Second National Report on Human Exposure to Environmental Chemicals

DEPARTMENT OF HEALTH & HUMAN SERVICES · USA

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CDC's *Second National Report on Human Exposure to Environmental Chemicals*: Background

The *National Report on Human Exposure to Environmental Chemicals* is an ongoing assessment of the exposure of the U.S. population to environmental chemicals using biomonitoring. The first *Report* on 27 chemicals was issued in March 2001. This *Second Report*, released in January 2003, presents blood and urine levels of 116 environmental chemicals from a sample of people that represent the noninstitutionalized, civilian U.S. population during the two-year period 1999-2000.

Scientists from CDC's Environmental Health Laboratory measured chemicals or their metabolites (breakdown products) in blood and urine samples from selected participants in the National Health and Nutrition Examination Survey (NHANES). Conducted by CDC's National Center for Health Statistics, NHANES is a series of surveys designed to collect data on the health and nutritional status of the U.S. population.

For this *Report*, an environmental chemical means a chemical compound or chemical element that is present in air, water, food, soil, dust, or other environmental media. Biomonitoring is the assessment of human exposure to chemicals by measuring the chemicals or their metabolites (breakdown products) in human specimens such as blood or urine. Blood and urine levels reflect the amount of the chemical in the environment that actually gets into the body.

This *Second Report* presents exposure data from NHANES 1999-2000 for 116 chemicals, including expanded information on the 27 chemicals listed in the first *Report* and 89 new chemicals. This *Report* also presents exposure data for the U.S. population by age, sex, and race/ethnicity.

The first *Report* provided data on lead, mercury, cadmium, and other metals; dialkylphosphate metabolites of organophosphate pesticides; cotinine; and phthalates. The *Second Report* includes data on these chemicals and adds the following:

- Polycyclic aromatic hydrocarbons (PAHs)
- Dioxins, furans, and coplanar polychlorinated biphenyls (PCBs)
- Non-coplanar PCBs
- Phytoestrogens
- Selected organophosphate pesticides
- Organochlorine pesticides
- Carbamate pesticides
- Herbicides
- Pest repellents and disinfectants

Public Health Uses of the *Report*

The overall purpose of the *Report* is to provide unique exposure information to physicians, scientists, and health officials to help prevent disease that results from exposure to environmental chemicals. The following are specific public health uses of the exposure information in the *Second Report*:

- To determine which chemicals get into Americans and at what concentrations.
- For each chemical with a known toxicity level, to determine the prevalence of people with levels above that toxicity level (e.g., a blood lead level greater than or equal to 10 micrograms per deciliter [µg/dL]).
- To establish reference ranges that can be used by physicians and scientists to determine whether or not a person or group of people has an unusually high exposure.
- To assess the effectiveness of public health efforts to reduce exposure of Americans to specific chemicals.
- To determine whether exposure levels are higher among minorities, children, women of childbearing age, or other potentially vulnerable groups.
- To track, over time, trends in levels of exposure in the population.
- To set priorities for research on human health effects.

Interpreting Data in the *Report*

Just because people have an environmental chemical in their blood or urine does not mean that the chemical causes disease. The toxicity of a chemical is related to its dose or concentration. Small amounts may be of no health consequence, whereas larger amounts may cause disease. Research studies, separate from the *Report*, are required to determine which levels of a chemical may cause disease and which levels are of negligible health concern. For some chemicals, such as lead, research studies provide a good understanding of health risks associated with various blood levels. For most of the environmental chemicals in the *Second Report*, more research is needed to determine whether exposure to the chemical at levels reported here is a cause for health concern. CDC conducts such research and provides biomonitoring measurements for this type of research in collaboration with other agencies and institutions.

The *Second Report* presents data collected to provide estimates of exposure for the civilian, noninstitutionalized U.S. population. The current survey design does not permit us to estimate exposure on a state-by-state or city-by-city basis. For example, it is not possible to extract a subset of data and examine levels of blood lead that represent a state population.

Chemicals in the *Report*

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

Polycyclic Aromatic Hydrocarbons (PAHs)
- 1-Hydroxybenz[a]anthracene
- 3-Hydroxybenz[a]anthracene
- 1-Hydroxybenzo[c]phenanthrene
- 2-Hydroxybenzo[c]phenanthrene
- 3-Hydroxybenzo[c]phenanthrene
- 3-Hydroxychrysene
- 6-Hydroxychrysene
- 3-Hydroxyfluoranthene
- 2-Hydroxyfluorene
- 3-Hydroxyfluorene
- 1-Hydroxyphenanthrene
- 2-Hydroxyphenanthrene
- 3-Hydroxyphenanthrene
- 1-Hydroxypyrene

Tobacco Smoke
- Cotinine

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

Phytoestrogens
- Daidzein
- Enterodiol
- Enterolactone
- Equol
- Genistein
- O-Desmethylangolensin

Polychlorinated Dibenzo-*p*-dioxins, Polychlorinated Dibenzofurans, and Coplanar Polychlorinated Biphenyls
- 1,2,3,4,6,7,8,9-Octachlorodibenzo-*p*-dioxin (OCCD)
- 1,2,3,4,6,7,8-Heptachlorodibenzo-*p*-dioxin (HpCDD)
- 1,2,3,6,7,8-Hexachlorodibenzo-*p*-dioxin (HxCDD)
- 1,2,3,7,8,9-Hexachlorodibenzo-*p*-dioxin (HxCDD)
- 1,2,3,7,8-Pentachlorodibenzo-*p*-dioxin (PeCDD)
- 2,3,7,8-Tetrachlorodibenzo-*p*-dioxin (TCDD)
- 1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)
- 1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF)
- 1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)
- 1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDF)
- 1,2,3,7,8,9-Hexachlorodibenzofuran (HxCDF)
- 1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)
- 2,3,4,6,7,8-Hexachlorodibenzofuran (HxCDF)
- 2,3,4,7,8-Pentachlorodibenzofuran (PeCDF)
- 2,3,7,8-Tetrachlorodibenzofuran (TCDF)
- 3,3',4,4',5,5'-Hexachlorobiphenyl (PCB 169)
- 3,3',4,4',5-Pentachlorobiphenyl (PCB 126)
- 3,4,4',5-Tetrachlorobiphenyl (PCB 81)

Polychlorinated Biphenyls
- 2,4,4'-Trichlorobiphenyl (PCB 28)
- 2,2',5,5'-Tetrachlorobiphenyl (PCB 52)
- 2,3',4,4'-Tetrachlorobiphenyl (PCB 66)
- 2,4,4',5-Tetrachlorobiphenyl (PCB 74)
- 2,2',4,4',5-Pentachlorobiphenyl (PCB 99)
- 2,2',4,5,5'-Pentachlorobiphenyl (PCB 101)
- 2,3,3',4,4'-Pentachlorobiphenyl (PCB 105)
- 2,3',4,4',5-Pentachlorobiphenyl (PCB 118)
- 2,2',3,3',4,4'-Hexachlorobiphenyl (PCB 128)
- 2,2',3,4,4',5'-Hexachlorobiphenyl (PCB 138)
- 2,2',3,4',5,5'-Hexachlorobiphenyl (PCB 146)
- 2,2',4,4',5,5'-Hexachlorobiphenyl (PCB 153)
- 2,3,3',4,4',5-Hexachlorobiphenyl (PCB 156)
- 2,3,3',4,4',5'-Hexachlorobiphenyl (PCB 157)
- 2,3',4,4',5,5'-Hexachlorobiphenyl (PCB 167)
- 2,2',3,3',4,4',5-Heptachlorobiphenyl (PCB 170)
- 2,2',3,3',4,5,5'-Heptachlorobiphenyl (PCB 172)
- 2,2',3,3',4,5',6'-Heptachlorobiphenyl (PCB 177)
- 2,2',3,3',5,5',6-Heptachlorobiphenyl (PCB 178)
- 2,2',3,4,4',5,5'-Heptachlorobiphenyl (PCB 180)
- 2,2',3,4,4',5',6-Heptachlorobiphenyl (PCB 183)
- 2,2',3,4',5,5',6-Heptachlorobiphenyl (PCB 187)

Organophosphate Pesticides: Dialkyl Phosphate Metabolites
- Dimethylphosphate
- Dimethylthiophosphate
- Dimethyldithiophosphate
- Diethylphosphate
- Diethylthiophosphate
- Diethyldithiophosphate

Organophosphate Pesticides: Specific Metabolites
- Malathion dicarboxylic acid
- *para*-Nitrophenol
- 3,5,6-Trichloro-2-pyridinol
- 2-Isopropyl-4-methyl-6-hydroxypyrimidine

Organochlorine Pesticides
- Hexachlorobenzene
- Hexachlorocylclohexane
  - Beta-hexachlorocyclohexane
  - Gamma-hexachlorocyclohexane
- Dichlorodiphenyltrichloroethane
  - *p,p'*-DDT
  - *p,p'*-DDE
  - *o,p'*-DDT
- Oxychlordane
- *trans*-Nonachlor
- Heptachlor epoxide
- Mirex
- Pentachlorophenol
- Trichlorophenols
  - 2,4,5-Trichlorophenol
  - 2,4,6-Trichlorophenol

Carbamate Pesticides
- 1-Naphthol
- 2-Isopropoxyphenol
- Carbofuranphenol

Herbicides
- 2,4,5-Trichlorophenoxyacetic acid
- 2,4-Dichlorophenoxyacetic acid
- 2,4-Dichlorophenol
- Atrazine mercapturate
- Alachlor mercapturate

Pest Repellents and Disinfectants
- 2-Naphthol
- 2,5-Dichlorophenol
- N,N-diethyl-3-methylbenzamide
- *ortho*-phenylphenol

Table 2. Lead

Geometric mean and selected percentiles of blood concentrations (in µg/dL) for the U.S. population aged 1 year and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 1 and older	1.66 (1.58-1.73)	.800 (.700-.800)	1.00 (1.00-1.10)	1.60 (1.50-1.60)	2.40 (2.30-2.60)	3.80 (3.50-4.00)	4.90 (4.50-5.50)	7970
Age group								
1-5 years	2.23 (1.99-2.49)	1.00 (.800-1.10)	1.40 (1.10-1.50)	2.20 (1.90-2.50)	3.30 (2.80-3.90)	4.80 (4.00-6.60)	7.00 (5.20-9.90)	723
6-11 years	1.51 (1.35-1.69)	.700 (.600-.900)	.900 (.800-1.10)	1.30 (1.20-1.60)	2.00 (1.70-2.40)	3.30 (2.60-3.90)	4.50 (3.30-6.30)	905
12-19 years	1.10 (1.03-1.18)	.400 (.400-.500)	.800 (.700-.800)	1.00 (1.00-1.10)	1.40 (1.30-1.60)	2.30 (2.10-2.40)	2.80 (2.50-3.00)	2135
20 years and older	1.75 (1.67-1.83)	.700 (.700-.800)	1.00 (1.00-1.10)	1.70 (1.60-1.70)	2.50 (2.40-2.70)	3.90 (3.60-4.10)	5.20 (4.70-5.70)	4207
Gender								
Males	2.01 (1.92-2.10)	.800 (.800-.900)	1.30 (1.20-1.30)	1.80 (1.80-1.90)	2.90 (2.70-3.00)	4.40 (4.00-4.80)	6.00 (5.40-6.50)	3913
Females	1.37 (1.30-1.45)	.600 (.500-.600)	.800 (.800-.900)	1.30 (1.20-1.30)	1.90 (1.80-2.10)	3.00 (2.80-3.30)	4.00 (3.60-4.40)	4057
Race/ethnicity								
Mexican Americans	1.83 (1.71-1.95)	.800 (.700-.800)	1.20 (1.10-1.20)	1.80 (1.60-1.90)	2.70 (2.50-3.00)	4.20 (3.80-4.60)	5.80 (5.10-6.60)	2743
Non-Hispanic blacks	1.87 (1.73-2.02)	.700 (.700-.800)	1.10 (1.00-1.30)	1.70 (1.60-1.90)	2.80 (2.50-2.90)	4.20 (3.90-4.70)	5.70 (5.00-6.30)	1842
Non-Hispanic whites	1.62 (1.53-1.71)	.600 (.600-.700)	1.00 (1.00-1.10)	1.60 (1.40-1.60)	2.40 (2.20-2.50)	3.60 (3.30-3.90)	5.00 (4.30-5.90)	2715

Table 158. *p,p'*-DDE (lipid adjusted)

Geometric mean and selected percentiles of serum concentrations (nanograms/gram [ng/g] of lipid or parts-per-billion on a lipid weight basis) for the U.S. population aged 12 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. Interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 12 and older	260 (234-289)	74.2 (66.1-84.2)	114 (99.8-129)	226 (191-267)	538 (485-609)	1120 (991-1290)	1780 (1520-2230)	1964
Age group								
12-19 years	118 (101-137)	45.9 (34.9-56.6)	69.8 (59.2-80.4)	108 (90.6-132)	185 (141-233)	343 (255-479)	528 (364-644)	686
20 years and older	297 (267-330)	86.0 (75.2-96.7)	130 (115-150)	269 (229-303)	626 (538-697)	1250 (1100-1420)	1990 (1570-2510)	1278
Gender								
Males	249 (221-281)	77.6 (68.6-88.2)	119 (101-133)	222 (182-266)	489 (383-570)	985 (756-1130)	1350 (1190-1610)	937
Females	270 (241-302)	68.9 (55.1-82.5)	112 (96.0-129)	228 (191-286)	604 (516-697)	1320 (1100-1600)	2150 (1650-2750)	1027
Race/ethnicity								
Mexican Americans	674 (572-795)	154 (133-214)	300 (252-370)	623 (505-750)	1350 (1090-1660)	3090 (2100-4610)	4940 (3280-7810)	657
Non-Hispanic blacks	295 (253-344)	62.2 (56.9-80.5)	113 (98.3-128)	203 (164-253)	452 (392-571)	1340 (974-1910)	2160 (1470-4010)	416
Non-Hispanic whites	217 (193-244)	73.0 (63.2-82.2)	107 (94.5-127)	197 (175-238)	459 (372-513)	852 (693-1010)	1220 (1040-1410)	732

Selected Findings

First-time information about exposure levels for the U.S. population

The *Second Report* provides information about exposure to environmental chemicals in the U.S. population for physicians, scientists, and the public. Covering the years 1999 and 2000, the *Second Report* has *first time* exposure information for 89 chemicals in the U.S. population and expanded new information for 27 chemicals that were measured in the first *Report*. Chemicals added in the *Second Report* are dioxins, furans, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), herbicides, carbamate pesticides, selected organophosphate pesticides, phytoestrogens, and organochlorine pesticides.

Reference range values for physicians and health researchers

Physicians use "normal" ranges of laboratory results to determine whether their patients have high or low values that would indicate a health problem. These normal ranges are obtained from people who are generally healthy. In the *Second Report*, CDC presents "reference ranges," which are levels of chemicals in blood and urine that were found in the general population. These ranges sometimes are referred to as background levels. The *Second Report* contains reference ranges for all 116 chemicals included in the *Report* with separate reference ranges presented for population subgroups defined by age, sex, and race/ethnicity.

Reference ranges give physicians and health researchers the information needed to determine if a person or group of people have an unusual level of exposure. For example, if a physician was concerned about a patient's possible exposure to cadmium and measured a cadmium level in the patient's urine, that level could be compared with the reference range in the *Second Report*. A cadmium level similar to those found in the *Report* would indicate exposure that was no different from exposure found in the general population, and a level much higher than the reference range in the *Report* would indicate unusual exposure that might require further investigation.

Decline in the number of children with elevated blood lead levels

In the first *Report*, 1999 blood lead data for children aged 1-5 years showed a decrease in average blood lead levels compared with levels in the early 1990s. The *Second Report* has additional lead data that allow us to estimate the number of children with elevated blood lead levels (levels $10 µg/dL). In the early 1990s, 4.4% of children had elevated blood lead levels. The *Second Report* indicates that for 1999-2000, the percentage of children aged 1-5 years with elevated blood lead levels has decreased to 2.2%. This decrease documents that public health efforts to reduce the number of children with elevated blood lead levels have been successful. 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 major public health concern.

Exposure of the population to dioxins, furans, and polychlorinated biphenyls (PCBs)

Dioxins, furans, and PCBs are chemicals known to persist for years in the environment and in the human body. Furans and coplanar PCBs have dioxin-like toxicity that varies by the number and position of chlorine atoms in the chemical. CDC scientists measured these compounds using high-resolution mass spectrometry in serum samples with an average volume of about 5 milliliters. For the chemical 2,3,7,8-tetrachlorodibenzo-*p*-dioxin, the method used to analyze this serum volume could measure levels as low as about 4.5 picograms per gram of lipid, or 4.5 parts per trillion. For dioxins, furans, and coplanar PCBs, most people in the *Second Report* had levels that were below what the analytical method could detect. This finding was encouraging. Future *Reports* will include analyses of these chemicals that use larger volumes of serum to provide better measurement of these levels of dioxin and dioxin-like chemicals

Environmental Tobacco Smoke

Cotinine is a metabolite of nicotine that tracks exposure to environmental tobacco smoke (ETS) among nonsmokers. Higher cotinine levels indicate more exposure to ETS, which has been identified as a known human carcinogen. The first *Report* found that among nonsmokers in the overall population, cotinine levels decreased substantially during the 1990s. The *Second Report* contains additional results for the years 1999 and 2000 and results for population groups defined by age, sex, and race/ethnicity. From 1991-1994 to 1999-2000, cotinine levels decreased 58% for children, 55% for adolescents, and 75% for adults. However, in 1999-2000, cotinine levels in children were more than twice those of adults. Non-Hispanic blacks had levels more than twice those of Mexican Americans and non-Hispanic whites. Although efforts to reduce ETS exposure during the 1990s were successful, ETS exposure remains a major public health concern.

Exposure of the population to dichlorodiphenyltrichloroethane (DDT)

DDT is an insecticide that was originally used against mosquitoes but was banned in the United States by EPA in 1973. DDT is still being produced and used in limited quantities in other countries. In the body, DDE (1,1'-(2,2-dichloro-ethenylidene)-bis(4-chlorobenzene)) is a prominent breakdown product (metabolite) of DDT. The *Second Report* presents data showing serum DDE levels three times higher among Mexican Americans than among non-Hispanic whites or non-Hispanic blacks. DDE levels are clearly measurable in people aged 12-19 years, even though they were born after DDT was banned in the United States. Compared with levels found in several smaller studies of DDT exposure among selected groups in the United States before 1990, DDT levels presented in the *Report* are clearly lower. The National Toxicology Program has classified DDT as reasonably anticipated to be a human carcinogen. No generally recognized guidelines are available for serum levels of DDT or DDE that are a threshold value for other adverse health effects. Continued exposure in the United States may be from persisting DDT/DDE in the environment or DDT residues in food.

Baseline data on exposure of the population to chlorpyrifos, a commonly used organophosphate pesticide

Chlorpyrifos is a heavily used organophosphate pesticide. Retail sales of chlorpyrifos for residential use stopped in December 2001. The *Second Report* provides urine levels for the major metabolite of chlorpyrifos (i.e., 3,5,6-trichloro-2-pyridinol) for 1999-2000. In future *Reports*, CDC will compare chlorpyrifos levels with these baseline levels in the *Second Report* to assess the effectiveness of the recent restriction on chlorpyrifos use in reducing exposure of the U.S. population. In addition, the *Second Report* shows chlorpyrifos levels in children that were about twice as high as those found in adults. No generally recognized guidelines are yet available for urine levels of chlorpyrifos metabolites that are a threshold value for adverse health effects.

More findings for many other environmental chemicals

The *Second Report* covers a host of chemicals. Many findings from the *Report*, not highlighted here, will guide public health efforts to identify and prevent exposure problems. These findings include data on phthalates, mercury, cadmium, other heavy metals, organophosphate pesticides, carbamate pesticides, herbicides, polycyclic aromatic hydrocarbons (PAHs), phytoestrogens, and organochlorine pesticides.

Future Plans

Current plans are to release future *Reports* of exposure of the U.S. population that cover two-year periods (e.g., 2001-2002, 2003-2004, 2005-2006). Future releases will include more chemicals than the 116 in this *Report*. Future *Reports* will provide additional information on trends of exposure in population groups defined by age, sex, and race or ethnicity. CDC has solicited and received nominations for chemicals or categories of chemicals to include in future *Reports*. Selection criteria and the process for nominating chemicals were published in the October 7, 2002 issue of the *Federal Register* (Vol. 67, No. 194, p. 62477-8).

Future *Reports* will also include exposure information for special-exposure populations from studies of people exposed from localized or point sources (for example, 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 published in future *Reports* will help us answer these 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?

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