Income Disparities in Body Mass Index and Obesity in the United States, 1971-2002

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Background: Although obesity is frequently associated with poverty, recent increases in obesity may not occur disproportionately among the poor. Furthermore, the relationship between income and weight status may be changing with time.

Methods: We use nationally representative data from the National Health and Nutrition Examination Surveys (1971-2002) to examine (1) income differentials in body mass index (calculated as weight in kilograms divided by the square of height in meters) and (2) change over time in the prevalence of obesity (body mass index, ≥30) at different levels of income.

Results: Over the course of 3 decades, obesity has increased at all levels of income. Moreover, it is typically not the poor who have experienced the largest gains. For example, among black women, the absolute increase in obesity is 27.0% (1.05% per year) for those at middle incomes, but only 14.5% (0.54% per year) for the poor. Among black men, the increase in obesity is 21.1% (0.77% per year) for those at the highest level of income, but only 4.5% (0.06% per year) for the near poor and 5.4% (0.50% per year) for the poor. Furthermore, all race-sex groups show income differentials on body mass index, but patterns show substantial variation between groups and consistency and change within groups over time. For example, white women consistently show a strong inverse gradient, while a positive gradient emerges in later waves for black and Mexican American men.

Conclusion: The persistence and emergence of income gradients suggests that disparities in weight status are only partially attributable to poverty and that efforts aimed at reducing disparities need to consider a much broader array of contributing factors.

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REDUCING OBESITY IS A NATIONAL health priority in the United States, where the prevalence of obesity has increased from 23% to 30% during the past decade and 65% of adults are overweight or obese.[1-3] Recent attention has also centered on a link between obesity and poverty,[4,5] but it is not known whether recent weight gains have occurred disproportionately among the poor. In addition, there has been relatively less focus on the relationship between weight status and the entire income distribution. Like other health outcomes, weight status may in fact bear a graded relationship with socioeconomic status (SES).[6] Although poverty is a powerful correlate of health, broader gradients suggest that mechanisms linking SES to health are not limited to the more obvious material and social disadvantages imposed by severe impoverishment.

In a review published in 1989, Sobal and Stunkard[7] find that studies on developed societies tend to show a strong inverse relationship between SES and obesity among women. While some studies show a similarly inverse relationship for men, others find a positive relationship or no relationship at all. More recent studies[8-22] continue to show strong inverse relationships among women and inconsistent associations among men. There are limitations to prior work: few consider racial/ethnic differences, and almost all have either used relatively coarse categories of SES or only tested for a linear relationship. Such approaches can fail to capture nonlinear or complex relationships and, consequently, may contribute to discrepant findings between studies.[9]

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A second potential reason for inconsistent findings is that differentials may be changing with time. Flegal et al[23,24] examined secular trends in the relationship of body mass index (BMI) (calculated as weight in kilograms divided by the square of height in meters) to income from 1960 to 1980. They found a decreasing inverse association among women and a stable positive association among men. Incorporating more recent data, Zhang and Wang[22] found a decreasing inverse association between obesity and education since the 1970s. While education is indeed a constituent of SES, the social significance and monetary return for set educational cat-

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egories (eg, high school graduate) have changed quite markedly with time, limiting the utility of education relative to income in assessing trends over time. Little is known about income trends after 1980, the period when the distribution of BMI has shifted most dramatically.

We examine income differentials on BMI and obesity among US adults during a 3-decade period (1971-2002). We consider whether income gradients vary by race-sex groups and whether such gradients have changed over time. We also examine shifts over time in the prevalence of obesity at different points along the income distribution. While attention is often drawn to the prevalence of obesity among the poor, some data suggest that secular changes have occurred among persons with a higher SES as well.[25]

METHODS

We use 4 successive waves of the National Health and Nutrition Examination Survey (NHANES): I (1971-1974), II (1976-1980), III (1988-1994), and continuous (1999-2002). The NHANES is designed to provide nationally representative cross-sectional estimates at successive points in time and obtains health information through in-person interviews and physical examinations, which include measured height and weight. We restrict our samples to adults (aged 18-64 years), non-Hispanic whites and blacks, Mexican Americans, and examined nonpregnant persons. For NHANES I and II, we define non-Hispanic white or black as persons who are coded as white or black for race but do not have any of several Hispanic ancestry codes. For later waves, a combined race/ethnicity recode is available. All analyses are stratified by race-sex group; sample sizes in the first 2 waves are not adequate for separate analyses of Mexican Americans.

We use the poverty-income ratio (PIR) to measure income status. The PIR is the ratio of a family's income to its appropriate poverty threshold. In contrast to household income, the PIR is continuous rather than interval data, adjusts for household characteristics, and accounts for inflation between waves and across years within the same wave. The numbers of respondents missing data on the PIR are as follows: 353 (3.7%) of 9546 in NHANES I, 335 (3.7%) of 9145 in NHANES II, 1084 (8.8%) of 12 356 in NHANES III, and 661 (9.7%) of 6850 in the continuous NHANES. Less than 3% of respondents are missing data for BMI in all survey waves, and no persons are missing data on sex, age, or race. We do not include education because educational categories have shifted in meaning and value. Furthermore, high school graduate is the highest category provided in the most recent data. Given the current education distribution in the country, this is not an adequately detailed categorization to address our study questions.

We consider the relationship between income and weight status in 2 related, yet distinct, ways. First, we graph the relationship between BMI and PIR. Preliminary analyses, using categories of income as well as piecewise linear functions, revealed significant nonlinear relationships, particularly among men and nonwhites. Because this concerns our relationship of interest, we fit regression models using polynomial functions of income to best represent and capture the form of the relationship. Because the PIR is right skewed, we transform it by taking its square root. Then, we model the transformed variable along with its square and cube. These 3 terms, PIR raised to the 0.5, 1, and 1.5 powers, permit substantial flexibility while retaining model parsimony and consistency across survey-race-sex groups. The fractional terms extend greater flexibility than higher-order terms, which tend to create artifactual and often steep turns.[26] In none of the 20 combinations of race-sex-wave grouping is the inclusion of PIR^3 significant, and in only 1 model is the addition of PIR^2 significant. For that model, though, excluding PIR^2 has minimal effect on the form of the relationship. For comparability across models, we choose to include the same 3 terms in every model. All models adjust for age and age squared.

Second, we estimate the prevalence of obesity (BMI, ≥30) along 4 categories of income for each group. These estimates are age standardized by the direct method to the 2000 US standard population.[27] We also estimated change in obesity for each income category from the earliest to the latest survey and test weighted least squares estimates of linear trend across waves. Analyses throughout are conducted using Stata 8.0, and account for complex survey design elements to generate appropriate population estimates and standard errors.[28]

RESULTS

Sample characteristics for each of the 4 surveys are given in **Table 1**. The prevalence of obesity and mean BMI have increased substantially within each race-sex group from NHANES II to the last wave (1999-2002), with little change during the 1970s. Within sex groups, whites tend to have a lower percentage in the obese category than nonwhites, but these racial differences are much larger among women.

The **Figure** presents the results of polynomial models of the relationship between BMI and PIR. The y-axis ranges from a BMI of 24 to 30 for all groups except black women, for whom the range is 26 to 33, and Mexican Americans, for whom the range is 26 to 32. For whites and blacks, the curves show increasingly high BMI values across the entire income spectrum in the later 2 surveys, NHANES III and the continuous NHANES. In all but 4 of the 20 race-sex-survey models, a single 3-*df* test of the income terms is significant ($P < .05$), indicating a significant association between PIR and BMI. The 4 models in which the income terms are not significant are as follows: black men in NHANES I, Mexican American men in NHANES III, and Mexican American men and women in the continuous NHANES. Last, were income modeled as a single linear term, it would seem to be unassociated with BMI in several of the models in which a more flexible approach has revealed a significant relationship. For example, the *P* values for the single linear income term in NHANES II are .15 for black women and .93 for black men.

White women show a consistent inverse association between income and BMI in all periods, with a slight inverted U shape appearing around the poverty level in the continuous NHANES. Although the slope seems roughly similar, the intercept shifts upward with each wave. Women near the top of the income distribution (PIR, 3-4) in the continuous NHANES actually have a higher mean BMI than poor women at the bottom in NHANES I and II. For white men, the curves are generally flatter, but a slight inverse gradient emerges among incomes above poverty in the later waves, with curvature at the lower end of the income distribution.

Black women also show an inverse association between income and BMI, although there seems to be a positive gradient at levels below poverty in NHANES II and the continuous NHANES. Despite the presence of an inverse relationship along much of the income distribution in each wave, black women at the top of the income

Table 1. Characteristics of Study Subjects*

Variable	Non-Hispanic Groups				Mexican Americans	
	Whites		Blacks			
	Women	Men	Women	Men	Women	Men
NHANES I						
Sample size	4915	2882	1197	552	NA	NA
Age, y	36.3	38.8	35.2	38.2	NA	NA
PIR	2.78	2.99	1.55	1.85	NA	NA
Annual income, $	10 877	11 434	6209	7180	NA	NA
BMI	24.3	25.4	26.9	25.4	NA	NA
Obese, %	13.4	11.3	28.1	14.3	NA	NA
NHANES II						
Sample size	4122	3901	608	514	NA	NA
Age, y	38.6	38.0	36.3	36.3	NA	NA
PIR	2.76	3.00	1.75	2.09	NA	NA
Annual income, $	15 862	17 650	10 708	12 917	NA	NA
BMI	24.5	25.3	26.9	25.3	NA	NA
Obese, %	13.9	11.1	27.1	14.0	NA	NA
NHANES III						
Sample size	2358	2020	2198	1850	1909	2021
Age, y	39.4	38.5	36.9	36.0	35.3	33.5
PIR	3.38	3.51	1.98	2.26	1.77	1.87
Annual income, $	38 698	40 428	24 017	26 230	24 051	25 218
BMI	25.9	26.5	28.5	26.4	27.9	26.7
Obese, %	22.3	19.4	35.7	20.1	32.5	20.2
Continuous NHANES						
Sample size	1506	1616	829	824	1014	1061
Age, y	41.1	40.4	39.5	38.1	35.7	34.3
PIR	3.27	3.44	2.16	2.46	2.02	2.03
Annual income, $	64 202	66 971	39 933	45 987	42 663	42 601
BMI	27.6	27.9	31.0	27.3	28.6	27.6
Obese, %	30.6	27.5	47.7	25.9	35.6	25.4

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by the square of height in meters); NA, data not available; NHANES, National Health and Nutrition Examination Survey; PIR, poverty-income ratio.

*Data are given as means, except for sample sizes and percentage of obesity. Sample sizes reflect examined persons, excluding pregnant women; means and percentages are adjusted for survey weighting and design. Subjects were aged 18 to 64 years. The period for NHANES I was from 1971 to 1974; II, 1976 to 1980; III, 1988 to 1994; and continuous NHANES, 1999 to 2002.

distribution in the continuous NHANES have a higher mean BMI than women at all levels of income in all previous surveys. In black men, the shape of the relationship may be changing over time, with an increasingly positive gradient emerging in the later waves. In fact, the changing nature of the gradient suggests that black men at the higher end of the income distribution may have experienced greater increases over time than those at the lower end. Among Mexican Americans, women show a modest inverse gradient in NHANES III and a weaker and nonsignificant ($P=.31$) relationship in the continuous NHANES. Mexican American men show a modest positive gradient; although the income terms are nonsignificant for the polynomial model in NHANES III ($P=.26$) and the continuous NHANES ($P=.15$), a single linear term is significant ($P=.02$) in the last wave.

Table 2 and **Table 3** show the age-standardized prevalence of obesity by categories of income for women and men, respectively, and results are broadly consistent with patterns observed in the graphs on BMI. With the exception of near-poor (PIR, >1-2) black men, tests for trend over time within income groups are all significant among whites and blacks. For white women, the estimated prevalence of obesity decreases in monotonic fashion with increasing income within all waves except the last. With respect to change, the near poor show the largest, and those at the highest income (PIR, >4) show the lowest, absolute increase in obesity (near poor vs highest income, 22.6% vs 13.0%; $P=.02$). Among black women, estimates also decrease when going from the lowest to highest incomes within survey year, but not in monotonic fashion. As for change, the middle income (PIR, >2-4) group shows the largest estimated increase in obesity over time (absolute shift, 27.0%; trend, 1.05% per year), and the trend is significantly greater than that of the poor (PIR, 0-1) group (0.54% per year; $P=.02$) and the near poor (0.53% per year; $P=.03$). For Mexican American women, the poor also show the lowest estimated slope for trend, but this does not differ significantly ($P>.05$) from those of other income groups.

Among white men, the prevalence of obesity decreases in nonmonotonic fashion moving from the lowest to the highest income group, and the contrasts are more modest than those observed for white women. The poor show the largest absolute and trend increase with time, but these changes are not significantly different

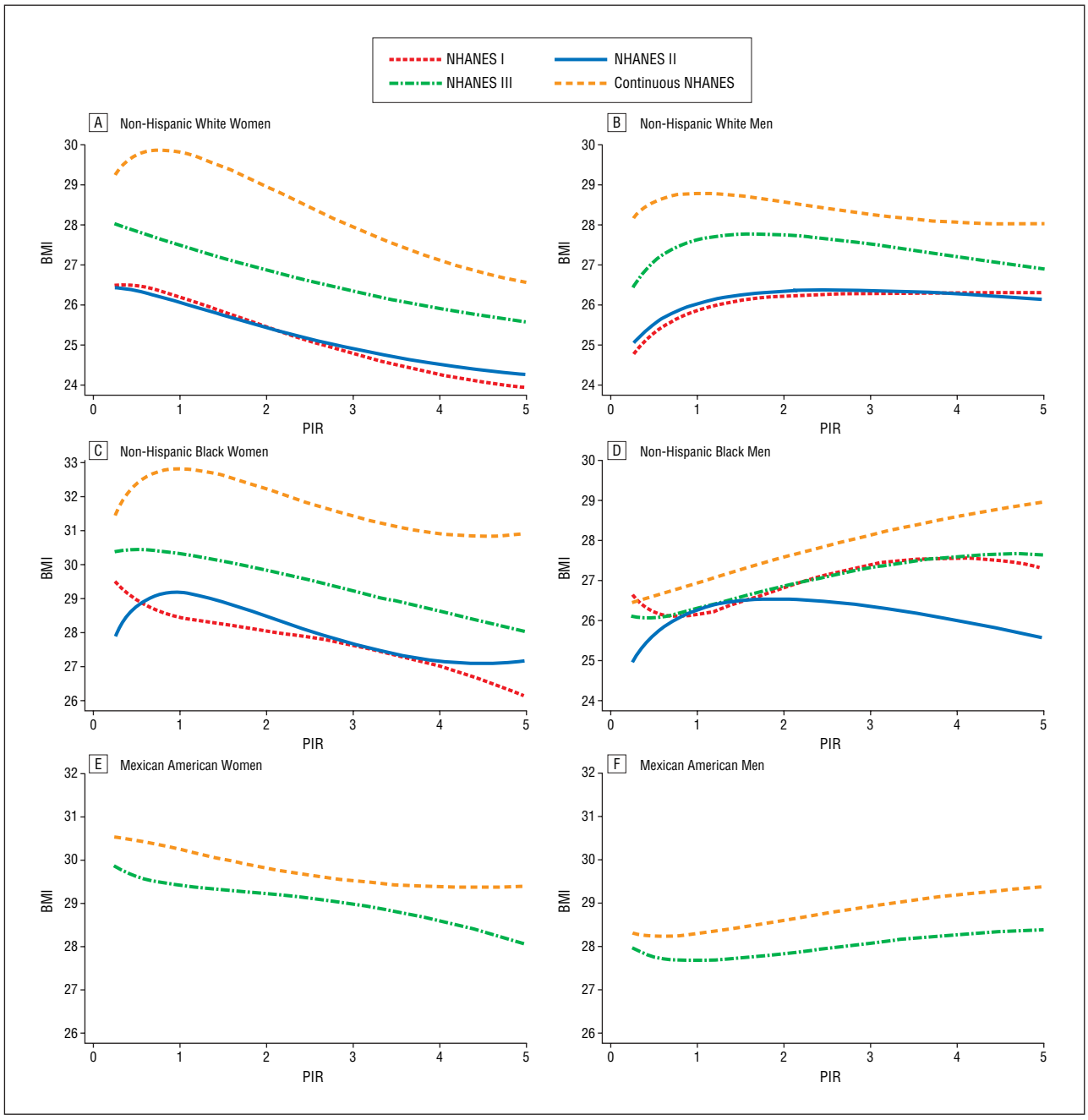

Figure. Body mass index (BMI) (calculated as weight in kilograms divided by the square of height in meters) and poverty-income ratio (PIR) for non-Hispanic white women (A) and men (B), non-Hispanic black women (C) and men (D), and Mexican American women (E) and men (F). Data are age adjusted; graphs display predicted BMI values at the age of 40 years. The period for National Health and Nutrition Examination Survey (NHANES) I was from 1971 to 1974; II, 1976 to 1980; III, 1988 to 1994; and continuous NHANES, 1999 to 2002.

($P > .05$) from those of the other income groups. Among black men, it seems that the highest income group transitions during the 32-year period from having less obesity (relative to the 2 lower-income groups) to having more obesity. Accordingly, the highest income group shows the largest increase over time in terms of absolute shift (21.1%) as well as trend (0.77% per year), and these changes are significantly different from those of the near poor (shift, 4.5%; $P = .02$; trend, 0.06% per year; $P < .01$). In units of relative change, obesity has increased by more than 296% for the highest income group compared with only 29% for the near poor. For Mexican American men, there seems to be a monotonic positive gradient in the continuous NHANES. As for change, the middle income group is the only group showing a statistically significant increase, although the trend differs significantly only from that of the poor ($P = .01$).

COMMENT

Obesity has increased at all levels of income during the past 3 decades, but there are notable discrepancies between income groups in the magnitude of such change.

Table 2. Age-Standardized Prevalence of Obesity by PIR for Women*

Variable	PIR 0-1	>1-2	>2-4	>4
Non-Hispanic Whites				
NHANES				
I	21.4 (2.6)	18.9 (1.6)	13.0 (1.0)	10.1 (1.3)
II	23.4 (2.3)	18.2 (1.5)	13.1 (0.9)	9.5 (1.2)
III	33.6 (4.0)	26.0 (2.5)	21.2 (1.6)	19.0 (1.8)
Continuous	39.9 (3.9)	41.4 (3.0)	31.3 (2.8)	23.1 (1.9)
Change from NHANES I to the continuous NHANES	18.6 (4.6)†	22.6 (3.4)†	18.3 (2.9)†	13.0 (2.3)†
Trend slope, %/y	0.68 (0.15)†	0.71 (0.11)†	0.56 (0.08)†	0.51 (0.07)†
Non-Hispanic Blacks				
NHANES				
I	31.9 (2.5)	32.4 (3.7)	21.8 (3.8)	14.9 (4.4)
II	33.0 (3.2)	35.3 (4.5)	21.5 (3.7)	24.7 (6.2)
III	41.5 (2.3)	36.3 (2.2)	38.4 (2.9)	26.6 (3.7)
Continuous	46.4 (3.6)	53.7 (4.3)	48.8 (3.3)	40.2 (4.5)
Change from NHANES I to the continuous NHANES	14.5 (4.4)†	21.3 (5.6)†	27.0 (5.0)†	25.4 (6.4)†
Trend slope, %/y	0.54 (0.13)†	0.53 (0.17)†	1.05 (0.16)†	0.79 (0.21)†
Mexican Americans				
NHANES				
III	38.7 (2.9)	33.4 (2.6)	32.8 (3.1)	34.6 (5.2)
Continuous	39.1 (3.5)	38.5 (3.6)	36.9 (3.9)	39.3 (5.8)
Change from NHANES III to the continuous NHANES	0.4 (4.6)	5.2 (4.4)	4.0 (5.0)	4.7 (7.8)
Trend slope, %/y	0.04 (0.48)	0.54 (0.46)	0.42 (0.53)	0.50 (0.82)

Abbreviations: See Table 1.
*Data are given as percentage (SE) of women who were obese unless otherwise indicated, and are age standardized by the direct method to the 2000 US standard population, using age groups of 18 to 24, 25 to 44, and 45 to 64 years. The period for NHANES I was from 1971 to 1974; II, 1976 to 1980; III, 1988 to 1994; and continuous NHANES, 1999 to 2002.
†$P<.01$.

Table 3. Age-Standardized Prevalence of Obesity by PIR for Men*

Variable	PIR 0-1	>1-2	>2-4	>4
Non-Hispanic Whites				
NHANES				
I	10.9 (2.8)	13.8 (1.9)	11.3 (1.1)	9.9 (1.3)
II	11.5 (2.3)	13.2 (1.5)	12.9 (0.9)	8.4 (1.0)
III	19.3 (3.3)	22.8 (2.5)	20.8 (1.5)	16.3 (1.6)
Continuous	33.5 (3.9)	28.0 (2.9)	30.5 (2.5)	24.3 (1.6)
Change from NHANES I to the continuous NHANES	22.6 (4.8)†	14.2 (3.5)†	19.2 (2.7)†	14.4 (2.1)†
Trend slope, %/y	0.76 (0.15)†	0.56 (0.11)†	0.62 (0.08)†	0.55 (0.07)†
Non-Hispanic Blacks				
NHANES				
I	17.8 (4.8)	15.6 (3.4)	21.5 (5.2)	7.1 (3.9)
II	7.5 (2.8)	23.2 (4.7)	13.5 (3.2)	8.8 (5.0)
III	19.0 (2.3)	17.4 (1.8)	25.1 (1.9)	19.6 (2.8)
Continuous	22.8 (4.2)	20.1 (3.5)	28.3 (3.5)	28.3 (3.2)
Change from NHANES I to the continuous NHANES	5.4 (6.4)	4.5 (4.9)	6.8 (6.3)†	21.1 (5.1)†
Trend slope, %/y	0.50 (0.17)†	0.06 (0.16)	0.51 (0.17)†	0.77 (0.17)†
Mexican Americans				
NHANES				
III	22.4 (1.8)	20.6 (2.3)	22.1 (2.0)	32.4 (5.4)
Continuous	19.3 (3.0)	24.7 (3.4)	33.1 (3.9)	36.2 (3.7)
Change from NHANES III to the continuous NHANES	−3.1 (3.5)	4.1 (4.1)	11.1 (4.4)‡	3.8 (5.6)
Trend slope, %/y	−0.32 (0.37)	0.43 (0.43)	1.17 (0.46)‡	0.40 (0.69)

Abbreviations: See Table 1.
*Data are given as percentage (SE) of men who were obese unless otherwise indicated, and are age standardized by the direct method to the 2000 US standard population, using the age groups of 18 to 24, 25 to 44, and 45 to 64 years. The period for NHANES I was from 1971 to 1974; II, 1976 to 1980; III, 1988 to 1994; and continuous NHANES, 1999 to 2002.
†$P<.01$.
‡$P<.05$.

For example, among black women, those at middle incomes have experienced the largest increase, and among black men, those at the highest incomes have experienced the largest increase. While attention is often focused on poverty as a risk factor for obesity, these findings suggest that those living below federal poverty levels may not be the group at highest risk in the years to come.

Our study also finds that weight status varies along a wide range of incomes, with considerable variation by race and sex in the pattern, strength, and consistency of the relationship over time. White and black women consistently show a strong inverse association between income and BMI throughout all waves, although the overall relationship seems more linear at some points than others. In comparison, Mexican American women show a weaker and nonsignificant (in the last wave) gradient, consistent with previous work on Hispanics.[29] Among white men, there seems to be a weaker inverse association for incomes above poverty in more recent waves. In contrast to white men, and in contrast to all groups of women, black and Mexican American men currently exhibit a positive relationship between income and weight status. Among black men, this represents a shift in the shape and direction of the gradient, a shift that is to some degree driven by the fact that higher-income black men have experienced a greater increase in weight status during this period than lower-income men.

Despite large secular increases in weight status among white and black women at all incomes, those at higher incomes maintain a distinct health advantage in terms of weight status in each time period. In graphical terms, the slope remains fairly stable relative to an intercept that exhibits considerable upward shifting after 1980. Hence, even though women at the top of the income distribution today have higher levels of obesity than low-income women in the 1970s, they continue to have lower levels of obesity than contemporaneous low-income women. As Link and Phelan[30(p81)] have argued, social conditions such as SES can be thought of as "fundamental causes of disease" that maintain persistent and tenacious associations with health—despite changing contexts over time—because they determine access to important resources, resources that ultimately modulate exposures to a changing constellation of risk and protective factors.

Diverse environmental factors have been suggested as contributors to the "epidemic" of obesity, such as the transition to a more sedentary service sector economy, the uptake of labor-saving devices and sedentary entertainment, a decrease in the relative price of food, and a surge in food advertising and portion sizes.[31,32] Despite these and other changes, women with a higher SES may be more resistant to their effects or more able to take compensatory action, thereby maintaining their relative advantage with time. This may be driven, in part, by variation across SES groups in aesthetic norms or cultural expectations with respect to weight standards.[33,34]

A cross-sectional relationship between SES and weight status may not derive solely from the effects of SES on weight status. It is also possible that weight status, particularly obesity, affects SES, and that common factors influence both outcomes.[35,36] With respect to the influence of weight status on SES, there is evidence that obesity may have a negative effect on wages, educational achievement, occupational opportunities, and marital mobility among women.[37-42] With respect to common antecedents of obesity and SES, the potential role of personality traits and hereditary factors has been noted.[35,36] Given the sex differences found in this and prior studies, however, any substantive contribution from genetic mechanisms would have to be sex specific. Moreover, changes to the association between SES and weight status over just a few decades point away from strong genetic effects.

The reasons for differences between men and women are far from clear, but a few points are worth noting. First, it is possible that low-income men engage in more manual occupational labor, thereby experiencing higher levels of physical activity. This could create a positive gradient or mitigate the effect of factors that would otherwise produce a stronger negative association. Second, the influence of obesity on SES is generally much weaker or absent among men.[37-40] Third, the association between income and weight-related ideals, which is often cited as an explanation for the inverse association observed among white women,[33] may vary across groups. Last, the positive gradient observed among nonwhite men could, to some extent, reflect a higher proportion of unhealthy or underweight men at lower incomes. However, within low-income groups, the prevalence of obesity itself has nevertheless increased over time.

There are limitations to these data. The cross-sectional nature of each wave precludes direct exploration of causal directions in the relationship between income and weight status. This study is also limited by the fact that we cannot distinguish secular from cohort effects. Changes between waves may be due, in part, to the movement of age cohorts bearing different associations into and out of the survey with time. A strength of these data is that they include measured rather than self-reported height and weight. Self-reports are well-known to be biased, and bias in reporting may be correlated with SES.[43,44]

In sum, we find that the association between income and weight status shows consistency and change within race-sex groups over time, and that increases in the prevalence of obesity are neither limited to nor typically highest among the poor. Although income gradients in health are well established, herein we see that gradients in weight status are highly dependent on sex and race. Indeed, the sex and race differences suggest that the material benefits of income are not the only factors at stake. Furthermore, racial/ethnic discrepancies in weight status persist at broadly equivalent levels of income, suggesting that race discrepancies are not reducible to income effects. Last, the graded income relationships suggest that disparities in weight status are only partially attributable to poverty and that public health efforts aimed at reducing disparities need to consider a much broader array of contributing factors.

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