

	Outcome	Population Tested	Metabolites or Parent Compound Measured	Phthalates Associated With Adverse Outcomes	Parent Phthalates* Associated with Adverse Outcomes	Reference
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

	Outcome	Population Tested	Metabolites or Parent Compound Measured	Phthalates Associated With Adverse Outcomes	Parent Phthalates* Associated with Adverse Outcomes	Reference
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, Σ 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, Σ 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 ₃ ; \uparrow MEP: \downarrow progesterone; \uparrow Σ DEHP: \downarrow free T ₄	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, Σ DBP (MnBP+ MiBP), Σ DEHP (MEHP+ MEHHP+ MEOHP+MECHP) in maternal urine	\uparrow MBzP: \uparrow diastolic BP	BBP	Werner et al 2015

	Outcome	Population Tested	Metabolites or Parent Compound Measured	Phthalates Associated With Adverse Outcomes	Parent Phthalates* Associated with Adverse Outcomes	Reference
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

	Outcome	Population Tested	Metabolites Measured	Metabolites Associated With Adverse Outcomes	Parent Phthalates* Associated with Adverse Outcomes	Reference
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

	Outcome	Population Tested	Metabolites Measured	Metabolites Associated With Adverse Outcomes	Parent Phthalates* Associated with Adverse Outcomes	Reference
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, Σ DEHP in maternal and child's urine	no association with maternal levels; \uparrow child's MEOHP and Σ 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	Σ DEHP, MBzP, MEP, MiBP, MnBP	\uparrow MBzP: \downarrow psychomotor score at 4 years; \uparrow Σ 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, MCP in urine	\uparrow DEHP, MCP, MEHHP, MEOHP, Σ 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, MCP, MEHP, MEHHP, MEOHP, MCP 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

	Outcome	Population Tested	Metabolites Measured	Metabolites Associated With Adverse Outcomes	Parent Phthalates* Associated with Adverse Outcomes	Reference
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

	Outcome	Population Tested	Metabolites Measured	Metabolites Associated With Adverse Outcomes	Parent Phthalates* Associated with Adverse Outcomes	Reference
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, MCPP 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, Σ DEHP, Σ high MW, Σ low MW in maternal urine	↑ Σ HMW: ↓ weight gain at 6 months in boys, ↑ weight gain in girls; ↑ Σ HMW: ↓ BMI in boys at all ages and ↑ BMI in girls; ↑ Σ HMW: ↓ systolic BP in girls only	Σ high 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, MCPP, MEHP, MEHHP, MEOHP, MECPP, BPA in third trimester urine and children	↑ MBzP, MEP, MCPP, Σ DEHP, Σ DnBP: 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	Σ DEHP, 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

	Outcome	Population Tested	Metabolites Measured	Metabolites Associated With Adverse Outcomes	Parent Phthalates* Associated with Adverse Outcomes	Reference
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

	Outcome	Population Tested	Metabolites Measured	Metabolites Associated With Adverse Outcomes	Parent Phthalates* Associated with Adverse Outcomes	Reference
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

	Outcome	Population Tested	Metabolites Measured	Metabolites Associated With Adverse Outcomes	Parent Phthalates* Associated with Adverse Outcomes	Reference
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

	Outcome	Population Tested	Metabolites Measured	Metabolites Associated With Adverse Outcomes	Parent Phthalates* Associated with Adverse Outcomes	Reference
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

	Outcome	Population Tested	Metabolites Measured	Metabolites Associated With Adverse Outcomes	Parent Phthalates* Associated with Adverse Outcomes	Reference
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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