (0.8) [112 (31)]
White	185	22.9 (5.5)	33.2	12.9	111.8 (10.1)	5.0 (0.4)	2.8 (0.7) [108 (27)]
18-24 y							
Black	375	25.4 (5.9)	35.3	23.1	117.9 (10.9)	5.3 (0.9)	3.2 (0.9) [123 (34)]
Mexican American	468	24.8 (4.1)	32.2	27.6	114.8 (10.0)	5.1 (0.6)	3.2 (0.9) [123 (34)]
White	265	23.9 (4.0)	33.5	40.7	115.4 (10.0)	4.9 (0.4)	3.2 (0.9) [123 (34)]
25-34 y‡							
Black	492	26.4 (5.7)	34.7	37.7	119.7 (11.0)	5.4 (0.7)	3.6 (1.0) [139 (39)]
Mexican American	580	26.5 (4.5)	32.2	34.5	115.8 (10.5)	5.3 (0.7)	3.9 (1.1) [150 (42)]
White	444	26.2 (4.8)	34.9	38.2	116.9 (10.9)	5.1 (0.5)	3.8 (1.0) [146 (39)]

*Means, SDs, and percentages were calculated with normalized sample weights. HbA_{1c} indicates glycosylated hemoglobin; HDL, high-density lipoprotein.
†Non-HDL cholesterol values were highly correlated with NHANES III low-density lipoprotein cholesterol values ($r = 0.95$) and were, on average, 0.65 mmol/L (25 mg/dL) higher than low-density lipoprotein cholesterol.
‡Data for men, aged 25-34 years, are presented for reference.

Figure. Interaction Between Ethnicity and Education for Smoking, Third National Health and Nutrition Examination Survey (NHANES III), 1988-1994, Young Men and Women Aged 18-24 Years



nificantly higher for black and Mexican American girls than for white girls, blood pressure levels were higher for black girls than white girls, glycosylated hemoglobin levels were higher for black and Mexican American girls and boys than for white girls and boys, and percentage of energy from fat was higher for black and Mexican American girls and black boys than for white girls and boys. In contrast, smoking prevalence was significantly higher for white girls and boys. Socioeconomic status was a significant predictor of BMI and smoking among girls, and smoking and glycosylated hemoglobin levels among boys, but was not a significant predictor of the other CVD risk factors after accounting for ethnicity. Each risk factor increased with age, with the exception of percentage of energy from fat and, among girls only, glycosylated hemoglobin and non–HDL-C levels. Results did not change significantly when poverty-income ratio was substituted for educational attainment and when total cholesterol was substituted for non–HDL-C in the linear models. There were several significant interactions noted in the linear models (discussed below).

TABLE 3 and **TABLE 4** present the means and SDs, or percentages, for girls and boys by age group to illustrate when ethnic differences were first apparent. The NHANES III data for women and men 25 to 34 years old are presented for comparison. The BMI levels were higher for both black and Mexican American girls than for white girls by 6 to 9 years of age. These ethnic differences increased from an average of approximately 0.5 BMI units among 6- to 9-year-olds to more than 2 BMI units among 18-

to 24-year-olds. For young women who were aged 18 to 24 years and of average height in this analysis (162 cm [5 ft, 4 in]), each BMI unit is equivalent to 2.6 kg (5.9 lb). An ethnic difference of 2 BMI units indicates that black and Mexican American women who were 162 cm (5 ft, 4 in) tall were, on average, approximately 5.4 kg (12 lb) heavier than white women of the same height.

A similar early onset of ethnic differences in percentage of energy from fat and glycosylated hemoglobin level was seen for black and Mexican American girls. For systolic blood pressure, black girls, but not Mexican American girls, had higher values than white girls by 6 to 9 years of age and in every age group thereafter.

Among black and Mexican American boys, glycosylated hemoglobin levels were higher than among white boys by 6 to 9 years of age and in every age group thereafter. A similar pattern was seen for percentages of energy from fat for black boys by 10 to 13 years of age.

Ethnic differences in cigarette smoking were evident by 10 to 13 years of age for both girls and boys. White girls and boys showed a sharp increase at 14 to 17 years of age, which more than doubled for girls and more than tripled for boys at 18 to 24 years of age. Smoking rates of Mexican American boys kept pace with white boys through 14 to 17 years of age and doubled at 18 to 24 years of age. There was also a dramatic age-related increase in smoking rates among black boys and black and Mexican American girls when they reached 18 to 24 years of age, narrowing the gap with whites.

In general, the ethnic differences in BMI, percentage of energy from fat, blood pressure, and glycosylated hemoglobin level were also apparent in adults, 25 to 34 years of age. Smoking rates in adults remained low for Mexican American women and increased for black men. These comparisons between age groups offer insight into the progression of ethnic differences in CVD risk factors into adulthood. However, the data are based on cross-sectional surveys; thus, when the youth from younger age groups grow older, they may not show the same risk factor levels that were observed for youth from the older age groups in this sample.

The significant interactions noted in the linear models (Table 2) can be seen in Tables 3 and 4 and the FIGURE. For BMI, black girls and boys had steeper increases in BMI levels than white girls and boys across age groups, resulting in greater ethnic differences in the older age groups than the younger age groups (significant interaction between black ethnicity and age). For smoking, ethnic differences were larger at the lower levels of education than at the higher levels. As shown in the Figure, white youths, 18 to 24 years old, from families with lower educational attainment reported substantially higher smoking rates than black and Mexican American youths from families with similar educational attainment (77% of young white men and 61% of young white women were current smokers compared with 35% of minority youth). With increasing education, smoking rates decreased sharply and were similar across ethnic groups.

COMMENT

These findings are among the first to show higher levels of BMI, energy from dietary fat, blood pressure, and glycosylated hemoglobin, and lower rates of smoking for black and Mexican American youths than white youths of comparable SES and age from a national sample. The findings are especially important because they add insight into the course of development of ethnic differences in CVD risk factors from childhood to young adulthood. Because the cardiovascular health of adults is determined, in part, by personal behaviors and societal influences present during childhood and young adulthood,[9,25,35] it is important to learn when ethnic differences in CVD risk factors are first apparent so that preventive interventions can be initiated before unhealthy lifestyles are established.

Our findings are consistent with a number of studies comparing black and white youth, or Mexican American and white youth, on BMI,[14,17,22,36] dietary intake,[15,20] blood pressure,[17,36] smoking,[37] and markers for diabetes.[16,18,36] Other studies have not always found the same significant ethnic differences in CVD risk factors; for example, our findings contrast with some studies for BMI, blood pressure, smoking, and lipoprotein levels.[1,17,38,39] However, our findings are the first from a nationally representative sample of children and young adults, spanning the entire age range from 6 to 24 years. Some of the differences may be explained by selection bias in previous studies, not accounting for SES, or ethnic groups that do not overlap sufficiently in SES distributions to permit valid adjustment for SES.

Strengths and Limitations

NHANES III is the most comprehensive national survey with data on CVD risk factors for children and young adults in the United States. The survey includes an oversampling of black and Mexican American children, the 2 largest groups of ethnic minority children. Because NHANES I and II did not include large numbers of Mexican American children and the Hispanic HANES did not include white children, this is the first NHANE survey to allow a direct comparison of Mexican American and white children. It also includes large numbers of children in each ethnic group from households at both the upper and lower levels of educational attainment. Extensive data are available from the home survey and medical examination, including standardized measures of blood pressure, lipids, and glycosylated hemoglobin, and several measures of SES.

Despite these strengths, our results should be interpreted with caution because of several design and measurement limitations. First, the cross-sectional design of NHANES III limits our ability to draw inferences about developmental or causal pathways and highlights the need for longitudinal studies to provide more definitive answers to results from cross-sectional studies. Second, our measures of SES may exhibit a certain degree of residual confounding with ethnicity, even after adjustment for educational attainment or poverty level. It is well-known that the same level of SES does not confer the same economic and social benefit to ethnic minority youth as to white youth.[40-42] In a previous NHANES III analysis, we found that equal levels of education did not translate into equal levels of income; for example, black and Mexican American women with a high school diploma were 2 to 3 times more likely than white women of the same educational level to live in poverty.[9] Third, there is the potential for bias from self-reported questions such as those on smoking and dietary fat. We validated self-reported smoking by examining a biochemical measure, serum cotinine. Among participants who reported being nonsmokers, 5.1%, 2.5%, and 4.7% of black, Mexican American, and white youths, and 3.7%, 4.5%, and 3.4% of youths from homes where the educational level was less than 12, 12, and more than 12 years, respectively, had positive cotinine values, indicating low levels of underreporting of smoking. Although self-reported measures of dietary intake are problematic, the 24-hour dietary recall is considered an appropriate measure for assessing average population-based dietary data.[43] Finally, the NHANES III data lack consistent physical activity questions for youth. There were 2 questions about exercising that were asked of youth 8 to 16 years old; neither of these 2 questions were asked of older youth, who instead were asked about leisure time activity. As a result, we did not include physical activity in our analysis.

Implications

Our findings suggest potential critical periods during childhood when preventive interventions may be most effective. Interventions to reduce ethnic differences in excess weight should start in early childhood and continue through adulthood, with particular attention to black and Mexican American girls.[1,44] Special attention should be devoted to interventions to reduce fat intake[20,45] and increase physical activity.[46] The large ethnic differences in BMI at early ages are especially important because excess weight in children is a risk factor for coronary heart disease morbidity and mortality[47,48] and may precipitate early onset of other CVD risk factors, including elevated blood pressure, adverse lipid levels, and type 2 diabetes.[35,49] Interventions to prevent type 2 diabetes should also focus on black and Mexican American girls and boys, as glycosylated hemoglobin levels were already greater than those of white girls and boys by 6 to 9 years of age.

The high rates of smoking among white youth from families with lower educational levels are alarming (ie, 61% of young women and 77% of young men aged 18 to 24 years from these homes smoked). This group is often overlooked because data for white youth are usually presented aggregated across levels of SES, thus masking the greatly elevated rates among lower SES youth. The lower smoking rates among black and Mexican American youth should not promote complacency since new evidence shows dramatic increases in their smoking rates.[50] Our finding that lower SES youth from each ethnic group have higher smoking rates than their higher SES counterparts highlights the need to understand individual and societal factors that influence lower SES youth to start and continue to smoke.

Our results suggest that preventive interventions for many CVD risk factors need to start early in childhood and continue throughout adolescence and into adulthood. The ethnic differences we found in risk factors, including BMI, energy from dietary fat, cigarette smoking, systolic blood pressure, and glycosylated hemoglobin, evident as early as 6 to 9 years of age, reinforce the need for early interventions.[37] The focus of attention in youth should be on promoting population-wide, heart-healthy behaviors in both children and their parents through programs at the family, school, community, and public policy levels. Given the increasing diversity of Americans, it is critical to tailor programs to the culture of youths, their group-specific attitudes, perceptions, expectations, norms, and values, and to appropriate languages and literacy levels. Finally, it is essential that preventive interventions be placed in a social context because of the countervailing societal forces that affect heart-healthy lifestyles.

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REFERENCES

1. The Bogalusa Heart Study 20th Anniversary Symposium. *Am J Med Sci.* 1995;310:S1-S138.
2. Bao W, Srinivasan SR, Valdez R, Greenlund KJ, Wattigney WA, Berenson GS. Longitudinal changes in cardiovascular risk from childhood to young adulthood in offspring of parents with coronary artery disease: the Bogalusa Heart Study. *JAMA.* 1997;278:1749-1754.
3. McNamara J, Molot M, Stremple J. Coronary artery disease in combat casualties in Viet Nam. *JAMA.* 1971;216:1185-1187.
4. Strong JP. Natural history and risk factors for early human atherogenesis: Pathobiological Determinants of Atherosclerosis in Youth (PDAY) Research Group. *Clin Chem.* 1995;41:134-138.
5. Berenson GS, Srinivasan SR, Bao W, Newman WP III, Tracy RE, Wattigney WA. Association between multiple cardiovascular risk factors and atherosclerosis in children and young adults. *N Engl J Med.* 1998;338:1650-1656.
6. US Public Health Service. *Health, United States.* Hyattsville, Md: US Public Health Service, National Center for Health Statistics; 1993. US Dept of Health and Human Services (Public Health Service) publication 1994.
7. Tyroler HA, Knowles MG, Wing SB, et al. Ischemic heart disease risk factors and twenty-year mortality in middle-aged Evans County black males. *Am Heart J.* 1984;108:738-746.
8. Shea S, Stein AD, Basch CE, et al. Independent associations of educational attainment and ethnicity with behavioral risk factors for cardiovascular disease. *Am J Epidemiol.* 1991;134:567-582.
9. Winkleby MA, Kraemer HC, Ahn DK, Varady AN. Ethnic and socioeconomic differences in cardiovascular disease risk factors: findings for women from the Third National Health and Nutrition Examination Survey, 1988-1994. *JAMA.* 1998;280:356-362.
10. Goff DC, Ramsey DJ, Labarthe DR, Nichaman MZ. Greater case-fatality after myocardial infarction among Mexican Americans and women than among non-Hispanic whites and men: the Corpus Christi Heart Program. *Am J Epidemiol.* 1994;139:474-483.
11. Haffner SM, Stern MP, Hazuda HP, Pugh JA, Patterson JK, Malina R. Upper body and centralized adiposity in Mexican-Americans and non-Hispanic whites: relationship to body mass index and other behavioral and demographic variables. *Int J Obesity.* 1986;10:493-502.
12. Boyko EJ, Keane EM, Marshall JA, Hamman RF. Higher insulin and C-peptide concentrations in Hispanic population at high risk for NIDDM: the San Luis Valley Diabetes Study. *Diabetes.* 1991;40:509-515.
13. Winkleby MA, Ahn D. Blood pressure findings for Mexican-American women and men from the Third National Health and Nutrition Examination Survey, 1988-1994. *BioMedicina.* 1998;1:321-325.
14. Resnicow K, Morabia A. The relation between body mass index and plasma total cholesterol in a multiracial sample of U.S. schoolchildren. *Am J Epidemiol.* 1990;132:1083-1090.

15. Belcher JD, Ellison RC, Shepard WE, et al. Lipid and lipoprotein distributions in children by ethnic group, gender, and geographic location—preliminary findings of the Child and Adolescent Trial for Cardiovascular Health (CATCH). *Prev Med.* 1993;22:143-153.
16. Jiang X, Srinivasan SR, Webber LS, Wattigney WA, Berenson G. Association of fasting insulin level with serum lipid and lipoprotein levels in children, adolescents, and young adults: the Bogalusa Heart Study. *Arch Intern Med.* 1995;155:190-196.
17. Liu K, Ruth KJ, Flack JM, et al. Blood pressure in young blacks and whites: relevance of obesity and lifestyle factors in determining differences: the CARDIA Study (Coronary Artery Risk Development in Young Adults). *Circulation.* 1996;93:60-66.
18. Batey LS, Goff DC Jr, Tortolero SR, et al. Summary measures of the insulin resistance syndrome are adverse among Mexican-American versus non-Hispanic white children: the Corpus Christi Child Heart Study. *Circulation.* 1997;96:4319-4325.
19. Tortolero SR, Goff DC Jr, Nichaman MZ, Labarthe DR, Grunbaum JA, Hanis CL. Cardiovascular risk factors in Mexican-American and non-Hispanic white children: the Corpus Christi Child Heart Study. *Circulation.* 1997;96:418-423.
20. McNutt SW, Hu Y, Schreiber GB, Crawford PB, Obarzanek E, Mellin L. A longitudinal study of the dietary practices of black and white girls 9 and 10 years old at enrollment: the NHLBI Growth and Health Study. *J Adolesc Health.* 1997;20:27-37.
21. Andersen RE, Crespo CJ, Bartlett SJ, Cheskin LJ, Pratt M. Relationship of physical activity and television watching with body weight and level of fatness among children: results from the Third National Health and Nutrition Examination Survey. *JAMA.* 1998;279:938-942.
22. Dwyer JT, Stone EJ, Yang M, et al. Predictors of overweight and overfatness in a multiethnic pediatric population: Child and Adolescent Trial for Cardiovascular Health Collaborative Research Group. *Am J Clin Nutr.* 1998;67:602-610.
23. Adler NE, Boyce T, Chesney M, Folkman S, Syme L. Socioeconomic inequalities in health: no easy solution. *JAMA.* 1993;269:3140-3145.
24. Lynch J, Kaplan GA, Salonen R, Cohen RD, Salonen JT. Socioeconomic status and carotid atherosclerosis. *Circulation.* 1995;92:1786-1792.
25. Smith GD, Hart C, Blane D, Hole D. Adverse socioeconomic conditions in childhood and cause specific adult mortality: prospective observational study. *BMJ.* 1998;316:1631-1635.
26. Kington RS, Smith JP. Socioeconomic status and racial and ethnic differences in functional status associated with chronic diseases. *Am J Public Health.* 1997;87:805-810.
27. National Center for Health Statistics. Plan and operation of the Third National Health and Nutrition Examination Survey, 1988-1994, series 1: programs and collection procedures. *Vital Health Stat 1.* 1994;No. 32:1-407.
28. Ezzati TM, Massey JT, Waksberg J, Chu A, Maurer K. Sample design: Third National Health and Nutrition Examination Survey, series 2: data evaluation and methods research. *Vital Health Stat 2.* 1992;No. 113:1-35.
29. Winkleby MA, Jatulis DE, Frank E, Fortmann SP. Socioeconomic status and health: how education, income, and occupation contribute to risk factors for cardiovascular disease. *Am J Public Health.* 1992;82:816-820.
30. Dietz WH, Robinson TN. Use of the body mass index (BMI) as a measure of overweight in children and adolescents. *J Pediatr.* 1998;132:191-193.
31. Cummings SR, Richard RJ. Optimum cutoff points for biochemical validation of smoking status. *Am J Public Health.* 1988;78:574-575.
32. Peters AL, Davidson MB, Schriger DL, Hasselblad V. A clinical approach for the diagnosis of diabetes mellitus: an analysis using glycosylated hemoglobin levels. *JAMA.* 1996;276:1246-1252.
33. Forrest RD, Jackson CA, Yudkin JS. The glycohaemoglobin assay as a screening test for diabetes mellitus: the Islington Diabetes Survey. *Diabet Med.* 1987;4:254-259.
34. Havel RJ, Rapaport E. Management of primary hyperlipidemia. *N Engl J Med.* 1995;332:1491-1498.
35. Srinivasan SR, Bao W, Wattigney WA, Berenson GS. Adolescent overweight is associated with adult overweight and related multiple cardiovascular risk factors: the Bogalusa Heart Study. *Metabolism.* 1996; 45:235-240.
36. Folsom AR, Burke GL, Ballew C, et al. Relation of body fatness and its distribution to cardiovascular risk factors in young blacks and whites: the role of insulin. *Am J Epidemiol.* 1989;130:911-924.
37. Lowry R, Kann L, Collins JL, Kolbe LJ. The effect of socioeconomic status on chronic disease risk behaviors among US adolescents. *JAMA.* 1996;276:792-797.
38. Daniels SR, Obarzanek E, Barton BA, Kimm SY, Similo SL, Morrison JA. Sexual maturation and racial differences in blood pressure in girls: the National Heart, Lung, and Blood Institute Growth and Health Study. *J Pediatr.* 1996;129:208-213.
39. Webber LS, Osganian SK, Feldman HA, et al. Cardiovascular risk factors among children after a 2 1/2-year intervention—the CATCH Study. *Prev Med.* 1996; 25:432-441.
40. Krieger N. Analyzing socioeconomic and racial/ethnic patterns in health and health care. *Am J Public Health.* 1993;83:1086-1087.
41. Williams DR, Collins C. U.S. socioeconomic and racial differences in health: patterns and explanations. *Annu Rev Sociol.* 1995;21:349-386.
42. Kaufman JS, Cooper RS, McGee DL. Socioeconomic status and health in blacks and whites: the problem of residual confounding and the resiliency of race. *Epidemiology.* 1997;8:621-628.
43. Rockett HRH, Colditz GA. Assessing diets of children and adolescents. *Am J Clin Nutr.* 1997;65(suppl): 1116S-1122S.
44. Council on Scientific Affairs of the American Medical Association. Hispanic health in the United States. *JAMA.* 1991;265:248-252.
45. Expert Panel on Detection Evaluation and Treatment of High Blood Cholesterol in Adults. Summary of the second report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel II). *JAMA.* 1993; 269:3015-3023.
46. US Department of Health and Human Services. *Physical Activity and Health: A Report of the Surgeon General.* Atlanta, Ga: US Dept of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion; 1996.
47. Must A, Jacques PF, Dallal GE, Bajema C J, Dietz WH. Long-term morbidity and mortality of overweight adolescents: a follow-up of the Harvard Growth Study of 1922 to 1935. *N Engl J Med.* 1992;327: 1350-1355.
48. Nieto FJ, Szklo M, Comstock GW. Childhood weight and growth rate as predictors of adult mortality. *Am J Epidemiol.* 1992;136:201-213.
49. Pinhas-Hamiel O, Dolan LM, Daniels SR, Standiford D, Khoury PR, Seitler P. Increased incidence of non-insulin-dependent diabetes mellitus among adolescents. *J Pediatr.* 1996;128:608-615.
50. Wagenknecht LE, Craven TE, Preisser JS, Manolio TA, Winders S, Hulley SB. Ten-year trends in cigarette smoking among young adults, 1986-1996: the CARDIA study. *Ann Epidemiol.* 1998;8:301-307.