Associations of Acculturation and Socioeconomic Status With Subclinical Cardiovascular Disease in the Multi-Ethnic Study of Atherosclerosis

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Objectives. We assessed whether markers of acculturation (birthplace and number of US generations) and socioeconomic status (SES) are associated with markers of subclinical cardiovascular disease—carotid artery plaque, internal carotid intima-media thickness, and albuminuria—in 4 racial/ethnic groups.

Methods. With data from the Multi-Ethnic Study of Atherosclerosis (n=6716 participants aged 45–84 years) and race-specific binomial regression models, we computed prevalence ratios adjusted for demographics and traditional cardiovascular risk factors.

Results. The adjusted US- to foreign-born prevalence ratio for carotid plaque was 1.20 (99% confidence interval [CI]=0.97, 1.39) among Whites, 1.91 (99% CI=0.94, 2.94) among Chinese, 1.62 (99% CI=1.28, 2.06) among Blacks, and 1.23 (99% CI=1.15, 1.31) among Hispanics. Greater carotid plaque prevalence was found among Whites, Blacks, and Hispanics with a greater number of generations with US residence ($P<.001$) and among Whites with less education and among Blacks with lower incomes. Similar associations were observed with intima-media thickness. There was also evidence of an inverse association between albuminuria and SES among Whites and Hispanics.

Conclusions. Greater US acculturation and lower SES were associated with a higher prevalence of carotid plaque and greater intima-media thickness but not with albuminuria. Maintenance of healthful habits among recent immigrants should be encouraged. (*Am J Public Health.* 2008;98:1963–1970. doi:10.2105/AJPH.2007.123844)

Beginning with the Ni-Hon-San study,[1,2] which was initiated in the 1960s, research has associated increased acculturation to Western lifestyles with more-adverse cardiovascular disease (CVD) risk factor profiles and with increased CVD morbidity and mortality. Specifically, greater Western acculturation has frequently been linked to increased body mass index (BMI; weight in kilograms divided by height in meters squared),[3–5] waist circumference and abdominal obesity,[6,7] hypertension,[7–9] type II diabetes,[10,11] and CVD morbidity and mortality.[1,12,13] However, little research has explored associations between acculturation and subclinical CVD.[14,15]

Abundant research also exists that links low socioeconomic status (SES) to increased levels of CVD risk factors, morbidity, and mortality.[14,16–18] In general, SES has been found to be inversely related to subclinical measures of CVD, including coronary artery calcification (CAC),[14,19–22] carotid artery plaque, and intima-media thickness[20,23–26] and albuminuria.[27] Relations with peripheral artery disease have been inconsistent.[28–30] The extent to which these associations vary by race/ethnicity has been examined infrequently. There is, however, some evidence that the relation between SES and disease may differ across racial/ethnic groups.[14,31,32] Specifically, in the Multi-Ethnic Study of Atherosclerosis (MESA) there was a higher prevalence of CAC among Whites with low education than among those with more education, whereas the reverse was true for Hispanics.[14]

We investigated whether acculturation and SES were associated with other measures of subclinical disease, specifically with carotid plaque and albuminuria. The relation of acculturation and SES to CAC has been described in MESA.[14] Although CAC, carotid plaque, and albuminuria are all subclinical measures of CVD and are related to adverse clinical outcomes, these measures represent different aspects of the disease process and have relatively weak intercorrelations.[33] Thus, they may be differentially related to our exposures of interest.

The investigation of these patterns is important from a public health perspective and may yield clues regarding the etiology of atherosclerosis. On the basis of previous work,[14] we hypothesized that increased Western acculturation, as assessed by place of birth, migration history, and duration of US residence, is associated with increased carotid plaque, intima-media thickness, and albuminuria. Additionally, we expected there to be an interaction between race/ethnicity and SES with respect to their associations with subclinical CVD. Specifically, we expected Whites and Blacks at lower SES to have more-adverse subclinical CVD profiles than those at higher SES, whereas for Hispanics and Chinese, we expected the reverse to be true.

METHODS

Study Population

MESA is a prospective epidemiological cohort study that was initiated in July 2000 to explore the prevalence, correlates, and progression of subclinical and clinical CVD.[34] A specific objective of MESA is to assess racial/ethnic, age, and gender differences in subclinical and clinical CVD. Local institutional review committees approved the MESA protocol, and all participants gave informed consent. A total of 6814 men and women aged 45 to 84 years, all of whom were free of reported clinical CVD at baseline, were recruited in 6 US field centers.

Individuals were classified as Hispanic, non-Hispanic Black, non-Hispanic White, or non-Hispanic Chinese on the basis of their answers to questions about race, ethnicity, and nationality that were modeled on questions

from the 2000 Census. White participants were recruited from all study sites. Black participants were recruited from Forsyth County, North Carolina; Chicago, Illinois; New York, New York; Baltimore, Maryland; and Los Angeles, California. Hispanics were recruited from St. Paul, Minnesota; New York City; and Los Angeles. Chinese participants were recruited from Chicago and Los Angeles.

Acculturation and Socioeconomic Status Definitions

Questionnaires administered as part of the baseline visit were used to obtain information on acculturation and SES, with country of birth, migration history, and time in the United States (for those not born in the United States) used as proxy measures of acculturation. For migration history or number of generations in the United States, participants not born in the United States were considered generation zero, those with 1 or both parents not born in the United States were considered first generation, those with both parents born in the United States but 2 or more grandparents not born in the United States were classified as second generation, and those with both parents born in the United States and 3 or more grandparents born in the United States were categorized as third generation.[14] Country of birth was collapsed into region of birth and was used in analyses of the Black and Hispanic subgroups. Black participants were categorized as being from Central America or the Caribbean, Africa, or the United States, and Hispanics were classified as being from Mexico, Central America or the Caribbean, South America, or the United States.

Education and income levels were used as indicators of SES. Participants were asked to select their highest level of schooling completed from 8 categories and their gross family income from 13 categories.[14] A priori, the education and income levels were collapsed into the following smaller categories for use as indicator variables in multivariate analyses: education—grade 8 or lower, grade 9 to 11, completed high school or obtained a general equivalency diploma, graduated technical school or associate degree or some college, undergraduate degree, or graduate or professional school; income—less than $12 000, $12 000 to $24 999, $25 000 to $34 999, $35 000 to $49 999, $50 000 to $74 999, $75 000 to $99 999, or $100 000 or more.

Subclinical Cardiovascular Disease Assessment

Images of bilateral common carotid and internal carotid arteries were obtained via high-resolution B-mode ultrasonography using a Logiq 700 ultrasound machine (GE Medical Systems, Waukesha, WI). Images of the near and far walls of the artery were obtained as in a previous study.[35] Central reading of the intima-media thickness took place at Tufts–New England Medical Center in Boston, Massachusetts. The maximum thicknesses of the common and internal carotid arteries were used in our analyses. Additionally, a dichotomous variable indicated the presence of atherosclerotic plaque (any stenosis in either the right or left internal or common carotid artery).

Urine albumin and creatinine concentrations were assayed in a single untimed urine sample at the Fletcher Allen Health Care Clinical Chemistry Laboratory in Burlington, Vermont. Urine albumin was measured by the Array 360 CE Protein Analyzer (Beckman Instruments, Drea, CA), and serum creatinine was measured by rate reflectance spectrophotometry using thin film adaptation of the creatine amidinohydrolase method on the Vitros analyzer (Johnson & Johnson Clinical Diagnostics, Rochester, NY). To estimate the albumin excretion rate (A/kC), gender-standardized urine albumin (μg/mL) to creatinine (mg/mL) ratios were calculated after multiplying men's urine creatinine concentrations by a constant (k=25/17), on the basis of the higher rate of creatinine excretion typical of men compared with women.[36,37] The gender-standardized urine albumin to creatinine ratio is represented both linearly and dichotomously, with participants having values greater than or equal to 25 mg/g defined as having albuminuria.[36]

Additional Covariates

Gender, age, cigarette smoking status (current, former, never), and use of statins, antihypertensives, and diabetes medications were self-reported. Resting blood pressure was measured 3 times in the seated position using a Dinamap model Pro 100 automated oscillometric sphygmomanometer (Critikon, Tampa, FL). The average of the last 2 measurements was used in the analyses. Participants were asked to fast for at least 8 hours before their baseline visit. Serum glucose was measured by rate reflectance spectrophotometry using thin film adaptation of the glucose oxidase method on the Vitros analyzer.

High-density lipoprotein (HDL) cholesterol was assessed in ethylenediaminetetraacetic acid (EDTA) plasma using the cholesterol oxidase method (Roche Diagnostics, Indianapolis, IN) after precipitation of non-HDL cholesterol with magnesium or dextran. Low-density lipoprotein (LDL) cholesterol was calculated in plasma specimens with a triglyceride value at less than 400 mg/dL using the Friedewald formula. Serum assays were performed at the Collaborative Studies Clinical Laboratory at Fairview-University Medical Center (Minneapolis).

At baseline, diet was assessed using a staff-assisted self-administered 127-item food frequency questionnaire and dietary supplement form, which has been described elsewhere.[38] Servings per day of the following food groups were calculated: fruit, vegetables, whole grains, refined grains, dairy, and meat. Physical activity was assessed with a detailed, semi-quantitative questionnaire adapted from the Cross-Cultural Activity Participation Study (Barbara Ainsworth, PhD, MPH, San Diego State University, oral communication, 1999). Leisure physical activity was computed as the sum of metabolic equivalent (MET)[39]-minutes per week of walking, conditioning, sports, and dance. A sedentary lifestyle score was the sum of MET-minutes per week of sitting or reclining, reading, knitting, sewing, driving a car, or watching television.

Statistical Analysis

All analyses were stratified by race/ethnicity and were performed with SAS version 9.1 (SAS Institute, Cary, NC). Given the large number of comparisons in this analysis, $P<.01$ was required for statistical significance. Means and frequencies of unadjusted demographics, acculturation measures, socioeconomic indicators, and measures of subclinical CVD were computed. Age- and gender-adjusted demographics and traditional CVD risk factors were also computed, stratified by place of birth (United States or other).

For our analyses of plaque and albuminuria, we used race/ethnicity-specific binomial regression models with a logit link (PROC GLIMMIX); we back-transformed predicted logits to give adjusted median prevalence of plaque and albuminuria and to assess differences in prevalence. Mean differences in the natural logarithm of internal carotid intima-media thickness and the natural logarithm of urine albumin excretion were assessed via multiple linear regression (PROC GLM). For primary exposures with more than 2 levels (i.e., education, income, generations of US residence), adjusted prevalence and means were computed with the exposures entered as indicator variables; the *P* value for the linear trend across the groups was computed with ordinal categories entered as continuous variables. The base model (model 1) adjusted for gender, age (years), and relevant combinations of country of birth (United States or other), education (6-level indicator variable), and income (7-level indicator variable).

We developed our second model to determine whether the associations observed were independent of traditional CVD risk factors. This model controlled for model 1 covariates and adjusted for major CVD risk factors, including smoking status (current, former, never), BMI (continuous), LDL cholesterol (continuous), HDL cholesterol (continuous), statin use (yes or no), systolic blood pressure (continuous), hypertension medication use (yes or no), and diabetes status by American Diabetes Association 2003 criteria (yes or no). Overall, differences between the base model (model 1) and the model adjusted for major CVD risk factors (model 2) were minimal. We present results from the base model and note instances in which adjustment for major CVD risk factors substantially affected estimates. We also explored a third model, which further adjusted for diet (fruit, vegetables, refined grains, whole grains, dairy, and meat) and physical activity (leisure physical activity, sedentary lifestyle score). However, as these additional adjustments rarely influenced our results, we chose not to present these data.

RESULTS

Our sample consisted of 2624 White, 803 Chinese, 1895 Black, and 1492 Hispanic participants aged 45–84 years. Race/ethnicity-stratified acculturation measures, socioeconomic indicators, and subclinical measures are shown in Table 1. Chinese participants were the most likely to have been born in another country (96.3%), followed by Hispanics (68.8%), Blacks (9.0%), and Whites (6.6%). On average, Whites born elsewhere had lived in the United States for a longer duration (mean years ±SD; 46 ±19) than had Blacks (38 ±18), Hispanics (30 ±15), and Chinese (19 ±12) participants, respectively. Of Blacks born outside the United States, 66% were born in Central America or the Caribbean, and 27% were born in Africa. Among Hispanics born in another country, 36% were from Mexico, 34% were from Central America or the Caribbean, and 11% were from South America.

Chinese and Hispanics not born in the United States generally had lower levels of income and formal education than those born in the United States (Table 2). BMI was significantly higher in US-born Chinese and Hispanics than in their non–US-born counterparts. Blacks born outside the United States were less likely to smoke than were those born in the United States.

Foreign-born Black and Hispanic participants had a significantly lower prevalence of carotid plaque than did their US-born counterparts (Table 3, Figure 1). We observed a similar trend for White and Chinese participants, although these contrasts did not reach statistical significance. After model 1 adjustments, the US- to foreign-born carotid plaque prevalence ratio was 1.20 (99% confidence interval [CI]=0.97, 1.39) among Whites, 1.91 (99% CI=0.94, 2.94) among Chinese participants, 1.62 (99% CI=1.28, 2.06) among Blacks, and 1.23 (99% CI=1.15, 1.31) among Hispanics. Although plaque prevalence increased with the number of generations the participants' family had lived in the United States in all racial/ethnic groups, it did not reach the chosen significance level among Chinese participants. Among Hispanics born outside the United States, each additional decade of US residence was associated with a 4.4% greater prevalence of plaque, following model 1 adjustments (P=.001). Decades of US residence was not significantly associated with plaque among other racial/ethnic groups (data not shown).

After model 1 adjustments, examination of region of birth revealed that Blacks born in Africa had a lower prevalence of plaque (11.4%) than did those born in the Caribbean and Central America (27.8%), who in turn had a lower prevalence than Blacks born in the United States (42.8%; P<.001 overall). Among Hispanics, those born in South America had the lowest prevalence of plaque (26.2%), followed by those born in the Caribbean and Central America (32.6%), Mexico (36.3%), and the United States (45.1%), respectively (P<.001 overall). Among Chinese, Black, and Hispanic participants, greater Western acculturation, as assessed by both place of birth and generation of US residence, was associated with greater mean internal carotid intima-media thickness, whereas there were no associations among Whites.

Greater educational attainment was associated with a lower prevalence of carotid plaque and with lower mean internal carotid intima-media thickness among Whites but not among other racial/ethnic groups. In Blacks, there was a higher prevalence of carotid plaque among those with lower income, although this association was attenuated with further adjustments. There were no associations between mean internal carotid intima-media thickness and income.

Place of birth and number of generations of US residence were not significantly associated with the prevalence of albuminuria or with mean urine albumin excretion in any racial/ethnic group (data available as a supplement to the online version of this article available at http://www.ajph.org). Among Whites, educational attainment was inversely associated with the prevalence of albuminuria in models 1 and 2. Mean urinary albumin excretion was also lower among Whites with greater education in model 1 but was not associated after model 2 adjustments. In Hispanics, there was some evidence for association of greater income with a lower prevalence of albuminuria and lower urine albumin excretion, whereas there were no relations in other racial/ethnic groups.

DISCUSSION

Our main and novel finding was that among Black and Hispanic participants, being born in the United States and having a

TABLE 1—Measures of Characteristics Among Participants (N = 6814), by Race/Ethnicity: Multi-Ethnic Study of Atherosclerosis, 2000–2002

	Whites	Chinese	Blacks	Hispanics	*P*
Total, no.	2624	803	1895	1492	
Demographics					
Age, y, mean (SD)	62.6 (10.2)	62.3 (10.3)	62.1 (10.0)	61.3 (10.3)	.002
Male, no. (%)	1261 (48.1)	390 (48.6)	844 (44.5)	718 (48.1)	.06
Acculturation measures					
Place of birth, no. (%)					<.001
United States	2445 (93.4)	30 (3.7)	1712 (91.0)	465 (31.2)	
Other country	172 (6.6)	772 (96.3)	169 (9.0)	1027 (68.8)	
Generation in the United States,[a] no. (%)					<.001
0 generations	172 (6.6)	772 (96.3)	169 (9.0)	1027 (68.8)	
First generation	455 (17.4)	28 (3.5)	36 (1.9)	301 (20.2)	
Second generation	656 (25.0)	2 (0.2)	23 (1.2)	111 (7.4)	
Third generation	1334 (51.0)	0 (0)	1653 (87.9)	53 (3.6)	
Socioeconomic indicators					
Income, no. (%)					<.001
< $20 000	277 (10.9)	332 (41.7)	378 (21.8)	573 (39.3)	
$20 000–$49 999	819 (32.1)	238 (29.9)	710 (41.0)	625 (42.9)	
≥ $50 000	1457 (57.0)	227 (28.4)	646 (37.2)	259 (17.8)	
Education, no. (%)					<.001
Less than high school diploma	129 (4.9)	199 (24.8)	230 (12.2)	667 (44.7)	
High school diploma or some college	1189 (45.5)	291 (36.3)	1015 (54.0)	678 (45.4)	
College degree	1298 (49.6)	312 (38.9)	636 (33.8)	147 (9.9)	
Subclinical cardiovascular disease measures					
Carotid plaque, no. %	1197 (46.0)	208 (26.0)	810 (44.0)	574 (39.0)	<.001
Common carotid IMT, mm, geometric mean	0.86	0.82	0.90	0.85	<.001
Internal carotid IMT, mm, geometric mean	1.06	0.83	1.03	0.97	<.001
% with A/kC > 25	248 (9.5)	134 (16.7)	299 (15.8)	234 (15.7)	<.001
Urine albumin excretion, mg/g, geometric mean	6.95	10.29	8.71	10.01	<.001

Note. IMT = intima-media thickness; A/kC = gender-standardized albumin to creatine ratio. Because of missing values in some instances, the sum of the categories is less than the race-specific total.
[a]Generation 0 means participant was not born in the United States; first generation, 1 or both parents were not born in the United States; second generation, both parents were born in the United States but 2 or more grandparents were not born in the United States; and third generation, both parents were born in the United States and 3 or more grandparents were born in the United States.

greater number of generations of US residence were strongly associated with a greater prevalence of carotid plaque. We observed similar trends among White and Chinese participants, although at times they did not reach statistical significance. Moreover, among Hispanic immigrants, the duration of US residence was positively associated with plaque prevalence. Greater Western acculturation was also associated with higher mean maximum internal carotid intima-media thickness in Chinese, Blacks, and Hispanics. These findings are consistent with previous research that has reported positive associations between Westernization and carotid intima-media thickness in Chinese[15] people and with MESA, which has reported positive associations between acculturation and CAC.[14]

Within-race analyses according to region of birth also support the notion that greater acculturation is associated with a greater prevalence of carotid plaque. In our data, Blacks born in Africa had a lower prevalence of plaque (11.4%) than did those born in the Caribbean and Central America (27.8%), who in turn had a lower prevalence than did Blacks born in the United States (42.8%). Among Hispanics, those born in South America had the lowest prevalence of plaque (26.2%), followed by those born in the Caribbean and Central America (32.6%), Mexico (36.3%), and the United States (45.1%).

Furthermore, there was some evidence of an inverse association between SES and carotid plaque. In Whites, educational attainment was inversely related to carotid plaque prevalence and mean internal carotid intima-media thickness, whereas in Blacks there was an inverse association between household income and carotid plaque prevalence. Inverse associations between carotid plaque and SES have been reported in other populations.[20,23–26]

In a recent meta-analysis, the relative risk per 0.10 mm common carotid intima-media thickness difference was 1.15 (95% CI=1.12, 1.17) for myocardial infarction and 1.18 (95% CI=1.16, 1.21) for stroke.[40] Thus, the intima-media thickness differences we observed in relation to acculturation and SES, frequently on the magnitude of 0.05 mm, are potentially clinically relevant. Current levels of CVD risk factors (gender, age, LDL cholesterol, HDL cholesterol, statin use, BMI, systolic blood pressure, hypertension medication use, smoking status, diabetes status) did not appear to account for the patterns of acculturation and SES we observed with carotid plaque. Although this is surprising, several possible explanations exist. First, error in the measurement of risk factors may have contributed. Second, as has been suggested previously,[41–43] early risk factor levels and cumulative environments, which we did not measure, are probably important in the development of atherosclerotic carotid plaque. Finally, it is possible that other unidentified factors related to US acculturation and SES may explain their associations with carotid plaque.

Within racial/ethnic groups, prevalent albuminuria was not associated with acculturation, and there was little variation with level of SES. The prevalence of albuminuria was inversely associated with education in Whites and with

TABLE 2—Socioeconomic Characteristics and Cardiovascular Risk Factors of US- and Non–US-Born Participants, by Race/Ethnicity: Multi-Ethnic Study of Atherosclerosis, 2000–2002

	White			Chinese			Black			Hispanic		
	US Born	Non-US Born	P[a]	US Born	Non-US Born	P[a]	US Born	Non-US Born	P[a]	US Born	Non-US born	P[a]
Total, no.	2445	172		30	772		1712	169		465	1029	
Demographic characteristics												
Men, %	48.3	43.5	.23	56.7	48.2	.36	44.6	45.7	.77	52.9	45.9	.01
Mean age, y	62.5	63.8	.12	61.1	62.4	.52	62.5	58.4	<.001	61.6	61.1	.38
Socioeconomic indicators												
Education[b]			.08			.005			.09			<.001
Less than high school diploma	4.8	6.4		3.3	25.7		11.9	15.4		20.0	55.9	
High school diploma or some college	46.0	37.4		33.3	36.4		53.6	58.0		67.7	35.4	
College degree	49.2	56.1		63.3	38.0		34.5	26.6		12.3	8.8	
Income,[b] %			.96			<.001			.87			<.001
< $20 000	10.8	11.2		3.5	43.1		21.6	23.5		25.5	45.7	
$20 000–$49 999	32.1	31.2		34.5	29.7		41.0	40.1		45.8	41.6	
≥ $50 000	57.0	57.7		62.1	27.2		37.3	36.4		28.8	12.7	
Behavioral and physiological characteristics												
Smoked within past 30 days, %	11.3	14.5	.21	5.9	5.6	.95	19.3	4.8	<.001	14.6	13.1	.42
Diabetes, %	4.3	5.2	.58	7.1	10.4	.56	14.2	5.5	.67	16.5	13.5	.12
BMI, kg/m^2, mean	27.8	27.2	.14	25.7	23.9	.004	30.2	29.4	.05	30.6	28.9	<.001
Statin use, %	16.6	16.5	.96	24.5	12.4	.05	15.8	12.2	.23	14.1	11.2	.11
LDL cholesterol level, mg/dL, mean	117.0	119.0	.36	108.0	115.0	.16	116.0	119.0	.38	117.0	121.0	.05
HDL cholesterol level, mg/dL, mean	52.2	53.2	.34	53.8	49.4	.05	52.3	53.3	.35	47.8	47.6	.80
Hypertension medication use, %	32.9	35.4	.49	18.4	29.2	.18	50.4	47.7	.48	32.2	32.5	.91
Systolic blood pressure, mm Hg, mean	124.0	120.0	.02	125.0	125.0	.82	131.0	129.0	.08	126.0	127.0	.17

Note. BMI = body mass index; LDL = low-density lipoprotein; HDL = high-density lipoprotein. Means and proportions of cardiovascular risk factors are adjusted for age and gender.
[a]For difference between US- and non-US-born individuals.
[b]Unadjusted values.

income in Hispanics. We did not observe any other associations. These findings are concordant with data from the Third National Health and Nutrition Examination Survey, which found a greater prevalence of albuminuria among participants living in poverty than among those living above the poverty level.[27]

The extent of differences in the relation between carotid plaque and measures of acculturation and SES, compared with those observed with albuminuria, is quite striking. However, these subclinical measures are heterogeneous and are relatively weakly correlated,[33] and each assesses a different aspect of subclinical CVD. Carotid intima-media thickness is an intermediate phenotype for early atherosclerosis in the large arteries,[40] whereas albuminuria is an indicator of microvascular disease.[44] Thus, the finding that there were different associations between our exposures and carotid plaque and albuminuria is not entirely unexpected.

Limitations

A major limitation of our analysis is that although the sample size for the different racial/ethnic groups may have been larger than that of other studies, stratification of acculturation and SES within racial/ethnic groups sometimes resulted in small numbers. Consequently, the study may have been underpowered and not able to find weak but real associations in some instances. Furthermore, within races/ethnicities, acculturation and SES were considerably associated with age; despite model adjustments for age, residual confounding by age may have remained.

An additional limitation of this study is its cross-sectional design, which inhibited us from inferring that either US acculturation or SES was causally related to measures of subclinical CVD. Further, acculturation and SES are complex constructs that are difficult to accurately measure. As demonstrated by the Ni-Hon-San study, assessing migration status or duration of residence may not be sufficient to fully capture acculturative processes.[2] Unfortunately, a validated acculturation scale was not administered in MESA. Yet, the measures we operationalized—place of birth and generations of US residence—have been used widely in other studies of acculturation and are thought to provide valuable information. Similarly, education and income are among the most commonly employed indicators of SES. Although there is no single best indicator of SES, because each emphasizes a particular aspect of social stratification, most indicators of SES are correlated.[45]

TABLE 3—Race/Ethnicity-Stratified Prevalence of Carotid Plaque and Mean Maximum Internal Carotid Intima-Media Thickness, by Acculturative and Socioeconomic Characteristics: Multi-Ethnic Study of Atherosclerosis, 2000–2002

	White (n = 2624)				Chinese (n = 803)				Black (n = 1895)				Hispanic (n = 1492)			
	Model 1	*P*	Model 2	*P*	Model 1	*P*	Model 2	*P*	Model 1	*P*	Model 2	*P*	Model 1	*P*	Model 2	*P*
Prevalence of carotid plaque																
Place of birth, %		.03		.02		.02		.02		< .001		< .001		.001		.003
Foreign born	37		35		23		22		24		25		34		34	
US born	46		45		45		44		43		42		45		44	
Generation in United States,[a,b] %		< .001		.003		.02		.02		< .001		< .001		.001		.002
0 generation	36		35		23		22		24		25		34		34	
First generation	41		41		45		44		37		36		43		42	
Second generation	45		45		. . .		. . .		53		53		49		48	
Third generation	48		47		. . .		. . .		43		42		48		48	
Education,[a] %		< .001		< .001		.74		.80		.53		.73		.08		.20
Less than high school diploma	51		46		24		23		44		44		40		38	
High school diploma or some college	52		50		23		22		40		40		37		37	
College degree	39		40		23		22		40		41		29		30	
Income,[a], %		.02		.10		.53		.35		.002		.02		.41		.12
< $20 000	48		45		23		23		48		46		39		38	
$20 000–$49 999	49		48		29		28		42		41		37		36	
$50 000	42		42		19		17		35		37		35		37	
Maximum internal carotid IMT (mm)																
Place of birth, geometric mean		.27		.25		.007		.004		< .001		.003		< .001		.003
Foreign born	1.01		1.01		.82		.82		.88		.91		.94		.95	
US born	1.05		1.05		1.02		1.04		1.03		1.03		1.04		1.03	
Generations in United States,[a,b] geometric mean		.05		.14		.007		.004		< .001		.002		< .001		< .001
0 generations	1.01		1.01		.82		.82		.88		.91		.94		.95	
First generation	1.02		1.03		1.02		1.04		.94		.94		1.01		1.0	
Second generation	1.05		1.05		. . .		. . .		1.07		1.07		1.03		1.02	
Third generation	1.07		1.06		. . .		. . .		1.03		1.03		1.21		1.21	
Education,[a] geometric mean		< .001		< .001		.40		.42		.11		.15		.40		.71
Less than high school diploma	1.16		1.12		.86		.86		1.1		1.1		.98		.97	
High school diploma or some college	1.11		1.09		.81		.81		1.0		1.0		.98		.98	
College degree	.99		1.0		.83		.83		1.0		1.01		.92		.93	
Income,[a] geometric mean		.05		.29		.56		.34		.04		.16		.32		.62
< $20 000	1.08		1.05		.83		.84		1.06		1.05		.98		.98	
$20 000–$49 999	1.08		1.07		.86		.85		1.02		1.02		.97		.96	
≥ $50 000	1.03		1.04		.80		.80		.98		.99		.94		.97	

Note. IMT = intima-media thickness. For model 1, each independent variable (place of birth, generations in US, education, and income) was considered one at a time and adjustments were made for age and gender. For place of birth and generations in the United States, each variable included education (6 levels) and income (7 levels). For income (3 levels), each level included place of birth and education (6 levels), and for education (3 levels), each level included place of birth and income (7 levels). Model 2 was adjusted for all variables in model 1 plus low-density lipoprotein cholesterol level, high-density lipoprotein cholesterol level, statin use, body mass index (in kg/m^2), systolic blood pressure, hypertension medication use, smoking status (current, former, never), and diabetes status. Ellipses indicate that the value was inestimable because of a small sample size.

[a]*P* value for linear trend across groups.

[b]Generation 0 means participant was not born in the United States; first generation, 1 or both parents were not born in the United States; second generation, both parents were born in the United States but 2 or more grandparents were not born in the United States; and third generation, both parents were born in the United States and 3 or more grandparents were born in the United States.

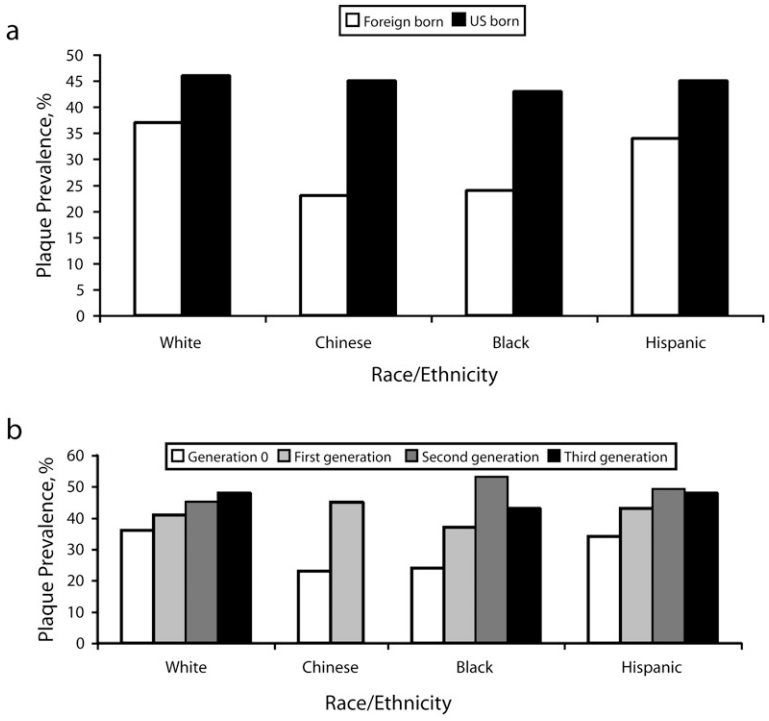

FIGURE 1—Prevalence of carotid plaque stratified by race/ethnicity and adjusted for age, gender, education, and income, by place of birth (a) and generation of US residence (b): Multi-Ethnic Study of Atherosclerosis, 2000–2002.

Additionally, it has been suggested by some that indicators of SES may have different meanings in different racial/ethnic groups.[46,47] As a final limitation, the measures of SES we examined were assessed only once in middle or late adulthood. Adult measures are only limited proxies for socioeconomic trajectories over the life course that are also clearly relevant to the development of atherosclerosis.[14]

Conclusions

Across all racial/ethnic groups, the prevalence of carotid plaque and mean intima-media thickness were substantially higher among those with greater US acculturation and lower SES, even after adjustment for traditional CVD risk factors. The relations with albuminuria were less convincing, although there was some evidence that SES was inversely associated with albuminuria prevalence. An implication of this analysis is that as greater acculturation is associated with increased carotid plaque, efforts should be considered to encourage maintenance of healthful habits among recent immigrants. This recommendation is particularly salient given that the proportion of immigrants living in the United States has increased dramatically in recent decades, with immigrants comprising an estimated 10.4% of the nation's population in 2000.[48] These data also highlight the known association between low SES and CVD health disparities within the United States. ■

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Contributors

P.L. Lutsey and A.R. Folsom designed the study and led in writing the article. P.L. Lutsey and D.R. Jacobs Jr conducted the analyses. All authors helped to conceptualize ideas, interpret findings, and review drafts of the article.

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Human Participant Protection

Local institutional review committees approved the MESA protocol, and all participants gave informed consent.

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