Parental Concern about Environmental Chemical Exposures and Children's Urinary Concentrations of Phthalates and Phenols

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Objectives To examine whether parents' concerns about environmental chemical exposures were associated with urinary phthalate and phenol concentrations in their school-age children.

Study design In a prospective cohort of 218 mother-child pairs from Cincinnati, Ohio (2010-2014), we measured 11 phthalate metabolites and 5 phenols in urine samples when children were age 8 years and used questionnaire data from caregivers. We estimated the covariate-adjusted percent difference in phthalates and phenols among children of parents who expressed concern about environmental chemical exposures compared with children whose parents did not.

Results Concentrations of 4 phthalates, bisphenol S, and bisphenol A were lower among children whose parents expressed concern about environmental chemicals (n = 122) compared with those who did not (n = 96). Di-2-ethylhexyl phthalate metabolites, bisphenol S, and bisphenol A concentrations were 23% (95% CI −38, −5), 37% (95% CI −49, −21), and 13% (95% CI −26, 3) lower, respectively, among children whose parents expressed concern compared with those whose parents did not. Triclosan concentrations were 35% greater (95% CI −2, 87) among children whose parents expressed concern compared with children whose parents did not.

Conclusions Parental concern about environmental chemicals was associated with lower childhood urine concentrations of several phthalates and phenols; unexpectedly, parental concern was associated with greater triclosan concentrations. These results suggest that parental concern may be an important factor in mitigating children's phthalate and phenol exposures. *(J Pediatr 2017;186:138-44).*

There is concern that early life exposure to environmental chemicals adversely could affect the development of the fetus, infant, or child to adversely impact brain development, growth, or immune function in infants and children.[1-3] Children may be uniquely susceptible to environmental chemicals because of their immature metabolic pathways and rapidly growing vital organs.[4] Moreover, compared with adults, children have greater exposure to some environmental chemicals, such as lead and persistent organic pollutants, as the result of differences in physiology, anatomy, and behaviors.[5-7]

Among environmental chemicals of concern, phthalates and phenols have received considerable attention during the last decade because of their potential health effects on children (**Table I**; available at www.jpeds.com). Phthalates are multifunctional chemicals used in personal care products, medications, and plastics. Some phthalates have endocrine-disrupting properties, and exposure has been associated with an increased risk of allergic disease, alterations in genital development, and neurobehavioral disorders.[3,8-11] Phenols are a broad class of chemicals that include bisphenol A (BPA), triclosan, triclocarban, and benzophenone. BPA is used in polycarbonate plastics and epoxy resins, whereas triclosan and triclocarban are used as antimicrobial agents in personal care products, textiles, and some household goods. Benzophenone is used as an ultraviolet light absorber and stabilizer in personal care products. Exposure to BPA and triclosan has been associated with adverse health outcomes, including neurobehavioral problems, allergic disease, and reduced circulating thyroxine levels, respectively.[3,12,13]

BPA	Bisphenol A
BPS	Bisphenol S
DEHP	Di-2-ethylhexyl phthalate
GM	Geometric mean
HOME	Health Outcomes and Measures of the Environment
MBzP	Mono-benzyl phthalate
MCNP	Mono-carboxynonyl phthalate
MCOP	Mono-carboxyoctyl phthalate
MECPP	Mono(2-ethyl-5-carboxypentyl) phthalate
MiBP	Mono-iso-butyl phthalate
MnBP	Mono-n-butyl phthalate
ΣDEHP	Weighted molar sum of mono(2-ethylhexyl) phthalate, mono(2-ethyl-5-hydroxyhexyl) phthalate, mono(2-ethyl-5-oxohexyl) phthalate, and mono(2-ethyl-5-carboxypentyl) phthalate

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Several studies have demonstrated that targeted behavioral interventions such as changes in diet and personal care product use can decrease exposure to specific environmental chemicals in controlled settings.[14-17] However, there has been little research to show whether individuals successfully can reduce their exposure to phthalates and phenols by actively changing their consumer habits.[16] Clinically, this knowledge would encourage clinicians to educate unconcerned parents by counseling them on how to reduce their children's exposures. It may also motivate clinicians to discuss specific behavioral interventions with concerned parents. In the absence of clear evidence, it is up to clinicians to decide on the risks and benefits of educating patients on phthalate and phenol exposures and possible behavioral interventions.

The purpose of this study was to determine whether there is a relationship between parents' concerns about environmental chemicals and their children's exposure to phthalates and phenols by using data from 218 parents and their children.

Methods

We used data from the Health Outcomes and Measures of the Environment (HOME) study, a prospective pregnancy and birth cohort study designed to examine the health impacts of early-life exposure to prevalent environmental chemicals. We previously described eligibility criteria, enrollment, and follow-up.[18] In summary, we recruited 401 pregnant women from 9 prenatal clinics associated with 3 hospitals in the Cincinnati, Ohio, area from March 2003 through January 2006. After delivery, we conducted extensive longitudinal follow-up with parents or caregivers and their children at 1, 2, 3, 4, 5, and 8 years of age. For this study, we used data from 218 singleton children who completed follow-up at 8 years of age and had urinary biomarker and covariate data available.

All women provided written informed consent for themselves and their children after the study protocols had been explained. The institutional review boards of Cincinnati Children's Hospital Medical Center, the Centers for Disease Control and Prevention, and the cooperating delivery hospitals approved this study. Brown University relinquished institutional review board authority to Cincinnati Children's Hospital Medical Center with an Interagency Agreement.

Parents' Concern about Chemical Exposures

We administered surveys to parents, typically the mother (otherwise the primary caregiver), during face-to-face interviews in our study clinic when children were an average of 8.1 years of age (range, 7.5-10 years). We used responses from 2 questions to assess whether parents were concerned or unconcerned about the potential for environmental chemicals influencing their child's health. The first question asked, "Are you concerned that chemicals used in the products you buy might affect your child's health?" Among parents who responded "yes," we asked them to list as many chemicals as they could in response to the question, "What chemicals are you most concerned about?" Parents were allowed to list more than one specific chemical or exposure of concern. A priori, we created categories that included arsenic, BPA, cadmium, flame retardants, lead, mercury, metals, nonstick compounds (eg, perfluoroalkyl substances), pesticides, phthalates, plastics, and other.

Children's Urinary Chemical Biomarker Concentrations

At the study visit, we collected a single urine sample from the child in a polypropylene specimen cup. We refrigerated urine samples before processing and storing them at or below −20°C until chemical analysis. We shipped urine samples on dry ice to the Centers for Disease Control and Prevention for phthalate and phenol analysis. We quantified the total concentration (free + conjugated) of 11 phthalate monoester metabolites and 5 phenols with analytic chemistry methods (**Table I**).[19,20] The limits of detection ranged from 0.1 to 1.0 ng/mL. The coefficients of variation for low and high concentrations quality control samples for phthalates ranged from 5.0% to 12% and for phenols from 2.5% to 16%. We also quantified urinary creatinine concentrations to control for urine dilution.

Because we quantified 4 monoester metabolites of di-2-ethylhexyl phthalate (DEHP) that were highly correlated with each other (Pearson R values ranged from 0.71 to 0.98), we created a weighted molar sum (ΣDEHP) of mono(2-ethylhexyl) phthalate, mono(2-ethyl-5-hydroxyhexyl) phthalate, mono(2-ethyl-5-oxohexyl) phthalate, and mono(2-ethyl-5-carboxypentyl) phthalate (MECPP). We expressed ΣDEHP concentrations in μg/L of MECPP by multiplying the molar sum of the individual metabolites by the molar mass of MECPP (308 g/mol).

Covariates

We considered adjusting for factors that might be associated with both parents' concern about environmental chemicals and children's urinary phthalate and phenol concentrations based on our previous studies in this cohort.[21,22] These variables included maternal education, maternal race/ethnicity, household income, child sex, and child age. Because of the small number of American Indian, Asian, or multiracial mothers, we created 2 categories of maternal race: non-Hispanic black and non-Hispanic white. To control for urine dilution, we adjusted for continuous $\log_{10}$-transformed urinary creatinine concentrations in our models. Finally, because the phenol benzophenone-3 is used in sunscreens, and children may have greater levels during the summer, we also adjusted these models for season (May-August vs September-April).

Statistical Analyses

We began our analysis by comparing the distribution of covariates among parents who did and did not express concern about environmental chemicals. Next, we described univariate statistics of urinary phthalate and phenol concentrations. Because phthalate and phenol concentrations were right-skewed, we $\log_{10}$-transformed them to satisfy normality assumptions. We then used linear regression to calculate the unadjusted and covariate-adjusted geometric mean (GM) urinary phthalate and phenol concentrations among chil-