Phthalates

General Information

Phthalates are industrial chemicals that can act as plasticizers, which, when added to plastic, impart flexibility and resilience. Many consumer products contain phthalates. Among these products are vinyl flooring; adhesives; detergents; lubricating oils; solvents; automotive plastics; plastic clothing, such as raincoats; and personal-care products, such as soap, shampoo, deodorants, fragrances, hair spray, nail polish; and some medical pharmaceuticals. Phthalates are widely used in flexible polyvinyl chloride plastics, such as plastic bags, garden hoses, inflatable recreational toys, blood-storage bags, intravenous medical tubing, and children's toys. Soil and water contamination can be greatest in areas of industrial use and waste disposal.

People are exposed through direct contact with products that contain phthalates. For the general population, the oral route of exposure has been considered a major route. However, both population studies (Adibi et al., 2003) and occupational studies (Dirven et al., 1993; Liss et al., 1985; Nielsen et al., 1985) have shown that personal air-sample levels of phthalate diesters correlate modestly well with concentrations of urinary metabolites, suggesting that inhalation is an important route of exposure (Otake et al., 2004). In contrast, urinary levels in children did not correlate with home- dust measurements of phthalate content (Becker et al., 2004). Generally, phthalates are metabolized and excreted quickly and do not accumulate in the body (Anderson et al., 2001). Ingested phthalate diesters are initially hydrolyzed in the intestine to their corresponding monoester, which is then absorbed. (Albro et al., 1982; Albro and Lavenhar, 1989). Absorbed monoester metabolites may be further oxidized in the body. Table 188 shows the monoester metabolites and other oxidized metabolites of phthalates measured in this *Report* and also includes their commonly used abbreviations.

Several of the phthalates produce testicular injury, liver injury, liver cancer, and teratogenicity in rodent studies, but these effects either have not been demonstrated when tested in non-human primates or people or have not been investigated. The monoester metabolites are thought to mediate toxic effects for some of the phthalates. Phthalates have weak or no estrogenic, antiestrogenic, or androgenic activity *in vitro*, although not all metabolites have been tested (Jobling et al., 1995; Coldham et al., 1997; Harris et al., 1997; Parks et al., 2000; Okubo et al., 2003) and have shown no estrogenic activity *in vivo* (Zacharewski et al., 1998; Milligan et al., 1998). However, in animal studies, several phthalates show antiandrogenic activity and exposure to high doses of di-2-ethylhexyl phthalate (DEHP), dibutyl phthalate (DBP), and benzylbutyl phthalate (BzBP) during the fetal period have produced lowered testosterone levels, testicular atrophy, and Sertoli cell abnormalities in male animals and, at higher doses, ovarian abnormalities in female animals (see reviews by the Center for the Evaluation of Risks to Human Reproduction, 2000; McKee et al., 2004; and Jarfelt et al., 2005). Such effects may also be mediated through an inhibition of testicular, adrenal, or ovarian steroidogenesis. Phthalate levels in men from an infertility clinic have been associated with several parameters of sperm analysis (Duty et al., 2003; Duty et al., 2004; Duty et al., 2005).

Differences between human and rodent studies in the timing of dosages relative to critical developmental periods and in the amounts of putative metabolites generated in animals versus humans, as well as the large

Table 187. Phthalates and their metabolites

Phthalate name (CAS number)	**Abbreviation**	**Urinary metabolite** (CAS number)	**Abbreviation**
Dimethyl phthalate (131-11-3)	DMP	Mono-methyl phthalate (4376-18-5)	MMP
Diethyl phthalate (84-66-2)	DEP	Mono-ethyl phthalate (2306-33-4)	MEP
Dibutyl phthalates (84-74-2)	DBP	Mono-n-butyl phthalate (131-70-4)	MnBP
		Mono-isobutyl phthalate	MiBP
Benzylbutyl phthalate (85-68-7)	BzBP	Mono-benzyl phthalate (2528-16-7) (some mono-n-butyl phthalate)	MBzP
Dicyclohexyl phthalate (84-61-7)	DCHP	Mono-cyclohexyl phthalate (7517-36-4)	MCHP
Di-2-ethylhexyl phthalate (117-81-7)	DEHP	Mono-2-ethylhexyl phthalate (4376-20-9)	MEHP
		Mono-(2-ethyl-5-oxohexyl) phthalate	MEOHP
		Mono-(2-ethyl-5-hydroxyhexyl) phthalate	MEHHP
Di-n-octyl phthalate (117-84-0)	DOP	Mono-n-octyl phthalate (5393-19-1)	MOP
		Mono-(3-carboxypropyl) phthalate	MCPP
Di-isononyl phthalate (28553-12-0)	DiNP	Mono-isononyl phthalate	MiNP

doses given to test animals, make it difficult to translate the effects observed in animals to health effects in people. For instance, blood levels of phthalate monoesters can be higher in rodents than in non-human primates that are given equivalent doses due to the greater absorption in rodents or possibly greater hydrolysis to the monoester metabolite (Kessler et al., 2004; Lake et al., 1977). In addition, phthalates cause peroxisomal proliferation, which may be a pathway to the development of liver cancers in animals. However, peroxisomal proliferation may be a less relevant pathway in people (Melnick, 2001).

The Center for the Evaluation of Risks to Human Reproduction of the NTP has reviewed the reproductive effects for many of the phthalates (see http://cerhr.niehs.nih.gov/news/phthalates/monographs.html). Information about external exposure (i.e., environmental levels) and health effects is also available for some phthalates 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 Phthalate Metabolites Reported in the Tables

Urinary levels of phthalate metabolites were measured in a subsample of NHANES participants aged 6 years and older. Participants were randomly selected within the specified age range to be a representative sample of the U.S. population. The concentrations for the monoester phthalate metabolites in the NHANES 2001-2002 subsample appear roughly similar to concentrations to those seen in an earlier survey of U.S. residents (Blount et al., 2000), pregnant women in New York City (Adibi et al., 2003), and in men from a Boston infertility clinic (Duty et al., 2004). In a small sample of Germans aged 7-64 years, median levels of mono-2-ethylhexyl phthalate (MEHP), mono-2-ethyl-5-hydroxyhexyl phthalate (MEHHP), mono-2-ethyl-5-oxohexyl phthalate (MEOHP) and mono-benzyl phthalate (MBzP) were about two-fold higher than median levels in the NHANES 2001-2002 subsample; the median level of mono-butyl phthalate (MBP) was about six-fold higher; and the median level of mono-ethyl phthalate (MEP) was slightly lower than the median levels of these metabolites in the NHANES 1999-2002 subsamples (Koch et al., 2003).

With the exception of MEP, the NHANES 1999-2000 and 2001-2002 subsamples showed that children aged 6-11 years excreted higher concentrations of metabolites than did older age groups, a finding that has been noted in other studies of German adults and children for DEHP metabolites (Koch et al., 2004; Becker et al., 2004). The 1999-2000 and 2001-2002 NHANES subsamples also showed other differences in concentrations of specific phthalate metabolites by age, gender, and race/ethnicity (see data on individual phthalates). It is known that there is variation from person to person in the proportions or amounts of the metabolite excreted after people received similar doses (Anderson et al., 2001) as well as variation in the same person during repetitive monitoring (Hauser et al., 2004; Hoppin et al., 2002). The proportions of each metabolite for a given phthalate may vary also by differing routes of exposure (Liss et al., 1985; Peck and Albro, 1982).

Differences among the levels of various phthalate metabolites within a person may be due to differences in either exposure or pharmacokinetics for each of those phthalates. For instance, DEHP has been one of the more widely used phthalates, yet levels of MEHP are found in lower concentrations than MEP, MBP, or MBzP. It is now known that a greater proportion of the dose is accounted by other DEHP urinary metabolites (e.g., MEOHP and MEHHP), which demonstrate higher urinary concentrations than MEHP (Barr et al., 2003; Koch et al., 2003). Likewise, the low detection rates for some of the monoester metabolites of the long alkyl chain phthalates (di-isononyl and dioctyl) may be due to lower exposure to these compounds, to less of the parent compound being metabolized to the measured monoester metabolite, or, as seen with DEHP, to further oxidation to other unmeasured metabolites.

Finding a measurable amount of one or more phthalate metabolites in urine does not mean that they cause an adverse health effect. Whether these levels of phthalate metabolites are cause for health concern is not yet known; more research is needed. These levels of phthalate metabolites in urine provide physicians with a reference range so that they can determine whether or not people have been exposed to higher levels of phthalates than levels found in the general population. These data will also help scientists plan and conduct research on phthalate exposure and health effects.

Mono-methyl Phthalate

CAS No. 4376-18-5

Metabolite of Dimethyl Phthalate, CAS No.131-11-3

General Information

Dimethyl phthalate (DMP) is used to manufacture solid rocket propellant and some consumer products such as insect repellants and plastics. People exposed to DMP will excrete mono-methyl phthalate (MMP) in their urine. The amount of MMP is an indicator of how much contact with DMP has occurred. Workplace air standards for external exposure to dimethyl phthalate have been established by NIOSH and ACGIH. DMP has not been completely classified with respect to carcinogenicity by IARC and NTP.

Comparing Adjusted Geometric Means

MMP was not measured in NHANES 1999-2000. For NHANES 2001-2002, geometric mean levels of urinary MMP for the demographic groups were compared after adjusting for the covariates of race/ethnicity, age, gender, and urinary creatinine (data not shown). Adjusted geometric mean levels of urinary MMP were found to be higher in children aged 6-11 years than in either of the groups aged 12-19 years and 20 years and older and levels in the group aged 12-19 years were higher than in the group aged 20 years and older. Females had higher levels than males. It is unknown whether these differences associated with age and gender represent differences in exposure, pharmacokinetics, or the relationship of dose per body weight.

Table 188. Mono-methyl phthalate

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6 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 6 and older	01-02	**1.15** (.985-1.34)	**1.50** (1.30-1.70)	**3.30** (2.80-3.70)	**6.00** (5.10-7.40)	**9.80** (8.00-12.5)	2782
Age group							
6-11 years	01-02	**1.45** (1.13-1.87)	**1.80** (1.40-2.60)	**4.00** (3.30-4.70)	**6.90** (6.00-8.00)	**11.6** (7.60-20.8)	393
12-19 years	01-02	**1.59** (1.28-1.96)	**2.10** (1.80-2.50)	**3.80** (3.30-4.70)	**8.50** (5.30-10.5)	**12.7** (9.60-17.8)	742
20 years and older	01-02	**1.06** (.904-1.25)	**1.40** (1.10-1.60)	**3.10** (2.40-3.50)	**5.60** (4.60-6.90)	**9.10** (7.10-11.8)	1647
Gender							
Males	01-02	**1.17** (.962-1.43)	**1.50** (1.20-1.80)	**3.30** (2.80-3.80)	**5.90** (4.80-7.90)	**9.10** (7.10-12.7)	1371
Females	01-02	**1.13** (.973-1.31)	**1.30** (1.10-1.60)	**3.30** (2.80-3.70)	**6.40** (4.90-7.80)	**10.3** (8.00-15.2)	1411
Race/ethnicity							
Mexican Americans	01-02	**1.21** (1.02-1.45)	**1.50** (1.30-1.70)	**3.30** (2.70-3.90)	**5.50** (4.70-7.30)	**8.30** (6.40-15.2)	677
Non-Hispanic blacks	01-02	**1.64** (1.37-1.98)	**2.00** (1.70-2.50)	**4.40** (3.50-5.10)	**8.30** (6.20-10.1)	**10.8** (9.50-13.4)	703
Non-Hispanic whites	01-02	**1.08** (.906-1.29)	**1.40** (1.10-1.60)	**3.10** (2.50-3.60)	**5.60** (4.60-6.60)	**9.70** (7.10-14.0)	1216

Table 189. Mono-methyl phthalate (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g of creatinine) for the U.S. population aged 6 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 6 and older	01-02	**1.08** (.935-1.24)	**1.33** (1.13-1.54)	**2.62** (2.36-2.95)	**5.00** (3.96-6.00)	**7.97** (6.07-10.9)	2772
Age group							
6-11 years	01-02	**1.65** (1.28-2.13)	**2.32** (1.72-2.86)	**3.93** (3.27-4.71)	**6.77** (5.75-9.41)	**12.5** (7.60-22.5)	392
12-19 years	01-02	**1.23** (1.01-1.48)	**1.51** (1.32-1.81)	**2.84** (2.52-3.33)	**5.36** (3.68-6.39)	**7.27** (5.64-11.4)	742
20 years and older	01-02	**1.00** (.866-1.16)	**1.21** (1.04-1.40)	**2.44** (2.14-2.65)	**4.49** (3.49-5.88)	**7.72** (5.54-11.7)	1638
Gender							
Males	01-02	**.953** (.792-1.15)	**1.17** (1.01-1.40)	**2.38** (2.03-2.78)	**4.12** (3.45-5.64)	**6.42** (4.94-9.32)	1367
Females	01-02	**1.21** (1.06-1.38)	**1.45** (1.24-1.82)	**2.86** (2.60-3.04)	**5.45** (4.55-7.07)	**10.0** (7.20-15.3)	1405
Race/ethnicity							
Mexican Americans	01-02	**1.14** (.969-1.34)	**1.47** (1.29-1.63)	**2.48** (2.19-2.94)	**4.19** (3.75-5.79)	**7.53** (4.76-15.2)	674
Non-Hispanic blacks	01-02	**1.15** (.945-1.40)	**1.39** (1.28-1.67)	**2.69** (2.35-2.93)	**4.86** (4.20-5.88)	**8.02** (5.85-10.9)	702
Non-Hispanic whites	01-02	**1.07** (.913-1.25)	**1.30** (1.05-1.58)	**2.60** (2.32-2.97)	**5.23** (3.72-6.82)	**8.29** (6.08-12.6)	1211

Mono-ethyl Phthalate

CAS No. 2306-33-4

Metabolite of Diethyl Phthalate, CAS No. 84-66-2

General Information

Diethyl phthalate (DEP) is an industrial solvent used in many consumer products, particularly those containing fragrances. Products that may contain DEP include perfume, cologne, deodorant, soap, shampoo, and hand lotion. People exposed to DEP will excrete monoethyl phthalate (MEP) in their urine. Workplace air standards for external exposure to DEP have been established by ACGIH or recommended by NIOSH. It has not been completely classified with respect to its carcinogenicity by IARC and NTP.

Interpreting Levels of Urinary Mono-ethyl Phthalate in the Tables

MEP levels in the NHANES 2001-2002 subsample appear similar to levels in a small sample of pregnant women in New York City (Adibi et al., 2003). MEP levels found in a small sample of German residents (Koch et al., 2003) are slightly lower than levels documented in this *Report*.

Table 190. Mono-ethyl phthalate

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6 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 6 and older	99-00	**179** (156-204)	**164** (136-201)	**450** (370-538)	**1260** (1010-1480)	**2840** (2150-3770)	2536
	01-02	**178** (159-199)	**169** (141-194)	**465** (415-527)	**1230** (1040-1440)	**2500** (1860-3220)	2782
Age group							
6-11 years	99-00	**91.3** (74.8-111)	**74.7** (62.1-93.7)	**197** (129-249)	**378** (290-730)	**756** (379-1070)	328
	01-02	**85.1** (71.2-102)	**71.9** (61.9-92.5)	**181** (142-217)	**444** (315-636)	**808** (572-1090)	393
12-19 years	99-00	**211** (160-278)	**193** (141-256)	**558** (419-818)	**1510** (1050-2150)	**3260** (1550-4420)	752
	01-02	**197** (159-243)	**184** (148-227)	**479** (387-651)	**1260** (983-1480)	**2060** (1470-3050)	742
20 years and older	99-00	**190** (164-219)	**180** (140-220)	**482** (390-590)	**1340** (1010-1660)	**3480** (2230-4640)	1456
	01-02	**191** (171-214)	**181** (152-212)	**498** (441-567)	**1350** (1060-1660)	**2720** (2160-3670)	1647
Gender							
Males	99-00	**179** (149-215)	**154** (119-197)	**523** (372-650)	**1430** (1020-2280)	**3480** (2130-4560)	1214
	01-02	**182** (157-211)	**171** (139-199)	**502** (419-603)	**1450** (1060-2110)	**3050** (2110-4390)	1371
Females	99-00	**178** (154-206)	**174** (138-210)	**425** (350-508)	**977** (880-1230)	**2230** (1370-3880)	1322
	01-02	**174** (153-198)	**167** (139-194)	**427** (387-498)	**1050** (879-1310)	**1840** (1490-2500)	1411
Race/ethnicity							
Mexican Americans	99-00	**181** (157-209)	**174** (146-210)	**441** (390-541)	**1250** (851-1510)	**1720** (1460-2130)	813
	01-02	**226** (195-262)	**220** (190-264)	**530** (444-660)	**1490** (1050-2110)	**2590** (1540-4460)	677
Non-Hispanic blacks	99-00	**322** (275-377)	**306** (256-350)	**789** (635-949)	**1880** (1410-2270)	**3600** (2130-4640)	603
	01-02	**352** (324-384)	**357** (290-407)	**839** (709-1090)	**2160** (1620-2470)	**3540** (2810-5070)	703
Non-Hispanic whites	99-00	**152** (133-175)	**133** (108-157)	**366** (287-482)	**977** (798-1340)	**2470** (1590-3880)	908
	01-02	**158** (141-178)	**147** (119-177)	**413** (366-451)	**1020** (905-1230)	**2310** (1560-2720)	1216

Comparing Adjusted Geometric Means

Geometric mean levels of urinary MEP for the demographic groups were compared after adjusting for the covariates of race/ethnicity, age, gender, and urinary creatinine (data not shown). In NHANES 2001-2002, the adjusted geometric mean levels of urinary MEP were lower in the group aged 6-11 years than either of the other age groups and the group aged 12-19 was had lower levels than the group 20 years and older. This age-related trend is opposite the direction shown for other phthalates. Non-Hispanic whites had lower levels than non-Hispanic blacks or Mexican Americans. Levels in non-Hispanic blacks were not significantly higher than in Mexican Americans. It is unknown whether these differences associated with age or race/ethnicity represent differences in exposure, pharmacokinetics, or the relationship of dose per body weight.

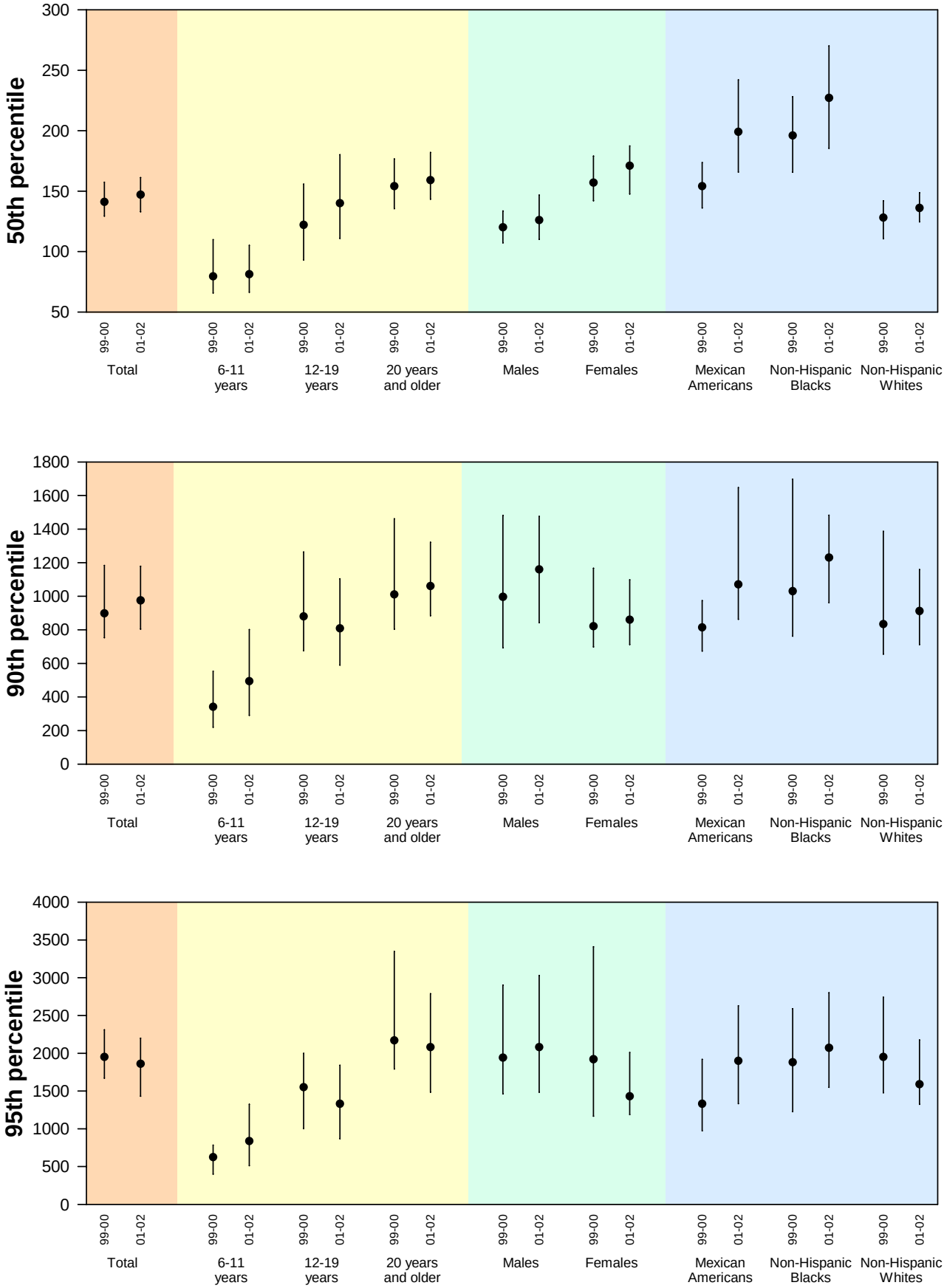
Table 191. Mono-ethyl phthalate (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g of creatinine) for the U.S. population aged 6 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 6 and older	99-00	**163** (149-178)	**141** (129-157)	**360** (307-422)	**898** (753-1180)	**1950** (1670-2310)	2536
	01-02	**167** (150-185)	**147** (133-161)	**388** (333-435)	**975** (804-1180)	**1860** (1430-2200)	2772
Age group							
6-11 years	99-00	**92.6** (77.9-110)	**79.4** (65.7-110)	**165** (127-208)	**341** (219-554)	**625** (400-784)	328
	01-02	**96.9** (82.4-114)	**81.2** (66.3-105)	**171** (135-224)	**494** (290-802)	**837** (512-1320)	392
12-19 years	99-00	**142** (119-169)	**122** (93.0-156)	**361** (275-495)	**879** (676-1260)	**1550** (1000-2000)	752
	01-02	**152** (126-184)	**140** (111-180)	**325** (249-409)	**808** (590-1100)	**1330** (868-1840)	742
20 years and older	99-00	**179** (161-199)	**154** (136-177)	**390** (336-452)	**1010** (803-1460)	**2170** (1790-3350)	1456
	01-02	**181** (164-200)	**159** (143-182)	**419** (363-486)	**1060** (883-1320)	**2080** (1490-2790)	1638
Gender							
Males	99-00	**141** (124-159)	**120** (107-134)	**324** (249-415)	**996** (693-1480)	**1940** (1460-2900)	1214
	01-02	**147** (129-168)	**126** (110-147)	**347** (279-418)	**1160** (843-1480)	**2080** (1490-3030)	1367
Females	99-00	**187** (165-211)	**157** (142-179)	**377** (307-495)	**821** (697-1170)	**1920** (1170-3410)	1322
	01-02	**187** (166-210)	**171** (148-187)	**410** (356-476)	**860** (712-1100)	**1430** (1190-2010)	1405
Race/ethnicity							
Mexican Americans	99-00	**164** (142-190)	**154** (136-174)	**382** (314-472)	**814** (673-974)	**1330** (974-1920)	813
	01-02	**214** (183-250)	**199** (166-242)	**472** (396-572)	**1070** (862-1650)	**1900** (1330-2630)	674
Non-Hispanic blacks	99-00	**208** (183-236)	**196** (166-228)	**443** (390-505)	**1030** (762-1700)	**1880** (1230-2590)	603
	01-02	**247** (225-271)	**227** (185-270)	**557** (478-618)	**1230** (961-1480)	**2070** (1550-2800)	702
Non-Hispanic whites	99-00	**149** (135-165)	**128** (111-142)	**313** (239-387)	**834** (655-1390)	**1950** (1480-2740)	908
	01-02	**156** (141-173)	**136** (124-149)	**337** (288-402)	**911** (712-1160)	**1590** (1320-2170)	1211

Figure 20. Mono-ethyl phthalate (creatinine corrected)

Selected percentiles with 95% confidence intervals of urine concentrations (in µg/g of creatinine) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2002.



Mono-n-butyl Phthalate

CAS No. 131-70-4

Metabolite of Di-n-butyl Phthalate, CAS No. 84-74-2 and Benzylbutyl Phthalate, CAS No. 85-68-7

Mono-isobutyl Phthalate

Metabolite of Di-isobutyl Phthalates, CAS No. 84-74-2

General Information

Dibutyl phthalates (di-n-butyl, di-isobutyl) are industrial solvents or additives used in many consumer products such as nail polish, cosmetics, some printing inks, pharmaceutical coatings, and insecticides. People exposed to dibutyl phthalates will excrete mono-butyl phthalates (n-butyl, iso-butyl) in their urine. Small amounts of mono-3-carboxypropyl phthalate are also produced from di-n-butyl phthalate. In addition, exposure to benzylbutyl phthalate (BzBP) will also result in small amounts of mono-n-butyl phthalate appearing in the urine (Anderson et al., 2001).

Workplace air standards for external exposure to dibutyl phthalate have been established by NIOSH and ACGIH. Dibutyl phthalates can produce reproductive toxicity in animals (Center for the Evaluation of Risks to Human Reproduction, 2003). Dibutyl phthalates have not been completely classified with respect to carcinogenicity by IARC or NTP.

Interpreting Levels of Urinary Mono-n-butyl and Mono-isobutyl Phthalates in the Tables

Mono-butyl phthalate (MBP) levels in the NHANES 1999-2000 subsample represented the sum of both

Table 192. Mono-n-butyl phthalate

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

	Survey years	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval) 50th	75th	90th	95th	Sample size
Total, age 6 and older	99-00	**24.6** (22.1-27.4)	**26.0** (23.6-29.2)	**51.6** (44.4-59.8)	**98.6** (90.2-114)	**149** (121-169)	2541
	01-02	**18.9** (17.4-20.6)	**20.4** (19.1-21.7)	**40.4** (36.5-44.2)	**73.6** (65.3-85.4)	**108** (94.1-122)	2782
Age group							
6-11 years	99-00	**41.4** (35.6-48.0)	**40.0** (36.2-49.2)	**75.5** (59.1-92.8)	**124** (98.4-159)	**163** (127-279)	328
	01-02	**31.1** (26.6-36.5)	**32.4** (25.5-36.4)	**62.1** (51.3-76.9)	**107** (84.3-136)	**157** (110-290)	393
12-19 years	99-00	**36.0** (30.8-42.1)	**36.1** (30.6-44.9)	**67.7** (55.9-79.7)	**119** (90.2-159)	**165** (121-227)	752
	01-02	**25.1** (21.6-29.2)	**26.4** (22.0-32.6)	**52.2** (48.1-60.4)	**92.4** (72.3-119)	**147** (105-183)	742
20 years and older	99-00	**21.6** (19.0-24.5)	**23.0** (19.7-26.0)	**46.1** (36.6-53.5)	**95.0** (78.7-111)	**142** (117-161)	1461
	01-02	**17.0** (15.4-18.8)	**19.1** (17.1-20.4)	**35.1** (31.6-40.2)	**64.8** (57.3-79.7)	**95.4** (84.6-113)	1647
Gender							
Males	99-00	**22.0** (20.1-24.1)	**23.1** (20.3-26.1)	**43.1** (36.6-49.5)	**83.9** (71.3-96.2)	**115** (97.8-132)	1215
	01-02	**17.7** (16.0-19.6)	**19.3** (17.0-20.6)	**34.4** (30.3-40.6)	**62.1** (54.1-75.5)	**95.2** (75.5-117)	1371
Females	99-00	**27.3** (23.6-31.5)	**30.0** (25.9-33.3)	**59.5** (51.6-69.6)	**119** (98.3-145)	**167** (143-223)	1326
	01-02	**20.2** (18.2-22.4)	**21.6** (19.7-24.3)	**46.7** (43.1-51.1)	**85.0** (72.7-92.5)	**120** (106-136)	1411
Race/ethnicity							
Mexican Americans	99-00	**23.4** (21.8-25.1)	**26.3** (23.9-28.1)	**48.1** (41.2-56.7)	**92.2** (78.9-101)	**116** (104-131)	814
	01-02	**20.1** (16.6-24.5)	**23.0** (17.9-26.3)	**41.9** (34.0-51.2)	**76.9** (62.9-92.5)	**112** (84.6-143)	677
Non-Hispanic blacks	99-00	**37.0** (31.9-42.9)	**38.7** (33.4-44.5)	**78.2** (58.7-91.8)	**117** (107-143)	**167** (143-197)	603
	01-02	**29.6** (26.6-33.1)	**31.5** (28.7-34.1)	**58.0** (49.3-62.5)	**91.7** (79.5-121)	**138** (110-184)	703
Non-Hispanic whites	99-00	**21.8** (19.3-24.6)	**23.1** (19.5-27.5)	**45.9** (37.5-53.3)	**90.2** (74.7-106)	**138** (111-161)	912
	01-02	**17.6** (16.0-19.3)	**19.1** (17.0-20.9)	**36.5** (32.4-42.6)	**69.2** (59.2-87.6)	**107** (89.8-123)	1216

Note: In 99-00, concentrations of mono-isobutyl phthalate and mono-n-butyl phthalate were measured together and expressed as a combined value.
For 01-02, mono-n-butyl phthalate levels were measured separately, and only mono-n-butyl phthalate levels are given in this table.

mono-isobutyl phthalate (MiBP) and mono-n-butyl phthalate (MnBP), whereas in NHANES 2001-2002 it was possible to measure the concentrations of these two phthalates separately. Levels in the 1999-2000 and 2001-2002 subsamples appear roughly similar when the sum of the MiBP and MnBP levels in 2001-2002 are compared with the 1999-2000 MBP levels. Concentrations reported in these two subsamples are generally similar to those reported in U.S. residents (Blount et al., 2000) and in men from an infertility clinic (Duty et al., 2004). Levels reported for 1999-2002 are six-fold lower than levels reported in German residents (Koch et al., 2003) and slightly lower than levels found in a small sample of pregnant women in New York City (Adibi et al.,2003).

Comparing Adjusted Geometric Means

Geometric mean levels of urinary monobutyl phthalates for the demographic groups were compared after adjusting for the covariates of race/ethnicity, age, gender, and urinary creatinine (data not shown). In NHANES 2001-2002, adjusted geometric mean levels of urinary MnBP were higher in children aged 6-11 years than in people aged 12-19 years and 20 years and older, and the group aged 12-19 years had higher levels than the group aged 20 years and older. Levels were higher in females than in males.

In NHANES 2001-2002, adjusted geometric mean levels of urinary MiBP were higher in children aged 6-11 years than in people aged 12-19 years and 20 years. Levels were higher in females than in males. Non-Hispanic whites had lower levels than non-Hispanic blacks or Mexican Americans. It is unknown whether these differences associated with age, gender, or race/ethnicity represent differences in exposure, pharmacokinetics, or the relationship of dose per body weight.

Table 193. Mono-n-butyl phthalate (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g of creatinine) for the U.S. population aged 6 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 6 and older	99-00	**22.4** (20.6-24.4)	**21.9** (19.8-24.3)	**38.9** (35.0-41.8)	**68.3** (60.3-78.3)	**97.5** (81.4-131)	2541
	01-02	**17.8** (16.7-18.9)	**17.4** (16.3-18.3)	**30.4** (28.2-32.4)	**52.4** (47.3-61.1)	**81.3** (71.0-92.5)	2772
Age group							
6-11 years	99-00	**41.9** (37.4-47.1)	**38.9** (34.3-49.0)	**65.7** (56.7-80.0)	**107** (71.2-179)	**159** (102-263)	328
	01-02	**35.5** (31.7-39.6)	**35.1** (29.3-38.9)	**55.4** (50.1-62.3)	**84.0** (69.0-113)	**146** (93.8-235)	392
12-19 years	99-00	**24.3** (21.2-27.8)	**23.6** (20.6-27.4)	**37.6** (31.6-43.8)	**62.3** (52.4-76.4)	**88.1** (61.4-142)	752
	01-02	**19.4** (17.3-21.7)	**20.3** (17.5-22.3)	**34.9** (30.5-37.9)	**53.4** (45.2-73.9)	**88.6** (60.3-106)	742
20 years and older	99-00	**20.4** (18.6-22.4)	**19.5** (18.1-21.4)	**34.9** (30.3-40.0)	**62.4** (53.4-72.1)	**91.0** (70.3-135)	1461
	01-02	**16.1** (15.0-17.3)	**15.4** (14.2-16.5)	**26.3** (24.2-28.6)	**44.3** (38.7-51.1)	**71.6** (61.2-85.6)	1638
Gender							
Males	99-00	**17.3** (16.1-18.6)	**17.0** (15.5-18.8)	**28.6** (25.8-32.1)	**49.1** (42.6-53.5)	**63.6** (57.3-71.5)	1215
	01-02	**14.4** (13.5-15.4)	**13.7** (13.0-14.9)	**22.9** (20.8-24.9)	**39.9** (35.6-44.0)	**60.0** (50.5-78.0)	1367
Females	99-00	**28.6** (25.3-32.3)	**28.6** (25.5-30.5)	**50.6** (41.9-56.3)	**84.3** (69.2-106)	**131** (93.6-155)	1326
	01-02	**21.7** (19.6-23.9)	**21.5** (19.7-23.6)	**35.9** (33.0-39.2)	**64.9** (58.9-70.2)	**91.5** (81.4-103)	1405
Race/ethnicity							
Mexican Americans	99-00	**21.2** (19.3-23.3)	**20.0** (18.2-22.9)	**40.1** (32.6-44.3)	**63.6** (57.5-70.1)	**81.6** (73.9-100)	814
	01-02	**19.0** (16.2-22.2)	**19.2** (16.3-21.4)	**33.3** (28.3-39.6)	**61.0** (43.9-84.0)	**86.7** (60.6-128)	674
Non-Hispanic blacks	99-00	**23.9** (21.3-26.8)	**25.0** (20.7-28.0)	**42.2** (35.9-49.6)	**69.6** (61.1-83.9)	**94.4** (83.9-105)	603
	01-02	**20.8** (18.7-23.0)	**20.2** (19.2-22.8)	**34.5** (30.8-36.6)	**61.9** (50.0-73.9)	**85.6** (71.6-99.0)	702
Non-Hispanic whites	99-00	**21.3** (19.1-23.8)	**20.5** (18.6-23.2)	**36.4** (31.5-41.0)	**67.1** (56.7-78.4)	**97.6** (73.5-142)	912
	01-02	**17.4** (16.3-18.6)	**16.5** (15.3-17.8)	**29.0** (26.6-32.2)	**50.7** (45.5-59.0)	**81.4** (68.5-103)	1211

Note: In 99-00, concentrations of mono-isobutyl phthalate and mono-n-butyl phthalate were measured together and expressed as a combined value.
For 01-02, mono-n-butyl phthalate levels were measured separately, and only mono-n-butyl phthalate levels are given in this table.

Table 194. Mono-isobutyl phthalate

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6 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 6 and older	01-02	**2.71** (2.49-2.94)	**2.60** (2.40-2.90)	**5.70** (5.30-6.00)	**11.9** (11.3-12.6)	**17.9** (16.3-19.8)	2782
Age group							
6-11 years	01-02	**4.22** (3.28-5.43)	**4.40** (3.10-6.10)	**10.7** (7.30-13.4)	**18.6** (14.2-22.0)	**23.4** (20.4-27.8)	393
12-19 years	01-02	**3.48** (2.90-4.17)	**3.80** (2.90-4.40)	**7.30** (6.00-9.00)	**14.5** (11.7-18.6)	**22.2** (16.2-33.4)	742
20 years and older	01-02	**2.46** (2.30-2.63)	**2.40** (2.10-2.50)	**5.00** (4.70-5.30)	**10.4** (9.40-12.0)	**16.3** (13.6-18.5)	1647
Gender							
Males	01-02	**2.73** (2.50-2.97)	**2.70** (2.40-3.10)	**5.60** (5.00-6.10)	**11.6** (10.1-12.6)	**16.6** (13.6-20.1)	1371
Females	01-02	**2.68** (2.44-2.96)	**2.50** (2.20-2.90)	**5.70** (5.20-6.20)	**12.6** (11.0-14.7)	**18.7** (16.3-24.0)	1411
Race/ethnicity							
Mexican Americans	01-02	**3.26** (2.72-3.91)	**3.40** (2.60-4.10)	**7.10** (6.10-9.00)	**12.1** (11.1-14.5)	**18.3** (14.1-25.6)	677
Non-Hispanic blacks	01-02	**4.90** (4.46-5.37)	**5.30** (4.50-6.00)	**10.6** (9.20-12.0)	**18.3** (15.7-18.9)	**25.4** (20.5-30.8)	703
Non-Hispanic whites	01-02	**2.33** (2.10-2.59)	**2.20** (1.90-2.60)	**4.90** (4.40-5.30)	**9.60** (8.30-11.4)	**15.6** (13.0-18.6)	1216

Note: In 99-00, concentrations of mono-isobutyl phthalate and mono-n-butyl phthalate were measured together and expressed as a combined value.
For 01-02, mono-isobutyl phthalate levels were measured separately, and only mono-isobutyl phthalate levels are given in this table.

Table 195. Mono-isobutyl phthalate (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g of creatinine) for the U.S. population aged 6 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 6 and older	01-02	**2.53** (2.35-2.72)	**2.44** (2.26-2.67)	**4.50** (4.12-4.83)	**8.02** (7.60-8.66)	**12.0** (10.8-13.5)	2772
Age group							
6-11 years	01-02	**4.80** (3.89-5.93)	**5.17** (4.13-6.32)	**9.17** (7.03-11.6)	**15.0** (11.1-24.3)	**24.3** (13.8-40.3)	392
12-19 years	01-02	**2.68** (2.29-3.15)	**2.83** (2.39-3.33)	**4.79** (4.04-5.51)	**7.60** (6.18-10.2)	**12.8** (8.76-15.6)	742
20 years and older	01-02	**2.31** (2.18-2.45)	**2.24** (2.06-2.43)	**3.79** (3.64-4.22)	**7.13** (6.88-7.63)	**10.6** (9.46-11.3)	1638
Gender							
Males	01-02	**2.21** (2.08-2.35)	**2.16** (1.97-2.35)	**3.71** (3.58-4.04)	**7.18** (6.44-7.95)	**10.9** (10.0-12.5)	1367
Females	01-02	**2.87** (2.59-3.17)	**2.83** (2.51-3.18)	**5.10** (4.61-5.83)	**8.66** (8.02-10.1)	**13.5** (11.1-15.0)	1405
Race/ethnicity							
Mexican Americans	01-02	**3.05** (2.55-3.66)	**2.98** (2.50-3.79)	**5.73** (4.86-6.99)	**10.5** (8.04-13.3)	**16.0** (12.2-19.4)	674
Non-Hispanic blacks	01-02	**3.43** (3.20-3.68)	**3.52** (2.95-3.81)	**6.10** (5.03-7.04)	**10.5** (8.80-12.6)	**15.6** (12.6-19.7)	702
Non-Hispanic whites	01-02	**2.29** (2.09-2.51)	**2.20** (1.99-2.43)	**3.77** (3.50-4.34)	**7.13** (6.67-7.78)	**10.7** (9.62-12.6)	1211

Note: In 99-00, concentrations of mono-isobutyl phthalate and mono-n-butyl phthalate were measured together and expressed as a combined value.
For 01-02, mono-isobutyl phthalate levels were measured separately, and only mono-isobutyl phthalate levels are given in this table.

Mono-benzyl Phthalate

CAS No. 2528-16-7

Metabolite of benzylbutyl phthalate, CAS No. 85-68-7

General Information

Benzylbutyl phthalate (BzBP) is an industrial solvent and additive used in products such as adhesives, vinyl-flooring products, sealants, car-care products, and to a lesser extent, some personal-care products. People exposed to BzBP will excrete MBzP and small amounts of mono-n-butyl phthalate in their urine. Workplace air standards for external exposures have not been established for BzBP. Like other phthalates, BzBP has low acute toxicity. It can produce reproductive toxicity in animals (Center for the Evaluation of Risks to Human Reproduction, 2000). BzBP is classified as a possible human carcinogen by U.S. EPA, but is considered not classifiable by IARC and unlisted by NTP.

Interpreting Levels of Urinary Mono-benzyl Phthalate in the Tables

The levels of MBzP in the NHANES 2001-2002 subsample appear generally similar to levels reported previously for U.S. residents (Blount et al., 2000), in a small sample of pregnant women in New York City (Adibi et al., 2003), in men from an infertility clinic (Duty et al., 2004), and in a small sample of German residents (Koch et al., 2003).

Table 196. Mono-benzyl phthalate

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6 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 6 and older	99-00	**15.3** (13.7-17.1)	**17.0** (15.3-18.9)	**35.3** (32.6-39.6)	**67.1** (55.3-82.0)	**103** (94.6-116)	2541
	01-02	**15.1** (13.9-16.3)	**15.7** (14.8-17.4)	**38.0** (34.5-41.2)	**80.8** (71.3-88.2)	**122** (102-142)	2782
Age group							
6-11 years	99-00	**39.4** (32.9-47.2)	**40.3** (33.8-48.6)	**82.0** (55.8-98.1)	**128** (98.1-214)	**214** (108-399)	328
	01-02	**33.4** (29.1-38.4)	**37.0** (26.6-43.4)	**68.5** (61.6-92.8)	**166** (116-191)	**226** (183-330)	393
12-19 years	99-00	**25.6** (21.9-30.0)	**28.3** (22.2-34.8)	**51.1** (43.7-58.5)	**87.9** (67.2-115)	**125** (93.7-170)	752
	01-02	**23.2** (19.9-27.2)	**24.7** (21.2-31.0)	**55.5** (47.4-62.9)	**113** (91.8-133)	**169** (134-198)	742
20 years and older	99-00	**12.4** (10.9-14.2)	**13.8** (12.1-15.6)	**28.9** (25.2-33.1)	**52.0** (43.9-62.5)	**86.3** (54.7-119)	1461
	01-02	**12.7** (11.7-13.9)	**13.8** (12.8-14.9)	**31.8** (28.5-33.5)	**65.4** (53.8-76.3)	**99.7** (82.8-121)	1647
Gender							
Males	99-00	**16.2** (14.1-18.6)	**17.7** (15.0-19.9)	**35.4** (31.5-40.3)	**69.4** (59.9-87.2)	**108** (96.3-130)	1215
	01-02	**15.6** (13.6-17.9)	**16.0** (14.2-18.3)	**37.0** (33.1-43.0)	**78.4** (63.5-97.4)	**122** (88.1-178)	1371
Females	99-00	**14.6** (12.7-16.6)	**16.0** (14.2-19.2)	**35.8** (30.8-41.4)	**63.7** (53.7-82.4)	**103** (84.2-116)	1326
	01-02	**14.6** (13.1-16.3)	**15.4** (13.7-17.9)	**38.1** (32.2-42.9)	**81.4** (68.3-91.6)	**122** (102-143)	1411
Race/ethnicity							
Mexican Americans	99-00	**13.9** (12.1-16.1)	**15.7** (13.4-16.8)	**33.0** (27.5-36.1)	**67.5** (55.5-84.0)	**98.3** (80.6-150)	814
	01-02	**13.2** (10.8-16.2)	**14.7** (10.8-18.5)	**29.5** (25.5-38.0)	**70.3** (53.0-85.4)	**91.6** (70.3-161)	677
Non-Hispanic blacks	99-00	**23.0** (20.7-25.5)	**23.0** (20.5-25.6)	**49.3** (43.4-55.6)	**94.0** (80.0-130)	**138** (106-241)	603
	01-02	**23.8** (21.0-26.9)	**24.2** (19.9-28.0)	**50.6** (41.5-62.9)	**101** (86.4-127)	**139** (127-179)	703
Non-Hispanic whites	99-00	**14.3** (12.7-16.1)	**16.1** (14.2-18.5)	**33.9** (30.6-38.4)	**58.7** (51.3-74.1)	**103** (74.1-116)	912
	01-02	**14.0** (12.7-15.4)	**14.6** (13.3-15.5)	**35.3** (32.2-39.5)	**76.6** (66.1-90.3)	**121** (93.2-155)	1216

Comparing Adjusted Geometric Means

Geometric mean levels of urinary mono-benzyl phthalate for the demographic groups were compared after adjusting for the covariates of race/ethnicity, age, gender, and urinary creatinine (data not shown). In NHANES 2001-2002, adjusted geometric mean levels of urinary mono-benzyl phthalate were higher in children aged 6-11 years than in people aged 12-19 years and 20 years and older, and the group aged 12-19 years had higher levels than the group aged 20 years and older. Levels in females were higher than in males. Mexican Amercians had lower levels than non-Hispanic whites, but were not significantly different from non-Hispanic blacks. It is unknown whether these differences associated with age, gender, or race/ethnicity represent differences in exposure, pharmacokinetics, or the relationship of dose per body weight.

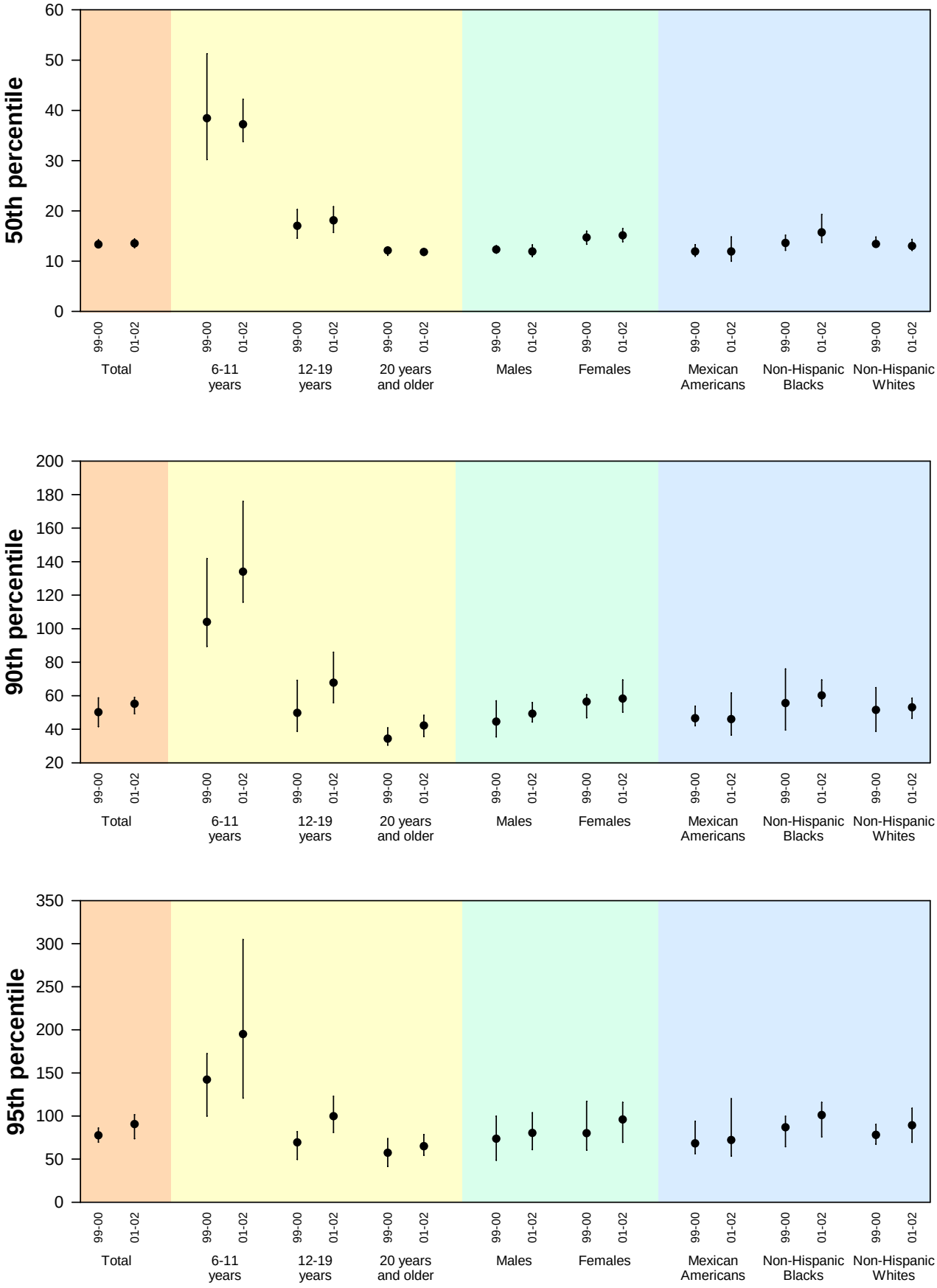
Table 197. Mono-benzyl phthalate (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g of creatinine) for the U.S. population aged 6 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 6 and older	99-00	**14.0** (13.0-15.0)	**13.3** (12.8-14.3)	**25.1** (23.4-27.2)	**50.1** (41.5-58.8)	**77.4** (69.6-86.3)	2541
	01-02	**14.1** (13.2-15.1)	**13.5** (12.7-14.4)	**26.6** (24.9-29.3)	**55.1** (49.2-59.0)	**90.4** (73.6-102)	2772
Age group							
6-11 years	99-00	**40.0** (33.6-47.6)	**38.4** (30.2-51.3)	**73.2** (56.6-99.1)	**104** (89.4-142)	**142** (99.8-173)	328
	01-02	**38.1** (34.5-42.1)	**37.2** (33.8-42.2)	**67.9** (55.8-80.4)	**134** (116-176)	**195** (121-305)	392
12-19 years	99-00	**17.3** (15.4-19.4)	**17.0** (14.6-20.3)	**28.3** (24.3-34.8)	**49.7** (38.8-69.2)	**69.3** (49.6-81.9)	752
	01-02	**17.9** (15.7-20.5)	**18.1** (15.7-20.8)	**33.9** (29.3-38.6)	**67.7** (55.8-85.9)	**99.7** (80.7-123)	742
20 years and older	99-00	**11.8** (10.7-12.9)	**12.1** (11.1-12.9)	**20.1** (18.4-23.3)	**34.3** (30.5-40.8)	**57.2** (41.3-73.9)	1461
	01-02	**12.0** (11.2-12.9)	**11.8** (11.2-12.5)	**21.6** (19.9-23.7)	**42.2** (35.7-48.3)	**64.9** (54.5-78.3)	1638
Gender							
Males	99-00	**12.7** (11.8-13.6)	**12.3** (11.6-13.0)	**23.7** (21.5-26.1)	**44.5** (35.5-57.0)	**73.5** (48.5-99.8)	1215
	01-02	**12.7** (11.4-14.2)	**11.9** (10.9-13.2)	**24.0** (21.2-26.4)	**49.2** (44.3-55.9)	**80.3** (60.9-104)	1367
Females	99-00	**15.3** (13.8-16.8)	**14.7** (13.3-16.0)	**25.9** (24.1-29.3)	**56.4** (46.8-60.6)	**80.0** (60.1-117)	1326
	01-02	**15.7** (14.2-17.3)	**15.1** (13.8-16.5)	**29.5** (25.9-34.3)	**58.2** (50.2-69.4)	**95.8** (69.4-116)	1405
Race/ethnicity							
Mexican Americans	99-00	**12.6** (11.4-14.0)	**11.9** (10.9-13.2)	**24.1** (21.5-26.5)	**46.5** (42.0-53.8)	**68.1** (56.4-93.8)	814
	01-02	**12.4** (10.7-14.4)	**11.9** (9.97-14.8)	**23.7** (19.7-29.3)	**46.0** (36.5-61.6)	**72.0** (53.5-120)	674
Non-Hispanic blacks	99-00	**14.8** (13.5-16.3)	**13.6** (12.2-15.2)	**26.9** (22.5-31.8)	**55.5** (39.5-76.0)	**86.8** (64.4-99.8)	603
	01-02	**16.7** (14.7-19.0)	**15.7** (13.7-19.3)	**33.4** (26.5-38.0)	**60.1** (53.7-69.4)	**101** (75.6-116)	702
Non-Hispanic whites	99-00	**14.0** (12.7-15.3)	**13.4** (12.8-14.8)	**25.2** (23.1-27.4)	**51.5** (38.8-64.8)	**77.9** (67.4-90.3)	912
	01-02	**13.9** (12.9-15.0)	**13.0** (12.1-14.3)	**25.7** (24.0-28.1)	**53.0** (46.5-58.5)	**89.2** (69.4-109)	1211

Figure 21. Mono-benzyl phthalate (creatinine corrected)

Selected percentiles with 95% confidence intervals of urine concentrations (in µg/g of creatinine) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2002.



Mono-cyclohexyl Phthalate

CAS No. 7517-36-4

Metabolite of Dicyclohexyl Phthalate, CAS No. 84-61-7

General Information

Dicyclohexyl phthalate (DCHP) is Used to stabilize some rubbers, resins, and polymers, including nitrocellulose, polyvinyl acetate, and polyvinyl chloride. People exposed to DCHP will excrete mono-cyclohexyl phthalate in their urine. Workplace air standards for external exposure have not been established for DCHP. It has not been completely classified as to its carcinogenicity by IARC and NTP.

In both the NHANES 1999-2000 and 2001-2002 subsamples, mono-cyclohexyl phthalate was characterized only at the 90th and 95th percentiles.

Table 198. Mono-cyclohexyl phthalate

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6 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 6 and older	99-00	*	**< LOD**	**< LOD**	**< LOD**	**1.00** (<LOD-1.60)	2541
	01-02	*	**< LOD**	**< LOD**	**.400** (<LOD-.400)	**.400** (.400-.500)	2782
Age group							
6-11 years	99-00	*	**< LOD**	**< LOD**	**1.00** (<LOD-1.10)	**1.70** (1.00-3.80)	328
	01-02	*	**< LOD**	**< LOD**	**.300** (.300-.500)	**.600** (.500-.700)	393
12-19 years	99-00	*	**< LOD**	**< LOD**	**1.00** (<LOD-1.50)	**1.70** (1.00-2.40)	752
	01-02	*	**< LOD**	**< LOD**	**.400** (<LOD-.400)	**.500** (.400-.600)	742
20 years and older	99-00	*	**< LOD**	**< LOD**	**< LOD**	**< LOD**	1461
	01-02	*	**< LOD**	**< LOD**	**.400** (<LOD-.400)	**.500** (.400-.500)	1647
Gender							
Males	99-00	*	**< LOD**	**< LOD**	**< LOD**	**1.00** (<LOD-2.00)	1215
	01-02	*	**< LOD**	**< LOD**	**.400** (<LOD-.400)	**.500** (.400-.500)	1371
Females	99-00	*	**< LOD**	**< LOD**	**< LOD**	**1.00** (<LOD-1.70)	1326
	01-02	*	**< LOD**	**< LOD**	**.400** (<LOD-.400)	**.500** (.400-.500)	1411
Race/ethnicity							
Mexican Americans	99-00	*	**< LOD**	**< LOD**	**< LOD**	**< LOD**	814
	01-02	*	**< LOD**	**< LOD**	**.400** (<LOD-.400)	**.500** (.300-.600)	677
Non-Hispanic blacks	99-00	*	**< LOD**	**< LOD**	**< LOD**	**1.00** (.900-1.20)	603
	01-02	*	**< LOD**	**< LOD**	**.300** (<LOD-.400)	**.400** (.400-.600)	703
Non-Hispanic whites	99-00	*	**< LOD**	**< LOD**	**< LOD**	**.900** (<LOD-1.30)	912
	01-02	*	**< LOD**	**< LOD**	**.400** (<LOD-.400)	**.500** (.400-.500)	1216

< 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 199. Mono-cyclohexyl phthalate (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g of creatinine) for the U.S. population aged 6 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 6 and older	99-00	*	**< LOD**	**< LOD**	**< LOD**	**3.00** (2.60-3.33)	2541
	01-02	*	**< LOD**	**< LOD**	**.588** (.513-.667)	**.854** (.769-.952)	2772
Age group							
6-11 years	99-00	*	**< LOD**	**< LOD**	**1.50** (1.20-1.94)	**2.82** (1.54-6.44)	328
	01-02	*	**< LOD**	**< LOD**	**.667** (.513-.741)	**.909** (.690-1.17)	392
12-19 years	99-00	*	**< LOD**	**< LOD**	**1.22** (.952-1.46)	**1.67** (1.36-1.82)	752
	01-02	*	**< LOD**	**< LOD**	**.465** (.385-.659)	**.769** (.526-1.02)	742
20 years and older	99-00	*	**< LOD**	**< LOD**	**< LOD**	**< LOD**	1461
	01-02	*	**< LOD**	**< LOD**	**.606** (.513-.669)	**.870** (.755-.952)	1638
Gender							
Males	99-00	*	**< LOD**	**< LOD**	**< LOD**	**2.14** (1.62-3.16)	1215
	01-02	*	**< LOD**	**< LOD**	**.500** (.417-.625)	**.800** (.667-1.00)	1367
Females	99-00	*	**< LOD**	**< LOD**	**< LOD**	**3.28** (2.86-3.51)	1326
	01-02	*	**< LOD**	**< LOD**	**.667** (.588-.755)	**.870** (.769-.952)	1405
Race/ethnicity							
Mexican Americans	99-00	*	**< LOD**	**< LOD**	**< LOD**	**< LOD**	814
	01-02	*	**< LOD**	**< LOD**	**.556** (.476-.669)	**.882** (.690-1.04)	674
Non-Hispanic blacks	99-00	*	**< LOD**	**< LOD**	**< LOD**	**1.43** (1.09-1.71)	603
	01-02	*	**< LOD**	**< LOD**	**.408** (.357-.465)	**.588** (.500-.723)	702
Non-Hispanic whites	99-00	*	**< LOD**	**< LOD**	**< LOD**	**3.00** (2.60-3.53)	912
	01-02	*	**< LOD**	**< LOD**	**.606** (.492-.690)	**.870** (.690-.952)	1211

< 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.

Mono-2-ethylhexyl Phthalate

CAS No. 4376-20-9

Mono-(2-ethyl-5-hydroxyhexyl) Phthalate

Mono-(2-ethyl-5-oxohexyl) Phthalate

CAS No. 40321-98-0

Metabolites of Di-2-ethylhexyl Phthalate, CAS No. 117-81-7

General Information

Di-2-ethylhexyl phthalate (DEHP) is primarily used to produce flexible plastics, mainly polyvinyl chloride, which is used for many home and garden products, toys, packaging film, and blood-product storage and intravenous delivery systems. Concentrations in plastic materials may reach 40% by weight. DEHP has been removed from or replaced in most children's toys and food packaging in the United States. Other sources of exposure include foods and foods in contact with plastic containging DEHP.

DEHP is metabolized into various metabolites (Albro et al., 1982; Dirven et al., 1993; Kato et al., 2004; Barr et al., 2003; Koch et al., 2003). Three of these metabolites, measured for this *Report* are mono-(2-ethyl-5-hexyl) phthalate (MEHP), mono-(2-ethyl-5-oxohexyl) phthalate (MEOHP), mono-(2-ethyl-5-hydroxyhexyl) phthalate (MEHHP).

MEHP is primarily formed by the hydrolysis of DEHP in

Table 200. Mono-2-ethylhexyl phthalate

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6 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 6 and older	99-00	**3.43** (3.19-3.69)	**3.20** (2.90-3.50)	**7.60** (6.80-8.20)	**14.8** (13.5-17.4)	**23.8** (19.2-28.6)	2541
	01-02	**4.27** (3.80-4.79)	**4.10** (3.60-4.90)	**9.80** (8.40-11.6)	**22.8** (18.9-27.4)	**38.9** (31.8-50.0)	2782
Age group							
6-11 years	99-00	**5.12** (4.42-5.92)	**4.90** (3.30-5.80)	**11.1** (8.30-13.6)	**19.0** (13.8-36.1)	**34.5** (15.6-130)	328
	01-02	**4.41** (3.90-5.00)	**4.40** (4.10-5.30)	**9.20** (7.80-11.7)	**19.3** (14.6-25.9)	**29.9** (20.7-47.4)	393
12-19 years	99-00	**3.75** (3.24-4.35)	**3.70** (2.80-4.60)	**8.10** (6.40-9.40)	**15.0** (11.4-20.5)	**22.8** (19.1-29.2)	752
	01-02	**4.57** (3.96-5.27)	**4.50** (3.70-5.10)	**11.0** (9.50-13.5)	**23.0** (17.6-31.7)	**42.5** (25.9-57.5)	742
20 years and older	99-00	**3.21** (2.94-3.51)	**3.00** (2.70-3.30)	**7.20** (6.40-8.00)	**14.2** (12.1-16.8)	**22.4** (17.5-27.0)	1461
	01-02	**4.20** (3.63-4.86)	**4.10** (3.40-4.80)	**9.40** (8.10-11.9)	**23.5** (18.0-29.8)	**39.5** (30.3-57.1)	1647
Gender							
Males	99-00	**3.68** (3.31-4.10)	**3.40** (2.90-3.90)	**8.00** (7.30-8.80)	**16.0** (14.0-19.0)	**25.3** (19.5-36.7)	1215
	01-02	**4.31** (3.84-4.83)	**4.30** (3.70-5.10)	**9.60** (8.20-11.1)	**23.0** (16.9-29.8)	**37.9** (29.9-48.4)	1371
Females	99-00	**3.21** (2.91-3.54)	**3.00** (2.80-3.40)	**7.00** (5.70-8.20)	**13.5** (11.4-15.3)	**21.6** (15.6-28.5)	1326
	01-02	**4.23** (3.67-4.86)	**4.10** (3.40-4.80)	**9.70** (8.40-12.2)	**23.0** (19.4-28.4)	**42.5** (31.4-53.7)	1411
Race/ethnicity							
Mexican Americans	99-00	**3.49** (3.16-3.85)	**3.50** (2.90-3.80)	**7.00** (5.70-8.60)	**13.3** (10.7-18.7)	**23.9** (17.4-27.3)	814
	01-02	**4.32** (3.75-4.98)	**4.70** (3.80-5.70)	**10.1** (8.30-11.0)	**19.4** (16.6-23.0)	**28.4** (24.2-39.9)	677
Non-Hispanic blacks	99-00	**4.82** (3.92-5.93)	**5.10** (4.10-5.80)	**9.40** (7.60-11.4)	**19.5** (12.9-26.5)	**29.2** (18.6-60.3)	603
	01-02	**6.60** (5.57-7.82)	**6.70** (5.40-8.10)	**15.4** (13.0-18.7)	**32.7** (26.5-41.4)	**52.1** (41.0-84.0)	703
Non-Hispanic whites	99-00	**3.16** (2.89-3.46)	**2.80** (2.50-3.10)	**7.30** (6.30-8.20)	**14.4** (12.2-17.0)	**22.4** (16.9-28.5)	912
	01-02	**3.85** (3.37-4.40)	**3.60** (3.10-4.30)	**8.60** (7.70-9.90)	**20.9** (17.3-25.9)	**37.9** (29.9-49.5)	1216

the gastrointestinal tract and then absorbed. MEOHP and MEHHP are produced by the oxidative metabolism of MEHP and are present at roughly three- to ten-fold higher concentrations than MEHP in urine (Barr et al., 2003; Koch et al., 2003).

MEHP is considered a toxic metabolite of DEHP. Liver toxicity, decreased testicular weight, and testicular atrophy have been observed in animal studies at high or chronic doses (Center for the Evaluation of Risks to Human Reproduction, 2003). DEHP has also been observed to suppress estradiol production in female rats (Lovecamp-Swan and Davis, 2003). Recently, the U.S. Food and Drug Administration (U.S. FDA) considered the amounts of DEHP or MEHP received from intravenous delivery systems or blood transfusions (MEHP is formed in situ in blood from DEHP) to be below thresholds likely to cause injury in adults. However, in lifesaving instances during which neonates would receive exchange blood transfusions, relatively higher exposures might occur (http://www.fda.gov/cdrh/ost/dehp-pvc.pdf; Calafat et al., 2004).

Workplace air standards for external exposure to DEHP are generally established by OSHA and ACGIH. It is classified as a probable human carcinogen by the U.S. EPA, reasonably anticipated to be a human carcinogen by NTP, but considered not classifiable by IARC.

Interpreting Levels of Urinary Di-2-ethylhexyl Phthalate Metabolites in the Tables

The levels of MEHP in the NHANES 2001-2002 subsample appear roughly comparable to those reported previously for U.S. residents (Blount et al., 2000) and in a small sample of pregnant women in New York City (Adibi et al., 2003), and in men from an infertility clinic (Duty et al., 2004). Levels of MEHP, MEOHP, and MHHP were similar or up to two-fold higher in a sample of German residents (Koch et al., 2003) and German children (Koch et al., 2004; Becker et al., 2004).

Table 201. Mono-2-ethylhexyl phthalate (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g of creatinine) for the U.S. population aged 6 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 6 and older	99-00	**3.12** (2.95-3.31)	**3.08** (2.82-3.27)	**5.88** (5.38-6.25)	**10.8** (9.62-12.5)	**18.5** (15.0-21.8)	2541
	01-02	**3.99** (3.57-4.46)	**3.89** (3.42-4.44)	**7.94** (7.14-9.02)	**18.2** (15.4-21.6)	**32.8** (25.2-42.9)	2772
Age group							
6-11 years	99-00	**5.19** (4.55-5.93)	**5.37** (4.52-5.95)	**9.11** (8.06-11.4)	**21.6** (11.5-41.9)	**41.9** (13.5-86.2)	328
	01-02	**5.02** (4.47-5.64)	**5.38** (4.51-6.21)	**9.82** (7.87-11.0)	**20.9** (13.7-28.8)	**31.2** (24.3-40.7)	392
12-19 years	99-00	**2.53** (2.14-2.99)	**2.31** (2.05-2.76)	**5.83** (4.38-6.29)	**9.63** (7.41-11.5)	**12.1** (10.5-17.3)	752
	01-02	**3.53** (3.09-4.03)	**3.62** (2.89-4.48)	**7.45** (6.51-8.67)	**15.2** (11.7-21.9)	**25.2** (17.7-32.8)	742
20 years and older	99-00	**3.03** (2.83-3.25)	**2.98** (2.73-3.23)	**5.55** (4.90-6.06)	**10.0** (8.60-12.9)	**17.5** (13.8-22.1)	1461
	01-02	**3.96** (3.48-4.50)	**3.81** (3.24-4.37)	**7.77** (6.88-9.00)	**18.4** (15.3-22.1)	**33.3** (23.1-47.9)	1638
Gender							
Males	99-00	**2.89** (2.60-3.22)	**2.76** (2.52-2.96)	**5.58** (4.71-6.08)	**10.3** (9.35-12.4)	**21.6** (14.1-27.7)	1215
	01-02	**3.49** (3.06-3.98)	**3.32** (2.76-3.90)	**7.00** (6.46-7.77)	**16.2** (12.9-20.9)	**31.2** (20.1-49.9)	1367
Females	99-00	**3.36** (3.11-3.63)	**3.33** (2.90-3.80)	**6.15** (5.55-6.77)	**11.1** (9.02-14.0)	**16.3** (12.4-24.6)	1326
	01-02	**4.53** (4.01-5.11)	**4.43** (3.79-5.13)	**9.17** (7.93-10.3)	**20.4** (16.6-24.8)	**35.1** (27.7-42.0)	1405
Race/ethnicity							
Mexican Americans	99-00	**3.16** (2.72-3.68)	**3.15** (2.52-3.81)	**5.88** (4.86-7.24)	**11.6** (9.63-13.1)	**15.7** (12.6-23.1)	814
	01-02	**4.05** (3.57-4.61)	**4.16** (3.75-4.89)	**7.76** (6.47-9.60)	**16.4** (13.5-18.9)	**24.5** (19.8-28.7)	674
Non-Hispanic blacks	99-00	**3.11** (2.59-3.73)	**3.13** (2.50-3.61)	**5.84** (4.43-7.32)	**10.2** (8.05-15.6)	**18.4** (11.6-35.2)	603
	01-02	**4.63** (3.95-5.42)	**4.59** (3.97-5.02)	**9.89** (7.95-12.5)	**21.2** (16.0-33.2)	**39.8** (27.1-48.1)	702
Non-Hispanic whites	99-00	**3.09** (2.84-3.36)	**3.08** (2.73-3.47)	**5.87** (5.11-6.67)	**10.6** (8.95-13.5)	**20.0** (13.7-23.9)	912
	01-02	**3.80** (3.33-4.33)	**3.63** (3.11-4.32)	**7.71** (6.63-9.17)	**17.0** (13.8-21.8)	**32.8** (21.5-46.9)	1211

Comparing Adjusted Geometric Means

Geometric mean levels of urinary MEHP for the demographic groups were compared after adjusting for the covariates of race/ethnicity, age, gender, and urinary creatinine (data not shown). In NHANES 2001-2002, adjusted geometric mean levels of urinary MEHP were higher in children aged 6-11 years than in people aged 12-19 years and 20 years. Females had slightly higher levels than in males. Adjusted geometric mean levels in non-Hispanic blacks were higher than levels in non-Hispanic whites.

Geometric mean levels of urinary MEOHP and MEHHP for the demographic groups were compared after adjusting for the covariates of race/ethnicity, age, gender, and urinary creatinine. In the NHANES 2001-2002 subsample (not measured in NHANES 1999-2000), levels of MEOHP and MEHHP were found to be higher in children aged 6-11 years than in people aged 12-19 years and 20 years and older. For MEOHP, females had slightly higher levels than males. It is unknown whether these differences associated with age, gender, or race/ethnicity represent differences in exposure, pharmacokinetics, or the relationship of dose per body weight. Koch et al. (2004) showed that levels of MEHP, MEOHP, and MEHHP were higher in nursery school children (aged 2-6 years) than in their teachers or parents. In another study of children (Becker et al., 2004), boys showed higher levels of all three DEHP metabolites than girls, and lower concentrations of MEHHP and MEOHP were seen in children aged 13-14 years compared with younger children.

Figure 22. Mono-2-ethylhexyl phthalate (creatinine corrected)

Selected percentiles with 95% confidence intervals of urine concentrations (in µg/g of creatinine) for the U.S. population aged 6 years and older National Health and Nutrition Examination Survey, 1999-2002.

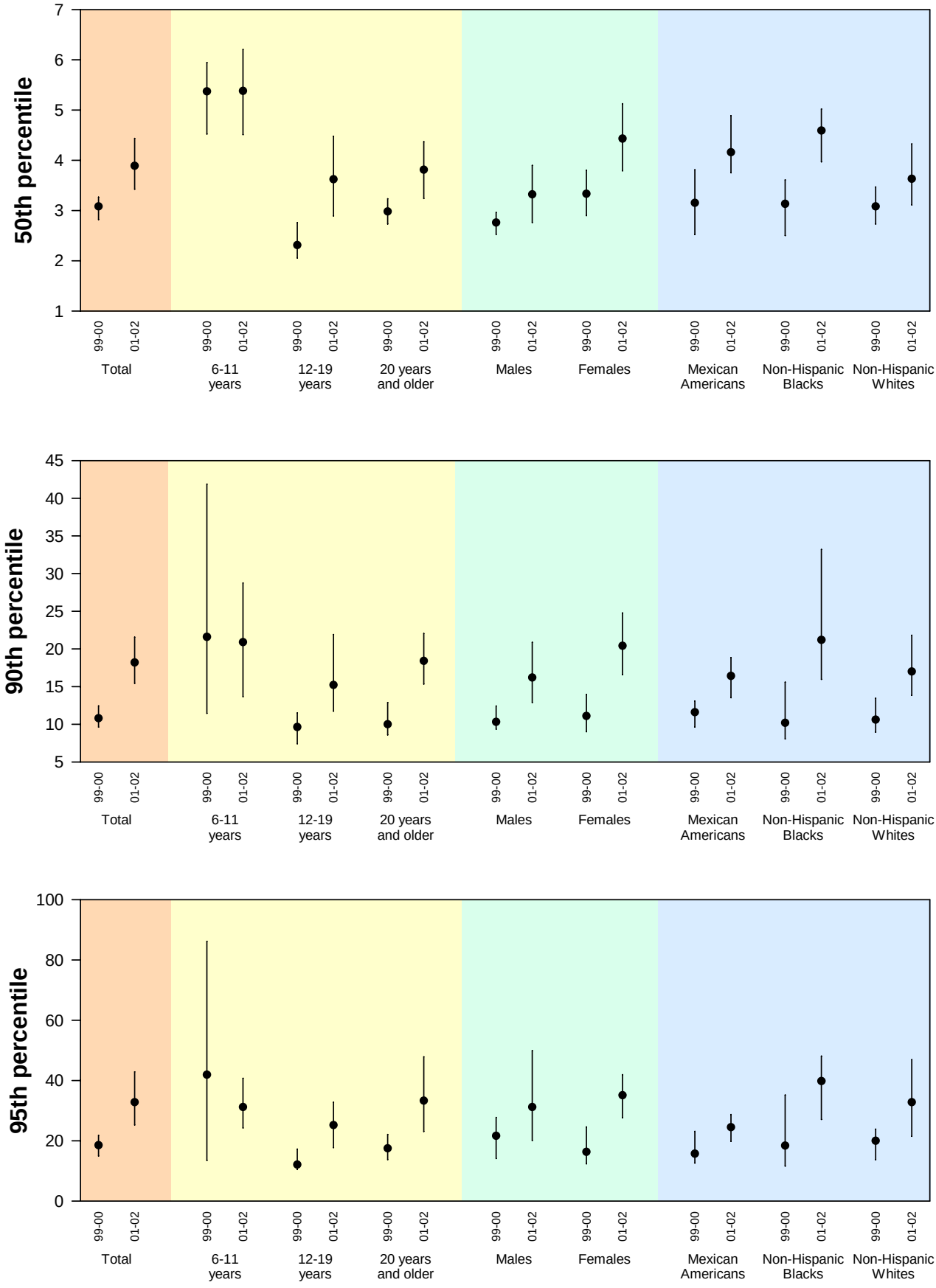


Table 202. Mono-(2-ethyl-5-hydroxyhexyl) phthalate

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6 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 6 and older	01-02	**20.0** (17.8-22.5)	**20.1** (17.8-22.4)	**43.6** (38.0-49.7)	**91.3** (77.0-108)	**192** (131-256)	2782
Age group							
6-11 years	01-02	**33.6** (29.7-37.9)	**32.9** (26.9-39.1)	**66.9** (49.7-74.0)	**126** (103-148)	**210** (137-280)	393
12-19 years	01-02	**24.9** (21.3-29.1)	**25.2** (22.9-31.3)	**50.6** (40.7-64.5)	**107** (78.5-148)	**202** (114-280)	742
20 years and older	01-02	**18.1** (15.7-20.9)	**17.7** (14.7-20.7)	**39.8** (32.5-47.8)	**86.2** (65.7-107)	**175** (110-279)	1647
Gender							
Males	01-02	**22.0** (19.5-24.7)	**21.2** (19.4-23.9)	**47.8** (40.9-54.3)	**94.2** (80.8-110)	**212** (130-256)	1371
Females	01-02	**18.3** (15.7-21.4)	**18.2** (14.9-22.1)	**39.8** (34.2-46.0)	**86.0** (69.4-115)	**170** (119-273)	1411
Race/ethnicity							
Mexican Americans	01-02	**18.5** (16.2-21.1)	**19.0** (16.2-21.6)	**36.3** (31.6-44.0)	**79.9** (66.4-93.9)	**123** (100-161)	677
Non-Hispanic blacks	01-02	**29.8** (26.1-34.1)	**30.9** (27.2-34.3)	**61.9** (52.6-68.3)	**126** (108-157)	**276** (157-339)	703
Non-Hispanic whites	01-02	**19.1** (16.7-21.9)	**19.2** (16.8-21.3)	**41.7** (35.3-50.7)	**91.1** (75.6-110)	**212** (130-275)	1216

Table 203. Mono-(2-ethyl-5-hydroxyhexyl) phthalate (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g of creatinine) for the U.S. population aged 6 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 6 and older	01-02	**18.8** (17.0-20.8)	**16.6** (14.9-18.6)	**32.3** (27.8-37.2)	**70.8** (58.4-88.3)	**147** (101-200)	2772
Age group							
6-11 years	01-02	**38.3** (34.3-42.6)	**34.2** (29.9-38.9)	**60.4** (51.9-76.4)	**107** (96.3-147)	**211** (122-313)	392
12-19 years	01-02	**19.2** (17.0-21.8)	**17.7** (15.6-20.0)	**34.9** (29.2-42.6)	**73.4** (58.4-80.7)	**102** (86.6-160)	742
20 years and older	01-02	**17.2** (15.2-19.4)	**15.0** (13.3-16.7)	**27.7** (23.2-34.7)	**63.2** (48.3-88.3)	**134** (84.7-207)	1638
Gender							
Males	01-02	**17.9** (16.2-19.7)	**15.4** (13.8-17.8)	**32.4** (28.0-37.2)	**73.4** (55.3-91.8)	**136** (97.7-224)	1367
Females	01-02	**19.7** (17.3-22.5)	**17.6** (15.4-19.5)	**32.3** (26.8-38.9)	**69.3** (57.6-93.7)	**160** (93.7-201)	1405
Race/ethnicity							
Mexican Americans	01-02	**17.5** (15.9-19.2)	**15.7** (14.6-17.6)	**30.7** (26.1-35.7)	**65.3** (50.6-83.9)	**106** (76.3-130)	674
Non-Hispanic blacks	01-02	**21.0** (18.8-23.3)	**19.7** (17.5-21.8)	**38.3** (32.1-46.0)	**93.5** (69.2-124)	**161** (130-183)	702
Non-Hispanic whites	01-02	**19.0** (17.1-21.1)	**16.3** (14.8-18.4)	**32.4** (27.6-37.3)	**71.5** (57.8-94.3)	**178** (99.3-242)	1211

Table 204. Mono-(2-ethyl-5-oxohexyl) phthalate

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6 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 6 and older	01-02	**13.5** (12.0-15.0)	**14.0** (12.5-15.1)	**29.6** (25.2-34.0)	**59.9** (50.4-70.9)	**120** (87.2-156)	2782
Age group							
6-11 years	01-02	**23.3** (20.9-26.1)	**22.6** (18.5-28.1)	**46.5** (38.1-52.0)	**80.5** (64.7-109)	**142** (93.9-178)	393
12-19 years	01-02	**17.5** (15.1-20.3)	**18.5** (16.0-20.7)	**35.0** (27.6-42.1)	**69.9** (52.2-104)	**118** (74.0-174)	742
20 years and older	01-02	**12.0** (10.5-13.9)	**12.2** (10.4-14.1)	**25.9** (21.3-32.1)	**52.3** (41.8-68.3)	**115** (74.9-160)	1647
Gender							
Males	01-02	**14.5** (13.0-16.2)	**14.6** (13.0-16.1)	**31.6** (25.6-34.7)	**60.4** (52.3-71.4)	**129** (84.4-167)	1371
Females	01-02	**12.5** (10.8-14.6)	**13.0** (10.9-14.9)	**28.1** (23.7-33.5)	**57.5** (45.8-72.7)	**115** (81.8-147)	1411
Race/ethnicity							
Mexican Americans	01-02	**13.1** (11.6-14.9)	**13.2** (11.6-15.0)	**25.3** (21.6-30.8)	**56.6** (40.6-70.3)	**76.5** (70.5-101)	677
Non-Hispanic blacks	01-02	**19.6** (17.1-22.5)	**20.0** (17.9-22.4)	**39.0** (34.8-44.2)	**80.5** (71.4-97.4)	**148** (102-228)	703
Non-Hispanic whites	01-02	**12.8** (11.2-14.6)	**13.1** (11.6-14.6)	**28.5** (23.6-34.0)	**58.6** (48.8-70.9)	**126** (83.7-172)	1216

Table 205. Mono-(2-ethyl-5-oxohexyl) phthalate (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g of creatinine) for the U.S. population aged 6 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 6 and older	01-02	**12.6** (11.5-13.9)	**11.2** (10.2-12.3)	**21.3** (18.3-23.9)	**45.1** (37.1-58.1)	**87.5** (69.0-124)	2772
Age group							
6-11 years	01-02	**26.6** (24.0-29.4)	**22.8** (20.3-25.0)	**43.3** (33.6-48.2)	**74.4** (69.0-91.9)	**130** (83.0-187)	392
12-19 years	01-02	**13.5** (12.0-15.2)	**12.0** (10.8-14.3)	**23.4** (19.9-28.5)	**48.4** (39.2-54.9)	**70.5** (55.0-97.2)	742
20 years and older	01-02	**11.4** (10.2-12.8)	**10.1** (8.90-11.4)	**17.5** (15.2-21.9)	**39.0** (30.3-53.9)	**84.3** (53.1-134)	1638
Gender							
Males	01-02	**11.8** (10.7-13.0)	**10.2** (8.93-11.7)	**21.0** (18.5-23.0)	**46.1** (34.9-58.7)	**83.1** (69.7-104)	1367
Females	01-02	**13.5** (11.9-15.3)	**12.0** (10.8-13.7)	**21.5** (18.0-25.9)	**44.8** (36.8-61.9)	**92.3** (59.3-139)	1405
Race/ethnicity							
Mexican Americans	01-02	**12.4** (11.4-13.5)	**10.8** (10.5-12.4)	**20.8** (18.5-24.4)	**46.4** (33.4-56.5)	**65.8** (53.1-83.1)	674
Non-Hispanic blacks	01-02	**13.8** (12.3-15.4)	**13.0** (12.0-14.1)	**23.9** (20.0-29.2)	**58.3** (45.3-77.7)	**101** (81.3-124)	702
Non-Hispanic whites	01-02	**12.7** (11.4-14.1)	**11.2** (9.91-12.3)	**21.0** (18.0-24.0)	**45.8** (36.2-66.0)	**96.0** (68.5-161)	1211

Mono-3-carboxypropyl Phthalate

Mono-n-octyl Phthalate

CAS No. 5393-19-1

Metabolites of di-n-octyl phthalate, CAS No. 117-84-0

General Information

Di-n-octylphthalate (DOP) is used primarily to produce flexible plastics. People exposed to DOP will excrete primarily mono-3-carboxypropyl phthalate (MCPP) and smaller amounts of mono-n-octyl phthalate (MOP) in their urine. Workplace air standards for external exposure are established for DOP by OSHA. Like other phthalates, DOP has low acute toxicity. It has not been classified with respect to carcinogenicity by IARC and NTP.

Interpreting Levels of Urinary Mono-3-carboxypropyl and Mono-n-octyl Phthalates in the Tables

In both the NHANES 1999-2000 and 2001-2002 subsamples, MOP was only detectable at the 90th and 95th percentiles. A low detection rate was also reported in a small sample of German residents (Koch et al., 2003). MCPP levels were measured only in the 2001-2002 subsample and were higher in children aged 6-11 years than in people aged 12-19 years and 20 years and older; the group aged 12-19 years had higher levels than in the group aged 20 years and older. Females had slightly higher levels than males. Additionally, levels of MCPP were lower in non-Hispanic blacks than in either non-Hispanic whites or Mexican Americans. It is unknown whether these differences associated with age, gender, or race/ethnicity represent differences in exposure, pharmacokinetics, or the relationship of dose per body weight.

Table 206. Mono-3-carboxypropyl phthalate

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6 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 6 and older	01-02	**2.75** (2.49-3.04)	**3.00** (2.80-3.30)	**5.70** (5.00-6.30)	**10.0** (8.80-11.2)	**14.6** (12.7-17.5)	2782
Age group							
6-11 years	01-02	**6.11** (5.46-6.84)	**6.60** (5.40-7.50)	**11.8** (10.2-13.2)	**20.1** (17.8-23.1)	**24.7** (22.2-31.6)	393
12-19 years	01-02	**3.71** (3.18-4.33)	**4.00** (3.40-4.70)	**7.00** (6.10-8.10)	**11.5** (9.50-12.7)	**13.9** (11.8-19.0)	742
20 years and older	01-02	**2.37** (2.11-2.66)	**2.60** (2.20-3.00)	**4.80** (4.20-5.30)	**8.10** (7.10-9.20)	**12.0** (10.0-14.2)	1647
Gender							
Males	01-02	**2.89** (2.64-3.17)	**3.10** (2.80-3.30)	**5.60** (4.90-6.70)	**9.80** (8.70-12.0)	**14.2** (12.4-18.0)	1371
Females	01-02	**2.62** (2.29-2.99)	**3.00** (2.40-3.30)	**5.60** (4.90-6.30)	**10.0** (8.30-11.2)	**14.7** (11.2-20.3)	1411
Race/ethnicity							
Mexican Americans	01-02	**2.67** (2.26-3.16)	**3.00** (2.30-3.40)	**5.30** (4.40-5.90)	**9.10** (7.30-12.4)	**13.6** (10.4-18.7)	677
Non-Hispanic blacks	01-02	**3.09** (2.81-3.40)	**3.20** (2.90-3.50)	**6.30** (5.50-6.50)	**10.8** (9.10-13.0)	**14.9** (13.5-22.4)	703
Non-Hispanic whites	01-02	**2.72** (2.40-3.08)	**2.90** (2.50-3.30)	**5.70** (4.80-6.70)	**10.3** (8.90-11.9)	**15.8** (12.6-19.5)	1216

Table 207. Mono-3-carboxypropyl phthalate (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g of creatinine) for the U.S. population aged 6 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 6 and older	01-02	**2.57** (2.34-2.82)	**2.45** (2.23-2.76)	**4.07** (3.85-4.46)	**7.25** (6.59-8.01)	**11.4** (10.1-12.6)	2772
Age group							
6-11 years	01-02	**6.96** (6.29-7.71)	**7.07** (5.77-7.87)	**11.3** (9.27-14.0)	**20.7** (15.5-22.3)	**26.4** (20.7-27.0)	392
12-19 years	01-02	**2.86** (2.52-3.25)	**2.93** (2.50-3.36)	**4.57** (4.03-5.23)	**6.69** (6.30-7.25)	**9.44** (8.03-10.7)	742
20 years and older	01-02	**2.24** (2.03-2.47)	**2.19** (1.99-2.39)	**3.49** (3.10-3.93)	**5.32** (4.79-6.18)	**7.71** (6.71-9.28)	1638
Gender							
Males	01-02	**2.35** (2.16-2.56)	**2.20** (2.01-2.42)	**3.76** (3.45-4.20)	**7.16** (6.03-7.98)	**11.6** (9.28-15.4)	1367
Females	01-02	**2.80** (2.47-3.18)	**2.75** (2.44-3.01)	**4.37** (3.97-4.86)	**7.65** (6.17-8.69)	**11.1** (8.66-15.9)	1405
Race/ethnicity							
Mexican Americans	01-02	**2.51** (2.20-2.87)	**2.36** (2.05-2.73)	**4.24** (3.65-5.00)	**7.42** (5.58-10.3)	**11.2** (8.18-14.5)	674
Non-Hispanic blacks	01-02	**2.17** (2.02-2.33)	**2.07** (1.88-2.28)	**3.64** (3.24-4.07)	**6.73** (5.46-7.70)	**10.0** (8.27-13.1)	702
Non-Hispanic whites	01-02	**2.69** (2.41-3.00)	**2.56** (2.23-2.92)	**4.16** (3.87-4.76)	**7.66** (6.59-8.47)	**11.8** (10.0-14.7)	1211

Table 208. Mono-n-octyl phthalate

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6 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 6 and older	99-00	*	**< LOD**	**< LOD**	**1.60** (1.20-2.00)	**2.90** (2.20-3.30)	2541
	01-02	*	**< LOD**	**< LOD**	**< LOD**	**< LOD**	2782
Age group							
6-11 years	99-00	*	**< LOD**	**< LOD**	**2.00** (.900-3.50)	**3.20** (1.70-4.30)	328
	01-02	*	**< LOD**	**< LOD**	**< LOD**	**< LOD**	393
12-19 years	99-00	*	**< LOD**	**< LOD**	**1.60** (.900-2.50)	**2.80** (2.00-4.20)	752
	01-02	*	**< LOD**	**< LOD**	**< LOD**	**< LOD**	742
20 years and older	99-00	*	**< LOD**	**< LOD**	**1.50** (1.10-1.90)	**2.90** (2.00-3.50)	1461
	01-02	*	**< LOD**	**< LOD**	**< LOD**	**< LOD**	1647
Gender							
Males	99-00	*	**< LOD**	**< LOD**	**1.60** (1.10-2.10)	**2.80** (2.00-3.40)	1215
	01-02	*	**< LOD**	**< LOD**	**< LOD**	**< LOD**	1371
Females	99-00	*	**< LOD**	**< LOD**	**1.40** (1.10-2.00)	**3.10** (2.20-3.70)	1326
	01-02	*	**< LOD**	**< LOD**	**< LOD**	**< LOD**	1411
Race/ethnicity							
Mexican Americans	99-00	*	**< LOD**	**< LOD**	**1.00** (<LOD-1.40)	**1.50** (1.40-2.60)	814
	01-02	*	**< LOD**	**< LOD**	**< LOD**	**< LOD**	677
Non-Hispanic blacks	99-00	*	**< LOD**	**< LOD**	**1.80** (<LOD-3.00)	**3.00** (2.20-3.70)	603
	01-02	*	**< LOD**	**< LOD**	**< LOD**	**< LOD**	703
Non-Hispanic whites	99-00	*	**< LOD**	**< LOD**	**1.50** (1.20-2.10)	**3.00** (2.30-3.50)	912
	01-02	*	**< LOD**	**< LOD**	**< LOD**	**< LOD**	1216

< 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 209. Mono-n-octyl phthalate (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g of creatinine) for the U.S. population aged 6 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 6 and older	99-00	*	**< LOD**	**< LOD**	**2.40** (2.07-2.61)	**3.51** (2.86-4.29)	2541
	01-02	*	**< LOD**	**< LOD**	**< LOD**	**< LOD**	2772
Age group							
6-11 years	99-00	*	**< LOD**	**< LOD**	**2.22** (1.60-3.75)	**3.75** (1.97-10.3)	328
	01-02	*	**< LOD**	**< LOD**	**< LOD**	**< LOD**	392
12-19 years	99-00	*	**< LOD**	**< LOD**	**1.49** (1.29-1.71)	**1.82** (1.54-3.33)	752
	01-02	*	**< LOD**	**< LOD**	**< LOD**	**< LOD**	742
20 years and older	99-00	*	**< LOD**	**< LOD**	**2.56** (2.07-2.91)	**3.47** (2.86-4.29)	1461
	01-02	*	**< LOD**	**< LOD**	**< LOD**	**< LOD**	1638
Gender							
Males	99-00	*	**< LOD**	**< LOD**	**1.82** (1.54-2.05)	**2.52** (1.94-3.45)	1215
	01-02	*	**< LOD**	**< LOD**	**< LOD**	**< LOD**	1367
Females	99-00	*	**< LOD**	**< LOD**	**2.95** (2.50-3.55)	**4.00** (3.33-5.56)	1326
	01-02	*	**< LOD**	**< LOD**	**< LOD**	**< LOD**	1405
Race/ethnicity							
Mexican Americans	99-00	*	**< LOD**	**< LOD**	**1.82** (1.43-2.61)	**3.16** (2.60-4.00)	814
	01-02	*	**< LOD**	**< LOD**	**< LOD**	**< LOD**	674
Non-Hispanic blacks	99-00	*	**< LOD**	**< LOD**	**1.36** (1.03-1.94)	**2.18** (1.50-3.27)	603
	01-02	*	**< LOD**	**< LOD**	**< LOD**	**< LOD**	702
Non-Hispanic whites	99-00	*	**< LOD**	**< LOD**	**2.60** (2.07-3.00)	**3.60** (3.00-4.62)	912
	01-02	*	**< LOD**	**< LOD**	**< LOD**	**< LOD**	1211

< 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.

Mono-isononyl Phthalate

Metabolite of Di-isononyl Phthalate, CAS No. 28553-12-0

General Information

Di-isononyl phthalate (DiNP) is actually a mixture of phthalates with branched alkyl side chains of varying length (C8, C9, and C10). DINP is primarily used to produce flexible plastics and has been used to replace di-2-ethylhexyl phthalate (DEHP) in some plastics. DiNP is now widely used in such products as children's toys, flooring, gloves, drinking straws, and garden hoses. People exposed to DiNP will excrete small amounts of mono-isononyl phthalate (MiNP) in their urine. As with DEHP, other oxidative metabolites of DiNP are probably the most abundant urinary metabolites (McKee et al., 2002). Because DiNP is a complex mixture, MiNP may not reflect total exposure to all DiNP components.

Workplace air standards for external exposure have not been established for DiNP, which although considered an animal carcinogen, has not been completely classified as to human carcinogenicity (IARC, NTP).

In both the NHANES 1999-2000 and 2001-2002 subsamples, MiNP was detectable only at the 95th percentiles.

Table 210. Mono-isononyl phthalate

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6 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 6 and older	99-00	*	**< LOD**	**< LOD**	**< LOD**	**3.50** (<LOD-13.8)	2541
	01-02	*	**< LOD**	**< LOD**	**< LOD**	**< LOD**	2782
Age group							
6-11 years	99-00	*	**< LOD**	**< LOD**	**< LOD**	**5.70** (<LOD-22.5)	328
	01-02	*	**< LOD**	**< LOD**	**< LOD**	**< LOD**	393
12-19 years	99-00	*	**< LOD**	**< LOD**	**< LOD**	**2.30** (<LOD-20.3)	752
	01-02	*	**< LOD**	**< LOD**	**< LOD**	**< LOD**	742
20 years and older	99-00	*	**< LOD**	**< LOD**	**< LOD**	**3.10** (<LOD-13.2)	1461
	01-02	*	**< LOD**	**< LOD**	**< LOD**	**< LOD**	1647
Gender							
Males	99-00	*	**< LOD**	**< LOD**	**< LOD**	**4.90** (<LOD-18.9)	1215
	01-02	*	**< LOD**	**< LOD**	**< LOD**	**< LOD**	1371
Females	99-00	*	**< LOD**	**< LOD**	**< LOD**	**2.50** (<LOD-6.80)	1326
	01-02	*	**< LOD**	**< LOD**	**< LOD**	**< LOD**	1411
Race/ethnicity							
Mexican Americans	99-00	*	**< LOD**	**< LOD**	**< LOD**	**1.40** (<LOD-2.70)	814
	01-02	*	**< LOD**	**< LOD**	**< LOD**	**1.00** (<LOD-1.20)	677
Non-Hispanic blacks	99-00	*	**< LOD**	**< LOD**	**2.30** (<LOD-13.8)	**6.80** (<LOD-30.2)	603
	01-02	*	**< LOD**	**< LOD**	**< LOD**	**1.00** (<LOD-1.70)	703
Non-Hispanic whites	99-00	*	**< LOD**	**< LOD**	**< LOD**	**3.50** (<LOD-16.0)	912
	01-02	*	**< LOD**	**< LOD**	**< LOD**	**< LOD**	1216

< 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 211. Mono-isononyl phthalate (creatinine corrected)

Geometric mean and selected percentiles of urine concentrations (in µg/g of creatinine) for the U.S. population aged 6 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 6 and older	99-00	*	**< LOD**	**< LOD**	**< LOD**	**4.29** (2.86-7.88)	2541
	01-02	*	**< LOD**	**< LOD**	**< LOD**	**< LOD**	2772
Age group							
6-11 years	99-00	*	**< LOD**	**< LOD**	**< LOD**	**6.00** (2.77-14.2)	328
	01-02	*	**< LOD**	**< LOD**	**< LOD**	**< LOD**	392
12-19 years	99-00	*	**< LOD**	**< LOD**	**< LOD**	**1.94** (1.30-7.65)	752
	01-02	*	**< LOD**	**< LOD**	**< LOD**	**< LOD**	742
20 years and older	99-00	*	**< LOD**	**< LOD**	**< LOD**	**4.62** (3.16-7.93)	1461
	01-02	*	**< LOD**	**< LOD**	**< LOD**	**< LOD**	1638
Gender							
Males	99-00	*	**< LOD**	**< LOD**	**< LOD**	**4.24** (1.94-10.2)	1215
	01-02	*	**< LOD**	**< LOD**	**< LOD**	**< LOD**	1367
Females	99-00	*	**< LOD**	**< LOD**	**< LOD**	**4.29** (3.33-5.79)	1326
	01-02	*	**< LOD**	**< LOD**	**< LOD**	**< LOD**	1405
Race/ethnicity							
Mexican Americans	99-00	*	**< LOD**	**< LOD**	**< LOD**	**3.51** (2.86-5.00)	814
	01-02	*	**< LOD**	**< LOD**	**< LOD**	**2.31** (1.76-2.73)	674
Non-Hispanic blacks	99-00	*	**< LOD**	**< LOD**	**2.03** (.759-5.31)	**4.26** (1.43-14.3)	603
	01-02	*	**< LOD**	**< LOD**	**< LOD**	**1.62** (1.25-1.88)	702
Non-Hispanic whites	99-00	*	**< LOD**	**< LOD**	**< LOD**	**5.00** (3.00-10.0)	912
	01-02	*	**< LOD**	**< LOD**	**< LOD**	**< LOD**	1211

< 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

Phytoestrogens