CDC
Environmental Health

National Report on Human Exposure to Environmental Chemicals

Centers for Disease Control and Prevention

Atlanta, Georgia

March 2001

National Report on Human Exposure to Environmental Chemicals

Centers for Disease Control and Prevention

March 2001

Contents

Executive Summary

Introduction

The *National Report on Human Exposure to Environmental Chemicals* is a new publication that provides an ongoing assessment of the exposure of the U.S. population to environmental chemicals using biomonitoring. For this Report, an environmental chemical means a chemical compound or chemical element present in air, water, soil, dust, food, or other environmental media. Biomonitoring is the assessment of human exposure to chemicals by measuring the chemicals or their metabolites (i.e., breakdown products) in human specimens, such as blood or urine.

The Report provides exposure information about people participating in an ongoing national survey of the general U.S. population—the National Health and Nutrition Examination Survey (NHANES). The survey is conducted by the National Center for Health Statistics of the Centers for Disease Control and Prevention (CDC). This survey is unique in its ability to examine public health issues that can best be addressed through physical and laboratory examinations of the U.S. population. The first release of the Report is restricted to general U.S. population data for the year 1999 from NHANES.

This first Report provides information about levels of 27 environmental chemicals measured in the U.S. population. These chemicals include metals, such as lead, mercury, and uranium; organophosphate pesticide metabolites; phthalate metabolites; and cotinine, a marker of exposure to tobacco smoke. Tables on the following pages summarize results of CDC's Environmental Health Laboratory measurements.

Public Health Uses of the Report

The overall purpose of the Report is to provide unique exposure information to scientists, physicians, and health officials to help prevent disease that results from exposure to environmental chemicals. Specific uses of information contained in the Report are discussed elsewhere in this document.

Interpreting Data Contained in the Report

This first report presents data for the general U.S. population for 1999 from CDC's NHANES. Because the sample size in any one year of NHANES is relatively small and for 1999 the survey was conducted in only 12 locations across the country, and because most analyses were conducted in subsamples of the population, more data will be needed to confirm these findings and to allow more detailed analysis to describe exposure levels in population subgroups.

Just because people have an environmental chemical in their blood or urine does not mean that the chemical causes disease. Advances in analytical methods allow us to measure low levels of environmental chemicals in people, but studies of varying exposure levels and health effects are needed to determine which blood or urine levels result in disease. These studies must also consider other factors such as duration of exposure.

The Report will contain new data each year. Next year, CDC will combine the 1999 and 2000 data from NHANES to provide updated national estimates. In the future, the Report will also include data from other large exposure studies and studies of exposure of special-population groups within the United States.

Major Findings of the Report

First-time information about exposure levels for the U.S. population
The 1999 Report provides measures of exposure for levels of 27 chemicals in the U.S. population that are based on blood and urine samples obtained from people participating in NHANES 1999. For three chemicals—lead, cadmium, and cotinine—CDC has previously assessed the population's exposure through NHANES, and this Report provides new data for the 1999 calendar year. The Report provides information for the first time about the U.S. population's exposure to 24 additional environmental chemicals (metals, organophosphate pesticides, and phthalates). Because the sample size in one year of NHANES is relatively small and because the 1999 survey was conducted only in 12 locations across the country, data from additional years of the survey will be needed to confirm these findings.

Reference range values for physicians and health researchers
Physicians use "normal"ranges for laboratory results to determine whether their patients have high or low values that would indicate a health problem. These ranges are obtained from people who are generally healthy. In the Report, CDC determined reference ranges for 24 environmental chemicals from a group of people not known to have any specific exposure to the chemicals beyond that experienced in the general population. Sometimes these reference ranges are referred to as "background-exposure levels."

Reference ranges are extremely helpful to physicians and health researchers because levels above the reference range usually indicate exposure to a particular source. For example, if a physician was concerned about a patient's potential exposure to cadmium and measured a cadmium level in the patient's urine, the results could be compared with the population reference range in the Report. A cadmium level similar to those found in the Report would indicate exposure no different from those levels found in the general population, and a level much higher than those found in the Report would indicate that there may have been an unusual exposure to cadmium worthy of further investigation.

Decline in blood lead levels among children since 1991-1994
Since 1976, CDC has measured blood lead levels as part of NHANES. Results presented in the Report for 1999 show that the geometric mean blood lead level for children aged 1-5 years has decreased to 2.0 micrograms per deciliter (µg/dL), from 2.7µg/dL, the geometric mean for the period 1991-1994. This decrease documents that blood lead levels continue to decline among U.S. children when considered as a group, highlighting the success of public health efforts to decrease the exposure of children to lead. However, special populations of children at high risk

for lead exposure (e.g., those living in homes containing lead-based paint or lead-contaminated dust) remain a public health concern.

Reduced exposure of the U.S. population to environmental tobacco smoke
Cotinine is a metabolite of nicotine that tracks exposure to environmental tobacco smoke (ETS) among nonsmokers. Higher cotinine levels reflect more exposure to ETS, which has been identified as a known human carcinogen. From 1988 through 1991, as part of NHANES III, CDC determined that the median level (50th percentile) of cotinine among nonsmokers in the United States was 0.20 nanograms per milliliter (ng/mL). Results from the 1999 Report showed that the median cotinine level among people aged 3 years and older has decreased to less than 0.050 ng/mL—more than a 75% decrease. This reduction in cotinine levels objectively documents a dramatic reduction in exposure of the general population to ETS since 1988-1991. However, since more than half of American youth are still exposed, ETS remains a major public health concern.

Better assessment of children's and women's exposure to mercury
The 1999 Report provides important new data about blood mercury levels among children aged 1-5 years and among women of childbearing age (16-49 years old). The geometric mean of blood mercury levels among children (0.3µg/L) was about 25% of the geometric mean of blood mercury levels among women of childbearing age (1.2µg/L). Compared with an adult, the fetus and child are usually more vulnerable to the effects of metals. Consequently, when addressing mercury exposures, health officials are particularly careful to protect the fetus and child. The Report provides data for children and levels for women of childbearing age that reflect levels of mercury to which the fetus is exposed. Scientists will use these new data to better estimate health risks for the fetus, children, and women of childbearing age from potential sources of mercury exposure.

Setting priorities for research on phthalates
Phthalates are compounds commonly used in consumer products such as soap, shampoo, hair spray, and many types of nail polish. Some phthalates are used in flexible plastics such as blood bags and tubing. Animal research has focused on evaluating reproductive effects of phthalates. For the 1999 Report, CDC scientists measured metabolites of seven major phthalates. Di-2-ethylhexyl phthalate (DEHP) and di-isononyl phthalate (DINP) are the two phthalates produced in greatest quantity, with diethyl phthalate (DEP) and dibutyl phthalate(DBP) produced in much lower quantities. However, data from the Report showed that levels of metabolites of DEP and DBP were much higher in the population than levels of metabolites of either DEHP or DINP.

These new data have prompted CDC to conduct additional studies to explain these findings by examining the pathways by which these phthalates get into people's bodies. The data also indicate that health research needs to focus on DEP and DBP, given that levels of their metabolites are much higher in the general population than metabolite levels of phthalates produced in the largest quantities.

Future Plans

The National Report on Human Exposure to Environmental Chemicals will be updated each year with new data for the general population. Next year, CDC will combine the 1999 and 2000 data from NHANES to provide updated national estimates. For the general population, current plans are for the Report to continue to measure these 27 chemicals and gradually expand the number until approximately 100 environmental chemicals are measured each year. Chemicals under consideration for future Reports include volatile organic compounds, polyaromatic hydrocarbons, dioxins, furans, polychlorinated biphenyls, trihalomethanes, haloacetic acids, carbamate pesticides, and organochlorine pesticides.

Future editions of the Report will provide more detailed assessments of exposure levels among different population groups defined by sex, race or ethnicity, age, urban or rural residence, education levels, income, and other characteristics. In addition, over time CDC will be able to track trends in exposure levels. Future reports will also include exposure information for special-exposure populations from studies of people exposed from localized or point-source exposures (e.g., people who eat mercury-contaminated fish from a polluted river) and studies of adverse health effects resulting from exposure to varying levels of environmental chemicals.

Data provided in future reports will help us answer the following questions:

- Are exposure levels increasing or decreasing over time?
- Are public health efforts to reduce exposure working?
- Do certain groups of people have higher levels of exposure than others?

Table 1. Selected percentiles and geometric means of blood and urine levels of environmental chemicals (or metabolites), National Health and Nutrition Examination Survey, United States, 1999

	Sample size	Units	Geometric mean (95% confidence interval)	Selected percentiles (95% confidence interval)				
				10th	25th	50th	75th	90th
Metals[1]								
Cadmium	3,189	µg/L	*	< LOD	< LOD	0.3 (0.2-0.3)	0.5 (0.4-0.6)	0.9 (0.7-1.1)
Lead	3,189	µg/dL	1.6 (1.4-1.8)	0.7 (0.6-0.7)	1.0 (0.9-1.1)	1.5 (1.4-1.7)	2.3 (2.2-2.6)	3.7 (3.2-4.3)
Mercury								
Children 1-5 years	248	µg/L	0.3 (0.2-0.4)	< LOD	< LOD	0.2 (0.2-0.3)	0.5 (0.4-0.8)	1.4[2] (0.7-4.8)
Females, 16-49 years	679	µg/L	1.2 (0.9-1.6)	0.2 (0.1-0.3)	0.5 (0.4-0.7)	1.2 (0.8-1.6)	2.7 (1.8-4.5)	6.2 (4.7-7.9)
Metals[3]								
Antimony	912	µg/L	0.1 (0.09-0.12)	< LOD	0.05 (0.03-0.07)	0.1 (0.09-0.12)	0.19 (0.16-0.21)	0.29 (0.27-0.34)
Barium	779	µg/L	1.6 (1.5-1.7)	0.3 (0.3-0.4)	0.8 (0.7-0.9)	1.7 (1.5-1.9)	2.9 (2.7-3.3)	5.5 (4.2-6.2)
Beryllium	1,007	µg/L	*	< LOD	< LOD	< LOD	< LOD	< LOD
Cadmium	1,007	µg/L	0.32 (0.30-0.33)	0.10 (0.08-0.12)	0.18 (0.15-0.19)	0.33 (0.29-0.35)	0.57 (0.52-0.62)	0.95 (0.85-1.04)
Cesium	1,006	µg/L	4.7 (4.2-5.2)	1.8 (1.4-2.2)	3.3 (2.9-3.6)	5.3 (4.7-5.8)	7.2 (6.7-8.0)	9.6 (8.5-11.6)
Cobalt	1,007	µg/L	0.36 (0.32-0.40)	0.11 (0.08-0.14)	0.23 (0.19-0.26)	0.40 (0.35-0.41)	0.60 (0.54-0.68)	0.89 (0.79-1.10)
Lead	1,007	µg/L	0.80 (0.68-0.91)	0.21 (0.15-0.26)	0.42 (0.34-0.51)	0.80 (0.72-0.88)	1.36 (1.17-1.69)	2.21 (1.89-2.72)
Molybdenum	904	µg/L	48.4 (43.6-53.2)	13.1 (10.8-17.3)	27.6 (23.4-32.8)	53.3 (47.3-61.5)	86.6 (78.6-97.5)	140 (120-174)
Platinum	1,007	µg/L	*	< LOD	< LOD	< LOD	< LOD	< LOD
Thallium	974	µg/L	0.19 (0.17-0.20)	0.07 (0.06-0.07)	0.12 (0.10-0.13)	0.21 (0.19-0.23)	0.30 (0.28-0.33)	0.42 (0.39-0.45)

	Sample size	Units	Geometric mean (95% confidence interval)	Selected percentiles (95% confidence interval)				
				10th	25th	50th	75th	90th
Tungsten	892	µg/L	0.10 (0.09-0.12)	< LOD	0.05 (0.03-0.06)	0.10 (0.08-0.11)	0.18 (0.16-0.22)	0.32 (0.27-0.45)
Uranium	1,006	µg/L	0.008 (0.006-0.011)	< LOD	< LOD	0.007 (0.004-0.010)	0.014 (0.009-0.030)	0.034 (0.022-0.053)

< LOD means below the limit of detection of the analytical method.
*Not calculated. Proportion of results below the limit of detection was too high to provide a valid result.
[1] Lead and cadmium are measured in blood among people aged 1 year and older; mercury is measured in blood among age groups specified above. Blood levels by selected demographic groups are available elsewhere in this document and at www.cdc.gov/nceh/dls/report
[2] Estimate meets minimum standards of reliability but should be interpreted with caution.
[3] Measured in urine in a subset of people aged 6 years and older.

Table 2. Selected percentiles and geometric means of blood and urine levels of environmental chemicals (or metabolites), National Health and Nutrition Examination Survey, United States, 1999

	Sample size	Units	Geometric mean (95% confidence interval)	Selected percentiles (95% confidence interval)				
				10th	25th	50th	75th	90th
Organophosphate Pesticide Metabolites[1]								
Dimethyl-phosphate	703	µg/L	1.84 (1.10-2.59)	< LOD	0.80 (0.36-1.11)	1.67 (1.04-2.86)	3.79 (2.38-7.46)	7.43 (5.43-17.3)
Diethyl-phosphate	703	µg/L	2.55 (1.33-3.78)	0.78 (0.70-0.90)	1.09 (0.93-1.31)	1.85 (1.19-4.11)	4.87 (2.58-14.0)	10.6[2] (6.29)
Dimethylthio-phosphate	703	µg/L	2.61 (1.77-3.45)	< LOD	0.72 (0.13-1.73)	3.80 (2.93-4.53)	9.00 (7.35-12.3)	22.9 (18.7-30.7)
Diethylthio-phosphate	703	µg/L	0.81 (0.69-0.94)	0.51 (0.41-0.53)	0.58 (0.55-0.59)	0.70 (0.64-0.78)	0.98 (0.78-1.45)	1.52 (1.16-2.91)
Dimethyldithio-phosphate	703	µg/L	0.51 (0.39-0.62)	< LOD	< LOD	0.60 (0.39- 0.78)	2.05 (1.65-2.42)	5.43 (3.16-10.3)
Diethyldithio-phosphate	703	µg/L	0.19 (0.14-0.23)	0.08 (0.07-0.08)	0.09 (0.09-0.09)	0.14 (0.09-0.26)	0.30 (0.25-0.39)	0.54 (0.44-0.86)
Phthalate Metabolites[1]								
Mono-benzyl phthalate	1,029	µg/L	17.4 (14.1-20.7)	3.5 (2.2-4.5)	8.0 (5.9-9.8)	18.5 (15.4-22.6)	38.6 (31.5-48.7)	82.3 (64.0-101)
Mono-butyl phthalate	1,029	µg/L	26.7 (23.9-29.4)	5.9 (4.6-7.3)	13.2 (10.5-15.4)	27.5 (24.6-31.5)	53.8 (51.2-59.7)	98.6 (89.1-122)
Mono-cyclohexyl phthalate	1,029	µg/L	*	< LOD	< LOD	< LOD	< LOD	< LOD
Mono-ethyl phthalate	1,029	µg/L	176.0 (132-220)	27.7 (17.5-38.3)	61.5 (43.1-80.0)	171 (121-226)	424 (362-563)	1,160 (971-1,350)
Mono-2-ethylhexyl phthalate	1,029	µg/L	3.5 (3.0-4.0)	< LOD	1.5 (0.8-1.9)	3.3 (3.0-3.8)	7.7 (6.1-9.6)	13.6 (11.2-17.3)
Mono-isononyl phthalate	1,029	µg/L	*	< LOD	< LOD	< LOD	< LOD	4.3 (0.6-22.3)
Mono-n-octyl phthalate	1,029	µg/L	*	< LOD	< LOD	< LOD	< LOD	1.9 (1.2-3.5)

	Sample size	Units	Geometric mean (95% confidence interval)	Selected percentiles (95% confidence interval)				
				10th	25th	50th	75th	90th
Cotinine[3]	2,263	ng/mL	*	< LOD	< LOD	< LOD	0.15 (0.11-0.23)	0.52 (0.38-1.01)

< LOD means below the limit of detection of the analytical method.
*Not calculated. Proportion of results below the limit of detection was too high to provide a valid result.
[1]Organophosphate pesticide metabolites are measured in urine in a subset of people aged 6 to 59 years. Phthalate metabolites are measured in urine in a subset of people aged 6 years and older.
[2] Upper end of the 95% confidence interval cannot be estimated reliably.
[3] Measured in serum among nonsmokers aged 3 years and older. Serum levels of cotinine for selected demographic groups are available elsewhere in this document and at www.cdc.gov/nceh/dls/report

Introduction

The *National Report on Human Exposure to Environmental Chemicals* is a new publication that provides an ongoing assessment of the U.S. population's exposure to environmental chemicals using biomonitoring. For this Report, an environmental chemical means a chemical compound or chemical element present in air, water, soil, dust, or other environmental media. Biomonitoring is the assessment of human exposure to chemicals by measuring the chemicals or their metabolites in human specimens, such as blood or urine. This report presents data for the noninstitutionalized, civilian U.S. population for 1999 from CDC's National Health and Nutrition Examination Survey (NHANES). NHANES is a series of surveys designed to collect data on the health and nutritional status of the U.S. population.

Currently, the Report includes data for exposure of the general population to these 27 environmental chemicals:

Metals

- Lead
- Mercury
- Cadmium
- Cobalt
- Uranium
- Antimony
- Barium
- Beryllium
- Cesium
- Molybdenum
- Platinum
- Thallium
- Tungsten

Tobacco smoke

- Cotinine (a metabolite of nicotine)

Organophosphate pesticides: urine metabolites of 28 pesticides, including chlorpyrifos, diazinon, fenthion, malathion, parathion, disulfoton, phosmet, phorate, temephos, and methyl parathion:

- Dimethylphosphate
- Dimethylthiophosphate
- Dimethyldithiophosphate
- Diethylphosphate
- Diethylthiophosphate
- Diethyldithiophosphate

Phthalates: urine metabolites of seven phthalates:

- Mono-ethyl phthalate
- Mono-isononyl phthalate
- Mono-butyl phthalate
- Mono-cyclohexyl phthalate
- Mono-2-ethylhexyl phthalate
- Mono-benzyl phthalate
- Mono-n-octyl phthalate

Data Presented for Each Environmental Chemical

The Report presents descriptive statistics on the distribution of blood or urine levels for each environmental chemical. Statistics include geometric means and percentiles with confidence intervals. Geometric means are calculated by taking the log of each concentration, then calculating the mean of those log values, and finally taking the antilog of that mean (the calculation can be done using log base e or log base 10). A geometric mean provides a better estimate of central tendency for data that are distributed with a long tail at the upper end of the distribution. This type of distribution is common when measuring environmental chemicals in blood or urine. The geometric mean is less influenced by high values than is the arithmetic mean. Percentiles (10^{th}, 25^{th}, 50^{th}, 75^{th}, and 90^{th}) are given to provide additional information about the shape of the distribution. For urine measurements, data are shown for both the concentration in urine and the concentration corrected for urine-creatinine level.

When sample sizes are adequate, the Report also presents data for the population and population subgroups defined by demographic variables such as age, sex, and race or ethnicity.

First-Time Information

The Report is a new publication that provides information to scientists, public health officials, and the public about exposure to environmental chemicals in the U.S. population. For 24 of the 27 environmental chemicals listed in the Report, this is the first time this type of exposure information has been available for the general U.S. population. CDC has previously assessed the population's exposure to three chemicals (lead, cadmium, and cotinine),[1-5] and this Report provides new data about these chemicals for the 1999 calendar year.

Interpreting Report Exposure Data: Important Factors

Research studies, separate from the Report, are required to determine which blood or urine levels are safe and which cause disease.

The measurement of an environmental chemical in a person's blood or urine does not by itself mean that the chemical causes disease. Advances in analytical methods allow us to measure low levels of environmental chemicals in people, but studies of varying exposure levels and health effects are needed to determine which blood or urine levels result in disease. These studies must also consider other factors such as duration of exposure. The Report does not present new data on health risks from different exposures.

For some environmental chemicals, such as lead, research studies have given us a good understanding of the health risks associated with different blood lead levels. However, for many environmental chemicals, we need more research to assess health risks from different blood or urine levels of a chemical. The results shown in the Report should help prioritize and foster research on human health risks that result from exposure to environmental chemicals. See the section titled "Toxicology and Health-Risk Information," which lists Internet sites providing health information about environmental chemicals. Each environmental chemical can be searched in databases at these Web sites using the chemical name or the chemical's Chemical Abstract Service (CAS) number, which is provided in the Report. If available for the chemical of interest, the Agency for Toxic Substances and Disease Registry (ATSDR) ToxFAQs provide a good summary of the chemical's toxicology, as well as answers to common questions about exposure and health effects.

Blood and urine levels of a chemical should not be confused with levels of the chemical in air, water, soil, dust or food.

Concentrations of environmental chemicals in blood or urine are not the same as those in air, water, soil, dust, or food. For example, a chemical concentration of 10 micrograms per liter (µg/L) in water does not produce a level of 10 µg/L in blood or urine. In fact, blood or urine levels may result from exposure to chemicals in more than one environmental medium. Blood lead levels reflect exposure from lead in air, water, soil, dust, and food. The blood and urine levels shown in the Report cannot be quantitatively extrapolated to specific air, water, soil, dust, or food levels.

The 1999 Report results are for the general U.S. population. Future Reports will include data for both the general population and populations in special-exposure situations.

The 1999 Report data are for the general U.S. population and should not be interpreted as representing groups of people in special-exposure situations. Future releases of the Report will include data from CDC studies of special-exposure populations. The 1999 Report contains results from a sample of people representing the civilian, noninstitutionalized U.S. population. Groups of people in special-exposure situations (e.g., pesticide applicators, people living near hazardous waste sites, people working in lead smelters) are not targeted in this set of results. For example, people working in lead smelters likely have a different distribution of blood lead levels than people in the general population. A specific study of people working in lead smelters would be needed to describe the distribution of blood lead levels in that group.

The 1999 Report Results are based on 1 year of NHANES data.

Because the sample size in any one year of NHANES is relatively small and for 1999 the survey was conducted in only 12 locations across the country, and because most analyses were conducted in subsamples of the population, more data will be needed to confirm these findings and to allow more detailed analysis to describe exposure levels in population subgroups. Data from additional sites are also needed to evaluate the potential influence of geographic clustering on blood and urine levels of chemicals.

CDC will update the Report each year. Next year, CDC will combine the 1999 and 2000 data from NHANES to provide new national estimates. In the future, the Report will also include data from other large exposure studies and studies of exposure of special-population groups within the United States.

Biomonitoring Exposure Measurements

The biomonitoring exposure measurements presented in the Report were made at CDC's Environmental Health Laboratory (Division of Laboratory Sciences, National Center for Environmental Health). The analytical methods used for measuring these environmental chemicals or their metabolites in blood and urine were isotope dilution mass spectrometry, inductively coupled plasma mass spectrometry, or graphite furnace atomic absorption spectrometry. Information about the analytical methods used appears in the "References for Analytical Methods" section of this document.

Data Sources

The National Health and Nutrition Examination Survey

The National Health and Nutrition Examination Survey (NHANES) is a series of surveys conducted by CDC's National Center for Health Statistics (NCHS) that is designed to collect data on the health and nutritional status of the U.S. population. NHANES is unique in its ability to examine public health issues that can best be addressed through physical and laboratory examinations of the U.S. population. NHANES collects information about a wide range of topics, from the prevalence of infectious diseases to risk factors for cardiovascular disease. Beginning in 1999, NHANES became a continuous and annual survey. The sampling plan for each year follows a complex, stratified, multistage, probability-cluster design to select a representative sample of the civilian, noninstitutionalized population.

The current sample design includes oversampling of African Americans, Mexican Americans, adolescents (12-19 years old), older Americans (60 years old and older), and pregnant women to produce more reliable estimates for these groups. The NHANES protocol includes a home interview followed by a standardized physical examination in a mobile examination center. As part of the examination protocol, blood is obtained by venipuncture for participants aged 1 year and older, and urine specimens are collected for people aged 6 years and older. The 1999 NHANES was conducted in 12 counties across the United States. From these locations, 5,325 people were selected to participate in the survey. Of these, 3,812 (71%) participated in the examination component.

Environmental chemicals were measured either in blood or urine specimens collected as part of the examination component. The age range for which a chemical was measured varied. Because of the availability of samples and the speed of analytical measurements, some environmental chemicals (metals, phthalate metabolites, and organophosphate metabolites) were measured only in randomly selected subsamples within specific age groups.

Blood lead and cadmium levels were measured in all people aged 1 year and older. Serum cotinine was measured in all people aged 3 years and older. Blood mercury was measured in children aged 1-5 years and in women 16-49 years of age. Urine measurements for metals and phthalates were conducted for random one-third samples of people aged 6 years and older. Urine organophosphate pesticide metabolites were measured in a random one-half sample of children aged 6 through 11 years and in a random one-quarter sample of people aged 12-59 years. Age groups and sample sizes for each exposure measurement are shown in the tables.

NHANES Data Analysis

Because the NHANES sample design is complex, sample weights must be used to account for the unequal probability of selection into the survey. Sample weights are also used to adjust for possible bias resulting from nonresponse and are post-stratified to U.S. Census Bureau estimates of the

U.S. population. All data analyses were conducted at NCHS using the statistical software package, WESVAR, which uses sample weights and calculates variance estimates that account for the complex survey design. Selected percentiles and geometric means of analyte concentrations are presented. For each estimate, 95% confidence intervals are shown. Results are shown for the total population. For analytes that were measured in the full sample of people, results are also shown by age, sex, and race or ethnicity.

For these analyses, race or ethnicity is categorized as non-Hispanic black, Mexican American, and all others (most are non-Hispanic white). Analyte-concentration levels less than the limit of detection were assigned a value equal to the detection limit divided by the square root of 2 for calculation of geometric means. If the proportion of results below the limit of detection was greater than 40%, geometric means were not calculated. For urine measures, the Report shows data for both the concentration in urine and the concentration corrected for urine-creatinine level. Creatinine-corrected values for results below the limit of detection were calculated only if the proportion of results below the limit of detection was less than 10%. In those cases, the fill value used to calculate geometric means was used in the calculation.

Limitations On Estimates of Chemical Exposures From One Year of Data

Although the current NHANES is conducted using annual samples that are nationally representative, the sample size in any one year is relatively small, resulting in large variability for estimates, especially those for detailed demographic groups or other detailed analyses. NHANES is designed to increase precision by combining data across calendar years. Because of the small sample size in 1999, a number of survey participants have large sample weights, and the potential exists that these sample weights may strongly influence estimates. This factor is particularly important for chemical results that were only measured in subsamples of the population.

Another analytic limitation of the NHANES sample is that it is selected from a relatively small number of sampling units (PSUs) or counties; the 1999 sample was planned for only 12 PSUs. With a small number of PSUs, variance estimates that account for the complex design will be relatively unstable, a factor which introduces a higher level of uncertainty in the annual estimates. Although the annual NHANES is nationally representative, it is not possible to produce environmental exposure estimates by geographic region. Because the number of geographic sites sampled each year is small and because environmental exposure measures may vary geographically, national estimates based on one year of data may be highly variable.

These limitations related to measuring environmental exposures from a single year of NHANES will be addressed as more data become available from the ongoing survey. More detailed analyses by demographic groups and other variables will be possible with increased sample size and with a larger number of geographic locations.

Major Findings

First-Time Information About Exposure Levels in the U.S. Population

The Report provides information to scientists, public health officials, and the public about exposure to environmental chemicals in the U.S. population. It provides measures of exposure for 27 chemicals in the U.S. population based on blood and urine samples from people participating in the 1999 NHANES. CDC has previously assessed the exposure of the population through NHANES for three chemicals: lead, cadmium, and cotinine. The Report provides new data on these chemicals for the 1999 calendar year as well as data on 24 additional environmental chemicals (metals, organophosphate pesticides, and phthalates). Because the sample size in any one year of NHANES is relatively small and because the 1999 survey was only conducted in 12 locations across the country, data from additional years of the survey will be needed to confirm these findings.

Information About U.S. Population-Based Reference Ranges for Physicians and Health Researchers

The 1999 Report provides unique reference range values that are based on a sampling of the U.S. population. CDC had previously determined U.S. population-based reference ranges for lead, cadmium, and cotinine using NHANES data; the 1999 Report provides U.S. population-based reference-range results for 24 additional environmental chemicals.

Physicians use "normal" ranges for laboratory results to determine whether their patients have high or low values that would indicate that a health problem exists. These normal ranges are obtained from people who are generally healthy. In the 1999 Report, CDC determined reference ranges for 24 environmental chemicals from a group of people in the general population who were selected without regard to known exposure to these chemicals. Sometimes these reference ranges are referred to as "background exposure levels."

Reference ranges are extremely helpful to physicians and health researchers because levels above the reference range usually indicate exposure to a particular source. For example, if a physician was concerned about a patient's potential exposure to cadmium and measured a cadmium level in the patient's urine, the results could be compared with the population reference range shown in the 1999 Report. A cadmium level similar to those found in the Report would indicate exposure no different from those found in the general population, and a level much higher than those in the Report would indicate that there may have been an unusual exposure to cadmium worthy of further investigation.

Decline in Blood Lead Levels Among Children Since 1991-1994

Since 1976, CDC has measured levels of lead in blood as part of NHANES. Results presented in the 1999 Report show that the geometric mean blood lead level for children aged 1-5 years has decreased to 2.0 micrograms per deciliter (µg/dL) from 2.7 µg/dL, the geometric mean for the period 1991-1994. This decrease documents that blood lead levels continue to decline among U.S. children when considered as a group and highlights the success of public health efforts to decrease the exposure of children to lead. Nevertheless, special populations of children at high risk for lead exposure (e.g., those living in homes containing lead-based paint or lead-contaminated dust) remain a major public health concern.

Better Assessment of Children's and Women's Exposure to Mercury

The 1999 Report provides important new data on levels of mercury in blood among children 1 to 5 years old and among women of childbearing age (16-49 years old). The geometric mean of blood mercury levels among children (0.3µg/L) was about 25% of the geometric mean of blood mercury levels among women of childbearing age (1.2 µg/L). Compared with an adult, the fetus or child is usually more vulnerable to the effects of metals. Consequently, when addressing mercury exposures, health officials are particularly careful to protect the fetus and child. The Report provides data for children and levels for women of childbearing age that reflect levels of mercury to which the fetus is exposed. Scientists will use these new data to better estimate health risks for the fetus, children, and women of childbearing age from potential sources of mercury exposure.

Setting Priorities for Research on Phthalates

Phthalates are compounds commonly used in such consumer products as soap, shampoo, hair spray, and many types of nail polish. Some phthalates are used in flexible plastics such as blood bags and tubing. Animal research has focused on the reproductive effects of phthalates. For the 1999 Report, CDC scientists measured metabolites of seven major phthalates. Di-2-ethylhexyl phthalate (DEHP) and di-isononyl phthalate (DINP) are the two phthalates produced in greatest quantity, with diethyl phthalate (DEP) and dibutyl phthalate (DBP) produced in much lower quantities. However, data from the 1999 Report showed that levels of metabolites of DEP and DBP were much higher in the population than metabolites of either DEHP or DINP.

These new data have prompted CDC to conduct additional studies to explain these findings by examining the pathways by which these phthalates get into people's bodies. The data also indicate that health research needs to focus on DEP and DBP, given that the levels of their metabolites are much higher in the U.S. population.

Reduced Exposure of the U.S. Population to Environmental Tobacco Smoke

Cotinine is a metabolite of nicotine that tracks exposure to environmental tobacco smoke (ETS) among nonsmokers; higher cotinine levels reflect more exposure to ETS, which has been identified as a known human carcinogen. From 1988 through 1991, as part of NHANES III, CDC determined that the median level (50th percentile) of cotinine among nonsmokers in the United States was 0.2 nanograms per milliliter (ng/mL). Results from the 1999 Report showed that the median cotinine level among people aged 3 years and older has decreased to less than 0.050 ng/mL—more than a 75% decrease. This reduction in cotinine levels objectively documents a dramatic reduction in exposure of the general U.S. population to ETS since the period 1988-1991. However, since more than half of American youth are still exposed, ETS remains a major public health concern.

Toxicology and Health-Risk Information

The Report presents new data on the exposure of the U.S. population to environmental chemicals. This new information can be used to promote and prioritize research to determine health risks from different exposure levels of these chemicals when the risks are not known. One important factor to include in such research is duration of exposure. The measurement of an environmental chemical in a person's blood or urine does not by itself mean that the chemical causes disease. Advances in analytical methods allow us to measure lower and lower levels of environmental chemicals in people, but studies of varying exposure levels and health effects are required to determine which blood and urine levels are safe and which result in disease.

Information Available on the Internet

Links to non-federal organizations are provided solely as a service to our readers. These links do not constitute an endorsement of these organizations or their programs by CDC or the federal government, and none should be inferred. CDC is not responsible for the content of the individual organization's Web pages found at these links. For information about toxicology and health risks, see the following sites:

Federal and Non-Federal Internet Links

- ATSDR ToxFAQs: www.atsdr.cdc.gov/toxfaq.html or www.atsdr.cdc.gov/toxprofiles
- National Institute for Occupational Safety and Health (NIOSH), Occupational Health and Safety Guidelines for Chemical Hazards: www.cdc.gov/niosh/81-123.html
- National Toxicology Program Report on Carcinogens: http://ehis.niehs.nih.gov/roc/
- EPA Integrated Risk-Information System (IRIS): www.epa.gov/iris/
- International Programme on Chemical Safety (IPCS): www.who.int/pcs
- Chemfinder: www.chemfinder.com
- Material Safety Data Sheets: www.hazard.com/msds/index.html

U.S. Government-Related Internet Links

Centers for Disease Control and Prevention (CDC)

- NIOSH Pocket Guide to Chemical Hazards: www.cdc.gov/niosh/npg/npgd0000.html
- Registry of Toxic Effects of Chemical Substances (RTECS): www.cdc.gov/niosh/rtecs.html
- CDC's Tobacco Information and Prevention Source: www.cdc.gov/tobacco/
- CDC's National Center for Health Statistics: www.cdc.gov/nchs
- National Health and Nutrition Examination Survey: www.cdc.gov/nchs/nhanes.htm
- CDC's Childhood Lead Poisoning Prevention Program: www.cdc.gov/nceh/lead/lead.htm
- Pesticides and Public Health: Integrated Methods of Mosquito Management: www.cdc.gov/ncidod/eid/vol7no1/rose.htm

U.S. Department of Health and Human Services (HHS)

- Environmental Health Policy Committee: http://web.health.gov/environment

U.S. Food and Drug Administration (FDA)

Center for Devices and Radiological Health: www.fda.gov/cdrh
Center for Food Safety and Applied Nutrition: www.cfsan.fda.gov/
Center for Toxicological Research: www.fda.gov/nctr/

National Institutes of Health (NIH)

National Cancer Institute: www.nci.nih.gov
National Institute of Child Health and Human Development: www.nichd.nih.gov
National Institute for Environmental Health Sciences: www.niehs.nih.gov
National Toxicology Program (NTP) Chemical Health and Safety Data: http://ntp-server.niehs.nih.gov/Main_Pages/Chem-HS.html
National Toxicology Program Report on Carcinogens: http://eihs.niehs.nih.gov/roc/toc9.html
Chemical Carcinogenesis Research Information System: http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?CCRIS
Hazardous Susbstances Data Bank (HSDB®): http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB

U.S. Environmental Protection Agency (EPA)

Office of Air and Radiation Organizational Chart: www.epa.gov/oar/
Office of Environmental Information (OEI): www.epa.gov/oei/
Office of Prevention, Pesticides, and Toxic Substances (OPPTS): www.epa.gov/opptsfrs/home/opptsim.htm
Office of Research and Development (ORD): www.epa.gov/ORD
Office of Water (OW): www.epa.gov/OW/
Office of Pesticide Programs: www.epa.gov/pesticides
EPA Integrated Risk-Information System (IRIS): www.epa.gov/iris
EPA Envirofacts: www.epa.gov/enviro/index_java.html
Organophosphate pesticide common and trade names: www.epa.gov/oppbead1/matrices/oplist.htm
Lead: www.epa.gov/OGWDW/dwh/c-ioc/lead.html

U.S. Department of Agriculture (USDA)

Food Safety and Inspection Service: http://www.fsis.usda.gov
USDA, Forest Service Pesticide Fact Sheets: http://svinet2.fs.fed.us/foresthealth/pesticide

U.S. Department of Energy

Office of Environment, Safety and Health: http://tis.eh.doe.gov/portal/home.htm

U.S. Department of Housing and Urban Development (HUD)

Office of Healthy Homes and Lead-Hazard Control: www.hud.gov/offices/lead/

U.S. Consumer Product Safety Commission (CPSC)

www.cpsc.gov/

U.S. Department of Transportation (DOT)

Hazardous Materials Emergency-Response Guidebook: http://hazmat.dot.gov/erg2000/psnsort.htm

U.S. Department of Labor, Occupational Safety and Health Administration (OSHA):

http://www.osha.gov/index.html

Other Related Internet Sites

American College of Occupational and Environmental Medicine: http://www.acoem.org/
Association of Occupational and Environmental Clinics: http://www.aoec.org/
Association of Public Health Laboratories: http://www.aphl.org
International Chemical Safety Cards: http://www.ilo.org/public/english/protection/safework/cis/products/icsc/dtasht/index.htm
NRC Mercury Report: http://books.nap.edu/books/0309071402/html/index.html

Results By Chemical Group

Metals

Lead (CAS No. 7439-92-1)
General Information

Elemental lead is a naturally occurring, blue-gray metal found in small amounts in rock and soil. Lead has no distinctive taste or smell. Lead and lead compounds are used in storage batteries, ammunition, metal products (solder and pipes), roofing, gasoline, and devices to shield people from X-rays. Because of health concerns, lead had been banned from gasoline, ceramic products, paints for residential use, and solder used on food cans.

Industrially, lead and lead-contaminated dusts are released into the environment from the burning of fossil fuels or waste. Workplace exposures come mostly from dusty environments. Lead-based paint and lead-contaminated dust from this type of paint are the primary sources of lead exposure in the home. Preventing adverse health effects to children resulting from lead exposure remains a major public health effort.

Interpreting Lead Levels Reported in Tables

Table 1 presents blood lead results, and Table 2 shows urine lead results. Because of lead's adverse effects on cognitive development, CDC has defined an elevated blood lead level as equal to or greater than (≥) 10 µg/dL for children younger than 6 years of age. Data from NHANES III, Phase 2 (1991-1994)[6] showed that the geometric mean blood lead level for children 1-5 years old was 2.7 µg/dL (95% confidence interval: 2.5 µg/dL–3.0 µg/dL). Results in this 1999 Report for the same age group show that the geometric mean blood lead level has decreased to 2.0 µg/dL (95% confidence interval 1.7 µg/dL–2.3µg/dL). The sample size in the Report for 1999 is too small to provide reliable estimates of the percentage of children with blood lead levels ≥ 10 µg/dL. In future Reports, more data about blood lead levels will be available for this group, thus permitting reliable estimates of the percentage of children with elevated blood lead levels.

For other age and population groups defined by sex and race or ethnicity, the 1999 Report data show consistently lower levels than those measured in the 1991-1994 period,[3] and the relation of blood lead levels to age is consistent with that seen previously as well.[3] A recent CDC publication[6] included data from the 1999 Report for children 1-5 years old and additional state and local surveillance data for elevated blood lead levels among children. The article notes that although blood lead levels are dropping in these children when considered as a group, elevated blood lead levels among children continue to be a major public health concern.

Table 2 presents urine lead levels. Measuring lead in urine is used less often to gauge lead exposure. Percentiles shown in Table 2 will serve as reference levels so that urine results for individual patients can be compared with background levels found in the U.S. population in 1999.

Table 1. Geometric mean and selected percentiles of blood lead concentrations (in µg/dL) for the U.S. population, aged 1 year and older, by selected demographic groups, National Health and Nutrition Examination Survey, 1999.

	Sample size	Geometric mean (95% confidence interval)	Selected percentiles (95% confidence interval)				
			10th	25th	50th	75th	90th
Total, age 1 and older	3,189	1.6 (1.4-1.8)	0.7 (0.6-0.7)	1.0 (0.9-1.1)	1.5 (1.4-1.7)	2.3 (2.2-2.6)	3.7 (3.2-4.3)
Gender							
Male	1,594	1.9 (1.7-2.1)	0.8 (0.7-0.9)	1.2 (1.1-1.4)	1.8 (1.7-2.0)	2.7 (2.5-3.1)	4.3 (3.7-5.3)
Females	1,595	1.3 (1.2-1.5)	0.6 (0.4-0.7)	0.8 (0.7-0.9)	1.2 (1.1-1.4)	1.9 (1.7-2.1)	3.0 (2.6-3.5)
Race/Ethnicity							
Black, non-Hispanic	693	1.7 (1.5-2.0)	0.8 (0.6-0.8)	1.1 (0.9-1.3)	1.6 (1.4-1.8)	2.5 (2.2-3.0)	4.2 (3.3-5.2)
Mexican American	1,289	1.8 (1.6-2.0)	0.7 (0.6-0.8)	1.1 (0.9-1.2)	1.6 (1.4-1.9)	2.8 (2.3-3.3)	4.1 (3.8-5.2)
White, non-Hispanic*	1,207	1.5 (1.4-1.7)	0.6 (0.5-0.7)	1.0 (0.8-1.1)	1.5 (1.3-1.6)	2.3 (2.1-2.5)	3.5 (3.1-4.1)
Age Group							
1-5 years	254	2.0 (1.7-2.3)	0.9** (0.5-1.1)	1.3 (1.1-1.5)	1.9 (1.6-2.1)	2.7 (2.2-4.4)	4.7** (3.5-9.8)
6-11 years	419	1.3 (1.0-1.6)	0.6 (0.5-0.7)	0.8 (0.7-1.0)	1.2 (1.0-1.5)	1.7 (1.4-2.2)	2.7 (1.9-4.7)
12-19 years	868	1.0 (0.8-1.2)	0.4 (0.2-0.5)	0.6 (0.5-0.8)	0.9 (0.8-1.1)	1.4 (1.2-1.6)	2.1 (1.9-2.4)
20-39 years	595	1.4 (1.2-1.5)	0.6 (0.5-0.7)	0.8 (0.8-1.0)	1.3 (1.1-1.5)	2.0 (1.7-2.2)	2.8 (2.5-3.2)
40-59 years	471	1.9 (1.7-2.0)	0.9 (0.7-1.0)	1.2 (1.1-1.3)	1.8 (1.6-1.9)	2.7 (2.4-3.2)	3.8 (3.6-4.4)
60+ years	582	2.5 (2.2-2.8)	1.2 (1.1-1.3)	1.6 (1.5-1.9)	2.3 (2.1-2.7)	3.5 (3.0-4.3)	5.0 (4.5-6.4)

Numbers in parentheses are 95% confidence intervals.
* Includes other racial/ethnic groups.
**Estimate meets minimum standards of reliability but should be interpreted with caution.

Table 2. Geometric mean and selected percentiles of urine lead concentrations and creatinine-adjusted levels for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999

	Sample size	Geometric mean (95% confidence interval)	Selected percentiles (95% confidence interval)				
			10th	25th	50th	75th	90th
µg/L of urine	1,007	0.80 (0.68-0.91)	0.21 (0.15-0.26)	0.42 (0.34-0.51)	0.80 (0.72-0.88)	1.36 (1.17-1.69)	2.21 (1.98-2.72)
µg/L of creatinine*	1,007	0.72 (0.62-0.83)	0.31 (0.23-0.36)	0.45 (0.39-0.50)	0.69 (0.61-0.79)	1.11 (0.96-1.35)	1.67 (1.47-2.31)

Numbers in parentheses are 95% confidence intervals.
*µg per gram of creatinine in urine.

Mercury (CAS No. 7439-97-6)
General Information

Mercury is a naturally occurring metal that has several forms. Metallic mercury is a shiny, silver-white, odorless liquid. If heated, it forms a colorless, odorless gas. Mercury combines with other elements, such as chlorine, sulfur, or oxygen to form inorganic mercury compounds or salts that are usually white powders or crystals. Mercury also combines with carbon to make organic mercury compounds. The most common of these, methylmercury, is produced mainly by small organisms in water and soil. Increased levels of mercury in the environment can increase the amount of methylmercury that these small organisms produce. Metallic mercury is used to produce chlorine gas and caustic soda. It is also used in thermometers, dental fillings, and batteries.

Inorganic mercury (metallic mercury and mercury compounds) enters the air from the mining of ore deposits, the burning of coal, and the incineration of waste. It also enters the water or soil from natural deposits, disposal of wastes, and volcanic activity. Methylmercury concentrates in the food chain. Fish contaminated with mercury are a major source of methylmercury. Organic mercury is more toxic than inorganic mercury. The blood mercury level in the Report is total blood mercury and thus includes both organic and inorganic mercury. Most measures of inorganic mercury were below the limit of detection; therefore, these measurements are a good indication of methylmercury exposure.

Interpreting Mercury Levels Reported in the Table

Total blood mercury levels shown in Table 3 are for children selected to represent the general U.S. population aged 1- 5 years and women aged 16-49 years. Extremely limited information has been available about children's exposure to mercury and how it relates to levels in adults. The geometric mean of blood mercury levels among children (0.3µg/L) was about 25% of the geometric mean of blood mercury levels among women of childbearing age (1.2µg/L). Levels among women of childbearing age are particularly important because they reflect levels of mercury to which the fetus is exposed.[7]

The National Research Council (NRC) recently completed a toxicologic review of mercury levels.[7] The NRC calculated a benchmark dose (BMD), which was an estimate of a methylmercury exposure to the fetus associated with an increase in abnormal scores on cognitive function tests among children.[7] The lower 95% confidence bound of the BMD was 59µg/L. The 90th percentiles of mercury levels among children 1- 5 years old and women of childbearing age are below this level. Approximately 10% of women have mercury levels within one-tenth of this level.

Table 3. Geometric mean and selected percentiles of total blood mercury concentrations (in µg/L) for U.S. children aged 1-5 years and women aged 16-49 years, National Health and Nutrition Examination Survey, 1999.

	Sample size	Geometric mean (95% confidence interval)	Selected percentiles (95% confidence interval)				
			10th	25th	50th	75th	90th
Children, aged 1-5 years, males and females	248	0.3 (0.2-0.4)	< LOD*	< LOD	0.2 (0.2-0.3)	0.5 (0.4-0.8)	1.4** (0.7-4.8)
Females, 16-49 years	679	1.2 (0.9-1.6)	0.2 (0.1-0.3)	0.5 (0.4-0.7)	1.2 (0.8-1.6)	2.7 (1.8-4.5)	6.2 (4.7-7.9)

Numbers in parentheses are 95% confidence intervals.
< LOD means below the limit of detection of the analytical method.
* Less than the limit of detection of 0.1µg/L blood.
**Estimate meets minimum standards of reliability but should be interpreted with caution.

Cadmium (CAS No. 7440-43-9)
General Information

Elemental cadmium is a silver-white metal. In nature, it is usually found combined with other elements such as oxygen (cadmium oxide), chlorine (cadmium chloride), or sulfur (cadmium sulfate, cadmium sulfide). Cadmium does not corrode easily and has many uses. In industry and consumer products, it is used for batteries, pigments, metal coatings, and plastics. Cadmium or its compounds have no definite taste or odor.

Cadmium gets into the environment from the weathering of rocks and minerals that contain cadmium. Exposure to cadmium can occur in industries, such as mining or electroplating, that commonly use or produce the chemical. Cadmium exposure can also occur from exposure to cigarette smoke.

*Interpreting Blood and Urine Cadmium Levels Reported in the Table*s

In the 1999 Report, blood cadmium levels were measured in people 1 year old and older, and urine cadmium levels were measured in a sample of people 6 years old and older. Blood cadmium results are shown in Table 4 and urine cadmium results in Table 5, expressed as urine concentration and urine concentration adjusted for creatinine. Blood and urine cadmium levels in these tables are for people selected to represent the general U.S. population. Measuring cadmium at these levels in blood and urine is possible because of advances in analytical chemistry. Finding a measurable amount of cadmium in the blood or urine does not mean that the level of cadmium causes an adverse health effect.

The Occupational Safety and Health Administration (OSHA) has developed criteria for evaluating occupational exposures. For blood cadmium, the criterion is 5 micrograms per liter (µg/L) of blood; for urine cadmium, the criterion is 3 µg/gram.[8] Occupational criteria are provided here for comparison only, not to imply a safety level for general population exposure. The 90th percentile for blood cadmium reported in Table 4 is less than the OSHA blood cadmium level, and the 90th percentile for urine cadmium shown in Table 5 is less that the OSHA urine cadmium level. Whether cadmium at the levels reported here is a cause for health concern is not yet known; more research is needed.

The blood cadmium data indicate that exposure is similar among males and females as well as among the racial or ethnic groups sampled. Levels were higher among people 20 years old and older than among people aged 1 through 19 years.

These data provide physicians with a reference range so that they can determine whether people have been exposed to higher levels of cadmium than those found in the general population. These data will also help scientists plan and conduct research about cadmium exposure and health effects.

Table 4. Geometric mean and selected percentiles of blood cadmium concentrations (in µg/L) for the U.S. population, aged 1 year and older, by selected demographic groups, National Health and Nutrition Examination Survey, 1999.

	Sample size	Selected percentiles (95% confidence interval)				
		10th	25th	50th	75th	90th
Total, age 1 year and older	3,189	< LOD**	< LOD	0.3 (0.2-0.3)	0.5 (0.4-0.6)	0.9 (0.7-1.1)
Gender						
Males	1,594	< LOD	< LOD	< LOD	0.5 (0.4-0.6)	0.9 (0.8-1.1)
Females	1,595	< LOD	< LOD	0.3 (0.2-0.3)	0.5 (0.4-0.6)	0.9 (0.7-1.2)
Race/Ethnicity						
Black, non-Hispanic	693	< LOD	< LOD	< LOD	0.5 (0.4-0.6)	0.9 (0.7-1.2)
Mexican American	1,289	< LOD	< LOD	0.3 (0.2-0.4)	0.5 (0.4-0.5)	0.7 (0.6-1.0)
White, non-Hispanic*	1,207	< LOD	< LOD	0.3 (0.2-0.3)	0.5 (0.4-0.6)	0.9 (0.7-1.1)
Age Group						
1-19 years	1,541	< LOD	< LOD	< LOD	< LOD	0.4 (0.3-1.0)
20+ years	1,648	< LOD	< LOD	0.3 (0.3-0.4)	0.6 (0.5-0.7)	1.0 (0.8-1.3)

Numbers in parentheses are 95% confidence intervals.
* Includes other racial/ethnic groups.
**Less than the limit of detection of the analytical method.

Table 5. Geometric mean and selected percentiles of urine cadmium concentrations and creatinine-adjusted levels for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999.

	Sample size	Geometric mean (95% confidence interval)	Selected percentiles (95 % confidence interval)				
			10th	25th	50th	75th	90th
µg/L of urine	1,007	0.32 (0.30-0.33)	0.10 (0.08-0.12)	0.18 (0.15-0.19)	0.33 (0.29-0.35)	0.57 (0.52-0.62)	0.95 (0.85-1.04)
µg/g of creatinine*	1,007	0.29 (0.27-0.31)	0.11 (0.10-0.13)	0.17 (0.15-0.19)	0.27 (0.26-0.30)	0.46 (0.43-0.50)	0.74 (0.66-0.79)

Numbers in parentheses are 95% confidence intervals.
* µg per gram of creatinine in urine.

Cobalt (CAS No. 7440-48-4)
General Information

Cobalt is an element that occurs in nature either as a steel-gray, shiny, hard metal or combined with other elements. The cobalt used in U.S. industry is imported or obtained by recycling scrap metal that contains cobalt. Among its many uses are making alloys (mixtures of metals), colored pigments, and fertilizers. It is also used as a drier for paint and porcelain enamel used on steel bathroom fixtures, large appliances, and kitchenware. Small amounts of cobalt naturally occur in food. In addition, vitamin B_{12} is a cobalt-containing compound that is essential for good health.

Cobalt occurs naturally in dust, seawater, and many types of soil. It is also emitted into the environment from burning coal and oil and from car and truck exhaust.

Interpreting Urine Cobalt Levels Reported in the Table

Urine cobalt levels were measured in a subsample of NHANES participants aged 6 years and older who were selected to be representative of the U.S. population. Measuring cobalt at these levels in urine is possible because of advances in analytical chemistry. Finding a measurable amount of cobalt in urine does not mean that the level of cobalt causes an adverse health effect.

There are no OSHA criteria for occupational levels of cobalt in blood or urine. The American Conference of Governmental Industrial Hygienists (ACGIH), a private organization, publishes biological exposure indices (BEIs) and has determined that the BEI "generally indicate a concentration below which nearly all workers should not experience adverse health effects."[9] The BEIs generally correspond to the uptake levels expected when workers are exposed at air-exposure limits set by ACGIH. This organization notes that these values are for workers and that it is not appropriate to apply them to the general population. Information about the BEI level is provided here for comparison, not to imply that the BEI is a safety level for general population exposure. For urine cobalt, the BEI is 15µg/L.[9] The 90th percentile of urine cobalt levels reported in Table 6 is less than this level. Whether cobalt at the levels reported here is a cause for health concern is not yet known; more research is needed.

These data provide physicians with a reference range so that they can determine whether people have been exposed to higher levels of cobalt than those found in the general population. These data will also help scientists plan and conduct research about cobalt exposure and health effects.

Table 6. Geometric mean and selected percentiles of urine cobalt concentrations and creatinine-adjusted levels for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999.

	Sample size	Geometric mean (95% confidence interval)	Selected Percentiles (95% confidence interval)				
			10th	25th	50th	75th	90th
µg/L of urine	1,007	0.36 (0.32-0.40)	0.11 (0.08-0.14)	0.23 (0.19-0.26)	0.40 (0.35-0.41)	0.60 (0.54-0.68)	0.89 (0.79-1.10)
µg/g of creatinine*	1,007	0.33 (0.29-0.36)	0.14 (0.12-0.16)	0.20 (0.18-0.22)	0.30 (0.27-0.34)	0.47 (0.42-0.54)	0.80 (0.63-1.11)

Numbers in parentheses are 95% confidence intervals.
*µg per gram of creatinine in urine.

Uranium (CAS No. 7439-97-6)
General Information

Uranium is a silver-white, extremely dense radioactive metal. It almost never occurs as an uncombined metal but rather as a compound with oxygen, chlorine, or fluorine. Uranium has many commercial uses, including its use in nuclear weapons, nuclear fuel, armor-piercing shells, and in colored glass and ceramics.

Uranium exposure generally is associated with its commercial uses, occurring mostly by inhaling dust and other small particles. Some uranium can be absorbed from food and water, especially in areas where large amounts of uranium occur naturally.

Interpreting Uranium Levels Reported in the Table

Urine uranium levels were measured in a subsample of NHANES participants 6 years old and older who were selected to be representative of the U.S. population. The analytical method used measured levels of the U^{238} isotope, not levels of the U^{235} isotope (the form of uranium used as nuclear fuel). More than 99% of naturally occurring uranium is U^{238}. Measuring uranium at these levels in urine is possible because of advances in analytical chemistry. Finding a measurable amount of uranium in urine does not mean that the level of uranium causes an adverse health effect. The United States Nuclear Regulatory Commission has set an action level for uranium in urine to protect workers occupationally exposed to uranium.[10] This urine uranium level is 15µg/L. The 90th percentile of urine uranium levels in Table 7 is below this level. Whether uranium at the levels reported here is cause for health concern is not yet known; more research is needed.

These urine uranium data provide physicians with a reference range so that they can determine whether people have been exposed to higher levels of uranium than those found in the general population. These data will also help scientists plan and conduct research about uranium exposure and health effects.

Table 7. Geometric mean and selected percentiles of uranium urine concentrations and creatinine-adjusted levels for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999.

	Sample size	Geometric Mean (95% confidence interval)	Selected percentiles (95% confidence intervals)				
			10th	25th	50th	75th	90th
µg/L of urine	1,006	0.008 (0.006-0.011)	< LOD**	< LOD	0.007 (0.004-0.010)	0.014 (0.009-0.030)	0.034 (0.022-0.053)
µg/g of creatinine*	1,006	---	< LOD	< LOD	(0.005) (0.002-0.009)	0.011 (0.005-0.026)	0.024 (0.015-0.109)

Numbers in parentheses are 95% confidence intervals.
* µg per gram of creatinine in urine.
**Less than the limit of detection of 0.004 µg/L in urine.

Antimony (CAS No. 7440-36-0)
General Information

Elemental antimony is a silver-white metal. In nature, antimony can be found in ores or other minerals, usually combined with oxygen to form antimony oxide. Antimony is used in storage batteries, solder, sheet and pipe metal, bearings, castings, and pewter. Antimony oxide is added to textiles and plastics to prevent them from catching fire. It is also used in paints; ceramics; fireworks; and in enamels for plastics, metal, and glass.

Antimony gets into the environment from natural sources and from industry. Exposure to antimony can come from food, drinking water, or air. Workplace exposure occurs as a result of breathing the air near industries such as smelters, coal-fired plants, and refuse incinerators that process or release antimony.

Interpreting Antimony Levels Reported in the Table

Urine antimony levels were measured in a subsample of NHANES participants aged 6 years and older who were selected to be representative of the U.S. population. Measuring antimony at these levels in urine is possible because of advances in analytical chemistry. Finding a measurable amount of antimony in urine does not mean that the level of antimony causes an adverse health effect. Whether antimony at the levels reported here is a cause for health concern is not yet known; more research is needed.

These urine antimony data provide physicians with a reference range so that they can determine whether people have been exposed to higher levels of antimony than those found in the general population. These data will also help scientists plan and conduct research about exposure to antimony and health effects.

Table 8. Geometric mean and selected percentiles of urine antimony concentrations and creatinine-adjusted levels for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999.

	Sample size	Geometric mean (95% confidence interval)	Selected percentiles (95% confidence intervals)				
			10th	25th	50th	75th	90th
µg/L of urine	912	0.10 (0.09-0.12)	< LOD**	0.05 (0.03-0.07)	0.10 (0.09-0.12)	0.19 (0.16-0.21)	0.29 (0.27-0.34)
µg/g of creatinine*	912	---	< LOD	0.4 (***-0.05)	0.08 (0.07-0.09)	0.13 (0.10-0.16)	0.19 (0.17-0.24)

Numbers in parentheses are 95% confidence intervals.
* µg per gram of creatinine in urine.
** Less than the limit of detection of 0.04 µg/L of urine
***Results that were below the limit of detection were not adjusted for creatinine. The lower confidence interval is not defined; the estimate is below the limit of detection.

Barium (CAS No. 7440-39-3)
General Information

Elemental barium is a silver-white metal. In nature, it combines with other chemicals such as sulfur or carbon and oxygen. Barium compounds are used by the oil and gas industries to make drilling muds. These compounds are also produced commercially for use in paint, bricks, tiles, glass, and rubber. Barium sulfate is used by doctors to perform medical tests and as a contrast medium for taking X-rays of the gastrointestinal tract.

People are exposed to barium in air, water, and food. Workers employed by industries that make or use barium compounds are exposed to barium dust. The health effects of the different barium compounds depend on how well the compound dissolves in water.

Interpreting Barium Levels Reported in the Table

Urine barium levels were measured in a subsample of NHANES participants aged 6 years and older who were selected to be representative of the U.S. population. Measuring barium at these levels in urine is possible because of advances in analytical chemistry. Finding a measurable amount of barium in urine does not mean that the level of barium causes an adverse health effect. Whether barium at the levels reported here is a cause for health concern is not yet known; more research is needed.

These urine barium data provide physicians with a reference range so that they can determine whether people have been exposed to higher levels of barium than those found in the general population. These data will also help scientists plan and conduct research about exposure to barium and health effects.

Table 9. Geometric mean and selected percentiles of urine barium concentrations and creatinine-adjusted levels for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999.

	Sample size	Geometric mean (95% confidence interval)	Selected percentiles (95% confidence interval)				
			10th	25th	50th	75th	90th
µg/L of urine	779	1.6 (1.5-1.7)	0.3 (0.3-0.4)	0.8 (0.7-0.9)	1.7 (1.5-1.9)	2.9 (2.7-3.3)	5.5 (4.2-6.2)
µg/g of creatinine*	779	1.5 (1.3-1.6)	0.4 (0.4-0.6)	0.9 (0.8-1.0)	1.5 (1.4-1.6)	2.4 (2.1-2.8)	4.5 (3.9-5.1)

Numbers in parentheses are 95% confidence intervals.
* µg per gram of creatinine in urine.

Beryllium (CAS No. 7440-41-7)
General Information

Pure beryllium is a hard, gray metal. In nature, beryllium can be found in mineral rocks, coal, soil, and volcanic dust. Beryllium compounds are commercially mined, and the beryllium is purified for use in mirrors; nuclear weapons; and electrical, aircraft, and machine parts. Beryllium compounds have no distinctive smell. Beryllium dust gets into ambient air from burning coal and oil. Exposure to beryllium occurs mostly in the workplace, near some hazardous waste sites, and from breathing tobacco smoke.

Interpreting Beryllium Results Reported in the Table

Urine beryllium levels were measured in a subsample of NHANES participants aged 6 years old and older who were selected to be representative of the U.S. population. All of the levels in the table are below the limit of detection of the analytical method for beryllium, which was 0.13 µg/L.

Table 10. Geometric mean and selected percentiles of urine beryllium concentrations and creatinine-adjusted levels for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999.

	Sample size	Geometric mean (95% confidence interval)	Selected percentiles (95% confidence interval)				
			10th	25th	50th	75th	90th
µg/L of urine	1,007	---	< LOD**	< LOD	< LOD	< LOD	< LOD
µg/g of creatinine*	1,007	---	< LOD	< LOD	< LOD	< LOD	< LOD

*µg per gram of creatinine in urine.
** Less than the limit of detection of 0.13 µg/L in urine.

Cesium (CAS No. 7440-46-2)
General Information

Cesium is a silver-white metal that ignites on contact with air and reacts explosively with water. Cesium can be found naturally in rock, soil, and clay. It occurs as an aluminosilicate (pollucite and lepidolite) and as a borate (rhodizite). Cesium compounds are commonly used in photomultipliers, vacuum tubes, scintillation counters, infrared lamps, semiconductors, high-power gas-ion devices, and photographic emulsions.[11, 12]

Interpreting Cesium Levels Reported in the Table

Urine cesium levels were measured in a subsample of NHANES participants aged 6 years and older who were selected to be representative of the U.S. population. Measuring cesium at these levels in urine is possible because of advances in analytical chemistry. Finding a measurable amount of cesium in urine does not mean that the level of cesium causes an adverse health effect.

Whether cesium at the levels reported here is cause for health concern is not yet known; more research is needed. These urine cesium data provide physicians with a reference range so that they can determine whether people have been exposed to higher levels of cesium than those found in the general population. These data will also help scientists plan and conduct research about exposure to cesium and health effects.

Table 11. Geometric mean and selected percentiles of urine cesium concentrations and creatinine-adjusted levels for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999.

	Sample size	Geometric mean (95% confidence interval)	Selected percentiles (95% confidence interval)				
			10th	25th	50th	75th	90th
µg/L of urine	1,006	4.7 (4.2-5.2)	1.8 (1.4-2.2)	3.3 (2.9-3.6)	5.3 (4.7-5.8)	7.2 (6.7-8.0)	9.6 (8.5-11.6)
µg/g of creatinine*	1,006	4.3 (3.8-4.7)	2.5 (2.1-2.7)	3.2 (2.9-3.5)	4.2 (3.8-4.6)	5.4 (4.9-6.3)	7.1 (6.5-8.7)

*µg per gram of creatinine in urine.
Numbers in parentheses are 95% confidence intervals.

Molybdenum (CAS No. 7439-98-7)
General Information

Molybdenum occurs naturally in compounds with other elements. Elemental molybdenum is a silver-white, hard metal with many commercial uses, including the production of metal alloys. Molybdenum is also a nutritionally essential trace element.

Molybdenum enters the environment from the weathering of ores that contain it and from water containing the metal in its soluble forms. In industry, the dust and other fine particles produced in refining or shaping molybdenum are the most important sources of exposure.

Interpreting Molybdenum Levels Reported in the Table

Urine molybdenum levels were measured in a subsample of NHANES participants aged 6 years and older who were selected to be representative of the U.S. population. Measuring molybdenum at these levels is possible because of advances in analytical chemistry. Finding a measurable amount of molybdenum in urine does not mean that the level of molybdenum causes an adverse health effect. Whether molybdenum at the levels reported here is cause for health concern is not yet known; more research is needed.

These urine molybdenum data provide physicians with a reference range so that they can determine whether people have been exposed to higher levels of molybdenum than those found in the general population. These data will also help scientists plan and conduct research about molybdenum exposure and health effects.

Table 12. Geometric mean and selected percentiles of molybdenum urine concentrations and creatinine-adjusted levels for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999.

	Sample size	Geometric mean (95% confidence interval)	Selected percentiles (95% confidence interval)				
			10th	25th	50th	75th	90th
µg/L of urine	904	48.4 (43.6-53.2)	13.1 (10.8-17.3)	27.6 (23.4-32.8)	53.3 (47.3-61.5)	86.6 (78.6-97.5)	140 (120-174)
µg/g of creatinine*	904	43.9 (40.6-47.2)	19.0 (15.4-23.3)	28.4 (26.6-29.3)	41.1 (38.6-44.9)	65.2 (61.4-71.5)	113 (90.6-126)

*µg per gram of creatinine in urine.
Numbers in parentheses are 95% confidence intervals.

Platinum (CAS No. 7440-06-4)
General Information

Platinum is a silver-gray, lustrous, malleable metal found naturally in the earth's crust and typically is associated with nickel, copper, or iron-sulfide seams. Important properties of platinum and the compounds it forms are resistance to corrosion, strength at high temperatures, and high catalytic activity.

Platinum-rhodium and platinum-palladium crystals are used to reduce automobile-exhaust emissions. Platinum-rhodium compounds are used in glass and glass-fiber manufacture and in high-temperature thermocouples. Other platinum compounds have a variety of uses, including anticancer treatments. Platinum compounds are also used in electrodes and jewelry, as oxidation catalysts in chemical manufacturing, and in thick-film circuits printed on ceramic substrates.[11, 12]

Interpreting Platinum Levels Reported in the Table

Urine platinum levels were measured in a subsample of NHANES participants aged 6 years and older who were selected to be representative of the U.S. population. All of the levels in the table are below the limit of detection of the analytical method for platinum, which was 0.04 µg/L.

Table 13. Geometric mean and selected percentiles of platinum urine concentrations and creatinine-adjusted levels for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999.

	Sample size	Geometric mean (95% confidence interval)	Selected percentiles (95% confidence interval)				
			10th	**25th**	**50th**	**75th**	**90th**
µg/L of urine	1,007	---	< LOD**	< LOD	< LOD	< LOD	< LOD
µg/g of creatinine*	1,007	---	< LOD	< LOD	< LOD	< LOD	< LOD

*µg per gram of creatinine in urine.
** Less than the limit of detection of 0.04µg/L in urine.

Thallium (CAS No. 7440-28-0)
General Information

Elemental thallium is a blue-white metal that is found in small amounts in soil and rocks. In the past, thallium was obtained as a byproduct of smelting other metals; however, it has not been produced in the United States since 1984. Thallium and most of its compounds are odorless and tasteless.

Thallium exposure occurs primarily from commercial processes such as coal-burning and smelting. In these and other sources, thallium is produced in fine particles that can then be absorbed by breathing. One rare, but significant, accidental exposure to thallium can occur by eating rat poison that contains water-soluble thallium salts. In the United States, thallium has been banned for use in rat poisons.

Interpreting Thallium Levels Reported in the Table

Urine thallium levels were measured in a subsample of NHANES participants aged 6 years and older who were selected to be representative of the U.S. population. Measuring thallium at these levels in urine is possible because of advances in analytical chemistry. Finding a measurable amount of thallium in urine does not mean that the level of thallium causes an adverse health effect. Whether thallium at the levels reported here is a cause for health concern is not yet known; more research is needed.

These urine thallium data provide physicians with a reference range so that they can determine whether people have been exposed to higher levels of thallium than those found in the general population. These data will also help scientists plan and conduct research about thallium exposure and health effects.

Table 14. Geometric mean and selected percentiles of urine thallium concentrations and creatinine-adjusted levels for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999.

	Sample size	Geometric mean (95% confidence interval)	Selected percentiles (95% confidence interval)				
			10th	25th	50th	75th	90th
µg/L of urine	974	0.19 (0.17-0.20)	0.07 (0.06-0.07)	0.12 (0.10-0.13)	0.21 (0.19-0.23)	0.30 (0.28-0.33)	0.42 (0.39-0.45)
µg/g of creatinine*	974	0.17 (0.16-0.18)	0.09 (0.08-0.09)	0.13 (0.11-0.14)	0.17 (0.16-0.18)	0.22 (0.21-0.24)	0.29 (0.27-0.35)

Numbers in parentheses are 95% confidence intervals.
*µg per gram of creatinine in urine.

Tungsten (CAS No. 7440-33-7)
General Information

Tungsten, also known as wolfram, is a steel-gray to tin-white metal naturally occurring in the earth's crust, mainly as scheelite ($CaWO_4$). A major use of tungsten is in the production of hard metals (i.e., tungsten carbide, which is common in rock drills and metal-cutting tools; or ferrotungsten, which is used in the steel industry). Additionally, tungsten compounds are used as catalysts in the petroleum industry, as lubricating agents, in filaments for incandescent lamps, and as bronzes in pigments.[11, 12]

Interpreting Tungsten Levels Reported in the Table

Urine tungsten levels were measured in a subsample of NHANES participants aged 6 years and older who were selected to be representative of the U.S. population. Measuring tungsten at these levels in urine is possible because of advances in analytical chemistry. Finding a measurable amount of tungsten in urine does not mean that the level of tungsten causes an adverse health effect. Whether tungsten at the levels reported here is a cause for health concern is not yet known; more research is needed.

These urine tungsten data provide physicians with a reference range so that they can determine whether people have been expose to higher levels of tungsten than those found in the general population. These data will also help scientists plan and conduct research about tungsten exposure and health effects.

Table 15. Geometric mean and selected percentiles of tungsten urine concentrations and creatinine-adjusted levels in the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999.

	Sample size	Geometric mean (95% confidence interval)	Selected percentiles (95% confidence interval)				
			10th	25th	50th	75th	90th
µg/L of urine	892	0.10 (0.09-0.12)	< LOD**	0.05 (0.03-0.06)	0.10 (0.08-0.11)	0.18 (0.16-0.22)	0.32 (0.27-0.45)
µg/g of creatinine*	892	---	< LOD	0.03 (***-0.05)	0.07 (0.06-0.09)	0.14 (0.11-0.18)	0.23 (0.19-0.38)

Numbers in parentheses are 95% confidence intervals.
*µg per gram of creatinine in urine.
** Less than the limit of detection of 0.04µg/L of urine.
***Results that were below the limit of detection were not adjusted for creatinine. The lower confidence interval is not defined; the estimate is below the limit of detection.

Tobacco Smoke

Cotinine (CAS No. 486-56-6)
General Information

Tobacco use is the most important, preventable cause of premature morbidity and mortality in the United States. The consequences of smoking and the use of smokeless tobacco products are well known and include, but are not limited to, an increased risk for cancer, emphysema, and cardiovascular disease. For example, lung cancer is the number-one cancer killer of both men and women in the United States, and smoking is by far the leading cause of lung cancer. Environmental tobacco smoke (ETS) is a known human carcinogen, and persistent exposure to ETS is associated with an increased risk for lung cancer and other disease. Children are at particular risk from ETS, which may exacerbate asthma among susceptible children and also greatly increase the risk for lower respiratory-tract illness, such as bronchitis and pneumonia, among young children.

Cotinine is a major metabolite of nicotine and is currently regarded as the best biomarker for exposure of active smokers and nonsmokers to ETS. Measuring cotinine is preferred over measuring nicotine because, although both are specific for exposure to tobacco, cotinine is retained in the body much longer than nicotine. Cotinine can be measured in blood (i.e., in serum), urine, saliva, and hair. Nonsmokers exposed to typical levels of ETS have cotinine levels of less than 1 ng/mL, with heavy exposure to ETS producing levels in the 1-15 ng/mL range. Active smokers almost always have levels higher than 15 ng/mL and sometimes greater than 500 ng/mL.

Interpreting Cotinine Levels Reported in the Table

Table 16 presents data for the U.S. nonsmoking population aged 3 years and older. For these results, nonsmoking is defined as a serum cotinine level less than or equal to ($\leq$) 15 ng/mL, and for people 12 years and older, no reported use of tobacco or nicotine-containing products in the last 5 days. The limit of detection (LOD) for these measurements was 0.050 ng/mL.

From 1988 through 1991, as part of NHANES III, CDC determined that the median level (50^{th} percentile) of cotinine among nonsmokers in the United States was 0.20 ng/mL.[5] Results shown in Table 16 show that the median cotinine level in 1999 has decreased to less than 0.050 ng/mL—more than a 75% decrease. This reduction in cotinine levels objectively documents a dramatic reduction in exposure of the general U.S. population to ETS since the period 1988-1991.

Compared with results for the period 1988-1991 for population groups defined by age, sex, and race or ethnicity,[5] all results in Table 16 show declines in cotinine levels. Previously, higher levels of cotinine have been noted for non-Hispanic blacks,[13] and although levels for this population group have declined, they are still higher than those of other racial or ethnic groups. As seen previously,[5] males continue to have higher levels than females, and people 20 years old and older have lower levels than those younger than 20 years of age. Table 16 appears on the next page.

Table 16. Selected percentile of serum cotinine concentrations (in ng/mL) for the U.S. nonsmoking population aged 3 years and older, National Health and Nutrition Examination Survey, 1999.

	Sample size	Selected percentiles (95% confidence intervals)				
		10th	25th	50th	75th	90th
Total, age 3 years and older	2,263	< LOD***	< LOD	< LOD	0.15 (0.11-0.23)	0.52 (0.38-1.01)
Gender						
Males	1,075	< LOD	< LOD	0.6 (0.04-0.09)	0.20 (0.13-0.31)	0.61 (0.41-1.46)
Females	1,188	< LOD	< LOD	< LOD	0.12 (0.09-0.17)	0.46 (0.30-0.93)
Race/Ethnicity						
Black, non-Hispanic*	467	< LOD	< LOD	0.12 (0.10-0.14)	0.50 (0.42-0.67)	1.59 (1.14-2.16)
Mexican American	937	< LOD	< LOD	< LOD	0.12 (0.08-0.24)	0.34 (0.21-1.01)
White, non-Hispanic**	859	< LOD	< LOD	< LOD	0.12 (0.09-0.21)	0.45 (0.30-1.01)
Age Group						
3-19 years	1,152	< LOD	< LOD	0.07 (0.04-0.13)	0.32 (0.16-0.63)	1.13 (0.58-2.77)
20+ years	937	< LOD	< LOD	< LOD	0.12 (0.09-0.15)	0.38 (0.30-0.56)

Numbers in parentheses are 95% confidence intervals.
*Research in progress to determine whether levels for black, non-Hispanic people may be affected by biological factors.
**Includes other racial/ethnic groups.
***Less than the limit of detection of 0.05ng/mL in serum.

Organophosphate Pesticides

General Information

Organophosphate pesticides account for about half of the insecticides used in the United States. Approximately 60 million pounds of organophosphate pesticides are applied to about 60 million acres of U.S. agricultural crops annually; nonagricultural uses account for about 17 million pounds per year.[14] Organophosphate pesticides are active against a broad spectrum of insects and are used on food crops as well as in residential and commercial buildings and on ornamental plants and lawns. Exposure of the general population to these pesticides occurs primarily from ingestion of food products or from residential use.

About 75% of the registered pesticides metabolize to the dialkyl phosphate metabolites.[15] This Report provides measurements in urine for the following six urinary metabolites of organophosphate pesticides:

- Dimethylphosphate (DMP).
- Dimethylthiophosphate (DMTP).
- Dimethyldithiophosphate (DMDTP).
- Diethylphosphate (DEP).
- Diethylthiophosphate (DEPT).
- Diethyldithiophosphate (DEDTP).

Table 17 shows the six urinary metabolites and their parent organophosphate pesticides. For example, chlorpyrifos metabolizes to diethylphosphate and diethythiophosphate. Measurement of these metabolites reflects exposure to organophosphate pesticides that has occurred predominantly in the last few days. Note that each of the six urinary metabolites can be produced from the metabolism of more than one organophosphate pesticide. In addition to reflecting exposure to the parent pesticides, the level of the metabolite in a person's urine may also reflect exposure to the metabolite itself if it was present in the person's environment.

The mechanism of toxicity of the organophosphate pesticides is inhibition of acetylcholinesterase, which catalyzes the deacetylation of acetylcholine. Acetylcholine helps transfer nerve impulses between nerve cells or from a nerve cell to other types of cells, such as muscle cells. Inhibition of the enzyme acetylcholinesterase leads to the build-up of acetylcholine, which then overstimulates muscles, causing symptoms such as weakness and sometimes paralysis.

Interpreting Organophosphate Metabolite Levels in the Tables

Urine levels of metabolites of organophosphate pesticides were measured in a subsample of NHANES participants 6 through 59 years of age who were selected to be representative of the U.S. population. As noted above, a particular metabolite may come from multiple parent organophosphate pesticides. Measuring these metabolites at these levels in urine is possible because of advances in analytical chemistry. Finding a measurable amount of one or more metabolites in urine does not mean that the level of the organophosphates causes an adverse health effect. Whether organophosphate pesticides at the levels of metabolites reported here are a cause for health concern is not known; more research is needed.

These data provide physicians with a reference range so that they can determine whether people have been exposed to higher levels of organophosphate pesticides than those experienced in the general population. Tables 18-23 summarize results of these tests. These data will help scientists plan and conduct research about exposure to organophosphate pesticides and health effects.

Table 17. Organophosphate pesticides and their metabolites

Pesticide	DMP*	DMTP	DMDTP	DEP	DEPT	DEDTP
Azinphos methyl	X	X	X			
Chlorethoxyphos				X	X	
Chlorpyrifos				X	X	
Chlorpyrifos methyl	X	X				
Coumaphos				X	X	
Dichlorvos (DDVP)	X					
Diazinon				X	X	
Dicrotophos	X					
Dimethoate	X		X			
Disulfoton				X	X	X
Ethion				X	X	X
Fenitrothion	X	X				
Fenthion	X	X				
Isazaphos-methyl	X	X				
Malathion	X	X	X			
Methidathion	X	X	X			
Methyl parathion	X	X				
Naled	X					
Oxydemeton-methyl	X	X				
Parathion				X	X	
Phorate				X	X	X
Phosmet	X	X	X			
Pirimiphos-methyl	X	X				

Pesticide	DMP*	DMTP	DMDTP	DEP	DEPT	DEDTP
Sulfotepp				X	X	
Temephos	X	X				
Terbufos				X	X	X
Tetrachlorviphos	X					
Trichlorfon	X					

Dimethylphosphate (CAS No. 813-78-5)

Table 18. Geometric mean and selected percentiles of dimethylphosphate urine concentrations and creatinine-adjusted levels for the U.S. population aged 6-59 years, National Health and Nutrition Examination Survey, 1999.

	Sample size	Geometric mean (95% confidence interval)	Selected percentiles (95% confidence interval)				
			10th	25th	50th	75th	90th
µg/L of urine	703	1.84 (1.10-2.59)	< LOD**	0.80 (0.36-1.11)	1.67 (1.04-2.86)	3.79 (2.38-7.46)	7.43 (5.43-17.3)
µg/g of creatinine*	703	---	< LOD	0.49 (***-0.80)	1.56 (0.83-2.84)	4.02 (2.96-7.76)	10.1 (7.47-19.7)

Numbers in parentheses are 95% confidence intervals.
*µg per gram of creatinine in urine.
**Less than the limit of detection of 0.51 µg/L of urine.
***Results that were below the limit of detection were not adjusted for creatinine. The lower confidence interval is not defined; the estimate is below the limit of detection.

Dimethylthiophosphate (CAS No. 1112-38-5)

Table 19. Geometric mean and selected percentiles of dimethylthiophosphate urine concentrations and creatinine-adjusted levels for the U.S. population aged 6-59 years, National Health and Nutrition Examination Survey, 1999.

	Sample size	Geometric mean (95% confidence interval)	Selected percentiles (95% confidence interval)				
			10th	25th	50th	75th	90th
µg/L of urine	703	2.61 (1.77-3.45)	< LOD**	0.72 (0.13-1.73)	3.80 (2.93-4.53)	9.00 (7.35-12.3)	22.9 (18.7-30.7)
µg/g of creatinine*	703	---	< LOD**	0.59 (***-0.42)	3.08 (2.33-3.53)	7.87 (6.16-11.5)	23.6 (17.0-27.2)

Numbers in parentheses are 95% confidence intervals.
*µg per gram of creatinine in urine.
**Less than the limit of detection of 0.18 µg/L in urine.
***Results that were below the limit of detection were not adjusted for creatinine. The lower end of the confidence interval is not defined; the estimate is below the limit of detection.

Dimethyl dithiophosphate (CAS No. 756-80-9)

Table 20. Geometric mean and selected percentiles of dimethyldithiophosphate urine concentrations and creatinine-adjusted levels for the U.S. population aged 6-59 years, National Health and Nutrition Examination Survey, 1999.

	Sample size	Geometric mean (95% confidence interval)	Selected percentiles (95% confidence interval)				
			10th	25th	50th	75th	90th
µg/L of urine	703	0.51 (0.39-0.62)	< LOD**	< LOD	0.60 (0.39-0.78)	2.05 (1.65-2.42)	5.43 (3.16-10.3)
µg/g of creatinine*	703	---	< LOD	< LOD	0.42 (0.31-0.55)	1.57 (1.31-2.00)	5.33 (3.99-6.72)

Numbers in parentheses are 95% confidence intervals.
*µg per gram of creatinine in urine.
**Less than the limit of detection of 0.08 µg/L in urine.

Diethylphosphate (CAS No. 598-02-7)

Table 21. Geometric mean and selected percentiles of diethylphosphate urine concentrations and creatinine-adjusted levels for the U.S. population aged 6-59 years, National Health and Nutrition Examination Survey, 1999.

	Sample size	Geometric mean (95% confidence interval)	Selected percentiles (95% confidence interval)				
			10th	25th	50th	75th	90th
µg/L of urine	703	2.55 (1.33-3.78)	0.78 (0.70-0.90)	1.09 (0.93-1.31)	1.85 (1.19-4.11)	4.87 (2.58-14.0)	10.6 (6.29-**)
µg/g of creatinine*	703	2.24 (1.11-3.37)	0.43 (0.40-0.49)	0.81 (0.48-1.25)	1.87 (1.12-4.13)	5.85 (2.77-12.1)	12.13 (8.69-26.9)

Numbers in parentheses are 95% confidence intervals.
*µg per gram of creatinine in urine.
**Upper end of confidence interval cannot be reliably estimated.

Diethylthiophosphate (CAS No. 5871-17-0)

Table 22. Geometric mean and selected percentiles of diethylthiophosphate urine concentrations and creatinine-adjusted levels for the U.S. population aged 6-59 years, National Health and Nutrition Examination Survey, 1999.

	Sample size	Geometric mean (95% confidence interval)	Selected percentiles (95% confidence interval)				
			10th	25th	50th	75th	90th
µg/L of urine	703	0.81 (0.69-0.94)	0.51 (0.41-0.53)	0.58 (0.55-0.59	0.70 (0.64-0.78)	0.98 (0.78-1.45)	1.52 (1.16-2.91)
µg/g of creatinine*	703	0.71 (0.56-0.87)	0.26 (0.24-0.29)	0.38 (0.33-0.42)	0.64 (0.47-0.84)	1.25 (0.91-1.90)	2.32 (1.85-3.00)

Numbers in parentheses are 95% confidence intervals.
*µg per gram of creatinine in urine.

Diethyldithiophosphate (CAS No. 298-06-6)

Table 23. Geometric mean and selected percentiles of diethyldithiophosphate urine concentrations and creatinine-adjusted levels for the U.S. population aged 6-59 years, National Health and Nutrition Examination Survey, 1999.

	Sample size	Geometric mean (95% confidence interval)	Selected percentiles (95% confidence interval)				
			10th	25th	50th	75th	90th
µg/L of urine	703	0.19 (0.14-0.23)	0.08 (0.07-0.08)	0.09 (0.09-0.09)	0.14 (0.09-0.26)	0.30 (0.25-0.39)	0.54 (0.44-0.86)
µg/g of creatinine*	703	0.16 (0.12-0.21)	0.04 (0.04-0.05)	0.07 (0.05-0.09)	0.14 (0.10-0.21)	0.33 (0.22-0.49)	0.70 (0.55-0.91)

Numbers in parentheses are 95% confidence intervals.
*µg per gram of creatinine in urine.

Phthalates

General Information

Phthalates are industrial chemicals commonly found in many consumer products, including vinyl flooring and wall covering; detergents; lubricating oils; solvents; food packaging; and personal-care products such as soaps, shampoo, hair spray, and nail polish. Other phthalates are used in flexible plastics, such as blood bags, tubing, or children's toys, and in some pharmaceutical and pesticide formulations.

Results of animal studies have found that some phthalates given at very high doses to animals during pregnancy produce birth defects among offspring.[16, 17] Table 24 shows the relation between phthalates and their metabolites and also includes their commonly used abbreviations.

Table 24. Phthalates and their metabolites

Phthalate name	Abbreviation	CAS Number	Primary urine metabolite
Diethyl phthalate	DEP	84-66-2	Mono-ethyl phthalate
Dibutyl phthalate	DBP	84-74-2	Mono-butyl phthalate
Benzylbutyl phthalate	BzBP	85-68-7	Mono-benzyl phthalate
Dicyclohexyl phthalate	DCHP	84-61-7	Mono-cyclohexyl phthalate
Di-2-ethylhexyl phthalate	DEHP	117-81-7	Mono-2-ethylhexyl phthalate
Dioctyl phthalate	DOP	117-84-0	Mono-n-octyl phthalate
Di-isononyl phthalate	DINP	28553-12-0	Mono-isononyl phthalate

Interpreting Phthalate Metabolite Levels Reported in the Tables

Urine levels of phthalates were measured in a subsample of NHANES participants aged 6 years and older who were selected to be representative of the U.S. population. Results are presented in tables 25-31. Measuring phthalate metabolites at these levels in urine is possible because of advances in analytical chemistry. Finding a measurable amount of one or more phthalate metabolites in urine does not mean that the level of one or more of these causes an adverse health effect. Whether phthalates at the levels of metabolites reported here are a cause for health concern is not yet known; more research is needed.

These levels of phthalate metabolites in urine provide physicians with a reference range so that they can determine whether people have been exposed to higher levels of phthalates than those experienced in the general population. These data will also help scientists plan and conduct research on phthalate exposure and health effects.

Mono-ethyl Phthalate (CAS No. 2306-33-4)
(Metabolized from diethyl phthalate, CAS No. 84-66-2)

People exposed to diethyl phthalate will excrete mono-ethyl phthalate in their urine. The amount of mono-ethyl phthalate is an indicator of how much contact with diethyl phthalate has occurred. Diethyl phthalate is an industrial solvent used in many consumer products, particularly those containing fragrances. Products that may contain diethyl phthalate include perfume, cologne, soap, shampoo, and hand lotion.

Table 25. Geometric mean and selected percentiles of mono-ethyl phthalate urine concentrations and creatinine-adjusted levels for the U.S. population, aged 6 years and older, National Health and Nutrition Examination Survey, 1999.

	Sample size	Geometric mean (95% confidence interval)	Selected percentiles (95% confidence interval)				
			10th	25th	50th	75th	90th
µg/L of urine	1,024	176.0 (132-220)	27.7 (17.5-38.3)	61.5 (43.1-80.0)	171 (121-226)	424 (362-563)	1160 (971-1,350)
µg/g of creatinine*	1,024	151.5 (121-182)	30.8 (20.5-42.7)	63.9 (45.6-84.3)	134 (112-152)	337 (265-402)	892 (716-1,400)

Numbers in parentheses are 95% confidence intervals.
*µg per gram of creatinine in urine.

Mono-butyl Phthalate (CAS No. 131-70-4)
(Metabolized from dibutyl phthalate, CAS No. 84-66-2)

People exposed to dibutyl phthalate will excrete mono-butyl phthalate in their urine. The amount of mono-butyl phthalate is an indicator of how much contact with dibutyl phthalate has occurred. Dibutyl phthalate is an industrial solvent used in many consumer products such as nail polish, cosmetics, and insecticides.

Table 26. Geometric mean and selected percentiles of mono-butyl phthalate urine concentrations and creatinine-adjusted levels for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999.

	Sample size	Geometric mean (95% confidence interval)	Selected percentiles (95% confidence interval)				
			10th	25th	50th	75th	90th
µg/L of urine	1,029	26.7 (23.9-29.4)	5.9 (4.6-7.3)	13.2 (10.5-15.4)	27.5 (24.6-31.5)	53.8 (51.2-59.7)	98.6 (89.1-122)
µg/g of creatinine*	1,029	23.0 (20.9-25.0)	8.2 (6.2-9.5)	13.0 (11.9-14.6)	22.0 (19.4-24.6)	38.7 (34.2-42.6)	69.0 (56.2-93.0)

Numbers in parentheses are 95% confidence intervals.
*µg per gram of creatinine in urine.

Mono-benzyl Phthalate (CAS No. 2528-16-7)
(Metabolized from benzylbutyl phthalate, CAS No. 85-68-7)

People exposed to benzylbutyl phthalate will excrete mono-benzyl phthalate in their urine. The amount of mono-benzyl phthalate is an indicator of how much contact with dibutyl phthalate has occurred. Benzylbutyl phthalate is an industrial solvent used in many consumer products such as adhesives, sealants, cosmetics, and car-care products.

Table 27. Geometric mean and selected percentiles of mono-benzyl phthalate urine concentrations and creatinine-adjusted levels for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999.

	Sample size	Geometric mean (95% confidence interval)	Selected percentiles (95% confidence interval)				
			10th	25th	50th	75th	90th
µg/L of urine	1.029	17.4 (14.1-20.7)	3.5 (2.2-4.5)	8.0 (5.9-9.8)	18.5 (15.4-22.6)	38.6 (31.5-48.7)	82.3 (64.0-101)
µg/g of creatinine*	1,029	15.0 (12.8-17.2)	4.7 (3.9-5.2)	8.0 (6.3-9.5)	14.2 (12.3-16.0)	25.7 (23.2-30.3)	57.5 (44.0-72.7)

Numbers in parentheses are 95% confidence intervals.
*µg per gram of creatinine in urine.

Mono-cyclohexyl Phthalate (CAS No. 7517-36-4)
(Metabolized from dicyclohexyl phthalate, CAS No. 84-61-7)

People exposed to dicyclohexyl phthalate will excrete mono-cyclohexyl phthalate in their urine. The amount of mono-cyclohexyl phthalate is an indicator of how much contact with dicyclohexyl phthalate has occurred. Dicyclohexyl phthalate is used primarily in research laboratories.

Table 28. Geometric mean and selected percentiles of mono-cyclohexyl phthalate urine concentrations and creatinine-adjusted levels for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999.

	Sample size	Geometric mean (95% confidence interval)	Selected percentiles (95% confidence interval)				
			10th	25th	50th	75th	90th
µg/L of urine	1,029	---	< LOD**	< LOD	< LOD	< LOD	< LOD
µg/g of creatinine*	1,029	---	< LOD	< LOD	<LOD	< LOD	< LOD

*µg per gram of creatinine in urine.
**Less than the limit of detection of 0.7µg/L of urine

Mono-2-ethylhexyl Phthalate (CAS No. 4376-20-9)
(Metabolized from di-2-ethylhexyl phthalate, CAS No. 117-81-7)

People exposed to di-2-ethylhexyl phthalate will excrete mono-2-ethylhexyl phthalate in their urine. The amount of mono-2-ethylhexyl phthalate is an indicator of how much contact with di-2-ethylhexyl phthalate has occurred. Di-2-ethylhexyl phthalate is primarily used to produce flexible plastics, such as PVC tubing and blood bags. Di-2-ethylhexyl phthalate has been removed from most children’s toys and food packaging in the United States.

Table 29. Geometric mean and selected percentiles of mono-2-ethylhexyl phthalate urine concentrations and creatinine-adjusted levels for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999.

	Sample size	Geometric mean (95% confidence interval)	Selected percentiles (95% confidence interval)				
			10th	25th	50th	75th	90th
µg/L of urine	1,029	3.5 (3.0-4.0)	< LOD**	1.5 (0.8-1.9)	3.3 (3.0-3.8)	7.7 (6.1-9.6)	13.6 (11.2-17.3)
µg/g of creatinine*	1,029	---	< LOD	1.1 (0.7-1.3)	2.8 (2.3-3.3)	5.2 (4.5-6.2)	9.1 (7.4-11.2)

Numbers in parentheses are 95% confidence intervals.
*µg per gram of creatinine in urine.
**Less than the limit of detection of 1.2 Fg/L of urine

Mono-n-octyl Phthalate (CAS No. 5393-19-1)
(Metabolized from dioctyl phthalate, CAS No. 117-84-0)

People exposed to dioctyl phthalate will excrete mono-n-octyl phthalate in their urine. The amount of mono-n-octyl phthalate is an indicator of how much contact with dioctyl phthalate has occurred. Dioctyl phthalate is used primarily to produce flexible plastics.

Table 30. Geometric mean and selected percentiles of mono-n-octyl phthalate urine concentrations and creatinine-adjusted levels for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999.

	Sample size	Geometric mean (95% confidence interval)	Selected percentiles (95% confidence interval)				
			10th	25th	50th	75th	90th
µg/L of urine	1,029	---	< LOD**	< LOD	< LOD	< LOD	1.9 (1.2-3.5)
µg/g of creatinine*	1,029	---	< LOD	< LOD	< LOD	< LOD	1.3 (0.7-2.9)

Numbers in parentheses are 95% confidence intervals.
*µg per gram of creatinine in urine.
**Less than the limit of detection of 0.9 µg/L of urine

Mono-isononyl Phthalate
(Metabolized from di-isononyl phthalate, CAS No. 28553-12-0)

People exposed to di-isononyl phthalate will excrete mono-isononyl phthalate in their urine. The amount of mono-isononyl phthalate is an indicator of how much contact with di-isononyl phthalate has occurred. Di-isononyl phthalate is actually a mixture of many compounds. These compounds are produced with side alkyl chains of C8, C9, and C10 isomers. Di-isononyl phthalate is primarily used to produce flexible plastics.

Table 31. Geometric mean and selected percentiles of mono-isononyl phthalate urine concentrations and creatinine-adjusted levels for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999.

	Sample size	Geometric mean (95% confidence interval)	Selected percentiles (95% confidence interval)				
			10th	25th	50th	75th	90th
µg/L of urine	1,029	---	< LOD**	< LOD	< LOD	0.6 (0.6-0.9)	4.3 (0.6-22.3)
µg/g of creatinine*	1,029	---	< LOD	< LOD	< LOD	< LOD	3.8 (0.2-12.1)

Numbers in parentheses are 95% confidence intervals.
*µg per gram of creatinine in urine.
**Less than the limit of detection of 0.8 µg/L of urine

References

1. Brody D, Pirkle JL, Kramer R, Gunter EW, Matte TD, Paschal DC, Flegal KM. Blood lead levels in the U.S. population: Phase I of the Third National Health and Nutrition Examination Survey. *JAMA* 1994;272:277-83.

2. Pirkle JL, Brody D, Gunter EW, Pashcal DC, Flegal KM, Matte TD. The decline in blood lead levels in the United States: The National Health and Nutrition Examination Surveys. *JAMA* 1994;272:284-91.

3. Pirkle JL, Kaufmann RB, Brody DJ, Hickman T, Gunter EW, Paschal DC. Exposure of the U.S. population to lead: 1991-1994. *Environ Health Perspect* 1998;106:745-50.

4. Paschal DC, Burse V, Gunter EW, Pirkle JL, Sampson EJ, Miller DT, Jackson RJ, Caudill SP. Exposure of the U.S. population aged 6 years and older to cadmium: 1988-1994. *Arch Environ Contam Toxicol* 2000;38:377-83.

5. Pirkle JL, Flegal KM, Bernert JT, Brody DJ, Etzel RA, Maurer KR. Exposure of the U.S. population to environmental tobacco smoke: The Third National Health and Nutrition Examination Survey, 1988-1991. *JAMA* 1996;275:1233-40.

6. Centers for Disease Control and Prevention. Blood lead levels in young children—United States and selected states, 1996–1999. *MMWR Morb Mortal Wkly Rep* ;49(50):1133-7.

7. National Academy of Sciences. Toxicologic effects of methylmercury. Washington (D.C.):National Research Council;2000.

8. Occupational Safety and Health Administration. OSHA 29 CFR 1910.1127, Section 1–Medical Surveillance. Washington (D.C.): OSHA; 1992.

9. American Conference of Government Industrial Hygienists. 2000 TLVs and BEIs: Threshold limit values for chemical substances and physical agents and biological exposure indices. Cincinnati (OH): ACGHI;2000. p.91, 97.

10. U.S. Nuclear Regulatory Commission. U.S. Nuclear Regulatory Commission (NRC) Guide 8.22–Bioassay at Uranium Mills. Washington (D.C.): NRC; July 1978.

11. Seiler HG, Sigel H, Sigel A, eds. Handbook on toxicity of inorganic compounds. New York: Mardel Decker, 1988. p. 217-21.

12. Budavari S, ed. The Merck Index. 11th ed. Rahway (NJ): Merck & Co., Inc; 1989. p. 308-9.

13. Caraballo R, Giovino G, Pechacek TF, Mowery PD, Richter PA, Strauss WJ, Sharp DJ, Eriksen MP, Pirkle JL, Maurer KR. Racial/ethnic differences in serum cotinine levels among U.S. adult cigarette smokers: The Third National Health and Nutrition Examination Survey, 1988-1991. *JAMA* 1998;280:135-140.

14. U.S. Environmental Protection Agency (EPA), Office of Pesticide Programs. Organophosphate pesticides in food: A primer on reassessment of residue limits [Online]. Available: www.epa.gov/pesticides/op/primer.htm [2001, March 16]

15. U.S. Environmental Protection Agency (EPA), Office of Pesticide Programs. Status summary of the organophosphate review process [Online]. Available: www.epa.gov/pesticides/op/status.htm [2001, March 16].

16. Mylchreest E, Cartley RC, Foster PMD. Male reproductive tract malformations in rats following gestational and lactational exposure to dibutyl phthalate: an antiandrogenic mechanism? *Toxicol Sci* 1998;43:47-60.

17. Thomas JA, Thomas MJ. Biological effects of diethylhexyl phthalate and other phthalic acid esters. *Crit Rev Toxicol* 1984;13:283-317.

References for Analytical Methods

Metals

1. Chen HP, Paschal DC, Miller DT, Morrow JC. Determination of total and inorganic mercury in whole blood by on-line digestion with flow injection. *Atomic Spectroscopy* 1998;19:176-9.

2. Miller DT, Paschal DC, Gunter EW, Stroud PE, D'Angelo J. Determination of lead in blood using electrothermal atomization atomic absorption spectrometry with a L'vov platform and matrix modifier. *Analyst* 1987;112:1701-4.

3. Paschal DC, Ting BG, Borrow JC, Pirkle JL, Jackson RJ, Sampson EJ, Miller DT, Caldwell KT. Trace metals in urine of United States residents: reference range concentrations. *Environ Res* 1998;76:53-9.

4. Stoeppler M, Brandt K. Determination of cadmium in whole blood and urine by electrothermal atomic-absorption spectrophotometry. *Fresenius A Anal Chem* 1980;300:372-80.

Tobacco Smoke (Cotinine)

Bernert JT, Turner WE, Pirkle JL, Sosnoff CS, Akins JR, Waldrep MK, Ann Q, Covey TR, Whitfield WE, Gunter EW, Miller BB, Patterson DG, Needham LL, Hannon WH, Sampson EJ. Development and validation of a sensitive measurement of serum cotinine in both smokers and nonsmokers by liquid chromatography/atmospheric pressure ionization tandem mass spectrometry. *Clin Chem* 1997;43:2281-91.

Metabolites of Organophosphate Pesticides

Bravo R, Driskell WJ, Whitehead Jr RD, Needham LL, Barr DB. Determination of dialkyl phosphate metabolites of organophosphate pesticides in urine using GC-MS/MS with stable isotope internal standards. [Note: This manuscript is in review for publication. For a copy of the methods, submit an e-mail request to ncehdls@cdc.gov.

Phthalate Metabolites

Blount BC, Milgram KE, Silva M, Malek N, Reidy J, Needham LL, Brock JW. Quantitative detection of eight phthalate metabolites in human urine using HPLC-APCI-MS/MS. *Anal Chem* 2000;72:4127-34.

Glossary

acaricide
A chemical agent that kills mites.

acetylcholinesterase
An enzyme that exists in skeletal muscle, red blood cells, and the gray matter of nerve tissue.

alkyl group
A group of atoms derived from an alkane (a hydrocarbon with no carbon-to-carbon multiple bonds) by the removal of one hydrogen atom.

alloy
A substance that is a mixture of two or more metals. Alloys are often harder, stronger, lighter, or more durable than individual metals.

analytical method
A laboratory procedure used to measure a chemical in a human specimen, such as blood or urine.

antimony (CAS No. 7440-36-0)
A silver-white metal found in the earth's crust. In nature, antimony can be found in ores and other minerals. Antimony ores are mixed with other metals to form antimony alloys, or they combine with oxygen to form antimony oxide.

barium (CAS No. 7440-39-3)
A silver-white metal that exists in nature and combines with other chemicals, such as sulfur or carbon and oxygen. These combinations are called compounds. Industry also produces barium compounds.

beryllium (CAS No. 7440-41-7)
A hard, gray metal. In nature, beryllium can combine with other chemicals in rocks, coal, soil, and volcanic dust.

biomonitoring
Laboratory analysis of human specimens, such as blood or urine, to measure people's exposure to chemicals in the environment.

blood
The fluid that circulates through the heart, arteries, veins, and capillaries of the body. Blood carries oxygen and nutrients to cells and removes carbon dioxide and other waste products from cells.

blood lead
Lead that is in blood.

blood mercury
Mercury that is in blood.

cadmium (CAS No. 7440-43-9)

A mineral that naturally exists in the earth's crust. All soils and rocks, including coal and mineral fertilizers, have some cadmium in them. Industry takes out cadmium during the production of other metals such as zinc, lead, and copper.

carbamate pesticides
A group of organic pesticides that are used as herbicides, insecticides, and fungicides. These pesticides do not stay in the soil for a long time.

carcinogenic
Capable of causing cancer.

CAS number
A unique number assigned to a given compound by the Chemical Abstracts Service, a division of the American Chemical Society. Also known as CAS registry number, CAS RN, or CAS #.

catalytic activity
The activity of a catalyst, a substance that increases the rate of a chemical reaction.

cesium (CAS No. 7440-46-2)
A silver-white metal that catches fire when exposed to air and that reacts explosively with water. Cesium is found naturally in rock, soil, and clay. Cesium sometimes combines with other chemicals. These combinations are called compounds. Cesium is used primarily to convert and conduct electricity.

chlorpyrifos (CAS No. 2921-88-2)
An organophosphate pesticide.

cobalt (CAS No. 7440-48-4)
An element that occurs in nature either as a steel-gray, shiny, hard metal or combined with other elements. These combinations are called compounds. Cobalt occurs naturally in many types of soil and in dust and seawater. Small amounts also occur naturally in food.

compound
A substance composed of two or more elements. For example, table salt (sodium chloride or Na Cl) is a compound composed of sodium (Na) and chlorine (Cl).

confidence interval
A range of statistical values within which a true value or result is expected to fall with a specific probability.

copper (CAS No. 7440-50-8)
An element that occurs in nature as a soft, reddish, flexible metal. Copper is an excellent conductor of electricity.

cotinine (CAS No. 486-56-6)
A metabolite—or breakdown product—of nicotine, one of the chemicals found in smoking and chewing tobacco. Cotinine is produced when the body takes in nicotine and breaks it down. Nicotine gets into people's bodies if they smoke or chew tobacco of if they are exposed to environmental tobacco smoke (also called "secondhand" smoke).

creatinine (CAS No. 60-27-5)
A nitrogen compound that is found in muscle, blood, and urine.

deciliter (dL)
A unit of volume equal to one-tenth of a liter, about one-half cup of liquid.

detection limit
The amount of a substance that a laboratory can measure reliably in a sample of air, water, soil, or other medium, such as blood or urine.

diazinon (CAS No. 333-41-5)
An insecticide. In 1986, the U.S. Environmental Protection Agency (EPA) banned its use in open areas, such as sod farms and golf courses, because it posed a danger to migratory birds. The ban applies to agricultural, home-lawn, or commercial-establishment uses.

diethyldithiophosphate (CAS No. 298-06-6)
An organophosphate pesticide metabolite or breakdown product that is formed when the body is exposed to one of four different organophosphate pesticides. This metabolite can be measured in a person's urine if that person has been exposed to disulfoton, ethion, phorate, or terbufos.

diethylphosphate (CAS No. 598-02-7)
An organophosphate pesticide metabolite or breakdown product that is formed when the body is exposed to one of ten different organophosphate pesticides. This metabolite can be measured in a person's urine if that person has been exposed to chlorethoxyphos, chlorpyrifos, coumaphos, diazinon, disulfoton, ethion, parathion, phorate, sulfotepp, or terbufos.

diethylthiophosphate (CAS No. 5871-17-0)
An organophosphate pesticide metabolite or breakdown product that is formed when the body is exposed to one of ten different organophosphate pesticides. This metabolite can be measured in a person's urine if that person has been exposed to chlorethoxyphos, chlorpyrifos, coumaphos, diazinon, disulfoton, ethion, parathion, phorate, sulfotepp, or terbufos.

dimethyldithiophosphate (CAS No. 756-80-9)
An organophosphate pesticide metabolite or breakdown product that is formed when the body is exposed to one of five different organophosphate pesticides. This metabolite can be measured in a person's urine if that person has been exposed to azinphos methyl, dimethoate, malathion, methidathion, or phosmet.

dimethylphosphate (CAS No. 813-78-5)
An organophosphate pesticide metabolite or breakdown product that is formed when the body is exposed to one of 18 different organophosphate pesticides. This metabolite can be measured in a person's urine if that person has been exposed to azinophos methyl, chlorpyrifos methyl, dichlorvos (DDVP), dicrotophos, dimethoate, fenitrothion, fenthion, isazaphos-methyl, malathion, methidathion, methyl parathion, naled, oxydemeton-methyl, phosmet, pirimiphos-methyl, temephos, tetrachlorviphos, or trichlorfon.

dimethylthiophosphate (CAS No. 1112-38-5)
An organophosphate pesticide metabolite or breakdown product that is formed when the body is exposed to one of 13 different organophosphate pesticides. This metabolite can be measured in a person's urine if that

person has been exposed to azinphos methyl, chlorpyrifos methyl, dimethoate, fenitrothion, fenthion, isazaphos-methyl, malathion, methidathion, methyl parathion, oxydemeton-methyl, phosmet, pirimiphos-methyl, or temephos.

dioxin
Any of a family of compounds known chemically as dibenzo-p-dioxins. Concern about these compounds arises from their potential toxicity and ability to contaminate commercial products.

disulfoton (CAS No. 298-04-4)
A pale yellow insecticide used on some vegetables and flowers.

element
A substance that cannot be separated into its constituent parts and still retain its chemical identity. An example of an element is sodium (Na).

exposure
Contact with a chemical by swallowing, breathing, or touching (such as through the skin or eyes). Exposure may occur immediately or over a longer period.

fenthion (CAS No. 55-38-9)
A substance that is used as an insecticide and acaricide.

fossil fuel
A substance found in the layers of the earth that can be burned. Fossil fuel is formed by the remains of plants and animals that lived millions of years ago. Oil, natural gas, peat, and coal are fossil fuels.

furan (CAS No. 110-00-9)
A colorless, flammable liquid that is used as a solvent. Furan is also used to make polymers such as nylon.

geometric mean
A special mathematical average.

gram (g)
A gram is basic unit of mass in the metric system and is equal to the weight of one cubic centimeter of water at 4 degrees centigrade.

inductively coupled plasma mass spectrometry (ICPMS)
A method for analyzing several chemicals at the same time.

industrial solvent
A substance or liquid that industry uses to dissolve other substances.

isomer
One of two or more molecules that have the same chemical formula but have a different arrangement of their atoms.

lead (CAS No. 7439-92-1)

A naturally occurring blue-gray metal found in the earth's crust. Lead is found in small amounts in rock and soil. Lead can be found in all parts of the environment. Most lead comes from human activities such as mining, manufacturing, and burning fossil fuels.

limit of detection
The minimum concentration of a substance being analyzed that can be measured with high confidence.

liter (L)
A liter is the basic unit of volume in the metric system, equal to 1.06 liquid quarts.

logarithmic scale
The power to which a base must be raised to equal a given number. In this Report, logarithms are expressed using a base of 10.

malathion (CAS No. 121-75-5)
A yellow-brown liquid that is widely used as an insecticide.

mass spectrometry
A scientific method that separates organic matter into basic elements and compounds and analyzes them according to atomic and molecular mass.

mean
A mathematical average.

median
In a group of numbers, the value of the middle number when the numbers are arranged in ascending order.

mercury (CAS No. 7439-97-6)
A naturally occurring metal that comes in several forms. Metallic mercury is a shiny, silver-white, odorless liquid. If heated, mercury forms a colorless, odorless gas. Mercury combines with other elements to form mercury compounds.

metabolism
All the chemical reactions that enable the body to work. For example, food is metabolized (chemically changed or broken down) to supply the body with energy. Chemicals can be metabolized and made either more or less harmful by the body.

metabolite
A byproduct of metabolism that happens when the body takes in a substance, such as an environmental chemical, and breaks it down.

metal
An element that is typically shiny and conducts heat and electricity. Mercury, lead, and cadmium are examples of metals.

methyl parathion (CAS No. 298-00-0)
Methyl parathion is an insecticide that comes in two forms: white crystals or a brown liquid. It smells like

rotten eggs, is similar to nerve gas, and is used to kill insects on farm crops, especially cotton. Methyl parathion is a restricted-use pesticide that only trained people are allowed to mix, load, and spray. It is banned for indoor residential use.

microgram (µg)
A unit of mass equal to one-millionth of a gram.

milliliter (mL)
A unit of volume equal to one-thousandth of a liter.

molybdenum (CAS No. 7439-98-7)
A silver-white, hard metal with many commercial uses. Molybdenum withstands high temperatures and high pressure and is a byproduct of copper mining.

mono-benzyl phthalate (CAS No. 2528-16-7)
A metabolite or breakdown product of benzylbutyl phthalate. This product can be measured in a person's urine.

mono-butyl phthalate (CAS No. 131-70-4)
A metabolite or breakdown product of dibutyl phthalate. This product can be measured in a person's urine.

mono-cyclohexyl phthalate (CAS No. 7517-36-4)
A metabolite or breakdown product of dicyclohexyl phthalate. This product can be measured in a person's urine.

mono-ethyl phthalate (CAS No. 2306-33-4)
A metabolite or breakdown product of diethyl phthalate. This product can be measured in a person's urine.

mono-2-ethylhexyl phthalate (CAS No. 4376-20-9)
A metabolite or breakdown product of di-2-ethylhexyl phthalate. This product can be measured in a person's urine.

mono-isononyl phthalate (does not have a CAS No.)
A metabolite or breakdown product of di-isononyl phthalate. This product can be measured in a person's urine.

mono-n-octyl phthalate (CAS No. 5393-19-1)
A metabolite or breakdown product of dioctyl phthalate. This product can be measured in a person's urine.

nanogram (ng)
A unit of mass equal to one-billionth of a gram.

National Health and Nutrition Examination Survey (NHANES)
A series of surveys designed to collect data on the health and nutritional status of the U.S. population. In 1999, NHANES became a continuous and annual survey.

nitrosamine

An organic compound that is found in many foods. Nitrosamines can cause cancer.

nonpersistent pesticide
A pesticide that breaks down into nontoxic components almost immediately after application or that only lasts for a few days before breaking down.

organophosphate pesticides
Pesticides that contain phosphorus. They can be poisonous to animals and people because they prevent essential nervous system enzymes from working. Organophosphate pesticides are chemically unstable or nonpersistent.

parathion (CAS No. 56-38-2)
An organophosphate pesticide used to control many insects and mites. Trade names for parathion include AC 3422, Alkron, Alleron, Aphamite, Corothion, E-605, ENT 15108, Ethyl parathion, Etilon, Fosferno 50, Niran, Orthophos, Panthion, Paramar, Paraphos, Parathene, Parawet, Phoskil, Rhodiatox, Soprathion, Stathion, and Thiophos.

percentile
The set of divisions that produce exactly 100 equal parts in a series of continuous values.

phorate (CAS No. 298-02-2)
A toxic, clear liquid used as an insecticide.

phosmet (CAS No. 732-11-6)
An organophosphate pesticide mainly used on apple trees, although it is also used on a other fruit crops, ornamentals, and vines to control aphids, suckers, mites, moths, and fruit flies. The compound is also an active ingredient in some pet collars. Trade names for phosmet include Appa, Decemtion, Fesdan, Imidan, Kemolate, Prolate, PMC, and Safidon.

phthalates
A family of chemicals used primarily as plasticizers that are added to products to make them soft or flexible.

pigment
A natural or synthetic substance that is used to transfer color to another substance.

platinum (CAS No. 7440-06-4)
A silver-gray, lustrous metal found naturally in the earth's crust. Platinum and the compounds it forms resist corrosion and can withstand high temperatures.

pollutant
Any substance or agent that causes pollution.

polyaromatic hydrocarbons (PAHs)
A group of more than 100 different chemicals that are formed during the incomplete burning of coal, oil, gas, garbage, or other organic substances, including tobacco or charbroiled meat. PAHs are found in soot, coal tar, crude oil, creosote, and roofing tar. Some PAHS are used in medicines, dyes, plastics, and pesticides.

polychlorinated biphenyls (PCBs)
A group of manufactured organic chemicals that contain 209 individual chlorinated chemicals (known as congeners). PCBs are oily liquids or solids and range from being colorless to light yellow. Products containing PCBs are old fluorescent lighting fixtures; electrical appliances containing PCB capacitators; old microscope oil; and hydraulic fluids, paints, inks, adhesives, electrical condensers, batteries, and lubricants.

reference range
A set of numerical quantities that serves as a base against which further quantities are measured.

sample
A portion of a population that is observed to make generalizations about the whole population.

sample size
The number of units (such as people or animals) in a population to be studied. If a scientist surveys 200 people about their pesticide use, the sample size would be 200.

serum
The liquid portion of blood that remains after the removal of clotting proteins and blood cells.

substrate
A compound that reacts with a substance.

temephos (CAS No. 3383-96-8)
An organophosphate pesticide used to control mosquito, midge, and black fly larvae. Temephos is used on lakes, ponds, and wetlands. It is also used to control fleas on dogs and cats and to control lice on humans. Trade names for temephos include Abat, Abate, Abathion, Acibate, Biothion, Difennthos, Ecopro, Nimitox, and Swebate.

thallium (CAS No. 7440-28-0)
A blue-white metal that is found in the earth’s crust. Thallium is found in small amounts in soil and rocks. In the past, thallium was obtained as a byproduct of smelting other metals; however, it has not been produced in the United States since 1984.

thermocouple
A device consisting of two different metallic conductors that are connected at both ends, producing a loop in which heat is converted into electrical current. A thermocouple is used to measure the temperature of a substance.

toxicant
A toxic or poisonous substance.

tungsten (CAS No. 7440-33-7)
A steel-gray to tin-white metal found naturally in the earth’s crust. This metal is highly flammable and may catch fire spontaneously when exposed to air. Tungsten may be combined with other chemicals such as carbon. Tungsten is also called wolfram.

uranium (CAS No. 7439-97-6)
A silver-white, extremely dense radioactive metal. Uranium almost never occurs by itself but rather in combination with oxygen, chlorine, or fluorine.

volatile organic compounds (VOCs)
Organic compounds that evaporate readily into the air. VOCs are released when cars or other machines burn fuel. VOCs contribute significantly to smog production. VOCs include chemicals such as benzene, toluene, methylene chloride, and methyl chloroform and can cause serious health problems.

zinc (CAS No. 7440-66-6)
One of the most common elements in the earth's crust. Zinc is found in air, soil, and water and is present in all foods. Pure zinc is a blue-white, shiny metal. Zinc is used in coatings to prevent rust and in dry-cell batteries. It is also mixed with other metals to make alloys such as brass and bronze. A zinc and copper alloy is used to make pennies in the United States. Zinc compounds are widely used in industry to make paint, rubber, dye, wood preservatives, and ointments.

Centers for Disease Control and Prevention
National Center for Environmental Health
Division of Laboratory Sciences
Mail Stop F-20
4770 Buford Highway, N.E.
Atlanta, Georgia 30341-3724
Telephone (toll-free): 1-866-670-6052
E-mail: ncehdls@cdc.gov
Web site: www.cdc.gov/nceh/dls/report
March 2001
NCEH Pub. No. 01-0379