America's Children and the Environment, Third Edition

DRAFT Indicators

Biomonitoring: Bisphenol A (BPA)

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 BPA topic in the Biomonitoring section.

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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/.

Bisphenol A

Bisphenol A (BPA) is a high-volume industrial chemical used in the production of epoxy resins and polycarbonate plastics. Polycarbonate plastics may be encountered in many products, notably food and drink containers, while epoxy resins are frequently used as inner liners of metallic food and drink containers to prevent corrosion. BPA also serves as a coating on some types of thermal paper that are often used as receipts from cash registers, automatic teller machines, and other similar devices. It has also been used in the polyvinyl chloride industries as well as in metal foundries where it is used to make casts and moldings. The primary route of human exposure to BPA is believed to be through diet, when BPA migrates from food and drink containers.[1-3] Migration is more likely to occur when the container is heated.[4]

The highest daily exposures to BPA are thought to occur in infants and children. Estimated daily intakes of BPA for children are higher than those in the general population, because pound for pound children breathe, eat, and drink more than adults do.[1] Biomonitoring studies demonstrate that BPA exposure is prevalent in the United States, with detectable levels of BPA present in 93% of tested urine samples.[5] Because BPA is metabolized quickly in the body, the high frequency of detection indicates that exposures are occurring regularly within the U.S. population.

BPA is a suspected endocrine disruptor.[6] Endocrine disruptors act by interfering with the biosynthesis, secretion, action, or metabolism of naturally occurring hormones.[7,8] Given the importance of hormones in human physiology, there is concern in the scientific community over the potential for endocrine disruptors to adversely affect children's health, particularly in reproduction, development, and behavior. BPA is described as a "weakly estrogenic" chemical, because its affinity for binding to estrogen receptors is approximately 10,000-fold weaker than natural estrogen.[9]

There has been increasing attention to the developmental effects of BPA, based on several laboratory studies and a better understanding of the mechanisms by which BPA exerts an estrogenic effect.[6,10,11] In animal studies, exposure to high levels of BPA during pregnancy or lactation resulted in reduced birth weight, slowed growth, reduced survival, and delayed time to the onset of puberty in offspring.[12-15] Another study found that low-dose BPA exposure in pregnant animals was associated with symptoms similar to gestational diabetes, suggesting that BPA exposures may have adverse effects in pregnant women.[16] The effects of low-dose exposure to BPA in lab animals are debated within the scientific community, with some researchers finding no developmental effects, while others have identified behavioral and neural effects, abnormal urinary tract development, development of lesions in the prostate gland, and early onset of puberty in females.[1,17-27] Based on a critical review of the existing scientific literature, in 2008 the National Toxicology Program determined that there was "some concern" (the midpoint

on a five-level scale ranging from "negligible" to "serious")[i] for effects of BPA on the brain, behavior, and prostate gland in fetuses, infants, and children; "minimal concern" for effects on the mammary gland and onset of puberty in females; and "negligible concern" for fetal or neonatal mortality, birth defects, or reduced birth weight and growth.[1]

Epidemiological data on the effects of BPA in human populations are limited. Studies on low-dose exposures seen in the general population suggest an association in adults between high urinary BPA concentrations and coronary heart disease, diabetes, and liver enzyme abnormalities.[28,29] Another study on occupational exposure in adult workers associated exposure with high levels of BPA to an increased risk of self-reported sexual dysfunction.[30,31] Finally, a recent study associated general population prenatal BPA exposure with aggression and hyperactivity in 2-year-old children.[32] In 2009, the National Institutes of Health announced that it would spend $30 million over two years to better understand the link between low-dose BPA exposure and human health effects.

Children, particularly developing fetuses and infants, are likely to be more sensitive to the effects of BPA due to their developmental stage. Previous studies have identified higher levels of BPA in the urine of children ages 6 to 11 years compared with adults, and found that consumption of soda and school lunches was also associated with higher urinary BPA concentrations.[33,34] Infants and children also have a higher estimated daily intake of BPA compared with adults.[1,35] Although less information is available on BPA levels in infants than in older children, one study demonstrated that premature infants in intensive care units had greater urinary BPA concentrations than those observed in other infants or even older children, though the route of exposure for the premature infants is unclear.[36] Evidence from laboratory animal studies indicates that younger animals are less effective at metabolizing BPA than older animals are; this observation may apply to human infants and developing fetuses.[1,27,37]

The following indicators present data for BPA levels in the U.S. population. The first indicator shows the distribution of median BPA concentrations in women ages 16 to 49 years, based on concerns for effects on children from BPA exposures in women who are pregnant or may become pregnant. The second indicator shows the distribution of median BPA concentrations in children ages 6 to 17 years.

[i] More information on NTP concern levels is available at http://www.niehs.nih.gov/news/media/questions/sya-bpa.cfm.

Indicator BPA1: Bisphenol A in women ages 16 to 49 years: Median concentrations in urine, by race/ethnicity and family income, 2003-2006

Indicator BPA2: Bisphenol A in children ages 6 to 17 years: Median concentrations in urine, by race/ethnicity and family income, 2003-2006

Overview

Indicators BPA1 and BPA2 present concentrations of bisphenol A (BPA) in urine of U.S. women ages 16 to 49 years and children ages 6 to 17 years, respectively. The data are from a national survey that collects urine specimens from a representative sample of the population, and then measures the concentration of total BPA in the urine. These indicators present comparisons of BPA in urine of women and children of different race/ethnicities and income levels. The focus on women of child-bearing age is based on concern for potential effects on children from exposures to women who are or may become pregnant.

NHANES

Data for these indicators are from the National Health and Nutrition Examination Survey (NHANES). NHANES is a nationally representative survey designed to assess the health and nutritional status of the civilian noninstitutionalized U.S. population, conducted by the Centers for Disease Control and Prevention (CDC). Interviews and physical examinations are conducted with approximately 5,000 people each year. CDC's National Center for Environmental Health measures concentrations of environmental chemicals in blood and urine samples collected from NHANES participants.[38] Concentrations of BPA in urine have been measured in a representative subset of NHANES participants ages 6 years and older beginning with the 2003–2004 survey cycle. The NHANES survey did not collect samples from children less than 6 years of age.

Creatinine Adjustment

NHANES data for BPA are based on a single urine sample for each person surveyed, and can be subject to substantial variability due to normal changes in an individual's urinary output. For example, a urine sample from an individual who is dehydrated would be smaller in volume, and would have a higher chemical concentration than if she or he were well hydrated. This variability is due only to the volume of the urine sample, and may mask differences between individuals in levels of BPA.

To help reduce measurement variability related to fluctuations in urine output, these indicators report BPA measurements in micrograms per gram of creatinine, rather than micrograms per liter

of urine.[39] Creatinine is a byproduct of muscle metabolism that is excreted in urine at a relatively constant rate, independent of the volume of urine. The constant excretion of creatinine in urine allows for an adjustment that partially accounts for the measurement variability due to changes in urinary output.

Creatinine correction is widely used in urinary biomonitoring,[38] but the adjustment does have important limitations. Urinary creatinine concentrations can vary due to age, sex, diet, health status (specifically renal function), body-mass index, race/ethnicity, and pregnancy status.[40,41] Thus the creatinine adjustment improves the comparability of chemical measurements across individuals, but the variability in creatinine concentrations may still affect comparisons between individuals or populations.

Bisphenol A and its Metabolites

The reported measurements of BPA in urine represent "total BPA," which includes both BPA itself and biologically inactive metabolites of BPA. Measured levels in the U.S. population may be composed predominantly of the inactive metabolites, but total BPA levels reflect previous exposure to the biologically active form of BPA.[42] Recent work has also highlighted the potential for conversion of inactive metabolites of BPA to the active form when crossing the placenta, increasing the relevance of total BPA measurements to children's health.[43]

Birthrate Adjustment

Measurements of BPA in urine of women ages 16 to 49 years are used to reflect the potential distribution of BPA exposures to women who are pregnant or may become pregnant. However, women of different ages have a different likelihood of giving birth. For example, in 2003–2004, women aged 27 had a 12% probability of giving birth, and women aged 37 had a 4% probability of giving birth. A birthrate-adjusted distribution of women's BPA levels is used in calculating this indicator, meaning that the data are weighted using the age-specific probability of a woman giving birth.[44]

Data Presented in the Indicators

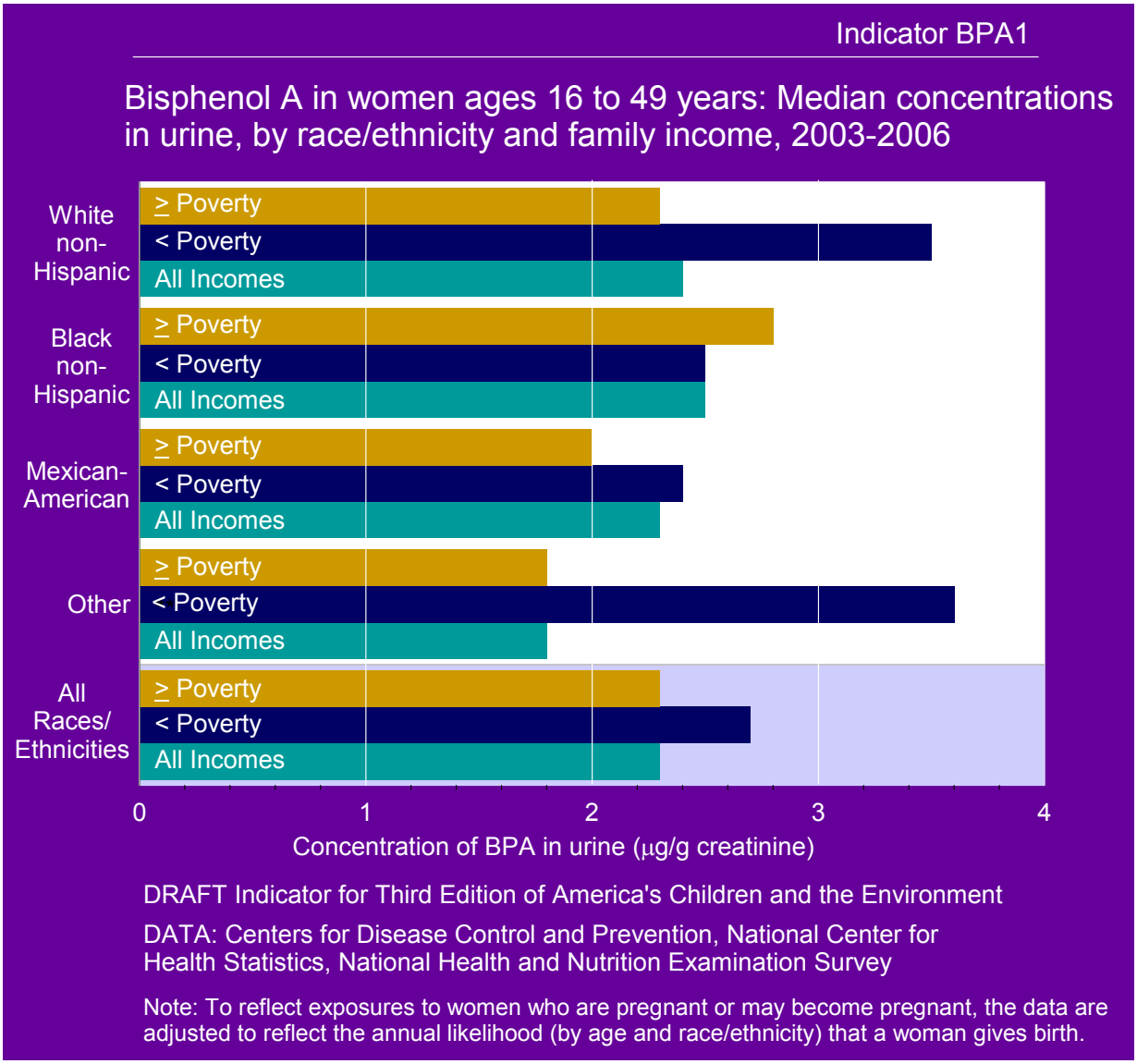
The BPA levels presented in these indicators are for the combined survey years 2003–2004 and 2005–2006. The data from two NHANES cycles are combined to increase the statistical reliability of the estimates for each race/ethnicity and income group. No time series is shown because data from only two NHANES cycles are too limited to depict possible changes over time. These indicators present the median (50^{th} percentile) of BPA levels. The median is the value in the middle of the distribution of BPA levels in urine: half of the measured population has BPA levels greater than the median, and half has levels below the median. The median can be thought of as representing a typical exposure. Four race/ethnicity groups are presented: 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. Data tables provide more specific

breakdowns of median BPA concentrations by race/ethnicity and poverty level, as well as 95th percentile values for each group.

Statistical Testing

Statistical analysis has been applied to the biomonitoring indicators to determine whether any changes in chemical concentrations over time, or any differences in chemical concentrations 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 biomonitoring 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, the amount of variability among the observations, and various aspects of the survey design. For example, if two groups have different median levels of a chemical in blood or urine, the statistical test is more likely to detect a difference when samples have been obtained from a larger number of people in those groups. Similarly, if there is low variability in levels of the chemical within each group, then a difference between groups is more likely to be detected. A finding that there is or is not a statistically significant difference in exposure levels between two groups or in exposure levels over time does not necessarily suggest any interpretation regarding the health implications of those differences.



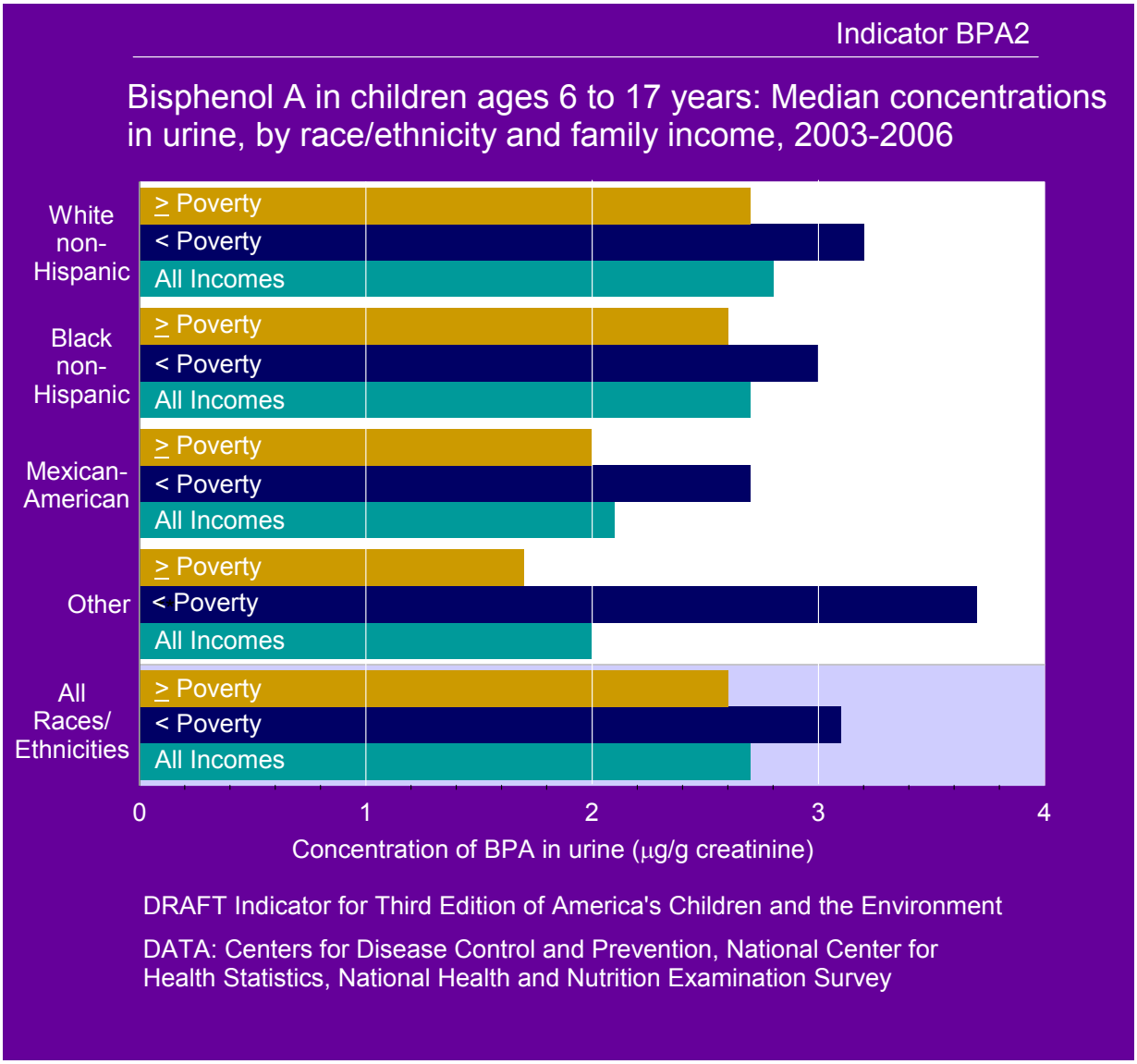
- The median concentration of BPA in women ages 16 to 49 years was 2.3 µg/g creatinine. The median concentration of BPA for women living below the poverty level was 2.7 µg/g creatinine, and for women living at or above the poverty level it was 2.3 µg/g creatinine. This difference is not statistically significant.
    - Statistical Note: After adjustment for age and race/ethnicity, the differences in median BPA concentrations by income groups were statistically significant.

- From 2003–2006, median concentrations of BPA in White non-Hispanic (2.4 µg/g creatinine) and Black non-Hispanic (2.5 µg/g creatinine) women's populations were slightly higher than the national median BPA concentration (2.3 µg/g creatinine).
    - Statistical Note: After adjustment for age and income difference, White non-Hispanic, Black non-Hispanic, and Mexican-American women each had statistically

significantly higher median BPA levels than women in the "Other" race/ethnicity group.

- While the median BPA levels in White non-Hispanics and the "Other" race/ethnicity group below the poverty level appear greater than for other race/ethnicity/income groups, these differences are frequently not statistically significant.

- The 95th percentile value of BPA concentrations was 8.3 µg/g creatinine. The ratio of the 95th percentile to 50th percentile of BPA concentrations for women ages 16 to 49 years was 3.6, indicating that BPA concentrations in the most exposed members of the population were nearly four times greater than the population median. (See Table BPA1a.)



- The median concentration of BPA in children ages 6 to 17 years for the survey period 2003–2006 was 2.7 µg/g creatinine. The median concentration of BPA for children living below the poverty level was 3.1 µg/g creatinine, and for children living at or above the poverty level it was 2.5 µg/g creatinine. The difference in BPA levels between income groups is statistically significant.

- The highest median BPA concentrations were observed in children of "Other" race/ethnicity identification (3.7 µg/g creatinine) who were below the poverty level.
    - Statistical note: While the median concentration was higher in children of "Other" race-ethnicity identification below the poverty level, the value is not generally statistically significantly different from median concentrations observed in the remaining race/ethnicity/income groups.

- Overall, the median BPA concentrations were greater for children living below the poverty level compared with children living at or above the poverty level.
    - Statistical note: While higher median BPA concentrations were observed in each race/ethnicity group for children living below the poverty level compared with children living at or above the poverty level, these differences were statistically significant only for the Mexican-American and "Other" race/ethnicity groups.

- The urinary BPA concentrations in highly exposed children ages 6 to 17 years (those in the 95th percentile) were more than 5 times the median (see Tables BPA2 and BPA2a). The 95th percentile urinary BPA concentrations in children ages 6 to 17 years were nearly twice those in women of child-bearing age. (See Tables BPA1a and BPA2a.)

- BPA concentrations in urine decrease as children grow older. Regardless of race or income, children ages 6 to 10 years had median BPA concentrations of 3.6 µg/g creatinine and 95th percentile concentrations of 19.9 µg/g creatinine. Children ages 11 to 15 years had median BPA concentrations of 2.2 µg/g creatinine and 95th percentile concentrations of 12.7 µg/g creatinine, while children ages 16 to 17 years had median BPA concentrations of 1.8 µg/g creatinine and 95th percentile concentrations of 7.8 µg/g creatinine. The age differences were statistically significant. (See Table BPA2b.)

Data Tables

Table BPA1: Bisphenol A in women ages 16 to 49 years: Median concentrations in urine, by race/ethnicity and family income, 2003-2006

Race / Ethnicity	Median concentration of BPA in urine (µg/g creatinine)					
	All Incomes	< Poverty Level	≥ Poverty Level	≥Poverty Level (Detail)		Unknown Income
				100-200% of Poverty Level	> 200% of Poverty Level	
All Races/Ethnicities	2.3	2.7	2.3	2.7	2.2	1.8
White non-Hispanic	2.4	3.5	2.3	3.0	2.2	NA**
Black non-Hispanic	2.5	2.5	2.8	2.8	2.7	NA**
Mexican-American	2.3	2.4	2.0	2.4	2.0	1.9
Other†	1.8	3.6	1.8	1.8	1.7	NA**

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

NOTES:

- The distribution of the data for women ages 16 to 49 years is adjusted for the likelihood that a woman of a particular age and race/ethnicity gives birth in a particular year. The intent of this adjustment is to approximate the distribution of exposure to pregnant women. Results will therefore differ from a characterization of exposure to adult women without consideration of birthrates.

- The reported measurements of BPA in urine include both BPA itself and biologically inactive metabolites of BPA.

† "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.

** 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).

Table BPA1a: Bisphenol A in women ages 16 to 49 years: 95th percentile concentrations in urine, by race/ethnicity and family income, 2003-2006

Race / Ethnicity	95th percentile concentration of BPA in urine (µg/g creatinine)					
	All Incomes	< Poverty Level	≥ Poverty Level	≥Poverty Level (Detail)		Unknown Income
				100-200% of Poverty Level	> 200% of Poverty Level	
All Races/Ethnicities	8.3	NA**	7.7	8.2*	7.2	24.5
White non-Hispanic	9.3*	NA**	7.7	NA**	6.5	NA**
Black non-Hispanic	7.9	NA**	7.5	7.5	NA**	NA**
Mexican-American	6.8*	8.9*	6.4*	NA**	6.0	4.8
Other†	NA**	8.1	NA**	7.6	NA**	NA**

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

NOTES:

- The distribution of the data for women ages 16 to 49 years is adjusted for the likelihood that a woman of a particular age and race/ethnicity gives birth in a particular year. The intent of this adjustment is to approximate the distribution of exposure to pregnant women. Results will therefore differ from a characterization of exposure to adult women without consideration of birthrates.

- The reported measurements of BPA in urine include both BPA itself and biologically inactive metabolites of BPA.

- BPA does not appear to accumulate in bodily tissues; thus the distribution of NHANES urinary BPA levels may overestimate high-end exposures as a result of collecting one-time urine samples rather than collecting urine for a longer time period.[45]

† "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.

* 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).

Table BPA2: Bisphenol A in children ages 6 to 17 years: Median concentrations in urine, by race/ethnicity and family income, 2003-2006

Race / Ethnicity	Median concentration of BPA in urine (µg/g creatinine)					
	All Incomes	< Poverty Level	≥ Poverty Level	>Poverty Level (Detail)		Unknown Income
				100-200% of Poverty Level	> 200% of Poverty Level	
All Races/Ethnicities	2.7	3.1	2.6	3.1	2.3	3.0
White non-Hispanic	2.8	3.2	2.7	3.5	2.5	NA**
Black non-Hispanic	2.7	3.0	2.6	2.6	2.7	NA**
Mexican-American	2.1	2.7	2.0	2.0	2.0	2.3*
Other†	2.0	3.7	1.7	2.9*	1.6	NA**

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

NOTE: The reported measurements of BPA in urine include both BPA itself and biologically inactive metabolites of BPA.

† "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.

* 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).

Table BPA2a: Bisphenol A in children ages 6 to 17 years: 95th percentile concentrations in urine, by race/ethnicity and family income, 2003-2006

Race / Ethnicity	95th percentile concentration of BPA in urine (µg/g creatinine)					
	All Incomes	< Poverty Level	≥ Poverty Level	≥Poverty Level (Detail)		Unknown Income
				100-200% of Poverty Level	> 200% of Poverty Level	
All Races/Ethnicities	14.6	14.5	14.2	18.9	12.2	61.3
White non-Hispanic	14.2	13.3*	12.2	19.9	11.7	61.3
Black non-Hispanic	12.8	13.2	NA**	11.3	24.1*	NA**
Mexican-American	13.0	14.1	11.2	11.2	NA**	14.6*
Other†	NA**	107.9	NA**	32.1	NA**	NA**

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

NOTES:

- The reported measurements of BPA in urine include both BPA itself and biologically inactive metabolites of BPA.
- BPA does not appear to accumulate in bodily tissues; thus the distribution of NHANES urinary BPA levels may overestimate high-end exposures as a result of collecting one-time urine samples rather than collecting urine for a longer time period.[45]

† "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.

* 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).

Table BPA 2b: Bisphenol A in children ages 6 to 17 years: Median and 95th percentile concentrations by age group, 2003–2006

	Concentration of Bisphenol A in urine (µg/g creatinine)			
	All ages	**Age 6 to <11 years**	**Age 11 to <16 years**	**Age 16 to <18 years**
Median	2.7	3.6	2.2	1.8
95th percentile	14.6	19.9	12.7	7.8

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

NOTE: The reported measurements of BPA in urine include both BPA itself and biologically inactive metabolites of BPA.

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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)

Metadata for	National Health and Nutrition Examination Survey (NHANES)
	reported by an adult informant.
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

BPA1. Bisphenol A in women ages 16 to 49 years: Median concentrations in urine, by race/ethnicity and family income, 2003-2006

BPA2. Bisphenol A in children ages 6 to 17 years: Median concentrations in urine, by race/ethnicity and family income, 2003-2006

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. The National Center for Environmental Health at CDC measures environmental chemicals in blood and urine samples collected from NHANES participants.[ii] This indicator uses creatinine-adjusted urine measurements of bisphenol A (BPA) in women ages 16 to 49 years and children ages 6 to 17 years. The NHANES 2003-2004 and 2005-2006 surveys included urine BPA data for children and adults ages 6 years and over.

Indicator BPA1 gives the median creatinine-adjusted concentrations of BPA for women ages 16 to 49 years for 2003-2006, stratified both by race/ethnicity and family income. The median is the estimated concentration such that 50% of all noninstitutionalized civilian women ages 16 to 49 years during the survey period have a BPA concentration below this level; a birthrate-adjusted distribution of women's BPA levels is used in calculating this indicator, meaning that the data are weighted using the age-specific probability of a woman giving birth. Table BPA1a gives the 95th percentile concentrations of BPA for women ages 16 to 49 years for 2003-2006, stratified by race/ethnicity. The 95th percentile for women is the estimated concentration such that 95% of all noninstitutionalized civilian women ages 16 to 49 years during the survey period have a BPA concentration below this level.

Indicator BPA2 gives the median creatinine-adjusted concentrations of BPA for children ages 6 to 17 years for 2003-2006, stratified both by race/ethnicity and family income. Table BPA2a gives the 95th percentile for children ages 6 to 17 for 2003-2006, stratified by race/ethnicity. The 95th percentile for children is the estimated concentration such that 95% of all noninstitutionalized civilian children ages 6 to 17 years have a BPA concentration below this level. Table BPA2b gives the median and 95th percentile creatinine-adjusted concentrations of

[ii] Centers for Disease Control and Prevention. 2009. Fourth National Report on Human Exposure to Environmental Chemicals. Atlanta, GA. Available at: www.cdc.gov/exposurereport.

BPA for children ages 6 to 17 years for 2003-2006, stratified by age. The survey data were weighted to account for the complex multi-stage, stratified, clustered sampling design.

Data Summary

Indicator	BPA1. Bisphenol A in women ages 16 to 49 years: Median concentrations in urine, by race/ethnicity and family income, 2003-2006. BPA2. Bisphenol A in children ages 6 to 17 years: Median concentrations in urine, by race/ethnicity and family income, 2003-2006.			
Time Period	2003-2006			
Data	Urine BPA (creatinine adjusted)			
Years/Subgroup	2003-2004/ Women 16-49	2005-2006/ Women 16-49	2003-2004/ Children 6-17	2005-2006/ Children 6-17
Limits of Detection (µg/L)*	0.4	0.4	0.4	0.4
Number of Non-missing Values**	611	616	852	896
Number of Missing Values	16	18	32	31
Percentage Below Limit of Detection***	5	8	3	4

* The Limit of Detection (LOD) is defined as the level at which the measurement has a 95% probability of being greater than zero.
**Non-missing values include those below the analytical LOD, which are reported as LOD/√2.
***This percentage is survey-weighted using the NHANES survey weights for the given period and, for women ages 16 to 49, is weighted by age-specific birthrates.

Overview of Data Files

The following files are needed to calculate this indicator. The 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/nhanes_questionnaires.htm.

- NHANES 2003-2004: Demographic file demo_c.xpt. Environmental Phenols Laboratory file l24eph_c.xpt. The demographic file demo_c.xpt is a SAS transport file that contains the subject identifier (SEQN), age (RIDAGEYR), sex (RIAGENDR), race/ethnicity (RIDRETH1), poverty income ratio (INDFMPIR), pseudo-stratum (SDMVSTRA) and the pseudo-PSU (SDMVPSU). The Environmental Phenols laboratory file l24eph_c.xpt contains SEQN, urine BPA (URXBPH), the BPA non-detect comment code (URDBPHLC), urine creatinine (URXUCR) and the sub-sample C survey weight (WTSC2YR). The two files are merged using the common variable SEQN.

- NHANES 2005-2006: Demographic file demo_d.xpt. Environmental Phenols and Parabens Laboratory file eph_d.xpt. The demographic file demo_d.xpt is a SAS transport

file that contains the subject identifier (SEQN), age (RIDAGEYR), sex (RIAGENDR), race/ethnicity (RIDRETH1), poverty income ratio (INDFMPIR), pseudo-stratum (SDMVSTRA) and the pseudo-PSU (SDMVPSU). The Environmental Phenols and Parabens laboratory file eph_d.xpt contains SEQN, urine BPA (URXBPH), the BPA non-detect comment code (URDBPHLC), urine creatinine (URXUCR) and the sub-sample B survey weight (WTSB2YR). The two files are merged using the common variable SEQN.

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. The National Center for Environmental Health at CDC measures environmental chemicals in blood and urine samples collected from NHANES participants. This indicator uses urine BPA measurements from NHANES 2003-2004 and 2005-2006 in women ages 16 to 49 and children ages 6 to 17. The NHANES data were obtained from the NHANES website: http://www.cdc.gov/nchs/nhanes.htm. Following the CDC recommended approach, values below the analytical limit of detection (LOD) were replaced by LOD/√2.[iii]

This analysis uses the creatinine-adjusted urine BPA concentration (µg/g creatinine). The unadjusted BPA (Bisphenol A, (2,2-[4-Hydroxyphenol] propane)) concentration is reported as µg/L. The creatinine concentration is reported as mg/dL. The creatinine-adjusted BPA concentration was calculated from the raw data as the ratio Unadjusted BPA/(0.01× Creatinine) µg/g creatinine.

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 sub-sample laboratory survey weights (WTC2YR for 2003-2004 and WTSB2YR for 2005-2006) to re-adjust the urine BPA data to represent the national population.

Age-Specific Birthrates

In addition to the NHANES survey weights, the data for women of child-bearing age (ages 16 to 49) were also weighted by the birthrate for women of the given age and race/ethnicity to estimate pre-natal exposures. Thus the overall weight in each two year period is the product of the NHANES survey weight and the total number of births in the two calendar years for the given

[iii] See Hornung RW, Reed LD. 1990. Estimation of average concentration in the presence of nondetectable values. *Applied Occupational and Environmental Hygiene* 5:46–51.

age and race/ethnicity, divided by twice the corresponding population of women at the midpoint of the two year period.[iv]

Race/Ethnicity and Family Income

For this indicator, the percentiles were calculated for demographic strata defined by the combination of race/ethnicity and family income.

The family income was characterized based on the INDFMPIR variable, 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

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 this indicator, 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

[iv] Axelrad, D.A., Cohen, J. 2011. Calculating summary statistics for population chemical biomonitoring in women of childbearing age with adjustment for age-specific natality. *Environmental Research* 111 (1) 149-155.

- 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.

Calculation of Indicator

Indicator BPA1 is the median for urine BPA in women of ages 16 to 49 years, stratified by race/ethnicity and family income. Indicator BPA2 is the median for urine BPA in children of ages 6 to 17 years, stratified by race/ethnicity and family income. Table BPA1a is the 95th percentile for urine BPA in women of ages 16 to 49 years, stratified by race/ethnicity. Table BPA2a is the 95th percentile for urine BPA in children of ages 6 to 17, stratified by race/ethnicity. Table BPA2b is the median and 95th percentile for urine BPA in children of ages 6 to 17, stratified by age. The median for women ages 16 to 49 is the estimated concentration such that 50% of all noninstitutionalized civilian women ages 16 to 49 years during the survey period have urine BPA concentrations below this level. The 95th percentile for women ages 16 to 49 is the estimated concentration such that 95% of all noninstitutionalized civilian women ages 16 to 49 years during the survey period have urine BPA concentrations below this level. To adjust the NHANES data to represent prenatal exposures, the data for each woman surveyed was multiplied by the estimated number of births per woman of the given age and race/ethnicity. The birthrate adjustment was not applied to children ages 6 to 17.

To simply demonstrate the calculations, we will use the NHANES 2003-2006 urine BPA values for women ages 16 to 49 years of all race/ethnicities and all incomes as an example. We have rounded all the numbers to make the calculations easier:

We begin with all the non-missing NHANES 2003-2006 urine BPA values for women ages 16 to 49 years. Assume for the sake of simplicity that valid BPA data were available for every sampled woman. Each sampled woman has an associated annual survey weight that estimates the annual number of U.S. women represented by that sampled woman. Since two 2-year periods are combined for these analyses, the associated annual survey weight for each woman is defined as WTSC2YR/2 for 2003-2004 and WTSB2YR/2 for 2005-2006, so that the combined 2003-2006 sample represents the annual population. Each sampled woman also has an associated birthrate giving the numbers of annual births per woman of the given age, race, and ethnicity. The product of the annual survey weight and the birthrate estimates the annual number of U.S. births represented by that sampled woman, which we will refer to as the adjusted survey weight. For example, the lowest urine BPA measurement for a woman between 16 and 49 years of age is 0.2 µg/g creatinine with an annual survey weight of 5,000, a birthrate of 0.2, and thus an adjusted survey weight of 1,000, and so represents 1,000 births. The total of the adjusted survey weights for the sampled women equals 4 million, the total number of annual U.S. births to women ages 16 to 49 years. The second lowest measurement is also 0.2 µg/g creatinine with an adjusted survey weight of 500, and so represents another 500 U.S. births. The highest measurement is

386.9 µg/g creatinine with an adjusted survey weight of 400, and so represents another 400 U.S. births.

To calculate the median, we can use the adjusted survey weights to expand the data to the entire U.S. population of births to women ages 16 to 49. We have 1,000 values of 0.2 µg/g creatinine from the lowest measurement, 500 values of 0.2 µg/g creatinine from the second lowest measurement, and so on, up to 400 values of 386.9 µg/g creatinine from the highest measurement. Arranging these 4 million values in increasing order, the 2 millionth value is 2.3 µg/g creatinine. Since half of the values are below 2.3 and half of the values are above 2.3, the median equals 2.3 µg/g creatinine. To calculate the 95th percentile, note that 95% of 4 million equals 3.8 million. The 3.8 millionth value is 8.3 µg/g creatinine. Since 95% of the values are below 8.3, the 95th percentile equals 8.3 µg/g creatinine.

In reality, the calculations need to take into account that urine BPA measurements were not available for every respondent, and to use exact rather than rounded numbers. There were urine BPA measurements for only 1,226 of the 1,261 sampled women ages 16 to 49 years. The adjusted survey weights for all 1,261 sampled women add up to 4.2 million, the U.S. population of births to women ages 16 to 49. The adjusted survey weights for the 1,226 sampled women with urine BPA data add up to 4.1 million. Thus the available data represent 4.1 million values and so represent only 98% of the U.S. population of births. The median and 95th percentiles are given by the 2.05 millionth (50% of 4.1 million) and 3.90 millionth (95% of 4.1 million) U.S. birth's value. These calculations assume that the sampled women with valid urine BPA data are representative of women giving birth without valid urine BPA data. The calculations also assume that the sampled women are representative of women that actually gave birth in 2003-2006, since NHANES information on pregnancy and births was not incorporated into the analysis.

Equations

These percentile calculations can also be given as the following mathematical equations, which are based on the default percentile calculation formulas from Statistical Analysis System (SAS) software. Exclude all missing urine BPA values. Suppose there are n women of ages 16 to 49 years with valid urine BPA values. Arrange the urine BPA concentrations in increasing order (including tied values) so that the lowest concentration is x(1) with an adjusted survey weight of w(1), the second lowest concentration is x(2) with an adjusted survey weight of w(2), …, and the highest concentration is x(n) with an adjusted survey weight of w(n).

1. Sum all the adjusted survey weights to get the total weight W:

$$W = \Sigma[1 \le i \le n]\ w(i)$$

2. Find the largest number i so that the total of the weights for the i lowest values is less than or equal to W/2.

$$\Sigma[j \le i]\ w(j) \le W/2 < \Sigma[j \le i + 1]\ w(j)$$

3. Calculate the median using the results of the second step. We either have

$$\Sigma[j \le i]\, w(j) = W/2 < \Sigma[j \le i + 1]\, w(j)$$

or

$$\Sigma[j \le i]\, w(j) < W/2 < \Sigma[j \le i + 1]\, w(j)$$

In the first case we define the median as the average of the i'th and i + 1'th values:

$$\text{Median} = [x(i) + x(i + 1)]/2 \text{ if } \Sigma[j \le i]\, w(j) = W/2$$

In the second case we define the median as the i + 1'th value:

$$\text{Median} = x(i + 1) \text{ if } \Sigma[j \le i]\, w(j) < W/2$$

(The estimated median does not depend upon how the tied values of x(j) are ordered).

A similar calculation applies to the 95th percentile. The first step to calculate the sum of the weights, W, is the same. In the second step, find the largest number i so that the total of the weights for the i lowest values is less than or equal to 0.95W.

$$\Sigma[j \le i]\, w(j) \le 0.95W < \Sigma[j \le i + 1]\, w(j)$$

In the third step we calculate the 95th percentile using the results of the second step. We either have

$$\Sigma[j \le i]\, w(j) = 0.95W < \Sigma[j \le i + 1]\, w(j)$$

or

$$\Sigma[j \le i]\, w(j) < 0.95W < \Sigma[j \le i + 1]\, w(j)$$

In the first case we define the 95th percentile as the average of the i'th and i + 1'th values:

$$95^{th} \text{ Percentile} = [x(i) + x(i + 1)]/2 \text{ if } \Sigma[j \le i]\, w(j) = 0.95W$$

In the second case we define the 95th percentile as the i + 1'th value:

$$95^{th} \text{ Percentile} = x(i + 1) \text{ if } \Sigma[j \le i]\, w(j) < 0.95W$$

Relative Standard Error

The uncertainties of the median and 95th percentile values were calculated using a revised version of the CDC method given in CDC 2005,[v] Appendix C, and the SAS® program provided by CDC. The method uses the Clopper-Pearson binomial confidence intervals adapted for complex surveys by Korn and Graubard (see Korn and Graubard, 1999,[vi] p. 65). The following text is a revised version of the Appendix C. For the birthrate adjusted calculations for women ages 16 to 49, the sample weight is adjusted by multiplying by the age-specific birthrate.

Step 1: Use SAS® Proc Univariate to obtain a point estimate P_{SAS} of the percentile value. Use the Weight option to assign the exact correct sample weight for each chemical result.

Step 2: Use SUDAAN® Proc Descript with Taylor Linearization DESIGN = WR (i.e., sampling with replacement) and the proper sampling weight to estimate the proportion (p) of subjects with results less than and not equal to the percentile estimate P_{SAS} obtained in Step 1 and to obtain the standard error (se_p) associated with this proportion estimate. Compute the degrees-of-freedom adjusted effective sample size

$$n_{df} = (t_{num}/t_{denom})^2 \, p(1 - p)/(se_p^2)$$

where t_{num} and t_{denom} are 0.975 critical values of the Student's t distribution with degrees of freedom equal to the sample size minus 1 and the number of PSUs minus the number of strata, respectively. Note: the degrees of freedom for t_{denom} can vary with the demographic sub-group of interest.

Step 3: After obtaining an estimate of p (i.e., the proportion obtained in Step 2), compute the Clopper-Pearson 95% confidence interval ($P_L(x,n_{df})$, $P_U(x,n_{df})$) as follows:

$$P_L(x,n_{df}) = v_1 F_{v1,v2}\,(0.025)/(v_2 + v_1 F_{v1,v2}(0.025))$$
$$P_U(x,n_{df}) = v_3 F_{v3,v4}\,(0.975)/(v_4 + v_3 F_{v3,v4}(0.975))$$

where x is equal to p times n_{df}, $v_1 = 2x$, $v_2 = 2(n_{df} - x + 1)$, $v_3 = 2(x + 1)$, $v_4 = 2(n_{df} - x)$, and $F_{d1,d2}(\beta)$ is the β quantile of an F distribution with d1 and d2 degrees of freedom. (Note: If n_{df} is greater than the actual sample size or if p is equal to zero, then the actual sample size should be used.) This step will produce a lower and an upper limit for the estimated proportion obtained in Step 2.

Step 4: Use SAS Proc Univariate (again using the Weight option to assign weights) to determine the chemical percentile values P_{CDC}, L_{CDC} and U_{CDC} that correspond to the proportion p obtained in Step 2 and its lower and upper limits obtained in Step 3. Do not round the values of p and the lower and upper limits. For example, if p = 0.4832, then P_{CDC} is the 48.32'th percentile value of the chemical. The alternative percentile estimates P_{CDC} and P_{SAS} are not necessarily equal.

Step 5: Use the confidence interval from Step 4 to estimate the standard error of the estimated percentile P_{CDC}:

$$\text{Standard Error } (P_{CDC}) = (U_{CDC} - L_{CDC}) / (2t_{denom})$$

Step 6: Use the estimated percentile P_{CDC} and the standard error from Step 4 to estimate the relative standard error of the estimated percentile P_{CDC}:

[v] CDC Third National Report on Human Exposure to Environmental Chemicals. 2005
[vi] Korn E. L., Graubard B. I. 1999. *Analysis of Health Surveys.* Wiley.

Relative Standard Error (%) = [Standard Error (P_{CDC}) / P_{CDC}] × 100%

The tabulated estimated percentile is the value of P_{SAS} given in Step 1. The relative standard error is given in Step 6, using P_{CDC} and its standard error.

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 without an estimated relative standard error, 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 percentiles were used to determine whether the differences between percentiles for different demographic groups were statistically significant. For these analyses, the percentiles and their standard errors were calculated for each combination of age group, sex (in the cases of children), income group (below poverty, at or above poverty, unknown income), and race/ethnicity group using the method described in the "Relative Standard Error" section. In the notation of that section, the percentile and standard error are the values of P_{CDC} and Standard Error (P_{CDC}), respectively. These calculated standard errors account for the survey weighting and design and, for women, for the age-specific birthrate.

Using a weighted linear regression model, the percentile was assumed to be the sum of explanatory terms for age, sex, income and/or race/ethnicity and a random error term; the error terms were assumed to be approximately independent and normally distributed with a mean of zero and a variance equal to the square of the standard error. Using this model, the difference in the value of a percentile between different demographic groups is statistically significant if the difference between the corresponding sums of explanatory terms is statistically significantly different from zero. 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 each type of comparison, we present unadjusted and adjusted analyses. The unadjusted analyses directly compare a percentile 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 percentiles between different race/ethnicity pairs. The adjusted race/ethnicity comparisons use the percentiles for each age/sex/income/race/ethnicity combination. The adjusted analyses add age, sex, and income terms to the statistical model and compare the percentiles 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 BPA level 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 between pairs of race/ethnicity groups are shown in Tables 1 and 2 for women ages 16 to 49 years and in Tables 3 and 4 for children ages 6 to 17 years. In Tables 1 and 3, 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 percentiles 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. The adjustment for sex is applicable only for children, and thus appears only in Tables 3 and 4.

In Tables 1 and 3, for the unadjusted "Below Poverty Level" and "At or Above Poverty Level" comparisons, the only explanatory variables are terms for each of the twelve 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 Tables 2 and 4 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 5 for women ages 16 to 49 years and in Table 6 for children ages 6 to 17 years. The AGAINST = "income" unadjusted p-value compares the BPA levels 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.

For women, the age groups used were 16-19, 20-24, 25-29, 30-39, and 40-49. For children, the age groups used were 6-10, 11-15, and 16-17.

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

Table 1. Statistical significance tests comparing the percentiles of BPA levels in women ages 16 to 49 years, between pairs of race/ethnicity groups, for 2003-2006.

				P-VALUES					
Variable	**Percentile**	**RACE1**	**RACE2**	**All incomes**	**All incomes (adjusted for age, income)**	**Below Poverty Level**	**Below Poverty Level (adjusted for age)**	**At or Above Poverty Level**	**At or Above Poverty Level (adjusted for age)**
BPA	50	White non-Hispanic	Black non-Hispanic	0.317	< 0.0005	0.132	0.003	0.029	0.826
BPA	50	White non-Hispanic	Mexican-American	0.763	0.386	0.215	0.181	0.264	0.099
BPA	50	White non-Hispanic	Other	< 0.0005	0.003	0.993	0.084	0.004	0.001
BPA	50	Black non-Hispanic	Mexican-American	0.376	< 0.0005	0.897	< 0.0005	0.016	0.210
BPA	50	Black non-Hispanic	Other	< 0.0005	0.518	0.192	0.131	< 0.0005	0.005
BPA	50	Mexican-American	Other	0.025	0.009	0.256	0.450	0.413	0.046
BPA	95	White non-Hispanic	Black non-Hispanic	0.698	< 0.0005	0.816	< 0.0005	0.948	0.139
BPA	95	White non-Hispanic	Mexican-American	0.453	0.819	0.829	< 0.0005	0.552	0.145

[vii] Cohen, J. 2010. *Selected statistical methods for testing for trends and comparing years or demographic groups in ACE NHIS and NHANES indicators.* Memorandum submitted to Dan Axelrad, EPA, 21 March, 2010.

				P-VALUES					
Variable	Percentile	RACE1	RACE2	All incomes	All incomes (adjusted for age, income)	Below Poverty Level	Below Poverty Level (adjusted for age)	At or Above Poverty Level	At or Above Poverty Level (adjusted for age)
BPA	95	White non-Hispanic	Other	0.963	< 0.0005	0.802	< 0.0005	0.997	< 0.0005
BPA	95	Black non-Hispanic	Mexican-American	0.645	< 0.0005	0.939	< 0.0005	0.587	0.822
BPA	95	Black non-Hispanic	Other	0.994	< 0.0005	0.971	0.340	0.997	< 0.0005
BPA	95	Mexican-American	Other	0.950	< 0.0005	0.826	0.007	0.947	< 0.0005

Table 2. Statistical significance tests comparing the percentiles of BPA levels in women ages 16 to 49 years, between pairs of race/ethnicity/income groups at different income levels, for 2003-2006.

				P-VALUES	
Variable	Percentile	RACEINC1	RACEINC2	Unadjusted	Adjusted (for age)
BPA	50	White non-Hispanic, < PL	White non-Hispanic, ≥ PL	0.083	0.014
BPA	50	White non-Hispanic, < PL	Black non-Hispanic, ≥ PL	0.308	0.010
BPA	50	White non-Hispanic, < PL	Mexican-American, ≥ PL	0.041	0.002
BPA	50	White non-Hispanic, < PL	Other, ≥ PL	0.015	< 0.0005
BPA	50	Black non-Hispanic, < PL	White non-Hispanic, ≥ PL	0.329	0.059
BPA	50	Black non-Hispanic, < PL	Black non-Hispanic, ≥ PL	0.171	0.350
BPA	50	Black non-Hispanic, < PL	Mexican-American, ≥ PL	0.114	0.606
BPA	50	Black non-Hispanic, < PL	Other, ≥ PL	0.001	0.010
BPA	50	Mexican-American, < PL	White non-Hispanic, ≥ PL	0.912	0.001
BPA	50	Mexican-American, < PL	Black non-Hispanic, ≥ PL	0.524	0.008
BPA	50	Mexican-American, < PL	Mexican-American, ≥ PL	0.589	< 0.0005
BPA	50	Mexican-American, < PL	Other, ≥ PL	0.345	< 0.0005
BPA	50	Other, < PL	White non-Hispanic, ≥ PL	0.135	0.409
BPA	50	Other, < PL	Black non-Hispanic, ≥ PL	0.373	0.330
BPA	50	Other, < PL	Mexican-American, ≥ PL	0.075	0.075
BPA	50	Other, < PL	Other, ≥ PL	0.035	0.003
BPA	95	White non-Hispanic, < PL	White non-Hispanic, ≥ PL	0.787	0.001
BPA	95	White non-Hispanic, < PL	Black non-Hispanic, ≥ PL	0.780	0.003
BPA	95	White non-Hispanic, < PL	Mexican-American, ≥ PL	0.724	0.010
BPA	95	White non-Hispanic, < PL	Other, ≥ PL	0.857	< 0.0005
BPA	95	Black non-Hispanic, < PL	White non-Hispanic, ≥ PL	0.917	0.001
BPA	95	Black non-Hispanic, < PL	Black non-Hispanic, ≥ PL	0.893	< 0.0005
BPA	95	Black non-Hispanic, < PL	Mexican-American, ≥ PL	0.697	< 0.0005
BPA	95	Black non-Hispanic, < PL	Other, ≥ PL	0.977	0.015
BPA	95	Mexican-American, < PL	White non-Hispanic, ≥ PL	0.761	0.972
BPA	95	Mexican-American, < PL	Black non-Hispanic, ≥ PL	0.720	0.024
BPA	95	Mexican-American, < PL	Mexican-American, ≥ PL	0.443	0.095
BPA	95	Mexican-American, < PL	Other, ≥ PL	0.960	< 0.0005

				P-VALUES	
Variable	**Percentile**	**RACEINC1**	**RACEINC2**	**Unadjusted**	**Adjusted (for age)**
BPA	95	Other, < PL	White non-Hispanic, ≥ PL	0.850	0.013
BPA	95	Other, < PL	Black non-Hispanic, ≥ PL	0.778	0.001
BPA	95	Other, < PL	Mexican-American, ≥ PL	0.342	0.001
BPA	95	Other, < PL	Other, ≥ PL	0.983	0.753

Table 3. Statistical significance tests comparing the percentiles of BPA levels in children ages 6 to 17 years, between pairs of race/ethnicity groups, for 2003-2006.

				P-VALUES					
Variable	**Percentile**	**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)**
BPA	50	White non-Hispanic	Black non-Hispanic	0.866	0.409	0.714	0.477	0.536	0.490
BPA	50	White non-Hispanic	Mexican-American	0.006	0.001	0.286	0.271	0.001	0.002
BPA	50	White non-Hispanic	Other	0.139	0.013	0.645		0.001	0.015
BPA	50	Black non-Hispanic	Mexican-American	0.011	0.015	0.389	0.251	0.009	0.033
BPA	50	Black non-Hispanic	Other	0.162	0.054	0.489		0.004	0.059
BPA	50	Mexican-American	Other	0.830	0.599	0.282		0.321	0.605
BPA	95	White non-Hispanic	Black non-Hispanic	0.888	< 0.0005	0.607	< 0.0005	0.994	0.839
BPA	95	White non-Hispanic	Mexican-American	0.889	< 0.0005	0.376	< 0.0005	0.645	0.428
BPA	95	White non-Hispanic	Other	0.459	< 0.0005	< 0.0005		0.565	< 0.0005
BPA	95	Black non-Hispanic	Mexican-American	0.956	0.178	0.805	0.062	0.857	0.362
BPA	95	Black non-Hispanic	Other	0.446	< 0.0005	< 0.0005		0.589	< 0.0005
BPA	95	Mexican-American	Other	0.448	< 0.0005	< 0.0005		0.524	0.001

Table 4. Statistical significance tests comparing the percentiles of BPA levels in children ages 6 to 17 years, between pairs of race/ethnicity/income groups at different income levels, for 2003-2006.

				P-VALUES	
Variable	**Percentile**	**RACEINC1**	**RACEINC2**	**Unadjusted**	**Adjusted (for age, sex)**
BPA	50	White non-Hispanic, < PL	White non-Hispanic, ≥ PL	0.325	0.328
BPA	50	White non-Hispanic, < PL	Black non-Hispanic, ≥ PL	0.190	0.271
BPA	50	White non-Hispanic, < PL	Mexican-American, ≥ PL	0.009	0.125
BPA	50	White non-Hispanic, < PL	Other, ≥ PL	0.003	0.101

				P-VALUES	
Variable	Percentile	RACEINC1	RACEINC2	Unadjusted	Adjusted (for age, sex)
BPA	50	Black non-Hispanic, < PL	White non-Hispanic, ≥ PL	0.450	0.357
BPA	50	Black non-Hispanic, < PL	Black non-Hispanic, ≥ PL	0.234	0.191
BPA	50	Black non-Hispanic, < PL	Mexican-American, ≥ PL	0.003	0.003
BPA	50	Black non-Hispanic, < PL	Other, ≥ PL	0.001	0.007
BPA	50	Mexican-American, < PL	White non-Hispanic, ≥ PL	0.796	0.600
BPA	50	Mexican-American, < PL	Black non-Hispanic, ≥ PL	0.819	0.961
BPA	50	Mexican-American, < PL	Mexican-American, ≥ PL	0.028	0.128
BPA	50	Mexican-American, < PL	Other, ≥ PL	0.010	0.108
BPA	50	Other, < PL	White non-Hispanic, ≥ PL	0.312	
BPA	50	Other, < PL	Black non-Hispanic, ≥ PL	0.237	
BPA	50	Other, < PL	Mexican-American, ≥ PL	0.067	
BPA	50	Other, < PL	Other, ≥ PL	0.038	
BPA	95	White non-Hispanic, < PL	White non-Hispanic, ≥ PL	0.700	< 0.0005
BPA	95	White non-Hispanic, < PL	Black non-Hispanic, ≥ PL	0.865	< 0.0005
BPA	95	White non-Hispanic, < PL	Mexican-American, ≥ PL	0.992	< 0.0005
BPA	95	White non-Hispanic, < PL	Other, ≥ PL	0.527	< 0.0005
BPA	95	Black non-Hispanic, < PL	White non-Hispanic, ≥ PL	0.796	0.930
BPA	95	Black non-Hispanic, < PL	Black non-Hispanic, ≥ PL	0.920	0.872
BPA	95	Black non-Hispanic, < PL	Mexican-American, ≥ PL	0.566	0.370
BPA	95	Black non-Hispanic, < PL	Other, ≥ PL	0.597	< 0.0005
BPA	95	Mexican-American, < PL	White non-Hispanic, ≥ PL	0.444	0.091
BPA	95	Mexican-American, < PL	Black non-Hispanic, ≥ PL	0.830	0.084
BPA	95	Mexican-American, < PL	Mexican-American, ≥ PL	0.299	0.577
BPA	95	Mexican-American, < PL	Other, ≥ PL	0.622	0.001
BPA	95	Other, < PL	White non-Hispanic, ≥ PL	< 0.0005	
BPA	95	Other, < PL	Black non-Hispanic, ≥ PL	< 0.0005	
BPA	95	Other, < PL	Mexican-American, ≥ PL	< 0.0005	
BPA	95	Other, < PL	Other, ≥ PL	0.004	

Table 5. Other statistical significance tests comparing the percentiles of BPA levels in women ages 16 to 49 years, for 2003-2006.

					P-VALUES	
Variable	Percentile	From	To	Against	Unadjusted	Adjusted*
BPA	50	2003	2006	income	0.124	< 0.0005
BPA	95	2003	2006	income	0.382	< 0.0005

For AGAINST = "income" the p-values are adjusted for age and race/ethnicity.

Table 6. Other statistical significance tests comparing the percentiles of BPA levels in children ages 6 to 17 years, for 2003-2006.

					P-VALUES	
Variable	Percentile	From	To	Against	Unadjusted	Adjusted*

					P-VALUES	
Variable	**Percentile**	**From**	**To**	**Against**	**Unadjusted**	**Adjusted***
BPA	50	2003	2006	age	< 0.0005	< 0.0005
BPA	50	2003	2006	income	0.009	0.032
BPA	95	2003	2006	age	< 0.0005	< 0.0005
BPA	95	2003	2006	income	0.866	< 0.0005

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