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**Abstract**

**Background:** Early life exposure to the endocrine disruptor bisphenol A (BPA) may contribute

to development of obesity. Prospective evidence in humans on this topic is limited.

**Objectives:** We examined prenatal and early childhood BPA exposures in relation to childhood

measures of adiposity in the Columbia Center for Children's Environmental Health (CCCEH)

New York City birth cohort.

**Methods**: BPA concentrations were measured in prenatal (n=375) and child ages 3 (n=408) and

5 years (n=518) spot urine samples. Childhood anthropometric and bioelectrical impedance

outcomes included body mass index z-scores (BMIZ) at 5 and 7 years, and fat mass index (FMI),

percent body fat (%BF), and waist circumference (WC) at 7 years. Associations were evaluated

using multiple linear regression with continuous and tertile BPA concentrations.

**Results**: Prenatal urinary BPA concentrations were positively associated with child age 7 FMI

(beta=0.31 kg/m$^2$, p-value=0.04, [95%CI 0.01, 0.60]), %BF (beta=0.79, p-value=0.04, [95%CI

0.03, 1.55]), and WC (beta=1.29 cm, p-value=0.01, [95%CI 0.29, 2.30]), but not BMIZ, or

change in BMIZ between ages 5 and 7 years (all p-values > 0.1). FMI results were sex-specific.

Child urinary BPA concentrations were not associated with child anthropometric outcomes (all

p-values > 0.05).

**Conclusions:** Analyses of the CCCEH longitudinal birth cohort found associations between

prenatal urinary BPA concentrations and FMI, %BF and WC. Our results suggest that prenatal

BPA exposure may contribute to developmental origins of adiposity. These findings are

consistent with several prior studies, raising concern about the pervasiveness of BPA.

**Introduction**

Obesity in children, defined by a body mass index (BMI) greater than or equal to the 95th

percentile for age and sex, is an epidemic of great concern in the United States. According to the

Robert Wood Johnson Foundation, childhood obesity rates (ages 2-19 years) have more than

tripled between the years 1980-2010 (RWJF 2012). Long-term risks of childhood obesity

include metabolic syndrome, type 2 diabetes, cardiovascular disease and reduced adult life

expectancy, with children of minority status at greater risk for becoming obese (Shaibi et al.

2007; Singh et al. 2010; Strauss and Pollack, 2001). The 2007-2008 overall prevalence of

obesity and overweight was 20.3% and 17.6% for New York City (NYC) public school children,

with African American and Hispanic having higher odds than white children of being obese

(O.R.=1.11, 95% CI:1.07, 1.15 and O.R.=1.48, 95% CI: 1.43, 1.53, respectively) (Rundle et al.

2012). Early-life exposure to endocrine disruptors, such as bisphenol A (BPA), may be

contributing to the obesity epidemic (Grün and Blumberg 2006). Endocrine disruptors may also

lead to altered metabolic regulation early in life (Chevalier and Fénichel 2014).

BPA is a known endocrine disrupting chemical and a key component in polycarbonate

plastics and epoxy resins which are commonly used in consumer products resulting in significant

human exposure (Calafat et al. 2008; Vandenberg et al. 2007, 2010). Exposure pathways include

oral, dermal and inhalation, with dietary intake the primary route (Wilson et al. 2003; Zalko et al.

2011). Prenatal exposure may occur *in utero* or by use of catheters during delivery (Ikezuki et

al. 2002; Schönfelder et al. 2002; Vandentorren et al. 2011).

Cross-sectional studies suggest that BPA exposure is associated with obesity in children

(Bhandari et al. 2013; Eng et al. 2013; Li et al. 2013; Trasande et al. 2012; Wang et al. 2012;

Wells et al. 2013). However, because diet is an exposure route, reverse causality cannot be ruled

out for these cross-sectional findings as obese children may have greater exposure to BPA due to

higher dietary intakes. Longitudinal data on effects of prenatal BPA exposure on postnatal

adiposity are limited due to dissimilarities in outcome measures, child age and geographic

reference (Braun et al. 2014; Chou et al. 2011; Harley et al. 2013; Lee et al. 2013; Philippat et al.

2014; Snijder et al. 2013; Tang et al. 2013; Valvi et al. 2013). Only two other US studies

investigated BPA exposure and obesity vary in their anthropometric outcomes: BMI trajectories

and waist circumference (Braun et al. 2014) and BMI, waist circumference, fat mass and body

fat percent (Harley et al. 2013). We hypothesized that prenatal and early childhood BPA

exposure would be positively associated with childhood adiposity at ages 5 and 7 years in a NYC

inner-city birth cohort.

**Methods**

*Study design and population*

Study subjects are participants in the prospective birth cohort of the Columbia Center for

Children's Environmental Health (CCCEH) in Northern Manhattan and the South Bronx, New

York. Mother-child pairs were selected if a maternal prenatal urine sample was analyzed for

BPA (n=375). We additionally included children if BPA concentration in urine was measured at

child age 3 (n=408) and/or 5 years (n=518). The CCCEH study design is described elsewhere

(Perera et al. 2003; Whyatt et al. 2003). Briefly, we enrolled 727 women ages 18–35 years old

during their third trimester of pregnancy. Women were included if they self-identified as either

African American or Dominican and had resided in Northern Manhattan or the South Bronx for

at least 1 year before pregnancy. Exclusion criteria included mother's report of: cigarette

smoking or use of other tobacco products during pregnancy, illicit drug use, diabetes,

hypertension, known HIV, or a first prenatal visit after the 20th week of gestation. Research

staff abstracted medical records of the mother and infant at delivery to ascertain prenatal medical history and birth outcomes. We contacted participants every 3 months until child age 5 and every 6 months thereafter for questionnaire follow-up, with children's biological samples collected biennially beginning at age 3 years. The CCCEH study has retained documentation regarding loss to follow-up status and reasons for missed intervals.

Data collection was completed through age 7 years in August 2013 and laboratory measurement of urinary BPA was completed for all samples. Study procedures, questionnaires and collection of biological samples were explained to each subject at enrollment and a signed consent, approved by the IRB of Columbia University Medical Center and the Centers for Disease Control and Prevention (CDC), was obtained.

*Urinary biomarker collection*

For mothers, urine was collected between 1999-2006 during the third trimester of pregnancy (mean gestational age: 34 weeks; SD: 3) concurrent with administration of the baseline questionnaire by trained bilingual interviewers. In children, urine was collected concurrent with follow-up questionnaires between 2001 and 2010. All samples were spot urine samples collected at varying times of day. The date, but not the exact time of collection, was available.

The total (free plus conjugated) BPA urinary concentrations (ng/mL) were measured as previously described (Calafat et al. 2008). The limit of detection (LOD) was 0.4 ng/mL. Specific gravity, as a measure of urinary dilution, was quantified at room temperature at Columbia University with a handheld refractometer (PAL 10-S, Atago).

We also measured four urinary metabolites of di-2-ethylhexyl phthalate (DEHP) at CDC: mono-2-ethylhexyl phthalate, mono-2-ethyl-5-carboxypentyl phthalate, mono-2-ethyl-5-

hydroxyhexyl phthalate, and mono-2-ethyl-5-oxohexyl phthalate (Kato et al. 2005; Silva et al. 2007). DEHP metabolite LODs ranged from 0.2 to 1.2 ng/mL. Urinary concentrations of DEHP metabolites and BPA were positively correlated (r coefficient range: 0.16, 0.34) in the CCCEH birth cohort (Hoepner et al. 2013), and in the Health Outcomes and Measures of the Environment (HOME) study (Braun et al. 2011). BPA was undetectable prenatally (6%) and at child ages 3 years (2%) and 5 years (2%). For the few BPA and DEHP metabolites results <LOD, the value of LOD/2 was substituted, consistent with prior analyses (Whyatt et al. 2003; Whyatt et al. 2009).

*Anthropometric measurements*

Weight prior to pregnancy was self-reported by the mother during the third trimester. Birth weight was collected from the hospital medical record. We collected body size measurements and/or body composition data for children aged 5 years (n=498) and 7 years (n=511). A Detecto Cardinal 750 digital scale/stadiometer (Cardinal Scale Manufacturing Company) was used to collect standing height measurements at ages 5 and 7 years until January 2010. After January 2010, we assessed standing height with the Holtain-Harpenden Wall Mounted Stadiometer Counter 602VR (Holtain Limited). Body composition values, including fat mass, were collected with the Tanita Digital Body Mass Indicator Scale BC-148 (Tanita Corporation of America) at age 7 years. Children wore light clothing and no shoes. Body mass index z-scores (BMIZ) were quantified using the SAS programs provided by the CDC (C.D.C., 2011). Fat mass index (FMI) was calculated using the algorithm [fat mass(kg)/height(m)$^2$] (VanItallie et al. 1990). Waist circumference (WC) was measured at a level midway between the lower rib margin and iliac crest using a non-stretchable measurement tape.

*Statistical analysis*

BPA concentrations and the molar sum of DEHP metabolite concentrations (∑DEHP)

were natural log-transformed for analysis to correct for their non-normal distribution. Specific

gravity values were standardized by z-score transformation to stabilize model constant estimates.

The standardized specific gravity concentrations were included in regression models as a

covariate except for models with BPA concentration tertiles as the predictor variables. As using

percentiles is a method of ordering by rank, we arithmetically adjusted BPA concentrations at

each urine collection interval to calculate tertiles by first accounting for urinary dilution and then

natural log-transforming using the formula: Specific gravity adjusted/log-transformed

BPA=LN(BPA $_{raw}$ * [(mean specific gravity for population at collection interval-1)/(individual

specific gravity-1)]) (Hauser et al. 2004). In other words, the prenatal BPA concentration was

first specific gravity adjusted and then natural-log transformed.

For childhood BPA exposure, we calculated the mean of BPA concentrations at ages 3

and 5 years. In the absence of two childhood urinary concentrations, the single existing

concentration was used (n=51).

Linear regression analyses were conducted to determine whether maternal prenatal

urinary BPA concentrations predicted birth weight, BMIZ at ages 5 and 7 years and the change

in BMIZ (ΔBMIZ) from age 5 to 7 years, as well as FMI, percent body fat (%BF) and WC at age

7 years. Additionally, linear regression was used to analyze whether child urinary BPA

concentrations from age 3 years or the mean of ages 3 and 5 years predict BMIZ at ages 5 and 7

years, ΔBMIZ from age 5 to 7 years, and FMI, %BF and WC at age 7 years. To assess the

representativeness of the subset analyzed, t-tests and chi-square tests were performed to compare

subjects with and without prenatal and postnatal BPA concentrations and with and without

anthropometric outcomes at 5 years and 7 years of age.

Maternal prenatal urinary BPA concentrations were evaluated separately from child based on prior analyses in the CCCEH birth cohort confirming prenatal BPA concentrations were not correlated with and were significantly lower than childhood BPA concentrations (Hoepner et al. 2013). However, we separately assessed as potential confounders the prenatal BPA concentrations in childhood predictor regression models and the childhood BPA concentrations in the prenatal predictor regression models and found no confounding. Furthermore, we did not find an association between prenatal BPA concentrations with maternal weight gain during pregnancy therefore we did not consider it to be a confounder variable in our analysis.

Variables were tested for in the regression models if we had previously found they were associated with BPA and if they were expected to be associated with dietary patterns and obesity (Hoepner et al. 2013, Rundle et al. 2012). Variables were included in the model if they were significantly ($p<0.05$) associated with the outcome. The following variables were controlled for in the analyses of child anthropometric measures at ages 5 and 7 years: specific gravity, ln $\sum$DEHP, race/ethnicity, dichotomous maternal pre-pregnancy obesity, child sex, birth weight, and gestational age. Models including prenatal BPA concentrations also included prenatal specific gravity and ln $\sum$DEHP, whereas models including childhood BPA concentrations included childhood specific gravity and ln $\sum$DEHP. Additionally, we controlled for height in the analyses of outcomes: %BF at age 7 years and WC at age 7 years.

We stratified analyses by child sex in order to explore differences in associations by sex that had been found in other studies (Harley et al. 2013). Possible interaction between BPA concentration and child sex were assessed for all BMIZ and 7 year body composition outcomes.

We conducted sensitivity analyses using baseline data and logistic regression models to

estimate inverse probability weighting (IPW) for successful follow-up to assess potential bias of

effect estimates due to loss to follow-up and missing anthropometric data (Curtis et al. 2007;

Hernan et al. 2004; Robins et al. 2000; Rundle et al. 2012; Widen et al. 2015).  To estimate the

weights, we included all variables in each of our final models, mother's satisfaction with living

conditions, mother's years of school completed at time of pregnancy, as well as geographic

information system variables using 2000 US Census block group data aggregated to 1 km radial

neighborhood buffers around the home: linguistic isolation and neighborhood socioeconomic

status (Rundle et al. 2012).

For all analyses, we considered results with $p<0.05$ to be statistically significant.

Analyses were performed using IBM SPSS Statistics version 22.0 (IBM Corp., Armonk, NY,

USA) and Stata version 13.0 (StataCorp, College Station, TX, USA).

**Results**

Demographic and clinical characteristics of the 369 participants with prenatal BPA

concentrations and available birth outcomes data are presented in Table 1.  Table 2 shows the

characteristics of the study participants grouped by BPA concentration interval and age at which

anthropometric measures were collected.  There was no significant difference between subjects

with and without prenatal and postnatal BPA concentrations.  Additionally, there was no

significant difference between subjects with and without anthropometric outcomes at 5 years and

7 years of age.

*Prenatal BPA concentration vs. child anthropometry*

Prenatal BPA concentrations were not associated with birth weight (see Supplemental

Material, Table S1).  Results from analyses of fully adjusted ln-transformed prenatal BPA

concentrations and child anthropometric outcomes are shown in Table 3. Overall, prenatal BPA concentrations were not significantly associated with BMIZ at ages 5 years or 7 years or ΔBMIZ from 5 to 7 years. Prenatal BPA concentrations were positively associated with FMI at age 7 years (beta=0.31 kg/m$^2$, p-value=0.04, [95%CI 0.01, 0.60]). Prenatal BPA concentrations were also positively associated with %BF at age 7 years (beta=0.79, p-value=0.04) and with WC at age 7 years (beta=1.29 cm, p-value=0.01).

To determine whether the FMI results were due to the fat mass or the height component of the index, we substituted the fat mass itself as the dependent variable in the model. Prenatal BPA concentrations were positively associated with fat mass regardless of the addition of height as a covariate (adjusting for height: beta=0.55 kg, p-value=0.02; without adjustment for height: beta=0.57 kg, p-value=0.03). Prenatal BPA concentrations and height were not associated. Exclusion of the prenatal ln ∑DEHP covariate from the model not appreciably change the associations.

*Prenatal tertile analysis*

Linear regression analysis using tertiles of prenatal BPA concentrations as predictor variables, with the first tertile as the reference, suggested positive linear associations with FMI, percent body weight and WC (see Table 3).

*Prenatal differences by child sex*

After stratifying by sex, among girls there was a positive association between prenatal BPA concentrations and 7 year FMI and WC (see Table 4). Among boys, there was no association between prenatal BPA concentrations and anthropometric outcomes. The interaction between sex and BPA concentrations was significant (see Table 4).

*Postnatal BPA concentration vs. child anthropometry*

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Child BPA concentrations had a borderline negative association with ΔBMIZ from 5 to 7

years (beta=-0.10, p-value=0.06, [95%CI -0.02, 0.005]). Child BPA concentrations were not

associated with FMI, %BF or WC at age 7 years (see Supplemental Material, Table S2).

*Postnatal tertile analysis*

Linear regression analysis using tertiles of child BPA concentrations as predictor

variables, with the first tertile as the reference, was consistent with the borderline negative

association with ΔBMIZ from 5 to 7 years (see Supplemental Material, Table S2). Higher

exposure to BPA may be associated with lower ΔBMIZ

*Postnatal differences by child sex*

When we conducted analyses stratified by sex we found a negative association between

child urinary BPA concentrations and ΔBMIZ from 5 to 7 years for girls and no associations for

boys (see Supplemental Material, Table S3). Interaction terms for postnatal BPA concentrations

and sex were not significant.

*IPW Analysis*

Weighting the data by the inverse probability of follow-up and complete anthropometric

and biomarker data collection by 7 years did not appreciably change the size of the effect

estimates (data not shown).

**Discussion**

We observed a positive association between prenatal urinary BPA concentration and

childhood FMI, %BF and WC at age 7 years. These results suggest prenatal BPA exposure is

associated with overall body fat and central adiposity, accounting for height. However, contrary

to our hypotheses, we found that maternal urinary BPA concentrations were not associated with

birth weight, childhood BMIZ at ages 5 and 7 years, and ΔBMIZ from age 5 to 7 years. The

differences in results across anthropometric outcomes may reflect differences in the construct

validity of body composition versus BMI as measures of child adiposity. BMIZ alone may not

be the best measure of adiposity in prepubertal children (Mueller et al. 2013). The few pediatric

studies in the US that evaluated BMI versus FMI concluded that these measures are not

equivalent for determining excess adiposity in children (Weber et al. 2013). This is particularly

important when considering sex as the body composition components of fat mass and lean body

mass differ between sexes (Weber et al. 2013). Literature on birth cohort studies of childhood

obesity outcomes related to BPA exposure is limited and only one study included longitudinal

analyses of prenatal BPA exposure effects on school aged boys and girls (Braun et al. 2014;

Harley et al. 2013; Philippat et al. 2014; Valvi et al. 2013).

In our analysis, we found sex-specific associations with prenatal BPA exposures and FMI

at age 7 years. In the Cincinnati-based HOME study, a prospective cohort composed primarily

of white (67%) and African American (27%) children (n=297), prenatal urinary BPA

concentrations were not associated with BMI at ages 2-5 years (Braun et al. 2014). In the

aforementioned study an increase in childhood BMIZ slope per prenatal BPA tertile was

observed, but sex-specific associations were weak and based on a small sample size (Braun et al.

2014). However, accelerated growth may be due to a variety of factors including fat mass and

fat free mass that can only be determined with body composition techniques.

Conversely, the "INfancia y Medio Ambiente" (INMA) population-based birth cohort in

Spain reported positive associations between prenatal urinary BPA concentration and body size

outcomes BMI and WC at age 4 years and no sex differences (Valvi et al. 2013). Others did not

identify an association of prenatal urinary BPA with weight or WC at age 3 years in a French

birth cohort subset of boys only (Philippat et al. 2014). In the Center for the Health Assessment

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of Mothers and Children of Salinas (CHAMACOS) birth cohort consisting primarily (98%) of

Mexican American mothers and children in California, researchers found prenatal urinary BPA

concentrations to be inversely related to 9 year BMIZ and %BF for girls only; concurrent urinary

BPA concentrations were positively related to 9 year BMI, fat mass and WC for both sexes

(Harley et al. 2013). Similar to our results, early childhood (5 year) urinary BPA concentrations

in the CHAMACOS cohort were not related to late childhood (9 year) anthropometric outcomes.

In addition, *in vitro* and *in vivo* experimental studies have shown positive associations between

BPA exposure and adipogenesis (García-Arevalo et al. 2014; Masuno et al. 2002, 2005; Riu et

al. 2011; Rubin et al. 2001; Somm et al. 2009). Our results are an important addition to the

growing literature on the potential role of BPA in the developmental origin of overweight, obese

and adipose deposition.

The longitudinal cohort design of this study is a major strength as prior cross-sectional

studies (Bhandari et al. 2013; Li et al. 2013; Trasande et al. 2012; Wang et al. 2012) may be

biased due to associations between body size and higher food intake, leading to higher exposures

to BPA from food. Strengths of our study include collecting repeated urinary BPA

concentrations and directly assessment of childhood anthropometric outcomes, with the addition

of bioelectrical impedance body composition measures at age 7 years. The analyses found

consistent results across the outcomes of FMI, %BF, and WC, although these are inter-

correlated.

Another strength of our study is our ability to control for socioeconomic and additional

environmental factors, including urinary phthalate concentrations measured concurrently with

BPA. Additionally, our study design provides the opportunity for analysis of adiposity in under-

studied inner-city minority populations. Although obesity prevalence among Hispanic children

increased by 24.2% from 2003 to 2007 (Singh et al. 2010), there is little prior information on

prenatal and early childhood exposure to BPA and effects on body size outcomes among US

minority populations. While obesity prevalence among African American children increased

1.75% from 2003 to 2007, according to National Health and Nutrition Examination Survey

(NHANES) data from 1999 to 2012, Hispanic and African American children had an obesity

prevalence of 20.9% and 20.3%, respectively (Skinner and Skelton 2014). Furthermore,

although the NHANES reports on BPA concentrations among different ethnic groups, it is

limited to adults and children ages 6 years and older (Calafat et al. 2008). To date, no other

study has evaluated the potential BPA effects on childhood body size in a birth cohort composed

entirely of more than one minority group. According to the 2010 US Census, African Americans

and Hispanics are the dominant minority populations in NYC (25.5% and 28.6%, respectively)

(US Census Bureau, 2012). In our NYC-based birth cohort, composed of African Americans

and Dominicans mother-child dyads currently being followed through adolescence, we found

associations between prenatal BPA exposures and age 7 years anthropometric outcomes

measures.

The use of spot urine samples is a potential limitation of our study. Prior studies of

minority populations in the US found a low interclass correlation (ICC) for BPA between serial

urine samples from pregnant women in Puerto Rico (ICC=0.27) (Meeker et al. 2013) and African

American and Hispanic children in NYC (ICC=0.22) (Teitelbaum et al. 2008). If, as expected,

the exposure misclassification because of variability of urinary BPA concentrations is non-

differential in regards to the outcome, bias towards the null is expected. Thus, due to the poor

reliability of the biomarkers, the findings for FMI, %BF and WC are likely to be underestimates

of the true effects.

While our study was limited by the lack of dietary data during pregnancy and childhood, accurate dietary data are extremely difficult to acquire from young children given age-related development of language skills and recall ability. Dietary measures would also require quantification of BPA in food items, which was outside the scope of this study. Another possible limitation is that body composition at age 7 years was assessed with bioelectrical impedance analysis which has been validated in some populations, but has not been compared to gold-standard reference methods in a population similar to ours (Haroun et al. 2009). There are also sex differences in pubertal development that may be associated with body composition (Ahmed et al. 1999; Blum et al. 1997; Kaplowitz 2008). Earlier puberty in girls may lead to an estrogen-mediated increase in body fat (Kaplowitz 2008). Hormonal and precocious puberty data were not available for this cohort. Therefore, pubertal timing cannot be ruled out as a possible driver of the sex-specific association observed between prenatal BPA concentrations and 7 year FMI and WC. Finally, while we had missing anthropometric and biomarker data from the children in our cohort, IPW analysis suggested that loss to follow-up did not bias our results.

## Conclusions

In our longitudinal birth cohort, we found positive associations between prenatal urinary BPA concentrations and adiposity measures at age 7 years: FMI, %BF, and WC. The association with FMI was sex-specific for girls. Thus, future studies of environmental effects on childhood adiposity may be guided to include puberty assessment. Our findings suggest that prenatal BPA exposure may have an effect on adiposity as children age, an effect which cannot be observed by BMI-based measures alone. Our study was the first to examine and show associations between prenatal exposure to BPA and adiposity outcomes in school-aged children. As the CCCEH

cohort ages into adolescence and emerging adulthood, follow-up studies will be critical for

evaluating whether the association between prenatal BPA and adiposity persists over time.

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**Table 1.** Characteristics of mothers and children with available birth weight and/or prenatal weight gain, and prenatal urinary BPA measures (N=369)

| *Categorical variables: N (%)* | |
|---|---|
| Sex of child | |
|     Female | 201 (54.5) |
|     Male | 168 (45.5) |
| Race/Ethnicity | |
|     African-American | 131 (35.5) |
|     Dominican | 238 (64.5) |
| Foreign Born [a] | |
|     US Born | 162 (44) |
|     Foreign Born | 206 (56) |
| Maternal Pre-pregnancy Obesity (BMI >30 kg/m$^2$)[a] | |
|     Yes | 75 (20.3) |
|     No | 285 (77.2) |
| Parity | |
|     Nulliparous | 168 (45) |
|     Multiparous | 201 (54) |
| *Continuous variables mean (SD)* | |
| Birth weight in g | 3365 (475) |
| Maternal Pre-pregnancy BMI[a] in kg/m$^2$ | 25.80 (6.00) |
| Prenatal BPA in ng/mL | 3.03 (4.16) |

[a] # subjects missing data on each variable: Foreign Born n=1, Pre-pregnancy Obese n=9, Pre-pregnancy BMI n=9.

**Table 2.** Characteristics of subjects with urinary BPA measures and childhood anthropometric outcomes

| | Prenatal BPA | | Age 3 Years BPA | Age 3 and/or 5 Years BPA |
|---|---|---|---|---|
| | 5 Year Anthropometry (N=300) | 7 Year Anthropometry (N=308) | 5 Year Anthropometry (N=317) | 7 Year Anthropometry (N=325) |
| *Categorical variables: N (%)* | | | | |
| Sex of Child | | | | |
|    Female | 165 (55) | 164 (53) | 164 (52) | 173 (53) |
|    Male | 135 (45) | 144 (47) | 153 (48) | 152 (47) |
| Race/Ethnicity | | | | |
|    African-American | 113 (38) | 113 (37) | 131 (41) | 136 (42) |
|    Dominican | 187 (62) | 195 (63) | 186 (59) | 189 (58) |
| Pre-pregnancy Obesity (BMI $\geq$ 30 kg/m$^2$) | | | | |
|    Yes | 64 (21) | 65 (21) | 71 (22) | 71 (22) |
| Child Overweight/Obese Status | | | | |
|    Overweight (BMI 85th - 95th %ile) | 49 (16) | 64 (21) | 52 (16) | 58 (18) |
|    Obesity (BMI$\geq$95th %ile) | 54 (18) | 72 (23) | 67 (21) | 86 (26) |
| *Continuous variables* | | | | |
| Mean Pre-pregnancy Weight (gms) (SD) | 67.24 (17.64) | 67.58 (17.69) | 68.35 (18.16) | 68.78 (18.12) |
| Mean Pre-pregnancy BMI (SD) | 25.66 (6.11) | 25.79 (6.14) | 25.87 (6.11) | 25.95 (6.13) |
| Mean Birth Weight (gms) (SD) | 3356 (480) | 3371 (487) | 3381 (492) | 3385 (499) |
| Mean BMI (SD) | 16.52 (2.73) | 17.93 (3.43) | 16.78 (2.82) | 18.19 (3.62) |
| Mean BMI Z-score (SD) | 0.42 (1.42) | 0.79 (1.15) | 0.58 (1.37) | 0.86 (1.15) |
| Median BMI Percentile (inter-quartile range) | 69.47 (32.36, 92.13) | 81.12 (53.38, 94.27) | 74.88 (37.40, 93.11) | 81.17 (54.24, 95.72) |
| Mean Fat Mass (kg) (SD) | -- | 7.19 (3.92) | -- | 7.47 (4.09) |

| | | | | |
|---|---|---|---|---|
| Mean FMI [a] (SD) | -- | 4.51 (2.18) | -- | 4.67 (2.25) |
| Mean Percent Body Fat [a] (SD) | -- | 24.13 (6.06) | -- | 24.53 (6.14) |
| Mean Waist Circumference [a] (cm) SD) | -- | 23.50 (8.27) | -- | 23.50 (8.43) |
| Mean Prenatal BPA (ng/mL) (SD) | 3.12 (4.42) | 3.06 (4.35) | -- | -- |
| Mean Child BPA (ng/mL) (SD) | -- | -- | 8.12 (12.70) | 3 year: 8.05 (12.53)<br>5 year: 5.35 (6.51)<br>3 and/or 5 year: 6.72 (7.43) |

[a] # subjects with prenatal BPA concentration and missing data on each variable at age 7 years: fat mass index n=8, fat mass n=8, percent body fat n=8, waist circumference n=11; # subjects with mean childhood BPA concentration and missing data on each variable at age 7 years: fat mass index n=22, fat mass n=22, percent body fat n=22, waist circumference n=28

**Table 3.** Associations between prenatal urinary BPA concentrations and child anthropometric outcomes

| BPA measures | Beta Coefficient (95% CI) | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| | Age 5 Yrs | Change From Age 5 to 7 Yrs | Age 7 Yrs | | | |
| | BMI Z-score | | | FMI | Percent Body Fat | Waist Circumference (cm) |
| Continuous ln-transformed BPA concentrations[a,c] | | | | | | |
| Prenatal BPA | (N=300) 0.04 (-0.16, 0.24) | (N=279) 0.06 (-0.06, 0.18) | (N=308) 0.11 (-0.04, 0.26) | (N=300) 0.31* (0.01, 0.60) | (N=300) 0.79* (0.03, 1.55) | (N=297) 1.29* (0.29, 2.30) |
| Tertiles of specific gravity-adjusted ln-transformed prenatal BPA concentrations (in ng/mL)[b,c] | | | | | | |
| <0.33 | Reference | Reference | Reference | Reference | Reference | Reference |
| 0.33-0.98 | -0.29 (-0.70, 0.12) | 0.16 (-0.09, 0.40) | -0.10 (-0.42, 0.21) | 0.004 (-0.61, 0.40) | 0.13 (-1.45, 1.71) | 0.89 (-1.21, 3.00) |
| >0.98 | -0.09 (-0.51, 0.32) | 0.16 (-0.09, 0.41) | 0.10 (-0.22, 0.42) | 0.47 (-0.14, 1.09) | 0.73 (-0.86, 2.32) | 1.93 (-0.20, 4.06) |

[a] All analyses controlled for: maternal variables: pre-pregnancy obesity, race/ethnicity, prenatal $\sum$DEHP, prenatal urinary specific gravity; child variables: sex, birth weight, gestational age.
[b] All analyses controlled for: maternal variables: pre-pregnancy BMI, race/ethnicity, prenatal $\sum$DEHP; child variables: sex, birth weight, gestational age.
[c] Additionally, height was controlled for in analyses of percent body fat and waist circumference.
*$p < 0.05$  #$p<0.1$

**Table 4.** Associations[a] between ln-transformed prenatal urinary BPA concentrations and child anthropometric outcomes stratified by sex and age 7 year interaction analysis

| Prenatal BPA (ng/mL) | Beta Coefficient (95% CI) | | | | | |
|---|---|---|---|---|---|---|
| | Age 5 Yrs | Change From Age 5 to 7 Yrs | Age 7 Yrs | | | |
| | BMI Z-score | | | FMI | Percent Body Fat | Waist Circumference (cm) |
| Girls | (N=165) 0.02 (-0.26, 0.30) | (N=153) 0.04 (-0.14, 0.20) | (N=164) 0.12 (-0.10, 0.33) | (N=161) 0.48* (0.5, 0.91) | (N=161) 0.74 (-0.32, 1.81) | (N=160) 1.45* (0.5, 2.85) |
| Boys | (N=135) 0.09 (-0.20, 0.37) | (N=126) 0.03 (-0.14, 0.21) | (N=144) 0.10 (-0.12, 0.32) | (N=139) 0.06 (-0.35, 0.47) | (N=139) 0.73 (-0.40, 1.87) | (N=137) 1.07 (-0.47, 2.61) |
| p-value (BPA) x (Sex) | - | - | 0.41 | 0.04* | 0.51 | 0.32 |

[a] All analyses controlled for: maternal variables: pre-pregnancy obesity, race/ethnicity, prenatal ∑DEHP, prenatal urinary specific gravity; child variables: birth weight, gestational age. Additionally, height was controlled for in analyses of percent body fat and waist circumference.

*p < 0.05  #p<0.1