America's Children and the Environment, Third Edition

DRAFT Indicators

Health: Obesity

EPA is preparing the third edition of *America's Children and the Environment* (ACE3), following the previous editions published in December 2000 and February 2003. ACE is EPA's compilation of children's environmental health indicators and related information, drawing on the best national data sources available for characterizing important aspects of the relationship between environmental contaminants and children's health. ACE includes four sections: Environments and Contaminants, Biomonitoring, Health, and Special Features.

EPA has prepared draft indicator documents for ACE3 representing 23 children's environmental health topics and presenting a total of 42 proposed children's environmental health indicators. This document presents the draft text, indicators, and documentation for the obesity topic in the Health section.

For more information on America's Children and the Environment, please visit www.epa.gov/ace. For instructions on how to submit comments on the draft ACE3 indicators, please visit www.epa.gov/ace/ace3drafts/.

Obesity

Obesity is the term used to indicate the high range of weight for an individual of given height that is associated with adverse health effects.[1] This unhealthy weight range is often a result of the accumulation of excess body fat. Obesity has rapidly become a serious public health concern in the United States, and is associated with several adverse health effects in childhood as well as later in life, including cardiovascular disease risk factors (which includes hypertension and elevated lipids),[2-10] cancer,[5,11,12] psychological stress,[13-16] asthma,[17-19] and diabetes.[20-23] Obesity has also been implicated in the timing of the onset of puberty and early menarche in girls, though the extent to which the obesity epidemic contributes to early puberty is unclear.[24-26]

An emerging body of research suggests there may be common biological mechanisms underlying a cluster of adverse health effects (obesity, hypertension, insulin resistance, and other metabolic abnormalities) referred to as metabolic syndrome. While the clinical utility of a diagnosis of metabolic syndrome is debated in the medical literature,[27-29] the term describes an area of active research. Metabolic syndrome has been identified in obese children and adolescents, and studies suggest a developmental origin of the condition.[30-32] The consideration of obesity and metabolic effects as a group is supported by findings in laboratory animals, where early-life exposure to certain organophosphate pesticides can disrupt adult lipid metabolism, induce weight gain, and cause other metabolic responses that mimic those seen in diabetes and obesity.[33-35] Given these relationships, obesity and other health conditions related to metabolism are discussed below.

The prevalence of excessive body weight in the United States population has been increasing for several decades, though it has stabilized over the last several years.[36-39] Definitions of overweight and obesity for adults are based on set cutoff points directly related to an individual's body mass index (BMI, weight in kilograms divided by the square of height in meters), which is correlated to body fat, but BMI varies with age and sex in children more than it does in adults. Thus the designation of a child or adolescent (ages 2 to 19 years) as either overweight or obese is based on comparing his or her BMI to a sex- and age-specific reference population (the CDC growth charts). Children and adolescents between the 85th and 94th percentiles of BMI-for-age are considered overweight; those greater than or equal to the 95th percentile are considered obese. The percentiles used to identify children as overweight or obese are fixed, and based on data collected from 1963–1980 (or, for children ages 2 to 6 years, data from 1963–1994).[1,40,41]

BMI is the most common screening measure used to determine whether an individual may be overweight or obese. The BMI does not measure body fat directly, but is used as a surrogate measure since it correlates with direct measures of body fat, especially at high BMI levels, and is inexpensive and easy to obtain in a clinical setting. The significance of a child being overweight is complicated by the BMI's inability to distinguish between differences in mass due to muscle or due to the unhealthy accumulation of fatty tissue. A recent study found that less than half of "overweight" children had excess body fat, and that there are differences among race/ethnicity groups in the amount of body fat for a given BMI in children.[42] Among children with an elevated BMI, some may have excess body fat, and others may be incorrectly identified as overweight because they have a higher amount of mass attributed to nonfatty tissue. Despite the limitations

imposed by measuring the BMI, a rise in the prevalence of overweight children is cause for concern, since overweight children are more likely to become overweight or obese adults.[43,44]

Obesity is due primarily to an imbalance between caloric intake and activity. Increased caloric intake and reduced physical activity are likely the major drivers of obesity in children, but there is increasing recognition of the possible roles of certain environmental chemical exposures. These chemicals, which are referred to as obesogens, are thought to be capable of disrupting the human body's regulation of metabolism and the accumulation of fatty tissue.[45] Some chemicals have also been associated with diabetes in adults. Diabetes (Type 2) results from the body's inability to regulate blood sugar levels with insulin in response to dietary intake, and is positively associated with the increasing rates of obesity seen in the U.S. population.[46] Excess body weight is a risk factor for Type 2 diabetes. In the past, Type 2 diabetes has been diagnosed almost exclusively in adult populations, but it is now being diagnosed in youth—although with low prevalence (0.25%).[46-49]

While the relative contribution of chemical exposures to obesity is not clear, a growing number of animal and cellular studies provide evidence that environmental chemical exposures may be contributing to the increase in obesity, as well as rates of diabetes, in the United States. Studies demonstrating associations between chemical exposures and obesity in children are limited. A recent study identified an association between prenatal hexachlorobenzene exposure and increased BMI and weight in children at 6.5 years.[50] Another recent study identified an association between prenatal exposure to polychlorinated biphenyls (PCBs) and DDE (the primary metabolite of the pesticide DDT) with increased BMI during early childhood.[51] In adults, PCBs and dioxins have both been associated with the occurrence of diabetes.[52,53] Organochlorine and organophosphate pesticides have also been associated with an increased risk of diabetes in adults.[54] Several animal and cellular studies suggest that endocrine-disrupting chemicals (including bisphenol A, diethylstilbestrol, and tributyltin) may contribute to increased weight and diabetes.[55-59]

Air pollution has also been associated with obesity and diabetes in children. In one recent study, adult mice fed a high-fat diet and exposed to particulate air pollution ($PM_{2.5}$) experienced an increase in blood glucose levels and insulin resistance, which are precursors of diabetes.[60] Other studies in animals and children demonstrate that obesity may result in greater susceptibility to the adverse effects of airborne pollutants such as $PM_{2.5}$ and ozone, including airway inflammation, cardiovascular effects, and increased deposition of particles in the lungs.[18,61,62] Air pollution may increase the prevalence of childhood obesity by limiting the number of days when air quality is appropriate for outdoor recreational activity, particularly in children with pre-existing respiratory conditions such as wheeze and asthma.[63]

Other environmental factors are thought to contribute to the increasing rates of overweight and obesity seen in the U.S. population. The term "built environment" is used to describe the physical elements of the environment for a population.[64,65] Several properties of the built environment have demonstrated relationships with overweight and obesity and/or levels of physical activity in children, including the level of urbanization, the level of safety in the neighborhood, the extent of urban sprawl, the density of housing in an environment, the distance to fast food restaurants, and the distance to playgrounds and/or green space.[64-69] The relationship

between characteristics of the built environment and obesity is likely more significant in children than adults, because children are less able to leave their local environment without the help of an adult.[70,71] Built environments that promote exercise through the inclusion of nearby recreational areas and walkable communities, and those that provide healthy eating options through reducing the number of fast food restaurants while providing access to fresh produce, are thought to reduce the frequency of obesity in children.[64,65] Factors contributing to the prevalence of obesity may differ among environments. Socioeconomically disadvantaged populations are more likely to be located in built environments with characteristics that promote lifestyles that increase rates of obesity in children.[72-74] However, a child living in a suburban community with a higher socioeconomic status may spend greater amounts of time commuting in a car rather than walking, which may also contribute to a sedentary lifestyle that promotes obesity.[75,76]

The following indicators present data for obesity rates in the U.S. child population. The first indicator shows the prevalence of obesity among children ages 2 to 17 years from 1976–2008. The second indicator presents the prevalence of obesity by race/ethnicity and family income in 2005–2008.

Indicator OBS1: Percentage of children ages 2 to 17 years who were obese, 1976–2008

Indicator OBS2: Percentage of children ages 2 to 17 years who were obese, by race/ethnicity and family income, 2005–2008

Overview

Indicators OBS1 and OBS2 present the prevalence of obesity in U.S. children ages 2 to 17 years. The data are from a national survey that measures weight and height in a representative sample of the U.S. population. Indicator OBS1 shows the trend in obesity prevalence from 1976–2008. Indicator OBS2 presents comparisons of obesity rates in children of different race/ethnicities and income levels during the period 2005–2008.

NHANES

These indicators use data from the National Health and Nutrition Examination Survey (NHANES). NHANES is a nationally representative survey of the health and nutritional status of the civilian noninstitutionalized U.S. population, conducted by the National Center for Health Statistics at the Centers for Disease Control and Prevention (CDC). Interviews and physical examinations are conducted with approximately 5,000 people each year. Height and weight are measured for survey participants of all ages.

Obesity and BMI

Determination of obesity in children is based on the calculation of body mass index (BMI), which is correlated with body fat.[77] The BMI is calculated by dividing an individual's weight in kilograms by the square of his or her height in meters. For children and teenagers in the United States, the BMI number is compared with an age- and sex-specific reference population based on the 2000 CDC growth charts. These charts are based on national data collected from 1963–1994 for children 2 through 6 years of age and from 1963–1980 for children ages 7 years and older.[40] Children and teenagers with BMIs at or above the 95th percentile on the growth charts are classified as obese.[1,41]

Data Presented in the Indicators

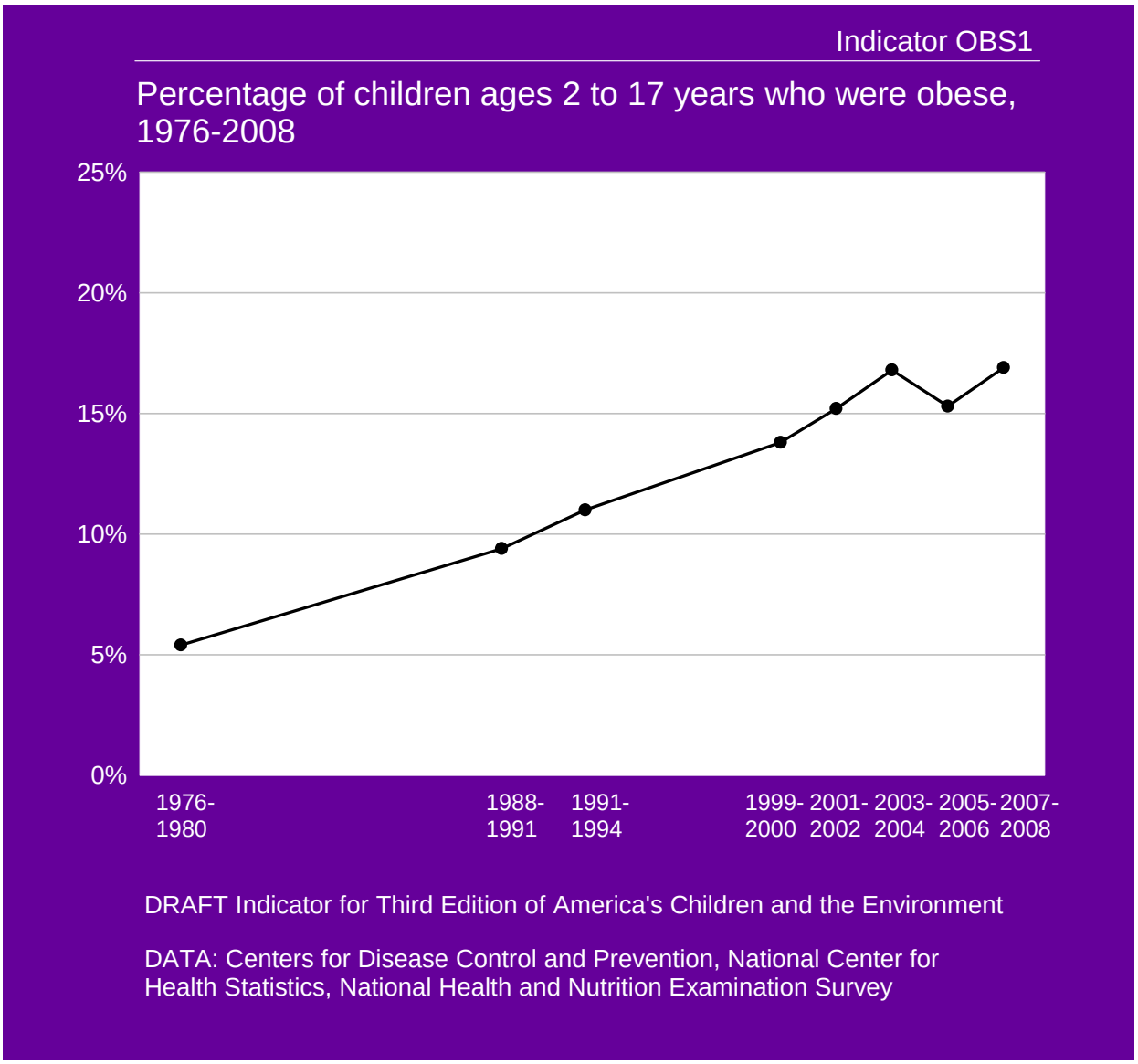
Indicator OBS1 presents the percentage of children ages 2 to 17 years who were obese from NHANES surveys conducted from 1976 through 2008. Indicator OBS2 presents the percentage of children who were obese by race/ethnicity and family income for the combined survey years 2005–2006 and 2007–2008. The data from two NHANES cycles are combined to increase the statistical reliability of the estimates for each race/ethnicity and income group. Four race/ethnicity groups are presented in Indicator OBS2: White non-Hispanic, Black non-Hispanic, Mexican-American, and "Other." The "Other" race/ethnicity category includes Asian non-Hispanic, Native American non-Hispanic, Hispanic other than Mexican-American, those

reporting multiple racial categories, and those with a missing value for race/ethnicity. The data are also tabulated across three income categories: all incomes, below the poverty level, and greater than or equal to the poverty level.

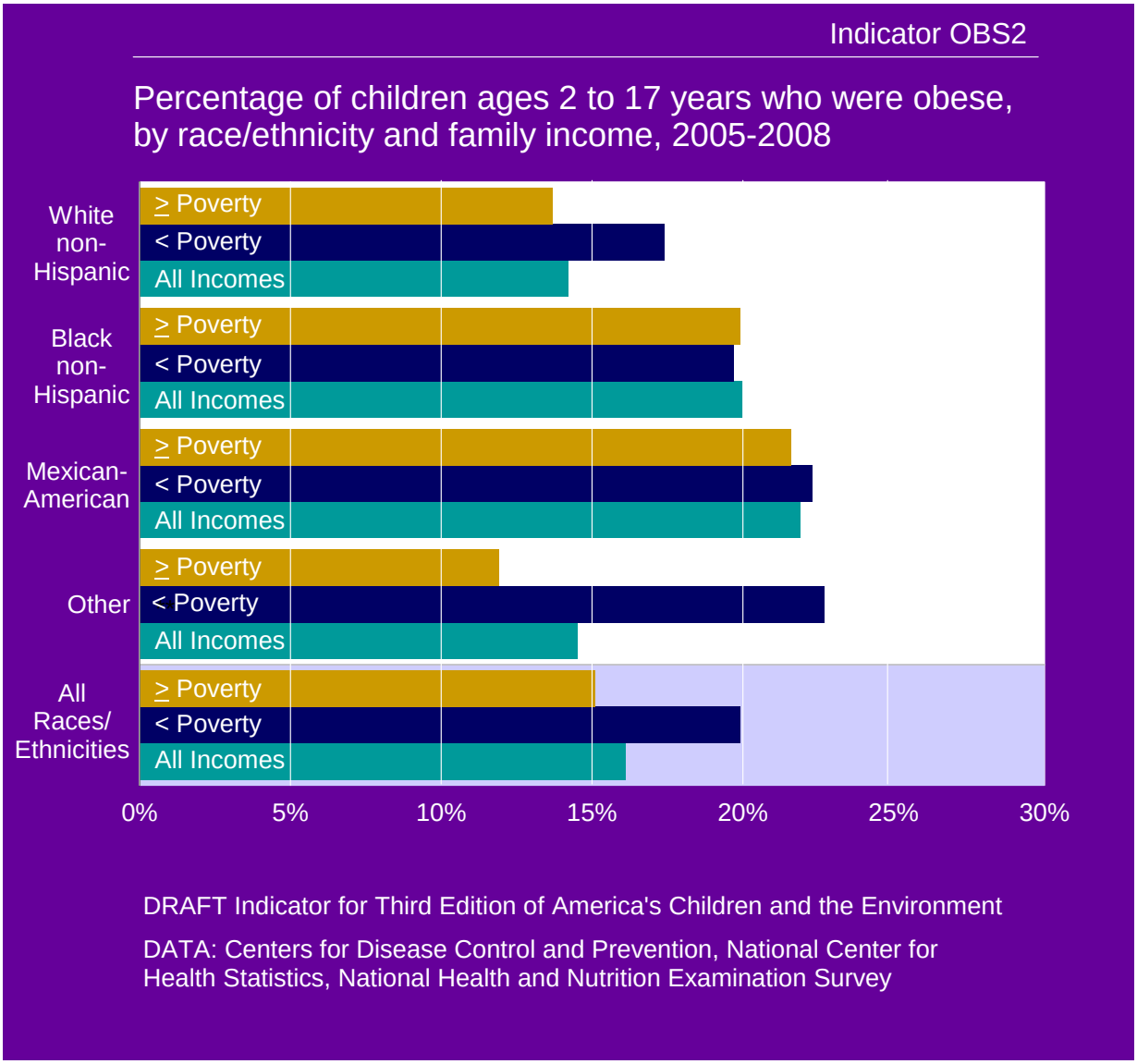
Statistical Testing

Statistical analysis has been applied to the indicators to determine whether any changes in prevalence over time, or any differences in prevalence between demographic groups, are statistically significant. These analyses use a 5% significance level ($p \leq 0.05$), meaning that a conclusion of statistical significance is made only when there is no more than a 5% chance that the observed change over time or difference between demographic groups occurred randomly. It should be noted that when statistical testing is conducted for differences among multiple demographic groups (e.g., considering both race/ethnicity and income level), the large number of comparisons involved increases the probability that some differences identified as statistically significant may actually have occurred randomly.

A finding of statistical significance for a health indicator depends not only on the numerical difference in the value of a reported statistic between two groups, but also on the number of observations in the survey and various aspects of the survey design. For example, if the prevalence of a health effect is different between two groups, the statistical test is more likely to detect a difference when data have been obtained from a larger number of people in those groups. A finding that there is or is not a statistically significant difference in prevalence between two groups or in prevalence over time is not the only information that should be considered when determining the public health implications of those differences.



- Between 1976 and 2008, the percentage of children identified as obese has increased. In 1976–1980, 5.4% of children ages 2 to 17 years were obese. This percentage reached a high of 17.0% in 2007–2008. However, between 1999–2000 and 2007–2008, no significant increase in the prevalence of obesity was observed.
    - Statistical Note: From 1976–2008, the increasing trend in prevalence of obese children was statistically significant for children overall, and for children of each race/ethnicity (See Table OBS1). From 1999–2008, the trends were not statistically significant for each of these groups.



- In 2005–2008, about 16% of children ages 2 to 17 years were classified as obese.

- Black non-Hispanic and Mexican-American children were more likely to be obese than children of other ethnic groups; these differences by race/ethnicity were statistically significant.

- Among children overall, the prevalence of obesity is greater in children with family incomes below poverty level than in those above poverty level. When accounting for differences by race/ethnicity as well as poverty status, children of "Other" race/ethnicity were the only group to have a statistically significant association between low family income and higher prevalence of obesity. While similar trends were observed in the remaining race/ethnic groups, excluding Black non-Hispanics, the results were not statistically significant.

Data Tables

Table OBS1. Percentage of children ages 2 to 17 years who were obese, 1976-2008

	1976-1980	1988-1991	1991-1994	1999-2000	2001-2002	2003-2004	2005-2006	2007-2008
All Races/Ethnicities	5.4%	9.4%	11.0%	13.8%	15.2%	16.8%	15.3%	16.9%
White non-Hispanic	4.7%	8.8%	9.7%	10.5%	13.4%	15.7%	13.0%	15.4%
Black non-Hispanic	7.3%	11.2%	13.4%	18.2%	17.9%	19.7%	20.1%	19.9%
Mexican-American	10.7%	13.3%	15.6%	20.7%	19.6%	19.4%	22.7%	21.0%
Other†	6.5%	6.9%	11.3%	17.5%	16.4%	16.0%	12.3%	16.3%

DATA: Centers for Disease Control and Prevention, National Center for Health Statistics, National Health and Nutrition Examination Survey

† "Other" includes Asian non-Hispanic; Native American non-Hispanic; Hispanic other than Mexican-American; those reporting multi-racial; and those with a missing value for race/ethnicity.

Table OBS1a. Percentage of children who were obese, by age group, 1976-2008

	1976-1980	1988-1991	1991-1994	1999-2000	2001-2002	2003-2004	2005-2006	2007-2008
2-5 years	4.7%	7.3%	7.1%	10.4%	10.5%	13.6%	10.9%	10.1%
6-10 years	6.2%	10.1%	12.7%	14.3%	16.0%	17.3%	14.5%	19.3%
11-15 years	5.5%	9.1%	13.2%	15.9%	17.0%	18.0%	18.1%	19.5%
16-17 years	4.8%	12.3%	8.8%	13.4%	16.3%	18.1%	17.9%	18.2%
2-17 years	5.4%	9.4%	11.0%	13.8%	15.2%	16.8%	15.3%	16.9%

DATA: Centers for Disease Control and Prevention, National Center for Health Statistics, National Health and Nutrition Examination Survey

Table OBS2. Percentage of children ages 2-17 who were obese, by race/ethnicity and family income, 2005–2008

Race / Ethnicity	All Incomes	< Poverty Level	≥ Poverty Level	≥ Poverty (Detail)		Unknown Income
				100-200% of Poverty Level	> 200% of Poverty Level	
All Races/Ethnicities	16.1%	19.9%	15.1%	18.4%	13.8%	16.2%

				≥ Poverty (Detail)		
White non-Hispanic	14.2%	17.4%	13.7%	17.9%	12.5%	13.5%*
Black non-Hispanic	20.0%	19.7%	19.9%	21.6%	18.8%	22.7%
Mexican-American	21.9%	22.3%	21.6%	21.0%	22.3%	21.7%
Other†	14.5%	22.7%	11.9%	11.9%	11.9%	NA**

DATA: Centers for Disease Control and Prevention, National Center for Health Statistics, National Health and Nutrition Examination Survey

* The estimate should be interpreted with caution because the standard error of the estimate is relatively large: the relative standard error, RSE, is at least 30% but is less than 40% (RSE = standard error divided by the estimate).

** The estimate is not reported because it has large uncertainty: the relative standard error, RSE, is at least 40% (RSE = standard error divided by the estimate).

† "Other" includes Asian non-Hispanic; Native American non-Hispanic; Hispanic other than Mexican-American; those reporting multi-racial; and those with a missing value for race/ethnicity.

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Metadata

Metadata for	National Health and Nutrition Examination Survey (NHANES)
Brief description of the data set	The National Health and Nutrition Examination Survey (NHANES) is a program of studies designed to assess the health and nutritional status of adults and children in the United States, using a combination of interviews, physical examinations, and laboratory analysis of biological specimens.
Who provides the data set?	Centers for Disease Control and Prevention, National Center for Health Statistics.
How are the data gathered?	Laboratory data are obtained by analysis of blood and urine samples collected from survey participants at NHANES Mobile Examination Centers. Health status is assessed by physical examination. Demographic and other survey data regarding health status, nutrition and health-related behaviors are collected by personal interview, either by self-reporting or, for children under 16 and some others, as reported by an informant.
What documentation is available describing data collection procedures?	See http://www.cdc.gov/nchs/nhanes.htm for detailed survey and laboratory documentation by survey period.
What types of data relevant for children's environmental health indicators are available from this database?	Concentrations of environmental chemicals in urine, blood, and serum. Body measurements. Health status, as assessed by physical examination, laboratory measurements and interview responses. Demographic information.
What is the spatial representation of the database (national or other)?	NHANES sampling procedures provide nationally-representative data. Analysis of data for any other geographic area (region, state, etc.) is possible only by special arrangement with the NCHS Research Data Center, and such analyses may not be representative of the specified area.
Are raw data (individual measurements or survey responses) available?	Individual laboratory measurements and survey responses are generally available. Individual survey responses for some questions are not publicly released.
How are database files obtained?	http://www.cdc.gov/nchs/nhanes.htm
Are there any known data quality or data analysis concerns?	Some environmental chemicals have large percentages of values below the detection limit. Data gathered by interview, including demographic information, and responses regarding health status, nutrition and health-related behaviors are self-reported, or (for individuals age 16 years and younger) reported by an adult informant.

Metadata for	**National Health and Nutrition Examination Survey (NHANES)**
What documentation is available describing QA procedures?	http://www.cdc.gov/nchs/nhanes.htm includes detailed documentation on laboratory and other QA procedures. Data quality information is available at http://www.cdc.gov/nchs/about/policy/quality.htm.
For what years are data available?	Some data elements were collected in predecessors to NHANES beginning in 1959; collection of data on environmental chemicals began with measurement of blood lead in NHANES II, 1976-1980. The range of years for measurement of environmental chemicals varies; apart from lead and cotinine (initiated in NHANES III), measurement of environmental chemicals began with 1999-2000 or later NHANES.
What is the frequency of data collection?	Data are collected on continuous basis, but are grouped into NHANES cycles: NHANES II (1976-1980); NHANES III phase 1 (1988-1991); NHANES III phase 2 (1991-1994); and continuous two-year cycles beginning with 1999-2000 and continuing to the present.
What is the frequency of data release?	Data are released in two-year cycles (e.g. 1999-2000); particular data sets from a two-year NHANES cycle are released as available.
Are the data comparable across time and space?	Detection limits can vary across time, affecting some comparisons. Some contaminants are not measured in every NHANES cycle. Within any NHANES two-year cycle, data are generally collected and analyzed in the same manner for all sampling locations.
Can the data be stratified by race/ethnicity, income, and location (region, state, county or other geographic unit)?	Data are collected to be representative of the U.S. population based on age, sex, and race/ethnicity. The public release files allow stratification by these and other demographic variables, including family income range and poverty income ratio. Data cannot be stratified geographically except by special arrangement with the NCHS Research Data Center.

1

Methods

Indicator

OBS1. Percentage of children ages 2 to 17 years who were obese, 1976-2008
OBS2. Percentage of children ages 2 to 17 years who were obese, by race/ethnicity and family income, 2005–2008

Summary

Since the 1970s, the National Center for Health Statistics, a division of the Centers for Disease Control and Prevention, has conducted the National Health and Nutrition Examination Surveys (NHANES), a series of U.S. national surveys of the health and nutrition status of the noninstitutionalized civilian population. Indicators OBS1 and OBS2 use body mass index measurements in children ages 2 to 17 years from the NHANES surveys in 1976-1980, 1988-1991, 1991-1994, 1999-2000, 2001-2002, 2003-2004, 2005-2006, and 2007-2008. The body mass index is the weight in kilograms divided by the square of the height in meters. Indicator OBS1 presents the percentages of children ages 2 to 17 years who are obese for each NHANES period. Indicator OBS2 presents the percentages of children ages 2 to 17 years who are obese for 2005-2008, stratified by race/ethnicity and family income. Obese is defined as having a body mass index that is at or above the 95th percentile for the age and sex, based on the 2000 CDC growth charts. Table OBS1 displays the percentages of children who are obese for each NHANES period, stratified by race/ethnicity. Table OBS1a displays the percentages of children who are obese for each NHANES period, stratified by age. The survey data were weighted to account for the complex multi-stage, stratified, clustered sampling design.

Data Summary

Indicator	OBS1. Percentage of children ages 2 to 17 years who were obese, 1976-2008 OBS2. Percentage of children ages 2 to 17 years who were obese, by race/ethnicity and family income, 2005–2008							
Time Period	1976-2008							
Data	Weight and height data in children ages 2 to 17							
Years	1976-1980	1988-1991	1991-1994	1999-2000	2001-2002	2003-2004	2005-2006	2007-2008
Number of non-missing values	6,724	5,207	4,905	3,533	3,760	3,458	3,685	2,969
Number of missing values	56	155	98	64	251	74	68	63

Overview of Data Files

The following files are needed to calculate this indicator. The NHANES files together with the survey documentation and SAS programs for reading in the data are available at the NHANES

website: http://www.cdc.gov/nchs/nhanes.htm. The growth chart files are available from the CDC at the url: http://www.cdc.gov/growthcharts/percentile_data_files.htm.

- NHANES II (1976-1980): Anthropometry file DU5301.txt. This text file contains the body weight (N2BM0412), body height (N2BM0418), examination calendar year (N2BM0198), examination calendar month (N2BM0184), date of birth year (N2BM0053), date of birth month (N2BM0051), sex (N2BM0055), race (N2BM0056), natural origin or ancestry (N2BM0060), poverty income ratio (N2BM0210 – given as a percentage), survey weight (N2BM0282), pseudo-stratum (N2BM0324), and pseudo-PSU (N2BM0326). The age in months at the examination was calculated from the date variables. The body mass index was calculated from the weight and height variables.

- NHANES III (1988-1994): Body Measures Examination Data file EXAM.DAT. This text file contains the body weight (BMPWT), body height (BMPHT), Examination / Interview Status (DMPSTAT – defines whether the body measurements were made at the MEC or at home), age in months at MEC exam (MXPAXTMR), age in months at home exam (HXPAXTMR), sex (HSSEX), race (DMARACER), ethnicity (DMAETHNR), poverty income ratio (DMPPIR), NHANES III Phase (SDPPHASE), pseudo-stratum (SDPSTRA1 for Phase 1 and SDPSTRA2 for Phase 2), pseudo-PSU (SDPPSU1 for Phase1 and SDPPSU2 for Phase 2), and the survey weights (WTPFHX1 for Phase I and WTPFHX2 for Phase 2). The body mass index was calculated from the weight and height variables.

- NHANES 1999-2000: Demographic file demo.xpt. Body Measures Examination Data file bmx.xpt. The demographic file demo.xpt is a SAS transport file that contains the subject identifier (SEQN), age at examination in months (RIDAGEEX), sex (RIAGENDR), race/ethnicity (RIDRETH1), the poverty income ratio (INDFMPIR), the laboratory survey weight (WTMEC2YR), the pseudo-stratum (SDMVSTRA), and the pseudo-PSU (SDMVPSU). The Body Measures Examination Data file bmx.xpt contains SEQN, the body weight (BMXWT), and the body height (BMXHT). The two files are merged using the common variable SEQN. The body mass index was calculated from the weight and height variables.

- NHANES 2001-2002: Demographic file demo_b.xpt. Body Measures Examination Data file bmx_b.xpt. The demographic file demo_b.xpt is a SAS transport file that contains the subject identifier (SEQN), age at examination in months (RIDAGEEX), sex (RIAGENDR), race/ethnicity (RIDRETH1), the poverty income ratio (INDFMPIR), the laboratory survey weight (WTMEC2YR), the pseudo-stratum (SDMVSTRA), and the pseudo-PSU (SDMVPSU). The Body Measures Examination Data file bmx_b.xpt contains SEQN, the body weight (BMXWT), and the body height (BMXHT). The two files are merged using the common variable SEQN. The body mass index was calculated from the weight and height variables.

- NHANES 2003-2004: Demographic file demo_c.xpt. Body Measures Examination Data file bmx_c.xpt. The demographic file demo_c.xpt is a SAS transport file that contains the subject identifier (SEQN), age at examination in months (RIDAGEEX), sex (RIAGENDR), race/ethnicity (RIDRETH1), the poverty income ratio (INDFMPIR), the laboratory survey weight (WTMEC2YR), the pseudo-stratum (SDMVSTRA), and the pseudo-PSU (SDMVPSU). The Body Measures Examination Data file bmx_c.xpt contains SEQN, the body weight (BMXWT), and the body height (BMXHT). The two files are merged using the common variable SEQN. The body mass index was calculated from the weight and height variables.

- NHANES 2005-2006: Demographic file demo_d.xpt. Body Measures Examination Data file bmx_d.xpt. The demographic file demo_d.xpt is a SAS transport file that contains the subject identifier (SEQN), age at examination in months (RIDAGEEX), sex (RIAGENDR), race/ethnicity (RIDRETH1), the poverty income ratio (INDFMPIR), the laboratory survey weight (WTMEC2YR), the pseudo-stratum (SDMVSTRA), and the pseudo-PSU (SDMVPSU). The Body Measures Examination Data file bmx_d.xpt contains SEQN, the body weight (BMXWT), and the body height (BMXHT). The two files are merged using the common variable SEQN. The body mass index was calculated from the weight and height variables.

- NHANES 2007-2008: Demographic file demo_e.xpt. Body Measures Examination Data file bmx_e.xpt. The demographic file demo.xpt is a SAS transport file that contains the subject identifier (SEQN), age at examination in months (RIDAGEEX), sex (RIAGENDR), race/ethnicity (RIDRETH1), the poverty income ratio (INDFMPIR), the laboratory survey weight (WTMEC2YR), the pseudo-stratum (SDMVSTRA), and the pseudo-PSU (SDMVPSU). The Body Measures Examination Data file bmx_e.xpt contains SEQN, the body weight (BMXWT), and the body height (BMXHT). The two files are merged using the common variable SEQN. The body mass index was calculated from the weight and height variables.

- Growth chart files. Body Mass Index Excel file (BMI for age) bmiagerev.xls. This file contains the sex, age in months (AGEMOS), and the 95th percentile of BMI (P95).

National Health and Nutrition Examination Surveys (NHANES)

Since the 1970s, the National Center for Health Statistics, a division of the Centers for Disease Control and Prevention, has conducted the National Health and Nutrition Examination Surveys (NHANES), a series of U.S. national surveys of the health and nutrition status of the noninstitutionalized civilian population. Indicators OBS1 and OBS2 use body mass index measurements in children ages 2 to 17 years from the NHANES surveys in 1976-1980, 1988-1991, 1991-1994, 1999-2000, 2001-2002, 2003-2004, 2005-2006, and 2007-2008. The NHANES data were obtained from the NHANES website: http://www.cdc.gov/nchs/nhanes.htm. For these analyses, the child's age was defined using the age in months at the time of the NHANES examination.

The NHANES use a complex multi-stage, stratified, clustered sampling design. Certain demographic groups were deliberately over-sampled, including Mexican-Americans and Blacks. Oversampling is performed to increase the reliability and precision of estimates of health status indicators for these population subgroups. The publicly released data includes survey weights to adjust for the over-sampling, non-response, and non-coverage. The statistical analyses used the survey weights (N2BM0282 for 1976-1980, WTPFHX1 for 1988-1991, WTPFHX2 for 1991-1994, and WTMEC2YR for 1999 and later) to re-adjust the body mass index data to represent the national population.

Obesity

Obesity was defined using the 2000 CDC growth charts. The growth chart files are available from the CDC at the url: http://www.cdc.gov/growthcharts/percentile_data_files.htm. These analyses used the BMIAGE Excel file. Each child was determined to be obese or not obese based on comparing the measured body mass index (BMI) with the 95th percentile in the growth chart files for the same age and sex. For this comparison, 0.5 was added to the age in months at the time of the NHANES examination, since the value of AGEMOS in the growth charts is tabulated at half-months to represent the entire month and the NHANES age variable is reported as integer months. For example, AGEMOS = 24.5 months means the age is at least 24 months but less than 25 months, corresponding to an NHANES age in months of 24. Obese is defined as having a body mass index that is at or above the 95th percentile for age and sex, based on the 2000 CDC growth charts.

Race/Ethnicity and Family Income

For Indicator OBS2, the percentiles were calculated for demographic strata defined by the combination of race/ethnicity and family income. For Table OBS1, the percentiles were calculated for demographic strata defined by the race/ethnicity.

The family income was characterized based on the INDFMPIR variable (N2BM0210 for 1976-1980 and DMPPIR for 1988-1994), which is the ratio of the family income to the poverty level. The National Center for Health Statistics used the U.S. Census Bureau Current Population Survey to define the family units, and the family income for the respondent was obtained during the interview. The U.S. Census Bureau defines annual poverty level money thresholds varying by family size and composition. The poverty income ratio (PIR) is the family income divided by the poverty level for that family. Family income was stratified into the following groups:

- Below Poverty Level: PIR < 1
- Between 100% and 200% of Poverty Level: 1 ≤ PIR ≤ 2
- Above 200% of Poverty level: PIR > 2
- Above Poverty Level: PIR ≥ 1 (combines the previous two groups)
- Unknown Income: PIR is missing

For 1999 and later, race/ethnicity was characterized using the RIDRETH1 variable. The possible values of this variable are:

- 1. Mexican American
- 2. Other Hispanic
- 3. Non-Hispanic White
- 4. Non-Hispanic Black
- 5. Other Race – Including Multi-racial
- "." Missing

Category 5 includes: all Non-Hispanic single race responses other than White or Black; and multi-racial responses.

For these indicators, the RIDRETH1 categories 2, 5, and missing were combined into a single "Other" category. This produced the following categories:

- White non-Hispanic: RIDRETH1 = 3
- Black non-Hispanic: RIDRETH1 = 4
- Mexican-American: RIDRETH1 = 1
- Other: RIDRETH1 = 2 or 5 or missing

The "Other" category includes Asian non-Hispanic; Native American non-Hispanic; Hispanic other than Mexican-American; those reporting multi-racial; and those with a missing value for race/ethnicity.

For 1976-1980, NHANES II, the same race/ethnicity categories were developed using the race variable N2BM0056 and the natural origin or ancestry variable N2BM0060. The possible values for these variables are:

N2BM0056

- 1. White
- 2. Black
- 3. Other

N2BM0060

- 1. Countries of Central or South America
- 2. Chicano
- 3. Cuban
- 4. Mexican
- 5. Mexicano
- 6. Mexican-American
- 7. Puerto Rican
- 8. Other Spanish
- 9. Other European

- 10. Black, Native, or Afro-American
- 11. American Indian or Alaska Native
- 12. Asian or Pacific Islander
- 13. Another group not listed.
- 88. Blank

These two variables were combined as follows:

- White non-Hispanic: N2BM0060 = 9, 10, 11, 12, 13 or 88 and N2BM0056 = 1
- Black non-Hispanic: N2BM0060 = 9, 10, 11, 12, 13 or 88 and N2BM0056 = 2
- Mexican-American: N2BM0060 = 4, 5, or 6
- Other: N2BM0060 = 1, 2, 3, 7, or 8 or (N2BM0060 = 9, 10, 11, 12, 13 or 88 and N2BM0056 = 3)

For 1988-1994, NHANES III, the same race/ethnicity categories were developed using the race variable DMARACER and the ethnicity variable DMAETHNR. The possible values for these variables are:

DMARACER

- 1. White
- 2. Black
- 3. Other
- 4. Mexican-American of unknown race

DMAETHNR

- 1. Mexican American
- 2. Other Hispanic
- 3. Not Hispanic

These two variables were combined as follows:

- White non-Hispanic: DMAETHNR = 3 and DMARACER = 1
- Black non-Hispanic: DMAETHNR = 3 and DMARACER = 2
- Mexican-American: DMAETHNR = 1
- Other: DMAETHNR = 2 or DMARACER = 3

Calculation of Indicator

Indicator OBS1 gives the percentages of children ages 2 to 17 years who are obese for each NHANES period. Indicator OBS2 gives the percentages of children ages 2 to 17 years who are obese for 2005-2008, stratified by race/ethnicity and family income. Table OBS1 gives the percentages of children ages 2 to 17 years who are obese for each NHANES period, stratified by

race/ethnicity. Tables OBS1a gives the percentages of children who are obese for each NHANES period, stratified by age. The definition of obese is given above.

To simply demonstrate the calculations, we will use the NHANES 2007-2008 body mass index (BMI) data values to estimate the percentage of children ages 2 to 17 years of all race/ethnicities and all incomes who were obese as an example for Indicator OBS1. Calculations for Indicator OBS2 and the supplementary tables are similar. We have rounded all the numbers to make the calculations easier:

We begin with all the non-missing BMI data from the NHANES 2007-2008 survey for children ages 2 to 17. Let a Yes response denote a child who is obese (i.e., has a body mass index above the 95th percentile for that age and sex), a No response denote a child who is not obese, and a missing response denote a child with missing body mass index data. Assume for the sake of simplicity that Yes or No responses were available for every sampled child. Each sampled child has an associated annual survey weight WTMEC2YR that estimates the annual number of U.S. children in 2007-2008 represented by that sampled child. For example, the first response for a child aged 2 to 17 years was No with a survey weight of 10,000, and so represents 10,000 children ages 2 to 17 years. A second child aged 2 to 17 years responded Yes with a survey weight of 11,000, and so represents 11,000 children ages 2 to 17 years. A third child aged 2 to 17 years responded No with a survey weight of 11,000, and so represents 11,000 children ages 2 to 17 years. The total of the survey weights for the sampled children equals 65 million, the annual U.S. population of children ages 2 to 17 years for the period 2007-2008.

To calculate the proportion of obese children ages 2 to 17 years, we can use the survey weights to expand the data to the 2007-2008 annual U.S. population of 65 million children ages 2 to 17 years. We have 10,000 No responses from the first child, 11,000 Yes responses from the second child, 11,000 Yes responses from the third child, and so on. Of these 65 million responses, a total of 11 million responses are Yes and the remaining 54 million are No. Thus 11 million of the 65 million children are obese, giving a proportion of about 17%.

In reality, the calculations need to take into account that Yes or No responses were not reported for every child, and to use exact rather than rounded numbers. There were non-missing responses for 2,969 of the 3,032 sampled children ages 2 to 17 years. The survey weights for all 3,032 sampled children add up to 65.6 million, the total U.S. population of children ages 2 to 17 years. The survey weights for the 2,969 sampled children with non-missing responses add up to 64.5 million. Thus the available data represent 64.5 million children, which is 98%, but not all, of the 2007-2008 annual U.S. population of children ages 2 to 17 years. The survey weights for the Yes responses add up to 10.9 million, which is 16.9% of the population with responses (10.9 million/64.5 million = 16.9%). Thus we divide the sum of the weights for participants with Yes responses by the sum of the weights for participants with non-missing responses. These calculations assume that the sampled children with non-missing data are representative of the children with missing data.

Equations

The following equations give the mathematical calculations for the example of obese children in 2007-2008. Let w(i) denote the survey weight for the i'th surveyed child of ages 2 to 17 years. Exclude any surveyed children with missing BMI data. Let the response indicator c(i) = 1 if the i'th surveyed child was obese and let c(i) = 0 if the i'th surveyed child was not obese.

1. Sum all the survey weights multiplied by the income indicators to get the total weight W:

$$W = \Sigma\, w(i)$$

2. Sum all the survey weights multiplied by the response indicators to get the total weight D for obese children:

$$D = \Sigma\, w(i) \times c(i)$$

3. Divide D by W to get the percentage of children who were obese:

$$\text{Percentage} = (D / W) \times 100\%$$

Relative Standard Error

The uncertainties of the percentages were calculated using SUDAAN® (Research Triangle Institute, Research Triangle Park, NC 27709) statistical survey software. The relative standard error depends upon the survey design. For this purpose, the public release version of NHANES includes the variables SDMVSTRA and SDMVPSU, which are the Masked Variance Unit pseudo-stratum and pseudo-primary sampling unit (pseudo-PSU). For approximate variance estimation, the survey design can be approximated as being a stratified random sample with replacement of the pseudo-PSUs from each pseudo-stratum; the true stratum and PSU variables are not provided in the public release version to protect confidentiality.

Percentiles with a relative standard error less than 30% were treated as being reliable and were tabulated. Percentiles with a relative standard error greater than or equal to 30% but less than 40% were treated as being unstable; these values were tabulated but were flagged to be interpreted with caution. Percentiles with a relative standard error greater than or equal to 40% or missing were treated as being unreliable; these values were not tabulated and were flagged as having a large uncertainty.

Questions and Comments

Questions regarding these methods, and suggestions to improve the description of the methods, are welcome. Please use the "Contact Us" link at the bottom of any page in the America's Children and the Environment website.

Statistical Comparisons

Statistical analyses of the percentages of obese children were used to determine whether the differences between percentages for different demographic groups were statistically significant. Using a logistic regression model, the logarithm of the odds that a given child is obese is assumed to be the sum of explanatory terms for the child's age group, sex, income group and/or race/ethnicity. The odds of being obese are the probability of being obese divided by the probability of not being obese. Thus if two demographic groups have similar (or equal) probabilities of being obese, then they will also have similar (or equal) values for the logarithm of the odds. Using this model, the difference in the percentage between different demographic groups is statistically significant if the difference between the corresponding sums of explanatory terms is statistically significantly different from zero. The uncertainties of the regression coefficients were calculated using SUDAAN® (Research Triangle Institute, Research Triangle Park, NC 27709) statistical survey software to account for the survey weighting and design. A p-value at or below 0.05 implies that the difference is statistically significant at the 5% significance level. No adjustment is made for multiple comparisons.

For these statistical analyses we used three income groups, below poverty level, at or above poverty level, and unknown income. We used four race/ethnicity groups: White non-Hispanic; Black non-Hispanic; Mexican-American; Other. We used four age groups: 2-5, 6-10 and 11-15, and 16-17.

For each type of comparison, we present unadjusted and adjusted analyses. The unadjusted analyses directly compare a percentage between different demographic groups. The adjusted analyses add other demographic explanatory variables to the statistical model and use the statistical model to account for the possible confounding effects of these other demographic variables. For example, the unadjusted race/ethnicity comparisons use and compare the percentages between different race/ethnicity pairs. The adjusted analyses add age, sex, and income terms to the statistical model and compare the percentages between different race/ethnicity pairs after accounting for the effects of the other demographic variables. For example, if White non-Hispanics tend to have higher family incomes than Black non-Hispanics, and if the prevalence of obesity strongly depends on family income only, then the unadjusted differences between these two race/ethnicity groups would be significant but the adjusted difference (taking into account income) would not be significant.

Comparisons of the prevalence of obese children ages 2 to 17 years between pairs of race/ethnicity groups are shown in Table 1. For the unadjusted "All incomes" comparisons, the only explanatory variables are terms for each race/ethnicity group. For these unadjusted comparisons, the statistical tests compare the percentage for each pair of race/ethnicity groups. For the adjusted "All incomes (adjusted for age, sex, income)" comparisons, the explanatory variables are terms for each race/ethnicity group together with terms for each age, sex, and income group. For these adjusted comparisons, the statistical test compares the pair of race/ethnicity groups after accounting for any differences in the age, sex and income distributions between the race/ethnicity groups.

In Table 1, for the unadjusted "Below Poverty Level" and "At or Above Poverty Level" comparisons, the only explanatory variables are terms for each of the 12 race/ethnicity/income combinations (combinations of four race/ethnicity groups and three income groups). For example, in row 1, the p-value for "Below Poverty Level" compares White non-Hispanics below the poverty level with Black non-Hispanics below the poverty level. The same set of explanatory variables are used in Table 2 for the unadjusted comparisons between one race/ethnicity group below the poverty level and the same or another race/ethnicity group at or above the poverty level. The corresponding adjusted analyses include extra explanatory variables for age and sex, so that race/ethnicity/income groups are compared after accounting for any differences due to age or sex.

Additional comparisons are shown in Table 3. The AGAINST = "age" unadjusted p-value compares the percentages for different age groups. The adjusted p-value includes adjustment terms for income, sex, and race/ethnicity in the model. The AGAINST = "sex" unadjusted p-value compares the percentages for boys and girls. The adjusted p-value includes adjustment terms for age, income, and race/ethnicity in the model. The AGAINST = "income" unadjusted p-value compares the percentages for those below poverty level with those at or above poverty level, using the explanatory variables for the three income groups (below poverty, at or above poverty, unknown income). The adjusted p-value includes adjustment terms for age, sex, and race/ethnicity in the model. The AGAINST = "year" p-value examines whether the linear trend in the percentages is statistically significant; the adjusted model for trend adjusts for demographic changes in the populations from year to year by including terms for age, sex, income, and race/ethnicity. The SUBSET column specifies the demographic group of interest. For the AGAINST = "age," "sex," and "income" comparisons, the comparisons are for all children and so no SUBSET is defined. For the AGAINST = "year" trend analyses, results are given for the overall trend (SUBSET = missing) and for the trends in each sex or race/ethnicity group, so that, for example, the SUBSET = "Males" examines whether there is a statistically significant trend for boys ages 2 to 17.

For more details on these statistical analyses, see the memorandum by Cohen (2010).[1]

Table 1. Statistical significance tests comparing the percentages of children ages 2 to 17 years who were obese, between pairs of race/ethnicity groups, for 2005-2008.

			P-VALUES					
Variable	**RACE1**	**RACE2**	**All incomes**	**All incomes (adjusted for age, sex, income)**	**Below Poverty Level**	**Below Poverty Level (adjusted for age, sex)**	**At or Above Poverty Level**	**At or Above Poverty Level (adjusted for age, sex)**
Obese	White non-Hispanic	Black non-Hispanic	0.003	0.005	0.471	0.434	0.003	0.002
Obese	White non-Hispanic	Mexican-American	< 0.0005	< 0.0005	0.045	0.022	0.002	0.001

[1] Cohen, J. 2010. *Selected statistical methods for testing for trends and comparing years or demographic groups in other ACE health-based indicators.*. Memorandum submitted to Dan Axelrad, EPA, 15 November, 2010.

			P-VALUES					
Variable	RACE1	RACE2	All incomes	All incomes (adjusted for age, sex, income)	Below Poverty Level	Below Poverty Level (adjusted for age, sex)	At or Above Poverty Level	At or Above Poverty Level (adjusted for age, sex)
Obese	White non-Hispanic	Other	0.882	0.939	0.104	0.084	0.436	0.483
Obese	Black non-Hispanic	Mexican-American	0.247	0.183	0.328	0.218	0.421	0.356
Obese	Black non-Hispanic	Other	0.010	0.015	0.503	0.462	0.002	0.002
Obese	Mexican-American	Other	0.003	0.003	0.933	0.994	0.003	0.002

Table 2. Statistical significance tests comparing the percentages of children ages 2 to 17 who were obese, between pairs of race/ethnicity/income groups at different income levels, for 2005-2008.

			P-VALUES	
Variable	RACEINC1	RACEINC2	Unadjusted	Adjusted (for age, sex)
Obese	White non-Hispanic, < PL	White non-Hispanic, >= PL	0.115	0.093
Obese	White non-Hispanic, < PL	Black non-Hispanic, >= PL	0.267	0.322
Obese	White non-Hispanic, < PL	Mexican-American, >= PL	0.148	0.147
Obese	White non-Hispanic, < PL	Other, >= PL	0.072	0.068
Obese	Black non-Hispanic, < PL	White non-Hispanic, >= PL	0.049	0.033
Obese	Black non-Hispanic, < PL	Black non-Hispanic, >= PL	0.932	0.954
Obese	Black non-Hispanic, < PL	Mexican-American, >= PL	0.529	0.549
Obese	Black non-Hispanic, < PL	Other, >= PL	0.028	0.022
Obese	Mexican-American, < PL	White non-Hispanic, >= PL	< 0.0005	< 0.0005
Obese	Mexican-American, < PL	Black non-Hispanic, >= PL	0.220	0.080
Obese	Mexican-American, < PL	Mexican-American, >= PL	0.770	0.518
Obese	Mexican-American, < PL	Other, >= PL	< 0.0005	< 0.0005
Obese	Other, < PL	White non-Hispanic, >= PL	0.006	0.003
Obese	Other, < PL	Black non-Hispanic, >= PL	0.417	0.304
Obese	Other, < PL	Mexican-American, >= PL	0.814	0.730
Obese	Other, < PL	Other, >= PL	0.006	0.005

Table 3. Other statistical significance tests comparing the percentages of children ages 2 to 17 who were obese for 2005-2008 (trends for 1976-2008 and 1999-2008).

					P-VALUES	
Variable	From	To	Against	Subset	Unadjusted	Adjusted*
Obese	2005	2008	age		< 0.0005	< 0.0005
Obese	2005	2008	income	Known Income	0.005	0.020
Obese	2005	2008	sex		0.153	0.148
Obese	1976	2008	year		< 0.0005	< 0.0005
Obese	1976	2008	year	2-5 years	< 0.0005	< 0.0005

					P-VALUES	
Variable	**From**	**To**	**Against**	**Subset**	**Unadjusted**	**Adjusted***
Obese	1976	2008	year	6-10 years	< 0.0005	< 0.0005
Obese	1976	2008	year	11-17 years	< 0.0005	< 0.0005
Obese	1976	2008	year	Males	< 0.0005	< 0.0005
Obese	1976	2008	year	Females	< 0.0005	< 0.0005
Obese	1976	2008	year	White non-Hispanic	< 0.0005	< 0.0005
Obese	1976	2008	year	Black non-Hispanic	< 0.0005	< 0.0005
Obese	1976	2008	year	Mexican-American	< 0.0005	< 0.0005
Obese	1976	2008	year	Other	< 0.0005	< 0.0005
Obese	1976	2008	year	Below Poverty Level	< 0.0005	< 0.0005
Obese	1976	2008	year	At or Above Poverty Level	< 0.0005	< 0.0005
Obese	1976	2008	year	Unknown Income	0.004	0.006
Obese	1999	2008	year		0.076	0.078
Obese	1999	2008	year	2-5 years	0.920	0.816
Obese	1999	2008	year	6-10 years	0.073	0.076
Obese	1999	2008	year	11-17 years	0.140	0.151
Obese	1999	2008	year	Males	0.101	0.091
Obese	1999	2008	year	Females	0.203	0.219
Obese	1999	2008	year	White non-Hispanic	0.086	0.084
Obese	1999	2008	year	Black non-Hispanic	0.214	0.289
Obese	1999	2008	year	Mexican-American	0.484	0.379
Obese	1999	2008	year	Other	0.438	0.413
Obese	1999	2008	year	Below Poverty Level	0.212	0.193
Obese	1999	2008	year	At or Above Poverty Level	0.149	0.208
Obese	1999	2008	year	Unknown Income	0.097	0.074

*For AGAINST = ”age,” the p-values are adjusted for sex, race/ethnicity, and income.
For AGAINST = ”sex,” the p-values are adjusted for age, race/ethnicity, and income.
For AGAINST = ”income,” the p-values are adjusted for age, sex, and race/ethnicity.
For AGAINST = “year,” the p-values are adjusted for age, sex, race/ethnicity, and income.