Urinary Phthalates

Phthalates are industrial chemicals added to many consumer products such as food packaging, adhesives, detergents, plastics (e.g., plastic bags, garden hoses, recreational toys, medical tubing, plastic clothes), and personal-care products (such as soap, shampoo, and nail polish). Exposure can occur through food that has been in contact with phthalate-containing packaging, as well as direct contact with products that contain phthalates.

Acute high-dose exposure to di-2-ethylhexyl phthalate, for example, may be associated with mild gastrointestinal disturbances, nausea, and vertigo. Chronic exposure to phthalate compounds has been associated with damage to the liver and testes, cancer, birth defects, male reproductive effects, and endocrine system effects in animal studies. The extent to which these effects occur in humans is the subject of ongoing research (ATSDR, 2002; CDC, 2009, 2017; Kavlock et al., 2002a-g; NRC, 2008).

This indicator is based on data collected by the National Health and Nutrition Examination Survey (NHANES). NHANES is a series of surveys conducted by the Centers for Disease Control and Prevention's (CDC's) National Center for Health Statistics that is designed to collect data on the health and nutritional status of the civilian, non-institutionalized U.S. population using a complex, stratified, multistage, probability-cluster design. CDC's National Center for Environmental Health conducted the laboratory analyses for the biomonitoring samples. Beginning in 1999, NHANES became a continuous and annual national survey. Metabolites of phthalates are measured in urine as a biomarker of phthalate exposure in the population. Data for the 1999-2000, 2001-2002, 2003-2004, 2005-2006, 2007-2008, 2009-2010, 2011-2012, 2013-2014, and 2015-2016 survey periods are presented here.

What the Data Show

Exhibit 1 presents the geometric means and four percentiles for urinary concentrations and creatinine-adjusted urinary concentrations of selected metabolites of phthalates among a subsample of participants age 6 years and older from NHANES (1999-2000, 2001-2002, 2003-2004, 2005-2006, 2007-2008, 2009-2010, 2011-2012, 2013-2014, and 2015-2016). Nine of the 12 metabolites were consistently detected across the survey periods. Three metabolites are no longer measured in the survey (starting with the 2011-2012 or 2013-2014 cycle) largely because they were undetectable in earlier survey periods (mono-methyl phthalate, mono-n-octyl phthalate, and mono-cyclohexyl phthalate).

Mono-ethyl phthalate (the metabolite for diethyl phthalate, an industrial solvent used in many products including those containing fragrances) was the phthalate detected in the highest concentration during the nine survey periods, with creatinine-adjusted geometric mean concentrations ranging between 34.7 (2015-2016) and 120 (2003-2004) micrograms per gram (μg/g) of creatinine. In addition, other phthalate metabolites such as mono-n-butyl phthalate (a metabolite for dibutyl phthalate, which is an industrial solvent used in cosmetics, printing inks, and insecticides) and mono-benzyl phthalate (a metabolite for benzylbutyl phthalate, which is an industrial solvent used in adhesives, vinyl flooring, and car care products) were detected in urine samples. Creatinine-adjusted geometric means for the other phthalate metabolites were below 25 μg/g of creatine.

During the first seven of the nine survey periods, the creatinine-adjusted geometric mean levels for mono-ethyl phthalate were lower in the group aged 6-11 years than in either of the other two age groups (12-19 and 20 and older), and then lowest in the group aged 12-19 years in the 2013-2014 and 2015-2016 survey periods. This age-related observation is opposite the direction seen for most other phthalates, where the creatinine-adjusted geometric mean levels tended to be higher in the group aged 6-11 years. Other population estimates also differed by sex and race ethnicity. For example, females tended to have a higher level than males for mono-ethyl, mono-n-butyl, and mono-benzyl phthalates. Non-Hispanic blacks had higher levels of mono-ethyl phthalate than non-Hispanic whites or Mexican Americans (CDC, 2019). (Data not shown.)

Limitations

- Urine creatinine concentrations were used to adjust the urinary concentrations of phthalates and metabolites of phthalates in subsets of adults participating in NHANES. Traditionally, this approach has been used in population groups without much diversity. However, the inclusion of multiple demographic groups (e.g., children) in NHANES may increase the variability in the urinary creatinine levels when comparing across these different study populations (Barr et al., 2005).
- Differences in the excretion of various phthalates may be due to differences in either exposure or toxicokinetics. The low detection rates for some of the long alkyl chain phthalate metabolites may be due to significantly less metabolism to the monoester metabolite.
- It is unknown whether differences between ages, genders, or races/ethnicities represent differences in exposure, body-size relationships, or metabolism.
- Health-based benchmarks for phthalate metabolites in urine have not been established.
- The relatively small number of samples collected in a two-year cycle (e.g., 1999-2000 or 2001-2002) may, in some cases, result in measures of central tendency that are unstable from one survey period to the next.

Data Sources

Data used for this indicator were obtained directly from CDC's Fourth National Report on Human Exposure to Environmental Chemicals, Updated Tables, January 2019 (CDC, 2019), which presents results of the ongoing NHANES. The underlying laboratory data supporting CDC's report are available online in SAS® transport file format at https://wwwn.cdc.gov/nchs/nhanes/Default.aspx.

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Exhibit 1. Urine concentrations of selected phthalate metabolites in the U.S. population age 6 years and older, 1999–2016

			Geometric mean and selected percentiles of phthalate metabolite concentrations				
	Survey years	Sample size	Geometric mean	50th percentile	75th percentile	90th percentile	95t perce
Mono-methyl phthalate							
µg/L of urine	2001–2002	2,782	1.15	1.50	3.30	6.00	9.8
	2003–2004	2,605	NC	1.30	3.90	9.70	16.
	2005–2006	2,548	NC	<LOD	2.50	7.40	12.
	2007–2008	2,604	NC	<LOD	2.20	6.50	11.
	2009–2010	2,749	NC	0.940	2.89	6.72	12.
	2011–2012	2,489	NC	1.00	3.00	7.00	11.
µg/g of creatinine	2001–2002	2,782	1.08	1.33	2.62	5.00	8.0
	2003–2004	2,605	NC	1.53	3.45	7.95	13.
	2005–2006	2,548	NC	<LOD	2.85	6.53	12.
	2007–2008	2,604	NC	<LOD	2.79	5.68	10.

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