



























	<b>Outcome</b>	<b>Population Tested</b>	<b>Metabolites or Parent Compound Measured</b>	<b>Phthalates Associated With Adverse Outcomes</b>	<b>Parent Phthalates* Associated with Adverse Outcomes</b>	<b>Reference</b>
25.	preconception biomarkers and birth outcome: maternal and paternal exposure	US, 2005-2009, 233 infants	MMP, MEP, MBP, MiBP, MEHP, MEHHP, MEOHP, MECPP, MCMHP, MBzP, MCHP, MCP, MNP in maternal and paternal urine before pregnancy (90% pregnant within 6 months after sampling)	↑ maternal MCMHP, MMP, MEP, MnOP, MEHP: ↓ birth weight; ↑ paternal MEHP: ↓ birth weight; ↑DMP, DEP, DEHP metabolites: ↓ birth length, head circumference	DEHP, DnOP, DMP, DEP	Smarr et al 2015
26.	intrauterine growth restriction: fetal exposure	China, dates not given, mother-infant pairs, 42 cases, 84 controls	MnBP, MMP, MEHP, MEOHP, MEHHP in third trimester urine	MMP, MEHHP, MEOHP, ΣDEHP: ↑ in cases than controls; ↑ MEHHP, MEOHP: ↓ fetal growth in all subjects; males more affected	DMP, DEHP	Zhao et al 2014
27.	clinical pregnancy loss: embryonic/fetal exposure	China, 2011-2014, 132 cases, 172 controls	MMP, MEP, MiBP, MnBP, MEHP in urine	↑ MEP, MiBP, MnBP: ↑ pregnancy loss	DEP, DiBP, DnBP, BBP	Mu et al 2015
28.	expression of genes in placenta associated with fetal growth and development: fetal exposure	China, 187 mother-infant pairs	DMP, DEP, BBP, DEHP, DNOP (i.e. parent compounds) in umbilical cord blood	↑ DEHP: ↓ birth weight and gestational age in male infants; ↑ DMP, DEHP, DEP: ↑ gene expression of several genes associated with growth and development	DEHP, DMP, DEP	Li et al 2016

	<b>Outcome</b>	<b>Population Tested</b>	<b>Metabolites or Parent Compound Measured</b>	<b>Phthalates Associated With Adverse Outcomes</b>	<b>Parent Phthalates* Associated with Adverse Outcomes</b>	<b>Reference</b>
29.	biomarkers of oxidative stress (which may result in adverse pregnancy outcome): maternal exposure	US, 2006-2008 130 cases, 352 controls	MEHP, MEHHP, MEOHP, MECPP, $\Sigma$ DEHP, MBzP, MnBP, MiBP, MEP, MCPP in urine measured 4x during pregnancy	all metabolites: $\uparrow$ oxidative stress; strongest associations with MBzP, MnBP, MiBP	DnBP, BBP, DEHP, DiNP, DEP, DnOP	Ferguson et al 2015a
30.	biomarkers of inflammation during pregnancy: maternal exposure	US, 2006-2008 130 cases, 352 controls	MEHP, MEHHP, MEOHP, MECPP, $\Sigma$ DEHP, MBzP, MnBP, MiBP, MEP, MCPP in urine measured 4x during pregnancy	$\uparrow$ MCPP, MBzP: increased inflammation	BBP, DnOP, DnBP	Ferguson et al 2015b
31.	thyroid and sex hormones: maternal exposure	Puerto Rico, 2010-2012, 106 pregnant women	MEHP, MnBP, MEHHP, MEOHP, MECPP, MCPP, MCOP, MCNP, MBzP, MiBP, MEP in urine	$\uparrow$ MCPP and MCOP: $\downarrow$ free T <sub>3</sub> ; $\uparrow$ MEP: $\downarrow$ progesterone; $\uparrow$ $\Sigma$ DEHP: $\downarrow$ free T <sub>4</sub>	DiNP, DEP, DEHP DnOP, DnBP	Johns et al 2015
32.	thyroid function: fetal exposure	Taiwan, 2009-2010, 148 mother-infant pairs	MEHP, MEHHP, MEOHP, MnBP, MiBP, MEP, MMP, MiNP, MBzP in cord blood	$\uparrow$ MBzP in cord blood: $\downarrow$ serum TSH	BBP	Kuo et al 2015
33.	blood pressure during pregnancy: maternal exposure	US, 2003-2006 369 women	MEP, MBzP, MCPP, $\Sigma$ DBP (MnBP+ MiBP), $\Sigma$ DEHP (MEHP+ MEHHP+ MEOHP+MECHP) in maternal urine	$\uparrow$ MBzP: $\uparrow$ diastolic BP	BBP	Werner et al 2015

	<b>Outcome</b>	<b>Population Tested</b>	<b>Metabolites or Parent Compound Measured</b>	<b>Phthalates Associated With Adverse Outcomes</b>	<b>Parent Phthalates* Associated with Adverse Outcomes</b>	<b>Reference</b>
34.	congenital heart defects and parental exposure: fetal exposure	China, 2012-2013, 761 cases, 609 controls, occupationally exposed	"phthalates" unspecified in urine	↑maternal phthalates: ↑ventricular septal defects, pulmonary valve stenosis, patent ductus arteriosis; ↑paternal phthalates: ↑ventricular septal defect	"phthalates"	Wang et al 2015c

\* MCPP is a metabolite of both DnBP and DnOP. MnBP is a metabolite of both DnBP AND BBP. Therefore both parent compounds are listed when associations to these metabolites are observed.

**Table 4. Adverse outcomes in children associated with fetal exposure**

	<b>Outcome</b>	<b>Population Tested</b>	<b>Metabolites Measured</b>	<b>Metabolites Associated With Adverse Outcomes</b>	<b>Parent Phthalates* Associated with Adverse Outcomes</b>	<b>Reference</b>
35.	IQ at 7 years: fetal exposure	US, 1998-2006, 328 mother-offspring pairs	MnBP, MBzP, MEHHP, MEHP, MEP, MiBP in maternal urine	↑ MnBP, MiBP: ↓ full-scale IQ and processing speed, perceptual reasoning, working memory; ↑ MiBP: ↓ verbal comprehension; ↑ MBzP; ↓ perceptual reasoning	DnBP, DiBP, BBP	Factor-Litvak et al 2014
36.	neurobehavioral development in 6-10 years old boys and girls: fetal exposure	US, 1999-2005, 153 mother-infant pairs	MEHP, MEHHP, MEOHP, MiBP, MnBP, MBzP, MEP in maternal urine	↑ MiBP: ↑ inattention, rule-breaking, aggression, conduct problems in boys; ↑ ∑DEHP: ↑ somatic problems in boys; ↑ MBzP: ↑ oppositional behavior and conduct problems in boys, ↓ anxiety in girls	DEHP, DiNP, BBP	Kobrosly et al 2014
37.	behavioral outcomes in 8-year-old children: fetal exposure	Taiwan, 2000-2009, 122 mother-child pairs	MMP, MEP, MnBP, MBzP, MEOHP, MEHHP, MEHP in maternal urine	↑ MnBP, MEOHP, MEHP: ↑ externalizing problems; ↑ MnBP, MEOHP: ↑ delinquent and aggressive behavior	DnBP, DEHP, BBP	Lien et al 2015



	<b>Outcome</b>	<b>Population Tested</b>	<b>Metabolites Measured</b>	<b>Metabolites Associated With Adverse Outcomes</b>	<b>Parent Phthalates* Associated with Adverse Outcomes</b>	<b>Reference</b>
38.	cognitive function at 2-12 years of age: fetal and childhood exposure	Taiwan, 2001-2002, 73-110 children depending on age of testing at 2, 5, 8,11, years	MMP, MEP, MnBP, MBzP, MEHP, MEHHP, MEOHP, $\Sigma$ DEHP in maternal and child's urine	no association with maternal levels; $\uparrow$ child's MEOHP and $\Sigma$ DEHP: $\downarrow$ IQ across ages	DEHP	Huang et al 2015
39.	neuropsychological development at 1, 4 and 7 years: fetal exposure	Spain 2004-2006, 367 children	$\Sigma$ DEHP, MBzP, MEP, MiBP, MnBP	$\uparrow$ MBzP: $\downarrow$ psychomotor score at 4 years; $\uparrow$ $\Sigma$ DEHP: $\uparrow$ social competence and $\downarrow$ ADHD scores; $\uparrow$ MEP: $\downarrow$ inattention at 4 years	BBP DEHP better outcome, but results not stratified by sex	Gascon et al 2015b
40.	neuropsychological development: fetal exposure and concurrent exposure at 2 years	Poland, begun 2007, 165 mother-infant pairs	MEP, MiBP, MnBP, MEHP, MEHHP, MEOHP, MnOP, MCOP, MCiOP, MCPP in urine	$\uparrow$ DEHP, MCPP, MEHHP, MEOHP, $\Sigma$ DnBP, high MW: $\downarrow$ psychomotor development at 2 years; no effect of postnatal exposure	DEHP, DnBP, DnOP	Polanska et al 2014
41.	female sexual maturation: fetal and concurrent childhood exposure	Mexico, 1997-2004, 116 mothers, 129 children ages 8-13 years	BPA, MEP, MnBP, MiBP, MBzP, MCPP, MEHP, MEHHP, MEOHP, MECPP in urine, hormones in blood	$\uparrow$ maternal MEHP and other DEHP metabolites: $\uparrow$ pubic hair development and hormones associated with adrenarche; $\uparrow$ maternal MBzP, MEP: $\uparrow$ testosterone; no relation with concurrent exposure; no effect of BPA	DEHP, BBP, DEP	Watkins et al 2014

	<b>Outcome</b>	<b>Population Tested</b>	<b>Metabolites Measured</b>	<b>Metabolites Associated With Adverse Outcomes</b>	<b>Parent Phthalates* Associated with Adverse Outcomes</b>	<b>Reference</b>
42.	pubertal development: fetal exposure	China, 2001-2002, 133 children at 8 and 11 years old	MEHP, MEHHP, MEOHP, MnBP, MBzP, MMP, MEP in third trimester urine	↑ MEHP, ∑DEHP: ↓ uterine size; ↑ MBzP: ↓ bone age in girls	DEHP, BBP	Su et al 2014
43.	male sexual maturation: fetal and concurrent childhood exposure	Mexico, 1994-2004, mothers and 118 boys ages 8-14 years	BPA, MEP, MnBP, MiBP, MBzP, MCP, MEHP, MEHHP, MEOHP, MECPP in urine, hormones in blood	↑ maternal MEOHP, MBzP, MnBP, MCP: ↑ sex hormone binding globulin; ↑ concurrent MEHP, MEOHP, MEHHP, MCP, MBzP, MCP: ↓ testosterone, ↑ SHBG; ↑ concurrent MiBP: ↓ testosterone	DEHP, DiBP, BBP, DnBP, DnOP	Ferguson et al 2014c
44.	sex steroid levels and reproductive development: fetal and concurrent childhood exposure	Taiwan, 2001-2009, 180 children 8 years old	MEHP, MEOHP, MEHHP, ∑DEHP, MnBP, MBzP, MMP, MEP in urine of pregnant women and children	no association with maternal levels; ↑ MEHP, MBzP; ↑ progesterone in girls; ↑ MnBP, MBzP: ↑ FSH in girls	DEHP, BBP, DnBP	Su et al 2014
45.	BMI and overweight status: fetal exposure	US, 1998-2006, 707 children exposed prenatally, 3 birth cohorts	MEP, MnBP, MiBP, MCP, MBzP, MEHP, MEHHP, MEOHP, MECPP in maternal urine	↑ MCP: ↑ overweight status in boys; ∑DEHP, MEP: ↓ BMI in girls	DEHP, DEP, DnOP, DnBP	Buckley et al 2016

	<b>Outcome</b>	<b>Population Tested</b>	<b>Metabolites Measured</b>	<b>Metabolites Associated With Adverse Outcomes</b>	<b>Parent Phthalates* Associated with Adverse Outcomes</b>	<b>Reference</b>
46.	body size in children ages 5 and 7: fetal exposure	US, 1998-2006, 326-330 offspring, depending on age of testing	MEHP, MEHHP, MEOHP, MECPP, MiBP, MnBP, MBzP, MEP, MCP, in maternal urine	↑ non-DEHP component: ↓ BMI, waist circumference, fat mass in boys; DEHP component: no effect	DiNP+DnBP+B BP+ DEP+DnOP	Maresca et al 2016
47.	childhood growth and blood pressure: fetal exposure	Spain, 2004-2006, 391 mother-infant pairs, children assessed at 6 months through 7 years	MBzP, MEHP, MEHHP, MEOHP, MECPP, MiBP, MnBP, ΣDEHP, Σhigh MW, Σlow MW in maternal urine	↑ ΣHMW: ↓ weight gain at 6 months in boys, ↑ weight gain in girls; ↑ ΣHMW: ↓ BMI in boys at all ages and ↑ BMI in girls; ↑ ΣHMW: ↓ systolic BP in girls only	Σhigh MW (DEHP + BBP)	Valvi et al 2015
48.	metabolic measures of diabetes and metabolic syndrome: fetal and peripubertal exposure	Mexico, women recruited 1997-2004, 250 offspring tested at 8-14 years old	MEP, MnBP, MiBP, MBzP, MCP, MEHP, MEHHP, MEOHP, MECPP, BPA in third trimester urine and children	↑ MBzP, MEP, MCP, ΣDEHP, ΣDnBP: numerous changes in homeostasis, depending on sex and pubertal status	DEHP, DnBP, BBP, DEP, DnOP	Watkins et al 2016
49.	asthma: fetal or concurrent postnatal exposure at 2-8 years	Taiwan, 2000-2001, 171 children tested at 2, 5, 8 years old	ΣDEHP, MEHP, MBzP, MnBP, MEP in maternal and child's urine	↑ maternal DEHP, MBzP; ↑ wheezing in boys; ↑ MEHP at 2 and 5 years; ↑ asthma in boys; ↑ MEP at 5 years; ↑ wheezing and asthma in boys	DEHP, DEP, BBP, DnBP	Ku et al 2015

	<b>Outcome</b>	<b>Population Tested</b>	<b>Metabolites Measured</b>	<b>Metabolites Associated With Adverse Outcomes</b>	<b>Parent Phthalates* Associated with Adverse Outcomes</b>	<b>Reference</b>
50.	asthma in children 5-11 years: fetal exposure	US, 1998-2006, 300 pregnant women	MEHHP, MBzP, MnBP, MEP in maternal urine	↑ MBzP, MnBP: ↑ asthma and asthma-like symptoms	BBP, DnBP	Whyatt et al 2014
51.	IgE levels and atopic dermatitis (AD): fetal and childhood exposure at 2 and 5 years	Taiwan, 2004, 161-192 mothers and children depending on age	MEP, MBP, MBzP, MEHP in urine	↑ MEHP at 2 years: ↑ IgE levels in boys; ↑ MBzP at 2 years: ↑ AD	DEHP, BBP	Wang et al 2014
52.	food allergy and eczema: fetal and childhood exposure	Poland, 2007-, pregnant mothers and children at 2 years old, 147 children tested	MEP, MiBP, MnBP, MCPP, MEHP, MEHHP, MEOHP, MCOP, MCiOP, MnOP in maternal and child urine	↑ maternal MBzP: ↑ food allergy	BBP	Stelmach et al 2015
53.	respiratory tract infection and allergy at 6 and 14 months and 4 and 7 years: fetal exposure	Spain, 2004-2008, 174-391 children depending on outcome	MBzP, MECPP, MEHHP, MEHP, MEOHP, MEP, MiBP, MnBP in urine	↑ ∑DEHP: ↑ wheeze, chest infections, bronchitis; ↑ MBzP: ↑ chest infections; ↑ ∑DEHP, MBzP: ↑ asthma at 7 years	DEHP, BBP	Gascon et al 2015a

\* MCPP is a metabolite of both DnBP and DnOP. MnBP is a metabolite of both DnBP AND BBP. Therefore both parent compounds are listed when associations to these metabolites are observed.

**Table 5. Adverse outcomes associated with concurrent childhood exposure**

	<b>Outcome</b>	<b>Population Tested</b>	<b>Metabolites Measured</b>	<b>Metabolites Associated With Adverse Outcomes</b>	<b>Parent Phthalates* Associated with Adverse Outcomes</b>	<b>Reference</b>
54.	delayed growth and puberty: childhood exposure	China, 2013-2014, 8-15 year old boys, 57 cases, 110 controls	MBP, MnBP, MiBP, MMP, MEP, MEHP, MEOHP, MEHHP in urine	↑ MBP, MEP, ∑ phthalates: ↓ serum testosterone; MEP, MBP, MEHP, total phthalates: risk of Constitutional Delay of Growth and Puberty (CDGP) (↓ bone age, height, puberty)	DBP, DEP, DEHP, ∑DBP + DEP + DEHP + DiBP + DnBP	Xie et al 2015
55.	pubertal timing : concurrent childhood exposure	China, 2010, 503 children 7-14 years old	MnBP, MMP, MEP, MEHP, MEHHP, MEOHP, ∑DEHP in urine	↑ MnBP: ↓ testicular volume; ↑ MEHHP, MEOHP: ↓ pubic hair stage in boys; ↑ MEHP, MEHHP, MEOHP, ∑DEHP: ↑ breast stage in girls	DEHP, DnBP, BBP	Shi et al 2015
56.	serum testosterone: concurrent exposure in men, women, children	US NHANES, 2011-2012, men, women, children, 2208 individuals	∑DEHP (MEHP+ MEHHP+ MEOHP+ MECPP), MBzP, MBP, MiBP, MEP, MCPP, MCNP, MCOP, MiNP, MMP in urine	↑ DEHP metabolites: ↓ T boys 6-12 years; ↑ DEHP and DnBP metabolites men 40-60: ~↓ T; ↑ ∑DEHP, MBzP, MnBP, MiBP, MCPP, MCNP, MCOP each: ↓ T at one or more ages in females	DEHP, BBP, DnBP, DiDP, DiNP, DiBP, DnOP	Meeker and Ferguson 2014

	<b>Outcome</b>	<b>Population Tested</b>	<b>Metabolites Measured</b>	<b>Metabolites Associated With Adverse Outcomes</b>	<b>Parent Phthalates* Associated with Adverse Outcomes</b>	<b>Reference</b>
57.	obesity, pubertal maturity: childhood exposure	Taiwan, 2012-2013, 270 6.5-15 year olds	MMP, MEP, MiBP, MnBP, MBzP, MEHP, MEOHP, MEHHP, MECPP, nonylphenol in urine	↑ metabolites of DEP, DnBP, DiBP, DEHP: ↑ obesity; ↑ MMP: ↓ plutarch in boys	DEHP, DEP, DiBP, DnBP, BBP, DMP	Hou et al 2015
58.	obesity: concurrent childhood exposure	China, 2001, 493 children tested at 8-10 or 11-13 years	LMW (MnBP+ MMP+ MEP), MEHP, MEHHP, MEOH, ΣDEHP in urine	↑Σ LHW, MEP: ↑obesity in boys; ↑ MEHP, MEHHP, ΣDEHP: ↓ obesity in girls	DEP, DEHP, DnBP + DMP + DEP	Zhang et al, 2014
59.	obesity: concurrent exposure of children, adolescents, adults	US NHANES, 2007-2010	MnBP, MEP, MiBP, MECPP, MEHHP, MEOHP, MEHP, MBzP, MCNP, MCOP	↑ low MW (MnBP + MEP + MiBP): ↑ obesity in male children and adolescents; ↑ high MW (MECPP + MEHHP + MEOHP + MEHP + MBzP + MCNP + MCOP): ↑ obesity in adults; ↑ ΣDEHP: ↑ obesity in female adults	DEHP, DnBP + DEP + DiBP, DEHP + BBP + DiDP + DiNP	Buser et al 2014
60.	adiposity and insulin insensitivity: concurrent childhood exposure	Italy, 41 obese, 31 control children, age 12 years	MEHP, MEHHP, MEOHP, MECPP, MCMHP in urine	↑ levels of MECPP and MEHHP in obese compared to controls; differences in DEHP metabolism depending on obesity, age, and pubertal status	DEHP	Smerieri et al, 2015

	<b>Outcome</b>	<b>Population Tested</b>	<b>Metabolites Measured</b>	<b>Metabolites Associated With Adverse Outcomes</b>	<b>Parent Phthalates* Associated with Adverse Outcomes</b>	<b>Reference</b>
61.	atopic dermatitis (AD): concurrent childhood exposure	Korea, 2012, 224 cases, 224 controls ages 3-6 years	MEHHP, MEOHP in urine	↑ ∑DEHP: ~↑ AD at 3 years; non-monotonic function: ↓ risk at low and ↑ risk at high levels	DEHP	Choi et al 2014
62.	asthma, allergic rhinoconjunctivitis, AD: concurrent childhood exposure	Denmark, 222 controls, 68-81 cases depending on outcome, children 3-5 years	MEP, MnBP, MiBP, MBzP, MEHP, MEHHP, MEOHP, MECPP in urine	↑ MEP: ~↑ AD	DEP	Callesen et al 2014
63.	blood pressures and markers of lipid metabolism in children and adolescents: concurrent exposure	US NHANES, 2009-2012, 1329 children for BP, 367 for triglyceride, 4105 for HDL cholesterol	DEHP, DiNP, DiDP metabolites, low molecular weight (MEP + MnBP + MiBP + MMP), high molecular weight DEHP metabolites (MEHP + MEHHP + MEOHP + MECPP), high molecular weight non-DEHP metabolites (MBzP + MCP + MCOP + MiNP + MCNP) in urine	↑ high molecular weight, DEHP, DiNP and DiDP metabolites: ↑ systolic BP; also association with individual high molecular weight metabolites	DEHP, DiNP, DiDP, total high molecular weight (DEHP + BBP DnOP + DiNP + DiDP)	Trasande and Attina 2015

	<b>Outcome</b>	<b>Population Tested</b>	<b>Metabolites Measured</b>	<b>Metabolites Associated With Adverse Outcomes</b>	<b>Parent Phthalates* Associated with Adverse Outcomes</b>	<b>Reference</b>
64.	externalizing behavior and brain cortical thickness: childhood exposure	Korea, 180 children 6-15 years with ADHD, 438 controls	MBP, MEHP, MEOHP in urine	↑ MEHP, MEOHP, MBP: ↑ in cases than controls; ↑ ∑DEHP: ↓ cortical thickness; ↑ DEHP and DEP metabolites: poorer performance in children with ADHD on Clinical Global Impression, Disruptive Behavior Disorder Rating Scale; ↑ MBP: ↑ aggression and externalizing behavior in ADHD children; ↑ DEHP: increased impulsivity on test	DBP, DEHP	Park et al 2015
65.	attention deficit disorder, learning disabilities, or ADD + LD: childhood and adolescent exposure	US NHANES, 2001-2004, 1493 children 6-15 years old	∑DEHP(MEHP+MEHP+MEOHP), ∑DnBP (MnBP+ MiBP), ∑DnOP (MCPP+MOP), MBzP, MEP MiNP, MMP in urine	↑ ∑DEHP and high MW: ↑ ADD; ↑ ∑DEHP, ∑DBP and high MW ~ ↑ ADD plus LD in girls (HMW = MBzP + MCPP + MEHP + MEHHP + MEOHP)	DEHP, DBP, BBP + DnOP + DEHP + DnBP	Chopra et al 2014

\* MCPP is a metabolite of both DnBP and DnOP. MnBP is a metabolite of both DnBP AND BBP. Therefore both parent compounds are listed when associations to these metabolites are observed.



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