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Original Contribution

Do Socioeconomic Gradients in Body Mass Index Vary by Race/Ethnicity, Gender, and Birthplace?

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Despite the well-documented negative socioeconomic status (SES) gradient in body mass index (BMI; weight (kg)/height (m)^2) among women in developed societies, the presence and strength of the gradient is less consistent among men. Far less clear is the SES patterning of BMI among racial/ethnic minorities and immigrants. Using data from the 2001 California Health Interview Survey, a cross-sectional representative sample of California adults, the authors examined whether the SES patterning of BMI varied across 4 major US racial/ethnic groups ($n = 37{,}150$) by gender and birthplace. The shape and strength of the relation between SES and BMI differed markedly by race/ethnicity; and within racial/ethnic groups, it varied by gender. Irrespective of race/ethnicity, there were negative income and education gradients in BMI among women; however, there was considerable variation among men. The effect of education on BMI differed by birthplace in some groups. A clear education gradient in BMI was found among all US-born participants, a quadratic education pattern in BMI was found among foreign-born Asian men, a flat pattern was found among foreign-born Asian women, and no clear pattern was found in the remaining foreign-born groups. There is substantial heterogeneity in the contemporaneous SES gradient in BMI. US social disparities in BMI require simultaneous consideration of race/ethnicity and SES, but also birthplace.

body mass index; continental population groups; emigrants and immigrants; ethnic groups; obesity; population groups; sex factors; social class

Abbreviations: BMI, body mass index; NHANES, National Health and Nutrition Examination Survey; SES, socioeconomic status.

Epidemiologists have consistently documented an inverse association between socioeconomic status (SES) and health (1–6). However, there are indications that SES gradients may vary by gender, race/ethnicity, and immigration status. In relation to body mass index (BMI) and obesity, numerous studies have shown a strong inverse SES gradient among women in economically developed societies, but such a gradient is less consistent among men (7). Far less clear is the SES patterning in BMI across the 4 major US racial/ethnic groups and among immigrants.

While some evidence suggests that the socioeconomic patterning in BMI is different among blacks and Mexican Americans compared with whites (8, 9), few investigators have examined these patterns among Asians. Additionally, research that explicitly examines SES gradients in BMI among Hispanics is relatively recent (8, 10, 11); yet Hispanics are the largest and fastest-growing minority in the United States and a greatly heterogeneous group with a high proportion (~40%) of foreign-born persons (12).

Furthermore, evidence indicates that BMI is lower among immigrants than among the US-born (13–15), although immigrants typically have lower SES than their US-born counterparts (16). The SES patterns in BMI may differ among immigrants based on whether they immigrated from countries where the SES-BMI association is positive (17) or negative (18–20). Despite rapid growth of the foreign-born population (16, 21–23), the socioeconomic gradient in health among immigrants has been infrequently examined systematically (1, 24).

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To strengthen knowledge on US socioeconomic inequalities in BMI, we used white, black, Asian, and Hispanic samples to investigate 1) whether the SES gradients in BMI observed among men and women in the overall US population are shared across 4 racial/ethnic groups in California and 2) whether the SES-BMI association varies according to birthplace within gender-race groups.

MATERIALS AND METHODS

Study population

We used cross-sectional data from the 2001 California Health Interview Survey, a biannual population-based telephone survey of 56,270 civilian households in California. The survey employed random digit dialing to select households, with oversampling of Asian subgroups, blacks, and some Latinos. From each sampled household, 1 adult aged 18 years or older was randomly selected and asked to give consent. Data were collected between November 2000 and October 2001. Respondents were interviewed in English, Spanish, Chinese (Mandarin or Cantonese), Vietnamese, Korean, or Cambodian. The California Health Interview Survey is comparable to telephone surveys conducted by the National Center for Health Statistics. California Health Interview Survey data are weighted to account for the complex sample design, and the data are adjusted for nonresponse and for households without telephones (25). The California Health Interview Survey was designed to provide population-based estimates for California's overall adult population and its major racial/ethnic groups.

We used SAS-callable SUDAAN software (Research Triangle Institute, Research Triangle Park, North Carolina) to adjust for the complex survey sampling design. A 2-tailed P value of <0.05 was considered statistically significant for all analyses, including interaction terms. We received institutional review exemption from the Harvard School of Public Health human subjects committee.

Body mass index

A continuous outcome, BMI was calculated as weight in kilograms divided by height in meters squared. We used BMI because it is insensitive to cutoffs in Asian populations, which have been previously contested (26, 27).

Exposure variables

Total annual household income before taxes was adjusted for household size, using a standard approach previously employed in the Luxemburg Income Study (28). Equivalized annual income was categorized as follows: <\$15,000, \$15,001–\$30,000, \$30,001–\$50,000, \$50,001–\$75,000, or ≥\$75,001. Education was categorized as less than high school, completion of high school or 12th grade, some college or an associate degree, a college (bachelor's) degree, or any graduate-level schooling. Birthplace was based on whether respondents had been born in the United States or elsewhere and was classified as US-born versus foreign-born.

Other covariates included gender; self-reported race/ethnicity, categorized as white, black, Asian/Pacific Islander, or Hispanic; marital status, classified as married versus never married, separated, living with a partner, or divorced; self-identified national origin for Hispanics (Mexican, Central American, Puerto Rican, South American, other Hispanic, or Hispanic with 2 or more ethnicities) and Asian subgroups (Chinese, Filipino, Korean, Vietnamese, Pacific Islander, other Asian, or Asian with 2 or more ethnicities); and fruit and vegetable consumption, categorized as whether or not respondents had consumed 5 or more servings of fruits and vegetables daily in the past week. Exercise was a dichotomous variable indicating whether the respondent had engaged in any moderate or vigorous physical activity (defined as exercise that caused light sweating or a slight-to-moderate increase in breathing or heart rate) in the past month (25). Current smoking versus "other" was a dichotomous variable, where current smokers were defined as persons who had smoked at least 100 cigarettes in their entire lifetime and currently smoked cigarettes either daily or on some days. Alcohol use was categorized as no alcohol consumption, infrequent-to-moderately frequent consumption of small quantities, frequent consumption of small quantities, and consumption of large quantities (regardless of frequency). Age was used as a continuous covariate, starting at 25 years as the lower cutpoint, because education is generally completed after this age. We used age 64 years as the upper cutpoint because BMI has been found to be less informative of health risks and mortality in the elderly population (29, 30).

Statistical analysis

Younger (<25 years) and older (≥65 years) adults (n = 14,702), persons of "other" race/ethnicity and American Indians/Alaska Natives (n = 1,755), pregnant women (n = 440), participants with missing data on BMI (n = 1,019), persons with a BMI above 65 (n = 52), and participants with missing information on the covariates of interest (n = 1,152) were excluded from all analyses. The potential for bias associated with missing data was examined by comparing participants with missing and nonmissing data. Moreover, sensitivity analyses were conducted to assess the extent of the effect of bias on regression results due to missing BMI. First, we refitted the regression models (as described below) imputing missing BMI at the lower 10th percentile or the 90th percentile of the BMI distribution. This is consistent with the assumption that BMI could be missing not at random, which would incur the highest possible bias. Second, for groups which had the highest proportion of missing data on the covariates, we refitted the regression models including respondents with missing information as a separate category.

Gender differences in BMI and in demographic, socioeconomic, and behavioral factors were evaluated by race/ethnicity using t tests and chi-square statistics. We computed weighted mean BMIs for men and women within each racial/ethnic group and compared these values across levels of income and education.

To justify stratification of the analysis by race/ethnicity, we used the full sample to test for an interaction between

Table 1. Characteristics of Participants Aged 25–64 Years, by Race/Ethnicity and Gender, California Health Interview Survey, 2001[a]

	Whites		Blacks		Asians		Hispanics	
	Women (n = 14,191)	Men (n = 10,773)	Women (n = 1,237)	Men (n = 704)	Women (n = 2,035)	Men (n = 1,584)	Women (n = 3,757)	Men (n = 2,869)
Mean age, years	44.6 (0.1)[b]	44.1 (0.1)	42.8 (0.4)	43.4 (0.5)	42.1 (0.3)	41.5 (0.3)	39.4 (0.2)	38.2 (0.2)
Married	63.2	65.1	34.2	47.3	72.8	73.8[c]	60.2	66.9
Education								
Less than high school	6.1	5.7	9.6	9.2[c]	12.7	9.1	56.5	53.6[c]
High school or grade 12	20.9	19.5	25.6	21.0	16.6	12.9	19.8	22.5
Some college or associate degree	32.6	27.4	37.4	40.2	19.9	17.8	15.7	15.3
Bachelor's degree	24.9	26.7	17.9	17.2	37.2	34.5	5.8	6.2
Any graduate school	15.6	20.8	9.4	12.4	13.8	25.6	2.2	2.5
Equivalized annual income								
<$15,000	13.9	10.9	40.6	26.0	27.8	21.3	67.4	59.8
$15,001–$30,000	22.7	18.6	23.7	24.6	22.6	18.9	19.5	22.8
$30,001–$50,000	29.5	28.2	19.8	24.7	22.8	24.5	8.5	11.4
$50,001–$75,000	16.6	18.7	9.2	12.8	12.4	16.2	2.5	3.7
≥$75,001	17.3	23.7	6.8	12.0	14.4	19.1	2.1	2.4
Birthplace								
US-born	90.2	90.9[c]	95.5	90.2	16.3	19.3[c]	25.5	25.1[c]
Foreign-born	9.8	9.1[c]	4.5	9.8	83.7	80.7	74.5	74.9
Behavioral factors								
Did not exercise in past month	18.8	12.6	35.3	24.3	39.5	27.2	50.5	37.2
Did not consume 5 or more fruits or vegetables in past month	54.1	41.3	64.8	54.5	59.3	49.8	49.3	43.8
Not a current smoker	81.1	78.8	77.5	73.7[c]	93.7	76.1	91.0	78.2
Alcohol use								
No alcohol consumption	34.9	26.3	50.5	39.2	67.2	39.4	62.8	36.1
Infrequent-to-moderately frequent consumption of small quantities	41.7	32.7	36.3	34.6	27.1	38.2	28.2	24.3
Frequent consumption of small quantities	15.8	20.9	4.8	10.0	4.0	9.4	1.39	5.5
Consumption of large quantities (regardless of frequency)	7.6	20.2	8.4	16.3	1.7	13.0	7.5	34.2

[a] All data presented are percentages except those for age. Percentages are weighted to reflect California population estimates.
[b] Numbers in parentheses, standard error.
[c] There were no statistically significant gender differences; otherwise, covariates were statistically significant at $P < 0.01$ by way of χ^2 tests or t tests.

SES and race/ethnicity in a regression model that controlled for race/ethnicity, income, education, age, marital status, gender, fruit and vegetable consumption, smoking, exercise, and alcohol use. To further justify stratification by gender, we tested for an interaction between SES and gender in analyses stratified by race/ethnicity. In race/ethnicity- and gender-stratified analyses, we tested for an interaction between SES and birthplace among Asians, Hispanics, and whites. All regression models in stratified analyses controlled for demographic and behavioral factors. The foreign-born black sample was small; thus, testing for interactions in this group was not feasible. Because income and education may influence health outcomes in distinct ways (31), the models simultaneously adjusted for both.

We tested for a linear trend and a deviation from linearity in the effects of education and income on BMI and for a quadratic trend where necessary.

RESULTS

There were 37,150 adults in our analytic sample, which included 56% whites, 6% blacks, 13% Asians, and 25% Hispanics (weighted to represent California population

Table 2. Mean Body Mass Index[a] Among Participants Aged 25–64 Years, by Race/Ethnicity, Gender, and Socioeconomic Status, California Health Interview Survey, 2001[b]

	Whites		Blacks		Asians		Hispanics	
	Women (n = 14,191)	Men (n = 10,773)	Women (n = 1,237)	Men (n = 704)	Women (n = 2,035)	Men (n = 1,584)	Women (n = 3,757)	Men (n = 2,869)
Education								
Less than high school (referent)	27.8 (0.4)[c]	27.9 (0.4)	30.7 (1.0)	28.8 (0.9)	23.6 (0.4)	24.2 (0.4)	29.4 (0.3)	28.4 (0.2)
High school or grade 12	26.7** (0.2)	27.6[d] (0.1)	29.3[d] (0.4)	27.6[d] (0.5)	23.7[d] (0.3)	25.8* (0.7)	27.6 (0.3)	28.1[d] (0.2)
Some college or associate degree	26.2 (0.1)	27.7[d] (0.1)	30.0[d] (0.4)	28.6[d] (0.4)	23.7[d] (0.3)	26.0 (0.3)	27.4 (0.3)	28.7[d] (0.3)
Bachelor's degree	24.3 (0.1)	26.9** (0.1)	27.6** (0.5)	28.6[d] (0.6)	23.0[d] (0.1)	25.0* (0.2)	26.4 (0.5)	27.4** (0.3)
Any graduate school	24.5 (0.2)	26.5 (0.1)	26.8 (0.7)	27.2[d] (0.7)	22.2 (0.2)	24.4[d] (0.2)	26.2 (0.6)	27.1* (0.6)
Equivalized annual income								
<$15,000 (referent)	27.3 (0.2)	27.5 (0.2)	30.5 (0.6)	28.6 (0.6)	23.7 (0.3)	24.9 (0.4)	29.0 (0.2)	28.4 (0.2)
$15,001–$30,000	26.5** (0.2)	27.4[d] (0.2)	29.3[d] (0.5)	27.8[d] (0.5)	23.4[d] (0.3)	25.3[d] (0.3)	27.9** (0.3)	28.3[d] (0.2)
$30,001–$50,000	25.6 (0.1)	27.3[d] (0.1)	27.7 (0.4)	28.5[d] (0.5)	23.2[d] (0.2)	25.5[d] (0.3)	27.2 (0.4)	28.5[d] (0.2)
$50,001–$75,000	25.1 (0.1)	27.1[d] (0.1)	27.6 (0.6)	27.7[d] (0.5)	22.9[d] (0.3)	24.8[d] (0.2)	27.1** (0.7)	27.6[d] (0.3)
≥$75,001	23.9 (0.1)	26.9** (0.1)	27.1 (0.7)	28.4[d] (0.6)	22.2 (0.2)	24.5[d] (0.2)	26.3** (0.8)	27.2* (0.5)

* $P < 0.05$; ** $P < 0.01$.
[a] Weight (kg)/height (m)^2. All data presented are weighted mean values.
[b] Unless otherwise indicated, differences are statistically significant at $P < 0.001$ based on t tests within race/ethnicity-gender groups, with the lowest education and income groups used as the reference categories.
[c] Numbers in parentheses, standard error.
[d] Not significant.

estimates). Respondents missing data on BMI were more likely to be Hispanic, female, and less educated (less than some college), to have a low annual household income, and to be foreign-born. Additionally, out of the 1,152 participants with missing information on the covariates, 63% had missing data on fruit and vegetable intake. Having missing fruit and vegetable data was associated with lower BMI only among Asian men ($P = 0.008$). However, results from sensitivity analyses (available upon request) suggested that the likelihood of material biases associated with missing data among Hispanics and Asian men was fairly small and that within Hispanics, the results reported below are probably conservative. Moreover, since the proportion of missing-BMI participants among Asians (1.5%), whites (1.46%), and blacks (1.65%) was much smaller than that among Hispanics and the overall proportions of participants with missing data among the other covariates were also relatively small (~1%), the likelihood of a material bias would be even more minimal.

Table 1 shows that within all racial/ethnic groups, there were significant income disparities by gender, with higher proportions of women than men being represented at the bottom of the income distribution. Among Asians and whites (but not blacks and Hispanics), there were significant gender differences in educational attainment.

Mean BMI by SES, race/ethnicity, and gender

Table 2 displays mean BMI by SES, race/ethnicity, and gender. There was a negative education gradient in BMI among white and Hispanic women, but there were no clear patterns among black and Asian women. Regardless of race/ethnicity, there was a clear negative income gradient in BMI among females. However, the education and income patterns in BMI were considerably less discernible among men.

Do SES gradients in BMI vary across racial/ethnic and gender groups?

In analyses stratified by race/ethnicity, the interaction between SES and gender was statistically significant for whites, Hispanics, and blacks. Among Asians, the education × gender (but not income) interaction was significant, although we included it for comparison purposes.

The SES gradients tended to be weaker among men than among women in all racial/ethnic groups, but there were variations by race/ethnicity for each gender in both the shape and level of the gradient. Specifically, the education and income gradients were stronger among women than among men (Figure 1 and Table 3). In women, we found a significant negative linear trend in the income gradient in BMI across all racial/ethnic groups. Education was inversely associated with BMI, although we found evidence of a deviation from linearity among Hispanic, black, and white women. For Hispanic women, the deviation from linearity was primarily driven by the dramatic decrease in mean BMI from less than a high school education to high school graduation. For black women, the source of the deviation from linearity was the increase in BMI among

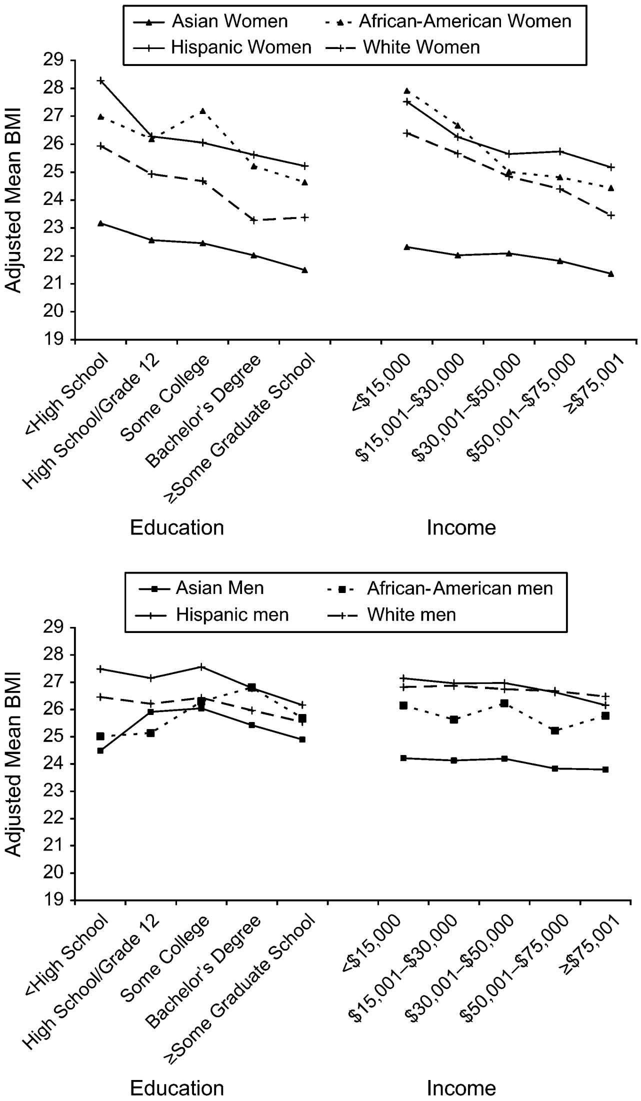

Figure 1. Socioeconomic gradients in body mass index (BMI; weight (kg)/height (m)^2) by race/ethnicity and gender, California Health Interview Survey, 2001. Estimated mean values were derived from analyses stratified by race/ethnicity, based on a linear regression model with adjustment for age, marital status, immigrant status, exercise, fruit and vegetable consumption, smoking, and alcohol use and simultaneous control for both income and education and their interaction with gender.

persons with some college education and a downward decrease in BMI thereafter. For white women, there was a plateau in mean BMI after attainment of a bachelor's degree.

Contrary to findings for women, the income patterns in BMI among men varied markedly by race/ethnicity. While there was a clear negative income gradient in BMI among Hispanic males, the income patterning in BMI among white and Asian men was nearly flat. Only among white and Hispanic men was there a negative association of education with BMI. We found evidence of a deviation from linearity in the effect of education on BMI among white men, where mean BMI appeared to stabilize between a high school education and some college education, decreasing thereafter. By contrast, among Asian men, we observed a significant quadratic trend in the association between education and BMI, where mean BMI increased with increasing education, peaked at some college education, and then declined with increasing education. There were no clear patterns in BMI relative to income or education among black men.

Does the SES-BMI association vary by birthplace?

The interaction between education and birthplace was significant among Asians and Hispanic men, but not among whites or Hispanic women (Figures 2–4). While the education pattern in BMI was nearly flat among foreign-born Asian men and women and Hispanic men, there were clear negative education gradients among their respective US-born counterparts (Figures 2 and 3). Importantly, the nonsignificant interaction among whites and Hispanic women provides evidence that the effect of education on BMI did not differ according to birthplace (Figures 3 and 4). Namely, irrespective of birthplace, there were negative and generally similar education gradients in these groups. Finally, the interaction between income and birthplace was significant only among Hispanic men. Nevertheless, the patterns were generally similar to those described for the education × birthplace interaction (e.g., a negative income gradient among all US-born participants and a shallower income pattern among the foreign-born participants, with the exception of white men).

DISCUSSION

Our analyses of the socioeconomic patterning in BMI from a representative sample of the California adult population revealed that the shape and strength of the relation between SES and BMI differed markedly by race/ethnicity, and within racial/ethnic groups, it varied by gender. Specifically, irrespective of race/ethnicity, there were negative income and education gradients in BMI among women. However, there was considerable variation among men. Moreover, this study demonstrated a differential effect of education on BMI by birthplace among Asians and Hispanic men and a differential effect of income on BMI among Hispanic men.

To our knowledge, this study is one of the first to have explicitly and systematically examined differential patterns in the effects of income and education on BMI by birthplace across racial/ethnic and gender groups. Another unique contribution of this study is that it presents the strongest evidence to date on the existence of a negative SES gradient in BMI among Hispanics, identifying a steeper SES gradient among women than among men. Combined, these results reveal substantial heterogeneity in the socioeconomic patterning of BMI, highlighting the need to simultaneously consider not only race/ethnicity and SES but also birthplace. Particularly important among Asians, investigations that did not consider birthplace would mask the negative education gradient among the US-born and thwart distinctions in the

Table 3. Association of Education and Income With Body Mass Index[a] in Multiple Linear Regression Models,[b] by Race/Ethnicity and Gender, California Health Interview Survey, 2001

	Asians				Blacks				Hispanics				Whites			
	Women		Men		Women		Men		Women		Men		Women		Men	
	β	95% CI	β	95% CI	β	95% CI	β	95% CI	β	95% CI	β	95% CI	β	95% CI	β	95% CI
Education																
Less than high school	1.38	0.5, 2.25	−0.1	−1.15, 1.96	0	Referent	0	Referent	0	Referent	0	0	1.94	1.2, 2.67	1.62	0.83, 2.41
High school or grade 12	0.92	0.26, 1.59	1.08	−0.16, 2.32	−0.41	−2.2, 1.38	−0.312	−2.38, 1.75	−1.66	−2.45, −0.87	−0.618	−1.33, 0.09	1.15	0.79, 1.52	1.14	0.8, 1.47
Some college or associate degree	0.87	0.28, 1.46	1.22	0.4, 2.04	0.674	−1.13, 2.48	0.685	−1.4, 2.77	−1.9	−2.66, −1.13	−0.189	−0.94, 0.56	0.99	0.59, 1.4	1.25	0.93, 1.56
Bachelor's degree	0.49	0.01, 1.97	0.61	0.01, 1.21	−1.15	−3.31, 1.01	0.941	−1.69, 3.57	−2.37	−3.44, −1.29	−0.853	−1.72, 0.02	−0.1	−0.5, 0.23	0.53	0.21, 0.84
Any graduate school	0	Referent	0	Referent	−1.64	−4, 0.71	−0.107	−2.68, 2.46	−2.85	−4.26, −1.44	−1.51	−2.82, −0.2	0	Referent	0	Referent
P for overall gender × education interaction	0.002				0.02				0.001				0			
P for deviation from linearity	0.806		0.006		0.05		0.22		0.07		0.19		0.0002		0.0046	
P for linear trend	0.001		0.81		0.147		0.73		0.0001		0.021		0		0	
Equivalized annual income																
<$15,000	0.57	−0.1, 1.25	0.95	−0.2, 2.1	0	Referent	0	Referent	0	0	0	0	1.83	1.36, 2.31	0.1	−0.37, 0.57
$15,001–$30,000	0.59	−0.07, 1.24	0.8	0.03, 1.57	−0.99	−2.39, 1.42	−0.91	−2.41, 0.59	−0.77	−1.5, −0.03	−0.68	−1.24, −0.12	1.48	1.08, 1.87	0.07	−0.3, 0.44
$30,001–$50,000	0.69	0.08, 1.29	0.86	0.14, 1.58	−2.3	−3.99, −0.61	−0.288	−2.12, 1.54	−1.09	−2, −0.17	−0.915	−1.69, −0.14	0.96	0.6, 1.31	0.01	−0.3, 0.32
$50,001–$75,000	0.47	−0.16, 1.09	0.16	−0.44, 0.75	−2.32	−4.37, −0.27	−1.49	−3.13, 0.15	−0.88	−2.3, 0.55	−1.571	−2.5, −0.64	0.72	0.37, 1.06	0.08	−0.25, 0.41
≥$75,001	0	Referent	0	Referent	−2.39	−4.73, −0.04	−1.067	−2.97, 0.83	−1.61	−3.24, 0.03	−1.998	−3.25, −0.75	0	Referent	0	Referent
P for overall gender × income interaction	0.81				0.01				0.01				0			
P for deviation from linearity	0.45		0.614		0.33		0.31		0.7		0.82		0.28		0.94	
P for linear trend	0.13		0.04		0.02		0.2		0.07		0.001		0		0.7	

Abbreviation: CI, confidence interval.

[a] Weight (kg)/height (m)^2.

[b] Education and income were modeled together. Results were controlled for age, marital status, birthplace, ethnic ancestry (among Hispanics and Asian women), exercise, fruit and vegetable consumption, alcohol use, and current smoking status.

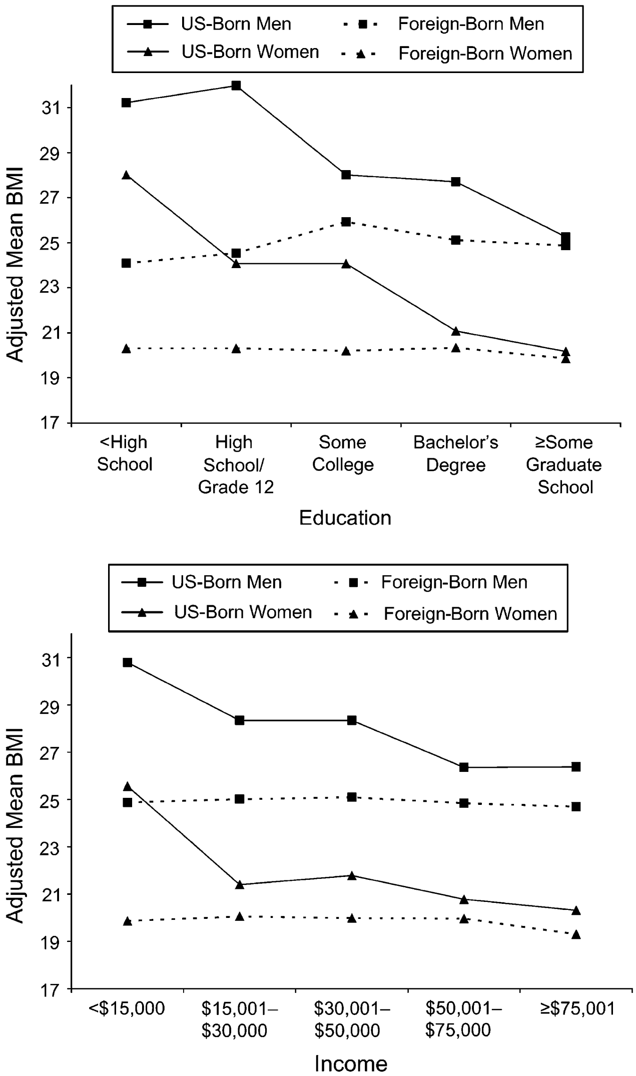

Figure 2. Education and income patterning of body mass index (BMI; weight (kg)/height (m)^2) by birthplace and gender among Asians, California Health Interview Survey, 2001. Estimated mean values were based on a linear regression model with adjustment for age, marital status, Asian ethnicity (women only), exercise, fruit and vegetable consumption, smoking, and alcohol use and simultaneous control for both income and education and their interaction with birthplace. Interaction between education and birthplace: $P < 0.001$ for women and $P < 0.001$ for men. Interaction between income and birthplace: $P < 0.15$ for women and $P < 0.006$ for men.

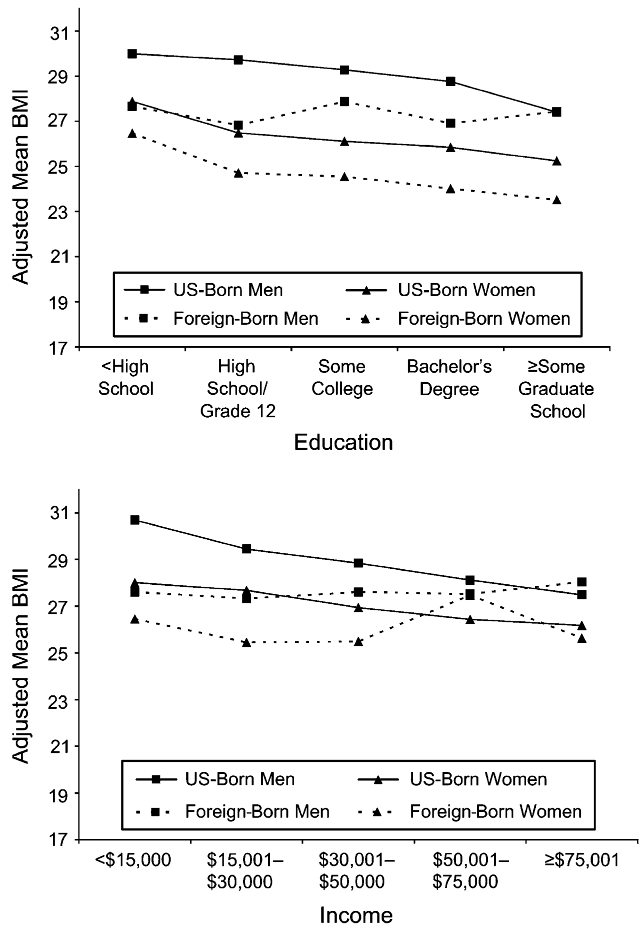

Figure 3. Education and income patterning of body mass index (BMI; weight (kg)/height (m)^2) by birthplace and gender among Hispanics, California Health Interview Survey, 2001. Estimated mean values were based on a linear regression model with adjustment for age, marital status, Latino ethnicity, exercise, fruit and vegetable consumption, smoking, and alcohol use and simultaneous control for both income and education and their interaction with birthplace. Interaction between education and birthplace: $P = 0.99$ for women and $P = 0.02$ for men. Interaction between income and birthplace: $P = 0.33$ for women and $P = 0.004$ for men.

education patterning in BMI between the US-born and the foreign-born.

The mechanisms for the observed differences in the SES patterning of BMI remain unclear, although there are several likely explanations. A constellation of psychosocial factors may account for the steeper SES gradient among women than among men across racial/ethnic groups. For example, perceptions of weight status vary according to race/ethnicity, gender, and SES (32, 33). Women, whites, and persons of higher SES have been found to be more sensitive to self-perceived overweight than men, minorities, and lower-SES groups (32). Additionally, women may face greater social pressures to conform to ideals of body image than men. Some evidence shows that men are less likely to report body dissatisfaction than women (34). The pervasive imagery of ideal body weight often imposed on women by the mass media probably increases social pressure to conform, which may vary by individual SES. Women in higher social classes may be more susceptible to media messages and/or better able to pursue methods of achieving the ideal body weight.

Behavioral factors may also play a role in the SES patterning of BMI. Studies have documented an SES gradient in dietary choices (35), which may partially account for the SES differential in BMI, especially among women (36). Although our study accounted for dietary factors, there may have been residual confounding. Additionally, the

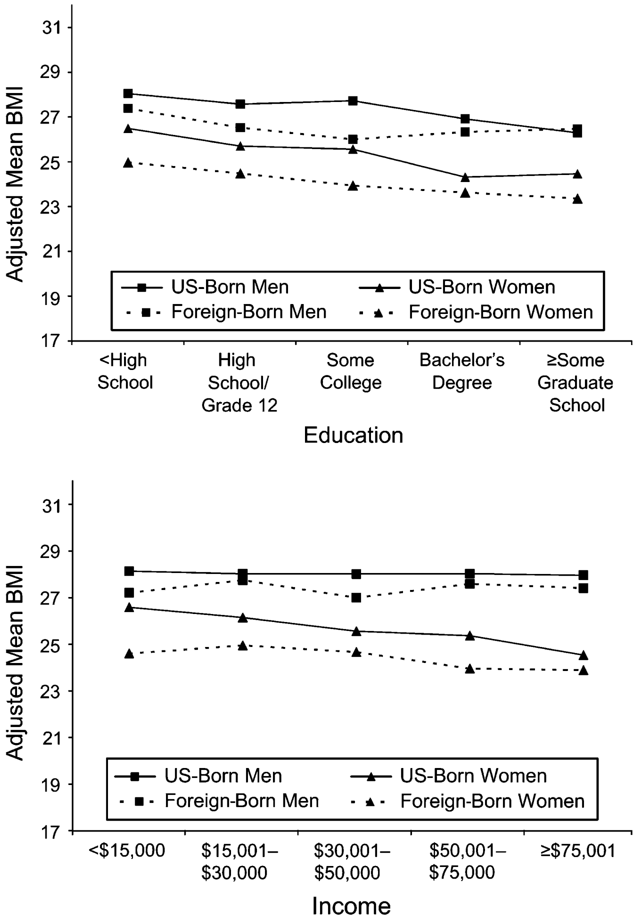

Figure 4. Education and income patterning of body mass index (BMI; weight (kg)/height (m)^2) by birthplace and gender among whites, California Health Interview Survey, 2001. Estimated mean values were based on a linear regression model with adjustment for age, marital status, exercise, fruit and vegetable consumption, smoking, and alcohol use and simultaneous control for both income and education and their interaction with birthplace. Interaction between education and birthplace: $P = 0.15$ for women and $P = 0.08$ for men. Interaction between income and birthplace: $P = 0.12$ for women and $P = 0.69$ for men.

observed SES pattern in BMI may be due to the influence of SES on biologic functioning (e.g., allostatic load, neuroendocrine hormonal changes) (37). Further investigations on the biologic mechanisms underlying such a gradient are needed.

Additionally, environmental processes at the national and neighborhood levels may play a role in the SES patterning in BMI by gender, race/ethnicity, and immigrant status. Our findings regarding differential education patterning of BMI by birthplace among Asians and Hispanic men imply that country of origin exerts environmental influences on BMI. In less developed countries, SES has been positively associated with BMI (18) and with consumption of unhealthy foods (e.g., high-sugar beverages, fast foods) (38), although this is changing (18). By contrast, in developed countries, SES is negatively associated with BMI, though mostly among women (7). Moreover, higher education and income groups have been found to have healthier diets than their counterparts (39). Of particular relevance is our finding of a strong negative education gradient in BMI only among US-born Asian men and women, which stands in contrast to a seemingly quadratic pattern in Asian men and shallower education gradients among Asian women prior to testing for the education-birthplace interaction.

Finally, there is growing evidence that the social and physical features of residential environments influence susceptibility to increased BMI (40–43). McLaren and Gauvin found that neighborhood-level female average BMI was associated with body dissatisfaction among women (44) and that higher neighborhood affluence was associated with greater likelihood of body dissatisfaction among women regardless of BMI (45), suggesting that social pressure may be particularly heightened in affluent neighborhoods.

The observed negative education and income gradients in BMI among Hispanics are noteworthy, because previous studies have generated inconsistent results. While some studies have found no statistically significant associations between income or education and BMI among Hispanic men and women (11, 46), others have shown that education was negatively associated with waist circumference among Mexican-American women (but not men) (47). Chang and Lauderdale (46) reported a slight inverse income gradient among Mexican-American women in the Third National Health and Nutrition Examination Survey (NHANES III) and a nonsignificant income-BMI relation in NHANES 1999–2002. They also reported a modest positive, nonsignificant income relation among men (46).

In contrast to all but 1 study (47), we controlled for potential confounding by birthplace and Hispanic ethnic ancestry (i.e., in race/gender-stratified analyses). Additionally, we adjusted household income for household size. Since most published studies on the SES gradient in BMI have used samples of Mexicans, we conducted subgroup analyses only for Mexicans in order to directly compare our results. The SES gradients for Mexicans did not differ from those reported for all Hispanics in this study (data not shown).

The use of different SES measures, outcomes (e.g., SES index, waist circumference vs. BMI), and years of data may explain the differing results. Moreover, all of the above studies employed national data from NHANES. Recent analyses suggest that some national surveys (e.g., NHANES) may not be adequately representative of the socioeconomic distribution of racial/ethnic subgroups (e.g., Hispanics and American Indians) among older persons (e.g., ages ≥45 years) (48). Although the education distribution among Hispanic men in our sample was similar to that of Hispanic men in the nation as a whole, a higher proportion of the California Hispanic women had a high school education or less (76%) compared with Hispanic women throughout the nation (69.7%) (49). A lack of representation of women at the lower end of the education distribution could generate a shallower gradient and a nonsignificant association between SES and BMI in Hispanic women.

Consistent with previous investigations that examined overall gender differences in the SES gradient in BMI (i.e., absent race/ethnicity), our study found that the SES gradients in BMI were stronger and more consistent among women than among men (7, 50–52). Comparably to other studies (46, 53), our study found a negative income and education gradient in BMI among black and white women and a relatively weak income gradient among white men. To our knowledge, only 1 prior study has investigated the relation between income and BMI among Asians. Using data from the National Health Interview Survey (1992–1995), Lauderdale and Rathouz (54) reported a negative association between family income and BMI among US-born Asian women but not US-born men; however, this relation was weak and marginally statistically significant among foreign-born women. In contrast, there was a positive association between income and BMI among foreign-born Asian men (54).

Limitations of our study included the cross-sectional nature of the data, which hampered our ability to examine trends and to rule out reverse causation. We used self-reported weight and height, which can lead to underestimation of relative weight (55). Gillum and Sempos (56) reported large racial/ethnic differences in the validity of self-reported weight and height, which resulted in greater underestimation of overweight/obesity prevalence among Mexican Americans than in other racial/ethnic groups. Assuming that such underestimates are associated with lower income and education, our study results would have tended to underestimate the SES gradients in BMI among Hispanics. It is unclear whether underestimation of overweight/obesity prevalence varies by nativity among Mexican Americans. Santillan and Camargo (57), studying Mexican-origin populations, reported inconsistent results, where higher underreported weight and height were observed among men (compared with women) and higher education was associated with bias in self-reported BMI. Conversely, diminishing error estimations of weight, height, and BMI with increasing education have been reported in Mexican-origin adults (58).

Nevertheless, in this study we compared socioeconomic differences in continuous BMI within race/ethnicity-gender groups and controlled for factors associated with underestimation of height and weight (e.g., age, smoking status). Thus, the potential for bias may have been minimized. We are not aware of studies assessing the accuracy of self-reported height and weight among Asian and Hispanic subpopulations and by nativity. The heterogeneity within these groups (e.g., nativity, SES, ethnicity, and languages spoken) presents significant challenges in assessing this question.

The low number of foreign-born blacks constrained our ability to test for interactions in this group. Because of sparse data, we could not control for Asian ethnic ancestry in stratified analyses among Asian men. Our findings may not be generalizable beyond California or to adults younger than 25 or older than 64 years.

This study showed that the negative SES gradients in BMI are present primarily among women across racial/ethnic groups, not among men. The SES patterning of BMI in the United States is likely to be significantly influenced by the demographic growth of US immigrants and their heterogeneous health patterns. To adequately address and monitor disparities in BMI, future research should consider both race/ethnicity and birthplace, particularly among Asians and Hispanics.

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