Dramatic Increases in Obesity and Overweight Prevalence and Body Mass Index Among Ethnic-Immigrant and Social Class Groups in the United States, 1976–2008

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Abstract This study examined trends in US obesity and overweight prevalence and body mass index (BMI) among 30 immigrant groups, stratified by race/ethnicity and length of immigration, and among detailed education, occupation, and income/poverty groups from 1976 to 2008. Using 1976–2008 National Health Interview Surveys, differentials in obesity, overweight, and BMI, based on self-reported height and weight, were analyzed by using disparity indices, logistic, and linear regression. The obesity prevalence for the US population aged ≥18 tripled from 8.7% in 1976 to 27.4% in 2008. Overweight prevalence increased from 36.9% in 1976 to 62.0% in 2008. During 1991–2008, obesity prevalence for US-born adults increased from 13.9 to 28.7%, while prevalence for immigrants increased from 9.5 to 20.7%. While immigrants in each ethnic group and time period had lower obesity and overweight prevalence and BMI than the US-born, immigrants’ risk of obesity and overweight increased with increasing duration of residence. In 2003–2008, obesity prevalence ranged from 2.3% for recent Chinese immigrants to 31–39% for American Indians, US-born blacks, Mexicans, and Puerto Ricans, and long-term Mexican and Puerto Rican immigrants. Between 1976 and 2008, the obesity prevalence more than quadrupled for those with a college education or sales occupation. Although higher prevalence was observed for lower education, income, and occupation levels in each period, socioeconomic gradients in obesity and overweight decreased over time because of more rapid increases in prevalence among higher socioeconomic groups. Continued immigrant and socioeconomic disparities in prevalence will likely have substantial impacts on future obesity trends in the US.

Keywords Obesity · Overweight · Trend · Immigrant status · Ethnicity · Socioeconomic status · Acculturation · Disparities · Physical activity · Diet · United States

Introduction

The prevalence of obesity has risen dramatically in the United States. The rates for adults have more than doubled during the past 3 decades [1]. Increases in obesity prevalence have been marked across all gender, race, and socioeconomic groups [1]. Because of a relatively high prevalence, a rapidly increasing trend, and large social-group disparities, adult obesity is recognized as a major public health problem in the US [1, 2].

While obesity data for US adults are routinely available by age, gender, and race/ethnicity [1, 3], prevalence
among them [4–7]. The immigrant population in the US has increased four-fold in the last four decades [8–10]. In 2008, there were 38 million immigrants, an increase of 28.4 million since 1970 [8–10]. Immigrants currently account for 12.5% of the total US population [10].

Given such a rapid population increase, analysis of obesity patterns among immigrants of various ethnicities assumes a special importance [4, 11]. In addition to ethnic and immigrant disparities, monitoring socioeconomic inequalities in health has long represented an important research and policy focus [1, 2]. Socioeconomic inequalities as well as immigrant differentials in health, life expectancy, and mortality from major causes of death have not only remained substantial in the US but have also increased over time [4, 12–15]. Inequalities in chronic disease risk factors such as obesity, smoking, physical inactivity, and poor diet have contributed greatly to the persistence and/or widening of the health gradients [1, 12, 13, 16]. The purpose of this study was to describe national trends in immigrant and social class inequalities in the prevalence of obesity and overweight and to identify immigrant and social class groups who are at high risk of obesity and who have experienced substantial increases in their obesity rates. Specifically, we (1) estimate over time changes in obesity and overweight prevalence among 30 major immigrant groups stratified by race/ethnicity and length of immigration and among detailed education, occupation, and income groups, using large, nationally representative samples of US adults and (2) compare the magnitude of ethnic-immigrant and socioeconomic disparities in obesity and overweight prevalence among adults aged ≥18 over time.

Methods

Temporal individual-level data on obesity, overweight, and selected socioeconomic, demographic, and behavioral characteristics were derived from the 1976 and 1991–2008 National Health Interview Surveys (NHIS) [17, 18]. The NHIS, which is conducted by the National Center for Health Statistics, uses a complex, multistage probability design and is representative of the civilian non-institutionalized population of the US [17, 18]. The household response rate for an annual NHIS generally exceeds 85%. All data are based on self-reports, including height and weight information, and obtained via in-home person interviews [1, 17, 18]. Substantive and methodological details of the NHIS are described elsewhere [1, 17, 18].

Annual trends in obesity and overweight prevalence and BMI were estimated for the overall immigrant and US-born groups and for five educational groups from 1991 to 2008. To analyze trends over time by detailed ethnic-immigrant and socioeconomic characteristics, we pooled 4 years of the NHIS data from 1992 to 1995 and 6 years of data from 2003 to 2008. Aggregating data for several years in this fashion ensured sufficient sample sizes for analyzing patterns for groups stratified by ethnicity, immigrant status, and length of immigration. We could not use the 1991 NHIS file in the pooled analyses because it lacked detailed ethnic and income groupings. The 1976 NHIS, the earliest survey to collect height and weight data, was used to provide baseline estimates for various socioeconomic groups. The 1976 NHIS did not include information on immigrant status.

Obesity and overweight differentials were analyzed for 323,627 adults in 1992–1995 and 154,649 adults aged ≥18 in 2003–2008 for whom information on BMI was available. Adult overweight was defined as a BMI ≥ 25 kg/m² and obesity as a BMI ≥ 30 kg/m² [1, 4, 19]. Note that the overweight category includes obese individuals.

Immigrant status was defined on the basis of adults’ place of birth [4, 9, 11]. US-born were those born in one of the 50 US states or Washington, DC. Immigrants or foreign-born refer to those born outside these territories [4, 9, 11]. Race/ethnicity was classified into 11 major categories: non-Hispanic whites, non-Hispanic blacks, American Indians/Alaska Natives, Chinese, Asian Indians, Filipinos, other Asian/Pacific Islanders, Mexicans, Puerto Ricans, Cubans, and Central and South Americans, including other Hispanics. The joint variable of ethnic-immigrant status included 30 categories, with each racial/ethnic group (except for American Indians/Alaska Natives who are, by definition, a native group) divided into the US-born group, the recent immigrant group, and the long-term immigrant group [9]. Although all Puerto Ricans are US citizens, those born in Puerto Rico and abroad were classified as “immigrants” for convenience. Following a previous study and given the health and socio-behavioral profiles by duration of residence, recent immigrants were defined as those who immigrated to the US in the previous 15 years, whereas long-term immigrants were those who immigrated to the US more than previous 15 years [9].

In addition to ethnic-immigrant status, we considered the following socioeconomic and demographic factors that are known to influence obesity: age, gender, marital status, region of residence, educational attainment, family income/poverty status, occupation, and physical activity (PA) [4, 5, 7, 11, 19]. These covariates were measured as shown in Tables 1 and 2.

Educational attainment was measured both as a categorical variable (0–8, 9–11, 12, 13–15, ≥16 years) and a continuous variable in terms of years of school completed. Annual family income was also measured both as a
Table 1 Observed (weighted) prevalence and adjusted odds of obesity (BMI ≥ 30) among 30 ethnic-immigrant groups aged 18+ years and by selected socioeconomic and demographic characteristics: The National Health Interview Survey, 1992–2008

| Covariates | 1992–1995 (N = 323,627) | 2003–2008 (N = 154,649) | 1992–2008 |
|------------|--------------------------|-------------------------|-----------|
|            | Prevalence | Adjusted odds ratioa | Prevalence | Adjusted odds ratioa | % Increase in prevalence |
|            | % | SE | OR | 95% CI | % | SE | OR | 95% CI | % |
| Duration of residence in the US (years) | | | | | | | | |
| <1 | 5.7 | 0.8 | 0.41 | 0.30 | 0.55 | 8.1 | 1.5 | 0.27 | 0.18 | 0.41 | 44.1 |
| 1–5 | 7.9 | 0.5 | 0.53 | 0.46 | 0.61 | 10.8 | 0.7 | 0.35 | 0.29 | 0.40 | 36.0* |
| 5–9 | 7.6 | 0.3 | 0.43 | 0.39 | 0.48 | 14.6 | 0.6 | 0.42 | 0.37 | 0.47 | 91.2* |
| 10–14 | 9.7 | 0.4 | 0.57 | 0.52 | 0.63 | 16.4 | 0.8 | 0.47 | 0.42 | 0.53 | 68.4* |
| 15+ | 13.1 | 0.3 | 0.72 | 0.68 | 0.76 | 22.0 | 0.4 | 0.66 | 0.62 | 0.70 | 67.9* |
| US-born | 15.6 | 0.1 | 1.00 | Reference | 26.5 | 0.2 | 1.00 | Reference | 70.6* |
| Relative index of disparity | 36.12 | 2.24 | 38.15 | 2.23 | 5.6 |
| Gamma (γ) | 0.18 | 0.008 | 0.21 | 0.008 | 16.7* |
| Non-Hispanic White | | | | | | | | |
| Recent immigrantsb | 9.1 | 0.6 | 0.66 | 0.57 | 0.77 | 10.5 | 0.9 | 0.41 | 0.34 | 0.50 | 14.8 |
| Long-term immigrantsb | 11.3 | 0.4 | 0.74 | 0.68 | 0.80 | 19.2 | 0.9 | 0.75 | 0.67 | 0.83 | 69.6* |
| US-born | 14.2 | 0.1 | 1.00 | Reference | 24.7 | 0.2 | 1.00 | Reference | 73.3* |
| Non-Hispanic Black | | | | | | | | |
| Recent immigrants | 11.9 | 1.0 | 0.82 | 0.68 | 0.99 | 17.3 | 1.4 | 0.64 | 0.53 | 0.79 | 46.1* |
| Long-term immigrants | 13.8 | 1.1 | 0.88 | 0.72 | 1.08 | 25.7 | 1.8 | 0.95 | 0.79 | 1.14 | 86.9* |
| US-born | 23.9 | 0.3 | 1.71 | 1.65 | 1.77 | 36.1 | 0.4 | 1.60 | 1.53 | 1.67 | 51.2* |
| American Indian/Alaska Native | | | | | | | | |
| Chinese | | | | | | | | |
| Recent immigrants | 1.1 | 0.3 | 0.07 | 0.04 | 0.13 | 2.3 | 0.8 | 0.08 | 0.04 | 0.17 | 108.1 |
| Long-term immigrants | 2.2 | 0.5 | 0.14 | 0.09 | 0.22 | 3.2 | 0.9 | 0.11 | 0.06 | 0.19 | 45.5 |
| US-born | 5.9 | 1.6 | 0.54 | 0.32 | 0.91 | 8.4 | 2.1 | 0.40 | 0.23 | 0.67 | 43.4 |
| Filipino | | | | | | | | |
| Recent immigrants | 2.1 | 0.5 | 0.15 | 0.09 | 0.24 | 7.6 | 1.9 | 0.29 | 0.18 | 0.48 | 256.5* |
| Long-term immigrants | 4.8 | 0.9 | 0.32 | 0.22 | 0.47 | 12.6 | 1.6 | 0.45 | 0.34 | 0.59 | 164.2* |
| US-born | 11.3 | 2.7 | 1.03 | 0.63 | 1.68 | 19.7 | 2.5 | 0.85 | 0.62 | 1.15 | 74.7* |
| Asian Indian | | | | | | | | |
| Recent immigrants | 3.3 | 0.7 | 0.23 | 0.15 | 0.35 | 5.7 | 1.0 | 0.23 | 0.16 | 0.33 | 75.7* |
| Long-term immigrant/US-born | 5.3 | 1.1 | 0.38 | 0.25 | 0.59 | 8.8 | 1.4 | 0.33 | 0.23 | 0.47 | 65.6 |
| Other Asian and Pacific Islanders | | | | | | | | |
| Recent immigrants | 2.8 | 0.5 | 0.17 | 0.12 | 0.25 | 4.0 | 0.8 | 0.13 | 0.09 | 0.20 | 40.4 |
| Long-term immigrants | 4.5 | 0.8 | 0.28 | 0.19 | 0.41 | 7.1 | 0.9 | 0.22 | 0.17 | 0.29 | 60.2* |
| US-born | 7.9 | 1.0 | 0.63 | 0.50 | 0.81 | 18.1 | 2.3 | 0.82 | 0.62 | 1.09 | 129.9* |
| Mexican | | | | | | | | |
| Recent immigrants | 12.8 | 0.7 | 0.75 | 0.67 | 0.84 | 18.9 | 0.7 | 0.66 | 0.59 | 0.74 | 47.9* |
| Long-term immigrants | 21.3 | 0.8 | 1.15 | 1.05 | 1.26 | 30.8 | 0.8 | 1.03 | 0.94 | 1.13 | 44.8* |
| US-born | 21.2 | 0.5 | 1.59 | 1.50 | 1.69 | 34.6 | 0.8 | 1.64 | 1.51 | 1.77 | 62.9* |
| Puerto Rican | | | | | | | | |
| Recent immigrants | 14.9 | 1.1 | 0.91 | 0.76 | 1.08 | 27.6 | 3.0 | 1.18 | 0.89 | 1.57 | 84.7* |
| Long-term immigrants | 22.4 | 1.2 | 1.22 | 1.07 | 1.40 | 32.7 | 1.7 | 1.23 | 1.06 | 1.44 | 46.2* |
| US-born | 14.2 | 0.8 | 1.10 | 0.96 | 1.27 | 30.6 | 1.5 | 1.32 | 1.15 | 1.51 | 116.2* |
| Cuban | | | | | | | | |
| Recent immigrants | 12.5 | 0.9 | 0.67 | 0.57 | 0.79 | 22.0 | 3.2 | 0.72 | 0.49 | 1.04 | 75.4* |
| Long-term immigrants | 16.0 | 2.3 | 0.98 | 0.71 | 1.37 | 24.2 | 1.8 | 0.84 | 0.69 | 1.01 | 50.7* |
| US-born | 14.1 | 0.1 | 1.16 | 0.88 | 1.53 | 24.1 | 2.9 | 1.13 | 0.82 | 1.55 | 71.3* |
Table 1 continued

| Covariates | 1992–1995 (N = 323,627) | 2003–2008 (N = 154,649) | 1992–2008 |
|------------|--------------------------|-------------------------|-----------|
|            | Prevalence | Adjusted odds ratio | Prevalence | Adjusted odds ratio | % Increase in prevalence |
|            | % | SE | OR | 95% CI | % | SE | OR | 95% CI | % |
| Central and South Americans and other Hispanics | | | | | | | | | |
| Recent immigrants | 9.1 | 0.6 | 0.55 | 0.48 | 0.63 | 14.6 | 0.9 | 0.48 | 0.42 | 0.56 | 60.4* |
| Long-term immigrants | 13.3 | 0.7 | 0.76 | 0.68 | 0.85 | 25.4 | 1.3 | 0.84 | 0.72 | 0.97 | 91.6* |
| US-born | 14.8 | 0.7 | 1.15 | 1.02 | 1.29 | 28.0 | 1.4 | 1.29 | 1.12 | 1.49 | 89.6* |
| Relative index of disparity | 39.51 | 2.11 | | 38.44 | 1.97 | |
| Gender | | | | | | |
| Male | 14.9 | 0.1 | 1.00 | Reference | 25.4 | 0.2 | 1.00 | Reference | 70.4* |
| Female | 15.1 | 0.1 | 0.96 | 0.94 | 0.99 | 25.2 | 0.2 | 0.96 | 0.93 | 0.99 | 66.9* |
| Education (years of school completed) | | | | | | |
| 0–8 | 20.9 | 0.3 | 1.90 | 1.80 | 2.01 | 28.0 | 0.6 | 1.63 | 1.51 | 1.76 | 34.3* |
| 9–11 | 19.0 | 0.3 | 1.71 | 1.63 | 1.79 | 29.1 | 0.4 | 1.64 | 1.55 | 1.74 | 52.9* |
| 12 | 16.0 | 0.1 | 1.46 | 1.40 | 1.51 | 28.2 | 0.3 | 1.55 | 1.47 | 1.62 | 76.5* |
| 13–15 | 13.6 | 0.2 | 1.34 | 1.29 | 1.39 | 26.7 | 0.3 | 1.54 | 1.47 | 1.61 | 95.7* |
| 16+ | 10.3 | 0.1 | 1.00 | Reference | 18.4 | 0.3 | 1.00 | Reference | 78.8* |
| Relative index of disparity | 54.95 | 0.22 | | 41.62 | 0.01 | |
| Gamma (β) | −0.19 | 0.004 | | −0.14 | 0.004 | |
| Family income ($) | | | | | | |
| <10,000 | 20.0 | 0.5 | 1.62 | 1.51 | 1.74 | 28.4 | 0.7 | 1.44 | 1.32 | 1.58 | 42.3* |
| 10,000–19,999 | 18.7 | 0.3 | 1.56 | 1.48 | 1.64 | 27.2 | 0.5 | 1.36 | 1.27 | 1.45 | 45.3* |
| 20,000–24,999 | 17.4 | 0.3 | 1.45 | 1.38 | 1.53 | 26.1 | 0.6 | 1.26 | 1.16 | 1.36 | 49.7* |
| 25,000–34,999 | 16.4 | 0.3 | 1.39 | 1.31 | 1.46 | 27.1 | 0.5 | 1.30 | 1.22 | 1.39 | 65.1* |
| 35,000–44,999 | 15.5 | 0.2 | 1.30 | 1.25 | 1.36 | 27.8 | 0.5 | 1.32 | 1.24 | 1.41 | 79.6* |
| 45,000–64,999 | 14.8 | 0.2 | 1.23 | 1.18 | 1.28 | 26.2 | 0.5 | 1.19 | 1.12 | 1.26 | 77.7* |
| 65,000+ | 11.7 | 0.2 | 1.00 | Reference | 22.1 | 0.3 | 1.00 | Reference | 88.5* |
| Relative index of disparity | 39.34 | 0.39 | | 19.40 | 0.52 | |
| Gamma (β) | −0.14 | 0.004 | | −0.08 | 0.005 | |
| Poverty status (ratio of family income to poverty threshold) | | | | | | |
| <100% | 28.3 | 0.5 | 1.33 | 1.25 | 1.42 | | |
| 100–199% | 28.3 | 0.4 | 1.29 | 1.22 | 1.36 | | |
| 200–299% | 27.7 | 0.4 | 1.24 | 1.18 | 1.31 | | |
| 300–399% | 27.4 | 0.4 | 1.22 | 1.16 | 1.29 | | |
| 400–499% | 24.8 | 0.5 | 1.10 | 1.03 | 1.16 | | |
| ≥500% | 22.2 | 0.3 | 1.00 | Reference | | |
| Relative index of disparity | 19.16 | 0.22 | | 19.40 | 0.52 | |
| Gamma (β) | −0.09 | 0.004 | | −0.08 | 0.005 | |
| Occupation | | | | | | |
| Professional/managerial | 12.5 | 0.2 | 1.00 | Reference | 22.0 | 0.3 | 1.00 | Reference | 75.9* |
| Sales/clerical/technical support | 13.7 | 0.2 | 0.97 | 0.93 | 1.01 | 25.5 | 0.3 | 1.02 | 0.98 | 1.07 | 86.2* |
| Service | 16.5 | 0.3 | 1.05 | 1.00 | 1.10 | 27.5 | 0.4 | 1.07 | 1.01 | 1.13 | 66.8* |
| Craft and repair | 15.4 | 0.3 | 0.94 | 0.89 | 0.99 | 27.6 | 0.4 | 0.98 | 0.93 | 1.04 | 78.8* |
| Laborers | 17.7 | 0.2 | 1.06 | 1.01 | 1.11 | 31.5 | 0.5 | 1.21 | 1.14 | 1.29 | 78.4* |
| Unemployed/not in labor force | 16.1 | 0.2 | 1.06 | 1.03 | 1.10 | 22.7 | 0.6 | 1.00 | 0.92 | 1.08 | 40.7* |
| Relative index of disparity | 21.14 | 0.21 | | 21.85 | 0.09 | |
| Gamma (β) | −0.11 | 0.004 | | −0.09 | 0.004 | |
categorical variable and a continuous variable. The seven income strata for 2003–2006 were: <10,000, 10,000–19,999, 20,000–24,999, 25,000–34,999, 35,000–44,999, 45,000–64,999, and ≥65,000. The corresponding income strata for 1992–1995 were: <7,000, 7,000–14,999, 15,000–19,999, 20,000–24,999, 25,000–34,999, 35,000–49,999, and ≥50,000. Detailed income categories were not available for 2007–2008. The income categories were roughly comparable for the 1992–1995 and 2003–2006 periods, given an increase by a factor of about 1.3 in the consumer price index between 1995 and 2005 [20]. Continuous income was measured in thousands of dollars for both time periods.

Occupational class was defined in terms of 5 broad categories: professional and managerial occupations, sales/clerical and technical support occupations, service, craft and repair, and laborers. These occupational groups, derived from the major occupational groups defined by the Census Bureau, are consistent with previously defined social class positions of upper white collar, lower white collar, upper blue collar, and lower blue collar jobs [20, 21]. “Professional and managerial” occupations included executives, managers, administrators, engineers, architects, mathematical and computer scientists, teachers, writers, artists, and other professional specialty occupations. “Sales/clerical and technical support” occupations included technicians, health technologists, sales workers, computer equipment operators, secretaries, typists, and financial records processing, mail, message distributing, and other administrative support occupations. “Service” occupations included private household, protective service, food service, health service, cleaning and building service occupations, farm and other agricultural workers. “Craft and repair” occupations included mechanics, repairers, and those in construction, extractive trades, and precision production jobs. “Laborers” included machine operators, fabricators, assemblers, motor vehicle and material moving equipment operators, construction laborers, handlers, equipment cleaners, and helpers. In addition, a residual category for the unemployed and those outside the labor force was used.

PA level was measured by the number of times/week of vigorous activities of at least 10 min that caused heavy sweating or large increases in breathing or heart rate. The variable was coded as <1, 1–2, 3–4, ≥5 times/week of activity. PA was not available in 1976 and 1992–1995 [18].

Multivariate logistic regression was used to examine the association between the binary outcomes of obesity and overweight and selected socioeconomic and demographic factors. Least squares regression was used to model mean BMI. To account for the complex sample design of the NHIS, SUDAAN software was used to conduct all statistical analyses [22].

The two-sample t test was used to test the difference in prevalence between any two groups at one point in time or to test for change in prevalence between two time points for a specific group. The gamma (γ) statistic, varying between −1 and 1, was used to measure the magnitude of the association between an ordinal covariate and obesity [16]. An index of disparity (ID), which approximated in relative terms the average deviation of the rates from the rate for the best-off ethnic-immigrant or socioeconomic group, was used to summarize disparities across all social groups [16, 23]. The relative mean deviation index of disparity was calculated as:

$$ID = \left\{ \frac{\sum_i |O_{ri} - O_{rl}|/I}{O_{rl}} \right\} \times 100; \quad O_{rl} > 0$$

where $O_{ri}$ is the obesity/overweight prevalence for the ith group, $O_{rl}$ is the rate for the “standard” group or group with the lowest obesity/overweight prevalence, and I is the number of groups. A simulation method was used to estimate the standard error for ID [24].

Results

Annual Trends in Obesity and Overweight Prevalence by Immigrant Status and Educational Attainment, 1976 and 1991–2008

The obesity prevalence for the total US adult population aged ≥18 tripled from 8.7% in 1976 to 27.4% in 2008. The overweight prevalence for all US adults increased from 36.9% in 1976 to 62.0% in 2008. In 2008, 59 million US adults were obese and 134 million overweight. This represented an absolute increase of 47 million obese and 80 million overweight adults since 1976.
Table 2  Observed (weighted) prevalence and adjusted odds of overweight (BMI ≥ 25) among 30 ethnic-immigrant groups aged 18+ years and by selected socioeconomic and demographic characteristics: The National Health Interview Survey, 1992–2008

| Covariates                                | 1992–1995 (N = 323,627) | 2003–2008 (N = 154,649) | 1992–2008 | % Increase in prevalence |
|-------------------------------------------|-------------------------|-------------------------|-----------|--------------------------|
|                                           | Prevalence   | Adjusted odds ratio<sup>a</sup> | Prevalence | Adjusted odds ratio<sup>a</sup> | % Increase |
|                                           | %          | SE | OR | 95% CI | %          | SE | OR | 95% CI |          |
| Duration of residence in the US (years)   |            |    |    |        |            |    |    |        |          |
| <1                                        | 25.9        | 1.7 | 0.51 | 0.43 | 0.60 | 37.7 | 3.3 | 0.43 | 0.32 | 0.58 | 45.5* |
| 1–5                                       | 32.8        | 0.9 | 0.66 | 0.60 | 0.71 | 45.4 | 1.3 | 0.58 | 0.52 | 0.65 | 38.3* |
| 5–9                                       | 38.7        | 0.6 | 0.71 | 0.67 | 0.76 | 49.9 | 1.0 | 0.58 | 0.53 | 0.64 | 29.0* |
| 10–14                                     | 41.2        | 0.9 | 0.79 | 0.74 | 0.86 | 55.2 | 1.0 | 0.71 | 0.64 | 0.78 | 33.9* |
| 15+                                       | 48.1        | 0.5 | 0.89 | 0.85 | 0.92 | 60.9 | 0.5 | 0.82 | 0.78 | 0.87 | 26.7* |
| US-born                                   | 48.3        | 0.2 | 1.00 | Reference | 61.3 | 0.2 | 1.00 | Reference | 26.9* |
| Relative index of disparity               | 18.89       | 1.37 |        |        | 15.60 | 1.73 |        |        | −17.4 |
| Gamma (γ)                                 | 0.09        | 0.005 |        |        | 0.09 | 0.006 |        |        | 0.0 |
| Non-Hispanic White                        |            |    |    |        |            |    |    |        |          |
| Recent immigrants<sup>b</sup>             | 39.0        | 1.3 | 0.81 | 0.73 | 0.91 | 46.3 | 1.7 | 0.70 | 0.61 | 0.81 | 18.5* |
| Long-term immigrants<sup>b</sup>          | 46.2        | 0.7 | 0.92 | 0.86 | 0.97 | 58.0 | 1.1 | 0.91 | 0.83 | 0.99 | 25.5* |
| US-born                                   | 46.7        | 0.2 | 1.00 | Reference | 59.6 | 0.2 | 1.00 | Reference | 27.8* |
| Non-Hispanic Black                        |            |    |    |        |            |    |    |        |          |
| Recent immigrants                         | 49.4        | 1.7 | 1.32 | 1.17 | 1.49 | 51.4 | 1.9 | 0.83 | 0.71 | 0.97 | 4.1 |
| Long-term immigrants                      | 55.8        | 1.4 | 1.40 | 1.23 | 1.59 | 67.7 | 1.9 | 1.35 | 1.12 | 1.62 | 21.4* |
| US-born                                   | 58.4        | 0.3 | 1.79 | 1.74 | 1.84 | 69.7 | 0.4 | 1.72 | 1.65 | 1.79 | 19.3* |
| American Indian/Alaska Native             | 56.3        | 1.4 | 1.59 | 1.40 | 1.80 | 69.6 | 2.0 | 1.58 | 1.31 | 1.92 | 23.5* |
| Chinese                                   |            |    |    |        |            |    |    |        |          |
| Recent immigrants                         | 15.0        | 1.0 | 0.22 | 0.19 | 0.26 | 19.8 | 2.3 | 0.19 | 0.14 | 0.26 | 32.2 |
| Long-term immigrants                      | 21.3        | 2.2 | 0.28 | 0.22 | 0.37 | 23.2 | 2.2 | 0.19 | 0.15 | 0.24 | 9.1 |
| US-born                                   | 24.6        | 2.3 | 0.50 | 0.41 | 0.60 | 40.1 | 3.3 | 0.64 | 0.48 | 0.85 | 63.3* |
| Filipino                                  |            |    |    |        |            |    |    |        |          |
| Recent immigrants                         | 23.8        | 1.6 | 0.42 | 0.35 | 0.51 | 39.6 | 3.4 | 0.51 | 0.39 | 0.67 | 66.8* |
| Long-term immigrants                      | 32.6        | 2.4 | 0.56 | 0.45 | 0.71 | 47.7 | 2.4 | 0.59 | 0.48 | 0.73 | 46.3* |
| US-born                                   | 35.7        | 5.4 | 0.91 | 0.6   | 1.38 | 54.5 | 3.5 | 1.03 | 0.77 | 1.36 | 52.6* |
| Asian Indian                              |            |    |    |        |            |    |    |        |          |
| Recent immigrants                         | 26.4        | 1.9 | 0.46 | 0.38 | 0.57 | 37.7 | 2.2 | 0.51 | 0.42 | 0.62 | 42.5* |
| Long-term immigrant/US-born               | 36.6        | 2.5 | 0.66 | 0.54 | 0.81 | 46.0 | 2.9 | 0.59 | 0.47 | 0.74 | 42.5* |
| Other Asian and Pacific Islanders         |            |    |    |        |            |    |    |        |          |
| Recent immigrants                         | 18.9        | 1.1 | 0.29 | 0.25 | 0.34 | 23.0 | 1.8 | 0.23 | 0.18 | 0.29 | 21.8 |
| Long-term immigrants                      | 23.5        | 1.4 | 0.36 | 0.31 | 0.42 | 34.4 | 1.6 | 0.33 | 0.29 | 0.38 | 46.2* |
| US-born                                   | 35.9        | 1.2 | 0.79 | 0.70 | 0.88 | 49.2 | 3.0 | 0.81 | 0.65 | 1.03 | 37.1* |
| Mexican                                   |            |    |    |        |            |    |    |        |          |
| Recent immigrants                         | 49.0        | 0.9 | 1.21 | 1.12 | 1.31 | 60.7 | 0.9 | 1.19 | 1.08 | 1.30 | 23.8* |
| Long-term immigrants                      | 62.2        | 0.8 | 1.63 | 1.52 | 1.74 | 73.9 | 0.8 | 1.60 | 1.45 | 1.76 | 18.7* |
| US-born                                   | 56.9        | 0.7 | 1.79 | 1.69 | 1.90 | 69.3 | 0.7 | 1.81 | 1.68 | 1.95 | 21.9* |
| Puerto Rican                              |            |    |    |        |            |    |    |        |          |
| Recent immigrants                         | 50.6        | 2.1 | 1.36 | 1.13 | 1.63 | 59.3 | 3.4 | 1.19 | 0.90 | 1.56 | 17.2* |
| Long-term immigrants                      | 61.4        | 1.2 | 1.51 | 1.36 | 1.68 | 71.2 | 1.9 | 1.51 | 1.26 | 1.82 | 16.0* |
| US-born                                   | 46.9        | 1.4 | 1.30 | 1.16 | 1.47 | 65.9 | 1.7 | 1.50 | 1.29 | 1.75 | 40.7* |
| Cuban                                     |            |    |    |        |            |    |    |        |          |
| Recent immigrants                         | 55.3        | 2.1 | 1.28 | 1.09 | 1.51 | 64.7 | 3.7 | 1.12 | 0.79 | 1.60 | 17.1* |
| Long-term immigrants                      | 55.3        | 2.4 | 1.25 | 1.03 | 1.51 | 64.8 | 2.4 | 1.04 | 0.86 | 1.27 | 17.1* |
| US-born                                   | 46.0        | 2.2 | 1.23 | 1.02 | 1.48 | 56.5 | 3.4 | 1.12 | 0.84 | 1.48 | 23.0* |
Table 2 continued

| Covariates | 1992–1995 (N = 323,627) | 2003–2008 (N = 154,649) | 1992–2008 |
|------------|-------------------------|-------------------------|------------|
|            | Prevalence | Adjusted odds ratio | % Increase | Prevalence | Adjusted odds ratio | % Increase |
|            | %         | OR 95% CI         |           | %         | OR 95% CI         |           |
| Central and South Americans and other Hispanics | | | | | | |
| Recent immigrants | 40.7 | 1.3 | 0.86 | 0.77 | 0.95 | 54.4 | 1.4 | 0.86 | 0.76 | 0.97 | 33.7* |
| Long-term immigrants | 49.4 | 1.1 | 1.02 | 0.92 | 1.12 | 69.1 | 1.2 | 1.32 | 1.17 | 1.49 | 39.9* |
| US-born | 47.8 | 1.1 | 1.26 | 1.16 | 1.37 | 64.4 | 1.4 | 1.50 | 1.32 | 1.69 | 34.8* |

Relative index of disparity 23.92 0.78 20.56 1.26 -14.0*

Gender | | | | | | |
| Male | 57.0 | 0.2 | 1.00 | Reference | 68.1 | 0.2 | 1.00 | Reference | 19.6* |
| Female | 39.1 | 0.2 | 0.45 | 0.44 | 0.46 | 53.1 | 0.3 | 0.50 | 0.48 | 0.51 | 35.8* |

Education (years of school completed) | | | | | | |
| 0–8 | 56.7 | 0.3 | 1.50 | 1.44 | 1.56 | 66.0 | 0.6 | 1.39 | 1.29 | 1.49 | 16.5* |
| 9–11 | 52.1 | 0.3 | 1.44 | 1.38 | 1.49 | 62.2 | 0.5 | 1.38 | 1.30 | 1.45 | 19.5* |
| 12 | 49.1 | 0.2 | 1.31 | 1.28 | 1.35 | 63.5 | 0.3 | 1.40 | 1.35 | 1.46 | 29.5* |
| 13–15 | 44.8 | 0.2 | 1.23 | 1.20 | 1.27 | 61.1 | 0.3 | 1.42 | 1.36 | 1.47 | 36.4* |
| 16+ | 42.3 | 0.3 | 1.00 | Reference | 54.5 | 0.3 | 1.00 | Reference | 28.9* |

Relative index of disparity 15.86 0.08 12.84 0.07 -19.0*

Gamma (γ) -0.13 0.003 -0.12 0.004 -7.7

Family income ($) | | | | | | |
| <10,000 | 48.4 | 0.8 | 1.24 | 1.16 | 1.33 | 57.7 | 0.8 | 1.10 | 1.02 | 1.19 | 19.2* |
| 10,000–19,999 | 49.7 | 0.4 | 1.23 | 1.18 | 1.28 | 59.8 | 0.5 | 1.12 | 1.05 | 1.19 | 20.4* |
| 20,000–24,999 | 50.4 | 0.4 | 1.22 | 1.18 | 1.27 | 61.2 | 0.7 | 1.14 | 1.05 | 1.22 | 21.6* |
| 25,000–34,999 | 49.3 | 0.4 | 1.18 | 1.14 | 1.22 | 61.4 | 0.6 | 1.11 | 1.05 | 1.18 | 24.5* |
| 35,000–44,999 | 49.5 | 0.3 | 1.19 | 1.16 | 1.23 | 62.7 | 0.6 | 1.14 | 1.07 | 1.21 | 26.7* |
| 45,000–64,999 | 48.9 | 0.3 | 1.15 | 1.12 | 1.18 | 62.4 | 0.5 | 1.11 | 1.05 | 1.17 | 27.6* |
| 65,000+ | 45.0 | 0.2 | 1.00 | Reference | 59.2 | 0.4 | 1.00 | Reference | 31.6* |

Relative index of disparity 8.39 0.27 3.16 0.11 -62.3*

Gamma (γ) -0.06 0.003 -0.01 0.005 -83.3*

Poverty status (ratio of family income to poverty threshold) | | | | | | |
| <100% | 58.6 | 0.6 | 1.12 | 1.06 | 1.18 | | | | | |
| 100–199% | 62.0 | 0.4 | 1.15 | 1.09 | 1.2 | | | | | |
| 200–299% | 62.3 | 0.4 | 1.12 | 1.07 | 1.17 | | | | | |
| 300–399% | 62.4 | 0.5 | 1.12 | 1.07 | 1.18 | | | | | |
| 400–499% | 62.2 | 0.5 | 1.12 | 1.06 | 1.19 | | | | | |
| ≥500% | 59.4 | 0.4 | 1.00 | Reference | | | | | |

Relative index of disparity 3.39 0.02 |

Gamma (γ) -0.01 0.004 |

Occupation | | | | | | |
| Professional/managerial | 45.4 | 0.2 | 1.00 | Reference | 58.1 | 0.3 | 1.00 | Reference | 28.2* |
| Sales/clerical/technical support | 43.1 | 0.2 | 0.98 | 0.95 | 1.00 | 58.3 | 0.3 | 1.04 | 1.00 | 1.08 | 35.4* |
| Service | 48.6 | 0.4 | 1.07 | 1.03 | 1.10 | 61.1 | 0.4 | 1.07 | 1.02 | 1.12 | 25.7* |
| Craft and repair | 58.1 | 0.4 | 1.05 | 1.02 | 1.09 | 68.5 | 0.4 | 0.99 | 0.94 | 1.04 | 17.8* |
| Laborers | 55.8 | 0.3 | 1.09 | 1.05 | 1.13 | 69.5 | 0.5 | 1.13 | 1.07 | 1.20 | 24.6* |
| Unemployed/not in labor force | 47.1 | 0.2 | 0.99 | 0.96 | 1.01 | 50.4 | 0.7 | 0.91 | 0.85 | 0.97 | 7.1* |

Relative index of disparity 12.87 0.10 8.43 0.06 -34.5*

Gamma (γ) -0.13 0.003 -0.13 0.004 0.00
During 1991–2008, the obesity prevalence for US-born adults increased from 13.9 to 28.7%, whereas the prevalence for immigrants increased from 9.5 to 20.7% (Fig. 1). The average annual rates of increase for the two groups were 4.5% and 4.6%, respectively. During 1991–2008, increases in overweight prevalence were equally marked among both US-born and immigrant adults, with the prevalence for the US-born rising from 45.7 to 62.7%, while that for immigrants rising from 39.6 to 58.4%. Immigrant differentials in BMI increased over time. The mean BMI for the US-born increased from 25.24 in 1991 to 27.75 in 2008, while for immigrants it increased from 24.55 to 26.56 (Fig. 1).

Annual trends by educational attainment show persistent disparities in obesity and overweight prevalence and BMI (Fig. 1). Educational gradients were more consistent and pronounced in 1976 and the 1990s than during the first decade of the 2000s. The rate of increase in obesity and overweight was greater for those with 12, 13–15 and ≥16 years of education than for those with 0–8 and 9–11 years of education. During 1991–2008, the average annual rates of increase in obesity for the 5 (low to high) educational groups were 2.58, 3.63, 4.75, 5.54, and 5.05%, respectively. The corresponding rates of increase in overweight were 1.36, 1.90, 2.32, 2.90, and 2.25%.

Socioeconomic Profiles of Ethnic-Immigrant Groups, 2003–2008

The immigrant groups varied substantially in their socioeconomic characteristics (Fig. 2). Overall, immigrants had nearly twice the poverty levels of the US-born. They were also twice as likely to be without a high school diploma as the US-born. Socioeconomic achievement levels increased with increasing duration of residence in the US. During 2003–2008, less than 6% of Mexican immigrants were college graduates, compared with 67% of recent Asian Indian immigrants. Less than 9% of Mexican immigrants were employed in professional and managerial occupations, as compared with 52% of recent Asian Indian immigrants and 53% of US-born Chinese. Poverty rates varied from a low of 5% for long-term Filipino immigrants to a high of 33% for recent Mexican immigrants.

Ethnic-immigrant and Socioeconomic Disparities in Obesity and Overweight Prevalence, 1976, 1992–1995, and 2003–2008

Table 1 shows increases in obesity prevalence between 1992–1995 and 2003–2008 for detailed ethnic-immigrant and socioeconomic groups. Regardless of ethnicity, all immigrant groups experienced a substantial increase in prevalence, with the increase being greater among the US-born population and longer-term immigrants.

Tables 1 and 2 show considerable disparities in obesity and overweight prevalence by immigrant status and selected socioeconomic factors. The observed obesity prevalence in 2003–2008 ranged from 2.3% for recent Chinese immigrants to 30.6% or higher for American Indians, US-born blacks, Mexicans, and Puerto Ricans, and long-term Mexican and Puerto Rican immigrants (Table 1). The overweight prevalence in 2003–2008 ranged from 19.8% for recent Chinese immigrants to 70% or higher for American Indians, US-born blacks and Mexicans, and long-term Mexican and Puerto Rican immigrants (Table 2). Mean BMI in 2003–2008 varied from a low of 22.6 for recent Chinese immigrants to a high for 28.9 for US-born blacks and American Indians, and 28.6 for US-born Mexicans (Table 3). The summary index of disparity showed similar ethnic-immigrant disparities in obesity and overweight prevalence in 1992–1995 and 2003–2008.

The odds and prevalence of obesity and overweight, even after adjusting for sociodemographic factors, increased with increasing duration in the US (Tables 1, 2). The obesity gradients by length of immigration were steeper in 2003–2008 than in 1992–1995. Compared with the US-born, immigrants who had lived in the US for <1 year or ≥15 years had 73 or 34% lower odds of obesity in 2003–2008 and 59 or 28% lower odds of obesity in 1992–1995, respectively (Table 1). Immigrants who had lived in the US for <1 year or ≥15 years had 57 or 18% lower odds of overweight than the US-born in 2003–2008 (Table 2). During 1992–2008, the disparity indices suggest a slight increase in obesity differentials between US-born and immigrants of various durations.

Compared with US-born whites, the odds of obesity were 59 and 25% lower for recent and long-term white
immigrants, 36% lower for recent black immigrants, 55–92% lower for US- and foreign-born Chinese, Asian Indians, and Filipino immigrants, 34–52% lower for recent Mexican and Central/South American immigrants, respectively. However, US-born blacks, American Indians, Mexicans, and Puerto Ricans, and long-term Puerto Rican immigrants had 60, 81, 64, 32, and 23% higher odds of obesity, respectively than US-born whites (Table 1).

Compared with Chinese immigrants, US-born blacks, Mexicans, Puerto Ricans, and Central/South Americans, and American Indians had 14–19 times higher odds of obesity, whereas white, black, Mexican, Cuban, and Central/South American immigrants had 4–13 times higher odds of obesity. Compared with Chinese immigrants, all other ethnic-immigrant groups had 3–10 times higher odds of overweight (Table 4).

Fig. 1  Trends in Obesity and Overweight Prevalence (%) among US Adults by Immigrant Status and Education, 1976–2008
Socioeconomic gradients in obesity, although substantial in each period, were less pronounced in 2003–2008 than in 1992–1995 and 1976. The summary indices also indicate decreasing educational disparities over time. Between 1976 and 2008, obesity prevalence doubled for those with <9 years of education, while it increased 4–5 fold for those with a college education. Those with <9 years of education had 152% higher adjusted odds of obesity in 1976, 90% higher odds in 1992–1995, and 63% higher odds in 2003–2008 than those with a college degree. In terms of continuous education, each additional year of education was associated with 11% lower odds of obesity (OR = 0.89; 95% CI = 0.89–0.90) and 7% lower odds of overweight (OR = 0.93; 95% CI = 0.93–0.94) in 1976, 8% lower odds of obesity (OR = 0.92; 95% CI = 0.92–0.92) and 6% lower odds of overweight (OR = 0.94; 95% CI = 0.94–0.94) in 1992–1995, and 6% lower odds of obesity and overweight (OR = 0.94; 95% CI = 0.94–0.95) in 2003–2008. Each additional year of education was associated with a 0.17 point decrease in BMI.

![Fig. 2 Selected Socioeconomic Characteristics (% of 30 Ethnic-Immigrant Groups, US Adults Aged 18 years and Older, 2003–2008](image-url)
| Duration of residence in the US (years) | 1992–1995 (N = 323,627) | 2003–2008 (N = 154,649) | 1992–2008 |
|----------------------------------------|--------------------------|--------------------------|------------|
|                                        | Observed | Adjusted | Observed | Adjusted | Increase in BMI |
|                                        | BMI     | SE      | BMI     | SE      | % Absolute     |
| <1                                     | 23.3    | 0.17    | 24.1    | 0.14    | 4.3 1.0        |
| 1–5                                    | 23.9    | 0.10    | 24.5    | 0.09    | 4.1 1.0        |
| 5–9                                    | 24.4    | 0.05    | 24.5    | 0.06    | 5.1 1.3        |
| 10–14                                  | 24.7    | 0.09    | 24.8    | 0.07    | 5.9 1.5        |
| 15+                                    | 25.4    | 0.05    | 25.1    | 0.04    | 5.8 1.5        |
| US-born                                 | 25.6    | 0.02    | 25.6    | 0.02    | 7.1 1.8        |
| Non-Hispanic White                     |          |          |          |          |                |
| Recent immigrants                      | 24.5    | 0.11    | 24.8    | 0.10    | 2.0 0.5        |
| Long-term immigrants                   | 25.2    | 0.07    | 25.0    | 0.07    | 5.1 1.3        |
| US-born                                 | 25.4    | 0.02    | 25.3    | 0.02    | 6.9 1.8        |
| Non-Hispanic Black                     |          |          |          |          |                |
| Recent immigrants                      | 25.4    | 0.14    | 25.6    | 0.13    | 2.3 0.6        |
| Long-term immigrants                   | 26.0    | 0.13    | 25.7    | 0.13    | 6.5 1.7        |
| US-born                                 | 27.0    | 0.04    | 27.0    | 0.04    | 7.1 1.9        |
| American Indian/AN                     |          |          |          |          |                |
| Recent immigrants                      | 26.6    | 0.18    | 26.6    | 0.19    | 8.6 2.3        |
| Long-term immigrants                   |          |          |          |          |                |
| US-born                                 |          |          |          |          |                |
| Chinese                                |          |          |          |          |                |
| Recent immigrants                      | 22.0    | 0.11    | 22.3    | 0.10    | 2.7 0.6        |
| Long-term immigrants                   | 22.8    | 0.16    | 22.7    | 0.16    | 1.5 0.4        |
| US-born                                 | 23.2    | 0.29    | 24.1    | 0.22    | 4.7 1.1        |
| Filipino                                |          |          |          |          |                |
| Recent immigrants                      | 23.1    | 0.13    | 23.6    | 0.13    | 5.3 1.2        |
| Long-term immigrants                   | 23.8    | 0.16    | 23.9    | 0.16    | 6.8 1.6        |
| US-born                                 | 24.6    | 0.46    | 25.5    | 0.38    | 7.4 1.8        |
| Asian Indian                           |          |          |          |          |                |
| Recent immigrants                      | 23.2    | 0.16    | 23.6    | 0.16    | 3.6 0.8        |
| Long-term imm/US-born                  | 24.0    | 0.16    | 24.1    | 0.15    | 3.3 0.8        |
| Other Asian/Pacific Islander           |          |          |          |          |                |
| Recent immigrants                      | 22.3    | 0.11    | 22.5    | 0.11    | 2.9 0.6        |
| Long-term immigrants                   | 23.0    | 0.19    | 23.2    | 0.20    | 4.9 1.1        |
| US-born                                 | 24.2    | 0.17    | 24.7    | 0.15    | 7.2 1.7        |
| Mexican                                |          |          |          |          |                |
| Recent immigrants                      | 25.6    | 0.09    | 25.6    | 0.09    | 4.1 1.1        |
| Long-term immigrants                   | 26.9    | 0.11    | 26.2    | 0.09    | 5.1 1.4        |
| US-born                                 | 26.6    | 0.08    | 26.8    | 0.08    | 7.4 2.0        |
| Puerto Rican                           |          |          |          |          |                |
| Recent immigrants                      | 25.5    | 0.19    | 25.5    | 0.18    | 6.9 1.8        |
| Long-term immigrants                   | 26.9    | 0.12    | 26.1    | 0.12    | 4.7 1.3        |
| US-born                                 | 25.3    | 0.13    | 25.8    | 0.13    | 12.0 3.0       |
| Cuban                                  |          |          |          |          |                |
| Recent immigrants                      | 25.6    | 0.16    | 25.2    | 0.16    | 6.2 1.6        |
| Long-term immigrants                   | 26.0    | 0.34    | 25.7    | 0.31    | 5.8 1.5        |
| US-born                                 | 25.3    | 0.28    | 25.8    | 0.27    | 7.2 1.8        |
in 2003–2008, the effect being significantly lower than the 0.19 point decrease in BMI in 1992–1995 ($P < .001$).

Income gradients were steeper in 1992–1995 than in 2003–2006, with income disparities in prevalence, as measured by the summary indices, diminishing over time. During 2003–2006, those with family income $<$ $10,000 had 44% higher odds of obesity than those with income $\geq$ $65,000$; the roughly comparable odds in 1992–1995 were 62% higher for those with family income $<$ $7,000$ than for those with income $\geq$ $50,000$. A $5,000$ increase in family income was associated with 7% (OR = 0.93; 95% CI = 0.93–0.93) and 4% (OR = 0.96; 95% CI = 0.96–0.96) lower odds of obesity and overweight, respectively in 1992–1995; in 2003–2006, the

### Table 3 continued

| Covariates                          | 1992–1995 ($N = 323,627$) | 2003–2008 ($N = 154,649$) | 1992–2008 | Increase in BMI$^b$ |
|-------------------------------------|--------------------------|--------------------------|-----------|-------------------|
| Central and South Americans and other Hispanics | | | | |
| Recent immigrants                   | 24.7 0.11 24.8 0.09      | 26.0 0.12 26.0 0.13      | 5.1 1.3   | |
| Long-term immigrants                | 25.5 0.10 25.1 0.10      | 27.6 0.13 27.0 0.14      | 8.2 2.1   | |
| US-born                             | 25.5 0.10 25.9 0.09      | 27.6 0.19 27.9 0.18      | 8.1 2.1   | |
| Gender                              | | | | |
| Male                                | 26.1 0.02 26.2 0.02      | 27.6 0.03 27.6 0.03      | 5.7 1.5   | |
| Female                              | 24.9 0.02 24.9 0.02      | 26.9 0.03 26.8 0.03      | 7.8 1.9   | |
| Education (years of school completed) | | | | |
| 0–8                                 | 26.5 0.04 26.1 0.04      | 27.8 0.08 27.5 0.08      | 4.6 1.2   | |
| 9–11                                | 26.1 0.04 25.9 0.04      | 27.6 0.06 27.5 0.06      | 6.0 1.6   | |
| 12                                  | 25.7 0.02 25.6 0.02      | 27.7 0.04 27.5 0.04      | 7.8 2.0   | |
| 13–15                               | 25.2 0.03 25.5 0.02      | 27.4 0.04 27.5 0.04      | 8.7 2.2   | |
| 16+                                 | 24.8 0.02 24.9 0.03      | 26.3 0.03 26.4 0.04      | 5.8 1.5   | |
| Family income ($$)                  | | | | |
| <10,000                             | 26.0 0.09 26.1 0.08      | 27.6 0.12 27.9 0.12      | 6.2 1.6   | |
| 10,000–19,999                       | 26.0 0.04 26.0 0.04      | 27.4 0.07 27.6 0.07      | 5.7 1.5   | |
| 20,000–24,999                       | 25.8 0.04 25.8 0.04      | 27.4 0.09 27.5 0.09      | 6.2 1.6   | |
| 25,000–34,999                       | 25.7 0.04 25.7 0.04      | 27.4 0.07 27.4 0.07      | 6.8 1.7   | |
| 35,000–44,999                       | 25.6 0.03 25.6 0.03      | 27.6 0.07 27.4 0.07      | 7.6 1.9   | |
| 45,000–64,999                       | 25.5 0.03 25.5 0.03      | 27.4 0.06 27.3 0.06      | 7.5 1.9   | |
| 65,000+$^c$                         | 25.1 0.02 25.1 0.03      | 26.8 0.05 26.7 0.05      | 6.9 1.7   | |
| Poverty status (ratio of family income to poverty threshold) | | | | |
| <100%                               | 27.6 0.08 27.8 0.06      | 27.6 0.08 27.8 0.06      | 6.9 1.7   | |
| 100–199%                            | 27.7 0.05 27.7 0.05      | 27.7 0.05 27.7 0.05      | 6.9 1.7   | |
| 200–299%                            | 27.5 0.05 27.4 0.05      | 27.5 0.05 27.4 0.05      | 6.9 1.7   | |
| 300–399%                            | 27.5 0.06 27.4 0.06      | 27.5 0.06 27.4 0.06      | 6.9 1.7   | |
| 400–499%                            | 27.2 0.06 27.1 0.06      | 27.2 0.06 27.1 0.06      | 6.9 1.7   | |
| $\geq$500%                          | 26.8 0.04 26.8 0.04      | 26.8 0.04 26.8 0.04      | 6.9 1.7   | |
| Occupation                          | | | | |
| Professional/managerial             | 25.2 0.02 25.5 0.02      | 26.8 0.04 27.2 0.04      | 6.3 1.6   | |
| Sales/clerical.tech support         | 25.1 0.02 25.4 0.02      | 27.1 0.04 27.3 0.04      | 8.3 2.1   | |
| Service                             | 25.7 0.04 25.6 0.03      | 27.5 0.06 27.4 0.06      | 7.1 1.8   | |
| Craft and repair                    | 26.2 0.03 25.4 0.04      | 27.8 0.05 27.1 0.05      | 6.1 1.6   | |
| Laborers                            | 26.2 0.03 25.6 0.03      | 28.3 0.07 27.7 0.07      | 8.1 2.1   | |
| Unemployed/not in LF                | 25.5 0.02 25.6 0.03      | 26.4 0.10 27.1 0.10      | 3.6 0.9   | |

$^a$ Adjusted BMI was derived from fitted least square regression models that included survey year, age, gender, ethnic-immigrant status (or race/ethnicity and length of immigration), marital status, family size, region of residence, education, occupation, and family income or poverty status.

$^b$ All percentage and absolute increases in BMI during 1992–2008 were statistically significantly different from 0 ($P < .01$).
corresponding odds ratios were smaller: 0.97 (95% CI = 0.97–0.98) for obesity and 0.99 (95% CI = 0.98–0.99) for overweight. A $5,000 increase in family income was associated with a 0.08 point decrease in BMI in 2003–2006, the effect being significantly lower than the 0.14 point decrease in BMI in 1992–1995 ($P < .001$).

### Table 4

| Ethnic-immigrant group | Obesity Age-sex—year adjusted model | Obesity Covariate adjusted model | Overweight Age-sex—year adjusted model | Overweight Covariate adjusted model |
|------------------------|-------------------------------------|---------------------------------|----------------------------------------|-------------------------------------|
|                        | OR 95% CI                           | OR 95% CI                       | OR 95% CI                              | OR 95% CI                           |
| Non-Hispanic White     |                                     |                                 |                                        |                                     |
| Recent immigrants      | 4.50 2.83 7.18                      | 4.33 2.71 6.91                  | 3.78 2.99 4.79                        | 3.70 2.92 4.69                      |
| Long-term immigrants   | 8.30 5.34 12.90                     | 7.81 5.02 12.16                 | 5.04 4.06 6.26                        | 4.78 3.83 5.96                      |
| US-born                | 11.91 7.75 18.31                    | 10.46 6.77 16.14                | 5.87 4.82 7.14                        | 5.27 4.31 6.44                      |
| Non-Hispanic Black     |                                     |                                 |                                        |                                     |
| Recent immigrants      | 8.39 5.18 13.57                     | 6.73 4.13 10.98                 | 5.01 3.87 6.47                        | 4.37 3.37 5.67                      |
| Long-term immigrants   | 11.77 7.44 18.62                    | 9.92 6.25 15.76                 | 7.85 6.05 10.19                       | 7.10 5.45 9.25                      |
| US-born                | 21.30 13.88 32.68                   | 16.74 10.86 25.80               | 10.30 8.42 12.60                      | 9.05 7.36 11.12                     |
| American Indian/Alaska Native | 24.11 15.11 38.48                 | 18.93 11.82 30.31               | 9.74 7.40 12.83                       | 8.33 6.31 11.00                     |
| Chinese Immigrants (all) | 1.00 Reference                    | 1.00 Reference                  | 1.00 Reference                         | 1.00 Reference                      |
| US-born                | 3.59 1.76 7.34                      | 4.16 2.02 8.59                  | 3.00 2.06 4.37                        | 3.37 2.30 4.93                      |
| Filipino               |                                     |                                 |                                        |                                     |
| Recent immigrants      | 3.10 1.59 6.02                      | 3.03 1.57 5.86                  | 2.75 2.01 3.74                        | 2.69 1.97 3.66                      |
| Long-term immigrants   | 4.79 2.91 7.91                      | 4.68 2.83 7.73                  | 3.22 2.41 4.29                        | 3.12 2.32 4.20                      |
| US-born                | 9.54 5.68 16.00                     | 8.87 5.28 14.88                 | 5.55 4.00 7.69                        | 5.41 3.86 7.58                      |
| Asian Indian           |                                     |                                 |                                        |                                     |
| Recent immigrants      | 2.34 1.35 4.06                      | 2.43 1.40 4.22                  | 2.61 2.01 3.40                        | 2.69 2.07 3.50                      |
| Long-term immigrants/US-born | 3.34 1.93 5.77                    | 3.43 1.98 5.94                  | 3.05 2.24 4.15                        | 3.11 2.28 4.24                      |
| Other Asian and Pacific Islanders | 1.57 0.85 2.91                  | 1.41 0.76 2.60                  | 1.27 0.93 1.74                        | 1.22 0.89 1.68                      |
| Mexican                |                                     |                                 |                                        |                                     |
| Recent immigrants      | 9.81 6.34 15.17                     | 6.89 4.44 10.71                 | 7.70 6.26 9.48                        | 6.26 5.07 7.73                      |
| Long-term immigrants   | 15.15 9.84 23.31                    | 10.82 7.01 16.71                | 10.32 8.32 12.80                      | 8.42 6.77 10.48                     |
| US-born                | 21.43 13.78 33.32                   | 17.10 10.99 26.63               | 11.09 9.02 13.63                      | 9.54 7.73 11.76                     |
| Puerto Rican           |                                     |                                 |                                        |                                     |
| Recent immigrants      | 15.85 9.45 26.59                    | 12.31 7.28 20.80                | 7.28 5.21 10.17                       | 6.25 4.46 8.77                      |
| Long-term immigrants   | 16.76 10.65 26.38                   | 12.88 8.14 20.36                | 9.26 7.16 11.97                       | 7.98 6.12 10.39                     |
| US-born                | 17.30 11.04 27.08                   | 13.82 8.79 21.72                | 9.18 7.21 11.68                       | 7.91 6.19 10.10                     |
| Cuban                 |                                     |                                 |                                        |                                     |
| Recent immigrants      | 10.01 5.62 17.81                    | 7.48 4.21 13.30                 | 7.04 4.68 10.60                       | 5.91 3.91 8.94                      |
| Long-term immigrants   | 10.97 6.83 17.60                    | 8.76 5.44 14.12                 | 6.35 4.77 8.46                       | 5.50 4.14 7.32                      |
| US-born                | 13.28 7.87 22.39                    | 11.78 6.96 19.94                | 6.40 4.54 9.03                       | 5.88 4.17 8.30                      |
| Central and South Americans and other Hispanics | 6.60 4.17 10.46                 | 5.05 3.17 8.03                  | 5.35 4.26 6.72                       | 4.53 3.59 5.72                      |
| Recent immigrants      | 11.43 7.28 17.95                    | 8.75 5.55 13.79                 | 8.15 6.50 10.22                       | 6.95 5.52 8.75                      |
| US-born                | 15.64 10.21 23.94                   | 13.52 8.79 20.79                | 8.65 6.91 10.83                       | 7.88 6.27 9.91                      |

* Adjusted for survey year, age, gender, marital status, family size, region of residence, education, occupation, and poverty status
The obesity prevalence for individuals in sales occupations quadrupled and for those in other occupations tripled between 1976 and 2003–2008. In 2003–2008, after adjusting for education, income, and other demographic factors, service workers and laborers had 7 and 21% higher odds of obesity than those employed in professional/managerial occupations. Although observed occupational inequalities in obesity were substantial, most of the occupational effects were accounted for by education and income differences.

After adjusting for ethnicity and socioeconomic factors, physical inactivity was associated with 54% higher odds of obesity (OR = 1.54; 95% CI = 1.46–1.62) and 36% higher odds of overweight (OR = 1.36; 95% CI = 1.30–1.42) in 2003–2008 (data from the full model not shown).

Discussion

Race/ethnicity, immigrant status, and social class have long been considered three of the most important axes of health and social stratification [1, 2, 21]. Health and social inequalities by these factors remain quite marked in the contemporary US [1, 4, 12, 20, 21]. Our study examined long-term trends and inequalities in obesity and overweight prevalence among adults from a wide range of social class and immigrants groups, using nationally representative annual cross-sectional samples of the US population. Although immigrant differentials in adult obesity have been examined previously in the US [4, 11, 25], immigrant disparities in obesity across all of the major racial/ethnic groups had not been explored. Furthermore, previous national studies had not examined a wide range of socioeconomic differentials in adult obesity using different socioeconomic measures, such as education, occupation, income, and poverty status [1, 5–7].

Decreasing social class gradients in obesity shown here are consistent with those reported for adult obesity trends in Canada and England, where men and women in higher income or social class groups, despite having lower prevalence than their counterparts from lower income groups, have experienced faster increases in their obesity rates [26–28]. Diminishing socioeconomic differentials in US adult obesity prevalence, along with steeper increases in obesity among higher socioeconomic groups over time, were also found using measured height and weight data from the NHANES [1, 5, 6]. Socioeconomic trends in US adult obesity rates, however, differ from US childhood obesity trends—which indicate rising social inequalities in prevalence during this decade [16]. Declining physical activity levels and increases in total energy intake may have contributed to rising trends in adult obesity [1, 29]. In analyses not shown here, we found that although increased PA was associated with reduced obesity risks in both immigrants and natives, adjusting for PA levels had little impact on the magnitude of ethnic-immigrant differentials in adult obesity. Indeed, because immigrants had higher inactivity levels, adjusting for PA only widened immigrant differentials in obesity. Although PA did partly account for socioeconomic differences in obesity risks during 2003–2008, the extent to which social class trends in physical inactivity and sedentary activities account for obesity trends is not known due to lack of temporal data.

Ethnic-immigrant and social class differences in dietary factors in Appendix Table 5 might provide some insights into understanding the obesity differentials shown here. Immigrants in each racial/ethnic group have significantly lower total calorie and fat intake than the US-born. Moreover, immigrants’ likelihood of excess calorie and fat intake increases with increasing length of residence in the US. Contrary to expectation, the NHANES data show lower total calorie and fat intake among adults in lower SES groups. However, studies have found higher consumption of lower-quality diets and energy-dense foods and lower intakes of fruits and vegetables among lower SES groups [30, 31]. Income or education differences in energy density, fruit and vegetable intake, and other dietary outcomes have persisted or narrowed over time, with individuals in higher socioeconomic groups losing their relative advantage in diet quality in more recent times [30]. These dietary trends appear to coincide with the social class trends in obesity reported here. Future studies need to directly assess the significance of dietary influences in explaining temporal changes in obesity risks and differentials between immigrant and social class groups.

Positive immigrant selectivity in health, education, skills, and ambition has been suggested as a possible explanation for lower obesity risks among immigrants [4, 9]. Those migrating to the US in recent decades have come predominantly from Latin America and Asia, who tend to be healthier than those who remain in their countries of origin. Given the US immigration laws of the past four decades, most immigrants are chosen rather than randomly self-selected based primarily on their skill criteria [4]. Asian immigrants, in particular, are a highly selective group with relatively high socioeconomic attainment levels as noted in Fig. 2 [4].

Immigrant patterns in obesity shown here are consistent with those observed for other health indicators, including smoking, breastfeeding, infant mortality, low birthweight, morbidity, mortality, and life expectancy [4, 9, 11, 32]. Immigrants have a significant advantage over the US-born in most health and behavioral outcomes, which tends to decrease with increasing acculturation levels or length of residence in the US [4, 9, 11, 32]. Consistent with previous
research on acculturation and obesity risks among US and Canadian immigrants [11, 25, 33, 34], our study showed increasing obesity rates with increasing duration of US residence in both 1992–1995 and 2003–2008.

This study has some limitations. Obesity and overweight prevalence estimates from NHIS are derived from self-reported height and weight data, which may underestimate the actual prevalence among ethnic-immigrant and social class groups [1, 26]. In 2007–2008, for example, 26.8% of US adults aged ≥18 were classified as obese based on the NHIS data, whereas the NHANES prevalence was 33.0% [35]. However, the NHANES with its much smaller sample size does not permit detailed examinations of ethnic, immigrant, and socioeconomic disparities in obesity such as those shown here. Second, because of the cross-sectional nature of the NHIS, the obesity impacts of socioeconomic variables and PA may have been misestimated. Third, dietary information in the

| Characteristic | Energy intake in kcals | Calorie intake ≥ 3500 | Fat intake in g | Fat intake ≥ 120 g |
|----------------|-----------------------|------------------------|----------------|-------------------|
|                | Observed | SE | Adjusted* | Mean | SE | % | SE | OR | 95% CI | Observed | SE | Adjusted* | Mean | SE | % | SE | OR | 95% CI |
| Duration of residence in the US (years)b | | | | | | | | | |
| <5 | 2,002 | 67 | 1,895 | 58 | 7.0 | 1.6 | 0.49 | 0.26 | 0.93 | 64 | 3 | 63 | 3 | 7.6 | 2.6 | 0.29 | 0.14 | 0.57 |
| 5–9 | 2,194 | 110 | 2,092 | 100 | 9.5 | 2.3 | 0.69 | 0.38 | 1.27 | 78 | 5 | 77 | 5 | 12.9 | 3.2 | 0.55 | 0.30 | 1.00 |
| 10–19 | 2,161 | 102 | 2,052 | 101 | 9.4 | 2.3 | 0.72 | 0.36 | 1.42 | 78 | 5 | 75 | 5 | 13.8 | 2.8 | 0.55 | 0.31 | 1.00 |
| 20+ | 2,098 | 67 | 2,154 | 78 | 9.7 | 2.0 | 1.09 | 0.59 | 2.02 | 77 | 4 | 79 | 4 | 12.1 | 1.7 | 0.61 | 0.38 | 0.99 |
| US-born | 2,235 | 30 | 2,242 | 30 | 10.4 | 0.6 | 1.00 | Reference | 86 | 1 | 86 | 1 | 18.2 | 1.2 | Reference |
| Non-Hispanic White | | | | | | | | | |
| US-born | 2,248 | 15 | 2,265 | 15 | 11.2 | 0.4 | 1.00 | Reference | 86 | 1 | 86 | 1 | 18.5 | 0.6 | 1.00 | Reference |
| Immigrant | 2,177 | 62 | 2,180 | 51 | 10.1 | 1.9 | 0.82 | 0.53 | 1.29 | 81 | 3 | 81 | 3 | 14.4 | 2.0 | 0.70 | 0.50 | 0.98 |
| Non-Hispanic Black | | | | | | | | | |
| US-born | 2,181 | 24 | 2,186 | 21 | 11.3 | 0.8 | 0.94 | 0.79 | 1.11 | 83 | 1 | 84 | 1 | 17.3 | 0.8 | 0.93 | 0.83 | 1.06 |
| Immigrant | 1,994 | 62 | 1,921 | 67 | 4.1 | 1.6 | 0.26 | 0.11 | 0.63 | 67 | 3 | 65 | 3 | 6.3 | 1.5 | 0.24 | 0.13 | 0.42 |
| Mexican American | | | | | | | | | |
| US-born | 2,303 | 41 | 2,250 | 41 | 13.7 | 1.4 | 1.03 | 0.77 | 1.38 | 88 | 2 | 87 | 2 | 19.2 | 1.6 | 0.97 | 0.76 | 1.25 |
| Immigrant | 2,253 | 28 | 2,103 | 32 | 10.7 | 1.0 | 0.51 | 0.38 | 0.69 | 77 | 1 | 73 | 2 | 13.0 | 1.1 | 0.49 | 0.37 | 0.63 |
| Other Hispanic | | | | | | | | | |
| US-born | 2,100 | 74 | 2,106 | 55 | 4.7 | 1.5 | 0.34 | 0.18 | 0.65 | 78 | 4 | 79 | 3 | 14.7 | 2.9 | 0.81 | 0.50 | 1.32 |
| Immigrant | 2,076 | 65 | 2,017 | 64 | 6.4 | 1.8 | 0.40 | 0.20 | 0.78 | 73 | 3 | 72 | 3 | 10.9 | 2.2 | 0.45 | 0.28 | 0.71 |
| All other ethnic groups | | | | | | | | | |
| US-born | 2,285 | 65 | 2,226 | 62 | 10.0 | 1.9 | 0.72 | 0.48 | 1.07 | 87 | 3 | 85 | 2 | 17.2 | 2.3 | 0.81 | 0.58 | 1.13 |
| Immigrant | 1,939 | 43 | 1,945 | 45 | 4.7 | 1.1 | 0.37 | 0.22 | 0.63 | 65 | 2 | 65 | 2 | 5.8 | 1.3 | 0.25 | 0.15 | 0.42 |
| Education (years of school completed) | | | | | | | | | |
| <12 | 2,106 | 25 | 2,186 | 26 | 10.0 | 0.7 | 1.00 | Reference | 77 | 1 | 81 | 1 | 13.4 | 0.7 | 1.00 | Reference |
| 12 | 2,260 | 21 | 2,260 | 17 | 12.1 | 0.7 | 0.97 | 0.77 | 1.22 | 86 | 1 | 86 | 1 | 18.9 | 0.9 | 1.21 | 1.01 | 1.44 |
| 13+ | 2,245 | 14 | 2,218 | 15 | 10.4 | 0.4 | 0.83 | 0.66 | 1.04 | 85 | 1 | 84 | 1 | 17.7 | 0.6 | 1.09 | 0.93 | 1.28 |
| Poverty status (ratio of family income to poverty threshold) | | | | | | | | | |
| <100% | 2,188 | 24 | 2,205 | 25 | 10.8 | 0.8 | 1.00 | Reference | 80 | 1 | 83 | 1 | 16.3 | 0.9 | 1.00 | Reference |
| 100–199% | 2,149 | 25 | 2,211 | 23 | 10.3 | 0.7 | 1.06 | 0.82 | 1.36 | 80 | 1 | 84 | 1 | 14.7 | 0.8 | 0.92 | 0.74 | 1.13 |
| 200–299% | 2,186 | 27 | 2,185 | 23 | 11.3 | 0.9 | 1.09 | 0.83 | 1.44 | 83 | 1 | 83 | 1 | 17.8 | 1.4 | 1.00 | 0.80 | 1.27 |
| 300–399% | 2,263 | 35 | 2,223 | 33 | 9.8 | 0.9 | 0.82 | 0.62 | 1.08 | 85 | 2 | 83 | 2 | 16.7 | 1.2 | 0.82 | 0.66 | 1.04 |
| 400–499% | 2,260 | 26 | 2,223 | 28 | 10.2 | 0.8 | 0.88 | 0.68 | 1.13 | 87 | 1 | 85 | 1 | 18.5 | 1.2 | 0.94 | 0.76 | 1.16 |
| ≥500% | 2,295 | 22 | 2,255 | 21 | 11.7 | 0.9 | 1.05 | 0.80 | 1.37 | 88 | 1 | 85 | 1 | 19.8 | 0.8 | 0.98 | 0.79 | 1.20 |

* Adjusted by weighted least squares or logistic regression for time period, age, gender, ethnic-immigrant status (or race/ethnicity and length of immigration), marital status, education, and poverty status

b Duration of residence in the US was available only for the 2005–2006 NHANES
NHIS is lacking, and data on immigration and acculturation are limited. The survey does not collect information on legal status of immigrants as well as more direct measures of acculturation such as ethnic-cultural identity, social networks, and dietary preference [4, 9, 11, 33]. Finally, we did not examine if ethnic-immigrant and social class trends in obesity differed by gender; this should be examined in future studies.

In conclusion, continued immigrant and socioeconomic disparities in prevalence will likely have substantial impacts on future obesity trends in the US. Immigrants in each racial/ethnic group generally had lower obesity risks than their US-born counterparts, with immigrants’ obesity risks increasing with increasing length of stay in the US. Considerable heterogeneity in risk was observed, with US-born blacks, Mexicans, blacks, Puerto Ricans, and American Indians having 10–14 times higher obesity prevalence than Chinese immigrants. Barring US-born and foreign-born Chinese and Asian Indians, an average American was likely to be overweight. Nearly two-thirds of all US-born adults were obese or overweight. The overall obesity and overweight prevalence for US adults and an overweight prevalence of 70% or higher for some groups such as US-born blacks, American Indians, Mexican immigrants, and Puerto Rican immigrants rank among the highest in the world [19, 36, 37]. Clearly, the presence of such large ethnic-immigrant and social class disparities is a major reason for America’s unfavorable international standing in obesity. Continued monitoring of disparities in obesity prevalence among immigrant and social class groups is, therefore, essential in tracking progress towards achieving the national goal of eliminating health inequalities [1, 2].

**Conflict of interest statement** None

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### Appendix

See Table 5.

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