America's Children and the Environment, Third Edition

DRAFT Indicators

Biomonitoring: Polybrominated diphenyl ethers (PBDEs)

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, indicator, and documentation for the PBDEs topic in the Biomonitoring 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/.

Polybrominated Diphenyl Ethers (PBDEs)

Polybrominated diphenyl ethers (PBDEs) are a group of brominated flame retardant chemicals that have been incorporated into a variety of manufactured products, including foam cushioning used in furniture and plastics used in televisions and computers. Flame retardants are intended to slow the rate of ignition and fire growth, allowing more time for people to escape from a fire or extinguish it.

All PBDEs have a common structure of a diphenyl ether molecule, which may have anywhere from 1–10 bromine atoms attached; each particular PBDE variant is referred to as a congener. In theory, there could be as many as 209 PBDE congeners, but a much smaller number of congeners are commonly found in the commercial PBDE mixtures and in measurements of PBDEs in humans and the environment

Three commercial mixtures PBDEs have been used in manufactured products, with each mixture made up of congeners with varying degrees of bromination. The commercial pentabromodiphenyl ether (pentaBDE) and octabromodiphenyl ether (octaBDE) mixtures have not been manufactured or imported in the United States since 2004. The pentaBDE mixture, made up primarily of four- and five-bromine congeners, was used almost entirely in flexible polyurethane foam in furniture, mattresses, carpet padding, and automobile seats; and the octaBDE mixture, made up primarily of seven- and eight-bromine congeners, was used in acrylonitrile-butadiene-styrene (ABS) plastic for certain electric and electronic devices.

A third product, the commercial decabromodiphenyl ether (decaBDE) mixture, is still manufactured and used in the United States. The decaBDE mixture, made up almost entirely of the 10-bromine congener, is used primarily in high-impact polystyrene (HIPS) plastic that is frequently used to make the back part of television sets, and in other electronic devices. DecaBDE is also used as a flame retardant on certain types of textiles. The major U.S. importers and manufacturers of decaBDE have announced that this mixture will be phased out by the end of 2013.[1] As use of PBDEs is reduced, they are being replaced by other flame-retardant chemicals or by materials that are inherently resistant to fire. EPA has conducted an assessment of alternatives to commercial pentaBDE,[2] and is conducting a similar assessment of alternatives to commercial decaBDE.[3]

PBDEs can be released into the environment at various points in their lifecycle, from their production and application to consumer products to their release from discarded products in landfills. Since PBDEs are not chemically bound to the products in which they are used, they can easily migrate into the surrounding air, dust, soil, and water. Although production and use of the commercial PBDE mixtures has been phased out (pentaBDE and octaBDE) or will soon be phased out (decaBDE), it is likely that PBDE congeners will continue to be present in the environment for many years. This is because products previously manufactured with PBDEs (e.g., sofas) will stay in use for many years. PBDEs will continue to be released from these products while they are in use, and these releases may continue when the products are disposed

of or recycled. PBDEs are persistent in the environment, so even if there were no further releases they would continue to be detected for many years.

Exposure studies, focusing on selected PBDE congeners that were most predominant in the commercial mixtures or that are frequently measured in environmental samples, have concluded that the presence of PBDEs in house dust and in foods are both important contributors to PBDE exposures for people of all ages, and that exposures from house dust are generally greater than those from food.[4-10] Studies conducted in multiple locations have consistently found PBDEs in U.S. house dust at levels greater than those found in other countries.[11,12] This is likely due to greater use of PBDE-containing products in homes in the United States than in other countries. Within the United States, the highest levels of three frequently measured PBDE congeners in dust have been found in California; these congeners were all components of commercial pentaBDE mixtures, and the elevated levels may be due to California requirements for flame resistance in residential furniture that are not applicable in other states.[13] A study conducted in adults found that direct contact with PBDE-containing materials, rather than to PBDE-contaminated house dust, was more strongly associated with PBDE blood levels.[14]

A second pathway of exposure to PBDEs is through diet. PBDEs are generally persistent chemicals that accumulate in fat tissue, so they are commonly found in foods derived from animals. Information about how PBDEs enter the food web is limited, but release from manufacture of the PBDEs or of PBDE-containing products; release of PBDEs from products while they are in use; and release from products when disposed of or recycled are all likely contributors to PBDEs in the environment. PBDEs have been measured in a variety of supermarket foods, with the highest levels found in fish and other foods of animal origin.[15]

Levels of PBDEs measured in blood are substantially greater in North America than in Europe and Asia, a difference that appears to be due to the higher levels of PBDEs in house dust in North America.[6,12,16,17]

Early-life exposures to PBDEs may be elevated in a number of ways. A child's exposure to PBDEs begins in the prenatal period, as PBDEs have been measured in cord blood and fetal blood,[18,19] and continues in early infancy due to the presence of PBDEs in breast milk.[9,17,20-22] Levels of PBDEs in breast milk are higher in North America than elsewhere,[12] and estimated intakes of PBDEs are substantially greater for a breastfeeding infant than exposures that occur during other life stages.[5,17]

Exposures are also elevated for young children ages 1 to 5 years. While few studies have measured levels of PBDEs in young children, one large study conducted in Australia found that levels of PBDEs in blood are greatest for children ages 2 to 5 years, compared with older children and adults.[23] A study in the United States of 20 young children (ages 1.5 to 4 years) found that their PBDE blood levels were consistently higher than those of their mothers.[24]

The elevated exposures observed for young children are likely due to increased exposure to house dust, based on several studies that have estimated exposures based on measured levels of

PBDEs in house dust, air, and food.[5,6,8,25] Infants and small children may have the highest exposure to PBDEs in house dust due to their frequent and extensive contact with floors, carpets, and other surfaces where dust gathers, as well as their frequent hand-to-mouth activity.[26] However, children of all ages (as well as adults) are likely to be exposed to dust contaminants through hand-to-mouth activity and other ingestion pathways, such as the settling of dust onto food and food preparation surfaces in the kitchen, as well as inhalation.[8,17]

Concerns about the health effects of PBDEs are based largely on laboratory animal studies, along with findings of the limited number of human epidemiological studies that have been conducted to date. A primary concern from the animal studies is for effects on the developing brain and nervous system, including effects on learning, memory, and behavior.[27-29] A study of children in New York City found significant associations between children's prenatal exposure to PBDEs and performance on IQ tests at ages up through 6 years.[30] A second epidemiological study conducted in the Netherlands found that prenatal exposure to PBDEs was associated with reduced scores on some tests of neurological development and improved scores on other tests at ages 5 to 6 years.[31]

PBDEs are suspected endocrine disruptors.[27] Endocrine disruptors act by interfering with the biosynthesis, secretion, action, or metabolism of naturally occurring hormones.[32,33] 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.

Animal and human studies indicate that PBDEs may alter circulating levels of thyroid hormones.[27,34-36] Moderate deficits in maternal thyroid hormone levels during early pregnancy have been linked to reduced childhood IQ scores and other neurodevelopmental effects, as well as unsuccessful or complicated pregnancies.[37] Animal studies have found that PBDE exposure at critical stages of fetal development reduced levels of male hormones or caused other changes relevant to male reproductive development.[27,36,38-40] An epidemiological study of boys born in Denmark and Finland found that increased levels of PBDEs in breast milk were associated with an increased risk of cryptorchidism (undescended testes),[41] an effect that may be related to hormone disruption during critical stages of development.[42,43] Also, a study of Mexican immigrant women in California found effects on fertility (increased time to pregnancy) with increasing PBDE levels; this finding may be related to hormonal activity of PBDEs.[44]

The following indicator presents data on PBDE levels in women of child-bearing age, based on concerns for effects on children from prenatal exposures to PBDEs.

Indicator PBDE1: PBDEs in women ages 16 to 49 years: Median concentrations in blood serum, by race/ethnicity and family income, 2003-2004

Overview

Indicator PBDE1 presents concentrations of PBDEs in blood of U.S. women ages 16 to 49 years. The data are from a national survey that collects blood specimens from a representative sample of the population, and then measures the concentration of 10 PBDEs in the blood. The indicator presents comparisons of these 10 PBDEs in blood for women of different race/ethnicities, and for women of different income levels. The focus is on women of child-bearing age because blood levels of PBDEs during pregnancy have been associated with adverse children's health outcomes.

NHANES

Data used in this indicator come 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 for 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.[45] Concentrations of 10 PBDEs in blood serum have been measured in a representative subset of NHANES participants ages 12 years and older in the 2003–2004 survey cycle. NHANES data from 2003–2004 for women ages 16 to 49 years are used for Indicator PBDE1. These are the only years for which PBDE measurements are currently available.

PBDE Congeners

There are 209 possible PBDEs, referred to as "congeners," which are defined by the number of bromine atoms (from 1 to 10) and their position in the chemical structure. Each congener is assigned a specific brominated diphenyl ether (BDE) number, such as BDE-47 (a tetrabromodiphenyl ether congener – four bromine atoms). Most of these congeners have not been detected in the manufactured PBDE mixtures and have not been measured in environmental or human samples. NHANES sampled for 10 PBDE congeners in 2003–2004, including those most frequently measured in environmental and human samples. These include BDEs 17, 28, 47, 66, 85, 99, 100, 153, 154, and 183.

Most of these 10 congeners were components of the pentaBDE mixture that was used in polyurethane foam for furniture, mattresses, and automotive seating. Some of the congeners measured in NHANES were components of the octaBDE mixture, used in plastics for some

household electric devices. The primary congener comprising the decaBDE formulation, BDE-209, was not measured in NHANES in 2003–2004.

The indicator was calculated by summing together the measured values of the 10 congeners for each woman 16 to 49 years sampled in NHANES; this approach is commonly used in studies assessing levels of PBDEs in human blood samples and environmental samples.[10] If the congener was not detected in a sample, a default value below the detection limit was assigned for purposes of calculating the summed total. This assumption has a small impact on the reported blood levels of PBDEs, because almost all women sampled had values well above the detection limit for at least some congeners. BDEs 47, 100 and 153 were each detected in more than 90% of women.

Lipid Adjustment

PBDE concentrations are measured in blood serum. PBDEs are lipophilic, meaning that they tend to accumulate in fat. Body burdens of PBDEs are measured and expressed on a lipid-adjusted basis, as these are expected to better represent body burdens than unadjusted values.[45] The indicator uses lipid-adjusted concentrations, meaning that the concentration of PBDEs in serum is divided by the concentration of lipid in serum. The resulting units are nanograms of PBDE per gram of lipid (ng/g lipid) in serum.

Birthrate Adjustment

This indicator uses measurements of PBDEs in blood of women ages 16 to 49 years to represent the distribution of PBDE 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 years had a 12% annual probability of giving birth, and women aged 37 years had a 4% annual probability of giving birth.[46] A birthrate-adjusted distribution of women's PBDE levels is used in calculating this indicator, meaning that the data are weighted using the age-specific probability of a woman giving birth.[47]

Data Presented in the Indicator

The indicator presents median PBDEs in blood serum, computed as the sum of 10 PBDE congeners, for different population groups defined by race/ethnicity and family income.[i] The median is the value in the middle of the distribution of blood serum PBDE levels: half of the women have levels greater than the median, and half have levels below the median. The median can be thought of as representing a typical exposure. Median levels of PBDEs measured in blood for children ages 12 to 17 years are provided in the data tables.

Four race/ethnicity groups are presented in this indicator: 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

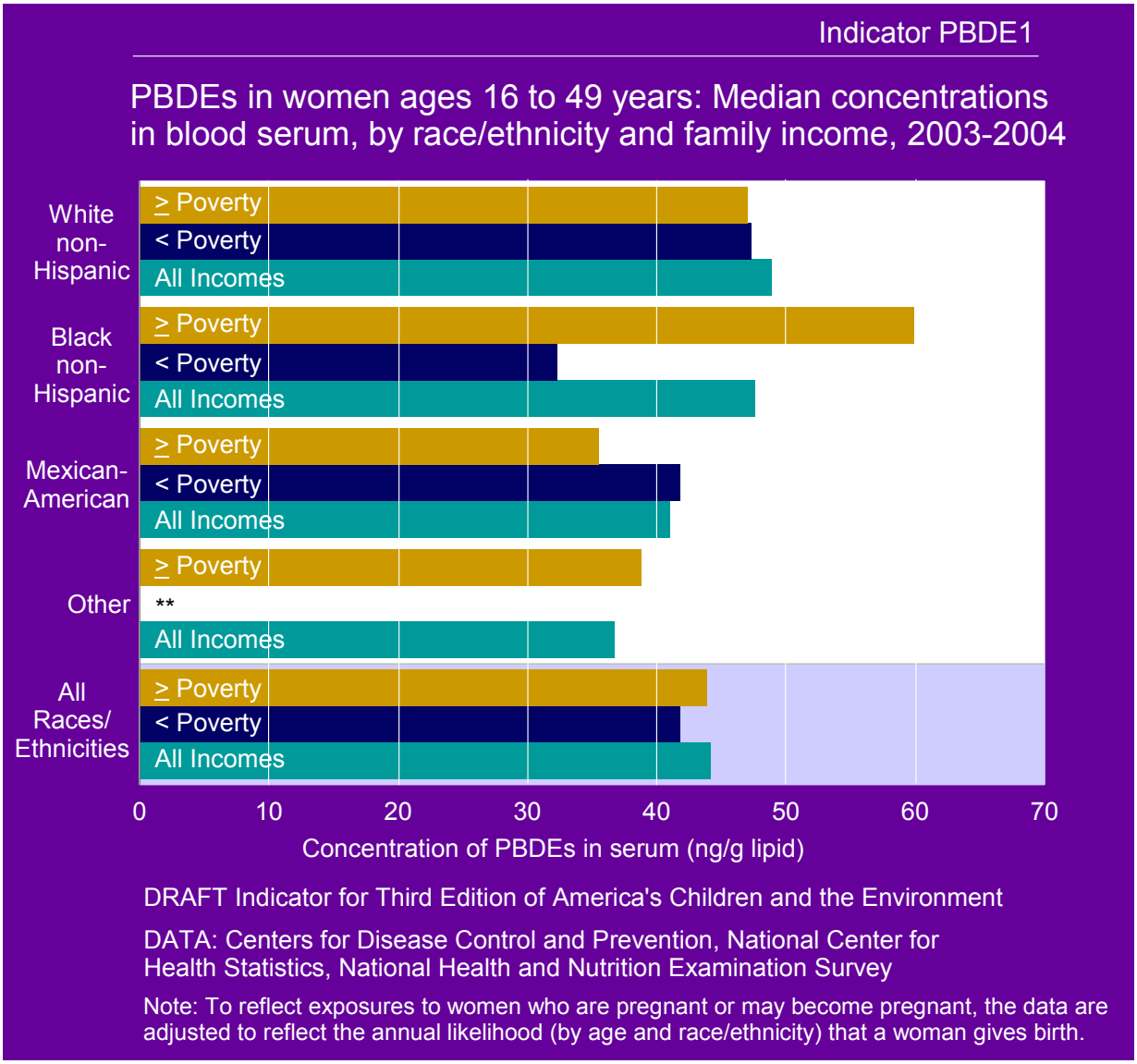
[i] Unlike other biomonitoring indicators in this report, 95th percentile PBDE levels are not provided in a supplementary table. This is because most 95th percentile PBDE values do not meet ACE statistical reliability criteria. There is more uncertainty in 95th percentile estimates for PBDEs than other chemicals because data are only available for two years (2003–2004) at this time.

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

- The median concentration of PBDEs in blood serum of women ages 16 to 49 years was 44 ng/g lipid in 2003–2004.

- Black non-Hispanic women with family incomes above poverty level had the highest median PBDE levels at 60 ng/g lipid.
    - Statistical Note: the observed differences between this value and the medians for other race/ethnicity and income groups were generally not statistically significant.

- The median concentration of PBDEs in children ages 12 to 17 years overall was 53 ng/g lipid. The median concentration of PBDEs for children with family incomes below poverty

was 63 ng/g lipid, and 50 ng/g lipid for children above poverty. (See Table PBDE1a.)

Data Tables

Table PBDE1. PBDEs in women ages 16 to 49 years: Median concentrations in blood serum, by race/ethnicity and family income, 2003-2004

Race / Ethnicity	Median concentration of PBDEs in serum (ng/g lipid)					
	All Incomes	< Poverty Level	≥ Poverty Level	≥Poverty (Detail)		Unknown Income
				100-200% of Poverty Level	> 200% of Poverty Level	
All Races/ Ethnicities	44.2	41.8	43.9	43.5	43.9	47.6
White non-Hispanic	48.9	47.3	47.0	44.2	47.0	NA**
Black non-Hispanic	47.6	32.3	59.9	NA**	62.8*	61.4
Mexican-American	41.0	41.8	35.5	NA**	30.3*	46.8
Other†	36.7	NA**	38.8	NA**	35.1*	NA**

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

NOTES:

- Values below the limit of detection are assumed equal to the limit of detection divided by the square root of 2.
- 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.

† "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 PBDE1a. PBDEs in children ages 12 to 17 years: Median concentrations in blood serum, by race/ethnicity and family income, 2003-2004

Race / Ethnicity	Median concentration of PBDEs in serum (ng/g lipid)					
	All Incomes	< Poverty Level	≥ Poverty Level	≥Poverty (Detail)		Unknown Income
				100-200% of Poverty Level	> 200% of Poverty Level	
All Races/ Ethnicities	52.9	62.6	49.8	50.4	47.6	NA**
White non-Hispanic	47.5	NA**	46.7	48.7	44.1	NA**
Black non-Hispanic	50.4	57.5	47.6	38.6	47.6	55.2
Mexican-American	62.9	59.8	63.7	59.9	64.4	NA**
Other†	68.9	88.8	63.4*	NA**	NA**	NA**

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

NOTE: Values below the limit of detection are assumed equal to the limit of detection divided by the square root of 2.

† "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).

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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

PBDE1. PBDEs in women ages 16 to 49 years: Median concentrations in blood serum, by race/ethnicity and family income, 2003-2004.

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 serum PBDE measurements of 10 PBDE congeners in women ages 16 to 49 years, summed to give the total serum PBDE. The NHANES 2003-2004 survey included serum PBDE data for children and adults ages 12 years and over. Indicator PBDE1 gives the median concentrations of total serum PBDE for women ages 16 to 49 years for 2003-2004, 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 total serum PBDE concentrations below this level; the population distribution was adjusted by age-specific birthrates to estimate the median pre-natal exposure to PBDEs. Table PBDE1a gives the median concentrations of total serum PBDE for children ages 12 to 17 years for 2003-2004, stratified both by race/ethnicity and family income. The survey data were weighted to account for the complex multi-stage, stratified, clustered sampling design.

Data Summary

Indicator	PBDE1. PBDEs in women ages 16 to 49 years: Median concentrations in blood serum, by race/ethnicity and family income, 2003-2004.
Time Period	2003-2004
Data	Serum PBDE for ten PBDE congeners.
Limits of Detection*	Limits of detection varied among the ten congeners and among the measurements of each congener.
Number of Non-missing Values**	540
Number of Missing Values	86
Percentage Below Limit of Detection***	BDE-47: 1%. BDE-99: 26%. BDE-100: 3%.

[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.

	BDE-153: 6%. Any one of 10 PBDE congeners: 97%

* 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. Includes samples with one or more non-missing congeners. 502 sampled women 16 to 49 years had non-missing values for all 10 PBDE congeners measured in NHANES.
***This percentage is survey-weighted using the NHANES survey weights for the given period and 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.htm.

- NHANES 2003-2004: Demographic file demo_c.xpt. PBDE Laboratory file l28pbe_c.xpt. The demographic file demo_c.xpt is a SAS transport file that contains the subject identifier (SEQN), age (RIDAGEYR), race/ethnicity (RIDRETH1), poverty income ratio (INDFMPIR), pseudo-stratum (SDMVSTRA) and the pseudo-PSU (SDMVPSU). The PBDE laboratory file l28pbe_c.xpt contains SEQN, the ten lipid-adjusted PBDE congeners (LBXBR1LA to LBXBR9LA and LBXBR66L), the ten PBDE non-detect comment codes (LBXBR1LC to LBXBR9LC and LBXBR66C), and the PBDE sub-sample laboratory 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 serum PBDE measurements of ten congeners from NHANES 2003-2004 in women ages 16 to 49. Table PBDE1a uses serum PBDE measurements of ten congeners from NHANES 2003-2004 in children ages 12 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]

The ten PBDE congeners measured in NHANES 2003-2004 are listed in the following table together with their SAS variable names:

[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.

BDE Code	Full name	SAS name (lipid-adjusted)	SAS name for non-detect comment code*
BDE-17	2,2',4-tribromodiphenyl ether	LBXBR1LA	LBXBR1LC
BDE-28	2,4,4'-tribromodiphenyl ether	LBXBR2LA	LBXBR2LC
BDE-47	2,2',4,4'-tetrabromodiphenyl ether	LBXBR3LA	LBXBR3LC
BDE-85	2,2',3,4,4'-pentabromodiphenyl ether	LBXBR4LA	LBXBR4LC
BDE-99	2,2',4,4',5-pentabromodiphenyl ether	LBXBR5LA	LBXBR5LC
BDE-100	2,2',4,4',6-pentabromodiphenyl ether	LBXBR6LA	LBXBR6LC
BDE-153	2,2',4,4',5,5'-hexabromodiphenyl ether	LBXBR7LA	LBXBR7LC
BDE-154	2,2',4,4',5,6'-hexabromodiphenyl ether	LBXBR8LA	LBXBR8LC
BDE-183	2,2',3,4,4',5',6-heptabromodiphenyl ether	LBXBR9LA	LBXBR9LC
BDE-66	2,3',4,4'-tetrabromodiphenyl ether	LBXBR66L	LBXBR66C

*The nondetect comment code equals 1 if the measurement is below the analytical limit of detection, and equals 0 if the measurement is at or above the analytical limit of detection,

This analysis uses the sum of the ten PBDE congeners listed in this table. If some but not all of the congeners are missing, then the sum is over the non-missing congeners.

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 PBDE sub-sample laboratory survey weights (WTSB2YR) to re-adjust the serum PBDE 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 is the product of the NHANES survey weight and the total number of births in 2003 and 2004 for the given age and race/ethnicity, divided by twice the corresponding population of women at the midpoint of 2003-2004.[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

[iv] Axelrad, D.A., Cohen, J. 2010. Calculating summary statistics for population chemical biomonitoring in women of childbearing age with adjustment for age-specific natality. *Environmental Research* 111 (1) 149-155.

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

For indicator B2, 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.

Calculation of Indicator

Indicator PBDE1 is the median for total serum PBDE in women of ages 16 to 49 years, stratified by race/ethnicity and family income. Table PBDE1a is the median for total serum PBDE in children of ages 12 to 17 years, stratified 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 total serum PBDE 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. Note that the calculations for Indicator PBDE1 also apply to Table PBDE1a, except that for children the birthrate adjustment is not applied.

To simply demonstrate the calculations, we will use the NHANES 2003-2004 total serum PBDE values for women ages 16 to 49 years as an example. We have rounded all the numbers to make the calculations easier:

We begin with all the non-missing NHANES 2003-2004 total serum PBDE values for women ages 16 to 49 years. Assume for the sake of simplicity that valid data on total serum PBDE were available for every sampled woman. Each sampled woman has an associated survey weight WTSB2YR that estimates the annual number of U.S. women represented by that sampled woman. Each sampled woman also has an associated birthrate giving the numbers of births per woman of the given age, race, and ethnicity. The product of the 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 total serum PBDE measurement for a woman between 16 and 49 years of age is 6.5 ng/g lipid with a survey weight of 20,000, a birthrate of 0.1, and thus an adjusted survey weight of 2,000, and so represents 2,000 births. The total of the adjusted survey weights for the sampled women equals 4 million, the total number of U.S. births to women ages 16 to 49 years. The second lowest measurement is 6.8 ng/g lipid with an adjusted survey weight of 3,000, and so represents another 3,000 U.S. births. The highest

measurement was 2260.5 ng/g lipid, with an adjusted survey weight of 2,000, and so represents another 2,000 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 2,000 values of 6.5 ng/g lipid from the lowest measurement, 3,000 values of 6.8 ng/g lipid from the second lowest measurement, and so on, up to 2,000 values of 2260.5 ng/g lipid from the highest measurement. Arranging these 4 million values in increasing order, the 2 millionth value is ng/g lipid μg/dL. Since half of the values are below 44.2 and half of the values are above 44.2, the median equals 44.2 ng/g lipid.

In reality, the calculations need to take into account that total serum PBDE measurements were not available for every respondent, and to use exact rather than rounded numbers. There were total serum PBDE measurements for only 540 of the 626 sampled women ages 16 to 49 years. The adjusted survey weights for all 626 sampled women add up to 4.1 million, the U.S. population of births to women ages 16 to 49. The adjusted survey weights for the 540 sampled women with total serum PBDE data add up to 3.7 million. Thus the available data represent 3.7 million values and so represent only 90% of the U.S. population of births. The median is given by the 1.85 millionth (50% of 3.7 million) U.S. birth's value. These calculations assume that the sampled women with valid total serum PBDE data are representative of women giving birth without valid total serum PBDE data. The calculations also assume that the sampled women are representative of women that actually gave birth in 2003-2004, 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 total serum PBDE values. Suppose there are n women of ages 16 to 49 years with valid total serum PBDE values. Arrange the total serum PBDE 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 a adjusted survey weight of w(n).

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

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

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.

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

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).

Relative Standard Error

The uncertainties of the median 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:

[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.

$$P_L(x,n_{df}) = v_1F_{v1,v2}(0.025)/(v_2 + v_1F_{v1,v2}(0.025))$$
$$P_U(x,n_{df}) = v_3F_{v3,v4}(0.975)/(v_4 + v_3F_{v3,v4}(0.975))$$

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}:

$$\text{Relative Standard Error (\%)} = [\text{Standard Error } (P_{CDC}) / P_{CDC}] \times 100\ \%$$

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 body burden 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 12 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 Table 3.

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 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 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 12 to 17 years. The AGAINST = "income" unadjusted p-value compares the body burdens 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 (for children), 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 12-14 and 15-17.

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

Table 1. Statistical significance tests comparing the percentiles of PBDEs in women ages 16 to 49 years, between pairs of race/ethnicity groups, for 2003-2004.

				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)**
PBDE	50	White non-Hispanic	White non-Hispanic	0.923	< 0.0005	0.170	< 0.0005	0.471	0.403
PBDE	50	White non-Hispanic	Mexican-American	0.181	0.386	0.611	0.003	0.296	0.283
PBDE	50	White non-Hispanic	Other	0.038	0.012	0.358	0.189	0.291	0.990
PBDE	50	White non-Hispanic	Mexican-American	0.435	0.011	0.512	0.913	0.190	0.066
PBDE	50	White non-Hispanic	Other	0.196	0.022	0.815	0.024	0.194	0.203
PBDE	50	Mexican-American	Other	0.410	0.268	0.541	0.090	0.921	0.214

[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.

Table 2. Statistical significance tests comparing the percentiles of PBDEs in women ages 16 to 49 years, between pairs of race/ethnicity/income groups at different income levels, for 2003-2004.

				P-VALUES	
Variable	Percentile	RACEINC1	RACEINC2	Unadjusted	Adjusted (for age)
PBDE	50	White non-Hispanic, < PL	White non-Hispanic, ≥ PL	0.970	0.022
PBDE	50	White non-Hispanic, < PL	White non-Hispanic, ≥ PL	0.479	< 0.0005
PBDE	50	White non-Hispanic, < PL	Mexican-American, ≥ PL	0.276	0.186
PBDE	50	White non-Hispanic, < PL	Other, ≥ PL	0.267	< 0.0005
PBDE	50	White non-Hispanic, < PL	White non-Hispanic, ≥ PL	0.186	0.020
PBDE	50	White non-Hispanic, < PL	White non-Hispanic, ≥ PL	0.137	0.078
PBDE	50	White non-Hispanic, < PL	Mexican-American, ≥ PL	0.809	0.001
PBDE	50	White non-Hispanic, < PL	Other, ≥ PL	0.718	0.001
PBDE	50	Mexican-American, < PL	White non-Hispanic, ≥ PL	0.634	0.105
PBDE	50	Mexican-American, < PL	White non-Hispanic, ≥ PL	0.342	0.269
PBDE	50	Mexican-American, < PL	Mexican-American, ≥ PL	0.669	0.032
PBDE	50	Mexican-American, < PL	Other, ≥ PL	0.713	0.093
PBDE	50	Other, < PL	White non-Hispanic, ≥ PL	0.367	0.638
PBDE	50	Other, < PL	White non-Hispanic, ≥ PL	0.226	0.268
PBDE	50	Other, < PL	Mexican-American, ≥ PL	0.711	0.764
PBDE	50	Other, < PL	Other, ≥ PL	0.666	0.599

Table 3. Statistical significance tests comparing the percentiles of PBDEs in children ages 12 to 17 years, between pairs of race/ethnicity groups, for 2003-2004.

				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)
PBDE	50	White non-Hispanic	White non-Hispanic	0.713	0.211			0.905	0.345
PBDE	50	White non-Hispanic	Mexican-American	0.084	0.091			0.063	0.042
PBDE	50	White non-Hispanic	Other	0.247	0.002			0.359	< 0.0005
PBDE	50	White non-Hispanic	Mexican-American	0.165	0.397	0.608	0.514	0.042	0.099
PBDE	50	White non-Hispanic	Other	0.325	< 0.0005	0.935	0.552	0.328	< 0.0005
PBDE	50	Mexican-American	Other	0.700	0.017	0.735	0.759	0.989	0.003

Table 4. Statistical significance tests comparing the percentiles of PBDEs in children ages 12 to 17 years, between pairs of race/ethnicity/income groups at different income levels, for 2003-2004.

				P-VALUES	
Variable	Percentile	RACEINC1	RACEINC2	Unadjusted	Adjusted (for age, sex)
PBDE	50	White non-Hispanic, < PL	White non-Hispanic, ≥ PL	0.325	0.472
PBDE	50	White non-Hispanic, < PL	White non-Hispanic, ≥ PL	0.262	0.906
PBDE	50	White non-Hispanic, < PL	Mexican-American, ≥ PL	0.432	0.199
PBDE	50	White non-Hispanic, < PL	Other, ≥ PL	0.683	0.003
PBDE	50	Mexican-American, < PL	White non-Hispanic, ≥ PL	0.079	0.216
PBDE	50	Mexican-American, < PL	White non-Hispanic, ≥ PL	0.050	0.508
PBDE	50	Mexican-American, < PL	Mexican-American, ≥ PL	0.696	0.728
PBDE	50	Mexican-American, < PL	Other, ≥ PL	0.862	0.054
PBDE	50	Other, < PL	White non-Hispanic, ≥ PL	0.355	0.198
PBDE	50	Other, < PL	White non-Hispanic, ≥ PL	0.300	0.612
PBDE	50	Other, < PL	Mexican-American, ≥ PL	0.548	0.400
PBDE	50	Other, < PL	Other, ≥ PL	0.733	0.012

Table 5. Other statistical significance tests comparing the percentiles of PBDEs in women ages 16 to 49 years, for 2003-2004.

					P-VALUES	
Variable	Percentile	From	To	Against	Unadjusted	Adjusted*
PBDE	50	2003	2004	income	0.814	0.950

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

Table 6. Other statistical significance tests comparing the percentiles of PBDEs in children ages 12 to 17 years, for 2003-2004.

					P-VALUES	
Variable	Percentile	From	To	Against	Unadjusted	Adjusted*
PBDE	50	2003	2004	income	0.185	0.181

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