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The Obesity Epidemic in the United States—Gender, Age, Socioeconomic, Racial/Ethnic, and Geographic Characteristics: A Systematic Review and Meta-Regression Analysis

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This review of the obesity epidemic provides a comprehensive description of the current situation, time trends, and disparities across gender, age, socioeconomic status, racial/ethnic groups, and geographic regions in the United States based on national data. The authors searched studies published between 1990 and 2006. Adult overweight and obesity were defined by using body mass index (weight (kg)/height $(m)^2$) cutpoints of 25 and 30, respectively; childhood "at risk for overweight" and overweight were defined as the 85th and 95th percentiles of body mass index. Average annual increase in and future projections for prevalence were estimated by using linear regression models. Among adults, obesity prevalence increased from 13% to 32% between the 1960s and 2004. Currently, 66% of adults are overweight or obese; 16% of children and adolescents are overweight and 34% are at risk of overweight. Minority and low-socioeconomic-status groups are disproportionately affected at all ages. Annual increases in prevalence ranged from 0.3 to 0.9 percentage points across groups. By 2015, 75% of adults will be overweight or obese, and 41% will be obese. In conclusion, obesity has increased at an alarming rate in the United States over the past three decades. The associations of obesity with gender, age, ethnicity, and socioeconomic status are complex and dynamic. Related population-based programs and policies are needed.

body mass index; ethnic groups; obesity; overweight; social class; United States

Abbreviations: Add Health study, National Longitudinal Survey of Adolescent Health; BMI, body mass index; BRFSS, Behavioral Risk Factor Surveillance System; NHANES, National Health and Nutrition Examination Surveys; SES, socioeconomic status.

INTRODUCTION

During the past three decades, the United States has witnessed a dramatic increase in the prevalence of obesity, which has become a public health crisis (1, 2). A growing body of evidence has reported large disparities between population groups and continuing changes in the associated patterns (2, 3). Several recent reviews attempted to describe the characteristics of the obesity epidemic in the United States while focusing on specific age groups (e.g., adults) and basing their analyses on selected data sets such as the National Health and Nutrition Examination Surveys (NHANES), without addressing all major characteristics or central obesity (4–6).

Based on national data in the United States, this systematic review and meta-analysis aims to provide a comprehensive description of the current situation, time trends, and disparities across gender, age, socioeconomic status (SES), and racial/ethnic groups and in geographic regions, as well as the manner in which disparities have changed over time. For some racial/ethnic groups, where no national data were available, we used other large, well-designed studies.

Information on self-reported weight and height has been widely used in epidemiologic studies, including some large, national monitoring survey programs such as the Behavioral Risk Factor Surveillance System (BRFSS). Although some studies have suggested good agreement between self-reported and measured weight and height (7, 8), others show considerable reporting bias (9, 10). For example, a recent study reported that, compared with NHANES (measured data), BRFSS (self-reported data) underestimated the overall

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prevalence of obesity and overweight in the United States by 9.5 percent and 5.7 percent for 1999–2000, respectively. The degree of underestimation varied across sociodemographic subgroups (10). Thus, it is likely that findings of the associations between these factors and obesity based on self-reported weight and height will be biased. Moreover, discrepancies in classifications may affect estimates of prevalence and trends in obesity among both adults and children (11–16). The present study attempted to include only those findings that used comparable classifications based on direct anthropometric measures whenever possible.

METHODS

Literature search strategy and study inclusion criteria

Using PubMed (National Library of Medicine, Bethesda, Maryland), we searched the English-language literature for the period 1990–2006 that quantitatively assessed obesity and overweight in the United States. The MeSH headings ''United States,'' ''obesity'' or ''overweight'' or ''body mass index (BMI)'' and ''race'' or ''ethnicity'' were used as an initial search step. Although more than 900 titles were examined, only those studies with estimates of obesity and/or overweight prevalence in the United States were included upon initial screening of abstracts and full text if needed. These studies were supplemented with others, which were brought to our attention by colleagues and experts consulted. Consequently, more than 80 journal papers, reports, and online data sheets were included in the present study for the literature review, while only about 20 were used for quantitative meta-analysis. Using a standardized data extraction form, we extracted and tabulated related data including measure of obesity or overweight, sociodemographic variables, and quantitative findings.

Definitions of overweight and obesity

According to the World Health Organization, obesity is a disease and is defined as the condition of excess body fat to the extent that health is impaired (17). For practical purposes and among both children and adults, BMI (weight (kg)/height(m)^2) is now widely used to assess obesity (11, 17, 18). BMI is closely correlated with body fat and obesity-related health consequences (13, 17).

Adults. The World Health Organization currently defines overweight and obesity by using BMI cutpoints of 25 and 30 kg/m^2, respectively (14, 17). These cutpoints were recommended by a National Heart, Lung, and Blood Institute's and North American Association for the Study of Obesity expert committee (19). Prior to this, various measures and BMI cutpoints have been used in the United States. In the present study, all overweight and obesity prevalence rates reported for adults were based on these BMI cutpoints; in most cases, we present the combined prevalence when using the term ''overweight.''

The National Heart, Lung, and Blood Institute/North American Association for the Study of Obesity committee also recommends using waist circumference cutpoints of 40 inches (102 cm) for men and 35 inches (88 cm) for women to define ''central obesity.'' Increasingly, research shows that waist circumference or central obesity is a better predictor of obesity-related diseases than overall obesity assessed by using BMI (20, 21). Waist circumference may be equally or more useful than BMI because of its higher predictive value for future health risks, ease of measurement, and understanding by the general public (19–21).

Children and adolescents. Two sets of BMI percentile references have been used in the United States, which are slightly different. The ''old'' BMI reference is age- and gender-specific percentiles for ages 6–19 years based on NHANES I data collected in 1971–1974 (22–24). ''Overweight'' is defined as a BMI greater than or equal to the sex-age–specific 95th BMI percentile, and ''at risk for overweight'' is defined as a BMI greater than or equal to the 85th percentile but less than the 95th percentile. The ''new'' BMI reference is provided in the 2000 Centers for Disease Control and Prevention Growth Charts (18), which were developed for all US children aged 2–19 years by using data collected from five national data sets between the 1960s and 1994. These ''new'' BMI 85th and 95th percentiles are recommended by the Centers for Disease Control and Prevention for screening overweight persons. For children younger than age 2 years, there is no BMI-for-age reference to define overweight, and the weight-for-length 95th percentile has been used (25). The majority of our reported figures for children and adolescents are based on the 2000 Centers for Disease Control and Prevention Growth Charts. Currently, no national recommendation exists regarding classification of central obesity in children and adolescents.

Main data sources

Most of the findings presented in our study were based on nationally representative data. Data from other studies were included to describe the situation in some low-SES and minority racial/ethnic groups that were inadequately covered in these national surveys (more details are provided in appendix 1).

NHANES. NHANES, a series of cross-sectional, nationally representative examination surveys conducted by the National Center for Health Statistics since the 1970s, includes NHANES 1 (1971–1974), II (1976–1980), and III (1988–1994). Beginning in 1999, NHANES became a continuous survey, and data were collected on people older than age 74 years. Data on weight and height were collected through direct physical examination in a mobile examination center (26).

BRFSS. BRFSS is an ongoing, nationally representative telephone health survey system, tracking health conditions and risk behaviors among US adults yearly since 1984. This survey is conducted by the 50 state health departments with support from the Centers for Disease Control and Prevention using standard procedures. BRFSS provides state-specific information; that is, it enables geographic differences to be examined (27).

Youth Risk Behavior Surveillance System. The ongoing Youth Risk Behavior Surveillance System was initiated in 1991 to monitor priority health risk behaviors that contribute markedly to the leading causes of death, disability, and social problems among youth and adults in the United

States. This system collected information on risk behaviors and self-reported weight and height (28).

National Longitudinal Survey of Adolescent Health. The National Longitudinal Survey of Adolescent Health (Add Health study) is a nationally representative, school-based study of youths (grades 7–12; approximately aged 12–17 years at baseline, wave I, in 1994–1995) followed up into young adulthood (approximately aged 18–26 years, wave III, in 2001–2002). In waves I and II (1996), information on self-reported weight and height and, in wave III, directly measured weight and height was collected. Compared with NHANES, the Add Health study oversampled more minority groups such as Asians and Native Americans (29, 30).

Statistical analysis

Analyses were conducted to examine the characteristics and trends of obesity and overweight prevalence. To estimate the average annual increase in prevalence and to predict the future situation regarding obesity and overweight among US adults and children, based on NHANES data, we fit linear regression models with prevalence as the dependent variable and survey years as the independent variable for different sociodemographic groups. In this projection analysis, we assumed that trends would be similar to those observed over the past two to three decades. Time periods for each survey were represented by their median. Beta coefficients were used to indicate the average annual increases in prevalence. The models fit the data well in each sociodemographic stratum, and they explained 48–100 percent (i.e., R^2) of the variance in prevalence. In the majority (~90 percent) of the models, $R^2 > 0.90$. We had fit the models based on both all of the available data (since NHANES I, 1971–1974) and those available since NHANES II, 1976–1980. Because prevalence increased little between NHANES I and NHANES II, the results based on only the second set of models were reported. Next, on the basis of our second set of linear regression models, we projected the situation for 2010 and 2015 by assuming that prevalence would continue to increase at a similar rate. One should be cautious when interpreting such projection results, particularly for issues related to predicting future events using linear models. Note that we considered alternative statistical models such as linear models with the quadratic term of year/time, but the results differed little, as indicated by the fact that the majority of the coefficients of determination (R^2) in our estimated models were between 96 percent and 99 percent. Thus, for simplicity, we chose to use the simple linear models. To assess SES disparities, we calculated prevalence ratios comparing low- with high-SES groups for each age, gender, and ethnicity group and across time. Our regression analysis was conducted by using STATA release 9.0 software (31).

RESULTS

US adults

Overall patterns and age and gender disparities

Current situation. Estimates of the national prevalence of overweight and obesity among adults based on the most recent NHANES data collected in 1999–2004 are shown in table 1. In 2003–2004, among men and women aged 20 years or older, approximately two thirds (66.3 percent) were overweight or obese, 32.42 percent were obese, and 4.8 percent were extremely obese (BMI $\geq$40 kg/m^2). The combined prevalence increased with age. Of persons in the United States aged 60 years or older, more than 70 percent were overweight or obese, and the trend was similar for men and women. However, there was no such clear trend with respect to obesity. More men than women were overweight or obese (68.8 percent vs. 61.6 percent in 2001–2002) (32).

Trends. The trends based on NHANES data are shown in table 2 and figure 1. Between 1971 and 2001, mean BMI increased by three units, from 24.4 to 27.6 kg/m^2 in men and from 25.3 to 28.2 kg/m^2 in women. During 1960–1980, prevalence increased slowly, but, since NHANES II (1976–1980), prevalence increased dramatically at an average annual rate of approximately 1 percentage point. The prevalence of obesity doubled between 1976–1980 and 1999–2000, increasing from 15.1 percent to 30.9 percent. The annual rate of increase was similar for men and women during this period. The rate of increase for the combined prevalence of overweight and obesity during that same period was smaller than that for obesity. Combined prevalence increased by about one third, from 47.4 percent to 64.5 percent. Among men, the rate of increase was similar across age groups. Among women, the group 20–34 years of age had the fastest increase.

Racial/ethnic disparities

Current situation. Data from NHANES, BRFSS, and the Add Health study show large racial/ethnic differences, especially for women. Non-Hispanic Blacks had the highest prevalence. Minority groups (i.e., non-Hispanic Blacks and Mexican Americans) had a higher combined prevalence than non-Hispanic Whites by almost 10 percentage points. The corresponding prevalences in 2003–2004 were 76.1 percent and 75.8 percent versus 64.2 percent. The racial/ethnic differences among men were much smaller than among women. In 1999–2002, the combined prevalence and the prevalence of obesity among non-Hispanic Black women was 20 percentage points higher than among White women (77.2 percent vs. 57.2 percent, and 49.0 percent vs. 30.7 percent, respectively). Among non-Hispanic Black women aged 40 years or older, more than 80 percent were overweight or obese, and more than 50 percent were obese. In 1999–2002, the prevalence of extreme obesity among African-American women was more than twice that among White and Mexican-American women (13.5 percent vs. 5.5 percent and 5.7 percent).

The NHANES data do not include an adequate number of people with minority backgrounds other than non-Hispanic Black and Mexican American. The 2001 BRFSS data show that the prevalence of obesity was much lower among Asian Americans than other racial/ethnic groups (5 percent vs. approximately 30 percent) (33). More Native Americans (34.3 percent) were obese than Whites (21.8 percent), but the prevalence was similar to that for Blacks (34.8 percent) and Pacific Islanders (33.0 percent) (33). The Add Health study shows that young Asian adults had the lowest

TABLE 1. Current prevalence (%) of overweight, obesity, and extreme obesity among US adults, by gender, age, and ethnicity, NHANES* 1999–2002 and 2003–2004† (sources: 2, 32)

Gender and age (years)	Overweight and obesity (BMI* ≥25)				Obesity (BMI ≥30)				Extreme obesity (BMI ≥40)			
	All	Non-Hispanic White	Non-Hispanic Black	Mexican American	All	Non-Hispanic White	Non-Hispanic Black	Mexican American	All	Non-Hispanic White	Non-Hispanic Black	Mexican American
						1999–2002						
Both genders												
≥20	65.1	63.3‡,§	70.7¶	72.5¶	30.4	29.4‡	39.4§,¶	32.6‡	4.9	4.4‡	9.0§,¶	4.2‡
20–39	57.5	54.8‡,§	63.2¶	63.6¶	25.9	23.8‡	36.2§,¶	26.7‡	4.6	3.8	8.1	3.5
40–59	69.7	68.0§	73.9	80.7¶	33.8	33.1‡	41.0¶	39.3	5.9	5.6	9.5	5.5
≥60	70.8	70.3‡	78.2¶	74.6	32.9	33.0‡	42.5§,¶	32.1‡	3.9	3.7	9.6	3.5
						2003–2004						
Both genders												
≥20	66.3	64.2	76.1	75.8	32.2	30.6	45	36.8	4.8	4.3	10.5	4.5
20–39	57.1	52.5	69.7	71.2	28.5	25.5	41.9	34	5.4	4.8	11.7	4.7
40–59	73.1	72.5	81.2	79.4	26.8	36.7	48.4	39.8	5.4	4.6	11.8	4.7
≥60	71	71.1	78.8	78.1	31.0	29.7	44.9	36.9	3	2.8	6.6	3.9
						1999–2002						
Men												
≥20	68.8	69.4‡	62.9§,¶	73.1‡	27.6	28.2	27.9	27.3‡	3.3	3.3	3.4	2.9
20–39	60.3	60	55.4	64.8	23	22.9	24.7	23.4	3.7	3.5	4.1	2.0#
40–59	74.7	76.1‡	65.0§,¶	80.5‡	30.7	31.3	29.7	31.3	3.9	4.1	2.9#	4.4
≥60	73.9	74.8	72.2	75.4	30.5	32.2	30.5	27.4	1.7	1.8	3.0#	1.9#
Women												
≥20	61.6	57.2‡,§	77.2¶	71.7¶	33.2	30.7‡,§	49.0§,¶	38.4‡,§,¶	6.4	5.5‡	13.5§,¶	5.7‡
20–39	54.5	49.0‡,§	70.3¶	61.8¶	29.1	24.9‡	46.6§,¶	31.2‡	5.6	4.2	11.8	5.5
40–59	64.9	59.9‡,§	81.5¶	80.9¶	36.7	34.9‡,¶	50.6‡	47.7¶	7.8	7.0	15.1	6.6
≥60	68.4	66.7‡	82.2¶	73.9	34.7	33.7‡	50.3*,¶	35.8‡	5.6	5.2	14.0	4.8

* NHANES, National Health and Nutrition Examination Surveys; BMI, body mass index (weight (kg)/height (m)^2).
† Data for the period 2003–2004 by gender and ethnicity were not available, and tests for ethnicity differences were not reported.
‡ Significantly different from non-Hispanic Blacks at $p \leq 0.05$, with Bonferroni adjustment.
§ Significantly different from Mexican Americans at $p \leq 0.05$, with Bonferroni adjustment.
¶ Significantly different from non-Hispanic Whites at $p \leq 0.05$, with Bonferroni adjustment.
# Does not meet the standard of statistical reliability and precision (relative standard error >30%).

prevalence of obesity, particularly among young women (9 percent) (table 3).

Other studies also show that the prevalence of overweight and obesity among Asian Americans was much lower than the national average, but differences between different Asian groups were considerable. A recent review found that prevalence was highest among Native Hawaiians and Samoans (34). In a study based on self-reported height and weight data collected from 254,153 participants aged 18–59 years included in the 1992–1995 National Health Interview Survey of the six largest Asian-American racial/ethnic groups, researchers found that the combined prevalence in Asian Americans was less than half that of the national average, and the prevalence of obesity among Asian-American men was only one fifth that for all US men; among Asian-American women, prevalence ranged from only 1 percent to 4 percent, while the national average was 15 percent (table 4). Asians born in the United States were four times more likely to be obese than their foreign-born counterparts. Among the foreign born, more years in the United States were associated with higher risk (35). Similar findings among young people have been reported by the Add Health study (36, 37).

Trends. In general, and based on NHANES data, the increase in prevalence of overweight and obesity was similar across racial/ethnic groups in both men and women over the past three decades, although they had different prevalences. Among women, between 1988–1994 and 1999–2002, the increase was slower for Mexican Americans than for non-Hispanic Whites and Blacks. The same rising trend occurred among Blacks although at a much higher baseline prevalence of obesity compared with that for Whites (figure 2).

SES disparities

Current situation. Given the well-known association between ethnicity and SES, racial/ethnic differences in

TABLE 2. Trends in the prevalence (%) of obesity and overweight among US adults, by gender and age, NHANES* 1960–2002 (sources: 32, 54)

	NHES* I 1960–1962	NHANES I 1971–1974	NHANES II 1976–1980	NHANES III 1988–1994	NHANES 1999–2000	NHANES 1999–2002†
Obesity (BMI* ≥30)						
All: age (years)						
≥20‡,§	13.3	14.6	15.1	23.3	30.9	30.4
Men: age (years)						
≥20‡,§	10.7	12.2	12.8	20.6	27.7	27.6
20–34	9.2	9.7	8.9	14.1	24.1	
35–44	12.1	13.5	13.5	21.5	25.2	
45–54	12.5	13.7	16.7	23.2	30.1	
55–64	9.2	14.1	14.1	27.2	32.9	
65–74	10.4	10.9	13.2	24.1	33.4	
≥75				13.2	20.4	
Women: age (years)						
≥20‡,§	15.7	16.8	17.1	26.0	34.0	33.2
20–34	7.2	9.7	11.0	18.5	25.8	
35–44	14.7	17.7	17.8	25.5	33.9	
45–54	20.3	18.9	19.6	32.4	38.1	
55–64	24.4	24.1	22.9	33.7	43.1	
65–74	23.2	22.0	21.5	26.9	38.8	
≥75				19.2	25.1	
Overweight (BMI ≥25)						
All: age (years)						
≥20‡,§	44.8	47.7	47.4	56.0	64.5	65.1
Men: age (years)						
≥20‡,§	49.5	54.7	52.9	61.0	67.0	68.8
20–34	42.7	42.8	41.2	47.5	58.0	
35–44	53.5	63.2	57.2	65.5	67.6	
45–54	53.9	59.7	60.2	70.5	72.5	
55–64	52.2	58.5	60.2	70.5	72.5	
65–74	47.8	54.6	54.2	68.5	77.2	
≥75				56.5	66.4	
Women: age (years)						
≥20‡,§	40.2	41.1	42.0	51.2	62.0	61.6
20–34	21.2	25.8	27.9	37.0	51.5	
35–44	37.2	40.5	40.7	49.6	63.6	
45–54	49.3	49.0	48.7	60.3	64.7	
55–64	59.9	54.5	53.7	66.3	73.1	
65–74	60.9	55.9	59.5	60.3	70.1	
≥75				52.3	59.6	

* NHANES, National Health and Nutrition Examination Surveys; NHES, National Health Examination Survey; BMI, body mass index (weight (kg)/height $(m)^2$).

† Data are reported for different age groups for obesity (refer to table 1). For NHANES 2003–2004, data were reported by age and ethnicity but not by gender.

‡ Prevalence of obesity and overweight for all ages (≥20 years) was adjusted for age.

§ Before 1988, the surveys included persons through 74 years of age; after 1988, there was no upper age limit. Data were not represented by age group for both genders.

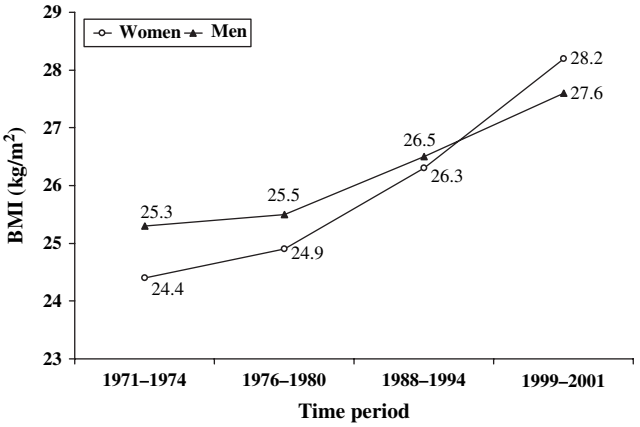

FIGURE 1. Trends in body mass index (BMI) means among US men and women, National Health and Nutrition Examination Survey, 1971–2001. (Source: 40).

obesity may simply be explained by individual SES (38). A handful of studies have tested this hypothesis by including in models of BMI both SES and ethnicity as predictors. Many of these recent studies, including ours, came to the conclusions that the association between SES and obesity varies by ethnicity and that ethnic/racial differences in BMI are not fully explained by individual SES (2, 3, 39–41). One major reason is that ethnic/racial differentials in BMI may be explained by contributing factors conceptually distinct from SES, such as body image, lifestyles, and social and physical environments. Another problem arises from the constrained explanatory power of SES because of differences in the construct validity of its markers between Whites and African Americans. Neither education nor income, two commonly used markers, reflect SES level equally across ethnic groups (3, 39–41). Meanwhile, it is possible that there may be a bidirectional causal relation between SES and obesity, because obesity may adversely affect one's opportunities for education, occupation, and marriage (42).

Although previously it was widely accepted that low-SES groups in the United States were at increased risk of obesity, a growing number of studies have revealed the complexity of the relation between gender, ethnicity, SES, and obesity among US adults since the late 1980s (43). Our recent study based on NHANES 1971–2002 data found considerable age, gender, and racial/ethnic differences in the association between SES and obesity among US adults and children, and the association had changed over time (40, 41). On the basis of NHANES 1999–2000 data, overall, less educated persons in the United States (those with less than a high school education) have a higher prevalence of obesity than their counterparts, with the exception of Black women. Black women with less than a high school education had the lowest prevalence compared with those who had higher educational levels. Interestingly, self-reported data from the 2001 BRFSS showed a clearer reverse linear relation between obesity and education than did NHANES. The prevalences of obesity were 27.4 percent, 23.2 percent, 21.0 percent, and 15.7 percent for persons with less than a high school education, a high school degree, some college, and college or above, respectively (44). One of our studies introduced the concentration index to assess SES inequality in obesity among US adults using NHANES III and showed a lower SES inequality in obesity within minority groups (41). Some other previous studies have also examined the complex relation between gender, ethnicity, SES, and obesity among US adults (45–48) (appendix 2).

Trends. Overall, the prevalence of obesity increased in all SES groups of men and women since the 1970s, but the patterns of the trends in SES disparities are complex (40). There are some age, gender, and racial/ethnic differences (figure 3). Among White men, the prevalence of obesity

TABLE 3. Means of BMI* and prevalence of overweight and obesity, by ethnicity: data from the 2001 BRFSS* and the Add Health study* 2001–2002 survey, United States (sources: 29, 33)

	Non-Hispanic White	Non-Hispanic Black	Hispanic	Asian	Native American	Pacific Islander
2001 BRFSS, self-reported data, persons aged ≥30 years						
Sample size (no.)	129,116	12,561	12,153	3,071	2,299	626
BMI (mean (standard error))	26.8 (0.2)	28.7 (0.1)	27.9 (0.1)	24.0 (0.2)	28.5 (0.3)	27.8 (0.5)
Overweight: BMI ≥25 (%)	39.2	39.5	42.2	32.8	35.1	40.8
Obese: BMI ≥30 (%)	21.8	34.8	28.3	4.8	34.3	33.0
2001–2002 Add Health study, measured data, persons aged 18–26 years						
Sample size (no.)	7,728	3,038	2,340	1,021	136	
Obese: BMI ≥30 (%)						
Men	19	22	22	21	41	
Women	21	34	26	9	28	

* BMI, body mass index (weight (kg)/height (m)^2); BRFSS, Behavioral Risk Factor Surveillance System; Add Health study, National Longitudinal Survey of Adolescent Health.

TABLE 4. Prevalence (%) of overweight (BMI* ≥25) and obesity (BMI ≥30) in different Asian-American groups, 1992–1995 National Health Interview Survey, United States† (source: 35)

Ethnicity	Men		Women	
	Overweight	Obesity	Overweight	Obesity
Total NHIS*	60	15	40	15
Asian Indian	33	4	25	4
Chinese	26	3	9	2
Filipino	40	5	22	4
Japanese	42	7	18	3
Korean	31	3	10	1
Vietnamese	17	0	9	1

* BMI, body mass index (weight (kg)/height (m)^2); NHIS, National Health Interview Survey.

† Based on self-reported data collected from 254,153 participants aged 18–59 years.

in the low-SES group decreased between 1988–1994 and 1999–2002, while, during this period, the prevalence increased at a much higher rate among low-SES Black men compared with other SES groups. Among Black women, obesity increased at a faster pace in the high- and medium-SES groups compared with the low-SES group between 1976–1980 and 1999–2002.

Geographic and urban-rural differences

Current situation. The 2005 BRFSS data show considerable differences in the prevalence of obesity across states (figure 4). In general, states in the southeastern United States have higher prevalence rates than states on the West Coast, in the Midwest, and on the northeast coast. In 2005, only four states (Colorado, Hawaii, Vermont, and Connecticut) had obesity prevalence rates of less than 20 percent, while 17 states had prevalence rates of 25 percent or higher; in three of those states (Louisiana, Mississippi, and West Virginia), prevalence was 30 percent or higher (26, 27, 44, 49, 50).

Trends. The regional differences became clearer over time between 1990 and 2005 (figure 4). In 1990, the regional difference was not clear, but, unmistakably in 1995, western and northeastern states had a lower prevalence (10–14 percent) compared with that in the other states (15–19 percent). In 2000 and 2005, the burden of obesity shifted toward southern and eastern regions. In 1990, only five states had obesity prevalence rates of 15–19 percent, and none had rates at or above 20 percent. In 1995, obesity prevalence in all 50 states was less than 20 percent. In 2000, 28 states had obesity prevalence rates of less than 20 percent. In

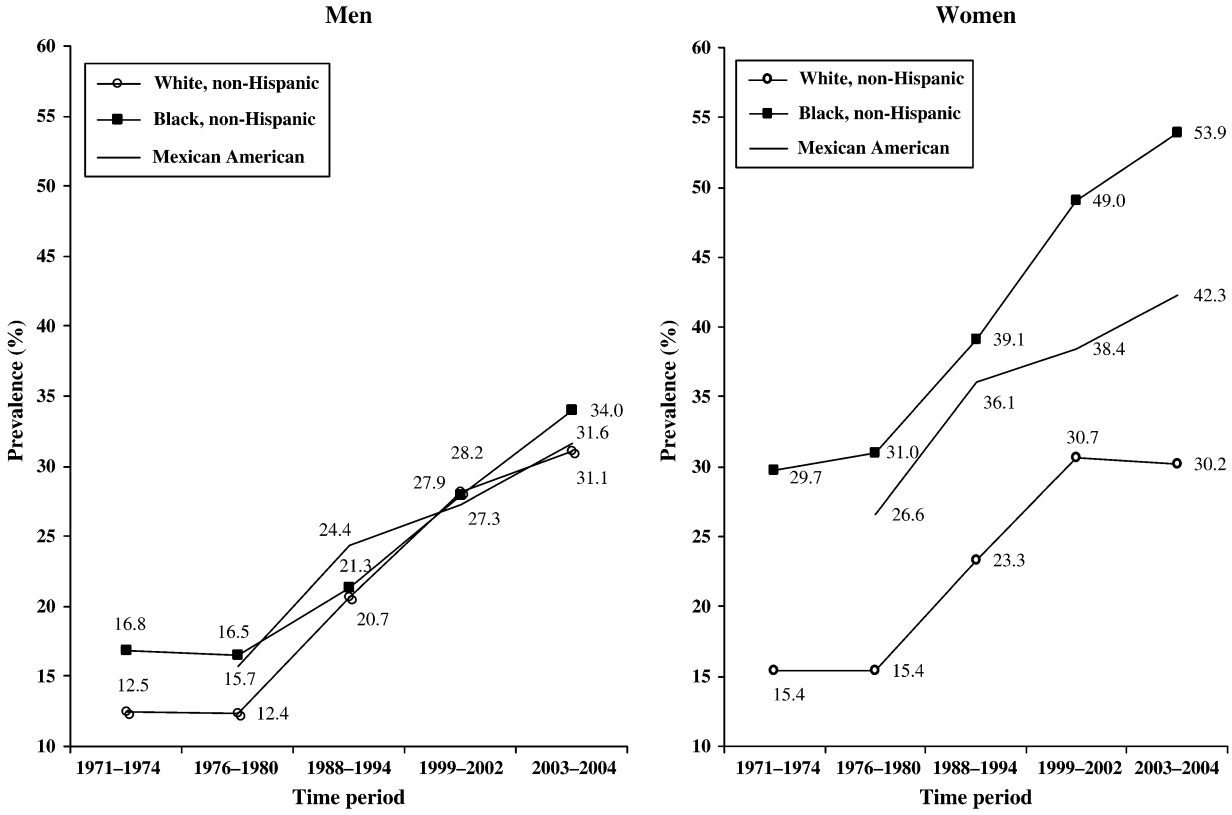

FIGURE 2. Trends in the prevalence of obesity (body mass index ≥30 kg/m^2) in US adults, by gender and ethnicity, National Health and Nutrition Examination Survey, 1971–2004. (Sources: 2, 54).

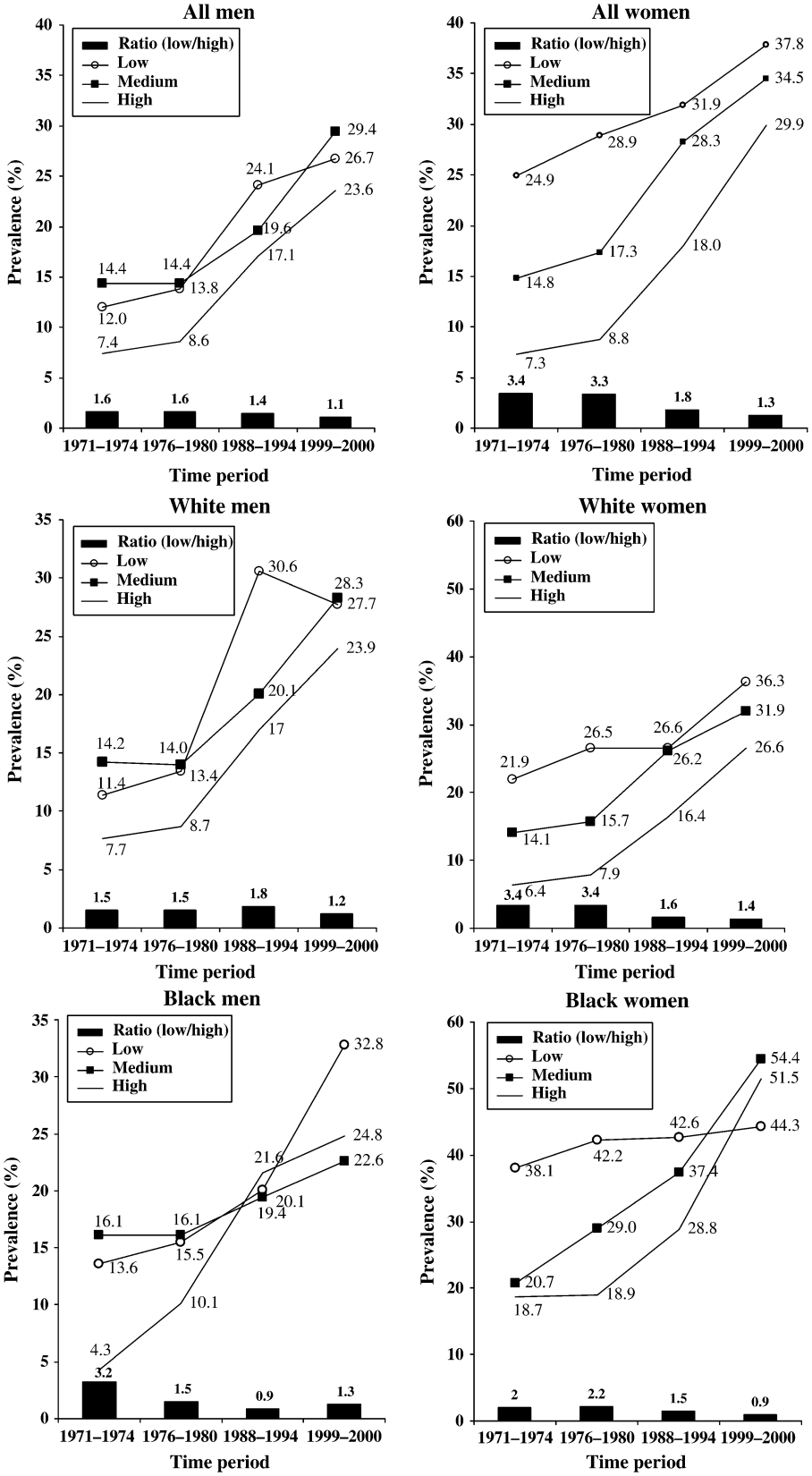

FIGURE 3. Trends in the socioeconomic status (SES) disparities of obesity in US adults during the National Health and Nutrition Examination Survey, 1971–2000, by gender and ethnicity: prevalence of obesity (body mass index $\geq$30 kg/m^2) and low to high-SES ratio (i.e., prevalence in low-SES group/prevalence in high-SES group). (Source: 40).

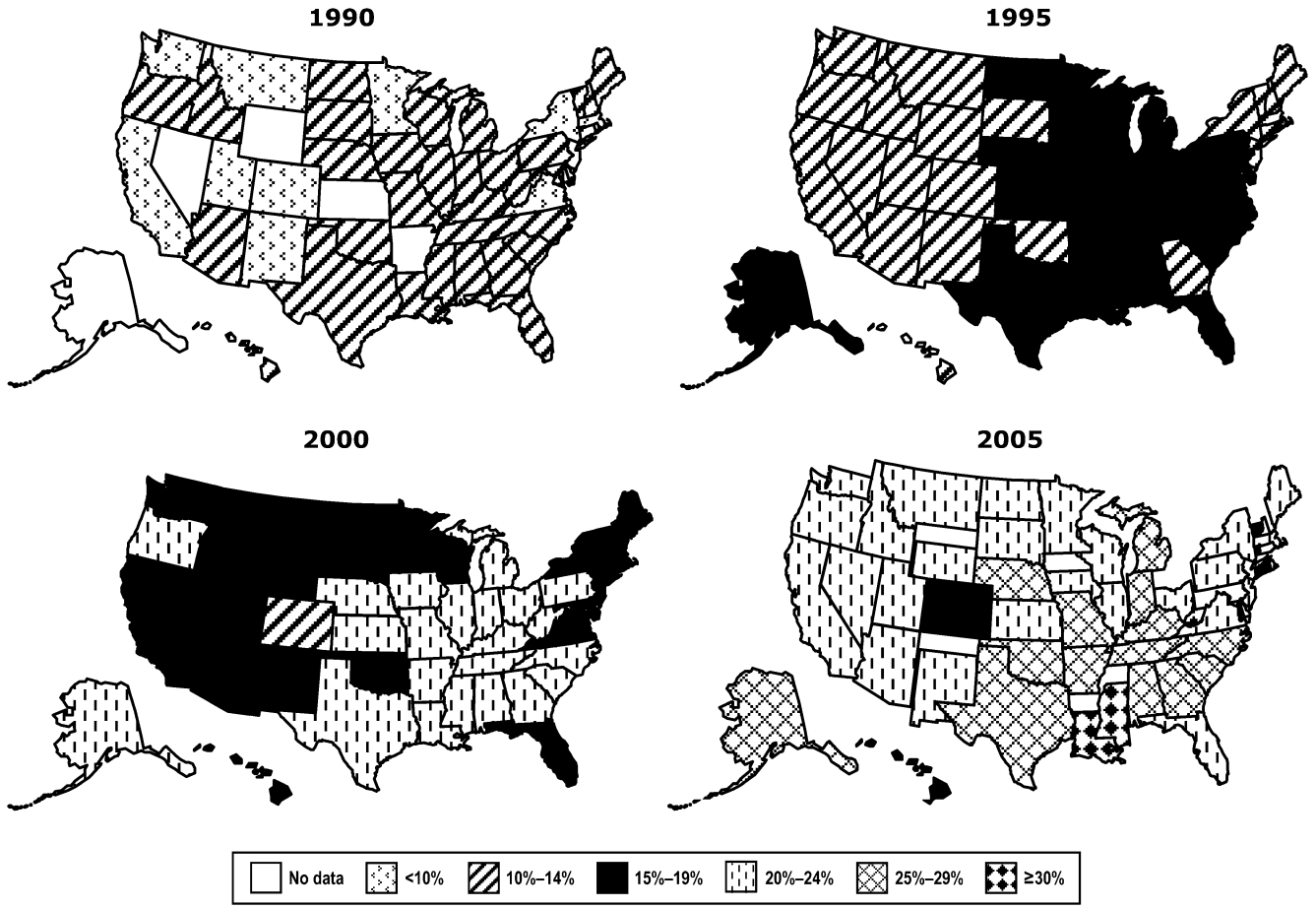

FIGURE 4. Trends in regional differences in the prevalence of obesity (body mass index $\geq$30 kg/m^2) in US adults, Behavioral Risk Factor Surveillance System data, 1990–2005. Self-reported body mass index data were used. (Source: 27).

2005, only four states had rates of 20 percent or higher, while 17 states had a prevalence rate of 25 percent or more, and three had a prevalence of 30 percent or higher (26, 27, 44, 49, 50).

Central obesity

Current situation. The NHANES 1999–2000 data show that the overall prevalence of central obesity was 38.3 percent among men versus 59.9 percent among women. As shown in figure 5, there are large gender and ethnicity differences. Prevalence was the highest among Black women (70.4 percent) and lowest among Mexican-American men (35.5 percent).

Trends. Between 1960 and 2000, the prevalence of central obesity and mean waist circumference increased steadily (figure 5). Mean waist circumference increased by 10 cm in men and 17 cm in women. Between 1988–1994 and 1999–2000, waist circumference increased in most age and racial/ethnic groups, except for men aged 30–59 years, women aged 40–59 years and 70 years or older, and women who were Mexican American or of ''other'' ethnicity. The prevalence of central obesity increased by approximately 10 percentage points, with the highest increase among women aged 20–29 years (51).

Ethnicity-specific trends showed no disparities between non-Hispanic Whites and Blacks in the early 1960s, while later surveys showed wide racial/ethnic differences; Whites, both men and women, had a lower mean waist circumference. However, in all surveys, waist circumference linearly increased with age, except in the age group 70–79 years, in which waist circumference decreased slightly. The prevalence of central obesity in all age groups showed a greater racial/ethnic disparity among women than among men (52). In general, Mexican-American women ranked first in prevalence in 1988–1994 but in 1999–2000 were surpassed by non-Hispanic Black women (52, 53).

US children and adolescents

Overall patterns and age and gender disparities

Current situation. Estimates of the national prevalence of at risk for overweight (BMI $\geq$85th percentile) and overweight (BMI $\geq$95th percentile) based on the most recent NHANES data collected in 1999–2004 are shown in table 5. In 2003–2004, more than one third (~35 percent) of older US children and adolescents aged 6–19 years were at risk

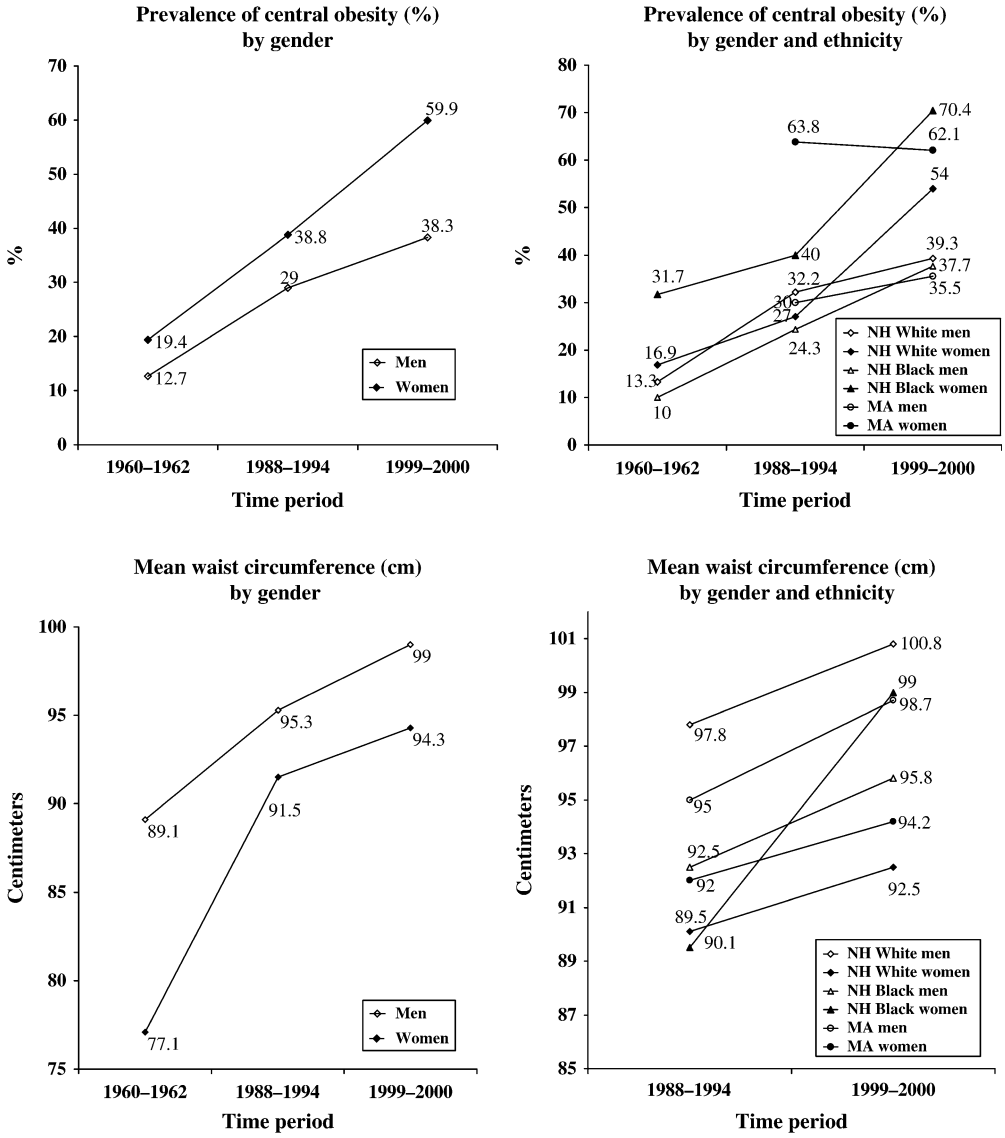

FIGURE 5. Trends as well as gender and ethnicity differences in the age-adjusted prevalence of central obesity (also known as abdominal obesity, defined as waist circumference >40 inches (102 cm) in men and >35 inches (88 cm) in women) and mean waist circumference among US adults (aged ≥20 years), National Health and Nutrition Examination Survey, 1960–2000. Data on mean waist circumference by gender and ethnicity are not available for 1960–1962. NH, non-Hispanic; MA, Mexican American. (Sources: 52, 53).

for overweight or overweight, and almost 17 percent were overweight; the figures were lower for young children aged 2–5 years (26.2 percent and 13.9 percent, respectively). Prevalence was similar among older children and adolescents (32). Similar patterns across age and gender were observed for 2003–2004 compared with 1999–2002 analyses (2). The overall national average prevalence is similar among boys and girls; however, large gender differences exist in some racial/ethnic groups. In 1999–2000 and 2003–2004, the prevalence of both outcomes showed a larger gender gap among non-Hispanic Blacks and Mexican-American children and adolescents compared with non-Hispanic Whites.

Trends. Trends data are shown in figures 6 and 7. In all age groups, the prevalence of overweight had increased since the 1960s. The increasing trend accelerated since NHANES II (1976–1980). Between 1976–1980 and 2003–2004, the average annual rate of increase was approximately 0.5 percentage points for children and adolescents aged 2 years or older. This rate was slower for young children. During this period, the prevalence of overweight among children aged 2–5 years increased from 7.2 percent to 10.3 percent; among children aged 6–11 years, it almost tripled, increasing from 6.5 percent to 15.8 percent. Among adolescents aged 12–19 years, it more than tripled, increasing from 5.0 percent to 16.1 percent. The NHANES 1999–2004 data showed that even during this short period of time, combined prevalence rose from 31.0 percent to 33.6 percent and the prevalence of overweight from 16 percent to 17.1 percent (2, 54).

TABLE 5. Current prevalence (%) of at risk for overweight and overweight in US children and adolescents, NHANES* 1999–2002 and 2003–2004† (sources: 2, 32, 54)

Gender and age (years)	Combined prevalence (BMI* ≥85th percentile)				Overweight (BMI ≥95th percentile)			
	All	Non-Hispanic White	Non-Hispanic Black	Mexican American	All	Non-Hispanic White	Non-Hispanic Black	Mexican American
				1999–2002				
Both genders								
2–19	31.0	28.2‡,§	35.4§,¶	39.9‡,¶	16.0	13.6‡,§	20.5¶	22.2¶
2–5	22.6	20.8	23.2	26.3	10.3	8.6	8.8	13.1
6–11	31.2	28.6§	33.7	38.9¶	15.8	13.5‡,§	19.8¶	21.8¶
12–19	30.9	27.9‡,§	36.8¶	40.7§,¶	16.1	13.7‡,§	21.1¶	22.5¶
				2003–2004				
Both genders								
2–19	33.6	33.5	35.1	37.0	17.1	16.3	20.0	19.2
2–5	26.2	25.0	24.0	32.6	13.9	11.5	13.0	19.2
6–11	37.2	36.9	40.0	42.9	18.8	17.7	22.0	22.5
12–19	34.3	34.7	36.5	34.3	17.4	17.3	21.8	16.3
				1999–2002				
Boys								
2–19	31.8	29.2§	31.0§	42.8‡,¶	16.8	14.3§	17.9§	25.5‡,¶
2–5	23.0	21.7	20.9	27.6	9.9	8.2	8.0	14.1
6–11	32.5	29.3§	29.7§	43.9‡,¶	16.9	14.0§	17.0§	26.5‡,¶
12–19	31.2	29.2§	32.1§	41.9‡,¶	16.7	14.6§	18.7	24.7¶
Girls								
2–19	30.3	27.0‡,§	40.1¶	36.6¶	15.1	12.9‡,§	23.2¶	18.5¶
2–5	22.3	20.0	25.6	25.0	10.7	9.1	9.6	12.2
6–11	29.9	27.7	37.9	33.8	14.7	13.1‡	22.8¶	17.1
12–19	30.5	26.5‡,§	41.9¶	39.3¶	15.4	12.7‡	23.6¶	19.9
				2003–2004				
Boys								
2–19	34.8	35.4	30.4	41.4	18.2	17.8	16.4	22.0
2–5	27.3	26.6	21.0	38.3	15.1	13.0	9.7	23.2
6–11	36.5	35.6	34.5	47.9	19.9	18.5	17.5	25.3
12–19	36.8	38.7	31.4	37.3	18.3	19.1	18.5	18.3
Girls								
2–19	32.4	31.5	40.0	32.2	16.0	14.8	23.8	16.2
2–5	25.2	23.5	27.0	26.7	12.6	10.0	16.3	15.1
6–11	38.0	38.2	45.6	37.4	17.6	16.9	26.5	19.4
12–19	31.7	30.4	42.1	31.1	16.4	15.4	25.4	14.1

* NHANES, National Health and Nutrition Examination Surveys; BMI, body mass index (weight (kg)/height $(m)^2$).

† Data for the period 2003–2004 by gender and ethnicity were not available, and tests for ethnicity differences were not reported.

‡ Significantly different from non-Hispanic Blacks at $p \leq 0.05$, with Bonferroni adjustment.

§ Significantly different from Mexican Americans at $p \leq 0.05$, with Bonferroni adjustment.

¶ Significantly different from non-Hispanic Whites at $p \leq 0.05$, with Bonferroni adjustment.

Between 1971–1974 and 1999–2002, on average, US children's and adolescents' BMI increased by 1.4 points and by 2 points among adolescent boys and girls, respectively (figure 7) (3). The pace of increases in mean BMI was slower than that of the prevalence, suggesting that more of the increase is attributable to the upper tail of the distribution.

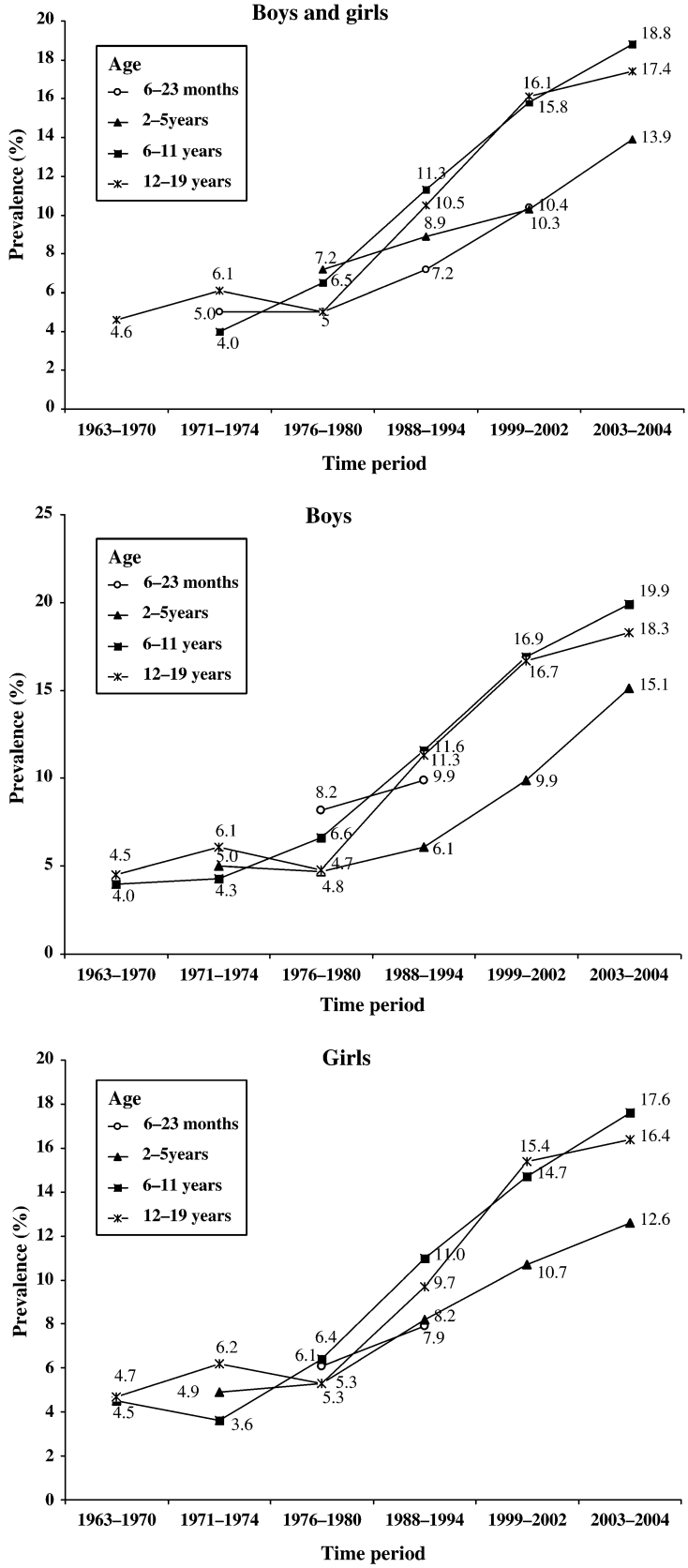

FIGURE 6. Trends in the prevalence of overweight (body mass index ≥95th percentile) in US children and adolescents, by gender, National Health and Nutrition Examination Survey, 1963–2004. (Sources: 2, 54).

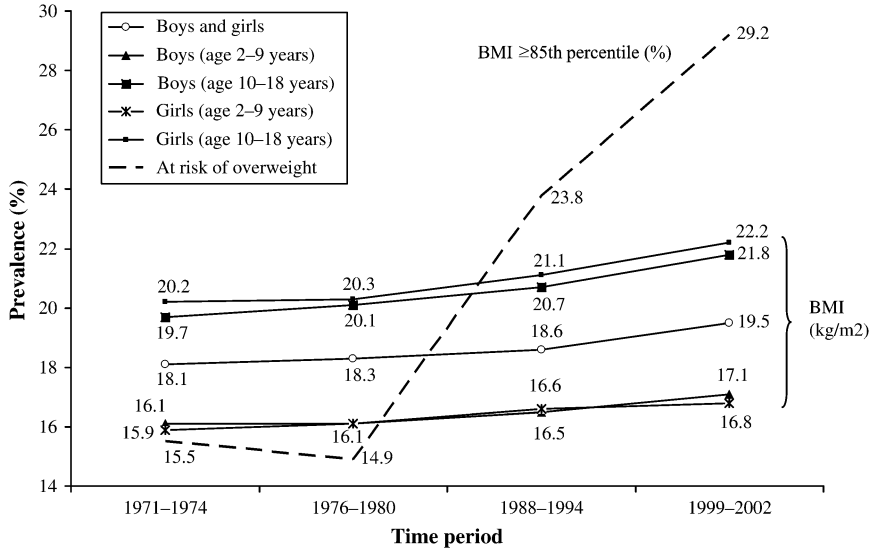

FIGURE 7. Trends in body mass index (BMI) means (cm) and combined prevalence (%) of at risk of overweight and overweight (BMI ≥85th percentile) in US children and adolescents, National Health and Nutrition Examination Survey, 1971–2002. (Source: 3).

Racial/ethnic disparities

Current situation. Similar to what was observed for adults, the NHANES data show considerable racial/ethnic disparities in obesity among US young people. Non-Hispanic White children and adolescents had the lowest prevalence compared with their non-Hispanic Black and Mexican-American counterparts. For example, combined prevalence was 28.2 percent, 35.4 percent, and 39.9 percent among those aged 6–19 years in the three racial/ethnic groups, respectively. Among boys, Mexican Americans aged 6–11 years had the highest combined prevalence and prevalence of overweight (43.9 percent and 26.5 percent, respectively). Among girls, non-Hispanic Black adolescents (aged 12–19 years) had the highest prevalence and non-Hispanic Whites had the lowest prevalence (41.9 percent vs. 23.6 percent) (32).

The Add Health study 1995–1996 data show that Asian adolescents had an obesity prevalence lower than the national average and all other main racial/ethnic groups (figure 8). The prevalence of at risk for overweight was 22.8 percent and 10.4 percent among Asian adolescent boys and girls compared with 26.5 percent and 22.2 percent among Caucasian adolescent boys and girls, respectively (36).

Large racial/ethnic disparities emerge at very young ages and exist even in homogeneous SES groups. For example,

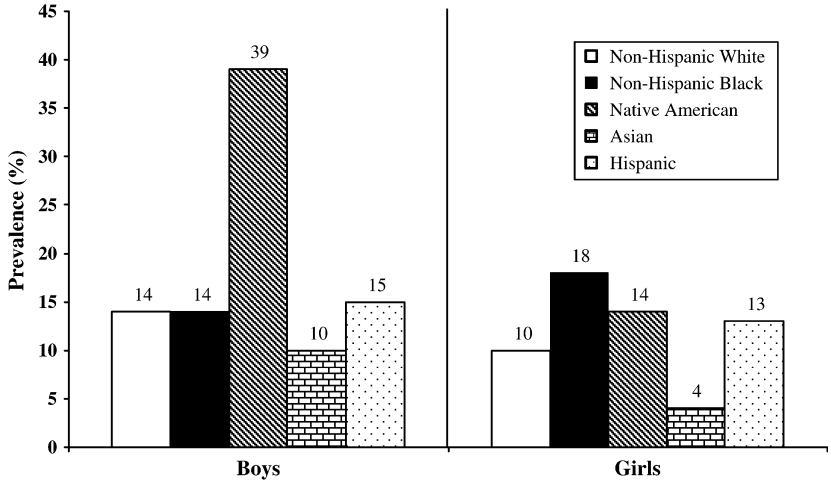

FIGURE 8. Prevalence of obesity (body mass index ≥30 kg/m^2) among US adolescents, by ethnicity, National Longitudinal Survey of Adolescent Health, 1994–1996 data. Data on self-reported weight and height were collected for 14,738 (waves I and II) adolescents aged 12–19 years. (Source: 29).

a recent, large study of 21,911 preschool children aged 12–59 months who participated in the Hawaiian Women, Infants, and Children program in 1997–1998 found large racial/ethnic differences in the prevalence of overweight (55). Of the eight racial/ethnic groups (White, Black, Asian, Filipino, Hawaiian, Hispanic, Samoan, and other), Samoan children had the highest prevalence (17.5 percent of those aged 1 year and 27.0 percent of those aged 2–4 years), while Asian children 1 year of age (2.3 percent) and Black children 2–4 years of age (7.3 percent) had the lowest rates. The overall prevalence was 5.9 percent among children 1 year of age and 11.4 percent in those aged 2–4 years.

The prevalence among American native Indian children was higher than the national average. Data collected in the PATHWAY study from 1,704 schoolchildren (in grades 2 and 3) in 41 schools from seven American Indian communities show that half of them were at risk of overweight or overweight (51.5 percent of girls vs. 46.5 percent of boys) and that 30.5 percent of girls and 26.8 percent of boys were overweight (56). Although there was a wide range in BMI across study sites, prevalence was consistently higher than the national averages in all seven communities and among both girls and boys (56).

Trends. NHANES data were available to enable us to compare the trends among White, Black, and Mexican-American children and adolescents since 1971 (figure 9). In all racial/ethnic groups, overweight increased. The racial/ethnic differences in the increase were small except for adolescent boys. Between 1988–1994 and 1999–2002, White adolescent boys had a slower increase than the other two racial/ethnic groups (2, 54). The prevalence of at risk for overweight among children and adolescents increased from 15.5 percent in 1971–1975 to 33.6 percent in 2003–2004. The Youth Risk Behavior Surveillance System data enabled us to examine the trends based on self-reported weight and height since the early 1990s. In general, they suggest similar patterns (28).

Socioeconomic disparities

Current situation. In general, the patterns for US children and adolescents and for adults share some similarities, but some features are unique. SES was inversely related to prevalence of obesity among Whites but not among African Americans or Hispanics. The patterns of the SES disparities in obesity are presented in table 6. Our recent study based on NHANES 1999–2002 data shows that high-SES young boys had the lowest prevalence compared with their counterparts, whereas the SES difference in prevalence was small among young girls (3). Among adolescents, no consistent association was found between SES and overweight for boys, but low-SES adolescent girls had a much higher prevalence than their medium- and high-SES counterparts (20.0 percent vs. 14.2 percent and 12.9 percent, respectively). This difference is mainly due to the strong inverse association between SES and overweight among White adolescent girls (3). High-SES Black adolescent girls were at increased risk compared with their lower-SES counterparts (38.0 percent vs. 18.7 percent and 24.5 percent, respectively). Main findings from other selected studies are highlighted in appendix 2 (36, 57, 58).

Trends. Our analysis of the NHANES data collected between 1971 and 2002 show that overweight increased in all SES groups cross-classified by sex-age-race/ethnicity (non-Hispanic White, non-Hispanic Black, Mexican American) except for low-SES Mexican-American girls aged 2–9 years (40). We found no consistent patterns for an SES difference in the increasing trend. Between 1976 and 1980 and between 1999 and 2002, the low- to high-SES ratio for prevalence increased from 0.8 to 1.8 among boys aged 2–9 years but then decreased from 1.9 to 1.0, respectively; among adolescent boys and girls, the ratio increased between 1976 and 1994 but then decreased between 1994 and 2002. Furthermore, the patterns varied across age-gender-racial/ethnic groups. Tertiles of family per capita income (assessed by using poverty income ratio) were used to define low-, medium-, and high-SES groups.

Geographic and urban-rural differences: current situation and trends. To our knowledge, limited studies have examined the regional differences in overweight among US children and adolescents. Our previous research based on the NHANES III data shows that the rural-urban differences are small, and they vary across age groups (16, 59). In children aged 6–9 years, the combined prevalence was higher in urban than in rural areas (26.1 percent vs. 22.8 percent), but the prevalence of overweight was almost the same (11.9 percent vs. 12.1 percent). Among adolescents aged 10–18 years, whereas the combined prevalence was slightly higher in rural than in urban areas (27.2 percent vs. 24.4 percent), the prevalence of overweight was comparable between areas (11.2 percent vs. 10.2 percent).

A recent study based on the Add Health study 1994–1995 baseline data examined the differences in US adolescents' risk of obesity and in their physical activity patterns according to neighborhood characteristics (60). Study participants were grouped into six categories: 1) rural working class; 2) exurban; 3) newer suburban; 4) upper-middle class, older suburban; 5) mixed-ethnicity urban; and 6) low-SES, inner-city areas. Compared with US adolescents living in newer suburbs, those living in rural working-class, exurban, and mixed-ethnicity urban areas were approximately 30 percent more likely to be overweight, independent of individual SES, age, and ethnicity. These findings illustrate important effects of the neighborhood on health and the inherent complexity of assessing residential landscapes across the United States. Simple classic urban-suburban-rural measures may mask the important complexities.

Central obesity. Unlike for adults, and because national guidelines for classifying central obesity are lacking, little is known about the status of central obesity in US children and adolescents. Nevertheless, a recent study based on NHANES III shows considerable racial/ethnic differences in waist circumference. The distribution of age- and gender-specific percentiles of waist circumference among children and adolescents aged 2–18 years differs across racial/ethnic groups, especially for the uppermost percentiles (75th and 90th) and for adolescents close to age 18 years (figure 10). In fact, compared with their counterparts, Mexican-Americans boys and non-Hispanic Black girls aged 18 years had the highest waist circumference values in the 90th percentile (61).

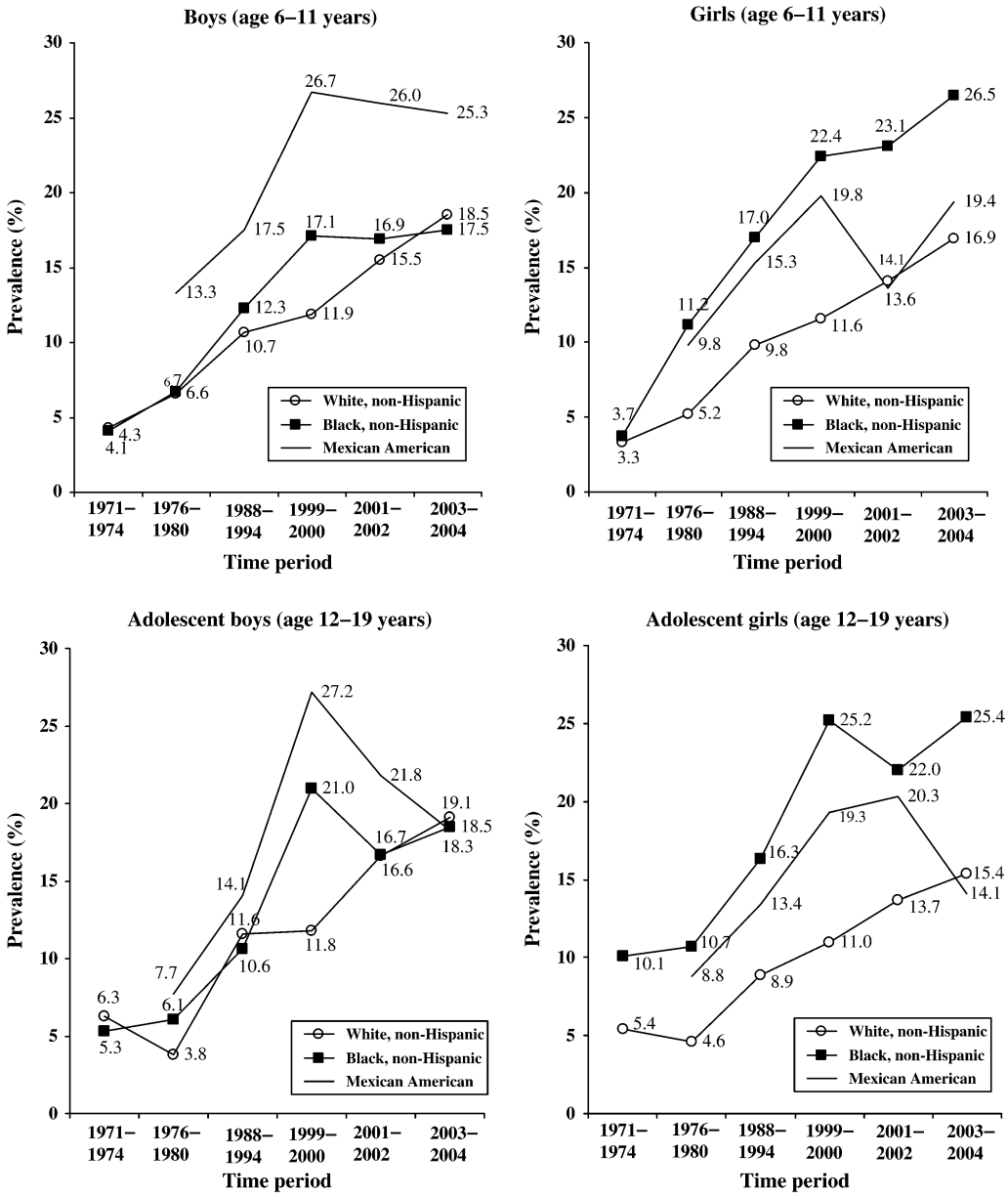

FIGURE 9. Trends in the prevalence of overweight (body mass index ≥95th percentile) in US children and adolescents, by gender, age, and ethnicity, National Health and Nutrition Examination Survey, 1971–2004. The dramatic decline in prevalence between 2001 and 2004 among Mexican-American adolescents may be due to sampling problems. (Sources: 2, 54).

Tracking of BMI and obesity from childhood to adulthood

A large number of studies have shown the tracking of BMI and obesity status from childhood to adulthood (62–67), providing additional support for early prevention. Overall, it is estimated that about one third of obese preschool children and about one half of obese school-age children become obese adults, although findings from different studies varied considerably. Recent studies also suggest some racial/ethnic differences in the tracking patterns. For example, when longitudinal data collected from 2,392 children (initially aged 5–14 years) over 17 years from childhood to adulthood were used (62), the tracking of childhood BMI was stronger in Blacks than in Whites. Among overweight children, 65 percent of White girls versus 84 percent of Black girls became obese adults; among boys, the corresponding figures were 71 percent versus 82 percent.

Average annual increase in prevalence and future projections

Using linear regression models, we estimated the average annual increase in the prevalence of overweight and obesity

TABLE 6. Trends in the SES*,† disparities in overweight (≥95th percentile) in US children and adolescents, prevalence (%), and ratio of low to high SES, NHANES* 1971–2002 (source: 3)

	Boys					Girls				
	1971–1975	1976–1980	1988–1994	1999–2002	Trend in ratios, 1976–2002‡	1971–1975	1976–1980	1988–1994	1999–2002	Trend in ratios, 1976–2002‡
All										
Aged 2–9 years										
Low SES	6.0	5.1	9.1	17.4		3.2	7.0	11.3	11.9	
Medium SES	4.3	3.5	8.2	15.0		4.9	6.9	9.6	14.7	
High SES	3.2	6.5	9.1	9.7		4.2	3.6	9.1	11.4	
Ratio: low/high	1.9	0.8	1.0	1.8	↑↑	0.8	1.9	1.2	1.0	↓↓
Aged 10–17 years										
Low SES	4.1	5.7	16.7	17.3		7.4	8.7	13.5	20.0	
Medium SES	6.4	6.5	11.8	18.8		7.2	5.2	12.2	14.2	
High SES	5.1	3.9	6.6	15.9		3.7	3.1	4.4	12.9	
Ratio: low/high	0.8	1.5	2.5	1.1	↑↓	2.0	2.8	3.1	1.6	↑↓
Non-Hispanic White										
Aged 2–9 years										
Low SES	5.2	4.5	8.0	15.5		2.3	7.2	6.2	7.8	
Medium SES	4.0	2.9	8.4	14.9		4.6	3.6	9.5	13.4	
High SES	3.2	5.3	8.4	8.7		4.3	5.2	8.6	12.3	
Ratio: low/high	1.6	0.8	1.0	1.8	↑↑	0.5	1.4	0.7	0.6	↓↓
Aged 10–17 years										
Low SES	3.9	4.9	18.2	14.4		7.1	7.1	17.4	17.9	
Medium SES	5.8	6.2	11.2	14.8		6.4	5.1	13.0	10.6	
High SES	5.1	2.8	6.4	14.2		3.8	3.1	2.7	10.6	
Ratio: low/high	0.8	1.8	2.8	1.0	↑↓	1.9	2.3	6.4	1.7	↑↓
Non-Hispanic Black										
Aged 2–9 years										
Low SES	7.8	3.8	8.3	12.9		2.8	4.9	11.5	15.4	
Medium SES	9.1	3.1	8.8	11.6		5.7	12.3	11.4	12.8	
High SES	0.0	15.6	11.9	18.6		0.4	9.4	18.5	24.6	
Ratio: low/high	—§	0.2	0.7	0.7	↑–	7.0	0.5	0.6	0.6	↑-
Aged 10–17 years										
Low SES	3.8	4.6	12.6	18.8		8.2	14.5	13.7	24.5	
Medium SES	6.7	0.0	14.5	18.4		14.8	8.2	15.6	18.7	
High SES	10.4	15.9	6.2	22.2		1.9	6.5	25.4	38.0	
Ratio: low/high	0.4	0.3	2.0	0.8	↑↓	4.3	2.2	0.5	0.6	↓↑
Mexican American										
Aged 2–9 years										
Low SES			13.7	21.3				15.5	13.6	
Medium SES			11.1	15.9				12.5	19.0	
High SES			25.4	18.5				12.0	5.1	
Ratio: low/high			0.5	1.2	↑			1.3	2.7	↑
Aged 10–18 years										
Low SES			16.5	25.8				9.9	24.0	
Medium SES			16.7	35.2				22.9	18.9	
High SES			22.3	22.7				12.0	18.3	
Ratio: low/high			0.7	1.1	↑			0.8	1.3	↑

* SES, socioeconomic status (based on poverty income ratio); NHANES, National Health and Nutrition Examination Surveys.
† No adequate number of Mexican Americans was selected in NHANES before 1988.
‡ Trend in ratios during 1976–1980 to 1988–1994 and 1988–1994 to 1999–2002: ↑, increasing; ↓, decreasing; –, constant.
§ Undefined ratio (denominator = 0).

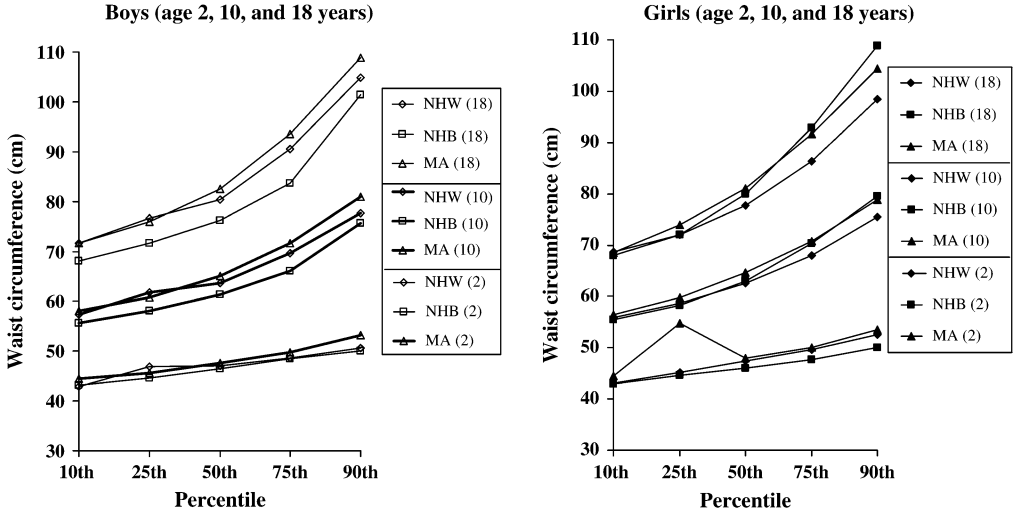

FIGURE 10. Ethnic differences in waist circumference (cm) and gender, age-, and ethnicity-specific percentiles among US children and adolescents, National Health and Nutrition Examination Survey III, 1988–1994. In the two keys, ages are given in parentheses. NHW, non-Hispanic White; NHB, non-Hispanic Black; MA, Mexican American. (Source: 61).

(BMI $\geq$30 kg/m^2) among adults and children between 1980 and 2004 (table 7). Among adults, the prevalence of obesity increased at a faster pace for women than men ($\beta = 0.911$ vs. $\beta = 0.653$) and particularly among non-Hispanic White women ($\beta = 0.654$), who had the fastest increase. Non-Hispanic Black women had the fastest increase in the prevalence of obesity ($\beta = 0.878$). Projections based on these models indicate that by 2015, the prevalence of obesity among adults will reach 40.8 percent among all and as high as 62.5 percent among non-Hispanic Black women. The projection is even more alarming for the prevalence of overweight. Overall, the prevalence will be 74.7 percent by 2015: 86.5 percent among non-Hispanic Black women and 82.2 percent among Mexican-American men.

Regarding children aged 6–11 years, non-Hispanic Black girls and Mexican-American boys have by far the fastest annual increase ($\beta = 0.564$ vs. 0.548) in the prevalence of overweight, which is expected to reach 31.1 percent and 32.9 percent, respectively, by 2015 (compared with an overall 22.7 percent). A similar pattern is observed for adolescents aged 12–19 years.

DISCUSSION

Currently, more than two thirds of US adults and approximately one third of US children and adolescents are overweight or obese, and some minority and low-SES groups are disproportionally affected. The prevalence of obesity and overweight among US children and adults has more than doubled since the 1970s, and the rate continues to rise. Numerous studies have shown that obesity increases morbidity and mortality (17). Obesity has become the second leading preventable cause of disease and death in the United States, second only to tobacco use (1). Obesity is likely to continue to increase and soon become the leading cause if no effective approaches to controlling it can be implemented.

Consistent with previous studies, our systematic analysis shows large racial/ethnic disparities in obesity among women, children, and adolescents in the United States. Some minority and low-SES groups such as non-Hispanic Black women and children, Mexican-American women and children, low-SES Black men and White women and children, Native Americans, and Pacific Islanders are disproportionally affected. On the other hand, some minority groups such as Asian Americans have a lower prevalence of obesity. Of great concern, our analysis shows that the prevalence of obesity and overweight has increased at an average annual rate of approximately 0.3–0.8 percentage point across different sociodemographic groups over the past three decades. If a similar increase in trend is assumed, by 2015, the majority of US adults (75 percent: BMI $\geq$25 kg/m^2) and nearly a quarter (24 percent) of US children and adolescents are expected to be overweight or obese (95th percentile of BMI). Some population groups will be more seriously affected. For example, by 2015, 86.5 percent of non-Hispanic Black women will be overweight or obese, and 62.5 percent will be obese. However, current available data are limited and do not enable us to examine the trends in other minority groups or to understand the factors that have led to the current obesity epidemic.

A good understanding of underlying causes that triggered the increase in obesity prevalence in the United States over the past three decades and the factors that have contributed to the disparities across groups is critical in fighting this growing public health crisis and achieving an important national priority to eliminate health disparities. Although obesity is caused by many factors, in most persons, weight gain results from a combination of excess calorie consumption and inadequate physical activity. To maintain a healthy

TABLE 7. Average annual increase in the prevalence of obesity and overweight among US adults and overweight among US children and adolescents, and future projections based on NHANES† 1976–1980 to 2003–2004‡ (sources: 2, 54)

	Gender	Ethnicity	Average annual increase (percentage points)§					Prevalence (%) projections	
			Rate (β)	SE†	*p* value	Intercept	R^2	2010	2015
Adults aged ≥20 years	All	All	0.682	0.031	<0.001	−1,333.4	0.99	37.42	40.83
Obesity (BMI† ≥30)	Men	All	0.685*	0.064	0.059	−1,343.0	0.98	33.85	37.28
	Women	All	0.778*	0.070	0.057	−1,521.3	0.98	42.48	46.37
	Men	Non-Hispanic White	0.727	0.037	0.003	−1,427.0	0.99	34.27	37.91
		Non-Hispanic Black	0.636	0.141	0.046	−1,242.0	0.87	36.36	39.54
		Mexican American	0.575	0.075	0.017	−1,122.5	0.97	33.25	36.13
	Women	Non-Hispanic White	0.616	0.055	0.008	−1,202.6	0.98	35.56	38.64
		Non-Hispanic Black	0.878	0.107	0.015	−1,706.7	0.97	58.08	62.47
		Mexican American	0.569	0.084	0.021	−1,099.3	0.96	44.39	47.23
Overweight§ (BMI ≥25)	All	All	0.772	0.044	<0.01	−1,480.9	0.99	70.82	74.68
	Men	All	0.653	0.022	0.022	−1,239.0	0.99	73.53	76.80
	Women	All	0.911*	0.153	0.106	−1,762.1	0.97	69.01	73.57
	Men	Non-Hispanic White	0.654	0.017	0.017	−1,239.8	0.99	74.74	78.01
		Non-Hispanic Black	0.419*	0.083	0.125	−777.9	0.96	64.29	66.39
		Mexican American	0.595	0.003	0.003	−1,116.7	1.00	79.25	82.22
	Women	Non-Hispanic White	0.856*	0.152	0.112	−1,655.4	0.97	65.16	69.44
		Non-Hispanic Black	0.694*	0.180	0.162	−1,311.9	0.94	83.04	86.51
		Mexican American	0.481*	0.094	0.124	−889.7	0.96	77.11	79.51
Children aged 6–11 years	All	All	0.462	0.051	0.012	−908.2	0.97	20.42	22.73
Overweight (BMI ≥95th percentile)¶	Boys	All	0.492	0.052	0.003	−968.1	0.97	20.82	23.28
	Girls	All	0.406	0.041	0.002	−796.3	0.97	19.76	21.79
	Boys	Non-Hispanic White	0.400	0.100	0.028	−784.3	0.84	19.70	21.70
		Non-Hispanic Black	0.441	0.0286	0.001	−865.0	0.99	21.41	23.62
		Mexican American	0.548	0.098	0.011	−1,071.3	0.91	30.18	32.92
	Girls	Non-Hispanic White	0.403	0.073	0.012	−793.0	0.91	17.03	19.05
		Non-Hispanic Black	0.564	0.056	0.002	−1,105.4	0.97	28.24	31.06
		Mexican American	0.314*	0.142	0.113	−610.9	0.62	20.24	21.81
Adolescents aged 12–19 years	All	All	0.492	0.016	<0.001	−967.8	0.99	21.12	23.58
Overweight (BMI ≥95th percentile)¶	Boys	All	0.528	0.018	<0.001	−1,040.2	0.99	21.08	23.72
	Girls	All	0.449	0.022	<0.001	−883.7	0.98	18.79	21.04
	Boys	Non-Hispanic White	0.526	0.108	0.017	−1,037.3	0.88	19.96	22.59
		Non-Hispanic Black	0.537	0.129	0.025	−1,057.3	0.85	22.07	24.76
		Mexican American	0.589	0.226	0.08	−1,158.6	0.69	25.29	28.24
	Girls	Non-Hispanic White	0.391	0.058	0.007	−769.0	0.94	16.91	18.87
		Non-Hispanic Black	0.581	0.096	0.009	−1,138.3	0.92	29.51	32.42
		Mexican American	0.360*	0.154	0.101	−703.2	0.64	20.40	22.20

* $p \geq 0.05$ for the null hypothesis that $\beta = 0$; all others, $p < 0.05$.

† NHANES, National Health and Nutrition Examination Surveys; SE, standard error; BMI, body mass index (weight (kg)/height $(m)^2$).

‡ In some of the projections, the last available data were for the period 1999–2000. These projections include adult, gender-specific obesity for all ethnic groups, and adult gender-specific overweight for each ethnic group and all ethnic groups.

§ Linear regression model included prevalence for each year per age/gender/ethnicity stratum as a function of time as the independent variable. The β coefficients can be interpreted as the annual change in prevalence, and the whole model (with intercept) can be used to project future prevalence. Note that time periods for each NHANES survey (1971–2004) were represented by the midpoint of the survey period. For Mexican Americans, only NHANES data collected between 1988 and 2004 were used.

¶ Based on the 2000 Centers for Disease Control and Prevention Growth Chart. No published data are known to have examined the trends of at risk for overweight (BMI ≥85th percentile) between 1971 and 2004 based on the Centers for Disease Control and Prevention Growth Charts by gender and ethnicity.

weight, there must be a balance between energy consumption through dietary intake and energy expenditure through metabolic and physical activity (17). A number of individual-, population-, and international-level factors and environmental determinants might have played a role in the obesity trends, such as changes in people's eating behaviors, physical activity and inactivity patterns, occupation, development of technology, culture exchange, and global trade (16, 17, 37). The NHANES data show a dramatic increase in the prevalence of overweight and obesity across all population groups and a declining disparity of obesity across SES groups over the past two decades. This finding indicates that individual characteristics are not the dominant factor to which the rising obesity epidemic is ascribed. Social environmental factors might have a more profound effect in influencing individuals' body weight status than do individuals' characteristics such as SES. A growing consensus is that environmental factors have played a pivotal role in influencing people's lifestyles and fueling the obesity epidemic in the United States and worldwide (17, 68, 69). The environment in the United States has been characterized as ''obesogenic'' because of its promotion of high energy intake and low energy expenditure (69). The current society provides Americans with abundant food at a relatively low cost and numerous opportunities to reduce energy expenditure at work and at home, which facilitates sedentary behaviors.

Nationally representative survey data examining trends in people's eating patterns between 1970 and the 1990s have indicated several patterns likely to put people in the United States at increased risk of obesity, such as increased consumption of total energy, soft drink, and snack foods; more frequent eating at fast-food and other restaurants; and inadequate consumption of vegetables and fruits compared with dietary recommendations (70–77). The increase in portion size in the United States over the past three decades probably is an important contributor to overconsumption of food and has fueled the growing obesity epidemic. Examination of the current portions of food products against previous portions and dietary intake data collected from individuals consistently show that portion sizes have risen sharply in the United States (73, 75, 78) (appendix 3).

Although our current understanding of the underlying complex causes of the disparities in obesity between population groups in the United States (e.g., gender, age, ethnicity, and SES groups) is still very limited, recent research has shed some important light on related factors at the individual, community, regional, and national levels. At the community level, disadvantage may constrain people's ability to acquire and maintain healthy diet and exercise behaviors. Differential rates of available local area physical fitness facilities, restaurants, and types of food stores by neighborhood characteristics may help explain why obesity does not affect all population groups equally (79, 80). A recent study shows significant disparities in the availability of food stores. African-American and Hispanic neighborhoods had fewer chain supermarkets compared with White and non-Hispanic neighborhoods, by about 50 percent and 70 percent, respectively (81). The availability of supermarkets has been associated with more healthful diets, higher vegetable and fruit consumption, and lower rates of obesity (82, 83). Shopping at supermarkets versus independent groceries has been associated with more frequent vegetable and fruit consumption (84). The Add Health study shows that lower-SES and minority population groups had less access to physical activity facilities, which in turn was associated with decreased physical activity and increased overweight (85).

Population-based policies and programs that emphasize environmental changes are most likely to be successful. Strategies to tackle obesity need to be incorporated into other existing health promotion programs, particularly those preventing chronic diseases by promoting healthful eating and physical activity. Childhood and adolescence are key times for persons to form lifelong eating and physical activity habits. Overweight children are likely to remain obese as adults. Thus, obesity prevention in schoolchildren is a public health priority. In addition, because the majority of children spend many of their waking hours in schools, schools should be key partners in the prevention of childhood obesity. The large racial/ethnic differences in the prevalence of overweight and obesity suggest that culturally sensitive and appropriate approaches are needed in promoting healthful eating in fighting the obesity epidemic. It is crucial to tailor treatment and prevention efforts to each particular ethnicity group's specific situation and needs. Policy makers and public health workers need to be aware of racial/ethnic differences that may affect one's health behaviors and body weight status, such as the differences in their local communities, perceptions of body weight, food preparation, eating practices, physical activity and inactivity patterns, and child-feeding practices. Without developing effective strategies to modify the current ''obesogenic'' environment in the United States, it is likely that the obesity epidemic will continue. Government agencies, industry, public health professionals, and individual persons all need to play an active role in the growing national efforts to combat the obesity epidemic.

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REFERENCES

1. US Department of Health and Human Services, Public Health Service. The Surgeon General's call to action to prevent and decrease overweight and obesity. Rockville, MD: Office of the Surgeon General, 2001. (www.surgeongeneral.gov/topics/obesity).

2. Ogden CL, Carroll MD, Curtin LR, et al. Prevalence of overweight and obesity in the United States, 1999–2004. JAMA 2006;295:1549–55.
3. Wang Y, Zhang Q. Are American children and adolescents of low socioeconomic status at increased risk of obesity? Changes in the association between overweight and family income between 1971 and 2002. Am J Clin Nutr 2006;84: 707–16.
4. Pender JR, Pories WJ. Epidemiology of obesity in the United States. Gastroenterol Clin North Am 2005;34:1–7.
5. Baskin ML, Ard J, Franklin F, et al. Prevalence of obesity in the United States. Obes Rev 2005;6:5–7.
6. Flegal KM. Epidemiologic aspects of overweight and obesity in the United States. Physiol Behav 2005;86:599–602.
7. Avila-Funes JA, Gutierrez-Robledo LM, Ponce De Leon Rosales S. Validity of height and weight self-report in Mexican adults: results from the national health and aging study. J Nutr Health Aging 2004;8:355–61.
8. Kuczmarski MF, Kuczmarski RJ, Najjar M. Effects of age on validity of self-reported height, weight, and body mass index: findings from the Third National Health and Nutrition Examination Survey, 1988–1994. J Am Diet Assoc 2001;101:28–34; quiz 5–6.
9. Taylor AW, Dal Grande E, Gill TK, et al. How valid are self-reported height and weight? A comparison between CATI self-report and clinic measurements using a large cohort study. Aust N Z J Public Health 2006;30:238–46.
10. Yun S, Zhu BP, Black W, et al. A comparison of national estimates of obesity prevalence from the behavioral risk factor surveillance system and the National Health and Nutrition Examination Survey. Int J Obes (Lond) 2006;30:164–70.
11. Guillaume M. Defining obesity in childhood: current practice. Am J Clin Nutr 1999;70:126S–30S.
12. Cole TJ, Bellizzi MC, Flegal KM, et al. Establishing a standard definition for child overweight and obesity worldwide: international survey. BMJ 2000;320:1240–3.
13. Wang Y. Epidemiology of childhood obesity—methodological aspects and guidelines: what is new? Int J Obes Relat Metab Disord 2004;28(suppl 3):S21–8.
14. WHO Expert Committee. Physical status, the use and interpretation of anthropometry. Geneva, Switzerland: World Health Organization, 1995. (Technical report series 54).
15. Troiano RP, Flegal KM. Overweight prevalence among youth in the United States: why so many different numbers? Int J Obes Relat Metab Disord 1999;23(suppl 2):S22–7.
16. Wang Y, Wang JQ. A comparison of international references for the assessment of child and adolescent overweight and obesity in different populations. Eur J Clin Nutr 2002;56: 973–82.
17. World Health Organization (WHO). Obesity: preventing and managing the global epidemic: Report of a WHO consultation. Geneva, Switzerland: World Health Organization, 2000. (Technical report series no. 894).
18. Kuczmarski RJ, Ogden CL, Grummer-Strawn LM, et al. CDC growth charts: United States. Adv Data 2000;314:1–27.
19. National Institutes of Health (NIH) National Heart, Lung, and Blood Institute's (NHLBI) North American Association for the Study of Obesity (NAASO). The practical guide: identification, evaluation, and treatment of overweight and obesity in adults. Rockville, MD: National Institutes of Health, 2000. (Publication no. 00-4084).
20. Zhu S, Heymsfield SB, Toyoshima H, et al. Race-ethnicity-specific waist circumference cutoffs for identifying cardiovascular disease risk factors. Am J Clin Nutr 2005;81: 409–15.
21. Wang Y, Rimm EB, Stampfer MJ, et al. Comparison of abdominal adiposity and overall obesity in predicting risk of type 2 diabetes among men. Am J Clin Nutr 2005;81:555–63.
22. Must A, Dallal GE, Dietz WH. Reference data for obesity: 85th and 95th percentiles of body mass index (wt/ht^2) and triceps skinfold thickness. Am J Clin Nutr 1991;53:839–46.
23. Himes JH, Dietz WH. Guidelines for overweight in adolescent preventive services: recommendations from an expert committee. The Expert Committee on Clinical Guidelines for Overweight in Adolescent Preventive Services. Am J Clin Nutr 1994;59:307–16.
24. Barlow SE, Dietz WH. Obesity evaluation and treatment: Expert Committee recommendations. The Maternal and Child Health Bureau, Health Resources and Services Administration and the Department of Health and Human Services. Pediatrics 1998;102:E29.
25. Black MM, Cutts DB, Frank DA, et al. Special Supplemental Nutrition Program for Women, Infants, and Children participation and infants' growth and health: a multisite surveillance study. Pediatrics 2004;114:169–76.
26. Center for Disease Control and Prevention (CDC). National Health and Nutrition Examination Survey. Atlanta, GA: CDC, 2006. (http://www.cdc.gov/nchs/nhanes.htm). (Accessed September 25, 2006).
27. Centers for Disease Control and Prevention (CDC). Behavioral Risk Factor Surveillance System: turning information into health. (http://www.cdc.gov/brfss). (Accessed October 2, 2006).
28. Centers for Disease Control and Prevention (CDC). YRBSS: Youth Risk Behavior Surveillance System. (http://www.cdc.gov/healthyyouth/yrbs). (Accessed September 2, 2006).
29. Harris KM, Gordon-Larsen P, Chantala K, et al. Longitudinal trends in race/ethnic disparities in leading health indicators from adolescence to young adulthood. Arch Pediatr Adolesc Med 2006;160:74–81.
30. Carolina Population Center (CPC). The National Longitudinal Study of Adolescent Health. (http://www.cpc.unc.edu/addhealth). (Accessed September 25, 2006).
31. STATA. Statistics/Data Analysis, release 9. College Station, TX: Stata Corporation, 2003.
32. Hedley AA, Ogden CL, Johnson CL, et al. Prevalence of overweight and obesity among US children, adolescents, and adults, 1999–2002. JAMA 2004;291:2847–50.
33. McNeely MJ, Boyko EJ. Type 2 diabetes prevalence in Asian Americans: results of a national health survey. Diabetes Care 2004;27:66–9.
34. Davis J, Busch J, Hammatt Z, et al. The relationship between ethnicity and obesity in Asian and Pacific Islander populations: a literature review. Ethn Dis 2004; 14:111–18.
35. Lauderdale DS, Rathouz PJ. Body mass index in a US national sample of Asian Americans: effects of nativity, years since immigration and socioeconomic status. Int J Obes Relat Metab Disord 2000;24:1188–94.
36. Gordon-Larsen P, Adair LS, Popkin BM. The relationship of ethnicity, socioeconomic factors, and overweight in US adolescents. Obes Res 2003;11:121–9.
37. Popkin BM, Udry JR. Adolescent obesity increases significantly in second and third generation U.S. immigrants: the National Longitudinal Study of Adolescent Health. J Nutr 1998;128:701–6.
38. Sobal J. Obesity and socioeconomic status: a framework for examining relationships between physical and social variables. Med Anthropol 1991;13:231–47.

39. Robert SA, Reither EN. A multilevel analysis of race, community disadvantage, and body mass index among adults in the US. Soc Sci Med 2004;59:2421–34.
40. Zhang Q, Wang Y. Trends in the association between obesity and socioeconomic status in U.S. adults: 1971 to 2000. Obes Res 2004;12:1622–32.
41. Zhang Q, Wang Y. Socioeconomic inequality of obesity in the United States: do gender, age, and ethnicity matter? Soc Sci Med 2004;58:1171–80.
42. Gortmaker SL, Must A, Perrin JM, et al. Social and economic consequences of overweight in adolescence and young adulthood. N Engl J Med 1993;329:1008–12.
43. Sobal J, Stunkard AJ. Socioeconomic status and obesity: a review of the literature. Psychol Bull 1989;105:260–75.
44. Mokdad AH, Ford ES, Bowman BA, et al. Prevalence of obesity, diabetes, and obesity-related health risk factors, 2001. JAMA 2003;289:76–9.
45. Burke GL, Jacobs DR Jr, Sprafka JM, et al. Obesity and overweight in young adults: the CARDIA study. Prev Med 1990;19:476–88.
46. Hazuda HP, Mitchell BD, Haffner SM, et al. Obesity in Mexican American subgroups: findings from the San Antonio Heart Study. Am J Clin Nutr 1991;53:1529S–34S.
47. Kahn HS, Williamson DF. Is race associated with weight change in US adults after adjustment for income, education, and marital factors? Am J Clin Nutr 1991;53:1566S–70S.
48. James SA, Fowler-Brown A, Raghunathan TE, et al. Life-course socioeconomic position and obesity in African American women: the Pitt County Study. Am J Public Health 2006;96:554–60.
49. Eaton DK, Kann L, Kinchen S, et al. Youth risk behavior surveillance—United States, 2005. J Sch Health 2006;76: 353–72.
50. Centers for Disease Control and Prevention (CDC). Overweight and obesity: obesity trends: U.S. obesity trends 1985–2005. (http://www.cdc.gov/nccdphp/dnpa/obesity/trend/maps/index.htm). (Accessed September 25, 2006).
51. Ford ES, Mokdad AH, Giles WH. Trends in waist circumference among U.S. adults. Obes Res 2003;11:1223–31.
52. Okosun IS, Chandra KM, Boev A, et al. Abdominal adiposity in U.S. adults: prevalence and trends, 1960–2000. Prev Med 2004;39:197–206.
53. Okosun IS, Choi ST, Boltri JM, et al. Trends of abdominal adiposity in white, black, and Mexican-American adults, 1988 to 2000. Obes Res 2003;11:1010–17.
54. Centers for Disease Control and Prevention (CDC). Tables 70 and 71. (http://www.cdc.gov/nchs/data/hus/tables/2002/02hus070.pdf#search='overweight%20and%2020%20years%20and%20over%20and%20CDC'). (http://www.cdc.gov/nchs/data/hus/tables/2002/02hus071.pdf#search='Table%2071.%20Overweight%20children%20and%20adolescents%206%E2%80%9319%20years%20of%20age%2C'). (Accessed September 5, 2004).
55. Baruffi G, Hardy CJ, Waslien CI, et al. Ethnic differences in the prevalence of overweight among young children in Hawaii. J Am Diet Assoc 2004;104:1701–7.
56. Caballero B, Himes JH, Lohman T, et al. Body composition and overweight prevalence in 1704 schoolchildren from 7 American Indian communities. Am J Clin Nutr 2003;78:308–12.
57. Kimm SY, Obarzanek E, Barton BA, et al. Race, socioeconomic status, and obesity in 9- to 10-year-old girls: the NHLBI Growth and Health Study. Ann Epidemiol 1996;6:266–75.
58. Whitaker RC, Orzol SM. Obesity among US urban preschool children: relationships to race, ethnicity, and socioeconomic status. Arch Pediatr Adolesc Med 2006;160:578–84.
59. Wang Y. Cross-national comparison of childhood obesity: the epidemic and the relationship between obesity and socioeconomic status. Int J Epidemiol 2001;30:1129–36.
60. Nelson MC, Gordon-Larsen P, Song Y, et al. Built and social environments associations with adolescent overweight and activity. Am J Prev Med 2006;31:109–17.
61. Fernandez JR, Redden DT, Pietrobelli A, et al. Waist circumference percentiles in nationally representative samples of African-American, European-American, and Mexican-American children and adolescents. J Pediatr 2004;145:439–44.
62. Freedman DS, Khan LK, Serdula MK, et al. Racial differences in the tracking of childhood BMI to adulthood. Obes Res 2005;13:928–35.
63. Guo SS, Chumlea WC. Tracking of body mass index in children in relation to overweight in adulthood. Am J Clin Nutr 1999;70:145S–8S.
64. Lake JK, Power C, Cole TJ. Child to adult body mass index in the 1958 British birth cohort: associations with parental obesity. Arch Dis Child 1997;77:376–81.
65. Mossberg HO. 40-year follow-up of overweight children. Lancet 1989;2:491–3.
66. Rolland-Cachera MF, Bellisle F, Sempe M. The prediction in boys and girls of the weight/height index and various skinfold measurements in adults: a two-decade follow-up study. Int J Obes 1989;13:305–11.
67. Whitaker RC, Wright JA, Pepe MS, et al. Predicting obesity in young adulthood from childhood and parental obesity. N Engl J Med 1997;337:869–73.
68. Egger G, Swinburn B. An ''ecological'' approach to the obesity pandemic. BMJ 1997;315:477–80.
69. Hill JO, Peters JC. Environmental contributions to the obesity epidemic. Science 1998;280:1371–4.
70. Briefel RR, Johnson CL. Secular trends in dietary intake in the United States. Annu Rev Nutr 2004;24:401–31.
71. Jahns L, Siega-Riz AM, Popkin BM. The increasing prevalence of snacking among US children from 1977 to 1996. J Pediatr 2001;138:493–8.
72. Miech RA, Kumanyika SK, Stettler N, et al. Trends in the association of poverty with overweight among US adolescents, 1971–2004. JAMA 2006;295:2385–93.
73. Nielsen SJ, Siega-Riz AM, Popkin BM. Trends in energy intake in U.S. between 1977 and 1996: similar shifts seen across age groups. Obes Res 2002;10:370–8.
74. Nielsen SJ, Siega-Riz AM, Popkin BM. Trends in food locations and sources among adolescents and young adults. Prev Med 2002;35:107–13.
75. Nielsen SJ, Popkin BM. Patterns and trends in food portion sizes, 1977–1998. JAMA 2003;289:450–3.
76. Nielsen SJ, Popkin BM. Changes in beverage intake between 1977 and 2001. Am J Prev Med 2004;27:205–10.
77. Siega-Riz AM, Popkin BM, Carson T. Differences in food patterns at breakfast by sociodemographic characteristics among a nationally representative sample of adults in the United States. Prev Med 2000;30:415–24.
78. Young LR, Nestle M. The contribution of expanding portion sizes to the US obesity epidemic. Am J Public Health 2002; 92:246–9.
79. Diez-Roux AV, Nieto FJ, Caulfield L, et al. Neighbourhood differences in diet: the Atherosclerosis Risk in Communities (ARIC) Study. J Epidemiol Community Health 1999;53:55–63.
80. Cummins S, Macintyre S. Food environments and obesity—neighbourhood or nation? Int J Epidemiol 2006;35:100–4.
81. Powell LM, Slater S, Mirtcheva D, et al. Food store availability and neighborhood characteristics in the United States. Prev Med 2007;44:189–95.

82. Morland K, Diez Roux AV, Wing S. Supermarkets, other food stores, and obesity: the Atherosclerosis Risk in Communities Study. Am J Prev Med 2006;30:333–9.
83. Morland K, Wing S, Diez Roux A. The contextual effect of the local food environment on residents' diets: the Atherosclerosis Risk in Communities Study. Am J Public Health 2002;92: 1761–7.
84. Zenk SN, Schulz AJ, Hollis-Neely T, et al. Fruit and vegetable intake in African Americans income and store characteristics. Am J Prev Med 2005;29:1–9.
85. Gordon-Larsen P, Nelson MC, Page P, et al. Inequality in the built environment underlies key health disparities in physical activity and obesity. Pediatrics 2006;117:417–24.
86. Kahn HS, Williamson DF, Stevens JA. Race and weight change in US women: the roles of socioeconomic and marital status. Am J Public Health 1991;81:319–23.
87. Shea S, Stein AD, Basch CE, et al. Independent associations of educational attainment and ethnicity with behavioral risk factors for cardiovascular disease. Am J Epidemiol 1991; 134:567–82.
88. Winkleby MA, Gardner CD, Taylor CB. The influence of gender and socioeconomic factors on Hispanic/white differences in body mass index. Prev Med 1996;25:203–11.
89. Mensah GA, Mokdad AH, Ford ES, et al. State of disparities in cardiovascular health in the United States. Circulation 2005;111:1233–41.

APPENDIX 1

More Details of Main Data Sources Used in the Present Study

NHANES. The NHANES data provide national estimates of overweight and obesity for Americans of all ages. NHANES, a series of cross-sectional, nationally representative examination surveys conducted by the National Center for Health Statistics of the Centers for Disease Control and Prevention since the 1960s, include NHANES 1 (1971–1974), II (1976–1980), and III (1988–1994). Beginning in 1999, NHANES became a continuous survey, and data from people older than age 74 years were collected. The surveys were designed by using stratified multistage probability samples. NHANES III and the 1999–2002 NHANES were designed to oversample Mexican Americans, African Americans, and adolescents to improve estimates for these groups. In each survey, standardized protocols were used for all interviews and examinations. Data on weight and height were collected for each person through direct physical examination in a mobile examination center. Recumbent length was measured in children younger than age 4 years and stature in children aged 2 years or older. Details regarding the NHANES study design and data collection have been provided elsewhere (26).

BRFSS. BRFSS is the world's largest ongoing telephone health survey system, tracking health conditions and risk behaviors in the United States yearly since 1984. Conducted by the 50 state health departments as well as those in the District of Columbia, Puerto Rico, Guam, and the US Virgin Islands, with support from the Centers for Disease Control and Prevention, this system uses standard procedures to collect data through a series of monthly telephone interviews with US adults. BRFSS provides state-specific information about issues such as obesity, asthma, diabetes, health care access, alcohol use, hypertension, cancer screening, nutrition and physical activity, and tobacco use; that is, it enables geographic differences to be examined (27).

YRBSS. The YRBSS was developed in 1990; the first survey was started in 1991 to monitor priority health risk behaviors that contribute markedly to the leading causes of death, disability, and social problems among youth and adults in the US. YRBSS collected information on risk behaviors (e.g., tobacco use, unhealthy dietary behaviors, inadequate physical activity, alcohol and other drug use, and sexual behaviors) as well as self-reported weight and height (28).

Add Health study. Add Health is a nationally representative, school-based study of youths (grades 7–12, approximately aged 12–17 years) followed up with multiple interview waves into young adulthood (approximately aged 18–26 years). The study used a multistage, stratified, school-based, clustered sampling design. A stratified sample of 80 high schools (and feeder middle schools) was selected with probability proportional to size. Wave I (1994–1995) included 20,745 adolescents (aged 12–19 years) and their parents. Wave II (1996) included 14,738 wave I adolescents (including school dropouts and excluding graduating seniors). Wave III (2001–2002) included 15,170 wave I adolescents, now aged 18–26 years and entering the transition to adulthood (76 percent response rate). In waves I and II, information on self-reported weight and height, and in wave III direct measured weight and height, was collected. Compared with NHANES, the Add Health study oversampled certain population groups, including more minority groups such as Asians and Native Americans (29, 30).

APPENDIX 2

Main Findings Regarding SES Disparities in Obesity from Other Selected Studies

Some other studies published since the early 1990s have also examined the complex relation between gender, ethnicity, SES, and obesity among US adults and children. For example, earlier data collected in the CARDIA study from 5,115 Black men and women and White men and women aged 18–30 years suggested that the association of education with obesity was negative among White women and positive among Black men, with no significant association noted among White men and Black women (45). The San Antonio Heart Study included Mexican Americans and concluded that among women, increased SES reduced the risk of obesity whereas, among men, those with a higher SES had a higher risk (46). Another study assessed the contribution of SES in explaining ethnic disparities in obesity among

adult women; it concluded that Black ethnicity was an independent SES risk factor for obesity (86). Similarly, another study based on a multiethnic sample in New York State as part of BRFSS came to the same conclusion. However, patterns of obesity were shown to differ by educational attainment within ethnic groups, which has implications for the segmentation of risk reduction programs (87). When Whites were compared with Hispanics, a matched-pair design study found the highest prevalence of overweight among the least educated Hispanic women (61.1 percent) and Hispanic men (48.4 percent). In a multiple regression model, the higher body mass index levels of Hispanic women and men relative to their White counterparts were not explained by age, gender, education, city of residence, time of survey, or language spoken (88).

A study of cardiovascular disease risk factors, including obesity, based on several national surveys found that for men, the highest prevalence of obesity (29.2 percent) was in Mexican Americans who had completed a high school education. Black women with or without a high school education had a higher prevalence of obesity (47.3 percent) than other gender-ethnicity-SES groups (89). Another study showed that socioeconomic deprivation in childhood was a strong predictor of adulthood obesity in African-American women, and the findings were consistent with both critical-period and cumulative-burden models of life-course socioeconomic deprivation and long-term risk for obesity (48).

Regarding young people, the 1995–1996 baseline data from the Add Health study show that overweight prevalence decreased with increasing SES among White females and remained elevated and even increased among higher SES African-American females. Thus, the African-American–White disparity in overweight prevalence increased at the highest SES. Conversely, disparity was lessened at the highest SES for White, Hispanic, and Asian females. Among males, disparity was lowest at the average SES level (36). The Growth and Health Study of the National Heart, Lung, and Blood Institute collected data from younger children (aged 9–10 years) and showed that higher-SES White girls had a lower prevalence of obesity, but there was no clear relation among Black girls (57). Another study of a nationwide sample of preschool children drawn from 20 large US cities showed that the higher prevalence of obesity among Hispanics relative to Blacks and Whites was not explained by ethnic differences in maternal education, household income, or food security (58).

APPENDIX 3

Increase in Portion Sizes in the United States

A study compared current portions of food products in the United States with past portions, concluding that the sizes of current marketplace foods almost universally exceed those offered in the past. The trend toward larger portion sizes in the United States began in the 1970s, and portion sizes increased sharply in the 1980s and have continued to increase. Study results show that, except for sliced white bread, all of the commonly available food portions exceeded the US Department of Agriculture and Food and Drug Administration standard portions, sometimes to a great extent. For example, the largest excess over US Department of Agriculture standards by 700 percent occurred in the cookie category, while cooked pasta, muffins, steaks, and bagels exceeded standards by 480 percent, 333 percent, 224 percent, and 195 percent, respectively. For french fries, hamburgers, and soda, the current portion sizes are 2–5 times larger than in the past (78). The influence of growing portion size on people's energy intake is magnified by the fact that more people in the United States increasingly eat meals away from home more often than they did in the past (73).

Dietary intake data collected from individuals also support a marked trend toward larger portion sizes in the United States. Based on nationally representative data collected between 1977 and 1996, a study reported that the portion sizes of food consumed both at home and outside the home had increased for a large number of foods. Some of the increases were substantial, very often ranging between 50 kcal and 150 kcal per item for commonly consumed food items such as salty snacks, soft drinks, hamburgers, french fries, and Mexican food. The potential impact of larger portion sizes on people's overconsumption of energy and weight gain can be remarkable. For example, an added 10 kcal per day of extra calories can result in an extra pound (0.45 kg) of weight gained per year (75).