Supporting Information

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SI Text

Data and Measures

We use data from the National Health and Nutrition Examination Survey (NHANES) program and the National Survey of Children's Health (NSCH) program, both conducted by the National Center for Health Statistics of the Centers for Disease Control and Prevention (CDC) (1–5). The NHANES is a series of cross-sectional, nationally representative surveys of the US civilian noninstitutionalized population obtained using a complex, stratified, multistage probability cluster sampling design based on selection of counties, blocks, households, and persons within households.

Our analyses are based on data from the NHANES III (1988–1994) and the first 12 y of the continuous NHANES (1999–2010). We use data on the subset of children aged 12–17 y who participated in the physical examination. We excluded respondents who were pregnant ($n = 74$) or missing one or both body mass index (BMI) components ($n = 154$) for an analytical sample size of 11,050.

Most of the published work on obesity using NHANES data appends multiple 2-y cycles of the continuous NHANES and presents estimates for 4-y or even 6-y groups (e.g., one point for 1999–2002 instead of one for 1999–2000 and another for 2001–2002). Despite some loss of statistical power, we present estimates for single 2-y cycles of the continuous NHANES and each half of the NHANES III because the additional time points give a better sense of the shape of the trend line and any points of inflection that may be present. Our results are qualitatively the same if we were to group multiple cycles together.

The NSCH is a large national survey that collects data on a variety of indicators of child health and well-being. The survey was conducted for the first time in 2003–2004. A second survey was fielded in 2007–2008, and the third was conducted in 2011–2012. The survey results are weighted to represent the national population of noninstitutionalized children aged 0–17 y. Telephone numbers are called at random to identify households with one or more children under 18 y of age. In each household, one child was randomly selected to be the subject of the interview. We excluded cases with missing BMI data ($n = 3,275$), yielding a final analytical sample size of 105,524.

In the NHANES, data on weight and height were collected for each individual through direct physical examination by trained technicians in mobile examination centers. BMI ($\text{BMI} = \text{kg}/\text{m}^2$) was calculated for each individual using measured weight and height. Based on age- and sex-specific BMI percentiles provided in the 2000 growth charts of the CDC, we categorize children with BMI values at or above the age- and sex-specific 95th percentiles as obese. The NSCH includes parent-reported (primarily mother's) information on children's age, weight, and height, as well as BMI status based on the CDC's age- and sex-specific growth charts. Although parent-reported data are not as accurate as clinically measured data collected in physical examinations, studies conducted by the CDC show that the estimates of overweight and obesity are valid for adolescents (6). Accordingly, we focus only on data from children aged 12–17 y.

Table S2 shows the weighted sample means/percentages of obesity and the other measures used in our analyses. Despite the differences in reporting and time periods, we find a similar prevalence of obesity across the two surveys: 16.2% [95% confidence interval (CI): 15.1–17.3] in the NHANES and 13.7% (95% CI: 13.2–14.2) in the NSCH.

Our measure of socioeconomic status (SES) is parental education. Income is an important and often used socioeconomic characteristic in health research, and the relationship between income and numerous health outcomes has been well documented. However, compared with parental education and other sociodemographic characteristics, income data from population-based surveys contain greater degrees of measurement error and rates of missing data. Respondents may have problems with recall, or they may simply refuse to provide income information because they consider it too private or sensitive. As a result, a nonnegligible proportion of respondents in most large population-based surveys have missing income information, and these records are often dropped from analyses. Excluding observations with missing information is problematic, because data on income are not missing at random. Instead, evidence shows that people at either tail of the income distribution are less likely to report their income than people in the middle, making it especially problematic to use income to assess socioeconomic disparities (7, 8).

In our analysis, we distinguish between children whose parents have a high school education (or less) and children whose parents have at least a bachelors degree in the NHANES sample and parents who have any postsecondary education experience in the NSCH sample. In the NSCH sample, we measured parental education as the higher level of education attained by the parents. In the NHANES sample, we used the education of the household head because the NHANES III does not include information about the level of education of the household head's spouse. We compared this measure with a measure similar to the one used in the NSCH for the period 1999–2010, and the trend lines were statistically indistinguishable.

The NSCH sample is more advantaged in terms of educational attainment; only 32.0% (95% CI: 31.4–32.7) of the NSCH sample has at most a high school education compared with 49.0% (95% CI: 46.9–51.1) of the NHANES sample. About one-third of this discrepancy is attributable to the earlier time periods included in the NHANES sample. Missing data are much more problematic for income (8.9% for NSCH and 7.6% for NHANES) than for education (0.9% for NSCH and 2.9% for NHANES).

Total caloric intake was derived from the 24-h dietary recall interviews in the NHANES. The participants reported all food eaten in the prior 24-h period (midnight to midnight) using a structured interview procedure. On average, adolescents in the entire NHANES consumed 2,250 calories (95% CI: 2,214–2,286) per day. The NSCH did not include dietary questions.

There is no consensus in the field about the appropriate units and metrics for the measurement of physical activity, so we use the two most consistent measures available across the two surveys. In the NHANES, physically active was defined as a dichotomous measure indicating respondents who reported any moderate or vigorous physical activity during the 30 d before the questionnaire interview. Information on physical activity was first collected in 1999 from respondents aged 12 y and older. Earlier surveys do not include comparable measures. In the NSCH, any respondent who reported at least 20 min of physical activity that made him/her sweat and breathe hard during the past week was coded as physically active. Respondents who reported no activity during the past week were coded as physically inactive. As expected, based on the question differences, there is a higher percentage of physically active adolescents in the NHANES sample, 90.4% (95% CI: 89.5–91.3), than in the NSCH sample, 86.7% (95% CI: 86.2–87.2).

Measurement of both calorie consumption and physical activity are self-reported, which may be subject to recall error, bias, or both. Although this measurement error introduces more random variation into our estimates, there is no reason to suspect that it varies systematically by SES or over time, thereby affecting our results.

Statistical Methods

Data were analyzed using R (version 2.15.3) and Stata (version 11.2; StataCorp) statistical software programs. All analyses included sampling weights that account for the unequal probabilities of selection, oversampling, and nonresponse. SEs were estimated using the Taylor series linearization method with the R survey package (version 3.28-2) and Stata SVY module for complex samples (9–11). The surveys were independently designed and independently drawn with no intended overlap. Therefore, it is reasonable to assume a covariance of zero when testing differences between surveys.

Differences by education, family income, and survey were tested univariately at the 0.05 significance level using the t statistic. We used simulations to test if the socioeconomic disparities in obesity have widened over time. First, we estimated a logistic regression model with the main effects and interactions of parental education and a categorical time measure. We then generated 250,000 random draws from the posterior distribution of the logistic regression parameter estimates (betas and the variance covariance matrix). For each random draw, we calculated the time- and parental education-specific predicted probabilities. We repeated the steps above with a linear time trend for the 2003–2010 time period. Similar simulations were done with the NSCH data and are shown in Fig. S2.

Table S1 quantifies the trends shown in Fig. 2. It shows the percentage of the 250,000 simulations in which the class gap grew (Table S1, first column), in which the prevalence of obesity declined among children of highly educated parents (Table S1, second column), and in which the prevalence of obesity increased among children of less educated parents (Table S1, third column) between each pair of years from 2003–2004 to 2009–2010. The percentages are analogous (and complementary) to one-sided hypothesis tests (e.g., the fact that the class gap in obesity was greater in 2009–2010 compared with 2003–2004 in 97.8% of the simulations is analogous to 1 minus the P value of the test of the null hypothesis that the 2003–2004 class gap is greater than or equal to the 2009–2010 class gap).

Trends by Family Income

Most of the previous work on socioeconomic gaps in youth obesity has used some measure of family income as the stratifying variable. We replicate the analysis shown in Fig. 1 with family income to show that our results are not driven by choice of SES indicator. Specifically, the measure of family income we use is the poverty income ratio based on self-reported data. During the NHANES household interview, respondents were asked to report the total (annual) income for themselves and for other members of their family. Respondents who did not answer were asked whether the family income was below or above $20,000 and to select 1 of 11 income categories ranging from less than $5,000 to more than $75,000. In the NSCH telephone interviews, the respondents were similarly first asked to report the total income for their family. Respondents who did not answer the question were asked whether the family income was below or above $20,000 and to select 1 of 13 income categories ranging from less than $7,500 to more than $75,000. The National Center for Health Statistics used the midpoint of each income category to calculate the poverty income ratio. The poverty thresholds are adjusted for family size and are updated annually for inflation. For example, the poverty cutoff for a family of four with two dependent children in 2004 was $19,157.

The NSCH sample is better off, in terms of income, than the NHANES samples; 15.7% (95% CI: 15.1–16.2) of the sample is below the poverty line, and 30.6% (95% CI: 29.9–31.2) of the sample is in families who earn at least fourfold the poverty line cutoff. The comparable figures for the NHANES data are 21.1% (95% CI: 19.7–22.5) and 23.0% (95% CI: 20.8–25.2), respectively.

Fig. S1 shows the prevalence of adolescent obesity by family poverty income ratio and survey. Fig. S1*A* shows data from the NHANES, whereas Fig. S1*B* plots the trend based on the NSCH. In the 1988–1991 and 1991–1994 NHANES, adolescents in poor families had a substantially higher prevalence of obesity than adolescents in higher income families but no discernible gaps after that. The income gaps that we find in the NHANES need to be interpreted with caution because the estimates for obesity among families earning at least 400% of the poverty line cutoff are based on only 35 and 84 cases, respectively. We find evidence of an income disparity in obesity prevalence in each of the NSCH surveys (2003–2011).

Trends Among Non-Hispanic Whites

Fig. S3 replicates the main simulation results on the NHANES sample restricted to non-Hispanic whites. Compared with Fig. 2, which shows overall trends, adolescents whose parents have at most a high school diploma show a larger increase in the prevalence of obesity since 2003–2004 and their peers whose parents have at least a 4-y college degree show a larger decrease. Thus, the class gap in adolescent obesity grows faster among non-Hispanic whites than it does among the population in general.

1. Centers for Disease Control and Prevention (1996) National Center for Health Statistics (NCHS) *National Health and Nutrition Examination Survey Data (1988–1994).* (US Department of Health and Human Services, Centers for Disease Control and Prevention, Hyattsville, MD).
2. Centers for Disease Control and Prevention (2011) National Center for Health Statistics (NCHS) *National Health and Nutrition Examination Survey Data (1999–2010).* (US Department of Health and Human Services, Centers for Disease Control and Prevention, Hyattsville, MD).
3. Maternal and Child Health Bureau in collaboration with the National Center for Health Statistics (2003) *2003 National Survey of Children's Health. NSCH Stata Indicator Data Set* (prepared by the Data Resource Center for Child and Adolescent Health, Child and Adolescent Health Measurement Initiative). Available at www.childhealthdata.org. Accessed May 20, 2012.
4. Maternal and Child Health Bureau in collaboration with the National Center for Health Statistics (2007) *2007 National Survey of Children's Health. NSCH Stata Indicator Data Set* (prepared by the Data Resource Center for Child and Adolescent Health, Child and Adolescent Health Measurement Initiative). Available at www.childhealthdata.org. Accessed May 20, 2012.
5. Maternal and Child Health Bureau in collaboration with the National Center for Health Statistics (2012) *2011/12 National Survey of Children's Health. NSCH Stata Indicator Data Set* (prepared by the Data Resource Center for Child and Adolescent Health, Child and Adolescent Health Measurement Initiative). Available at www.childhealthdata.org. Accessed May 20, 2012.
6. Akinbami LJ, Ogden CL (2009) Childhood overweight prevalence in the United States: The impact of parent-reported height and weight. *Obesity (Silver Spring)* 17(8): 1574–1580.
7. Lillard L, Smith J, Welch F (1986) What do we really know about wages? The importance of nonreporting and census information. *J Polit Econ* 94(31):489–506.
8. Kim S, Egerter S, Cubbin C, Takahashi ER, Braveman P (2007) Potential implications of missing income data in population-based surveys: An example from a postpartum survey in California. *Public Health Rep* 122(6):753–763.
9. Lumley T (2012) *Survey: Analysis of Complex Survey Samples, R package version 3.28-2.* Available at http://cran.r-project.org/web/packages/survey/index.html. Accessed November 14, 2013.
10. StataCorp (2011) Stata Statistical Software: Release 11 (StataCorp, College Station, TX).
11. R Core Team (2013) *R: A Language and Environment for Statistical Computing* (R Foundation for Statistical Computing, Vienna).

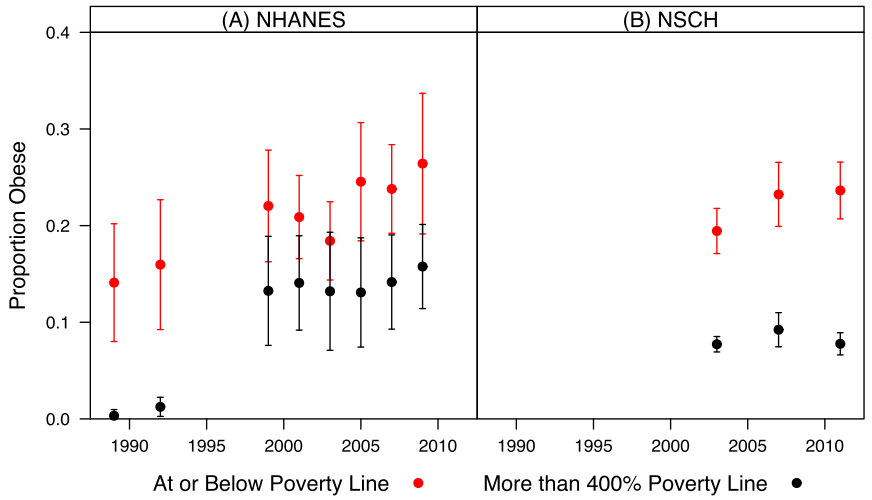

Fig. S1. Trends in adolescent obesity by poverty income ratio in the NHANES III (1999–2010) (*A*) and the NSCH (2003, 2007, and 2011). (*B*) Obesity is defined as being at or above the 95th percentile of the 2000 CDC growth charts.

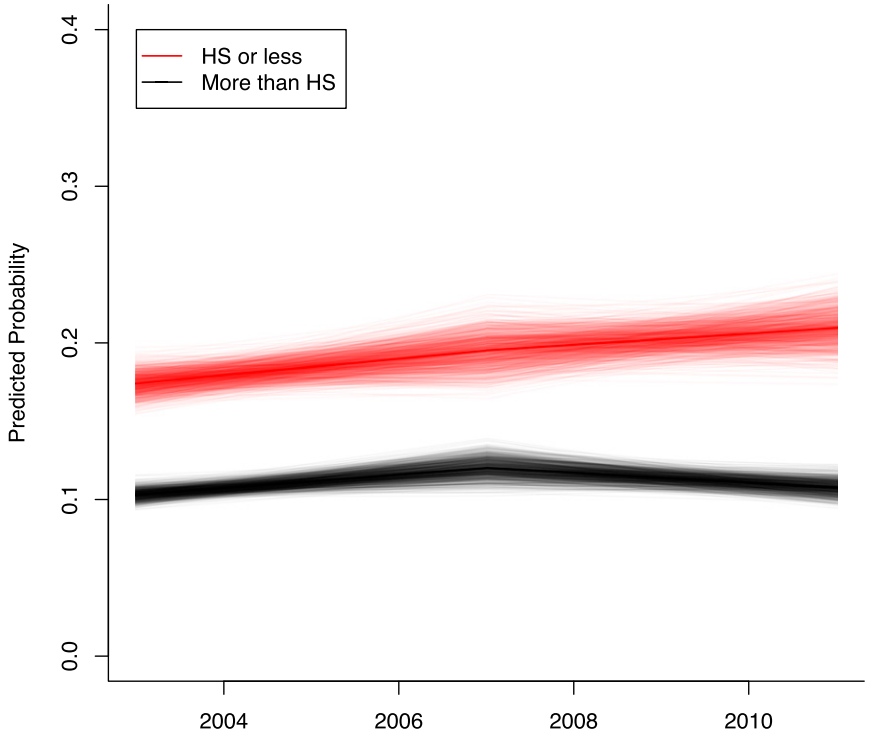

Fig. S2. Visualizing uncertainty in the obesity gap among adolescents aged 12–17 y in the NSCH (2003–2011). The narrow lines are based on 1,000 simulated trends, and the dark lines are the means of the various trend estimates. HS, high school.

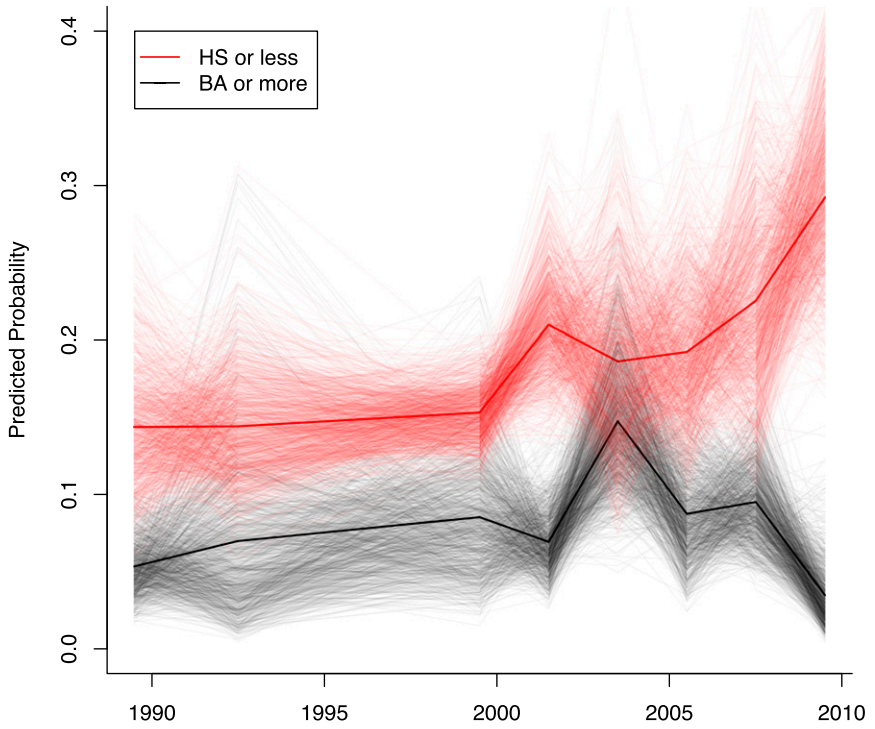

Fig. S3. Visualizing uncertainty in the obesity gap among non-Hispanic white adolescents aged 12–17 y in the NHANES III (1999–2010). The narrow lines are based on 1,000 simulated trends, and the dark lines are the means of the various trend estimates. BA, bachelor's degree.

Table S1. Percentage of simulations consistent with obesity trends (250,000 simulations)

Years	Growing gap, %	BA decline, %	HS increase, %
2009–2010 vs. 2003–2004	97.8	95.8	92.1
2009–2010 vs. 2005–2006	89.8	86.3	76.0
2009–2010 vs. 2007–2008	86.8	90.7	72.8
2007–2008 vs. 2003–2004	85.3	77.4	78.2
2007–2008 vs. 2005–2006	51.4	48.9	50.9
2005–2006 vs. 2003–2004	86.3	73.5	80.0

BA, Bachelor of Arts degree; HS, high school.

Table S2. Marginal means/percentages of variables by survey (age 12–17 y)

	NHANES (n = 11,050)		NSCH (n = 105,524)	
Measure	Mean/percent (95% CI)	Missing, %	Mean/percent (95% CI)	Missing, %
Obese	16.2% (15.1, 17.3)	0.0	13.7% (13.2, 14.2)	0.0
Physical activity	90.4% (89.5, 91.3)	12.7	86.7% (86.2, 87.2)	1.0
Calories	2,250 (2,214, 2,286)	3.6	—	—
Parental education		2.9		0.9
High school or less	49.0% (46.9, 51.1)		32.0% (31.4, 32.7)	
Some college	28.0% (26.3, 29.5)		—	
BA or more	23.0% (21.0, 25.1)		—	
More than high school	—		68.0% (67.3, 68.6)	
Poverty income ratio		7.6		8.9
0–100%	21.1% (19.7, 22.5)		15.7% (15.1, 16.2)	
101–399%	55.8% (53.8, 57.8)		53.8% (53.1, 54.5)	
400% or more	23.0% (20.8, 25.2)		30.6% (29.9, 31.2)	