

Organochlorine Pesticides

General Information

Organochlorine pesticides, including DDT, are effective against a variety of insects. Some organochlorines, including hexachlorobenzene and pentachlorophenol, have been used primarily as fungicides and antimicrobials. These chemicals were introduced in the 1940s, and many of their uses have been restricted by the U.S. EPA because of their persistence in the environment. Although many of these chemicals are no longer widely used in the United States, other countries continue to use them.

Organochlorine pesticides can enter the environment from direct application and runoff, disposal of contaminated wastes into landfills, emissions from waste incinerators, and releases from manufacturing plants that produce these chemicals. Some organochlorine pesticides are volatile or can adhere to soil or particles in the air. In aquatic systems, organochlorine pesticides are adsorbed onto sediments in water that can then bioaccumulate in fish and other marine mammals. Because these chemicals are soluble in fat, they are found at higher concentrations in fatty foods. In the general population, the diet is the main source of exposure to organochlorine pesticides, primarily through the ingestion of fatty foods (such as milk, dairy products, and fish). Minor sources of exposure for the general population include contaminated

drinking water and air. Infants can be exposed to these chemicals through breast milk and the fetus can be exposed in utero via the placenta. Workers can be exposed to organochlorine chemicals in the manufacture, formulation, or application of these chemicals. The U.S. FDA, U.S. EPA, and OSHA have developed criteria on the allowable levels of certain organochlorine chemicals in foods, the environment, and the workplace.

Organochlorine pesticides vary in their chemical structures and mechanisms of toxicity. They can be classified into four categories: dichlorodiphenylethanes (e.g., DDT), cyclodienes (e.g., heptachlor, dieldrin), chlorinated benzenes (e.g., hexachlorobenzene [HCB]), and cyclohexanes (e.g., hexachlorocyclohexane [HCH]). Table 226 shows the parent organochlorine pesticides and their metabolites that were measured for this *Report*. For example, DDT metabolizes to DDE. Measurements of these chemicals can reflect either recent or accumulated chronic exposures or both. Some of the metabolites can be produced from the metabolism of more than one pesticide. In addition to reflecting exposure to the parent pesticide, the level of the metabolite in a person's blood or urine may also reflect exposure to the metabolite itself if it was present in the person's environment. The health effects of exposure to organochlorine pesticides on the general population at current levels of exposure are unknown.

Table 225. Organochlorine pesticides and their metabolites

Organochlorine pesticide (CAS number)	Serum pesticide or metabolite(s) (CAS number)	Urinary pesticide or metabolite(s) (CAS number)
Hexachlorobenzene (118-74-1)	Hexachlorobenzene (118-74-1)	Pentachlorophenol (87-86-5) 2,4,6-Trichlorophenol (88-06-2) 2,4,5-Trichlorophenol (95-95-4)
Hexachlorocyclohexanes	Hexachlorocyclohexane (608-73-1) including beta-HCH (319-85-7) and gamma-HCH (58-89-9) isomers	Pentachlorophenol (87-86-5) 2,4,6-Trichlorophenol (88-06-2) 2,4,5-Trichlorophenol (95-95-4)
Pentachlorophenol (87-86-5)		Pentachlorophenol (87-86-5)
Trichlorophenols Including 2,4,5-Trichlorophenol (95-95-4) and 2,4,6-Trichlorophenol (88-06-2)		2,4,5-Trichlorophenol (95-95-4) 2,4,6-Trichlorophenol (88-06-2)
DDT (50-29-3) <i>p,p'</i> -DDT (50-29-3) <i>o,p'</i> -DDT (789-02-6)	<i>p,p'</i> -DDE (72-55-9)	
Heptachlor (76-44-8)	Heptachlor epoxide (1024-57-3)	
Chlordane (12789-03-6)	Oxychlordane (27304-13-8)	
Mirex (2385-85-5)	Mirex (2385-85-5)	
Aldrin (309-00-02)	Aldrin (309-00-02) Dieldrin (60-57-1)	
Dieldrin (60-57-1)	Dieldrin (60-57-1)	
Endrin (72-20-8)	Endrin (72-20-8)	

Hexachlorobenzene

CAS No. 118-74-1

General Information

Hexachlorobenzene (HCB) is an organochlorine pesticide that was once used in the United States as a fungicide to pretreat grain. The U.S. EPA cancelled the use of HCB as a fungicide in 1984. Hexachlorobenzene may also be produced as a byproduct in the manufacturing process for certain chemicals.

Hexachlorobenzene is a relatively persistent compound in the environment. Because HCB does not dissolve easily in water, it is usually not present in high concentrations in drinking water. The U.S. EPA has issued an advisory for safe levels of HCB in drinking water. In the general population, the diet, including foods high in fats, is a significant source of exposure to HCB. Small amounts of HCB have also been detected in outdoor air. Workers in chemical manufacturing industries may be exposed to higher levels of HCB via inhalation or dermal pathways of exposure.

HCB interferes with the normal synthesis of heme in the body, resulting in the accumulation of abnormal heme precursors. This interference can adversely affect the skin as well as other organ systems. Chronic dietary overexposure to HCB also has caused serious health effects. For example, during the years 1955-1959, HCB-treated grain was processed into bread and consumed by people living in southeastern Turkey. Those with significant exposures developed porphyria cutanea tarda; hyperpigmentation of the skin; and other manifestations, including weakness, paresthesia, thyromegaly, and arthritis. Children born to mothers exposed during that time developed sores on their skin, and many died within the first 2 years of life (Peters et al., 1982). HCB has been associated with reproductive and developmental disorders in experimental animal studies. IARC classifies hexachlorobenzene as possibly carcinogenic to humans, and NTP classifies hexachlorobenzene as reasonably anticipated to be a human carcinogen.

Table 226. Hexachlorobenzene (lipid adjusted)

Geometric mean and selected percentiles of serum concentrations (in 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, 1999-2002.

	Survey years	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)				Sample size
			50th	75th	90th	95th	
Total, age 12 and older	99-00	*	< LOD	< LOD	< LOD	< LOD	1702
	01-02	*	< LOD	< LOD	< LOD	< LOD	2277
Age group							
12-19 years	99-00	*	< LOD	< LOD	< LOD	< LOD	591
	01-02	*	< LOD	< LOD	< LOD	< LOD	747
20 years and older	99-00	*	< LOD	< LOD	< LOD	< LOD	1111
	01-02	*	< LOD	< LOD	< LOD	< LOD	1530
Gender							
Males	99-00	*	< LOD	< LOD	< LOD	< LOD	807
	01-02	*	< LOD	< LOD	< LOD	< LOD	1058
Females	99-00	*	< LOD	< LOD	< LOD	< LOD	895
	01-02	*	< LOD	< LOD	< LOD	< LOD	1219
Race/ethnicity							
Mexican Americans	99-00	*	< LOD	< LOD	< LOD	< LOD	583
	01-02	*	< LOD	< LOD	< LOD	< LOD	554
Non-Hispanic blacks	99-00	*	< LOD	< LOD	< LOD	< LOD	350
	01-02	*	< LOD	< LOD	< LOD	< LOD	511
Non-Hispanic whites	99-00	*	< LOD	< LOD	< LOD	< LOD	636
	01-02	*	< LOD	< LOD	< LOD	< LOD	1052

< LOD means less than the limit of detection, which may vary for some chemicals by year and by individual sample. See Appendix A for LODs.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Once exposure to HCB occurs, the chemical is distributed throughout the body and accumulates in fatty tissues. HCB can persist in body fat for many years and is eliminated very slowly from the body. Age-dependent increases of HCB in body fat have been consistently reported in studies of general populations (Bertram et al., 1986; Glynn et al., 2003; Becker et al.; 2002). Grimalt et al. (1994) reported that residents living near an HCB chemical plant had serum HCB levels that were about five-fold greater than levels of residents from a reference community. In another study, serum HCB levels in workers at an HCB plant were about five-fold greater than levels in the local population (Herrero et al., 1999).

Pentachlorophenol (PCP), 2,4,5-trichlorophenol (2,4,5-TCP), and 2,4,6-trichlorophenol (2,4,6-TCP) are urinary metabolites of HCB (To-Figueras et al., 1997). Urinary PCP can also result from exposure to other chlorinated hydrocarbons, such as pentachlorobenzene, hexachlorocyclohexane, or pentachloronitrobenzene. Similarly, urinary 2,4,5-TCP and 2,4,6-TCP can result from exposure to other chlorinated hydrocarbons such as hexachlorocyclohexane. Because urinary PCP, 2,4,5-

TCP, and 2,4,6-TCP can occur from exposures to chemicals other than HCB, measuring HCB in serum is a more specific indicator of exposure to HCB.

More information about external exposure (i.e., environmental levels) and health effects is available from the U.S. EPA's IRIS Web site at <http://www.epa.gov/iris> and from ATSDR's Toxicological Profiles at <http://www.atsdr.cdc.gov/toxprofiles>.

Interpreting Levels of Lipid-Adjusted Serum HCB Reported in the Tables

Serum hexachlorobenzene levels were measured in a subsample of NHANES participants aged 12 years and older. Participants were selected within the specified age range to be a representative sample of the U.S. population. In the NHANES 1999-2000 and 2001-2002 subsamples, hexachlorobenzene levels in serum were below the limit of detection. In a probability sample of the German population aged 18-69 years, the mean concentration of HCB in blood was 0.44 µg/L (Becker et al., 2002), which is slightly lower than the limit of

Table 227. Hexachlorobenzene (whole weight)

Geometric mean and selected percentiles of serum concentrations (in ng/g of serum or parts per billion) for the U.S. population aged 12 years and older, National Health and Nutrition Examination Survey, 1999-2002.

	Survey years	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)				Sample size
			50th	75th	90th	95th	
Total, age 12 and older	99-00	*	< LOD	< LOD	< LOD	< LOD	1702
	01-02	*	< LOD	< LOD	< LOD	< LOD	2277
Age group							
12-19 years	99-00	*	< LOD	< LOD	< LOD	< LOD	591
	01-02	*	< LOD	< LOD	< LOD	< LOD	747
20 years and older	99-00	*	< LOD	< LOD	< LOD	< LOD	1111
	01-02	*	< LOD	< LOD	< LOD	< LOD	1530
Gender							
Males	99-00	*	< LOD	< LOD	< LOD	< LOD	807
	01-02	*	< LOD	< LOD	< LOD	< LOD	1058
Females	99-00	*	< LOD	< LOD	< LOD	< LOD	895
	01-02	*	< LOD	< LOD	< LOD	< LOD	1219
Race/ethnicity							
Mexican Americans	99-00	*	< LOD	< LOD	< LOD	< LOD	583
	01-02	*	< LOD	< LOD	< LOD	< LOD	554
Non-Hispanic blacks	99-00	*	< LOD	< LOD	< LOD	< LOD	350
	01-02	*	< LOD	< LOD	< LOD	< LOD	511
Non-Hispanic whites	99-00	*	< LOD	< LOD	< LOD	< LOD	636
	01-02	*	< LOD	< LOD	< LOD	< LOD	1052

< LOD means less than the limit of detection, which may vary for some chemicals by year and by individual sample. See Appendix A for LODs.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

detection (on a lipid adjusted basis) in this *Report*. HCB was detected in only 4.9% of people in the 1976-1980 NHANES subsample (Stehr-Green et al., 1989). Mean levels in small sample of males and females in Spain were about 100 and 20 fold higher, respectively, than the detection limit in this *Report* (To-Figueras et al., 1997).

Finding a measurable amount of hexachlorobenzene in serum does not mean that the level of the hexachlorobenzene will result in an adverse health effect. These data will help scientists plan and conduct research about exposure to hexachlorobenzene and health effects. These data also provide physicians with a reference range so that they can determine whether or not other people have been exposed to higher levels of hexachlorobenzene than levels found in the general population.

Hexachlorocyclohexane

CAS No. 608-73-1

General Information

Hexachlorocyclohexane (HCH) is an organochlorine pesticide with several isomeric forms: alpha, beta, gamma, and delta. The gamma isomer, commonly known as lindane, is the only isomer with insecticidal activity. The other isomers are used either as fungicides or to synthesize other chemicals and also may be formed during the synthesis of lindane. Technical-grade HCH contains all four isomers but mostly the alpha isomer. In 1985, many agricultural uses of lindane were cancelled in the United States. Lindane has had limited registration for use in the preplanting treatment of seeds although the U.S. EPA has recently required additional studies about and restrictions on these uses. Agricultural workers may be exposed to lindane via dermal, inhalation, or ingestion routes when applying the chemical. Lindane is also approved for use by the U.S. FDA in topical pharmaceutical products to treat human scabies and lice.

At high doses, gamma-HCH (lindane) blocks inhibitory neurotransmitters in the central nervous system. Seizures and deaths among children have resulted from excess dermal application of 1% lindane lotions and from accidental ingestion of lindane vaporizer tablets used in the past. Workers who directly handled HCH have complained of headache, paresthesias, tremors, and memory loss (Nigam et al., 1986). Blood dyscrasias (anemia, leukopenia) have been reported after accidental or large exposures (Morgan et al., 1980; Rugman et al., 1990). Lindane and other HCH isomers are mainly metabolized to chlorophenols such as 2,4,6-trichlorophenol, 2,4,5-trichlorophenol, and 2,3,5-trichlorophenol. Beta-HCH has a blood elimination half-life of 7 years, whereas gamma-HCH has a shorter blood elimination half-life of only 20 hours.

IARC classifies hexachlorocyclohexane isomers as possibly carcinogenic to humans, and NTP classifies

Table 228. beta-Hexachlorocyclohexane (lipid adjusted)

Geometric mean and selected percentiles of serum concentrations (in 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, 1999-2002.

	Survey years	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)				Sample size
			50th	75th	90th	95th	
Total, age 12 and older	99-00	9.68 (<LOD-10.9)	< LOD	19.0 (16.0-21.6)	42.0 (33.4-50.6)	68.9 (50.6-87.6)	1893
	01-02	*	< LOD	10.3 (9.08-11.0)	23.6 (19.4-29.4)	43.3 (32.4-55.2)	2291
Age group							
	12-19 years						
	99-00	*	< LOD	< LOD	< LOD	11.4 (<LOD-16.1)	653
	01-02	*	< LOD	< LOD	< LOD	8.44 (<LOD-12.2)	758
20 years and older	99-00	10.9 (9.61-12.4)	< LOD	21.0 (18.9-24.0)	46.0 (35.9-56.8)	73.4 (52.7-96.0)	1240
	01-02	*	< LOD	11.2 (10.3-13.2)	25.5 (21.2-33.5)	46.2 (34.6-62.0)	1533
Gender							
	Males						
	99-00	*	< LOD	14.5 (10.7-19.1)	29.8 (23.3-38.7)	44.6 (32.8-68.9)	901
	01-02	*	< LOD	8.24 (7.15-10.1)	17.7 (15.5-22.2)	29.2 (22.7-35.8)	1067
Females	99-00	11.1 (9.56-12.8)	< LOD	22.0 (19.1-27.6)	51.3 (42.2-67.6)	81.1 (64.4-111)	992
	01-02	*	< LOD	11.8 (10.4-14.5)	30.6 (24.2-39.9)	54.5 (39.9-71.5)	1224
Race/ethnicity							
	Mexican Americans						
	99-00	16.7 (13.7-20.2)	15.5 (11.6-20.4)	37.5 (29.6-47.3)	97.9 (62.6-135)	139 (99.8-199)	632
	01-02	*	7.60 (<LOD-8.63)	16.6 (13.4-21.1)	44.0 (32.7-56.4)	84.4 (55.2-107)	563
Non-Hispanic blacks	99-00	*	< LOD	14.7 (12.0-23.1)	36.6 (30.0-41.7)	48.9 (40.9-81.1)	403
	01-02	*	< LOD	7.73 (<LOD-10.4)	23.3 (11.8-47.3)	45.9 (20.5-115)	513
Non-Hispanic whites	99-00	*	< LOD	17.5 (14.1-20.5)	34.4 (25.2-46.0)	51.3 (40.0-70.8)	702
	01-02	*	< LOD	9.27 (7.60-10.8)	20.4 (17.1-24.3)	33.5 (24.3-44.7)	1051

< LOD means less than the limit of detection, which may vary for some chemicals by year and by individual sample. See Appendix A for LODs.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

hexachlorocyclohexane isomers as reasonably anticipated to be human carcinogens. More information about external exposure (i.e., environmental levels) and health effects is available from the U.S. EPA's IRIS Web site at <http://www.epa.gov/iris> and from ATSDR's Toxicological Profiles at <http://www.atsdr.cdc.gov/toxprofiles>.

Interpreting Levels of Lipid-Adjusted Serum beta-HCH and gamma-HCH Reported in the Tables

Serum beta-HCH and gamma-HCH levels were measured in a subsample of NHANES participants aged 12 years and older. Participants were selected within the specified age range to be a representative sample of the U.S. population. Because of its longer half-life, beta-HCH is usually the isomer with the highest concentration in the general population.

The 95th percentile level of beta-HCH for the current 2001-2002 NHANES subsample is similar to the corresponding 95th percentile values reported in a study of adults in Germany (Wilhelm et al., 2003). Another

study of New Zealand adults older than age 15 years that recently reported beta-HCH mean levels to be 19.7 ng/gram of lipid (Bates et al., 2004b), which are slightly higher than mean levels reported for the 1999-2000 subsample. The levels of beta-HCH in serum shown in this *Report* are far below a biological tolerance level of 25 µg/L (approximately 4,200 ng/gram of serum lipid) in serum or plasma for workers at the end of their shifts as defined by the Deutsche Forschungsgemeinschaft (2000).

Beta-HCH levels in the U.S. population have been declining since 1970 (Radomski et al., 1971; Stehr-Green et al., 1989; Kutz et al., 1991; Sturgeon et al., 1998). Kutz et al. (1991) estimated that in 1970 nearly 100% of the U.S. population had detectable beta-HCH in adipose tissue and that 80% had detectable concentrations in 1980, with the mean adipose beta-HCH level decreasing from 0.37 µg/gram of lipid (370 ng/gram) in 1971 to 0.10 µg/gram of lipid (100 ng/gram) in 1983. In 1976, the median serum lipid-adjusted level of beta-HCH was 119 ng/gram for a control population of 7,712 Danish females (Hoyer et al., 1998). The large difference between these 1976 levels and current U.S. levels may represent a

Table 229. beta-Hexachlorocyclohexane (whole weight)

Geometric mean and selected percentiles of serum concentrations (in ng/g of serum or parts per billion) for the U.S. population aged 12 years and older, National Health and Nutrition Examination Survey, 1999-2002.

	Survey years	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)				Sample size
			50th	75th	90th	95th	
Total, age 12 and older	99-00	.058 (.051-.066)	< LOD	.124 (.103-.146)	.286 (.223-.359)	.447 (.359-.558)	1893
	01-02	*	< LOD	.066 (.058-.076)	.160 (.132-.196)	.296 (.218-.388)	2291
Age group 12-19 years	99-00	*	< LOD	< LOD	< LOD	.055 (.047-.070)	653
	01-02	*	< LOD	< LOD	< LOD	.048 (.030-.066)	758
20 years and older	99-00	.067 (.059-.077)	< LOD	.140 (.120-.162)	.324 (.243-.412)	.477 (.406-.616)	1240
	01-02	*	< LOD	.077 (.067-.093)	.175 (.145-.226)	.312 (.240-.446)	1533
Gender Males	99-00	*	< LOD	.093 (.077-.117)	.206 (.157-.249)	.286 (.215-.474)	901
	01-02	*	< LOD	.054 (.046-.061)	.131 (.099-.166)	.200 (.164-.254)	1067
Females	99-00	.065 (.056-.077)	< LOD	.149 (.122-.189)	.383 (.303-.447)	.556 (.422-.679)	992
	01-02	*	< LOD	.082 (.070-.098)	.204 (.165-.254)	.368 (.290-.455)	1224
Race/ethnicity Mexican Americans	99-00	.098 (.080-.119)	.093 (.073-.110)	.245 (.203-.307)	.582 (.386-.844)	.905 (.582-1.37)	632
	01-02	*	.043 (.034-.052)	.104 (.083-.129)	.301 (.211-.453)	.612 (.400-.851)	563
Non-Hispanic blacks	99-00	*	< LOD	.104 (.072-.142)	.243 (.186-.293)	.359 (.284-.465)	403
	01-02	*	< LOD	.044 (.030-.070)	.138 (.076-.265)	.226 (.125-.674)	513
Non-Hispanic whites	99-00	*	< LOD	.118 (.095-.142)	.244 (.172-.339)	.390 (.283-.508)	702
	01-02	*	< LOD	.060 (.051-.070)	.137 (.113-.169)	.220 (.164-.310)	1051

< LOD means less than the limit of detection, which may vary for some chemicals by year and by individual sample. See Appendix A for LODs.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

global change in levels over time.

Age-related increases in the levels of beta-HCH have previously been observed by the German Commission on Biological Monitoring (Ewers et al., 1999). In addition, such an age relationship was observed previously in both a nonrandom subsample from the NHANES II (1976-1980) and for beta-HCH levels in adipose tissue (Stehr-Green et al., 1989; Kutz et al., 1991). Also, higher levels in females than in males also had been observed for beta-HCH levels in serum (Stehr-Green et al., 1989), but not in adipose tissue (Burns, 1974).

In the NHANES 1999-2000 and 2001-2002 subsamples, serum levels of gamma-HCH were generally below the limit of detection, and detection limits were lower than values reported in studies of people in other countries including Spain (Botella et al., 2004) and India (Bhatnagar et al., 2004). Levels of lindane in the general population of other countries can be higher than levels in the U.S. population (Radomski et al., 1971), probably because of regional variations in the use of the pesticide.

Serum lindane levels in workers involved in the

manufacture, processing, application, or formulation of HCH were found to be several-fold higher than levels in people with no known occupational exposure to the pesticide (Nigam et al., 1986; Radomski et al., 1971; Angerer et al., 1983). The United Kingdom's benchmark guidance value for workers with lindane exposure is 35 nanomoles per liter (approximately 1,700 ng/gram of lipid) in whole blood or 70 nanomoles per liter in plasma (Wilson, 1999). The German Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area sets the biological tolerance value for lindane as 20 µg/L (approximately 3,300 ng/gram of lipid) (Deutsche Forschungsgemeinschaft, 2000).

Finding a measurable amount of HCH isomers in serum does not mean that the level will result in an adverse health effect. These data will help scientists plan and conduct research about the relation between exposure to HCH isomers and health effects. These data also provide physicians with a reference range so that they can determine whether or not other people have been exposed to higher levels of HCH isomers than levels found in the general population.

Table 230. gamma Hexachlorocyclohexane (lipid adjusted)

Geometric mean and selected percentiles of serum concentrations (in 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, 1999-2002.

	Survey years	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)				Sample size
			50th	75th	90th	95th	
Total, age 12 and older	99-00	*	< LOD	< LOD	< LOD	< LOD	1799
	01-02	*	< LOD	< LOD	< LOD	< LOD	2280
Age group							
12-19 years	99-00	*	< LOD	< LOD	< LOD	< LOD	660
	01-02	*	< LOD	< LOD	< LOD	< LOD	758
20 years and older	99-00	*	< LOD	< LOD	< LOD	< LOD	1139
	01-02	*	< LOD	< LOD	< LOD	< LOD	1522
Gender							
Males	99-00	*	< LOD	< LOD	< LOD	< LOD	863
	01-02	*	< LOD	< LOD	< LOD	< LOD	1060
Females	99-00	*	< LOD	< LOD	< LOD	< LOD	936
	01-02	*	< LOD	< LOD	< LOD	< LOD	1220
Race/ethnicity							
Mexican Americans	99-00	*	< LOD	< LOD	< LOD	< LOD	631
	01-02	*	< LOD	< LOD	< LOD	< LOD	563
Non-Hispanic blacks	99-00	*	< LOD	< LOD	< LOD	< LOD	380
	01-02	*	< LOD	< LOD	< LOD	< LOD	509
Non-Hispanic whites	99-00	*	< LOD	< LOD	< LOD	< LOD	646
	01-02	*	< LOD	< LOD	< LOD	< LOD	1045

< LOD means less than the limit of detection, which may vary for some chemicals by year and by individual sample. See Appendix A for LODs.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Table 231. gamma Hexachlorocyclohexane (whole weight)

Geometric mean and selected percentiles of serum concentrations (in ng/g of serum or parts per billion) for the U.S. population aged 12 years and older, National Health and Nutrition Examination Survey, 1999-2002.

	Survey years	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)				Sample size
			50th	75th	90th	95th	
Total, age 12 and older	99-00	*	< LOD	< LOD	< LOD	< LOD	1799
	01-02	*	< LOD	< LOD	< LOD	< LOD	2280
Age group							
12-19 years	99-00	*	< LOD	< LOD	< LOD	< LOD	660
	01-02	*	< LOD	< LOD	< LOD	< LOD	758
20 years and older	99-00	*	< LOD	< LOD	< LOD	< LOD	1139
	01-02	*	< LOD	< LOD	< LOD	< LOD	1522
Gender							
Males	99-00	*	< LOD	< LOD	< LOD	< LOD	863
	01-02	*	< LOD	< LOD	< LOD	< LOD	1060
Females	99-00	*	< LOD	< LOD	< LOD	< LOD	936
	01-02	*	< LOD	< LOD	< LOD	< LOD	1220
Race/ethnicity							
Mexican Americans	99-00	*	< LOD	< LOD	< LOD	< LOD	631
	01-02	*	< LOD	< LOD	< LOD	< LOD	563
Non-Hispanic blacks	99-00	*	< LOD	< LOD	< LOD	< LOD	380
	01-02	*	< LOD	< LOD	< LOD	< LOD	509
Non-Hispanic whites	99-00	*	< LOD	< LOD	< LOD	< LOD	646
	01-02	*	< LOD	< LOD	< LOD	< LOD	1045

< LOD means less than the limit of detection, which may vary for some chemicals by year and by individual sample. See Appendix A for LODs.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Pentachlorophenol

CAS No. 87-86-5

General Information

Pentachlorophenol (PCP) is used primarily as a fungicide to preserve wood in the United States. The use of PCP has decreased over the years as a result of regulations issued by the U.S. EPA in 1984. Compared with other organochlorine pesticides, PCP is not a highly persistent chemical in the environment. The general population may be exposed through food and water sources, which can be contaminated from either PCP releases or waste-site runoffs or from breakdown products of other organochlorine chemicals (e.g., hexachlorocyclohexane, hexachlorobenzene). Homes containing PCP-treated wood are another source of exposure. Workers who manufacture or apply PCP may inhale it or absorb the chemical through their skin. The U.S. EPA and OSHA have developed criteria for allowable levels of PCP in the environment and in workplaces.

PCP is not extensively metabolized and is eliminated from the body relatively rapidly over the course of hours to days. Some PCP is metabolized to tetrachlorhydroquinone and excreted to a minor extent as glucuronidated conjugates (Braun et al., 1979; Ahlborg et al., 1974). PCP in the body may also be the result of metabolism from HCB (To-Figueras et al., 1997). Acute overexposure to PCP can lead to the uncoupling of oxidative phosphorylation, resulting in severe hyperthermia. These effects have been observed when people ingest or inhale PCP or absorb it through the skin. IARC has determined that pentachlorophenol is possibly carcinogenic to humans. More information about external exposure (i.e., environmental levels) and health effects is available from the U.S. EPA's IRIS Web site at <http://www.epa.gov/iris> and from ATSDR's Toxicological Profiles at <http://www.atsdr.cdc.gov/toxprofiles>.

Table 232. Pentachlorophenol

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6-59 years, National Health and Nutrition Examination Survey, 1999-2002.

	Survey years	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)				Sample size
			50th	75th	90th	95th	
Total, age 6 and older	99-00	*	< LOD	< LOD	.360 (<LOD-.930)	1.30 (.480-2.10)	1994
	01-02	*	< LOD	< LOD	1.23 (.590-1.76)	1.94 (1.58-2.53)	2528
Age group							
6-11 years	99-00	*	< LOD	< LOD	.760 (<LOD-1.51)	1.65 (.990-2.00)	482
	01-02	*	< LOD	< LOD	1.37 (.890-1.70)	2.08 (1.58-2.75)	577
12-19 years	99-00	*	< LOD	< LOD	.650 (<LOD-2.60)	2.00 (.510-5.90)	681
	01-02	*	< LOD	< LOD	1.48 (.850-2.30)	2.30 (1.47-5.04)	826
20-59 years	99-00	*	< LOD	< LOD	< LOD	1.10 (.250-1.70)	831
	01-02	*	< LOD	< LOD	1.01 (<LOD-1.76)	1.86 (1.45-2.53)	1125
Gender							
Males	99-00	*	< LOD	< LOD	.630 (<LOD-1.30)	1.40 (.400-2.20)	973
	01-02	*	< LOD	< LOD	1.31 (.680-1.80)	1.94 (1.47-3.09)	1190
Females	99-00	*	< LOD	< LOD	< LOD	.860 (.280-2.00)	1021
	01-02	*	< LOD	< LOD	1.10 (<LOD-1.78)	1.92 (1.54-2.42)	1338
Race/ethnicity							
Mexican Americans	99-00	*	< LOD	< LOD	< LOD	.650 (<LOD-1.90)	696
	01-02	*	< LOD	< LOD	.990 (<LOD-2.37)	1.60 (<LOD-3.14)	680
Non-Hispanic blacks	99-00	*	< LOD	< LOD	.970 (<LOD-2.50)	1.64 (.860-2.70)	521
	01-02	*	< LOD	< LOD	1.73 (1.25-2.29)	2.75 (2.02-3.67)	696
Non-Hispanic whites	99-00	*	< LOD	< LOD	.350 (<LOD-1.10)	1.30 (<LOD-2.30)	603
	01-02	*	< LOD	< LOD	1.16 (<LOD-1.76)	1.91 (1.48-2.42)	951

< LOD means less than the limit of detection, which may vary for some chemicals by year and by individual sample. See Appendix A for LODs.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Interpreting Levels of Urinary Pentachlorophenol Reported in the Tables

Urinary levels of PCP were measured in a subsample of NHANES participants aged 6 years and older. Participants were selected within the specified age range to be a representative sample of the U.S. population. In NHANES 2001-2002, urinary PCP levels at the 95th percentile were approximately five-fold lower than 95th percentile values measured in a nonrandom subsample from NHANES III participants (Hill et al., 1995). Urinary PCP levels at the 95th percentile in this *Report* were approximately two-fold lower than the corresponding 95th percentile values reported in a study of German adults aged 18-69 years (Becker et al., 2003) and approximately seven-fold lower than the 95th percentile levels for children aged 6-14 years (Seifert et al., 2000). Urinary levels of pentachlorophenol in the NHANES 2001-2002 subsample are far below allowable workplace BEIs (ACGIH, 2001).

Finding a measurable amount of PCP in urine does not mean that the level of the PCP will result in an adverse health effect. These data will help scientists plan and conduct research about the relation between exposure to PCP and health effects. These data also provide physicians with a reference range so that they can determine whether or not other people have been exposed to higher levels of PCP than levels found in the general population.

Table 233. Pentachlorophenol (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g of creatinine) for the U.S. population aged 6-59 years, National Health and Nutrition Examination Survey, 1999-2002.

	Survey years	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)				Sample size
			50th	75th	90th	95th	
Total, age 6 and older	99-00	*	< LOD	< LOD	.720 (.643-.857)	1.12 (.892-1.26)	1994
	01-02	*	< LOD	< LOD	1.52 (1.25-1.75)	2.26 (1.67-3.09)	2527
Age group							
6-11 years	99-00	*	< LOD	< LOD	.930 (.581-1.13)	1.39 (.985-1.83)	482
	01-02	*	< LOD	< LOD	1.83 (1.29-3.18)	3.18 (1.83-3.89)	577
12-19 years	99-00	*	< LOD	< LOD	.525 (.277-1.53)	1.26 (.400-2.75)	681
	01-02	*	< LOD	< LOD	1.19 (.904-1.53)	1.82 (1.25-2.82)	825
20-59 years	99-00	*	< LOD	< LOD	< LOD	1.06 (.857-1.20)	831
	01-02	*	< LOD	< LOD	1.52 (1.25-1.75)	2.06 (1.67-2.99)	1125
Gender							
Males	99-00	*	< LOD	< LOD	.750 (.450-.947)	1.13 (.857-1.80)	973
	01-02	*	< LOD	< LOD	1.12 (.946-1.40)	1.73 (1.25-2.92)	1190
Females	99-00	*	< LOD	< LOD	< LOD	1.10 (.857-1.14)	1021
	01-02	*	< LOD	< LOD	1.67 (1.52-1.99)	2.69 (1.93-3.50)	1337
Race/ethnicity							
Mexican Americans	99-00	*	< LOD	< LOD	< LOD	.947 (.643-1.68)	696
	01-02	*	< LOD	< LOD	1.09 (.745-2.10)	1.94 (1.06-3.55)	680
Non-Hispanic blacks	99-00	*	< LOD	< LOD	.713 (.390-1.18)	1.34 (.816-1.38)	521
	01-02	*	< LOD	< LOD	1.30 (.780-1.66)	1.94 (1.46-2.59)	695
Non-Hispanic whites	99-00	*	< LOD	< LOD	.750 (.614-.857)	1.13 (.857-1.20)	603
	01-02	*	< LOD	< LOD	1.52 (1.27-1.67)	2.10 (1.67-3.08)	951

< LOD means less than the limit of detection, which may vary for some chemicals by year and by individual sample. See Appendix A for LODs.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

2,4,5-Trichlorophenol

CAS No. 95-95-4

2,4,6-Trichlorophenol

CAS No. 88-06-2

Metabolites of Organochlorine Pesticides and Other Environmental Chemicals

General Information

The chemicals 2,4,5-trichlorophenol (2,4,5-TCP) and 2,4,6-trichlorophenol (2,4,6-TCP) are metabolites of several organochlorine chemicals, including hexachlorobenzene and hexachlorocyclohexane. Trichlorophenols are no longer intentionally manufactured, but they may be produced as byproducts of the manufacture of other chlorinated aromatic compounds. Small amounts of trichlorophenols can be produced during combustion of natural materials and from the chlorination of waste water that contains phenols. IARC classifies polychlorophenols (including

trichlorophenols) as possibly carcinogenic to humans, and NTP classifies 2,4,6-TCP as reasonably anticipated to be a human carcinogen. More information about external exposure (i.e., environmental levels) and health effects is available from the U.S. EPA's IRIS Web site at <http://www.epa.gov/iris> and from ATSDR's Toxicological Profiles at <http://www.atsdr.cdc.gov/toxprofiles>.

Interpreting Levels of Urinary Trichlorophenol Reported in the Tables

Urinary levels of 2,4,5-TCP and 2,4,6-TCP were measured in a subsample of NHANES participants aged

Table 234. 2,4,5-Trichlorophenol

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6-59 years, National Health and Nutrition Examination Survey, 1999-2002.

	Survey years	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)				Sample size
			50th	75th	90th	95th	
Total, age 6 and older	99-00	*	< LOD	1.40 (.970-2.70)	5.40 (2.50-14.0)	16.0 (4.30-39.0)	1998
	01-02	*	< LOD	< LOD	< LOD	2.31 (<LOD-7.81)	2526
Age group							
6-11 years	99-00	*	< LOD	1.30 (1.00-2.70)	4.60 (2.30-11.0)	11.0 (4.10-36.0)	483
	01-02	*	< LOD	< LOD	< LOD	2.42 (<LOD-13.3)	577
12-19 years	99-00	*	< LOD	1.60 (.940-3.72)	5.40 (2.50-24.0)	24.0 (3.80-41.0)	682
	01-02	*	< LOD	< LOD	< LOD	1.90 (<LOD-6.10)	826
20-59 years	99-00	*	< LOD	1.40 (.950-2.60)	5.30 (2.30-15.0)	18.0 (4.30-44.0)	833
	01-02	*	< LOD	< LOD	< LOD	2.71 (<LOD-8.27)	1123
Gender							
Males	99-00	*	< LOD	1.40 (.950-3.40)	5.30 (2.60-8.20)	9.30 (5.30-27.0)	974
	01-02	*	< LOD	< LOD	< LOD	5.57 (<LOD-15.8)	1187
Females	99-00	*	< LOD	1.50 (.980-3.10)	6.50 (2.30-27.0)	21.0 (3.20-48.0)	1024
	01-02	*	< LOD	< LOD	< LOD	< LOD	1339
Race/ethnicity							
Mexican Americans	99-00	*	.940 (<LOD-1.30)	1.70 (1.40-3.50)	8.50 (4.60-18.0)	21.0 (8.90-33.0)	697
	01-02	*	< LOD	< LOD	< LOD	14.2 (<LOD-121)	680
Non-Hispanic blacks	99-00	*	< LOD	1.20 (.900-2.20)	4.80 (2.00-8.40)	8.60 (3.50-63.0)	524
	01-02	*	< LOD	< LOD	< LOD	2.31 (<LOD-9.03)	696
Non-Hispanic whites	99-00	*	< LOD	1.40 (.920-3.60)	4.50 (2.30-9.20)	9.20 (4.30-27.0)	603
	01-02	*	< LOD	< LOD	< LOD	2.42 (<LOD-8.27)	949

< LOD means less than the limit of detection, which may vary for some chemicals by year and by individual sample. See Appendix A for LODs.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

6-59 years. Participants were selected within the specified age range to be a representative sample of the U.S. population. In the current NHANES 2001-2002 subsample, urinary 2,4,6-TCP levels at the 95th percentile were several times higher than a nonrandom subsample from NHANES III during 1988-1994 (Hill et al., 1995) and several times higher than 95th percentile values reported in a study of German adults aged 18-69 years (Becker et al., 2003). Urinary levels of 2,4,5-TCP at the 95th percentile were similar to values reported in a nonrandom subsample from NHANES III during 1988-1994 (Hill et al., 1995) and several times higher than 95th percentile values reported in a study of German adults aged 18-69 years (Becker et al., 2003).

Comparing Adjusted Geometric Means

Geometric mean levels of urinary 2,4,5-TCP in the 1999-2000 and 2001-2002 subsamples and 2,4,6-TCP in the 2001-2002 subsample could not be calculated due to an insufficient detection rate. Geometric mean levels of urinary 2,4,6-TCP for the demographic groups in 1999-

2000 were compared after adjusting for the covariates of race/ethnicity, age, gender and urinary creatinine (data not shown). Adjusted geometric mean levels of urinary 2,4,6-TCP were slightly higher for children aged 6-11 years than for either groups aged 12-19 or 20-59 years, and the group aged 12-19 had higher levels than the group aged 20-59 years. It is unknown whether these differences associated with age represent differences in exposure, pharmacokinetics, or the relationship of dose per body weight.

Finding a measurable amount of 2,4,5-TCP or 2,4,6-TCP in urine does not mean that the level will result in an adverse health effect. These data will help scientists plan and conduct research about the relation between exposure to 2,4,5-TCP or 2,4,6-TCP and health effects. These data also provide physicians with a reference range so that they can determine whether or not other people have been exposed to higher levels of 2,4,5-TCP or 2,4,6-TCP than levels found in the general population.

Table 235. 2,4,5-Trichlorophenol (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g of creatinine) for the U.S. population aged 6-59 years, National Health and Nutrition Examination Survey, 1999-2002.

	Survey years	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)				Sample size
			50th	75th	90th	95th	
Total, age 6 and older	99-00	*	< LOD	2.36 (1.54-3.16)	5.50 (3.24-11.2)	11.9 (4.96-19.6)	1998
	01-02	*	< LOD	< LOD	< LOD	4.57 (3.18-7.11)	2525
Age group							
6-11 years	99-00	*	< LOD	2.27 (1.19-4.78)	5.79 (3.83-12.4)	12.8 (5.28-25.4)	483
	01-02	*	< LOD	< LOD	< LOD	5.64 (2.56-13.8)	577
12-19 years	99-00	*	< LOD	1.44 (.923-2.50)	3.77 (1.93-11.2)	11.2 (2.62-20.1)	682
	01-02	*	< LOD	< LOD	< LOD	2.67 (2.21-5.82)	825
20-59 years	99-00	*	< LOD	2.46 (1.60-3.20)	5.71 (3.37-11.5)	11.7 (4.78-19.6)	833
	01-02	*	< LOD	< LOD	< LOD	4.57 (3.37-7.11)	1123
Gender							
Males	99-00	*	< LOD	1.67 (1.01-3.15)	4.24 (3.05-8.02)	9.55 (4.13-13.6)	974
	01-02	*	< LOD	< LOD	< LOD	4.31 (2.56-8.37)	1187
Females	99-00	*	< LOD	2.57 (1.79-4.00)	7.73 (3.05-17.8)	16.2 (5.00-29.3)	1024
	01-02	*	< LOD	< LOD	< LOD	< LOD	1338
Race/ethnicity							
Mexican Americans	99-00	*	.980 (.726-1.33)	2.49 (1.68-4.24)	6.89 (4.17-12.4)	11.8 (6.88-16.9)	697
	01-02	*	< LOD	< LOD	< LOD	11.9 (1.83-48.9)	680
Non-Hispanic blacks	99-00	*	< LOD	1.16 (.790-2.29)	3.39 (2.15-6.32)	6.79 (2.69-18.2)	524
	01-02	*	< LOD	< LOD	< LOD	2.81 (1.33-9.17)	695
Non-Hispanic whites	99-00	*	< LOD	2.44 (1.53-3.24)	4.72 (3.47-8.43)	9.55 (4.27-17.8)	603
	01-02	*	< LOD	< LOD	< LOD	4.31 (3.20-7.21)	949

< LOD means less than the limit of detection, which may vary for some chemicals by year and by individual sample. See Appendix A for LODs.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Table 236. 2,4,6-Trichlorophenol

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6-59 years, National Health and Nutrition Examination Survey, 1999-2002.

	Survey years	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)				Sample size
			50th	75th	90th	95th	
Total, age 6 and older	99-00	2.85 (2.55-3.18)	2.45 (2.40-2.60)	4.80 (3.80-7.60)	14.8 (7.70-25.0)	25.0 (15.0-39.0)	1989
	01-02	*	1.68 (<LOD-2.43)	5.94 (4.89-6.63)	10.8 (9.98-11.7)	14.9 (13.4-17.9)	2503
Age group							
6-11 years	99-00	4.47 (3.36-5.95)	3.72 (2.70-5.90)	11.0 (4.71-18.0)	24.0 (14.0-38.0)	32.0 (20.5-46.0)	481
	01-02	*	2.99 (1.91-4.32)	7.79 (5.73-9.99)	13.4 (10.6-17.3)	19.2 (14.1-25.3)	574
12-19 years	99-00	3.56 (3.00-4.23)	3.00 (2.60-3.60)	6.00 (4.20-11.0)	20.0 (9.60-37.0)	37.0 (20.0-54.0)	678
	01-02	*	3.26 (2.32-4.37)	7.49 (6.45-9.40)	13.5 (11.0-18.2)	19.4 (17.3-26.6)	820
20-59 years	99-00	2.52 (2.23-2.85)	2.40 (2.10-2.40)	4.20 (3.50-5.20)	11.6 (6.00-21.0)	21.0 (11.0-37.0)	830
	01-02	*	< LOD	4.83 (3.70-6.28)	9.60 (8.72-10.7)	13.2 (11.8-15.2)	1109
Gender							
Males	99-00	2.92 (2.58-3.31)	2.60 (2.40-2.80)	5.10 (3.90-7.90)	15.0 (8.30-23.0)	26.0 (15.0-38.0)	970
	01-02	*	2.36 (1.68-3.02)	6.65 (5.98-7.53)	12.1 (10.8-13.1)	17.0 (13.6-22.2)	1178
Females	99-00	2.78 (2.35-3.28)	2.40 (2.10-2.45)	4.80 (3.40-7.59)	16.0 (6.00-32.0)	25.0 (13.0-47.0)	1019
	01-02	*	< LOD	4.69 (3.59-6.09)	9.71 (8.25-11.6)	13.1 (11.7-16.6)	1325
Race/ethnicity							
Mexican Americans	99-00	2.70 (2.20-3.32)	2.60 (2.10-3.10)	4.80 (4.10-6.50)	14.0 (8.20-23.0)	22.0 (13.0-34.0)	694
	01-02	*	2.07 (<LOD-3.23)	5.31 (3.95-6.54)	11.3 (8.51-12.8)	15.6 (12.6-19.8)	677
Non-Hispanic blacks	99-00	3.14 (2.40-4.12)	2.80 (2.10-3.40)	6.40 (3.40-14.0)	18.0 (9.30-33.0)	32.0 (16.0-68.0)	519
	01-02	*	2.58 (1.32-4.02)	6.45 (5.04-7.55)	11.1 (8.87-14.9)	17.9 (11.8-24.7)	696
Non-Hispanic whites	99-00	2.74 (2.46-3.06)	2.45 (2.30-2.70)	4.60 (3.80-6.60)	12.0 (6.40-21.0)	20.0 (12.0-37.0)	602
	01-02	*	1.57 (<LOD-2.20)	6.10 (5.01-6.65)	10.7 (9.67-12.3)	14.6 (13.3-17.9)	931

< LOD means less than the limit of detection, which may vary for some chemicals by year and by individual sample. See Appendix A for LODs.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Table 237. 2,4,6-Trichlorophenol (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in $\mu\text{g/g}$ of creatinine) for the U.S. population aged 6-59 years, National Health and Nutrition Examination Survey, 1999-2002.

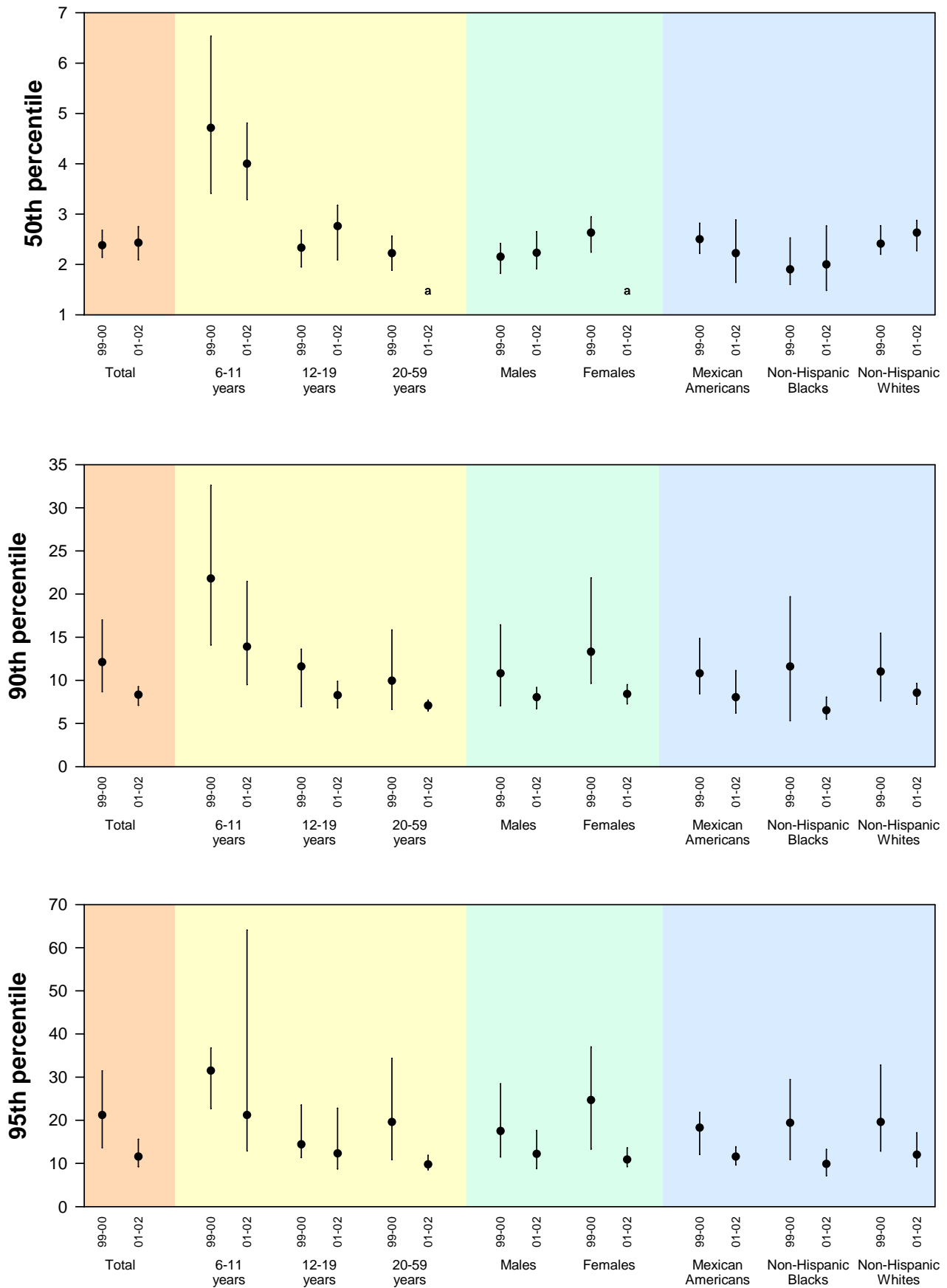
	Survey years	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)				Sample size
			50th	75th	90th	95th	
Total, age 6 and older	99-00	2.54 (2.30-2.81)	2.38 (2.14-2.68)	4.91 (3.83-6.49)	12.1 (8.67-17.0)	21.2 (13.6-31.5)	1989
	01-02	*	2.43 (2.09-2.75)	4.36 (4.14-4.70)	8.33 (7.10-9.26)	11.6 (9.25-15.6)	2502
Age group							
6-11 years	99-00	4.82 (3.87-6.00)	4.71 (3.41-6.53)	11.5 (7.63-15.3)	21.8 (14.1-32.6)	31.5 (22.7-36.8)	481
	01-02	*	4.00 (3.29-4.81)	8.26 (6.16-10.4)	13.9 (9.51-21.5)	21.2 (12.9-64.1)	574
12-19 years	99-00	2.40 (2.08-2.78)	2.33 (1.95-2.68)	4.27 (3.13-6.00)	11.6 (6.94-13.6)	14.4 (11.3-23.6)	678
	01-02	*	2.76 (2.09-3.17)	4.52 (3.83-5.92)	8.28 (6.81-9.89)	12.3 (8.73-22.8)	819
20-59 years	99-00	2.32 (2.04-2.63)	2.22 (1.89-2.56)	4.25 (3.38-5.63)	9.95 (6.64-15.9)	19.6 (10.9-34.4)	830
	01-02	*	< LOD	4.05 (3.66-4.38)	7.08 (6.43-7.72)	9.77 (8.53-11.9)	1109
Gender							
Males	99-00	2.24 (1.99-2.53)	2.15 (1.82-2.42)	4.41 (3.56-5.88)	10.8 (7.04-16.4)	17.5 (11.5-28.5)	970
	01-02	*	2.23 (1.91-2.65)	4.22 (3.77-4.73)	8.05 (6.70-9.17)	12.2 (8.79-17.7)	1178
Females	99-00	2.88 (2.49-3.33)	2.63 (2.24-2.95)	5.53 (3.88-7.23)	13.3 (9.65-21.9)	24.7 (13.3-37.0)	1019
	01-02	*	< LOD	4.53 (4.19-5.11)	8.40 (7.27-9.51)	10.9 (9.26-13.6)	1324
Race/ethnicity							
Mexican Americans	99-00	2.43 (2.06-2.87)	2.50 (2.22-2.82)	5.43 (3.87-7.10)	10.8 (8.46-14.9)	18.3 (12.1-21.8)	694
	01-02	*	2.22 (1.64-2.88)	4.25 (3.47-5.76)	8.05 (6.21-11.1)	11.6 (9.63-13.9)	677
Non-Hispanic blacks	99-00	2.13 (1.65-2.76)	1.90 (1.60-2.52)	3.97 (2.76-8.02)	11.6 (5.32-19.7)	19.4 (10.9-29.5)	519
	01-02	*	2.00 (1.48-2.76)	3.83 (3.15-4.81)	6.52 (5.50-8.06)	9.87 (7.14-13.2)	695
Non-Hispanic whites	99-00	2.59 (2.33-2.88)	2.41 (2.20-2.77)	4.87 (3.83-6.06)	11.0 (7.62-15.5)	19.6 (12.9-32.8)	602
	01-02	*	2.63 (2.27-2.88)	4.60 (4.29-4.98)	8.56 (7.22-9.65)	12.0 (9.25-17.1)	931

< LOD means less than the limit of detection, which may vary for some chemicals by year and by individual sample. See Appendix A for LODs.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Figure 29. 2,4,6-Trichlorophenol (creatinine corrected)

Selected percentiles with 95% confidence intervals of urine concentrations (in $\mu\text{g/g}$ of creatinine) for the U.S. population aged 6-59 years, National Health and Nutrition Examination Survey, 1999-2002.



^a Estimate is less than the limit of detection (LOD). See Appendix A for LODs.

Dichlorodiphenyltrichloroethane

CAS No. 50-29-3

General Information

Dichlorodiphenyltrichloroethane (DDT) is an insecticide that was used in the 1940s by the military against mosquitoes that carried vector-borne diseases (e.g., malaria). The U.S. EPA banned the use of DDT in the United States in 1973, and it is no longer being applied in this country. However, DDT is still used in other countries. Commercially available DDT (technical grade) contains three chemical forms of DDT: *p,p'*-DDT, *o,o'*-DDT, and *o,p'*-DDT.

DDT is converted in the environment to other more stable chemical forms, including 1,1'-(2,2-dichloro-ethenylidene)-bis[4-chlorobenzene] (DDE) and 1,1'-dichloro-(2,2-bis(p-chlorophenyl) ethane (DDD). All of these chemicals are highly persistent in the environment and can be found in soil, air, and water. The biodegradation half-life of DDT in soil varies from 2 years to 15 years, depending on conditions.

In the general population, food is the primary source of exposure to DDT. Many foods and commodities contain detectable residues of DDT or its degradation products. The estimated food intake of DDT in the United States has decreased since the 1950s (Walker et al., 1954; Durham et al., 1965; Duggan and Corneliusen, 1972). However, food imported into the United States from other countries that still use DDT may contain DDT or DDE residues. In addition, local spraying with DDT can add greatly to body burdens. For example, after a single application of DDT for malaria control, DDT levels were seven-fold higher in people tested 1 year after the application than in a comparison population (Dua et al., 1996).

After DDT enters the body, it is metabolized to DDE. DDT and DDE are widely distributed to different organs in the body, particularly fatty tissues. The concentration of DDT and metabolites in fatty tissues may be several

Table 238. *p,p'*-DDT (lipid adjusted)

Geometric mean and selected percentiles of serum concentrations (in 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, 1999-2002.

	Survey years	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)				Sample size
			50th	75th	90th	95th	
Total, age 12 and older	99-00	*	< LOD	< LOD	< LOD	28.0 (21.9-34.0)	1679
	01-02	*	< LOD	< LOD	< LOD	26.5 (22.4-32.7)	2305
Age group							
	12-19 years						
	99-00	*	< LOD	< LOD	< LOD	< LOD	677
	01-02	*	< LOD	< LOD	< LOD	< LOD	756
20 years and older	99-00	*	< LOD	< LOD	< LOD	30.5 (23.0-37.3)	1002
	01-02	*	< LOD	< LOD	< LOD	28.1 (23.8-39.0)	1549
Gender							
	Males						
	99-00	*	< LOD	< LOD	< LOD	25.1 (<LOD-39.3)	799
	01-02	*	< LOD	< LOD	< LOD	21.6 (<LOD-25.8)	1073
Females	99-00	*	< LOD	< LOD	< LOD	29.4 (23.0-35.8)	880
	01-02	*	< LOD	< LOD	18.1 (<LOD-21.9)	36.3 (25.5-54.3)	1232
Race/ethnicity							
	Mexican Americans						
	99-00	*	< LOD	< LOD	61.3 (27.0-155)	150 (59.3-590)	635
	01-02	*	< LOD	< LOD	83.1 (33.3-236)	236 (104-541)	566
Non-Hispanic blacks	99-00	*	< LOD	< LOD	22.2 (<LOD-31.5)	31.5 (23.2-65.0)	356
	01-02	*	< LOD	< LOD	22.1 (<LOD-40.9)	40.9 (21.2-95.8)	514
Non-Hispanic whites	99-00	*	< LOD	< LOD	< LOD	< LOD	564
	01-02	*	< LOD	< LOD	< LOD	17.7 (<LOD-20.7)	1061

< LOD means less than the limit of detection, which may vary for some chemicals by year and by individual sample. See Appendix A for LODs.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

hundred times greater than concentrations in other tissues. DDE persists longer in the body than DDT. Previous studies have reported that levels of DDT and DDE increase as a person ages.

DDT and its metabolites can cause adverse effects through different mechanisms—by interfering with the movement of ions through cells in the nervous system or by mimicking or blocking the action of reproductive hormones. The toxic effects of DDT demonstrated in experimental animals include infertility (Jonsson et al., 1975); a decrease in the number of implanted ova (Lundberg, 1974); intrauterine growth retardation (Fabro et al., 1984); cancer (Cabral et al., 1982); neurologic developmental disorders (Eriksson et al., 1990); and fetal death (Clement and Okey, 1974). In people, elevations of liver enzymes in serum have been observed after large accidental or workplace exposures; acute overdoses may cause tremors, gait disturbances, fatigue, headache, and vomiting (Hayes, 1976). The association of DDT with breast cancer has been studied, and a causal link is uncertain (Lebel et al., 1998; Hoyer et al., 1998; Helzlsouer et al., 1999; Hunter et al., 1997). IARC

classifies DDT (*p,p'*-DDT) as a possible human carcinogen; NTP considers that DDT is reasonably anticipated to be a human carcinogen.

More information about external exposure (i.e., environmental levels) and health effects is available from the U.S. EPA's IRIS Web site at <http://www.epa.gov/iris> and from ATSDR's Toxicological Profiles at <http://www.atsdr.cdc.gov/toxprofiles>.

Interpreting Levels of Lipid-Adjusted Serum DDT and DDE Reported in the Tables

Serum levels of *p,p'*-DDT, *o,p'*-DDT and *p,p'*-DDE were measured in a subsample of NHANES participants aged 12 years and older. Participants were selected within the specified age range to be a representative sample of the U.S. population. Geometric mean levels of *p,p'*-DDE in the NHANES 2001-2002 subsample were similar to measurements reported in a previous study of adults in Germany (Becker et al., 2002). The *p,p'*-DDE levels in the NHANES 2001-2002 subsample were approximately three-fold lower than serum *p,p'*-DDE measurements

Table 239. *p,p'*-DDT (whole weight)

Geometric mean and selected percentiles of serum concentrations (in ng/g of serum or parts per billion) for the U.S. population aged 12 years and older, National Health and Nutrition Examination Survey, 1999-2002.

	Survey years	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)				Sample size
			50th	75th	90th	95th	
Total, age 12 and older	99-00	*	< LOD	< LOD	< LOD	.172 (.131-.218)	1679
	01-02	*	< LOD	< LOD	< LOD	.184 (.161-.221)	2305
Age group							
	12-19 years						
	99-00	*	< LOD	< LOD	< LOD	< LOD	677
	01-02	*	< LOD	< LOD	< LOD	< LOD	756
20 years and older	99-00	*	< LOD	< LOD	< LOD	.187 (.147-.228)	1002
	01-02	*	< LOD	< LOD	< LOD	.201 (.167-.257)	1549
Gender							
	Males						
	99-00	*	< LOD	< LOD	< LOD	.147 (.107-.188)	799
	01-02	*	< LOD	< LOD	< LOD	.153 (.121-.184)	1073
Females	99-00	*	< LOD	< LOD	< LOD	.190 (.142-.232)	880
	01-02	*	< LOD	< LOD	.131 (.110-.146)	.239 (.175-.398)	1232
Race/ethnicity							
	Mexican Americans						
	99-00	*	< LOD	< LOD	.393 (.188-.998)	.998 (.331-4.26)	635
	01-02	*	< LOD	< LOD	.512 (.253-1.34)	1.56 (.569-4.01)	566
Non-Hispanic blacks	99-00	*	< LOD	< LOD	.123 (.090-.168)	.170 (.141-.420)	356
	01-02	*	< LOD	< LOD	.134 (.079-.285)	.229 (.121-.532)	514
Non-Hispanic whites	99-00	*	< LOD	< LOD	< LOD	< LOD	564
	01-02	*	< LOD	< LOD	< LOD	.125 (.103-.141)	1061

< LOD means less than the limit of detection, which may vary for some chemicals by year and by individual sample. See Appendix A for LODs.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

reported in studies of adults in New Zealand (Bates et al., 2004b) and ten times lower than serum measurements reported in adults in Slovakia (Pavuk et al., 2004).

The 95th percentile value for serum levels of *p,p'*-DDT and *p,p'*-DDE in the NHANES 2001-2002 subsample were approximately 15-fold and three-fold lower, respectively, than measurements reported in a nonrandom subsample from NHANES II (1976-1980) participants (Stehr-Green et al., 1989). Serum *p,p'*-DDT levels in the NHANES 2001-2002 subsample were many times lower than levels in women in Spain (Botella et al., 2004), or in men in India (Bhatnagar et al., 2004).

In the NHANES 1999-2000 and 2001-2002 subsamples, serum levels of *o,p'*-DDT were below the limit of detection.

Comparing Adjusted Geometric Means

Geometric mean levels of serum *p,p'*-DDE for the demographic groups were compared after adjusting for the covariates of race/ethnicity, age, gender, log serum cotinine, and lipid level (data not shown). In NHANES 2001-2002, adjusted geometric mean levels in the group aged 20 years and older were more than a two-fold higher level of *p,p'*-DDE than the group aged 12-19 years. These findings are consistent with previous measurements in NHANES II (1976-1980) participants, in whom levels of *p,p'*-DDE were also observed to be higher in older age groups (Stehr-Green et al., 1989). The adjusted geometric mean levels of *p,p'*-DDE in Mexican Americans was approximately two-fold higher than in non-Hispanic blacks and approximately three-fold higher than in non-Hispanic whites. Non-Hispanic blacks had higher levels than non-Hispanic whites. Other studies have also reported higher serum levels of *p,p'*-DDE in Mexican Americans (Akkina et al., 2004). In a study of African-American farmers, Martin et al. (2002) reported higher median lipid-adjusted levels of DDE than the median values that appear in this *Report*. It is unknown

Table 240. *p,p'*-DDE (lipid adjusted)

Geometric mean and selected percentiles of serum concentrations (in 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, 1999-2002.

	Survey years	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)				Sample size
			50th	75th	90th	95th	
Total, age 12 and older	99-00	260 (226-298)	226 (184-278)	537 (476-631)	1150 (976-1350)	1780 (1410-2300)	1964
	01-02	295 (267-327)	250 (227-277)	597 (521-699)	1400 (1210-1500)	2320 (1830-2780)	2298
Age group							
	12-19 years						
	99-00	118 (102-135)	108 (97.7-119)	185 (141-237)	339 (243-479)	528 (339-812)	686
	01-02	124 (106-146)	112 (98.5-138)	213 (172-253)	319 (282-389)	456 (343-722)	758
20 years and older	99-00	297 (256-344)	267 (213-323)	608 (530-693)	1250 (1030-1550)	2020 (1520-2620)	1278
	01-02	338 (303-376)	285 (249-337)	689 (590-798)	1470 (1310-1700)	2550 (1980-3080)	1540
Gender							
	Males						
	99-00	249 (220-283)	222 (182-262)	493 (380-578)	992 (789-1130)	1430 (1080-2160)	937
	01-02	285 (252-323)	245 (222-285)	520 (441-619)	1160 (937-1360)	1900 (1570-2390)	1069
Females	99-00	270 (226-322)	234 (184-302)	601 (490-707)	1350 (1040-1720)	2170 (1570-2810)	1027
	01-02	305 (273-341)	256 (219-297)	704 (567-844)	1480 (1400-1690)	2630 (1940-3300)	1229
Race/ethnicity							
	Mexican Americans						
	99-00	674 (574-792)	623 (545-701)	1350 (1090-1660)	3090 (2040-4950)	4940 (3070-9350)	657
	01-02	652 (569-747)	551 (455-690)	1380 (1050-1950)	4110 (2520-6550)	7030 (3080-15600)	566
Non-Hispanic blacks	99-00	295 (241-362)	251 (199-313)	651 (492-874)	1850 (1040-2220)	2300 (1560-5680)	416
	01-02	324 (262-400)	248 (223-296)	744 (583-999)	1580 (1180-2980)	3260 (1270-6900)	515
Non-Hispanic whites	99-00	217 (189-249)	191 (162-238)	438 (355-507)	825 (647-1010)	1160 (1010-1350)	732
	01-02	253 (226-284)	224 (203-254)	463 (402-558)	1140 (878-1340)	1640 (1410-1940)	1053

whether these differences associated with age or race/ethnicity represent differences in exposure, pharmacokinetics, or the relationship of dose per body weight.

There were no significant differences in serum *p,p'*-DDE levels between males and females in NHANES 2001-2002; however others have reported differences in levels of DDT or its metabolites between females and males (Waliszewski et al., 1996; Stehr-Green et al., 1989; Finklea et al., 1972; Sala et al., 1999).

Finding a measurable amount of *p,p'*-DDT or *p,p'*-DDE in serum does not mean that the level of the *p,p'*-DDT or *p,p'*-DDE will result in an adverse health effect. These data will help scientists plan and conduct research about the relation between exposure to DDT or DDE and health effects. These data also provide physicians with a reference range so that they can determine whether or not other people have been exposed to higher levels of DDT or DDE than levels found in the general population.

Table 241. *p,p'*-DDE (whole weight)

Geometric mean and selected percentiles of serum concentrations (in ng/g of serum or parts per billion) for the U.S. population aged 12 years and older, National Health and Nutrition Examination Survey, 1999-2002.

	Survey years	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)				Sample size
			50th	75th	90th	95th	
Total, age 12 and older	99-00	1.54 (1.33-1.79)	1.31 (1.09-1.66)	3.49 (2.97-4.27)	7.49 (6.14-9.25)	11.6 (9.25-14.8)	1964
	01-02	1.81 (1.64-2.01)	1.57 (1.37-1.72)	3.97 (3.43-4.59)	8.81 (7.85-10.1)	15.4 (12.9-17.6)	2298
Age group							
12-19 years	99-00	.561 (.488-.646)	.518 (.433-.603)	.872 (.682-1.18)	1.52 (1.13-2.25)	2.31 (1.76-3.56)	686
	01-02	.623 (.534-.726)	.592 (.495-.727)	.997 (.819-1.22)	1.65 (1.39-2.07)	2.30 (1.91-3.14)	758
20 years and older	99-00	1.83 (1.56-2.14)	1.61 (1.26-2.07)	4.17 (3.48-4.66)	8.12 (6.37-10.6)	12.3 (9.87-16.7)	1278
	01-02	2.14 (1.91-2.39)	1.76 (1.61-2.04)	4.59 (4.10-5.26)	9.75 (8.34-11.5)	16.8 (13.7-19.1)	1540
Gender							
Males	99-00	1.49 (1.30-1.70)	1.25 (1.10-1.44)	3.01 (2.56-3.74)	6.43 (5.40-8.00)	9.63 (6.63-15.6)	937
	01-02	1.77 (1.57-2.01)	1.59 (1.36-1.76)	3.40 (3.03-4.10)	7.48 (6.43-8.75)	13.1 (9.66-17.6)	1069
Females	99-00	1.59 (1.32-1.92)	1.38 (1.03-1.99)	4.05 (3.15-4.79)	8.12 (6.36-11.5)	13.2 (9.81-18.5)	1027
	01-02	1.85 (1.66-2.06)	1.49 (1.32-1.75)	4.57 (3.81-5.47)	10.1 (9.01-11.9)	16.8 (13.4-19.7)	1229
Race/ethnicity							
Mexican Americans	99-00	3.92 (3.40-4.51)	3.52 (3.17-3.91)	8.20 (7.26-10.4)	22.0 (12.2-32.2)	31.5 (19.7-48.1)	657
	01-02	3.92 (3.37-4.57)	3.53 (2.68-4.34)	9.33 (7.31-12.5)	26.6 (17.9-38.3)	40.9 (26.8-90.5)	566
Non-Hispanic blacks	99-00	1.63 (1.31-2.02)	1.34 (1.11-1.66)	3.80 (3.01-5.69)	11.1 (6.57-13.2)	14.6 (8.88-35.2)	416
	01-02	1.82 (1.46-2.28)	1.38 (1.22-1.72)	4.39 (3.52-6.06)	10.5 (7.24-17.6)	19.3 (8.51-49.3)	515
Non-Hispanic whites	99-00	1.32 (1.14-1.53)	1.13 (1.01-1.35)	2.85 (2.34-3.36)	5.71 (4.62-6.53)	8.04 (6.32-9.81)	732
	01-02	1.57 (1.39-1.76)	1.41 (1.27-1.58)	3.10 (2.56-3.68)	7.00 (6.02-8.34)	11.3 (8.60-13.7)	1053

Figure 30. *p,p'*-DDE (lipid adjusted)

Selected percentiles with 95% confidence intervals of serum concentrations (in 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, 1999-2002.

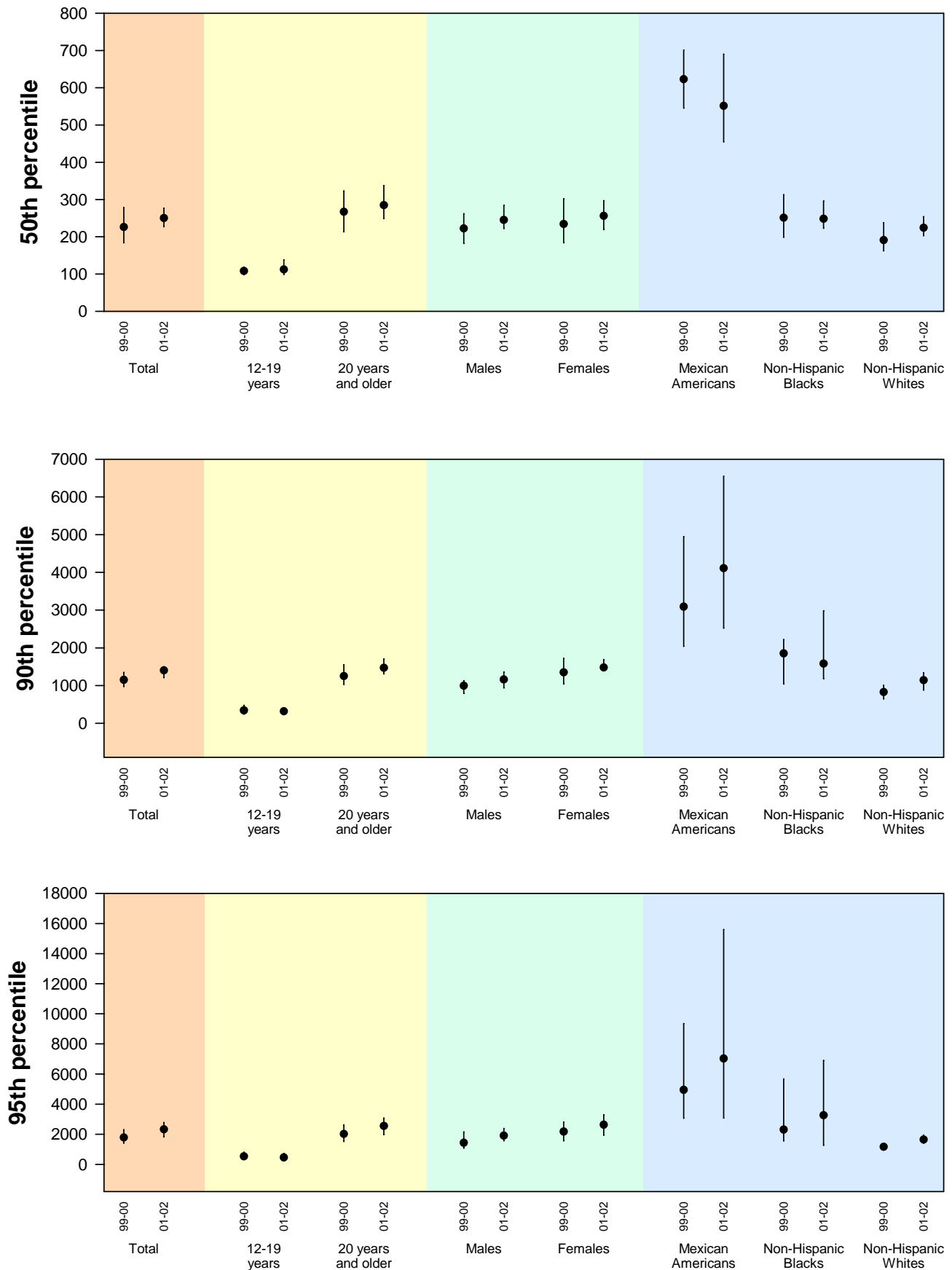


Table 242. o,p'-DDT (lipid adjusted)

Geometric mean and selected percentiles of serum concentrations (in 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, 1999-2002.

	Survey years	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)				Sample size
			50th	75th	90th	95th	
Total, age 12 and older	99-00	*	< LOD	< LOD	< LOD	< LOD	1669
	01-02	*	< LOD	< LOD	< LOD	< LOD	2279
Age group							
12-19 years	99-00	*	< LOD	< LOD	< LOD	< LOD	667
	01-02	*	< LOD	< LOD	< LOD	< LOD	756
20 years and older	99-00	*	< LOD	< LOD	< LOD	< LOD	1002
	01-02	*	< LOD	< LOD	< LOD	< LOD	1523
Gender							
Males	99-00	*	< LOD	< LOD	< LOD	< LOD	796
	01-02	*	< LOD	< LOD	< LOD	< LOD	1059
Females	99-00	*	< LOD	< LOD	< LOD	< LOD	873
	01-02	*	< LOD	< LOD	< LOD	< LOD	1220
Race/ethnicity							
Mexican Americans	99-00	*	< LOD	< LOD	< LOD	< LOD	632
	01-02	*	< LOD	< LOD	< LOD	< LOD	565
Non-Hispanic blacks	99-00	*	< LOD	< LOD	< LOD	< LOD	354
	01-02	*	< LOD	< LOD	< LOD	< LOD	507
Non-Hispanic whites	99-00	*	< LOD	< LOD	< LOD	< LOD	560
	01-02	*	< LOD	< LOD	< LOD	< LOD	1045

< LOD means less than the limit of detection, which may vary for some chemicals by year and by individual sample. See Appendix A for LODs.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Table 243. *o,p'*-DDT (whole weight)

Geometric mean and selected percentiles of serum concentrations (in ng/g of serum or parts per billion) for the U.S. population aged 12 years and older, National Health and Nutrition Examination Survey, 1999-2002.

	Survey years	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)				Sample size
			50th	75th	90th	95th	
Total, age 12 and older	99-00	*	< LOD	< LOD	< LOD	< LOD	1669
	01-02	*	< LOD	< LOD	< LOD	< LOD	2279
Age group							
12-19 years	99-00	*	< LOD	< LOD	< LOD	< LOD	667
	01-02	*	< LOD	< LOD	< LOD	< LOD	756
20 years and older	99-00	*	< LOD	< LOD	< LOD	< LOD	1002
	01-02	*	< LOD	< LOD	< LOD	< LOD	1523
Gender							
Males	99-00	*	< LOD	< LOD	< LOD	< LOD	796
	01-02	*	< LOD	< LOD	< LOD	< LOD	1059
Females	99-00	*	< LOD	< LOD	< LOD	< LOD	873
	01-02	*	< LOD	< LOD	< LOD	< LOD	1220
Race/ethnicity							
Mexican Americans	99-00	*	< LOD	< LOD	< LOD	< LOD	632
	01-02	*	< LOD	< LOD	< LOD	< LOD	565
Non-Hispanic blacks	99-00	*	< LOD	< LOD	< LOD	< LOD	354
	01-02	*	< LOD	< LOD	< LOD	< LOD	507
Non-Hispanic whites	99-00	*	< LOD	< LOD	< LOD	< LOD	560
	01-02	*	< LOD	< LOD	< LOD	< LOD	1045

< LOD means less than the limit of detection, which may vary for some chemicals by year and by individual sample. See Appendix A for LODs.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Chlordane

CAS No.12789-03-6 and 57-74-9

Heptachlor

CAS No. 76-44-8

General Information

Chlordane is an organochlorine pesticide that was once used on agricultural crops and lawns and in buildings to kill termites and other insects. In 1988, the U.S. EPA cancelled registration for the production and use of chlordane in the United States. Heptachlor is another organochlorine pesticide that has a chemical structure and mechanism of toxicity similar to that of chlordane. The use of heptachlor in the United States is restricted to include limited applications for controlling fire ants.

The technical-grade formulation of chlordane may consist of more than 50 related chemicals. The main components are *cis*- and *trans*-chlordane, *trans*-nonachlor, and heptachlor. Chlordane is metabolized in

the environment and in the body to oxychlordane.

Heptachlor is metabolized to heptachlor epoxide.

Chlordane is an unlikely source of exposure if heptachlor epoxide is found in the absence of either oxychlordane or *trans*-nonachlor.

Heptachlor, chlordane, and their metabolites are highly persistent chemicals in the environment as well as in the body. Fatty foods are the most likely source of exposure to these chemicals in the general population. In Hawaii during 1981 and 1982, heptachlor was used on pineapples, and the remnant pineapple tops (chops) were fed to milk-producing cows, resulting in human exposure when people drank the milk. (Takahashi and Parks, 1982). Consequently, increased levels of heptachlor epoxide were found in the breast milk of lactating

Table 244. Oxychlordane (lipid adjusted)

Geometric mean and selected percentiles of serum concentrations (in 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, 1999-2002.

	Survey years	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)				Sample size
			50th	75th	90th	95th	
Total, age 12 and older	99-00	*	< LOD	20.6 (17.8-23.0)	34.4 (30.5-38.6)	44.8 (40.2-49.6)	1661
	01-02	11.4 (<LOD-12.5)	11.1 (<LOD-12.5)	21.7 (19.2-24.4)	36.3 (31.4-41.4)	49.7 (42.0-61.2)	2249
Age group 12-19 years	99-00	*	< LOD	< LOD	< LOD	< LOD	663
	01-02	*	< LOD	< LOD	< LOD	11.4 (<LOD-12.6)	752
20 years and older	99-00	*	< LOD	23.3 (21.0-25.9)	37.7 (32.3-43.5)	47.7 (43.1-50.8)	998
	01-02	12.9 (11.7-14.3)	13.2 (11.4-14.9)	23.9 (21.2-26.6)	38.4 (33.4-45.7)	53.1 (44.1-65.9)	1497
Gender Males	99-00	*	< LOD	17.8 (16.1-19.5)	31.2 (25.8-37.5)	42.3 (35.3-49.6)	793
	01-02	11.1 (<LOD-12.6)	11.1 (<LOD-12.5)	20.6 (16.5-24.5)	33.1 (27.5-43.8)	48.1 (40.2-56.9)	1049
Females	99-00	*	< LOD	22.3 (20.1-25.9)	36.7 (31.4-39.1)	46.1 (39.1-51.8)	868
	01-02	11.7 (10.7-12.7)	11.0 (<LOD-12.9)	23.1 (20.7-25.0)	37.4 (34.5-42.1)	52.5 (42.7-70.0)	1200
Race/ethnicity Mexican Americans	99-00	*	< LOD	16.2 (<LOD-19.7)	28.9 (18.8-42.0)	39.8 (26.8-61.0)	628
	01-02	*	< LOD	13.9 (11.0-18.4)	27.1 (21.0-33.1)	37.9 (29.9-42.0)	557
Non-Hispanic blacks	99-00	*	< LOD	18.5 (<LOD-32.2)	39.9 (26.5-47.3)	47.5 (43.5-65.5)	350
	01-02	11.7 (<LOD-13.6)	< LOD	22.6 (17.2-28.3)	41.2 (30.6-53.7)	55.3 (41.8-73.5)	501
Non-Hispanic whites	99-00	*	< LOD	21.8 (18.6-24.6)	34.1 (28.9-40.9)	43.5 (37.2-49.8)	559
	01-02	12.1 (11.0-13.3)	11.7 (10.5-13.9)	22.9 (20.0-25.6)	37.4 (31.5-44.1)	50.8 (41.0-67.4)	1031

< LOD means less than the limit of detection, which may vary for some chemicals by year and by individual sample. See Appendix A for LODs.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

women. Indoor inhalational exposure to chlordane may occur for decades after the termite treatment of a residence. It is estimated that 80 million homes have been treated with chlordane. Indoor-air concentrations of chlordane have been measured that are higher than outdoor-air concentrations (U.S. EPA, 1990; Whitmore et al., 1994).

Chlordane, heptachlor, and their metabolites distribute widely in the body and accumulate in fatty tissues. The metabolites of chlordane and heptachlor are eliminated from the body very slowly over the course of months to years. At high doses, chlordane and heptachlor block inhibitory neurotransmitters in the central nervous system. In cases of human poisoning, headache, nausea, gastrointestinal inflammation, confusion, tremors, and seizures have been reported. For this class of chemicals, animal studies demonstrate liver, hematologic, and developmental toxicities and immunological effects. IARC considers chlordane and heptachlor as possibly carcinogenic to humans.

Information about external exposure (i.e., environmental

levels) and health effects of chlordane is available from ATSDR's Toxicological Profiles at <http://www.atsdr.cdc.gov/toxprofiles/tp31.html> and for heptachlor at <http://www.atsdr.cdc.gov/tfacts12.html>.

Interpreting Levels of Lipid-Adjusted Serum Oxychlordane, *trans*-Nonachlor, and Heptachlor Epoxide Reported in the Tables

Serum levels of oxychlordane, *trans*-nonachlor, and heptachlor epoxide were measured in a subsample of NHANES participants aged 12 years and older. Participants were selected within the specified age range to be a representative sample of the U.S. population.

Serum oxychlordane levels in both the NHANES 1999-2000 and the 2001-2002 subsamples are comparable to levels measured in Swedish men and women (Glynn et al., 2003). Levels of oxychlordane exceeding the 95th percentile in this *Report* were reported in a study of an Inuit population in Greenland (Van Oostdam et al., 2004). Serum *trans*-nonachlor levels in the NHANES 2001-2002 subsample were similar to levels in adult

Table 245. Oxychlordane (whole weight)

Geometric mean and selected percentiles of serum concentrations (in ng/g of serum or parts per billion) for the U.S. population aged 12 years and older, National Health and Nutrition Examination Survey, 1999-2002.

	Survey years	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)				Sample size
			50th	75th	90th	95th	
Total, age 12 and older	99-00	*	< LOD	.134 (.119-.150)	.255 (.202-.287)	.310 (.290-.343)	1661
	01-02	.070 (.063-.077)	.069 (.058-.078)	.143 (.126-.160)	.248 (.215-.297)	.352 (.289-.441)	2249
Age group							
	12-19 years						
	99-00	*	< LOD	< LOD	< LOD	< LOD	663
	01-02	*	< LOD	< LOD	< LOD	.058 (.050-.068)	752
20 years and older	99-00	*	< LOD	.154 (.136-.179)	.279 (.228-.304)	.328 (.299-.398)	998
	01-02	.082 (.074-.091)	.084 (.074-.094)	.157 (.137-.180)	.267 (.225-.318)	.370 (.307-.449)	1497
Gender							
	Males						
	99-00	*	< LOD	.122 (.101-.135)	.216 (.182-.279)	.303 (.264-.343)	793
	01-02	.069 (.061-.079)	.067 (.058-.082)	.133 (.116-.160)	.231 (.189-.299)	.319 (.252-.426)	1049
Females	99-00	*	< LOD	.143 (.126-.173)	.267 (.202-.306)	.319 (.291-.401)	868
	01-02	.071 (.065-.077)	.069 (.059-.078)	.146 (.132-.163)	.258 (.228-.308)	.365 (.278-.513)	1200
Race/ethnicity							
	Mexican Americans						
	99-00	*	< LOD	.100 (.082-.130)	.203 (.127-.317)	.282 (.186-.413)	628
	01-02	*	< LOD	.097 (.065-.126)	.194 (.144-.238)	.278 (.210-.363)	557
Non-Hispanic blacks	99-00	*	< LOD	.113 (.070-.174)	.237 (.171-.288)	.311 (.244-.426)	350
	01-02	.066 (.055-.077)	< LOD	.127 (.094-.168)	.259 (.181-.349)	.349 (.241-.560)	501
Non-Hispanic whites	99-00	*	< LOD	.139 (.124-.165)	.264 (.198-.296)	.316 (.281-.376)	559
	01-02	.075 (.068-.083)	.076 (.066-.086)	.151 (.131-.172)	.253 (.219-.312)	.365 (.280-.449)	1031

< LOD means less than the limit of detection, which may vary for some chemicals by year and by individual sample. See Appendix A for LODs.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

females in Sweden (Glynn et al., 2003), and two-fold lower than levels reported for women in New York (Wolff et al., 2000). Compared with serum levels in the NHANES 2001-2002 subsample, higher serum levels of *trans*-nonachlor were reported in an Inuit population in Greenland (Van Oostdam et al., 2004). Levels of heptachlor epoxide in both the 1999-2000 and the 2001-2002 subsamples approximately ten-fold lower at the corresponding 90th percentile for a historical cohort of women studied during the period 1963-1967 (James et al., 2002).

Comparing Adjusted Geometric Means

Geometric means levels of serum *trans*-nonachlor and oxychlordanes in the demographic groups were compared after adjusting for the covariates of race/ethnicity, age, gender, log serum cotinine, and lipid level (data not shown). Some comparisons are not possible due to a low detection rate for some demographic groups. For the adjusted geometric means levels of *trans*-nonachlor in NHANES 2001-2002, Mexican Americans were lower than non-Hispanic blacks and non-Hispanic whites. For

the adjusted geometric means levels of oxychlordanes in NHANES 2001-2002, improved detection limits permitted comparison of several demographic groups, but no differences were found.

Finding a measurable amount of oxychlordanes, *trans*-nonachlor, or heptachlor epoxide in serum does not mean that the level will result in an adverse health effect. These data will help scientists plan and conduct research about the relation between exposure to heptachlor or chlordane and health effects. These data also provide physicians with a reference range so that they can determine whether or not other people have been exposed to higher levels of heptachlor and chlordane than levels found in the general population.

Table 246. *trans*-Nonachlor (lipid adjusted)

Geometric mean and selected percentiles of serum concentrations (in 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, 1999-2002.

	Survey years	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)				Sample size
			50th	75th	90th	95th	
Total, age 12 and older	99-00	18.3 (16.7-20.0)	17.8 (16.0-19.8)	31.9 (28.9-36.0)	55.1 (48.4-62.6)	79.4 (67.6-88.1)	1933
	01-02	17.0 (15.2-18.9)	17.9 (15.5-20.5)	33.7 (30.2-37.2)	56.3 (49.6-65.9)	78.2 (63.6-111)	2286
Age group 12-19 years	99-00	*	< LOD	< LOD	18.8 (<LOD-20.2)	23.4 (19.1-28.4)	664
	01-02	*	< LOD	< LOD	13.3 (11.8-16.2)	18.9 (15.2-23.5)	758
20 years and older	99-00	20.8 (19.0-22.8)	20.6 (18.0-23.5)	35.2 (30.9-40.0)	59.9 (51.8-67.6)	82.2 (74.9-89.6)	1269
	01-02	19.8 (17.6-22.3)	20.8 (18.8-23.0)	36.6 (32.8-40.9)	60.6 (52.5-69.9)	84.9 (66.0-123)	1528
Gender Males	99-00	17.7 (16.5-19.1)	17.1 (14.6-19.6)	30.0 (27.7-34.2)	51.1 (47.3-58.6)	78.2 (60.2-88.1)	922
	01-02	17.0 (14.8-19.5)	18.3 (14.8-21.1)	34.4 (28.3-38.9)	54.8 (45.0-68.9)	77.2 (58.9-105)	1062
Females	99-00	18.8 (16.7-21.1)	18.4 (16.1-22.2)	32.9 (29.0-38.3)	58.7 (48.4-67.6)	80.8 (71.5-95.5)	1011
	01-02	17.0 (15.4-18.7)	17.5 (15.0-20.3)	32.8 (30.2-36.4)	56.4 (51.9-65.5)	76.8 (65.5-111)	1224
Race/ethnicity Mexican Americans	99-00	*	< LOD	25.0 (22.7-29.5)	40.7 (35.1-51.8)	55.9 (45.8-77.2)	650
	01-02	11.9 (<LOD-14.6)	10.6 (<LOD-14.4)	26.0 (19.3-30.4)	47.9 (36.3-57.2)	59.8 (49.3-74.1)	558
Non-Hispanic blacks	99-00	20.3 (17.0-24.1)	17.5 (14.7-22.7)	35.7 (28.3-45.4)	77.0 (60.8-90.7)	106 (84.0-143)	404
	01-02	18.8 (15.4-22.9)	19.2 (14.7-22.0)	36.8 (28.2-50.3)	72.9 (50.8-110)	112 (68.7-160)	514
Non-Hispanic whites	99-00	19.1 (17.2-21.1)	18.8 (16.8-21.9)	32.8 (28.0-37.6)	52.5 (44.9-64.4)	74.0 (62.3-86.7)	722
	01-02	17.5 (15.6-19.7)	18.8 (16.1-21.1)	34.0 (29.7-38.1)	55.5 (45.9-69.4)	78.5 (59.1-126)	1052

< LOD means less than the limit of detection, which may vary for some chemicals by year and by individual sample. See Appendix A for LODs.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Table 247. *trans*-Nonachlor (whole weight)

Geometric mean and selected percentiles of serum concentrations (in ng/g of serum or parts per billion) for the U.S. population aged 12 years and older, National Health and Nutrition Examination Survey, 1999-2002.

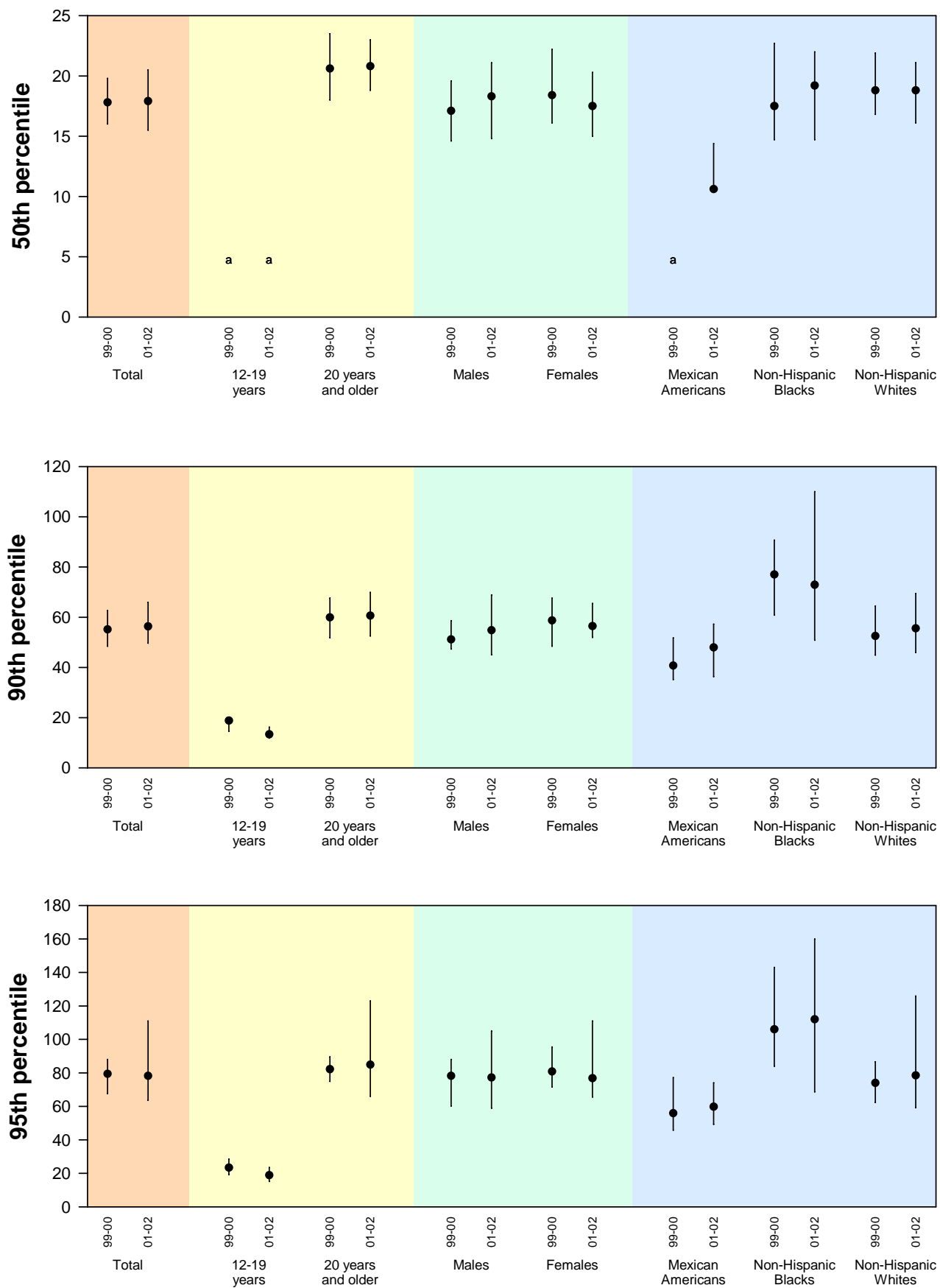
	Survey years	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)				Sample size
			50th	75th	90th	95th	
Total, age 12 and older	99-00	.109 (.099-.119)	.105 (.093-.123)	.212 (.187-.233)	.369 (.325-.418)	.544 (.468-.628)	1933
	01-02	.104 (.093-.116)	.112 (.097-.124)	.217 (.191-.243)	.389 (.328-.470)	.589 (.432-.797)	2286
Age group							
12-19 years	99-00	*	< LOD	< LOD	.089 (.063-.106)	.111 (.100-.128)	664
	01-02	*	< LOD	< LOD	.067 (.059-.083)	.093 (.075-.125)	758
20 years and older	99-00	.128 (.116-.141)	.126 (.107-.147)	.233 (.212-.255)	.401 (.360-.461)	.573 (.494-.686)	1269
	01-02	.125 (.111-.141)	.133 (.118-.148)	.241 (.213-.278)	.418 (.347-.537)	.642 (.469-.843)	1528
Gender							
Males	99-00	.106 (.098-.114)	.103 (.089-.118)	.207 (.179-.224)	.353 (.305-.401)	.514 (.401-.628)	922
	01-02	.105 (.091-.122)	.112 (.091-.134)	.224 (.192-.263)	.379 (.310-.495)	.579 (.390-.828)	1062
Females	99-00	.111 (.099-.125)	.112 (.093-.131)	.220 (.185-.250)	.383 (.310-.452)	.573 (.463-.694)	1011
	01-02	.103 (.093-.113)	.109 (.094-.123)	.214 (.184-.241)	.395 (.341-.448)	.589 (.429-.825)	1224
Race/ethnicity							
Mexican Americans	99-00	*	< LOD	.165 (.124-.205)	.300 (.244-.344)	.387 (.318-.520)	650
	01-02	.071 (.056-.091)	.064 (.044-.094)	.156 (.123-.209)	.328 (.272-.394)	.465 (.354-.594)	558
Non-Hispanic blacks	99-00	.112 (.093-.134)	.101 (.082-.134)	.215 (.174-.297)	.481 (.340-.595)	.748 (.511-.955)	404
	01-02	.106 (.085-.131)	.107 (.080-.125)	.218 (.162-.313)	.485 (.316-.680)	.680 (.408-1.19)	514
Non-Hispanic whites	99-00	.116 (.104-.129)	.119 (.100-.137)	.214 (.185-.244)	.366 (.302-.437)	.513 (.435-.632)	722
	01-02	.108 (.096-.122)	.117 (.101-.133)	.220 (.191-.250)	.388 (.305-.494)	.596 (.402-.927)	1052

< LOD means less than the limit of detection, which may vary for some chemicals by year and by individual sample. See Appendix A for LODs.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Figure 31. *trans*-Nonachlor (lipid adjusted)

Selected percentiles with 95% confidence intervals of serum concentrations (in 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, 1999-2002.



^a Estimate is less than the limit of detection (LOD). See Appendix A for LODs.

Table 248. Heptachlor epoxide (lipid adjusted)

Geometric mean and selected percentiles of serum concentrations (in 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, 1999-2002.

	Survey years	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)				Sample size
			50th	75th	90th	95th	
Total, age 12 and older	99-00	*	< LOD	< LOD	15.3 (<LOD-19.8)	23.9 (15.1-38.8)	1589
	01-02	*	< LOD	< LOD	14.8 (13.0-17.8)	21.6 (18.1-26.2)	2259
Age group							
12-19 years	99-00	*	< LOD	< LOD	< LOD	< LOD	638
	01-02	*	< LOD	< LOD	< LOD	< LOD	741
20 years and older	99-00	*	< LOD	< LOD	17.8 (<LOD-23.9)	27.1 (16.8-46.1)	951
	01-02	*	< LOD	< LOD	15.7 (13.6-18.8)	23.1 (19.1-29.1)	1518
Gender							
Males	99-00	*	< LOD	< LOD	< LOD	19.2 (<LOD-27.2)	760
	01-02	*	< LOD	< LOD	13.9 (12.0-17.3)	20.8 (15.9-25.3)	1047
Females	99-00	*	< LOD	< LOD	18.2 (<LOD-25.2)	27.0 (16.0-54.3)	829
	01-02	*	< LOD	< LOD	15.5 (13.3-18.2)	23.2 (18.9-29.8)	1212
Race/ethnicity							
Mexican Americans	99-00	*	< LOD	< LOD	15.2 (<LOD-23.6)	21.6 (<LOD-62.3)	598
	01-02	*	< LOD	< LOD	13.2 (<LOD-16.3)	16.6 (13.8-23.1)	553
Non-Hispanic blacks	99-00	*	< LOD	< LOD	< LOD	19.4 (<LOD-32.4)	336
	01-02	*	< LOD	< LOD	14.6 (11.7-19.0)	21.0 (18.2-27.3)	503
Non-Hispanic whites	99-00	*	< LOD	< LOD	16.5 (<LOD-21.8)	25.2 (<LOD-54.3)	539
	01-02	*	< LOD	< LOD	15.3 (12.9-19.1)	22.8 (18.9-29.8)	1041

< LOD means less than the limit of detection, which may vary for some chemicals by year and by individual sample. See Appendix A for LODs.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Table 249. Heptachlor epoxide (whole weight)

Geometric mean and selected percentiles of serum concentrations (in ng/g of serum or parts per billion) for the U.S. population aged 12 years and older, National Health and Nutrition Examination Survey, 1999-2002.

	Survey years	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)				Sample size
			50th	75th	90th	95th	
Total, age 12 and older	99-00	*	< LOD	< LOD	.110 (.091-.144)	.177 (.109-.220)	1589
	01-02	*	< LOD	< LOD	.102 (.089-.121)	.153 (.125-.179)	2259
Age group							
12-19 years	99-00	*	< LOD	< LOD	< LOD	< LOD	638
	01-02	*	< LOD	< LOD	< LOD	< LOD	741
20 years and older	99-00	*	< LOD	< LOD	.125 (.097-.170)	.188 (.125-.273)	951
	01-02	*	< LOD	< LOD	.107 (.092-.141)	.166 (.135-.187)	1518
Gender							
Males	99-00	*	< LOD	< LOD	< LOD	.149 (.108-.184)	760
	01-02	*	< LOD	< LOD	.099 (.088-.114)	.148 (.106-.179)	1047
Females	99-00	*	< LOD	< LOD	.118 (.091-.192)	.196 (.116-.310)	829
	01-02	*	< LOD	< LOD	.103 (.084-.122)	.166 (.126-.197)	1212
Race/ethnicity							
Mexican Americans	99-00	*	< LOD	< LOD	.103 (.079-.170)	.170 (.085-.318)	598
	01-02	*	< LOD	< LOD	.089 (.069-.109)	.114 (.098-.240)	553
Non-Hispanic blacks	99-00	*	< LOD	< LOD	< LOD	.112 (.055-.192)	336
	01-02	*	< LOD	< LOD	.092 (.069-.114)	.129 (.102-.180)	503
Non-Hispanic whites	99-00	*	< LOD	< LOD	.116 (.090-.162)	.184 (.109-.310)	539
	01-02	*	< LOD	< LOD	.103 (.089-.128)	.165 (.128-.187)	1041

< LOD means less than the limit of detection, which may vary for some chemicals by year and by individual sample. See Appendix A for LODs.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Mirex

CAS No. 2385-85-5

General Information

Mirex has not been produced or used in the United States since 1977. This chemical was formerly used in southern regions of the United States to control fire ants. It was also used as a flame-retardant additive. Mirex binds strongly to soil and is a highly persistent chemical in the environment. The most likely source of exposure to mirex in the general population is the diet. Some states and U.S. EPA have issued public advisories or warnings that fish from contaminated lakes and rivers may contain mirex.

After people are exposed to mirex, it accumulates in fatty tissues in the body and is not metabolized. At high doses, mirex blocks the action of inhibitory neurotransmitters in the central nervous system. This blocking action can cause abnormal excitation of the brain. Studies of workers exposed to chlordecone, an organochlorine insecticide structurally related to mirex, have reported

adverse effects on the liver, nervous system, and reproductive system. IARC classifies mirex as possibly carcinogenic to humans, and NTP classifies mirex as reasonably anticipated to be a human carcinogen.

More information about external exposure (i.e., environmental levels) and health effects is available from the U.S. EPA's IRIS Web site at <http://www.epa.gov/iris> and from the ATSDR's Toxicological Profiles at <http://www.atsdr.cdc.gov/toxprofiles>.

Interpreting Levels of Lipid-Adjusted Serum Mirex Reported in the Tables

Levels of mirex in serum were measured in a subsample of NHANES participants aged 12 years and older. Participants were selected within the specified age range to be a representative sample of the U.S. population.

In the NHANES 1999-2000 and 2001-2002 subsamples,

Table 250. Mirex (lipid adjusted)

Geometric mean and selected percentiles of serum concentrations (in 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, 1999-2002.

	Survey years	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)				Sample size
			50th	75th	90th	95th	
Total, age 12 and older	99-00	*	< LOD	< LOD	< LOD	< LOD	1853
	01-02	*	< LOD	< LOD	15.8 (<LOD-73.7)	57.1 (13.2-230)	2257
Age group							
	12-19 years						
12-19 years	99-00	*	< LOD	< LOD	< LOD	< LOD	659
	01-02	*	< LOD	< LOD	< LOD	< LOD	728
20 years and older	99-00	*	< LOD	< LOD	< LOD	< LOD	1194
	01-02	*	< LOD	< LOD	19.6 (<LOD-108)	71.0 (14.6-305)	1529
Gender							
	Males						
Males	99-00	*	< LOD	< LOD	< LOD	< LOD	887
	01-02	*	< LOD	< LOD	16.1 (<LOD-65.6)	50.8 (12.3-225)	1052
Females	99-00	*	< LOD	< LOD	< LOD	< LOD	966
	01-02	*	< LOD	< LOD	14.6 (<LOD-90.4)	63.0 (12.0-374)	1205
Race/ethnicity							
	Mexican Americans						
Mexican Americans	99-00	*	< LOD	< LOD	< LOD	< LOD	617
	01-02	*	< LOD	< LOD	< LOD	< LOD	548
Non-Hispanic blacks	99-00	*	< LOD	< LOD	15.5 (<LOD-42.2)	39.5 (<LOD-115)	398
	01-02	*	< LOD	13.5 (<LOD-44.2)	48.2 (15.4-230)	153 (30.5-425)	500
Non-Hispanic whites	99-00	*	< LOD	< LOD	< LOD	< LOD	688
	01-02	*	< LOD	< LOD	15.0 (<LOD-103)	66.7 (12.5-291)	1049

< LOD means less than the limit of detection, which may vary for some chemicals by year and by individual sample. See Appendix A for LODs.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

as well as in a subsample of NHANES II (1976-1980) participants, serum mirex levels were generally below the limits of detection (Stehr-Green, 1989). In the NHANES 2001-2002 subsample, only mirex levels at the 90th and 95th percentiles were characterized. In a study of fishermen in New York who consumed sport fish, median levels of lipid-adjusted serum mirex were lower than the 95th percentile values in this 2001-2002 subsample (Bloom et al., 2005).

Finding a measurable amount of mirex in serum does not mean that the level will result in an adverse health effect. These data will help scientists plan and conduct research about the relation between exposure to mirex and health effects. These data also provide physicians with a reference range so that they can determine whether or not other people have been exposed to higher levels of mirex than levels found in the general population.

Table 251. Mirex (whole weight)

Geometric mean and selected percentiles of serum concentrations (in ng/g of serum or parts per billion) for the U.S. population aged 12 years and older, National Health and Nutrition Examination Survey, 1999-2002.

	Survey years	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)				Sample size
			50th	75th	90th	95th	
Total, age 12 and older	99-00	*	< LOD	< LOD	< LOD	< LOD	1853
	01-02	*	< LOD	< LOD	.101 (.049-.468)	.414 (.080-1.73)	2257
Age group							
12-19 years	99-00	*	< LOD	< LOD	< LOD	< LOD	659
	01-02	*	< LOD	< LOD	< LOD	< LOD	728
20 years and older	99-00	*	< LOD	< LOD	< LOD	< LOD	1194
	01-02	*	< LOD	< LOD	.137 (.053-.687)	.468 (.089-1.92)	1529
Gender							
Males	99-00	*	< LOD	< LOD	< LOD	< LOD	887
	01-02	*	< LOD	< LOD	.111 (.055-.468)	.368 (.089-1.37)	1052
Females	99-00	*	< LOD	< LOD	< LOD	< LOD	966
	01-02	*	< LOD	< LOD	.087 (.043-.513)	.419 (.072-1.79)	1205
Race/ethnicity							
Mexican Americans	99-00	*	< LOD	< LOD	< LOD	< LOD	617
	01-02	*	< LOD	< LOD	< LOD	< LOD	548
Non-Hispanic blacks	99-00	*	< LOD	< LOD	.087 (.044-.221)	.221 (.124-.449)	398
	01-02	*	< LOD	.085 (.031-.240)	.293 (.092-1.41)	.826 (.166-3.02)	500
Non-Hispanic whites	99-00	*	< LOD	< LOD	< LOD	< LOD	688
	01-02	*	< LOD	< LOD	.098 (.047-.609)	.449 (.077-1.79)	1049

< LOD means less than the limit of detection, which may vary for some chemicals by year and by individual sample. See Appendix A for LODs.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Aldrin

CAS No. 309-00-02

Dieldrin

CAS No. 60-57-1

General Information

Aldrin and dieldrin are organochlorine pesticides that are no longer produced or used in the United States. From the 1950s to 1970, both chemicals were widely used insecticides on agricultural commodities including cotton and corn. These agricultural uses were cancelled in 1970. Aldrin and dieldrin were also registered for use to control termites, but this use was cancelled in 1987. Dieldrin was also used as a sheep-dip pesticide.

Aldrin is rapidly converted to dieldrin in the environment. Aldrin volatilizes from soil after agricultural application or is converted to dieldrin, which volatilizes more slowly. The most likely source of exposure to aldrin and dieldrin in the general population is the diet. Inhalation exposure may also occur among people living in residences where aldrin was previously applied as a pesticide. The U.S. EPA, OSHA, and U.S. FDA have developed criteria on the allowable levels of aldrin in drinking water, workplaces, and foods, respectively.

After aldrin enters the body, it is metabolized to dieldrin.

Dieldrin will accumulate in fatty tissues and its metabolites are excreted in bile and feces. It is also excreted in breast milk. The elimination half-life of dieldrin is approximately 1 year. At high doses, aldrin and dieldrin block inhibitory neurotransmitters in the central nervous system. This blocking action can cause abnormal excitation of the brain, leading to symptoms such as headache, confusion, muscle twitching, nausea, vomiting, and seizures.

More information about external exposure (i.e., environmental levels) and health effects is available from the U.S. EPA's IRIS Web site at <http://www.epa.gov/iris> and from ATSDR's Toxicological Profiles at <http://www.atsdr.cdc.gov/toxprofiles>.

Interpreting Levels of Lipid-Adjusted Serum Aldrin and Dieldrin Reported in the Tables

Serum aldrin and dieldrin levels were measured in a subsample of NHANES participants aged 12 years and older. Participants were selected within the specified age range to be a representative sample of the U.S. population.

Table 252. Aldrin (lipid adjusted)

Geometric mean and selected percentiles of serum concentrations (in 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, 2001-2002.

	Survey years	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)				Sample size
			50th	75th	90th	95th	
Total, age 12 and older	01-02	*	< LOD	< LOD	< LOD	< LOD	2275
Age group							
12-19 years	01-02	*	< LOD	< LOD	< LOD	< LOD	756
20 years and older	01-02	*	< LOD	< LOD	< LOD	< LOD	1519
Gender							
Males	01-02	*	< LOD	< LOD	< LOD	< LOD	1057
Females	01-02	*	< LOD	< LOD	< LOD	< LOD	1218
Race/ethnicity							
Mexican Americans	01-02	*	< LOD	< LOD	< LOD	< LOD	559
Non-Hispanic blacks	01-02	*	< LOD	< LOD	< LOD	< LOD	512
Non-Hispanic whites	01-02	*	< LOD	< LOD	< LOD	< LOD	1045

< LOD means less than the limit of detection, which may vary for some chemicals by year and by individual sample. See Appendix A for LODs.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

In the NHANES 2001-2002 subsample, serum levels of aldrin were below the limit of detection, which is consistent with findings of NHANES II (1976-1980) (Stehr-Green, 1989). As well, levels of aldrin were not detectable in a study of New Zealand adults aged 15 years and older (Bates et al., 2004b).

In the NHANES 2001-2002 subsample, the 95th percentile value for serum dieldrin was approximately ten times lower than levels measured in a subsample from NHANES II (1976-1980). In New Zealanders aged 15 years and older (Bates et al., 2004b) and in Norwegian women (Ward et al., 2000), levels of lipid-adjusted serum dieldrin were lower than the 95th percentile value for dieldrin in this NHANES 2001-2002 subsample.

Finding a measurable amount of aldrin or dieldrin in serum does not mean that the level will result in an adverse health effect. These data will help scientists plan and conduct research about the relation between exposure to aldrin or dieldrin and health effects. These data also provide physicians with a reference range so that they can determine whether or not other people have been exposed to higher levels of aldrin and dieldrin than levels found in the general population.

Table 253. Aldrin (whole weight)

Geometric mean and selected percentiles of serum concentrations (in ng/g of serum or parts per billion) for the U.S. population aged 12 years and older, National Health and Nutrition Examination Survey, 2001-2002.

	Survey years	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)				Sample size
			50th	75th	90th	95th	
Total, age 12 and older	01-02	*	< LOD	< LOD	< LOD	< LOD	2275
Age group							
12-19 years	01-02	*	< LOD	< LOD	< LOD	< LOD	756
20 years and older	01-02	*	< LOD	< LOD	< LOD	< LOD	1519
Gender							
Males	01-02	*	< LOD	< LOD	< LOD	< LOD	1057
Females	01-02	*	< LOD	< LOD	< LOD	< LOD	1218
Race/ethnicity							
Mexican Americans	01-02	*	< LOD	< LOD	< LOD	< LOD	559
Non-Hispanic blacks	01-02	*	< LOD	< LOD	< LOD	< LOD	512
Non-Hispanic whites	01-02	*	< LOD	< LOD	< LOD	< LOD	1045

< LOD means less than the limit of detection, which may vary for some chemicals by year and by individual sample. See Appendix A for LODs.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Table 254. Dieldrin (lipid adjusted)

Geometric mean and selected percentiles of serum concentrations (in 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, 2001-2002.

	Survey years	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)				Sample size
			50th	75th	90th	95th	
Total, age 12 and older	01-02	*	< LOD	< LOD	15.2 (14.3-17.0)	20.3 (18.7-22.4)	2159
Age group							
12-19 years	01-02	*	< LOD	< LOD	< LOD	< LOD	716
20 years and older	01-02	*	< LOD	10.5 (<LOD-11.6)	16.4 (15.1-18.2)	21.3 (19.1-24.0)	1443
Gender							
Males	01-02	*	< LOD	< LOD	15.7 (14.4-18.7)	20.2 (18.5-23.6)	1007
Females	01-02	*	< LOD	< LOD	15.2 (13.4-17.0)	19.8 (18.0-21.6)	1152
Race/ethnicity							
Mexican Americans	01-02	*	< LOD	< LOD	11.6 (<LOD-15.1)	15.4 (12.6-17.6)	539
Non-Hispanic blacks	01-02	*	< LOD	< LOD	15.0 (11.8-19.1)	20.2 (15.8-25.2)	484
Non-Hispanic whites	01-02	*	< LOD	< LOD	15.5 (14.8-17.7)	20.7 (18.9-23.6)	980

< LOD means less than the limit of detection, which may vary for some chemicals by year and by individual sample. See Appendix A for LODs.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Table 255. Dieldrin (whole weight)

Geometric mean and selected percentiles of serum concentrations (in ng/g of serum or parts per billion) for the U.S. population aged 12 years and older, National Health and Nutrition Examination Survey, 2001-2002.

	Survey years	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)				Sample size
			50th	75th	90th	95th	
Total, age 12 and older	01-02	*	< LOD	< LOD	.109 (.099-.121)	.146 (.129-.164)	2159
Age group							
12-19 years	01-02	*	< LOD	< LOD	< LOD	< LOD	716
20 years and older	01-02	*	< LOD	.067 (.062-.075)	.117 (.105-.127)	.158 (.141-.178)	1443
Gender							
Males	01-02	*	< LOD	< LOD	.114 (.102-.129)	.156 (.126-.190)	1007
Females	01-02	*	< LOD	< LOD	.097 (.089-.111)	.141 (.123-.157)	1152
Race/ethnicity							
Mexican Americans	01-02	*	< LOD	< LOD	.083 (.068-.103)	.119 (.086-.144)	539
Non-Hispanic blacks	01-02	*	< LOD	< LOD	.085 (.071-.113)	.118 (.086-.190)	484
Non-Hispanic whites	01-02	*	< LOD	< LOD	.109 (.100-.124)	.153 (.131-.175)	980

< LOD means less than the limit of detection, which may vary for some chemicals by year and by individual sample. See Appendix A for LODs.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Endrin

CAS No. 72-20-8

General Information

Endrin, a stereoisomer of dieldrin, is an organochlorine pesticide that is no longer registered for use in the United States. Production and use of endrin was discontinued in 1986. In contrast to aldrin and dieldrin, endrin was not extensively used for termite control in residences. Endrin is a persistent chemical in the environment, particularly in soils. It is transformed in the environment and the human body to metabolites including endrin aldehyde and endrin ketone. The main sources of human exposure to endrin come from residues on food items imported from countries where endrin is still used and living or working near hazardous waste sites where the chemical was produced.

After a person is exposed to endrin, most of the chemical is metabolized and eliminated from the body relatively quickly compared with length of time it takes for other organochlorine pesticides to be metabolized and excreted. Endrin does not accumulate in body tissues, and elimination occurs via its metabolites, which are excreted in the feces. At high doses, endrin blocks inhibitory neurotransmitters in the central nervous system. This blocking action can cause an abnormal excitation of the brain, producing seizures.

Information about external exposure (i.e., environmental

levels) and health effects of endrin is available from ATSDR's Toxicological Profiles at <http://www.atsdr.cdc.gov/toxprofiles>.

Interpreting Levels of Lipid-Adjusted Serum Endrin Reported in the Tables

Serum endrin levels were measured in a subsample of NHANES participants aged 12 years and older. Participants were selected within the specified age range to be a representative sample of the U.S. population. In the NHANES 2001-2002 subsample, serum levels of endrin were below the limit of detection. This finding is consistent the study of New Zealanders aged 15 years and older in whom levels of endrin were also below the limit of detection (Bates et al., 2004b). In another study of women in Spain, endrin was detected in 9% of serum samples at a mean concentration of 2.25 ng/mL (about 2.25 ng/g of serum) (Botella et al., 2004).

Finding a measurable amount of endrin in serum does not mean that the level will result in an adverse health effect. These data will help scientists plan and conduct research about the relation between exposure to endrin and health effects. These data also provide physicians with a reference range so that they can determine whether or not other people have been exposed to higher levels of endrin than levels found in the general population.

Table 256. Endrin (lipid adjusted)

Geometric mean and selected percentiles of serum concentrations (in 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, 2001-2002.

	Survey years	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)				Sample size
			50th	75th	90th	95th	
Total, age 12 and older	01-02	*	< LOD	< LOD	< LOD	5.10 (<LOD-5.20)	2187
Age group							
12-19 years	01-02	*	< LOD	< LOD	5.10 (<LOD-5.30)	5.60 (5.40-5.70)	730
20 years and older	01-02	*	< LOD	< LOD	< LOD	< LOD	1457
Gender							
Males	01-02	*	< LOD	< LOD	< LOD	5.20 (<LOD-5.20)	1022
Females	01-02	*	< LOD	< LOD	< LOD	< LOD	1165
Race/ethnicity							
Mexican Americans	01-02	*	< LOD	< LOD	< LOD	5.20 (<LOD-6.50)	547
Non-Hispanic blacks	01-02	*	< LOD	< LOD	< LOD	5.30 (<LOD-6.10)	487
Non-Hispanic whites	01-02	*	< LOD	< LOD	< LOD	5.10 (<LOD-5.30)	1000

< LOD means less than the limit of detection, which may vary for some chemicals by year and by individual sample. See Appendix A for LODs.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Table 257. Endrin (whole weight)

Geometric mean and selected percentiles of serum concentrations (in ng/g of serum or parts per billion) for the U.S. population aged 12 years and older, National Health and Nutrition Examination Survey, 2001-2002.

	Survey years	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)				Sample size
			50th	75th	90th	95th	
Total, age 12 and older	01-02	*	< LOD	< LOD	< LOD	.021 (.020-.021)	2187
Age group							
12-19 years	01-02	*	< LOD	< LOD	.021 (.020-.021)	.021 (.020-.021)	730
20 years and older	01-02	*	< LOD	< LOD	< LOD	< LOD	1457
Gender							
Males	01-02	*	< LOD	< LOD	< LOD	.020 (.020-.021)	1022
Females	01-02	*	< LOD	< LOD	< LOD	< LOD	1165
Race/ethnicity							
Mexican Americans	01-02	*	< LOD	< LOD	< LOD	.021 (.020-.021)	547
Non-Hispanic blacks	01-02	*	< LOD	< LOD	< LOD	.021 (.020-.021)	487
Non-Hispanic whites	01-02	*	< LOD	< LOD	< LOD	.021 (.020-.021)	1000

< LOD means less than the limit of detection, which may vary for some chemicals by year and by individual sample. See Appendix A for LODs.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

Results by Chemical Group

Organophosphate Pesticides: Dialkyl Phosphate Metabolites

