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Supplemental Material

Associations of Organophosphate Ester Flame Retardant Exposures during Pregnancy with Gestational Duration and Fetal Growth: The Environmental influences on Child Health Outcomes (ECHO) Program

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Table S1. Information on 16 ECHO cohorts contributing to this study.

Cohort name	**# of samples included [% out of 6646] / # of samples not included [% out of 5825][a] (sample selection criteria)**	**Sample description**	**Eligibility criteria**	**Primary method for obtaining birth outcomes**
Atlanta ECHO Cohort of EMORY University	20 [0.3%] / 477 [8.2%] (participants selected at random)	African American women recruited from two prenatal clinics in Atlanta, GA and their offspring.	Eligible women were self-reported Black/African American race/ethnicity, had singleton pregnancies, self-reported that they were born in the United States, had English fluency, were aged 18–40 years old, and did not have IVF or pre-existing chronic medical conditions.	GA – calculated based on the EDD determined by the 1st or 2nd trimester ultrasound BW – medical records
Conditions Affecting Neurocognitive Development and Learning in Early Childhood (CANDLE)	1453 [21.9%] / 25 [0.4%] (all participants with an available urine sample)	A majority African American sample of mother-child dyads recruited in pregnancy in Memphis, TN from safety net obstetrical clinics and local OB/GYN partners, television and radio advertisements, and directed mailings.	Eligibility criteria included planning to deliver at one of five hospitals in Memphis, aged between 16-40 years, residence in Shelby County, TN, and having a low medical risk pregnancy. Eligible women had English fluency, had a singleton pregnancy, and were between 16-28 weeks gestation at enrollment.	GA & BW – medical records
Chemicals in our Bodies (CIOB)	394 [5.9%] / 411 [7.1%] (all participants who consented to ECHO and had sufficient urine volume at the time of shipment)	Pregnant women recruited from 2 hospitals in San Francisco, CA and their offspring.	Eligible mothers were fluent in English or Spanish, had singleton births, were ≥18 years of age, and had no major pregnancy complications.	GA & BW – medical records
Early Autism Risk Longitudinal Investigation (EARLI)	91 [1.4%] / 28 [0.5%] (participants who had signed an ECHO consent were included)[b]	Pregnant women with a biological child with autism spectrum disorder (ASD) and the offspring of the current pregnancy, recruited from local community events, autism conferences, direct mail via autism service providers, and online and social media.	Eligible women had a biological child who had been diagnosed with an ASD, were competent to communicate in English (or, at two sites, in Spanish), were 18 years of age or older, lived within two hours of a study clinic, and were no more than 28 weeks pregnant.	GA & BW – medical records

Cohort name	**# of samples included [% out of 6646] / # of samples not included [% out of 5825][a] (sample selection criteria)**	**Sample description**	**Eligibility criteria**	**Primary method for obtaining birth outcomes**
Fair Start	206 [3.1%] / 145 [2.5%] (all participants with sufficient urine volume)	Dominican or African American low-income mothers and their offspring recruited at OB/GYN clinics in New York, NY.	Eligible mothers were fluent in English or Spanish, had singleton pregnancies, and were ≥18 years of age.	GA & BW – medical records
Healthy Start	550 [8.3%] / 829 [14.2%] (all participants with sufficient remaining volume of stored urine from pregnancy)	Pregnant women recruited from obstetrics clinics at a university hospital in the Denver, Colorado metropolitan area and their offspring.	Eligible women were ≥16 years old, had singleton pregnancies, and had no history of previous stillbirth or extremely preterm birth, and no self-reported history of diabetes, cancer, asthma treated with steroids, or psychiatric conditions.	GA & BW – medical records
Illinois Kids Development Study (IKIDS)	283 [4.3%] / 221 [3.8%] (sufficient urine available and the women remained in the study until at least the birth of her child with some data collected)	Pregnant women recruited from 2 OB/GYN clinics in central Illinois and their offspring.	Eligible mothers were 18–40 years old, had singleton pregnancies, were not in a high-risk pregnancy, were fluent in English, and were not planning to leave the area before the child's first birthday.	GA – calculated based on the EDD determined by an ultrasound at 16-18 weeks BW – recorded from the crib card during the hospital visit
Maternal and Developmental Risks from Environmental and Social Stressors (MADRES)	425 [6.4%] / 310 [5.3%] (all participants with an available urine specimens at the 3rd trimester)	Pregnant women recruited from 4 OB/GYN clinics serving low income populations in Los Angeles, CA and their offspring.	Eligible mothers were ≥18 years old, had singleton pregnancies, were fluent speakers of English or Spanish, were not incarcerated, were not HIV positive, and had no physical, mental or cognitive disability that would prevent participation or informed consent.	GA – >95% of participants had EDD abstracted (and GA at birth calculated) from medical records from ultrasound measurements or physician estimates BW – medical records
Magee	75 [1.1%] / 254 [4.4%] (all participants with a sufficient urine volume)	Women recruited during the first trimester of pregnancy from clinics in Pittsburgh, PA serving high psychosocial risk populations, oversampled for childhood trauma, and their offspring.	Eligibility criteria for mothers at enrollment: Inclusion criteria were a) ≥18 years age, b) singleton, intrauterine pregnancy, c) ≤16 weeks gestation at recruitment, and d) fluency in English. Exclusion criteria were a) presence of congenital mal-formations or fetal chromosomal abnormalities; b) presence of	GA & BW – medical records

Cohort name	# of samples included [% out of 6646] / # of samples not included [% out of 5825][a] (sample selection criteria)	Sample description	Eligibility criteria	Primary method for obtaining birth outcomes
			any conditions that may dysregulate endocrine, immune or oxidative state or systemic inflammation, such as autoimmune disorders requiring chronic systemic steroid or immunomodulator use.	
University of California - Markers of Autism Risk in Babies – Learning Early Signs (MARBLES)	284 [4.3%] / 82 [1.4%] (all participants with an available urine sample who had birth outcome data or were still pregnant were included)	Pregnant women who have a biological child diagnosed with autism spectrum disorder (ASD) and the offspring of the current pregnancy, recruited from the California Department of Developmental Services list of families receiving services for a child with ASD.	Eligible women a) had one or more biological child(ren) or first-degree relatives with ASD or the gestating child had an older half-sibling with ASD; b) was ≥18 years old; d) was proficient in English and the gestating child would be taught to speak English; e) lived within 2.5 hours of the Davis/Sacramento region.	GA – ultrasound dating from the medical records; when it was not available, it was calculated from LMP based on maternal self-report BW – medical records
New Hampshire Birth Cohort Study (NHBCS)	1317 [19.8%] / 994 [17.1%] (urine samples with sufficient volume available selected from participants on whom we measured urinary tobacco biomarkers and who had completed a survey about smoking)	Pregnant women recruited from prenatal clinics in the rural New Hampshire and their offspring.	Eligible women were 18-45 years old, spoke English, had singleton pregnancies, and used a private, unregulated water system (e.g., private well) at home.	GA – ultrasounds occurring between 11 and 13 weeks when possible; otherwise, estimated using the LMP date BW – medical records
The NYU Children's Health and Environment Study (NYU CHES)	208 [3.1%] / 666 [11.4%] (randomly selected urine samples from women who provided urine in the 3rd trimester and included those who provided postnatal consent)	Pregnant women recruited from prenatal clinics at NYU Langone Medical Center study sites.	Eligible women were ≥18 years old, <18 weeks gestation, not carrying a medically threatened pregnancy, and intending to deliver at one of three NYU-affiliated hospitals.	GA & BW – primarily used electronic medical records; in case of missing data because the participant delivered outside NYU, self-report via questionnaire was used

Cohort name	# of samples included [% out of 6646] / # of samples not included [% out of 5825][a] (sample selection criteria)	Sample description	Eligibility criteria	Primary method for obtaining birth outcomes
Pregnancy Environment and Lifestyle Study (PETALS)	349 [5.3%] / 1076 [18.5%] (all participants who signed an ECHO consent by the time of sample selection)[b]	Women identified as pregnant via hospital records from 4 California hospitals recruited before 10 weeks gestation via telephone and their offspring.	Eligible women were aged 18–45 years, able to provide informed consent in English, had singleton pregnancies, and did not have a pre-conception history of diabetes, cancer, hepatitis C, or liver cirrhosis.	GA – calculated from EDD from medical records and confirmed with ultrasound BW – medical records
Rochester	280 [4.2%] / 16 [0.3%] (all participants with a urine sample from the 2nd and 3rd trimesters)	Women recruited during the first trimester of pregnancy from clinics in Rochester, NY serving high psychosocial risk populations, oversampled for psychosocial stress.	Eligible women were ≥18 years old, had singleton pregnancies, and had no known substance abuse issues or history of psychotic illness, no major endocrine disorder, high-risk health condition, or significant obstetric concern at baseline.	GA – medical records (generally based on earliest ultrasound) BW – medical records
The Infant Development and the Environment Study (TIDES)	612 [9.2%] / 167 [2.9%] (randomly selected from those with ECHO consent and urine available)[b]	Pregnant women recruited during the first trimester from prenatal clinics in Minnesota, New York, California, and Washington, and their offspring.	Eligible women were ≥18 years old, with a non-medically threatened singleton pregnancy and able to communicate in English.	GA – ultrasound dating from the medical records; when it was not available, it was calculated from LMP BW – medical records
Vitamin C to Decrease Effects of Smoking in Pregnancy on Infant Lung Function (VCSIP)	99 [1.5%] / 124 [2.1%] (all participants who signed an ECHO consent)[b]	Pregnant women who smoke receiving prenatal care at 3 clinics across the US (Indiana, Washington, Oregon) and their offspring.	Eligible women were at least 15 years old, pregnant with randomization prior to 22 weeks of gestation, cigarette smoker, singleton gestation, English speaking, and receiving prenatal care at clinics delivering at specific locations.	GA – calculated from EDD from medical records and confirmed with ultrasound; BW – medical records

Note: BW, birth weight; ECHO, Environmental influences on Child Health Outcomes; EDD, estimated date of delivery; GA, gestational age; LMP, last menstrual period.

[a]Among participants from 16 cohorts, 6646 pregnant people were included in this study, and 5825 pregnant people not included. Percentage of samples included in this study = (number of samples in each cohort included in this study / 6646) * 100; Percentage of samples not included in this study = (number of samples in each cohort not included in this study / 5825) * 100

[b]Cohorts that were recruited prior to the beginning of ECHO recontacted participants once ECHO began and to sign a second consent form to participate in ECHO.

Table S2. Information on nine OPE biomarkers quantified in prenatal maternal serum samples in the ECHO cohorts.

OPE biomarker	Parent compound
Diphenyl phosphate (DPHP)	Triphenyl phosphate (TPHP)
Composite of dibutyl phosphate and di-isobutyl phosphate (DBUP/DIBP)	Tributyl phosphate (TBUP), tri-isobutyl phosphate (TIBP)
Bis(1,3-dichloro-2-propyl) phosphate (BDCPP)	Tris(1,3-dichloro-2-propyl) phosphate (TDCPP)
Bis(2-chloroethyl) phosphate (BCETP)	Tris(2-chloroethyl) phosphate (TCETP)
Bis(butoxyethyl) phosphate (BBOEP)	Tris (2-butoxyethyl) phosphate (TBOEP)
Bis(1-chloro-2-propyl) phosphate (BCPP)	Tris(1-chloro-2-propyl) phosphate (TCPP)
Bis(2-methylphenyl) phosphate (BMPP)	Tris(2-methylphenyl) phosphate (TMPP)
Bis(2-ethylhexyl) phosphate (BEHP)	Tris(2-ethylhexyl) phosphate (TEHP)
Dipropyl phosphate (DPRP)	Tripropyl phosphate (TPRP)

Note: ECHO, Environmental influences on Child Health Outcomes; OPE, organophosphate ester.

Table S3. Demographic characteristics of participants from 16 ECHO cohorts by study sample inclusion status.

Characteristics	Included (*n*=6646) *n* (%)[a]	Not included (*n*=5825) *n* (%)[a]
Maternal race/ethnicity		
Non-Hispanic White	3470 (52.5%)	2575 (44.9%)
Non-Hispanic Black	1288 (19.5%)	911 (15.9%)
Hispanic	1251 (18.9%)	1614 (28.1%)
Other races[b]	597 (9.0%)	634 (11.1%)
Missing	40	91
Maternal education		
Less than high school	535 (8.6%)	487 (9.5%)
High school degree, GED or equivalent	1337 (21.4%)	869 (17.0%)
Some college, no/associate degree, trade school	1115 (17.9%)	1311 (25.6%)
Bachelor's degree	1727 (27.7%)	1253 (24.5%)
Masters, professional, or doctorate degree	1522 (24.4%)	1204 (23.5%)
Missing	410	701
Maternal marital status		
Married or living with a partner	4768 (76.2%)	3755 (74.2%)
Widowed, separated, divorced	280 (4.5%)	182 (3.6%)
Single, never married, partnered, not living together	1213 (19.4%)	1127 (22.3%)
Missing	385	761
Maternal age at delivery (year)		
<20	209 (3.1%)	580 (10.0%)
20-24	975 (14.7%)	836 (14.4%)
25-29	1653 (24.9%)	1268 (21.8%)
30-34	2218 (33.4%)	1745 (30.0%)
35-39	1290 (19.4%)	1126 (19.3%)
≥40	301 (4.5%)	270 (4.6%)
Parity		
0	2566 (42.8%)	2493 (51.9%)
1	1994 (33.3%)	1521 (31.6%)
≥2	1436 (23.9%)	793 (16.5%)
Missing	650	1018
Pre-pregnancy BMI (kg/m^2)		
<25	3043 (48.8%)	2233 (49.4%)
25-30	1641 (26.3%)	1185 (26.2%)
>30	1552 (24.9%)	1099 (24.3%)
Missing	410	1308
Tobacco use during pregnancy		
No	5123 (92.8%)	4170 (92.8%)
Yes	396 (7.2%)	324 (7.2%)
Missing	1127	1331
Child's sex		

Female	3250 (48.9%)	2844 (49.9%)
Male	3396 (51.1%)	2851 (50.1%)

Note: BMI, body mass index; ECHO, Environmental influences on Child Health Outcomes; GED, general educational development.

[a]Percentage was calculated without missing observations.

[b]Other races include Asian, native Hawaiian or other Pacific Islanders, American Indian or Alaska native, and multiple race.

Table S4. Distributions of urinary dilution-standardized OPE biomarker concentrations by ECHO cohort.

Cohort name	DPHP	DBUP/DIBP	BDCPP	BCETP	BBOEP	BCPP	BMPP	BEHP	DPRP
	Median (25th, 75th, percentile)								
All	0.92 (0.54, 1.78)	0.19 (0.12, 0.30)	0.86 (0.31, 1.70)	0.52 (<LOD, 1.58)	0.05 (<LOD, 0.09)	0.12 (<LOD, 0.75)	<LOD (<LOD, 0.03)	<LOD (<LOD, 0.04)	<LOD (<LOD, 0.03)
Atlanta ECHO	1.49 (1.17, 2.43)	0.17 (0.11, 0.30)	1.28 (0.81, 2.09)	0.55 (<LOD, 1.32)	0.04 (<LOD, 0.09)	0.11 (<LOD, 0.60)	0.06 (0.03, 0.08)	<LOD (<LOD, <LOD)	<LOD (<LOD, <LOD)
CANDLE	1.15 (0.72, 2.34)	0.21 (0.15, 0.31)	1.15 (0.45, 2.08)	0.91 (0.22, 2.51)	0.05 (<LOD, 0.10)	<LOD (<LOD, 0.70)	<LOD (<LOD, 0.04)	<LOD (<LOD, 0.04)	<LOD (<LOD, 0.03)
CIOB	0.50 (0.33, 1.05)	0.14 (0.09, 0.25)	0.38 (0.08, 0.86)	0.14 (<LOD, 0.68)	<LOD (<LOD, 0.05)	0.14 (<LOD, 0.57)	<LOD (<LOD, <LOD)	<LOD (<LOD, 0.03)	<LOD (<LOD, 0.07)
EARLI	1.06 (0.62, 1.70)	0.15 (0.12, 0.22)	0.94 (0.37, 1.77)	1.04 (0.36, 2.46)	0.04 (<LOD, 0.07)	0.49 (0.06, 1.19)	0.02 (<LOD, 0.07)	<LOD (<LOD, 0.02)	<LOD (<LOD, 0.05)
Fair Start	0.97 (0.60, 1.94)	0.21 (0.16, 0.33)	0.83 (0.25, 1.70)	0.26 (<LOD, 1.51)	0.06 (<LOD, 0.11)	0.25 (<LOD, 0.98)	<LOD (<LOD, 0.03)	<LOD (<LOD, 0.09)	<LOD (<LOD, <LOD)
Healthy Start	1.18 (0.73, 2.04)	0.15 (0.11, 0.22)	1.02 (0.55, 2.01)	0.77 (0.29, 1.79)	0.04 (<LOD, 0.07)	0.27 (<LOD, 0.83)	<LOD (<LOD, 0.04)	<LOD (<LOD, <LOD)	<LOD (<LOD, <LOD)
IKIDS	1.14 (0.76, 1.74)	0.16 (0.11, 0.24)	0.91 (0.31, 1.72)	0.47 (<LOD, 1.25)	0.06 (0.03, 0.10)	0.35 (<LOD, 0.90)	<LOD (<LOD, 0.04)	<LOD (<LOD, 0.02)	<LOD (<LOD, <LOD)
MADRES	0.77 (0.47, 1.46)	0.18 (0.12, 0.26)	1.29 (0.61, 2.29)	0.52 (<LOD, 1.62)	0.04 (<LOD, 0.07)	0.17 (<LOD, 0.77)	<LOD (<LOD, 0.03)	<LOD (<LOD, 0.02)	<LOD (<LOD, <LOD)
Magee	1.02 (0.59, 1.51)	0.19 (0.13, 0.32)	0.89 (0.39, 1.85)	0.29 (<LOD, 1.12)	0.05 (<LOD, 0.09)	0.59 (<LOD, 1.17)	<LOD (<LOD, 0.04)	<LOD (<LOD, 0.08)	<LOD (<LOD, 0.04)
MARBLES	0.94 (0.63, 1.67)	0.17 (0.11, 0.27)	0.97 (0.36, 1.98)	0.74 (0.23, 1.53)	0.04 (<LOD, 0.08)	0.38 (<LOD, 1.03)	<LOD (<LOD, 0.03)	<LOD (<LOD, 0.04)	<LOD (<LOD, <LOD)
NHBCS	0.61 (0.28, 1.38)	0.17 (0.10, 0.30)	0.46 (0.12, 1.03)	0.23 (<LOD, 0.95)	0.05 (<LOD, 0.10)	0.03 (<LOD, 0.57)	<LOD (<LOD, 0.03)	<LOD (<LOD, <LOD)	<LOD (<LOD, 0.04)
NYU CHES	0.99 (0.58, 1.80)	0.45 (0.26, 0.81)	0.45 (0.08, 1.42)	0.03 (<LOD, 1.17)	0.04 (<LOD, 0.09)	<LOD (<LOD, 0.66)	<LOD (<LOD, <LOD)	<LOD (<LOD, 0.14)	<LOD (<LOD, <LOD)
PETALS	0.89 (0.58, 1.59)	0.19 (0.12, 0.34)	1.06 (0.51, 1.94)	0.64 (<LOD, 2.40)	0.05 (<LOD, 0.10)	0.24 (<LOD, 0.92)	<LOD (<LOD, 0.02)	<LOD (<LOD, 0.13)	<LOD (<LOD, <LOD)
Rochester	0.99 (0.63, 1.71)	0.18 (0.12, 0.27)	1.17 (0.55, 2.13)	0.29 (<LOD, 1.32)	0.05 (<LOD, 0.09)	0.27 (<LOD, 0.77)	<LOD (<LOD, 0.04)	<LOD (<LOD, 0.04)	<LOD (<LOD, 0.04)
TIDES	1.03 (0.58, 3.11)	0.18 (0.13, 0.31)	0.66 (0.22, 1.46)	0.50 (<LOD, 1.47)	0.05 (<LOD, 0.10)	<LOD (<LOD, 0.53)	<LOD (<LOD, 0.02)	<LOD (<LOD, 0.12)	<LOD (<LOD, 0.03)
VCSIP	0.92 (0.62, 2.12)	0.18 (0.13, 0.30)	1.04 (0.57, 1.56)	0.49 (0.17, 1.27)	0.04 (<LOD, 0.07)	0.17 (<LOD, 0.75)	<LOD (<LOD, 0.03)	<LOD (<LOD, 0.04)	<LOD (<LOD, <LOD)

Note: LOD values were 0.04 ng/mL for DBUP/DIBP, 0.03 ng/mL for DPHP and DPRP, 0.02 ng/mL for BDCPP, BCETP, BBOEP, BCPP, and BEHP, and 0.01 ng/mL for BMPP. BBOEP, bis(butoxyethyl) phosphate; BCETP, bis(2-chloroethyl) phosphate; BCPP, bis(1-chloro-2-propyl) phosphate; BDCPP, bis(1,3-dichloro-2-propyl) phosphate; BEHP, bis(2-ethylhexyl) phosphate; BMPP, bis(2-methylphenyl) phosphate; DBUP/DIBP, composite of dibutyl phosphate and di-isobutyl phosphate; DPHP, diphenyl phosphate; DPRP, dipropyl phosphate; ECHO, Environmental influences on Child Health Outcomes; OPE, organophosphate ester. Cohort names are provided in Table S1.

Table S5. Spearman's correlation coefficients among urinary dilution-standardized OPE biomarker concentrations among 6646 ECHO pregnant participants.

OPE biomarker	DPHP	DBUP/ DIBP	BDCPP	BCETP	BBOEP	BCPP	BMPP	BEHP	DPRP
DPHP	1.000	0.167 (<.001)	0.262 (<.001)	0.189 (<.001)	0.092 (<.001)	0.018 (0.148)	0.020 (0.105)	0.046 (<.001)	-0.054 (<.001)
DBUP/DIBP		1.000	0.077 (<.001)	0.063 (<.001)	0.195 (<.001)	0.040 (0.001)	0.010 (0.422)	0.253 (<.001)	0.081 (<.001)
BDCPP			1.000	0.149 (<.001)	0.088 (<.001)	0.106 (<.001)	0.118 (<.001)	0.053 (<.001)	0.004 (0.759)
BCETP				1.000	0.058 (<.001)	0.079 (<.001)	0.037 (0.003)	-0.017 (0.179)	0.045 (<.001)
BBOEP					1.000	0.056 (<.001)	0.116 (<.001)	0.127 (<.001)	0.087 (<.001)
BCPP						1.000	0.216 (<.001)	0.058 (<.001)	0.166 (<.001)
BMPP							1.000	0.019 (0.128)	0.243 (<.001)
BEHP								1.000	0.126 (<.001)
DPRP									1.000

Note: Numbers in cells indicate Spearman's correlation coefficients (*p*-values). BBOEP, bis(butoxyethyl) phosphate; BCETP, bis(2-chloroethyl) phosphate; BCPP, bis(1-chloro-2-propyl) phosphate; BDCPP, bis(1,3-dichloro-2-propyl) phosphate; BEHP, bis(2-ethylhexyl) phosphate; BMPP, bis(2-methylphenyl) phosphate; DBUP/DIBP, composite of dibutyl phosphate and di-isobutyl phosphate; DPHP, diphenyl phosphate; DPRP, dipropyl phosphate; ECHO, Environmental influences on Child Health Outcomes; OPE, organophosphate ester.

Table S6. Analysis results of urinary OPE biomarker concentrations in 191 blinded duplicate samples.

OPE biomarkers	LOD (ng/mL)	% >LOD (*n*=6646)	# of valid duplicate pairs (%)[a]	RPD[b] median (%)	# of discordant pairs (%)[c]	# of concordant pairs (%)[d]
DPHP	0.03	99.5	191 (100%)	6.2	0 (0%)	0 (0%)
DBUP/DIBP	0.04	95	179 (94%)	16.9	12 (6%)	0 (0%)
BDCPP	0.02	87	163 (85%)	12.3	19 (10%)	9 (5%)
BCETP	0.02	69	127 (66%)	13.3	35 (18%)	29 (15%)
BBOEP	0.02	66	99 (52%)	18.3	78 (41%)	14 (7%)
BCPP	0.02	53	71 (37%)	26.6	68 (36%)	52 (27%)
BMPP	0.01	36	38 (20%)	17.8	59 (31%)	94 (49%)
BEHP	0.02	30	21 (11%)	53.6	64 (34%)	106 (55%)
DPRP	0.03	25	9 (5%)	32.7	51 (27%)	131 (69%)

Note: A total of 191 duplicate samples is the sum of the number of valid duplicate pairs, discordant pairs, and concordant pairs. BBOEP, bis(butoxyethyl) phosphate; BCETP, bis(2-chloroethyl) phosphate; BCPP, bis(1-chloro-2-propyl) phosphate; BDCPP, bis(1,3-dichloro-2-propyl) phosphate; BEHP, bis(2-ethylhexyl) phosphate; BMPP, bis(2-methylphenyl) phosphate; DBUP/DIBP, composite of dibutyl phosphate and di-isobutyl phosphate; DPHP, diphenyl phosphate; DPRP, dipropyl phosphate; LOD, limit of detection; OPE, organophosphate ester; RPD, relative percent difference.

[a]Number of duplicate pairs where both were ≥LOD.

[b]RPD = |sample result – repeat result|/(sample result + repeat result)*100.

[c]Number of duplicate pairs where one was <LOD and the other one was ≥LOD.

[d]Number of duplicate pairs where both were <LOD.

Table S7. Sex-stratified associations between prenatal maternal urinary OPE biomarkers and gestational duration in the ECHO cohorts and *p*-value for the interaction term between child's sex and OPE biomarkers to test for effect measure modification.

		Gestational age (weeks)		Preterm (vs. full-term)		Early-term (vs. full-term)		Late/post-term (vs. full-term)	
OPE biomarkers	Sex	β (95% CI)	p_{int}	OR (95% CI)	p_{int}	OR (95% CI)	p_{int}	OR (95% CI)	p_{int}
Continuous (log2-transformed, dilution-standardized)									
DPHP	F	**-0.03 (-0.06, -0.01)**	**0.01**	**1.12 (1.05, 1.19)**	**<0.01**	1.01 (0.96, 1.05)	**0.02**	1.00 (0.93, 1.07)	0.99
	M	**0.02 (0.00, 0.04)**		0.97 (0.86, 1.09)		0.98 (0.90, 1.07)		1.00 (0.96, 1.04)	
DBUP/DIBP	F	**-0.03 (-0.06, 0.00)**	0.46	**1.09 (1.03, 1.16)**	0.33	0.99 (0.91, 1.09)	1.00	1.00 (0.92, 1.07)	0.96
	M	-0.01 (-0.08, 0.06)		1.00 (0.93, 1.09)		1.00 (0.93, 1.08)		1.00 (0.98, 1.01)	
BDCPP	F	-0.01 (-0.02, 0.01)	0.91	1.00 (0.97, 1.04)	0.94	0.99 (0.97, 1.01)	**0.10**	1.00 (0.98, 1.02)	0.17
	M	-0.01 (-0.02, 0.02)		1.00 (0.94, 1.06)		1.01 (0.97, 1.05)		0.99 (0.96, 1.02)	
High/Low (compared with nondetect)									
BCETP – Low	F	-0.08 (-0.21, 0.06)	0.24	1.18 (0.90, 1.55)	0.11	0.94 (0.73, 1.23)	0.86	**0.82 (0.71, 0.96)**	0.95
	M	0.05 (-0.08, 0.18)		0. 80 (0.56, 1.14)		0.96 (0.78, 1.19)		0.84 (0.68, 1.04)	
BCETP – High	F	**-0.13 (-0.24, -0.03)**	**<0.01**	**1.27 (1.03, 1.58)**	**<0.01**	0.96 (0.86, 1.07)	0.96	0.96 (0.83, 1.11)	0.76
	M	0.06 (-0.06, 0.18)		0.77 (0.55, 1.06)		0.97 (0.77, 1.21)		0.92 (0.72, 1.17)	
BBOEP – Low	F	0.07 (-0.08, 0.21)	0.15	0.88 (0.61, 1.28)	0.17	0.84 (0.69, 1.02)	0.15	0.95 (0.77, 1.17)	0.48
	M	-0.07 (-0.18, 0.05)		1.26 (0.93, 1.70)		1.00 (0.78, 1.27)		1.11 (0.82, 1.49)	
BBOEP – High	F	-0.07 (-0.23, 0.09)	0.87	1.32 (0.99, 1.76)	0.79	**0.75 (0.60, 0.94)**	**0.03**	0.95 (0.69, 1.31)	0.36
	M	-0.08 (-0.21 ,0.04)		1.19 (0.90, 1.57)		1.10 (0.89, 1.35)		1.11 (0.84, 1.47)	
BCPP – Low	F	0.06 (-0.05, 0.18)	0.97	0.81 (0.62, 1.05)	0.65	1.12 (0.95, 1.32)	0.42	1.06 (0.82, 1.36)	0.26
	M	0.09 (-0.02, 0.20)		0.85 (0.63, 1.13)		0.99 (0.82, 1.20)		**1.24 (1.04, 1.48)**	
BCPP – High	F	-0.02 (-0.12, 0.08)	0.73	0.96 (0.72, 1.27)	0.76	**1.25 (1.03, 1.51)**	0.57	1.03 (0.84, 1.28)	0.56
	M	-0.03 (-0.13, 0.07)		0.99 (0.74, 1.32)		1.13 (0.94, 1.37)		1.10 (0.90, 1.35)	
Detect (compared with nondetect)									
BMPP	F	-0.05 (-0.15, 0.05)	0.64	0.94 (0.75, 1.17)	0.50	1.03 (0.88, 1.21)	0.93	0.90 (0.69, 1.18)	0.20
	M	0.00 (-0.13, 0.12)		1.01 (0.77, 1.34)		1.01 (0.81, 1.26)		1.02 (0.89, 1.17)	
BEHP	F	-0.12 (-0.27, 0.02)	0.21	1.07 (0.78, 1.46)	0.62	1.05 (0.89, 1.24)	0.59	**0.75 (0.60, 0.94)**	**0.08**
	M	-0.02 (-0.16, 0.11)		0.99 (0.78, 1.27)		1.00 (0.79, 1.27)		0.99 (0.90, 1.08)	
DPRP	F	0.08 (-0.07, 0.23)	0.84	0.94 (0.64, 1.38)	0.85	1.08 (0.90, 1.29)	0.51	**1.25 (1.02, 1.52)**	0.35
	M	0.08 (-0.02, 0.19)		0.97 (0.74, 1.28)		1.00 (0.83, 1.20)		1.02 (0.89, 1.18)	

Note: Sample size of each birth outcome by child's sex is presented in Table 2. Regression models were adjusted for maternal race/ethnicity, maternal age at delivery, maternal education, maternal marital status, maternal pre-pregnancy BMI, maternal smoking during pregnancy, parity, and sample collection season and year. Estimates with *p*-values less than 0.05 and interaction term (child's sex × OPE) with *p*-values less than 0.1 are highlighted in bold. BBOEP, bis(butoxyethyl) phosphate; BCETP, bis(2-chloroethyl) phosphate; BCPP, bis(1-chloro-2-propyl) phosphate; BDCPP, bis(1,3-dichloro-2-propyl) phosphate; BEHP, bis(2-ethylhexyl)

phosphate; BMPP, bis(2-methylphenyl) phosphate; BW-GA, birth weight-for-gestational-age; CI, confidence interval; DBUP/DIBP, composite of dibutyl phosphate and di-isobutyl phosphate; DPHP, diphenyl phosphate; DPRP, dipropyl phosphate; ECHO, Environmental influences on Child Health Outcomes; F, female; LBW, low birth weight; M, male; OPE, organophosphate ester; OR, odds ratio.

Table S8. Sex-stratified associations between prenatal maternal urinary OPE biomarkers and fetal growth in the ECHO cohorts and *p*-value for the interaction term between child's sex and OPE biomarkers to test for effect measure modification.

				Term LBW					
		BW-GA z-score		(vs. term non-LBW)[a]		SGA		LGA	
OPE biomarkers	Sex	β (95% CI)	p_{int}	OR (95% CI)	p_{int}	β (95% CI)	p_{int}	OR (95% CI)	p_{int}
Continuous (log2-transformed, dilution-standardized)									
DPHP	F	**-0.02 (-0.03, 0.00)**	0.28	1.02 (0.87, 1.19)	0.27	1.03 (0.97, 1.09)	0.48	0.98 (0.92, 1.04)	**0.03**
	M	-0.03 (-0.06, 0.01)		**1.10 (1.01, 1.21)**		1.08 (0.96, 1.22)		**0.95 (0.91, 1.00)**	
DBUP/DIBP	F	-0.02 (-0.05, 0.02)	0.93	0.90 (0.74, 1.09)	0.76	1.04 (0.95, 1.15)	0.63	0.93 (0.85, 1.01)	0.21
	M	-0.02 (-0.04, 0.01)		0.94 (0.77, 1.14)		0.99 (0.91, 1.07)		1.01 (0.96, 1.06)	
BDCPP	F	-0.01 (-0.02, 0.01)	0.87	0.97 (0.93, 1.02)	0.50	1.01 (0.97, 1.05)	0.20	0.99 (0.96, 1.01)	0.53
	M	0.00 (-0.01, 0.00)		0.99 (0.94, 1.04)		**0.96 (0.94, 0.99)**		0.98 (0.96, 1.01)	
High/Low (compared with nondetect)									
BCETP – Low	F	0.05 (-0.04, 0.14)	0.35	1.01 (0.62, 1.65)	0.44	1.09 (0.76, 1.57)	**0.02**	**1.28 (1.04, 1.56)**	**<0.01**
	M	0.02 (-0.08, 0.11)		0.86 (0.43, 1.71)		**0.73 (0.55, 0.97)**		0.99 (0.82, 1.20)	
BCETP – High	F	0.01 (-0.10, 0.12)	0.85	0.67 (0.37, 1.22)	0.19	0.85 (0.59, 1.22)	0.96	1.02 (0.76, 1.35)	0.71
	M	0.04 (-0.02, 0.10)		1.22 (0.65, 2.30)		**0.77 (0.62, 0.97)**		1.05 (0.90, 1.23)	
BBOEP – Low	F	0.00 (-0.05, 0.04)	0.66	1.05 (0.71, 1.56)	0.44	0.91 (0.64, 1.29)	0.75	1.03 (0.88, 1.22)	0.69
	M	0.03 (-0.08, 0.13)		0.68 (0.29, 1.59)		0.79 (0.47, 1.33)		0.97 (0.77, 1.22)	
BBOEP – High	F	0.01 (-0.06, 0.09)	0.21	1.07 (0.70, 1.64)	0.89	1.10 (0.81, 1.51)	0.80	1.07 (0.85, 1.36)	0.15
	M	-0.05 (-0.17, 0.06)		0.95 (0.60, 1.51)		0.94 (0.64, 1.38)		0.90 (0.74, 1.09)	
BCPP – Low	F	0.07 (-0.01, 0.15)	0.89	0.92 (0.66, 1.28)	0.16	0.88 (0.62, 1.26)	0.11	1.09 (0.85, 1.41)	0.95
	M	0.07 (-0.04, 0.17)		0.56 (0.30, 1.03)		**0.71 (0.55, 0.91)**		1.05 (0.89, 1.24)	
BCPP – High	F	0.04 (-0.06, 0.14)	0.16	0.63 (0.34, 1.18)	0.27	0.96 (0.66, 1.41)	0.13	1.09 (0.88, 1.34)	0.47
	M	**0.11 (0.03, 0.19)**		**0.36 (0.15, 0.88)**		**0.69 (0.48, 1.00)**		1.02 (0.83, 1.25)	
Detect (compared with nondetect)									
BMPP	F	**0.09 (0.02, 0.17)**	0.26	1.01 (0.64, 1.62)	0.45	0.94 (0.75, 1.18)	0.26	1.16 (0.97, 1.38)	0.53
	M	0.05 (-0.01, 0.11)		0.90 (0.60, 1.34)		**0.73 (0.55, 0.98)**		1.06 (0.80, 1.41)	
BEHP	F	-0.02 (-0.09, 0.04)	0.88	1.28 (0.94, 1.74)	0.98	1.09 (0.87, 1.36)	0.83	0.91 (0.71, 1.16)	0.54
	M	-0.04 (-0.12, 0.04)		1.30 (0.67, 2.52)		1.12 (0.86, 1.46)		1.00 (0.81, 1.22)	
DPRP	F	0.05 (-0.01, 0.10)	0.84	0.73 (0.49, 1.09)	0.81	0.81 (0.62, 1.05)	0.19	1.05 (0.86, 1.27)	0.20
	M	0.03 (0.00, 0.07)		0.70 (0.41, 1.17)		0.97 (0.82, 1.15)		1.13 (0.97, 1.31)	

Note: Sample size of each birth outcome by child's sex is presented in Table 2. Regression models were adjusted for maternal race/ethnicity, maternal age at delivery, maternal education, maternal marital status, maternal pre-pregnancy BMI, maternal smoking during pregnancy, parity, and sample collection season and year. Estimates with *p*-values less than 0.05 and interaction term (child's sex × OPE) with *p*-values less than 0.1 are highlighted in bold. BBOEP, bis(butoxyethyl) phosphate; BCETP, bis(2-chloroethyl)

phosphate; BCPP, bis(1-chloro-2-propyl) phosphate; BDCPP, bis(1,3-dichloro-2-propyl) phosphate; BEHP, bis(2-ethylhexyl) phosphate; BMPP, bis(2-methylphenyl) phosphate; BW-GA, CI, confidence interval; birth weight-for-gestational-age; DBUP/DIBP, composite of dibutyl phosphate and di-isobutyl phosphate; DPHP, diphenyl phosphate; DPRP, dipropyl phosphate; ECHO, Environmental influences on Child Health Outcomes; F, female; LBW, low birth weight; M, male; OPE, organophosphate ester; OR, odds ratio.

[a]LBW vs. non-LBW among 6197 non-preterm birth (≥37 weeks gestation).

Table S9. Associations between prenatal maternal urinary OPE biomarkers and gestational duration in the ECHO cohorts when jointly modelling all OPE biomarkers in the same regression model.

	Gestational age (weeks) [*n*=6646]		Preterm [*n*=449] (vs. full-term [*n*=3947])		Early-term [*n*=1436] (vs. full-term [*n*=3947])		Late/post-term [*n*=814] (vs. full-term [*n*=3947])	
OPE biomarkers	β (95% CI)	*p*-value	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Continuous (log2-transformed, dilution-standardized)								
DPHP	0.00 (-0.02, 0.02)	0.99	1.01 (0.95, 1.09)	0.71	0.98 (0.95, 1.01)	0.14	1.00 (0.96, 1.05)	0.91
DBUP/DIBP	-0.02 (-0.05, 0.02)	0.39	1.06 (1.02, 1.11)	0.01	1.00 (0.95, 1.06)	0.95	1.00 (0.97, 1.03)	0.96
BDCPP	0.00 (-0.02, 0.01)	0.40	1.00 (0.97, 1.04)	0.94	1.01 (1.00, 1.02)	0.27	0.99 (0.97, 1.00)	0.07
High/Low (compared with nondetect)								
BCETP – Low	-0.03 (-0.12, 0.07)	0.59	0.99 (0.79, 1.24)	0.94	0.95 (0.81, 1.10)	0.47	0.80 (0.72, 0.90)	<0.001
BCETP – High	-0.03 (-0.12, 0.06)	0.51	0.97 (0.80, 1.18)	0.76	0.96 (0.84, 1.09)	0.50	0.91 (0.77, 1.08)	0.29
BBOEP – Low	0.01 (-0.06, 0.08)	0.80	1.06 (0.88, 1.29)	0.53	0.90 (0.75, 1.09)	0.28	1.03 (0.87, 1.21)	0.76
BBOEP – High	-0.06 (-0.12, 0.01)	0.12	1.23 (1.06, 1.42)	0.01	0.91 (0.78, 1.06)	0.20	1.04 (0.81, 1.33)	0.75
BCPP – Low	0.08 (-0.01, 0.17)	0.07	0.84 (0.67, 1.05)	0.13	1.05 (0.92, 1.18)	0.47	1.19 (1.01, 1.39)	0.04
BCPP – High	-0.01 (-0.10, 0.09)	0.92	0.96 (0.74, 1.25)	0.76	1.19 (1.04, 1.36)	0.01	1.08 (0.93, 1.25)	0.30
Detect (compared with nondetect)								
BMPP	-0.03 (-0.11, 0.05)	0.53	1.01 (0.87, 1.17)	0.88	1.03 (0.90, 1.18)	0.64	0.99 (0.83, 1.18)	0.89
BEHP	-0.06 (-0.16, 0.04)	0.22	0.95 (0.79, 1.15)	0.62	1.04 (0.92, 1.18)	0.51	0.83 (0.71, 0.97)	0.02
DPRP	0.09 (-0.01, 0.20)	0.08	0.89 (0.69, 1.15)	0.36	1.03 (0.93, 1.14)	0.60	1.18 (0.98, 1.42)	0.09

Note: Regression models were adjusted for maternal race/ethnicity, maternal age at delivery, maternal education, maternal marital status, maternal pre-pregnancy BMI, maternal smoking during pregnancy, parity, child's sex, and sample collection season and year. BBOEP, bis(butoxyethyl) phosphate; BCETP, bis(2-chloroethyl) phosphate; BCPP, bis(1-chloro-2-propyl) phosphate; BDCPP, bis(1,3-dichloro-2-propyl) phosphate; BEHP, bis(2-ethylhexyl) phosphate; BMPP, bis(2-methylphenyl) phosphate; BW-GA, birth weight-for-gestational-age; CI, confidence interval; DBUP/DIBP, composite of dibutyl phosphate and di-isobutyl phosphate; DPHP, diphenyl phosphate; DPRP, dipropyl phosphate; ECHO, Environmental influences on Child Health Outcomes; LBW, low birth weight; OPE, organophosphate ester; OR, odds ratio.

Table S10. Associations between prenatal maternal urinary OPE biomarkers and fetal growth in the ECHO cohorts when jointly modelling all OPE biomarkers in the same regression model.

	BW-GA z-score (*n*=6646)		Term LBW [*n*=150] (vs. term non-LBW [*n*=6047])[a]		SGA [*n*=419] (vs. non-SGA [*n*=6227])		LGA [*n*=1066] (vs. non-LGA [*n*=5580])	
OPE biomarkers	β (95% CI)	*p*-value	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Continuous (log2-transformed, dilution-standardized)								
DPHP	-0.02 (-0.04, 0.01)	0.13	1.06 (0.98, 1.15)	0.14	1.05 (1.00, 1.10)	0.04	0.97 (0.92, 1.03)	0.32
DBUP/DIBP	-0.01 (-0.03, 0.01)	0.38	0.89 (0.78, 1.02)	0.10	1.00 (0.94, 1.07)	0.99	0.98 (0.94, 1.02)	0.39
BDCPP	0.00 (-0.01, 0.01)	0.45	0.98 (0.96, 1.01)	0.15	0.99 (0.97, 1.01)	0.17	0.98 (0.96, 1.00)	0.12
High/Low (compared with nondetect)								
BCETP – Low	0.02 (-0.06, 0.10)	0.61	1.07 (0.64, 1.79)	0.81	0.96 (0.74, 1.25)	0.65	1.11 (0.93, 1.33)	0.23
BCETP – High	0.03 (-0.01, 0.07)	0.16	0.98 (0.62, 1.56)	0.93	0.84 (0.71, 0.99)	0.04	1.05 (0.94, 1.17)	0.42
BBOEP – Low	0.00 (-0.04, 0.05)	0.88	0.96 (0.70, 1.33)	0.82	0.90 (0.75, 1.08)	0.24	0.99 (0.89, 1.10)	0.83
BBOEP – High	-0.02 (-0.10, 0.05)	0.57	1.07 (0.75, 1.52)	0.71	1.05 (0.92, 1.21)	0.44	0.99 (0.85, 1.15)	0.85
BCPP – Low	0.06 (0.00, 0.12)	0.05	0.76 (0.56, 1.02)	0.07	0.82 (0.62, 1.08)	0.16	1.05 (0.89, 1.22)	0.59
BCPP – High	0.06 (-0.02, 0.14)	0.13	0.52 (0.31, 0.88)	0.02	0.88 (0.65, 1.19)	0.40	1.03 (0.85, 1.24)	0.77
Detect (compared with nondetect)								
BMPP	0.06 (0.01, 0.10)	0.02	1.08 (0.68, 1.70)	0.75	0.87 (0.70, 1.09)	0.24	1.09 (0.94, 1.26)	0.27
BEHP	-0.01 (-0.07, 0.05)	0.69	1.26 (0.96, 1.67)	0.10	1.04 (0.87, 1.25)	0.67	0.98 (0.82, 1.17)	0.80
DPRP	0.03 (0.00, 0.06)	0.06	0.72 (0.54, 0.97)	0.03	0.90 (0.75, 1.08)	0.24	1.07 (0.92, 1.25)	0.37

Note: Regression models were adjusted for maternal race/ethnicity, maternal age at delivery, maternal education, maternal marital status, maternal pre-pregnancy BMI, maternal smoking during pregnancy, parity, child's sex, and sample collection season and year. BBOEP, bis(butoxyethyl) phosphate; BCETP, bis(2-chloroethyl) phosphate; BCPP, bis(1-chloro-2-propyl) phosphate; BDCPP, bis(1,3-dichloro-2-propyl) phosphate; BEHP, bis(2-ethylhexyl) phosphate; BMPP, bis(2-methylphenyl) phosphate; BW-GA, birth weight-for-gestational-age; CI, confidence interval; DBUP/DIBP, composite of dibutyl phosphate and di-isobutyl phosphate; DPHP, diphenyl phosphate; DPRP, dipropyl phosphate; ECHO, Environmental influences on Child Health Outcomes; LBW, low birth weight; OPE, organophosphate ester; OR, odds ratio.

[a]LBW vs. non-LBW among 6197 non-preterm birth (≥37 weeks gestation).

Table S11. Median concentrations of prenatal maternal urinary OPE biomarkers across birth cohort studies.

Country/ recruitment or sampling year	Study population (*n*)	Median concentrations (ng/mL)						GA at sample collection	Reference
		DPHP	DBUP/ DIBP	BDCPP	BCETP	BBOEP	BCPP		
U.S. / 2007-2020	ECHO (*n*=6646)	0.92	0.19	0.86	0.52	0.05	0.12	1st-3rd trimester	This study
U.S. (CA) / 1999-2000	CHAMACOS (*n*=310)	0.93		0.41				26 weeks	Castorina et al. 2017[1]
U.S. (NC) / 2001-2006	PIN (*n*=349)	1.31		1.85			<0.33	24-30 weeks	Hoffman et al. 2018[2]
U.S. (OH) / 2003-2006	HOME (*n*=357)	1.43 (16w), 1.36 (26w), 2.16 (birth)	0.24 (16w, 26w, birth) [a]	0.70 (16w), 0.70 (26w), 0.83 (birth)	0.63 (16w), 0.75 (26w), 0.83 (birth)			16 and 26 weeks, at delivery	Percy et al. 2020[3]
U.S. (MA) / 2010-2017	LIFECODES (*n*=90)	0.74		0.67				11, 26, 35 weeks	Bommarito et al. 2021[4]
U.S. (PR) / 2011-2015	PROTECT (n=148)	1.55		1.41	0.84		0.26	20, 28 weeks	Ingle et al. 2019[5]
U.S. (RI) / 2014	Women and Infants Hospital of Rhode Island (*n*=58)	0.89 (12w), 1.10 (28w), 1.11 (35w)		0.94 (12w), 1.16 (28w), 1.55 (35w)	0.28 (12w). 0.25 (28w), 0.38 (35w)			12, 28, 35 weeks	Romano et al. 2017[6]

U.S. (MD) / 2017-2019	ORCHARD (*n*=90)	0.71 (15w), 1.00 (22w), 1.12 (31w)		0.61 (15w), 0.83 (22w), 0.51 (31w)		<0.01	15, 22, 31 weeks	Kuiper et al. 2020[7]
China (Wuhan) / 2014-2016	Wuhan Maternal and Child Healthcare Hospital (*n*=213)	0.23 (13w), 0.24 (24w), 0.23 (34w)	<0.25	0.08 (13w), 0.10 (24w), 0.10 (34w)	0.15 (13w), 0.15 (24w), 0.12 (34w)		13, 24, 34 weeks	Luo et al. 2021[8]

Note: OPE biomarkers that were only quantified in this study (i.e., DBUP/DIBP, BMPP, BEHP, DPRP) were excluded from the table. Studies with a sample size >30 are summarized. Except Percy et al. that used creatinine-corrected urinary concentrations,[3] all studies used specific gravity-corrected urinary concentrations. BBOEP, bis(butoxyethyl) phosphate; BCETP, bis(2-chloroethyl) phosphate; BCPP, bis(1-chloro-2-propyl) phosphate; BDCPP, bis(1,3-dichloro-2-propyl) phosphate; BEHP, bis(2-ethylhexyl) phosphate; BMPP, bis(2-methylphenyl) phosphate; DBUP/DIBP, composite of dibutyl phosphate and di-isobutyl phosphate; DPHP, diphenyl phosphate; DPRP, dipropyl phosphate; GA: gestational age; OPE, organophosphate ester.

[a]Percy et al. quantified di-*n*-butyl phosphate,[3] and Luo et al. quantified dibutyl phosphate.[8]

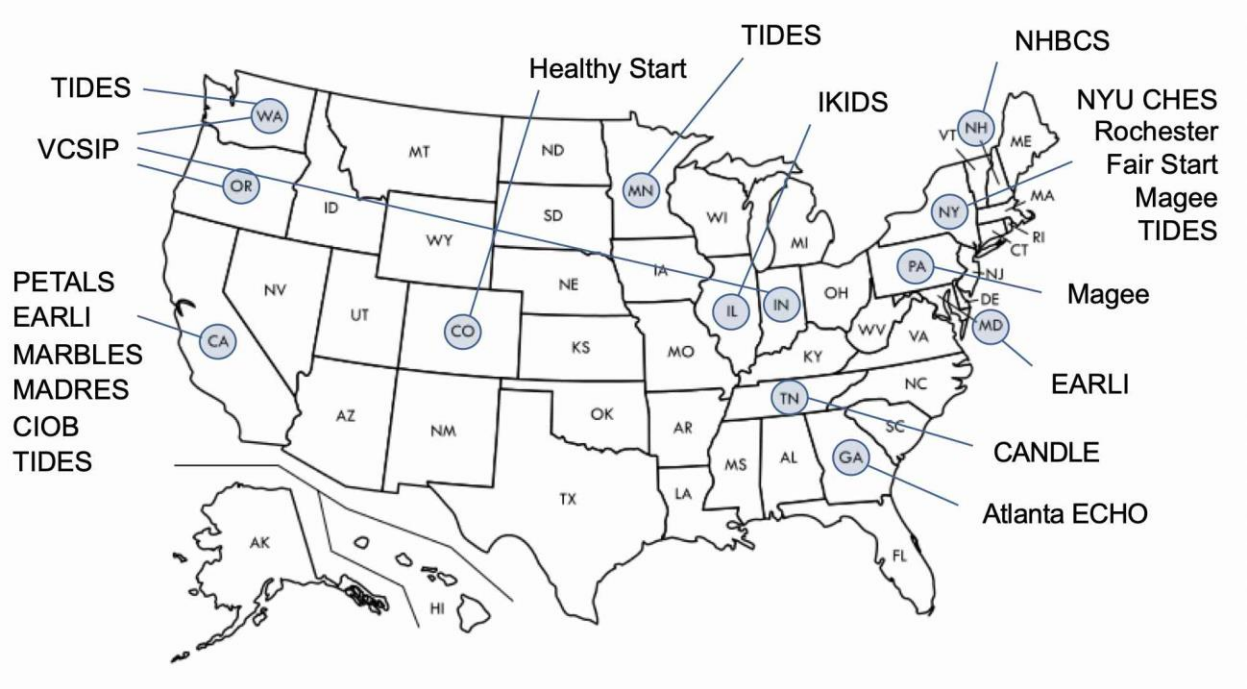

Figure S1. Geographic locations of 16 cohorts contributing to the ECHO study on organophosphate ester flame retardant exposures during pregnancy and gestational duration and fetal growth. Cohort names and participant numbers are provided in Table S1. ECHO, Environmental influences on Child Health Outcomes.

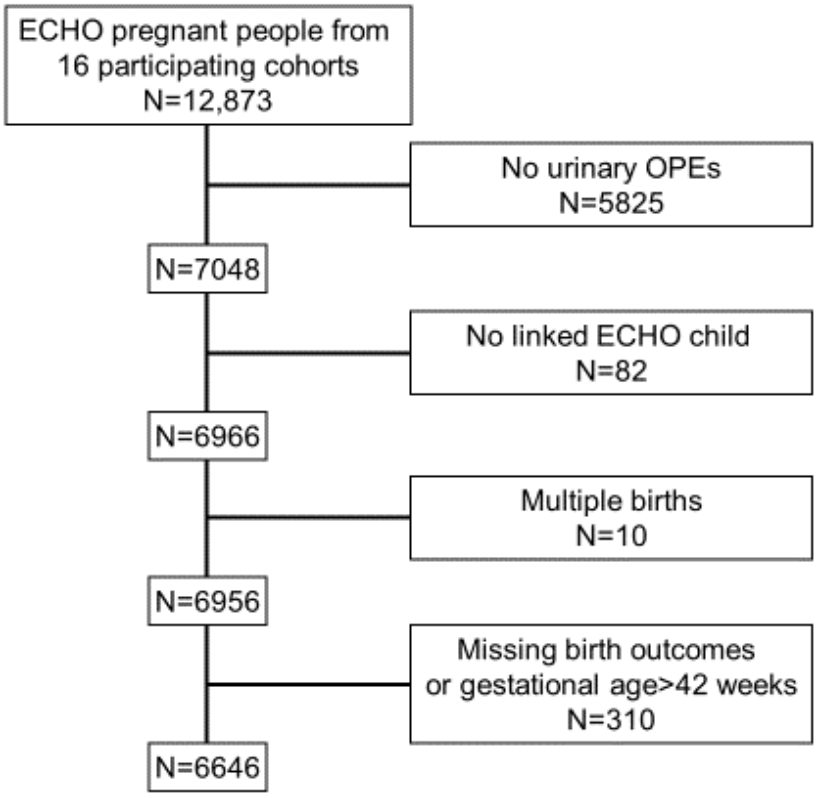

Figure S2. Flowchart depicting inclusion/exclusion criteria. ECHO, Environmental influences on Child Health Outcomes; OPE, organophosphate ester.

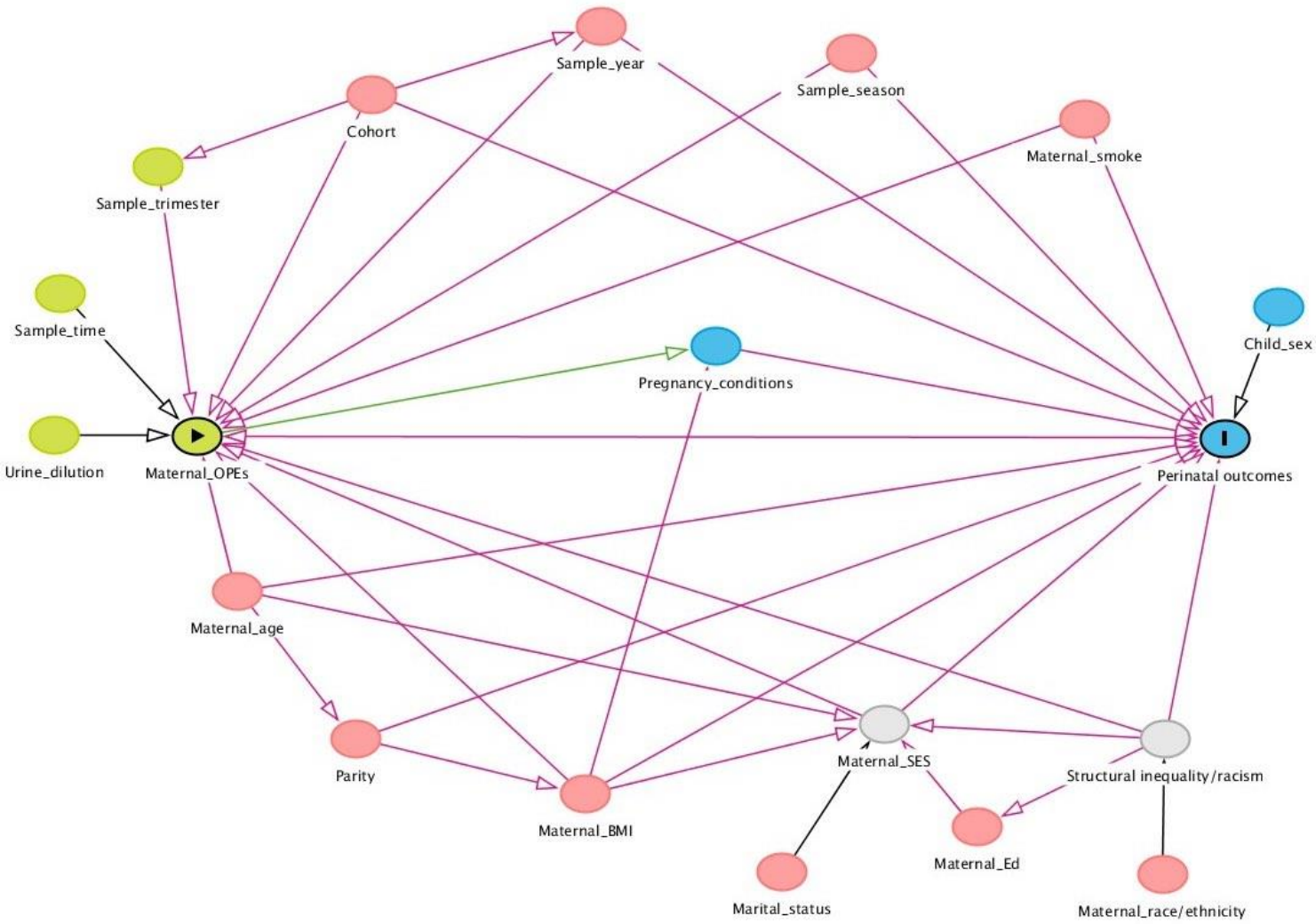

Figure S3. Directed acyclic graph for the relation between maternal OPE exposures during pregnancy and birth outcomes. Green circles represent the exposure or predictors of the exposure, blue circles represent the outcome or predictors of the outcome, pink circles represent predictors of both exposure and outcome, and grey circles are unobserved confounders. BMI, body mass index; Ed, education; OPE, organophosphate ester; SES, socio-economic status.

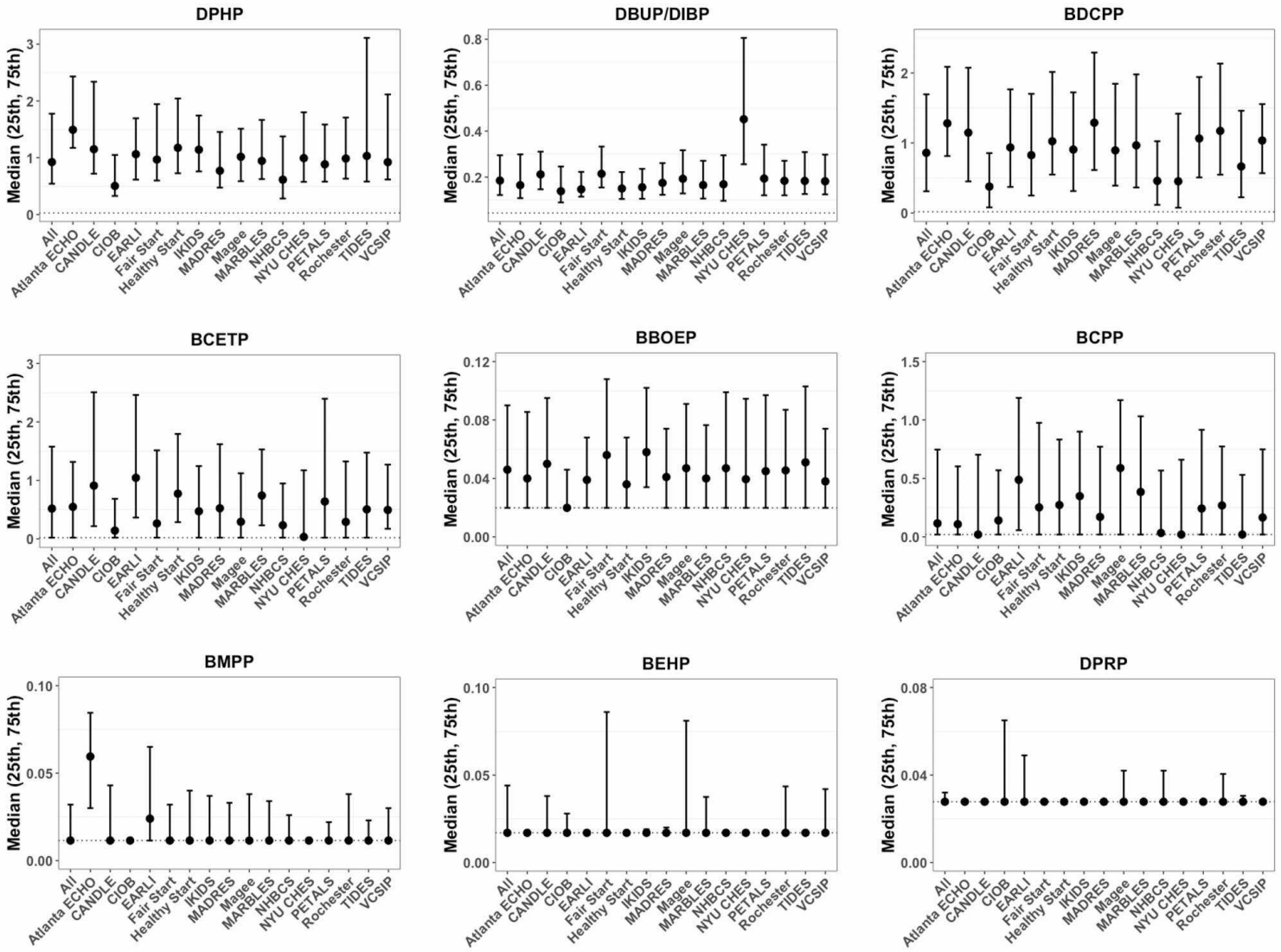

Figure S4. Graphical representation of distributions of dilution-standardized urinary OPE biomarker concentrations by ECHO cohort. Dotted lines indicate the limit of detection (LOD). Concentrations <LOD were replaced with LOD values of each OPE biomarker for

graphical representation. LOD values were 0.04 ng/mL for DBUP/DIBP, 0.03 ng/mL for DPHP and DPRP, 0.02 ng/mL for BDCPP, BCETP, BBOEP, BCPP, and BEHP, and 0.01 ng/mL for BMPP. Numeric data are presented in Table S4, and cohort names and participant numbers can be found in Table S1. BBOEP, bis(butoxyethyl) phosphate; BCETP, bis(2-chloroethyl) phosphate; BCPP, bis(1-chloro-2-propyl) phosphate; BDCPP, bis(1,3-dichloro-2-propyl) phosphate; BEHP, bis(2-ethylhexyl) phosphate; BMPP, bis(2-methylphenyl) phosphate; DBUP/DIBP, composite of dibutyl phosphate and di-isobutyl phosphate; DPHP, diphenyl phosphate; DPRP, dipropyl phosphate; OPE, organophosphate ester.

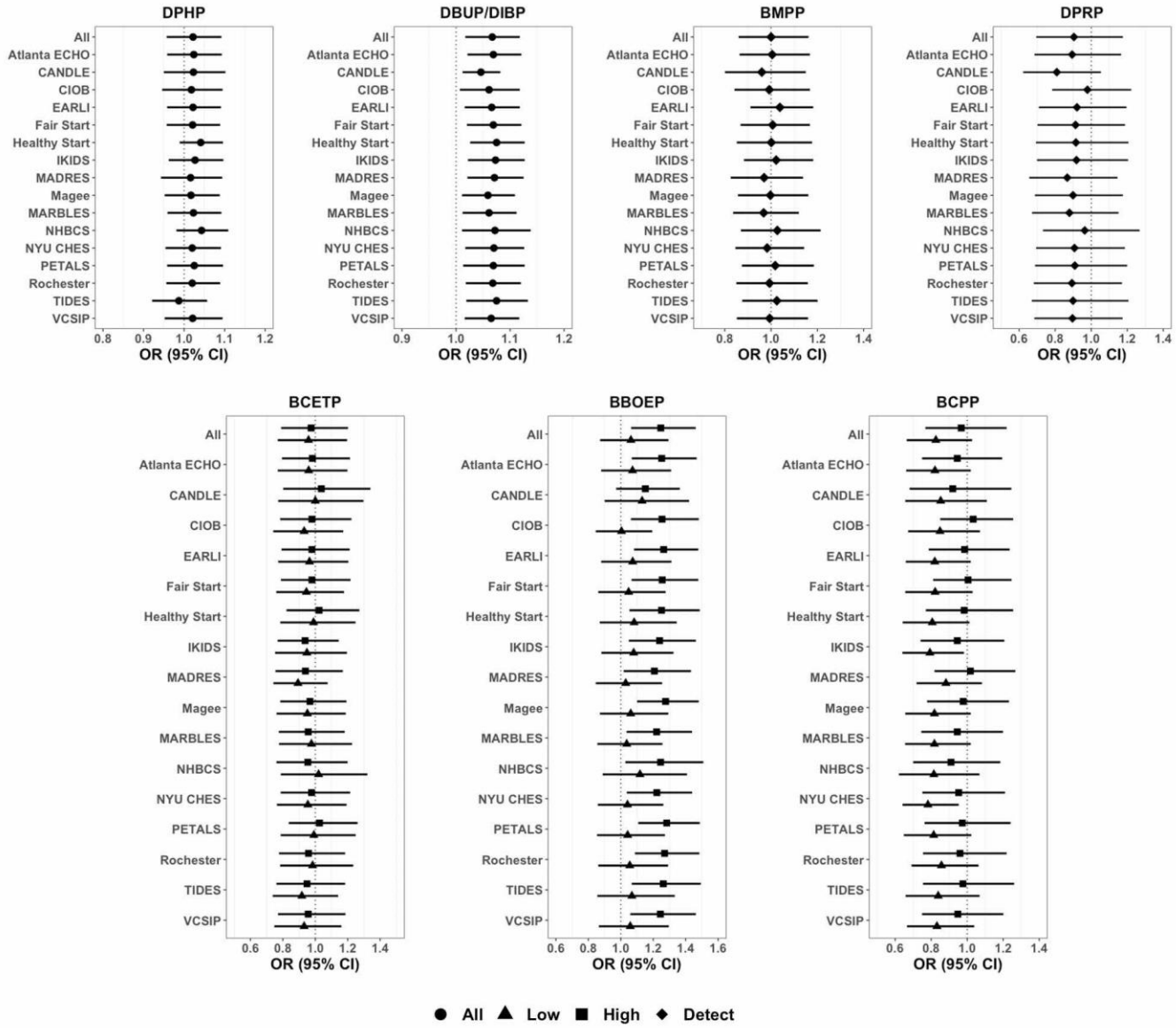

Figure S5. Graphical representation of leave-one-out analysis results for preterm birth (vs. full-term) in the ECHO cohorts. Point estimates indicate regression coefficients or odds ratios, and error bars indicate 95% confidence intervals. For categorized OPE biomarkers (i.e., BCETP, BBOEP, BCPP), estimates of low/high category were computed compared with the nondetect. Regression models were adjusted for maternal race/ethnicity, maternal age at delivery, maternal education, maternal marital status, maternal pre-pregnancy BMI, maternal smoking during pregnancy, parity, child's sex, and sample collection season and year. Numeric data are presented in Table S11, and cohort names and participant numbers can be found in Table S1. BBOEP, bis(butoxyethyl) phosphate; BCETP, bis(2-chloroethyl) phosphate; BCPP, bis(1-chloro-2-propyl) phosphate; BDCPP, bis(1,3-dichloro-2-propyl) phosphate; BEHP, bis(2-ethylhexyl) phosphate; BMI, body mass index; BMPP, bis(2-methylphenyl) phosphate; DBUP/DIBP, composite of dibutyl phosphate and di-isobutyl phosphate; DPHP, diphenyl phosphate; DPRP, dipropyl phosphate; OPE, organophosphate ester.

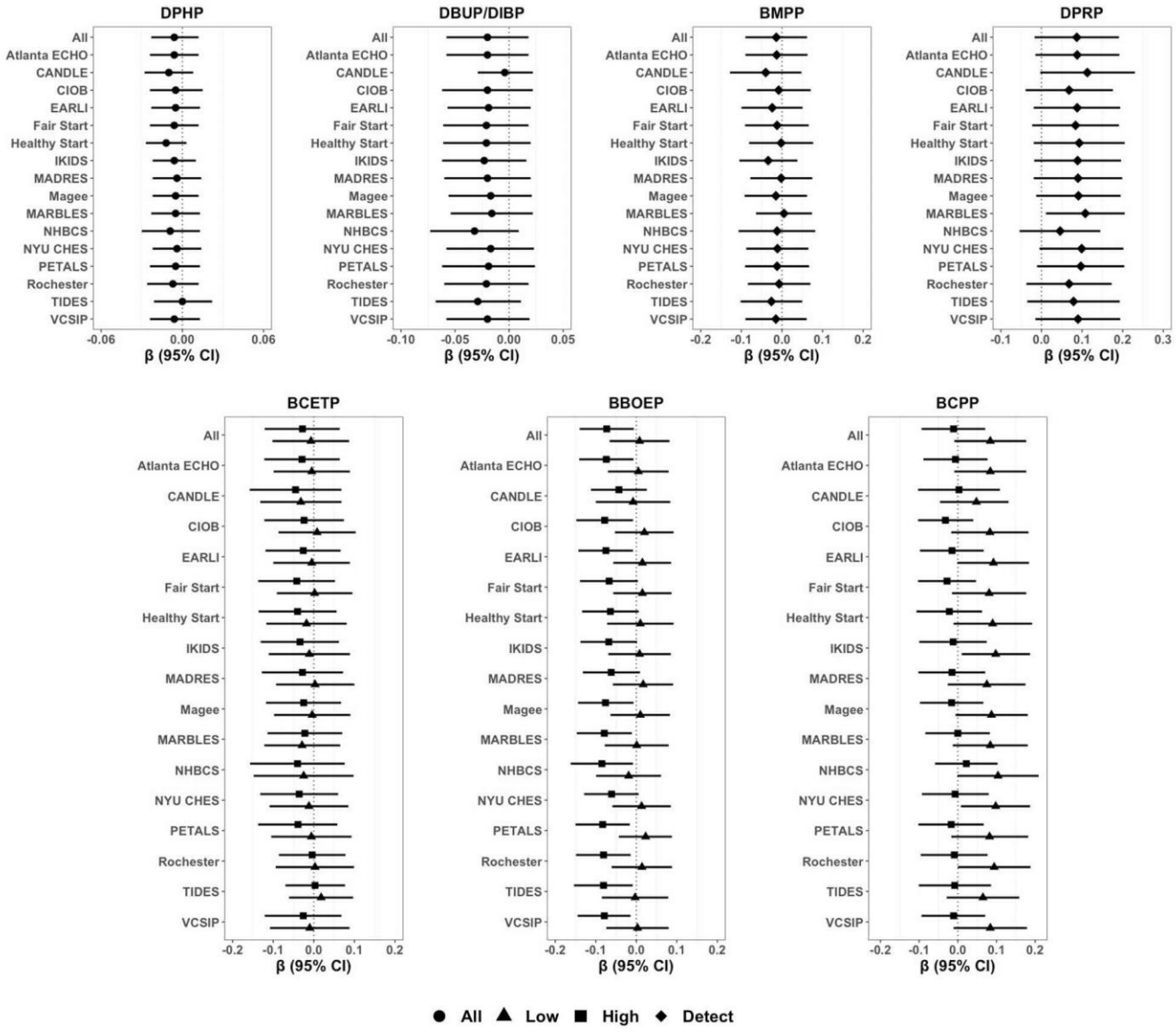

Figure S6. Graphical representation of leave-one-out analysis results for gestational age (weeks) in the ECHO cohorts. Point estimates indicate regression coefficients or odds ratios, and error bars indicate 95% confidence intervals. For categorized OPE biomarkers (i.e., BCETP, BBOEP, BCPP), estimates of low/high category were computed compared with the nondetect. Regression models were adjusted for maternal race/ethnicity, maternal age at delivery, maternal education, maternal marital status, maternal pre-pregnancy BMI, maternal smoking during pregnancy, parity, child's sex, and sample collection season and year. Numeric data are presented in Table S12, and cohort names and participant numbers can be found in Table S1. BBOEP, bis(butoxyethyl) phosphate; BCETP, bis(2-chloroethyl) phosphate; BCPP, bis(1-chloro-2-propyl) phosphate; BDCPP, bis(1,3-dichloro-2-propyl) phosphate; BEHP, bis(2-ethylhexyl) phosphate; BMI, body mass index; BMPP, bis(2-methylphenyl) phosphate; DBUP/DIBP, composite of dibutyl phosphate and di-isobutyl phosphate; DPHP, diphenyl phosphate; DPRP, dipropyl phosphate; OPE, organophosphate ester.

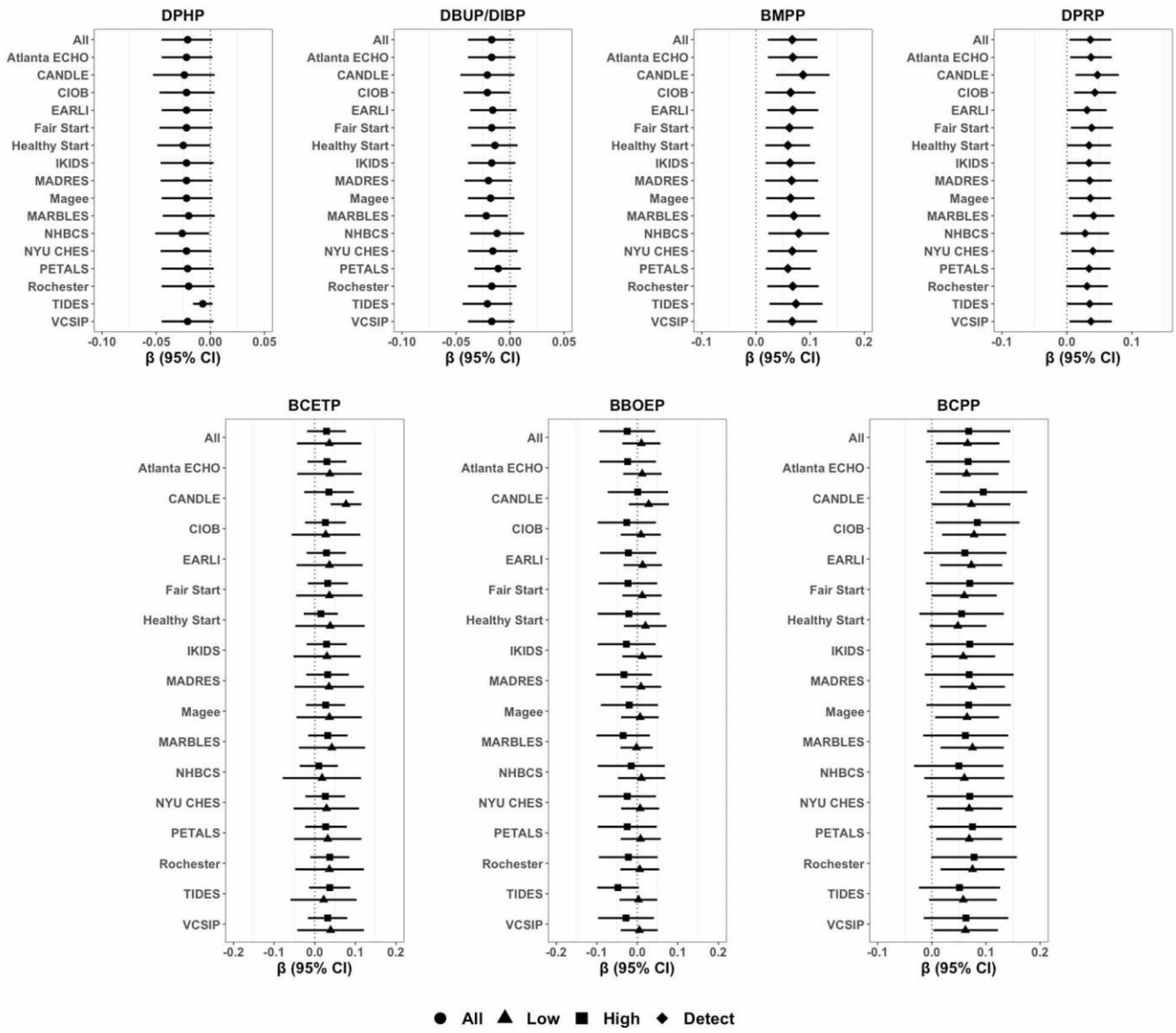

Figure S7. Graphical representation of leave-one-out analysis results for birth weight-for-gestational-age z-score in the ECHO cohorts. Point estimates indicate regression coefficients or odds ratios, and error bars indicate 95% confidence intervals. For categorized OPE biomarkers (i.e., BCETP, BBOEP, BCPP), estimates of low/high category were computed compared with the nondetect. Regression models were adjusted for maternal race/ethnicity, maternal age at delivery, maternal education, maternal marital status, maternal pre-pregnancy BMI, maternal smoking during pregnancy, parity, child's sex, and sample collection season and year. Numeric data are presented in Table S13, and cohort names and participant numbers can be found in Table S1. BBOEP, bis(butoxyethyl) phosphate; BCETP, bis(2-chloroethyl) phosphate; BCPP, bis(1-chloro-2-propyl) phosphate; BDCPP, bis(1,3-dichloro-2-propyl) phosphate; BEHP, bis(2-ethylhexyl) phosphate; BMI, body mass index; BMPP, bis(2-methylphenyl) phosphate; DBUP/DIBP, composite of dibutyl phosphate and di-isobutyl phosphate; DPHP, diphenyl phosphate; DPRP, dipropyl phosphate; OPE, organophosphate ester.

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